THE UNIVERSITY OF KANSAS
PALEONTOLOGICAL CONTRIBUTIONS
NEW SERIES

NUMBER 7

UPPER PERMIAN INOZOID, DEMOSPONGID, AND HEXACTINELLID SPONGES FROM DJEBEL TEBAGA, TUNISIA

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The University of Kansas Paleontological Institute

The University of Kansas, Lawrence, Kansas
ISSN 1046-8390
February 1996

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UPPER PERMIAN INOZOID, DEMOSPONGID, AND HEXACTINELLID SPONGES FROM DJEBEL TEBAGA, TUNISIA

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Abstract.—Fossil sponge faunas from Upper Permian reefs and inter-reef rocks in the Djebel Tebaga area of southern Tunisia include the most varied and abundant late Paleozoic inozoid fauna known. The inozoid sponge part of that assemblage, plus minor demosponge and hexactinellid sponges, are described from the numerous localities and collections. The Djebel Tebaga area of southern Tunisia includes the only outcrop of marine Upper Permian strata in the entire African continent and was in the western part of the classic Tethyan belt. The sponges described here were collected, in large part, weathered out from exposures of sandy carbonates, marls, and bioclastic limestones and are commonly associated with moderately large bioherms of which the sponges were the most important reef builders.

Genera and species of inozoid sponges described here are included in the new superorder Aspiculata and the new order Inozoida. Within the family Auriculospongiidae Termier and Termier, 1977a, is the new subfamily Auriculospongiinae, which includes the genera *Auriculospongia* Termier and Termier, 1974; *Cavusonella* Rigby, Fan, and Zhang, 1989; and *Radiotrabeculopora* Fan, Rigby, and Zhang, 1991. The new subfamily Daharellinae includes the new genus *Daharella;* the new subfamily Spinospongiinae includes the new genus *Spinospongia;* and the subfamily Acoeliinae Wu, 1991 includes the genus *Acoelia* Wu, 1991, not represented in the collections from Tunisia, and the new genus *Thallospongia.*

The family Stellispongiellidae Wu, 1991 includes the new subfamily Prestellispongiinae, which includes the diverse genus *Prestellispongia;* the subfamily Stellispongiellinae Wu, 1991, which includes the diverse genus *Stellispongiella* Wu, 1991; and the new subfamily Estrellospongiinae, which includes the new genus *Estrellospongia.*

The family Peronidellidae Wu, 1991 includes the subfamily Peronidellinae Wu, 1991, which includes the genera *Peronidella* Hinde, 1893, *Brevisiphonella* Russo, 1981, *Hodsia* Moiseev, 1944; the new genera *Paronadella* and *Radiofibra,* and the genus *Maeandrostia* Girty, 1908b. The new subfamily Permocorynellinae includes the new genera *Permocorynella, Saginospongia,* and *Djemelia.* The subfamily Precorynellinae Termier and Termier, 1977a includes the genera *Precorynella* Dieci, Antonacci, and Zardini, 1968, *Stallanella* Bizzarini and Russo, 1986, *Paracorynella* Wu, 1991, *Minispongia* new genus, *Ramostella* new genus, *Bisiphonella* Wu, 1991, and *Imperatoria* de Gregorio, 1930. The subfamily Heptatubispongiinae includes the new genus *Heptatubispongia.*

The family Virgulidae Termier and Termier, 1977a (includes the families Paracorynellidae Wu, 1991, and Polysiphonelliidae Wu, 1991) includes within the subfamily Virgulinae Termier and Termier, 1977a, the genera *Polysiphonella* Russo, 1981, *Paracorynella* Wu, 1991, *Intratubospongia* Rigby, Fan, and Zhang, 1989 (=*Virgola* Girty, 1908a); the new subfamily Preeudinae includes the genera *Grossotubenella* Rigby, Fan, and Zhang, 1989, *Preeudea* Termier and Termier, 1977a, and the new genera *Polytubifungia, Medenina,* and *Microsphaerispongia.* The new subfamily Pseudohimatellinae includes the new genus *Pseudohimatella,* and the new subfamily Parahimatellinae includes the new genus *Parahimatella.*

The new family Sphaeropontiidae includes the new genus *Sphaeropontia,* and the new family Exotubispongiidae includes the new genus *Exotubispongia.*

Seventy species are described of which fifty-four are new. Also included in the description are new examples of the demosponge *Heliospongia finksi* Termier and Termier, 1977a, and a fragmental brachiospongid hexactinellid.

Possible relationships of the Inozoida with the Paleozoic Heteractinida and Sphinctozoa are discussed. The latter are possible stem-groups from which the Inozoida may have developed during the Carboniferous.

The Inozoida were encrusters, frame builders, and bafflers for some of the bioherms in Djebel Tebaga. They produced moderately complicated community sequences, even on a small, hand-sample scale. Such sequences of encrustation, diagenesis, and preservation are described. Many hand samples show at least five generations of encrustation of sphinctozoans, inozoans, sclerosponges, and algae. [In this paper, we use the term sclerosponge as an equivalent of so-called sclerosponges or possible sclerosponges.]

INTRODUCTION

Fossil sponge faunas of Upper Permian reefs and reef-related assemblages from Tunisia are perhaps the most varied and most important late Paleozoic Porifera assemblages known. The several thousand specimens studied in this project were collected as part of our field work there over the past 20 years, and they represent the largest known collection of Permian sponges in the world. The sphinctozoan part of the assemblage has been described by Senowbari-Daryan and Rigby (1988, 1991), and the principal thrust of this research is a monographic study of the inozoids as a companion work to that done on the sphinctozoans. Sponges in the collections have not been well described nor figured earlier, although preliminary descriptions by Termier and Termier (1955, 1977a) documented some of the great diversity of the faunas and prompted our investigations.

LOCATION

The Djebel Tebaga area in southern Tunisia (Fig. 1) includes the only outcrop of marine Upper Permian strata in the entire African continent. These Upper Permian deposits include relatively clean and sandy carbonates, marls, and sandy dolomites. Some small to moderately large bioherms occur within these carbonates (Newell *et al.,* 1976; Driggs, 1977; Khessibi, 1985; Senowbari-Daryan and Rigby, 1988; Toomey, 1991). These bioherms and associated marly rocks of Djebel Tebaga have produced one of the most remarkable fossil sponge assemblages of the world. The sponges (inozoids, sphinctozoans, sclerosponges, and a few demosponges and hexactinellids) are the most important reef builders, most probably as bafflers, within the Permian reef bioherms in Djebel Tebaga. They also occur in great profusion in interbedded and laterally equivalent marly units.

The Djebel Tebaga region in southern Tunisia (Fig. 2) extends northeastward from approximately 33° 27' north latitude and 10° 11' east longitude to 33° 27' north latitude and 10° 18' east longitude. The outcrops lie approximately 25 km northwest of the town of Medenine and approximately 25 km south of the town of Mareth (Fig. 1). Upper Permian rocks in the Djebel Tebaga area are exposed in a series of hogbacks for an east-west distance of approximately 18 km. The exposed section is about 850 m thick (see Fig. 3) and is overlain in a general regressive sequence by nonmarine red beds of Permo-Triassic age (Newell *et al.,* 1976; Toomey, 1991). Wells to the southwest (Bir Soltane) and south of Djebel Tebaga indicate that the total thickness of the marine Permian may reach several thousand meters (Glintzboeckel and Rabate, 1964).

Fusulinids suggest a late Murgabian to early Pamirian (Midian) age for the reef limestones (Khessibi, 1985; Senowbari-Daryan and Rigby, 1988; Toomey, 1991; Vachard and Razgallah, 1993).

Additional outcrops of marine Permian deposits nearest to Djebel Tebaga are those in the Sosio Valley in Sicily (Fig. 1), where boulders of Permian carbonates up to one or two meters in diameter occur in the Triassic Lercara Formation (Senowbari-Daryan and Di Stefano, 1988) and as olistolites near the town of Palazzo Adriano (locality Pietro di Salomone; Flügel, Di Stefano, and Senowbari-Daryan, 1991). The boulders of Permian reefoidal carbonates within the Lercara Formation near the town of Lercara are of Early Permian age. The main frame builders in these carbonates are both inozoan and sphinctozoan sponges, as well as the problematic organisms *Tubiphytes* Maslov, 1956, and *Lercaritubus* Flügel, Senowbari-Daryan, and Di Stefano, 1990, which are in turn encrusted by *Archaeolithoporella* (Senowbari-Daryan and Di Stefano, 1988).

The carbonate blocks of the small locality of Pietro de Salomone are of different ages. The presence of fusulinids as well as conodonts suggests that these carbonates include clasts of Early, Middle, and Late Permian ages and are not solely of Middle Permian age as previously thought (Flügel, Di Stefano, and Senowbari-Daryan, 1991). Sponge faunas of both localities are very similar to sponge faunas from Djebel Tebaga, but the Sicilian localities have low species diversity.

PREVIOUS STUDIES

Sedimentology and facies of the Permian strata of Djebel Tebaga have been investigated by Glintzboeckel and Rabate (1964), Newell *et al.,* (1976), Driggs (1977), Khessibi (1985), and recently by Toomey (1991) and Vachard and Razgallah (1993).

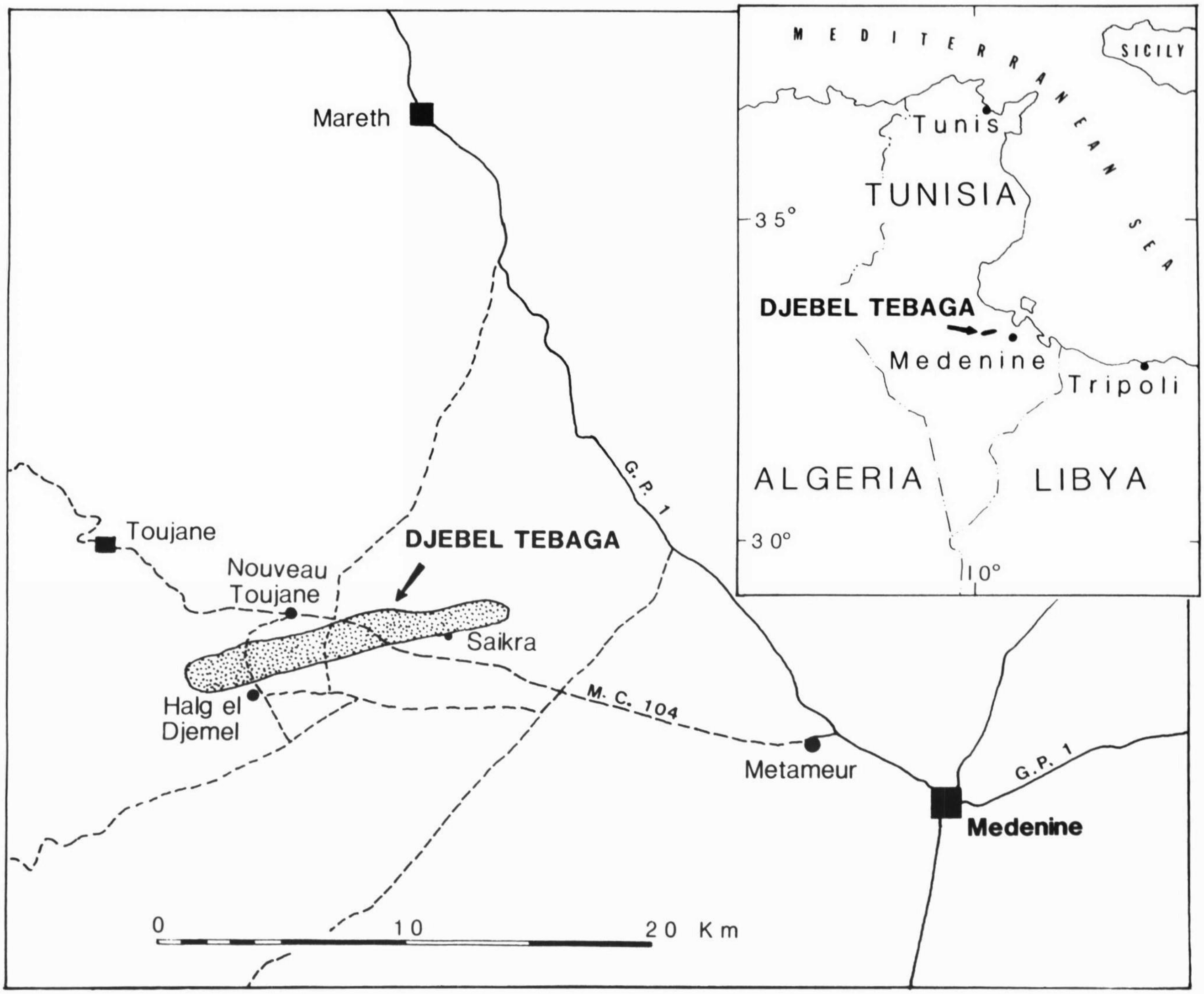

Figure 1. Index map of Tunisia showing position of the Djebel Tebaga Permian outcrops near Medenine in the southern part of the country (adapted from Newell *et al.*, 1976).

Since discovery of the Permian rocks of Djebel Tebaga by Berkaloff in 1932 (Douvillé, Solignac, and Berkaloff, 1933), several investigations of various groups of invertebrates have been published by different workers. Toomey (1991, table 1) provided an essentially complete list of works published to date on the different groups of organisms found in Djebel Tebaga.

The sponges and their mineralogy, microstructure, and diagenesis have been investigated by Termier and Termier (1955, 1957, 1973, 1974, 1975, 1977a, 1977b), Wendt (1977, 1984), Scherer and Wendt (1978), Gautret (1986), Scherer (1986), Cuif and Gautret (1987), Gautret and Razgallah (1987), Senowbari-Daryan and Rigby (1988, 1991), and Senowbari-Daryan (1989, 1990).

The present paper, part II of our contribution on Permian sponges in Djebel Tebaga, treats the nonsegmented inozoid sponges and other minor sponges. The segmented sphinctozoans were most recently described in part I (Senowbari-Daryan and Rigby, 1988). A short publication described three additional segmented sponges (Senowbari-Daryan and Rigby, 1991).

COLLECTIONS

The inozoid sponges described here were collected from approximately 130 different localities in Djebel Tebaga (Fig. 2–3). The major part of the collection was assembled in 1975 by J. K. Rigby and A. F. Driggs of Brigham Young University, N. D. Newell of the American Museum of Natural History, and D. W. Boyd of the University of Wyoming. Additional specimens were collected from different localities by J. K. Rigby and B. J. Kowallis in 1976, by C. and H. Faul in 1974, and by C. Faul in 1977. B. Senowbari-Daryan collected additional sponges from the area in 1983. Collections by Rigby's groups and by Senowbari-Daryan have been combined with other collections for our studies. Relationships of various spot localities to the measured sections are shown in Table 1, where such localities are along traverses of the sections.

Table 1. Occurrences of inozoid sponges in Perman rocks of the Djebel Tebaga region of Tunisia. Designations -R3 and +R3 refer to beds below and above Reef 3 in Section E, and -2 and -3 refer to beds below beds 2 and 3 of Section I, occasionally lateral to the traverse. Letter and number designations in sections listing spot localities collected by Stehli (1970) and Newell (1973) refer to the position of the spot locality with reference to measured sections and beds. For example, spot locality 1 collected by Stehli is equivalent to bed 1 of Section G, and spot locality 2 is equivalent to bed 26 of Section E, etc. Numbers in the body of the table refer to numbers of specimens of each species in our collections from each of the localities. Authorships in column of genera and species include: *T&T,* Termier and Termier; *P,* Parona; *RF & Z,* Rigby, Fan, and Zhang; *S-D,* Senowbari-Daryan; *dG,* de Gregorio. See pages 5–7.

Inozoid sponges in our collection are represented by several thousand specimens that were largely weathered out of matrix as complete sponges. More than 100 thin sections were made to investigate their internal structures. Almost all species were also investigated using scanning electron microscopy.

Collections, including type and reference specimens, are deposited in the United States National Museum in Washington, D.C.

GENERAL MORPHOLOGY AND TERMINOLOGY

Morphology.—Inozoid sponges are usually cylindrical to club shaped (Fig. 4); however, tabular to bladelike or mushroom-shaped to massive inozoans also occur. Most inozoid sponges are unbranched, but some of them, such as *Peronidella,* may be branched and bushlike. Inozoids are usually only a few millimeters to a few centimeters in diameter and about 10 cm tall. Some, however, may be up to 10 cm in diameter and up to 50 cm tall.

Outer surfaces of inozoids may be smooth, or they may be characterized by coarse to fine growth lines. Some species do not exhibit any perforation of the outer surfaces; however, in most instances the outer surface is perforated by numerous small pores or by less abundant large openings (ostia). Sponges with a cortex or dermal layer commonly have pores with circular or oval openings. Those without a cortex usually exhibit irregularly shaped pores that correspond to spaces between the skeletal fibers (Fig. 4). Differentiation between pores and ostia is not always easy, but they have been distinguished here following criteria suggested by Seilacher (1962) for sphinctozoan sponges. Pores are usually circular, although they also may be elliptical. Pores seem to be typical in those inozoids that have a dermal layer (cortex). Pores are located in depressions and do not have tubelike projections, as are sometimes characteristic of ostia.

Ostia are usually three to four times or more larger than pores and are usually less numerous than pores in the same area. Outlines of ostia are usually circular, but starlike ostia also occur. In some instances, edges of ostia are characterized by thickened rims or tubelike projections, called exaules by Finks (1983), for similar structures in sphinctozoan sponges. Lengths of exaules are usually less than 1 mm, although some may be more than 1 mm long. Long exaules, such as occur in such sphinctozoan sponges as *Girtyocoelia,* have not been observed in the inozoids from Djebel Tebaga. In some genera, e.g., in *Daharella,* a sievelike plate with small openings is developed at the base of each ostium. Pores and ostia, which usually do not occur together in the same sponge, are called inhalant openings in this paper.

Surface sculpture may be the same or quite different on opposite faces or sides in tabular or palmate inozoan sponges. For example, the genus *Auriculospongia* has a pattern of radially arranged furrows on one side and uniformly distributed pores on the other side (see section on systematic paleontology).

Some fossil inozoid genera completely lack axial openings. Evidently the water exited the sponge body through interfiber spaces. Distinct ostia or pores may occur on the exterior of these genera, or such openings may be absent.

Some inozoid genera are characterized by a single, shallow osculum or by several such depressions on their summits. An osculum may have a circular, elliptical, or starlike transverse section or outline. In such genera as *Stellispongiella* and *Pseudohimatella,* the osculum is a shallow depression limited to the summit and does not extend as a spongocoel far into the body of the sponge. In most other sponges, however, the osculum is merely the upper termination of the tubelike spongocoel in the sponge body. The spongocoel(s) may extend only part of the way through the sponge or may extend deeply to near its base. Thus, inozoid sponges without a spongocoel may be termed *acoeloid,* or *unicoeloid* when only one spongocoel is developed, and *bicoeloid* or *polycoeloid* when two or several spongocoels are present.

Many inozoid genera possess an axial bundle of spongocoels, as in *Precorynella,* but other genera may have many that are not located in the axial area, as for example in *Preeudea* and *Medenina* new genus, which have spongocoels or coarser exhalant tubes distributed throughout the whole sponge body.

The spongocoel is commonly a tubular interruption of the fibrous structure without a distinct skeletal wall. In other cases, however, the spongocoel may have a distinct wall that is pierced by openings that are called gastral, exhalant, or spongocoel pores. Those pores are usually circular but may be oval or slitlike and vertically elongate. Other shapes of gastral pores have not been observed in our Tunisian collections.

Ostia may open internally directly into interfiber openings or lead into well-defined, smaller, usually horizontally oriented canals called incurrent or inhalant canals or epirhyses. Such inhalant canals may grade into interspace

		Section B Beds		Section C Beds		Section E Beds									Section G Beds								Section H Beds	Section I Beds								
		1	2	16	18	11	14	15	21	26	27	29	-R3	+R3	4	5	9	14	15	16	19	30	Base	-2	2	-3	3	5	7	10	12	16
1	*Auriculospongia auriculata* T&T	-	-	3	1	-	1	-	-	-	3	-	15	-	4	3	-	-	-	-	-	-	-	-	5	2	-	-	-	-	1	-
2	*A. perforata* n. sp.	3	-	-	4	-	2	-	-	-	4	-	3	3	4	1	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	2
3	*Cavusonella caverna* RF & Z	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	*Radiotrabeculopora* cf. *xiangboensis*	5	-	-	-	-	3	-	-	1	7	-	8	1	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
5	***R. maokoui*** **RF & Z**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-
6	*R. reticulata* RF & Z	-	-	2	1	-	-	-	-	-	-	1	-	-	4	31	4	-	-	-	-	-	-	-	3	-	-	1	-	-	1	-
7	*R. patula*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	*Daharella ramosa* n. sp.	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1
9	*D. micella* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	***D. palmata*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	*Spinospongia radiata* n. sp.	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	*Thallospongia reticulata* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	*Stellispongiella bacilla* (T&T)	17	-	27	15	-	16	9	4	7	50	3	33	3	-	4	7	1	-	3	-	-	-	-	7	25	-	50	6	25	31	-
14	*S. insculpta* n. sp.	-	-	3	-	-	2	1	1	1	-	-	13	-	-	10	-	-	1	-	-	-	-	-	3	-	-	1	-	-	4	1
15	***S. reticulata*** **n. sp.**	-	4	-	-	-	-	1	-	-	2	-	1	-	1	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
16	*S. parva* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	*S. amplia* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	*S. porosa* n. sp.	-	-	-	-	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
19	*S. tumida* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
20	***Prestellispongia lobata*** **(P)**	4	-	-	-	-	-	1	-	-	3	-	-	-	4	-	-	-	-	-	-	-	-	-	2	2	-	1	-	-	-	1
21	*P. permica* (P)	1	-	1	-	-	-	-	-	1	2	-	6	-	2	1	-	-	-	1	-	-	-	-	3	-	1	-	-	-	-	-
22	*P. paula* n. sp.	8	-	-	2	-	2	-	-	4	33	-	-	-	6	15	-	-	-	-	-	-	-	2	11	-	-	13	-	-	1	-
23	*P. scapulata* n. sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	*P. bolaria* n. sp.	-	-	-	-	-	-	-	-	-	-	-	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	***P.*** **(?)** ***fasciculata*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	*Estrellospongia grossa* n. sp.	-	-	-	-	1	-	-	1	-	7	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	*Peronidella magna* n. sp.	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
28	*P.(?)* sp. cf. *P. magna*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
29	*P. multiosculata* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	***P. digitata*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
31	*P. rigbyi* S-D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	*Radiofibra lineata* n. sp.	-	-	-	-	-	-	-	-	-	2	-	-	-	4	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
33	*R. delicata* n. sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	*R. nodosa* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	***R. inordinata*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	*Permocorynella ovoidalis* (P)	2	-	1	-	-	-	2	-	-	-	-	-	1	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37	*P. (?) ovoidalis* (P)	-	-	-	-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	*P. osculifera* n. sp.	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	*P. fruticosa* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	***P. tuberosa*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
41	*Saginospongia angusta* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	*S. porosa* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	*S. crateria* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	*Djemelia amplia* n. sp.	-	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	***D. mediala*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	*D. nana* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
47	*Precorynella crysanthemum* (P)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
48	*P. virgosa* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	*P. diffusa* n. sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	***P. robusta*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	*P. ampliata* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
52	*Minispongia carinata* n. sp.	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53	*Ramostella stipulata* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
54	*Imperatoria marconii* dG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	***I. voluta*** **n. sp.**	-	-	3	-	-	-	-	-	-	6	-	2	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-
56	*I.* (?) *fistulata* n. sp.	-	-	-	-	-	-	3	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	4	-	-	3	-	-	-	-
57	*Heptatubispongia symmetrica* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
58	*H.* (?) cf. *H. symmetrica* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
59	*Intratubospongia osiensis* (dG)	2	-	10	-	-	-	5	1	7	59	3	27	1	137	32	-	3	-	1	4	-	-	-	9	37	-	-	-	-	12	2
60	***I. obscura*** **n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61	*Preeudea minima* T & T	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62	*Medenina laterala* n. sp.	-	-	-	-	-	-	-	-	-	-	-	2	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63	*Polytubifungia maxima* n. sp.	4	-	-	-	-	3	-	-	-	4	-	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
64	*P. minima* n. sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65	***Microsphaerispongia polyarteria*** **n. sp.**	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66	*Pseudohimatella pauciporata* (P)	2	-	1	8	-	-	-	1	-	13	-	14	-	14	14	-	-	-	-	-	1	-	-	-	-	6	-	-	-	-	-
67	*Parahimatella vesiculata* n. sp.	-	-	-	-	-	-	1	-	-	-	-	1	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68	*Sphaeropontia regulara* n. sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69	*Exotubispongia pustulata* n. sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	***E. virgulata*** **n. sp.**	-	-	-	-	-	18	-	-	-	7	-	-	6	6	-	1	-	-	-	-	-	1	-	-	-	5	-	-	-	1	-
71	*Heliospongia finksi* T & T	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	hexactinellid sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Section J Beds							S,T, and DJT Spot Localities collected by Stehli, 1970																											H&C Faul Collections		Spot Localities Collected by Rigby, 1976			
								G1	E26	G3	G5	G11	G6	G8	C18	C19	C11	B24	I12	D23		C16	C17	C31	C32	B21	B22	B23	B24	E26	E23	B31								
	1	5	14	17	18	25	26	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	24	26	27	31	32	34	18	24	89	105	106	109
1	-	-	-	1	-	2	9	-	-	-	10	-	-	-	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	2	-	-	2	-
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37	-	-	-	-	-	-	-	1?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3?	-	-	-	-	-
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59	-	-	-	108	2	7	33	6	-	6	7	15	18	4	-	2	1	4	1	2	-	1	1	-	-	-	-	-	-	2?	-	3?	-	10	-	-	1	-	-	1
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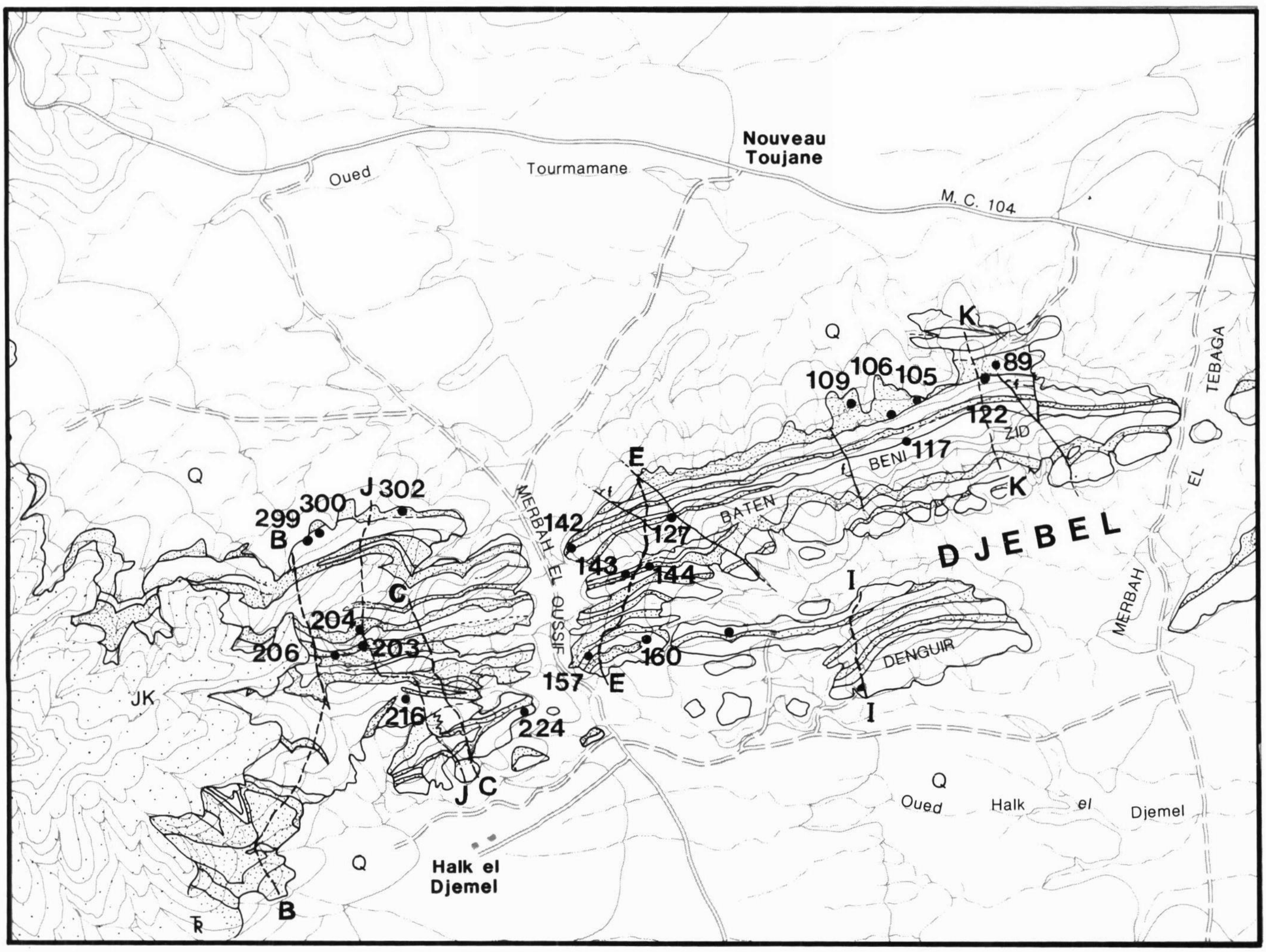

Figure 2. Generalized geologic map of Djebel Tebaga area, southern Tunisia. Measured stratigraphic sections are indicated by letters. Individual collecting localities away from stratigraphic sections are shown as numbered localities. Stippled areas are Permian sandstones or marly beds; *JK*, Jurassic and Cretaceous rocks; *Q*, Quaternary deposits; *f*, fault.

openings within the skeleton, or they may connect to exhalant openings that pass through the skeleton to open into the spongocoel. These latter canals may be termed excurrent or exhalant canals or aporhyses. In addition to these inhalant and exhalant canals, other canals may be developed within the sponge wall. These are usually longitudinal and parallel to the axis of the sponge, but they may be upwardly and outwardly divergent within the sponge wall. These longitudinal canals probably distributed water within the sponge wall, and some may have served as small excurrent tubes (spongocoels) for water to leave the sponge.

Water-circulation patterns in inozoid sponges from Djebel Tebaga.—Four main patterns of water circulation through inozoid sponges can be recognized in taxa from Djebel Tebaga (Fig. 5). They are defined by distribution and locations of ostia, inhalant and exhalant canals, spongocoels, and oscula. Water circulation in some genera was horizontal, but in others movement of water was vertical. Four different water circulation patterns may be named as follows, based on typical genera: (1) *Auriculospongia*-type, (2) *Peronidella*-type, (3) *Pseudohimatella*-type, and (4) *Stellispongiella*-type.

1. *Auriculospongia*-type (Fig. 5A). In these sheetlike sponges, one side is covered with furrows or small pores with or without a dermal layer or cortex. The other side is characterized by multibranched furrows containing large openings. Water passed horizontally through the small inhalant openings (small arrows, Fig. 5A) and, after circulation through the sponge, left the sponge body through large openings located in furrows on the exhalant side (large arrow, Fig. 5A). Water moved horizontally through the sponge as shown by the large arrow at the base.

2. *Peronidella*-type (Fig. 5B). *Peronidella* possesses an axial spongocoel that passes essentially through the sponge. In these sponges water entered through small, interfiber spaces and after circulation through the sponge body, moved

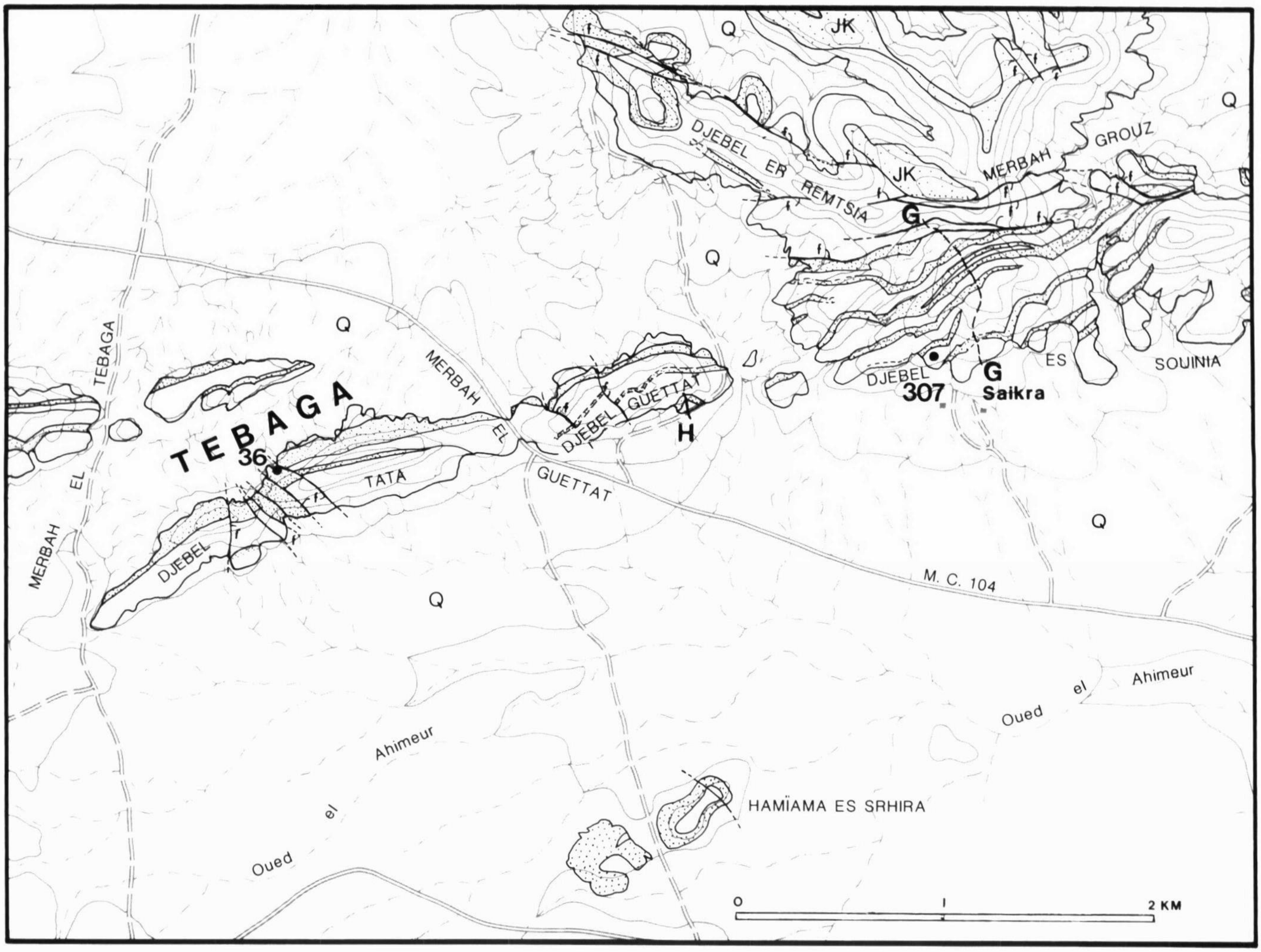

Figure 2. Explanation on facing page.

into the spongocoel to leave the sponge through the osculum at the summit. Water entered horizontally into the sponge body (small arrows, Fig. 5B) and left vertically (large arrow). Directions of water current were first horizontal and then vertical as shown by the large arrow at the base. Most Djebel Tebaga inozoid sponges have water circulation patterns of the *Peronidella*-type.

3. *Pseudohimatella*-type (Fig. 5C). The outer surface of *Pseudohimatella* is smooth and without inhalant openings but with growth lines in a dense dermal layer. Summits of these conical sponges, however, contain numerous openings that extend as canals or tubes down into the sponge. A large but shallow depression, the osculum, is present in the axial area of the summit, but it does not extend deeply into the sponge as does the spongocoel in *Peronidella*. Water most probably passed vertically through small inhalant openings on the summit and vertically down into the sponge (small arrows in Fig. 5C). After circulation through the sponge the water left vertically through larger exhalant openings and the large depression (large arrow, Fig. 5C). Water flowed first vertically downward and then vertically upward, as shown by the large arrow.

4. *Stellispongiella*-type (Fig. 5D). The cylindrical stemlike sponge, *Stellispongiella*, possesses starlike clusters of exhalant canals that are located partly on mamelonlike elevations. The surface of the sponge between the exhalant canal clusters is covered by numerous small openings (inhalant pores) through which the water passed horizontally (small arrows) into the sponge. After circulation through the sponge, water then left through the several starlike astrorhizal exhalant canals, in a direction opposite the inhalant current (large arrows). The water movement was principally horizontal, as in *Auriculospongia*, but in *Auriculospongia* inhalant and exhalant currents had the same direction of flow, whereas in *Stellispongiella* the inhalant current was oriented against the exhalant current.

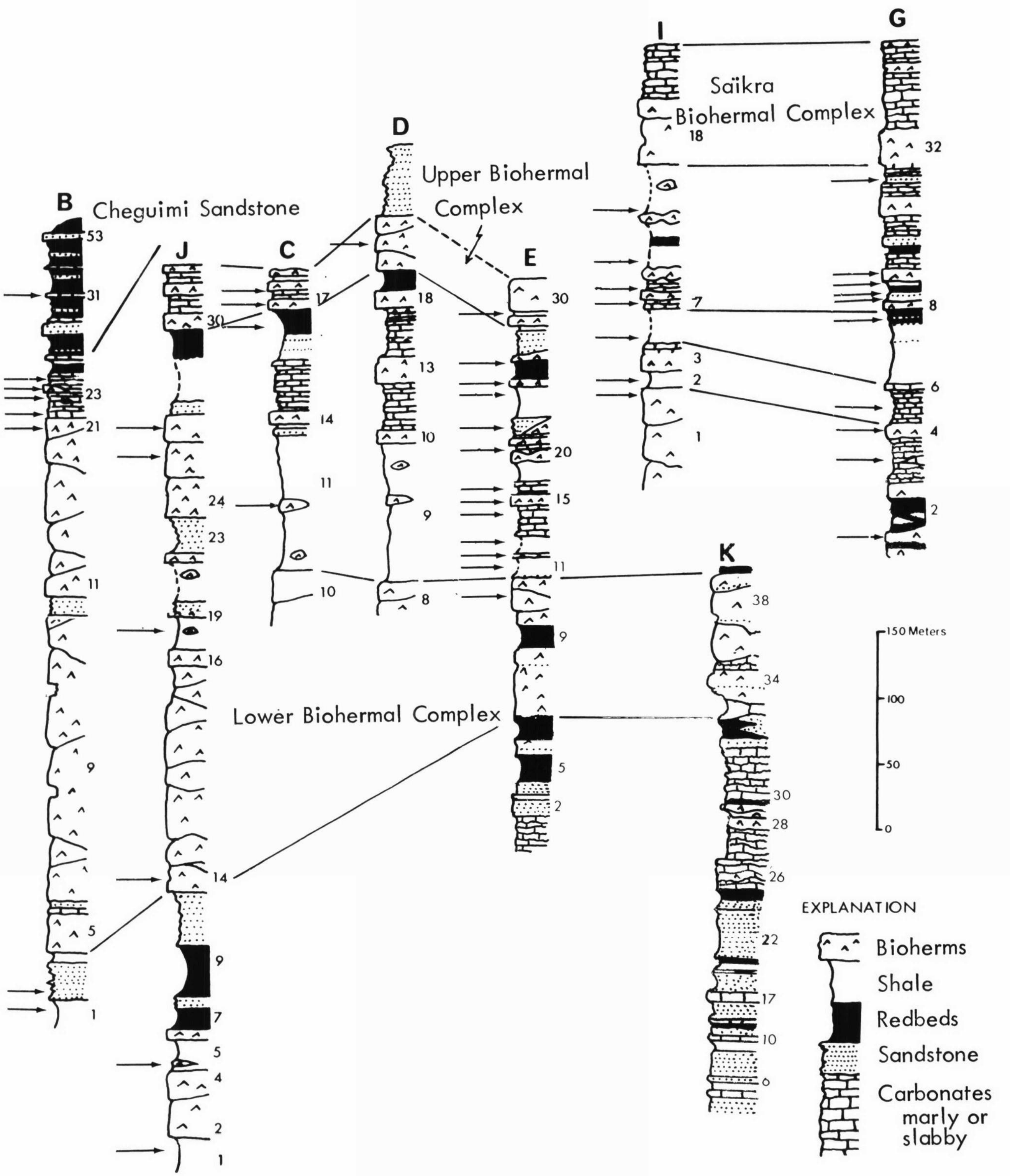

Figure 3. Correlation of measured stratigraphic sections of Permian rocks in the Djebel Tebaga area. Location of each of the measured sections is shown in Figure 2. Arrows on the left of each column indicate units from which inozoid sponges were collected. For descriptions of the sections see Newell *et al.*, 1976 (adapted from Newell *et al.*, 1976).

Skeletal structure.—Skeletons of inozoids are composed of fibrous structures. These fibers generally have thicknesses of only fractions of a millimeter but may be coarse in some genera. The fibers are usually irregularly oriented, though moderately consistently spaced (reticular), and commonly do not show any particular preferred orientation within the sponge wall. Some genera, however, have distinct regular skeletal patterns. For example, some show a pronounced upward and outward, divergent, jet-of-water structure. In other genera, for example, *Auriculospongia,* the arrangement of fibers is crudely rectangular, but it may appear different in sections normal or at high angles. The main morphological features of inozoid sponges are shown in Figure 4.

Composition of rigid skeleton.—All Upper Permian inozoids investigated in our study and those whose microstructure has been reported elsewhere had original skeletons composed of primary aragonite (Wendt, 1977, 1978, 1984; Finks, 1983). Neither primary calcite nor Mg-calcite were found as skeletal materials in the inozoids of Tunisia. Wendt (1984, p. 328) reported that inozoids with a calcite skeletal mineralogy appeared first in the Triassic; however, some Triassic inozoids have skeletons also composed of primary Mg-calcite.

Microstructure of the rigid skeleton.—Skeletons of almost all inozoid genera and species from Djebel Tebaga have been examined using scanning electron microscopy (Table 2). Most of those genera clearly have a spherulitic aragonite microstructure (see Fig. 6). Recrystallization has destroyed the microstructure in examples we examined of some genera. They also probably had spherulitic structure, but this could not be confirmed. Clinogonal (water-jet) microstructure also occurs in Permian inozoan sponges (Fig. 6), according to Wendt (1984), but there is no evidence of this in our collection. Clinogonal and irregular microstructures are relatively abundant microstructures within Triassic inozoids (Russo, 1981; Wendt, 1984), but such structures were not found in our Permian inozoids.

Table 2 shows the sizes of spherulites in the various inozoid sponges from Tunisia, sizes that usually range between 50 μm and 100 μm. The smallest spherulites, 20 to 50 μm, were found in *Spinospongia radiata* new species, and the largest spherulites, up to 250 μm in diameter, were found in *Sphaeropontia regulara* new species. Arrangement and packing of the spherulites range from alternating or irregular maximum packing to packing in distinct rows in most of the genera. The arrangement of spherulites in *Sphaeropontia,* however, differs from all other genera in the collection and is a widely spaced structure, described in more detail in descriptions of the species (see also Fig. 35–36).

Spicular skeleton.—All of the genera described here have been investigated using scanning electron microscopy. We searched for occurrences of spicules but did not find spicules or traces of spicules in any of these inozoid genera. Wendt (1977, 1978, 1979, 1984), who has investigated skeletal mineralogy and composition of Permian and Triassic inozoids, has not found spicules in inozoids of this age either. Whether a spicular skeleton was lacking in primary skeletons of these sponges and whether spicules were lost during fossilization or later diagenesis are discussed below.

If Paleozoic and most Triassic inozoids secreted spicular skeletons, those spicules should have been either calcitic or siliceous. If the inozoids had secreted calcite spicules,

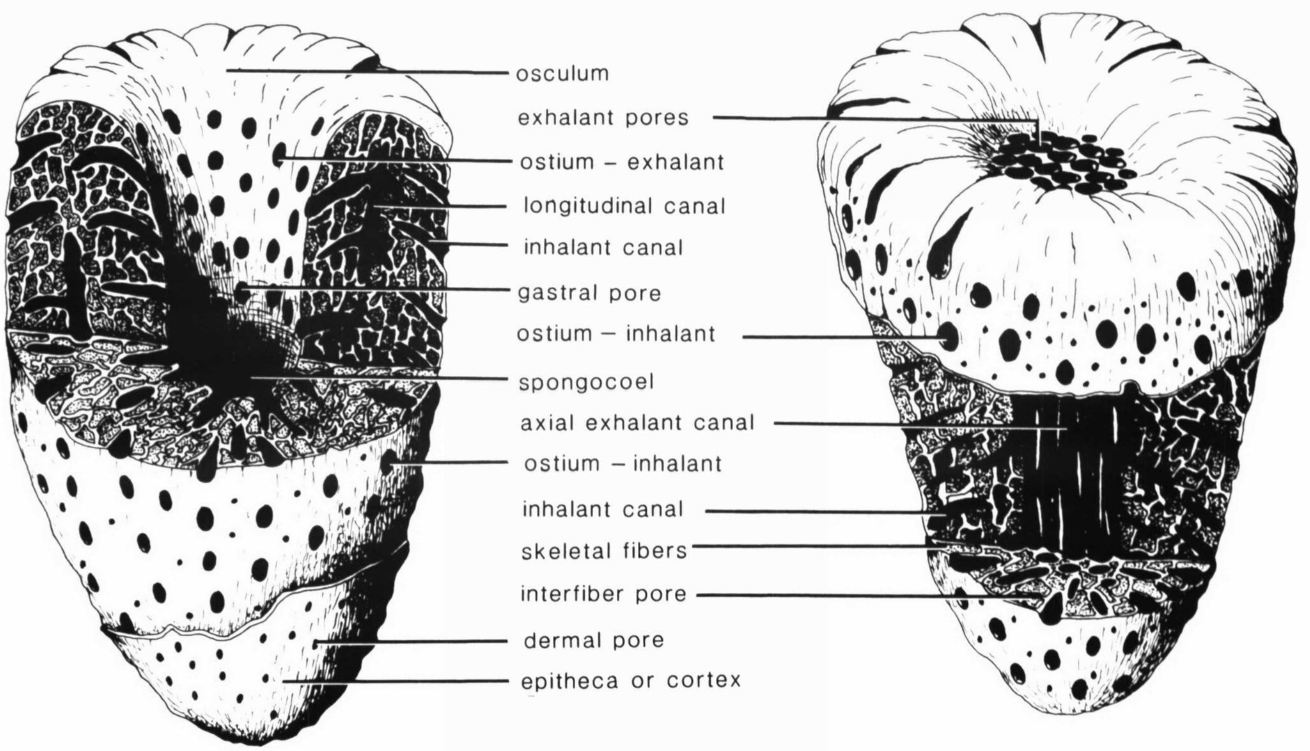

Figure 4. Exterior and interior features of inozoid sponges and their terminology. One of the generalized sponges shows a prominent, deep spongocoel and the other a cluster of axial exhalant canals ending in a shallow osculum (schematic, not to scale; adapted from Rigby, Fan, and Zhang, 1989).

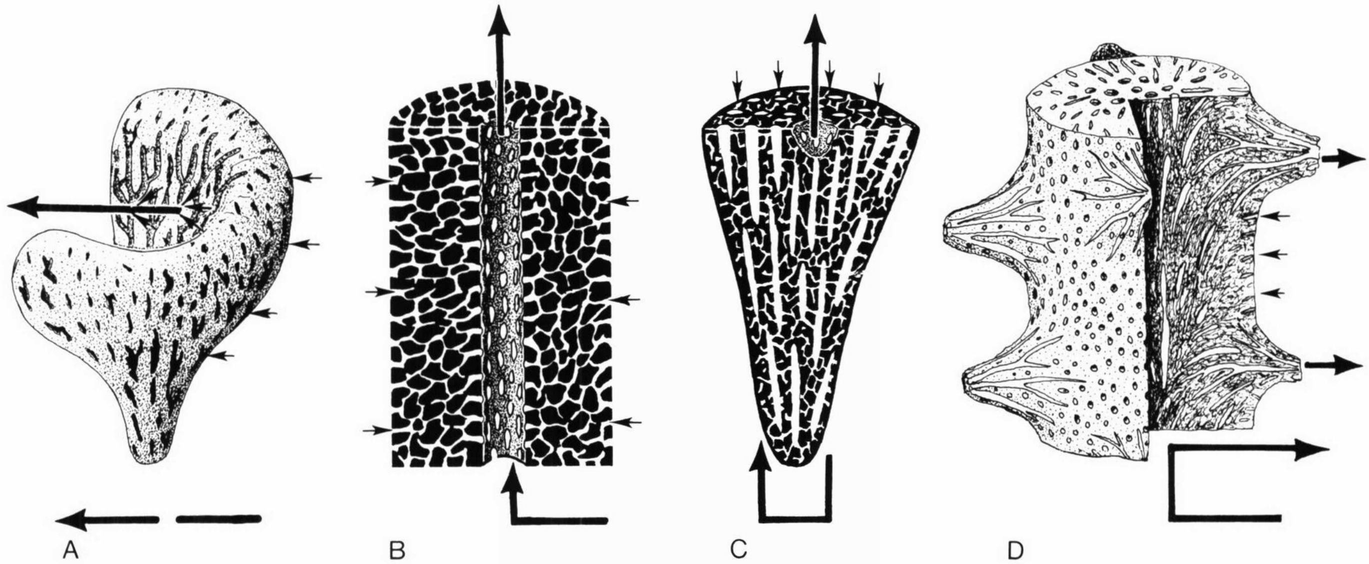

Figure 5. Pathways and water circulation through typical inozoid sponges found in Djebel Tebaga (arrows indicate the direction of water movement); *A, Auriculospongia*-type. In this type of sponge, water passes horizontally in through incurrent openings on one side of the sponge and after circulation through the interior leaves the sponge body horizontally through excurrent canals. Pathway: inhalant = horizontal; exhalant = horizontal; *B, Peronidella*-type; in this type of sponge, water passes horizontally through openings (ostia or interfiber spaces) into the sponge and after circulation through the interior leaves the sponge body vertically through one or several spongocoels or canals. Pathway: inhalant = horizontal; exhalant = vertically upward; *C, Pseudohimatella*-type. In this type of sponge, water passes vertically downward into the sponge body. The lower outer surface of the sponge does not have perforations. After circulation through the interior, water leaves the sponge body vertically through several spongocoels or exhalant canals. Pathway: incurrent = vertically downward; excurrent = vertically upward; *D, Stellispongiella*-type. In this type of sponge, water enters horizontally through ostia on all sides of the cylindrical stems and after circulation through the sponge exits through the starlike exhalant canals of astrorhizal systems scattered along the stem. Water exits essentially horizontally, opposed to the inhalant currents. Pathway: inhalant = horizontal; exhalant = horizontal.

some should have been embedded in the rigid skeleton or, perhaps, restricted to the soft tissue. If any of these Permian sponges secreted a spicular skeleton composed of primary calcite and those spicules were embedded in the rigid skeleton, such spicules should have been preserved in our specimens. Primary calcite spicules are preserved in Jurassic and Cretaceous inozoans, and if they were ever present they should also be preserved in our material.

If calcite spicules were present and lost by later recrystallization, aragonite of the rigid skeletons should have been transformed into calcite before the calcite spicules were destroyed. The aragonite spherulites are preserved, however, without evidence of included spicules. We have concluded that complete recrystallization with resulting loss of calcareous spicules has not taken place in our Tunisian collections and that primary calcite spicules were not secreted as part of the rigid skeleton.

If some calcite spicules were secreted and restricted to the soft body of the sponge, they should have been scattered within skeletal openings of the sponges after the decay of the soft parts. Such spicules should be preserved, at least partially, in interfiber spaces or somewhere in spongocoels of the sponges. We have not found traces of such spicules, neither in interiors of the sponges nor in the surrounding rocks.

It is possible, although unlikely, that the Tunisian inozoids were not calcisponges, but demosponges or sclerosponges. If so, they may have secreted primary siliceous spicules. Such spicules are likely to have been embedded in the rigid skeleton, perhaps restricted to the soft tissue, like those known in some modern sponges such as *Acanthochaetetes wellsi* Hartman and Goreau, 1975, or *Merlia normani* Kirkpatrick, 1911. Spicules of living demosponges and sclerosponges are composed of amorphous hydrated opaline silica and may be rapidly dissolved in seawater (Hartman and Goreau, 1966, 1970, 1972; Land, 1976; Hartman, 1979; Jones, 1979).

If the Permian inozoids secreted a spicular skeleton composed of siliceous spicules and if these were embedded in their rigid skeletons, the spicules could be missing because they may have been rapidly dissolved. The resulting cavities, however, should have been filled by sediment, cement, or other minerals. In some instances, spicules in other fossils have been replaced by calcite or some other mineral such as pyrite during sedimentation or diagenesis. If so, the primary siliceous spicules should be found as pseudomorphs composed of other minerals. They should appear as the spicules found in some sphinctozoan sponges from Djebel Tebaga (Senowbari-Daryan, 1989, 1990; Senowbari-Daryan and Rigby, 1991). Such pseudomorphs

Table 2. Microstructure and sizes of spherulites in the rigid skeletons of Permian inozoid sponges from Djebel Tebaga, Tunisia; *S*, poor preservation, spherulites not clearly recognizable or spherulites preserved in outline only; *?*, a specimen of the species was investigated but recrystallization has destroyed its primary microstructure; *??*, specimen of the species not investigated. Sizes of spherulites in μm.

Species	Microstructure	Size of spherulites (μm)
Auriculospongia auricula	spherulitic	40
A. perforata	spherulitic	50–70
Cavusonella caverna	spherulitic	60–100
Daharella micella	??	—
D. palmata	?	—
D. ramosa	?	—
Djemelia amplia	?	—
D. mediala	?	—
D. nana	??	—
Estrellospongia grossa	S	50
Exotubispongia pustulata	??	—
E. virgulata	??	—
Heptatubispongia symmetrica	??	—
Imperatoria(?) fistulata	?	—
I. marconii	??	—
I. voluta	S	—
Intratubospongia obscura	spherulitic	60
I. osiensis	spherulitic	50–100
Medenina laterala	S	—
Microsphaerispongia polyarteria	??	—
Minispongia carinata	?	—
Parahimatella spiculata	spherulitic	50–80
Permocorynella ovoidalis	S	—
P. fruticosa	S	30?
P. osculifera	S	—
P. tuberosa	??	—
Peronidella digitata	??	—
P. magna	spherulitic	100
P. multiosculata	spherulitic	60–100
P. rigbyi	??	—
Polytubifungia maxima	??	—
P. minima	?	—
Precorynella ampliata	??	—
P. crysanthemum	S	50–70
P. diffusa	??	—
P. robusta	??	—
P. virgosa	??	—
Preeudea minima	?	—
Prestellispongia bolaria	S	—
P.(?) fasciculata	?	—
P. lobata	?	—
P. paula	?	—
P. permica	spherulitic	—
P. scapulata	?	—
Pseudohimatella pauciporata	spherulitic	30–100
Radiofibra delicata	spherulitic	50–70
R. inordinata	spherulitic	60–70
R. lineata	spherulitic	100
R. nodosa	spherulitic	30
Radiotrabeculopora maokoui	??	—
R. patula	??	—
R. reticulata	S	—
R. cf. *xiangboensis*	spherulitic	100–130

Table 2. Continued.

Species	Microstructure	Size of spherulites (mm)
Ramostella stipulata	?	—
Ramostella sp.	spherulitic	30
Saginospongia angusta	??	—
S. crateria	?	—
S. porosa	??	—
Sphaeropontia regulara	spherulitic	100–250
Spinospongia radiata	spherulitic	20–50
Stellispongiella amplia	??	—
S. bacilla	spherulitic	40–70
S. insculpta	?	—
S. parva	spherulitic	30
S. porosa	??	—
S. reticulata	??	—
S. tumida	spherulitic	50–80
Thallospongia reticulata	??	—

are known in other sponges of various geologic ages (Kázmierczak, 1974, 1979; Dieci, Russo, and Marchi, 1977; Gray, 1980; Reitner and Engeser, 1985, 1987; Wood, 1987, 1990; Wood, Reitner, and West, 1989). We have not seen evidence of spicules in the Djebel Tebaga inozoids. As a result we conclude that primary siliceous spicules were not present in rigid skeletons of the inozoid sponges of Djebel Tebaga.

Similarly, the possibility of the existence of primary siliceous spicules restricted to the soft tissue of the sponge is rejected. Such spicules probably would have been scattered after the decay of the sponge, but they have left no record in our fossil sponges.

RELATIONSHIP BETWEEN PERMO-TRIASSIC INOZOIDA AND JURASSIC-CRETACEOUS INOZOANS

Lack of spicule development in Permian and most Triassic inozoids, on one hand, and their presence in Jurassic and Cretaceous inozoans (Fig. 6), on the other hand, suggest that Paleozoic and most Triassic inozoids are a different systematic group from the Jurassic and Cretaceous inozoans, even though both have calcareous skeletons and relatively similar growth forms. The microstructures of their rigid skeletons are also different. Jurassic and Cretaceous inozoans have mostly neomorphic calcite or orthogonal microstructure (Wendt, 1984), and Permian and Triassic inozoids have mostly spherulitic, or in some cases clinogonal structures (see Wendt, 1984; Finks, 1983, 1990). Such differences support our conclusion that the two groups (Inozoa and Inozoida) are different evolutionary lineages.

Reitner (1992) reported the occurrence of spicules in two Triassic genera and species, in *Stellispongia variabilis* (Münster) and *Sestrostomella robusta* Zittel. Both taxa occur in reef boulders in the Carnian Cassian Formation in the

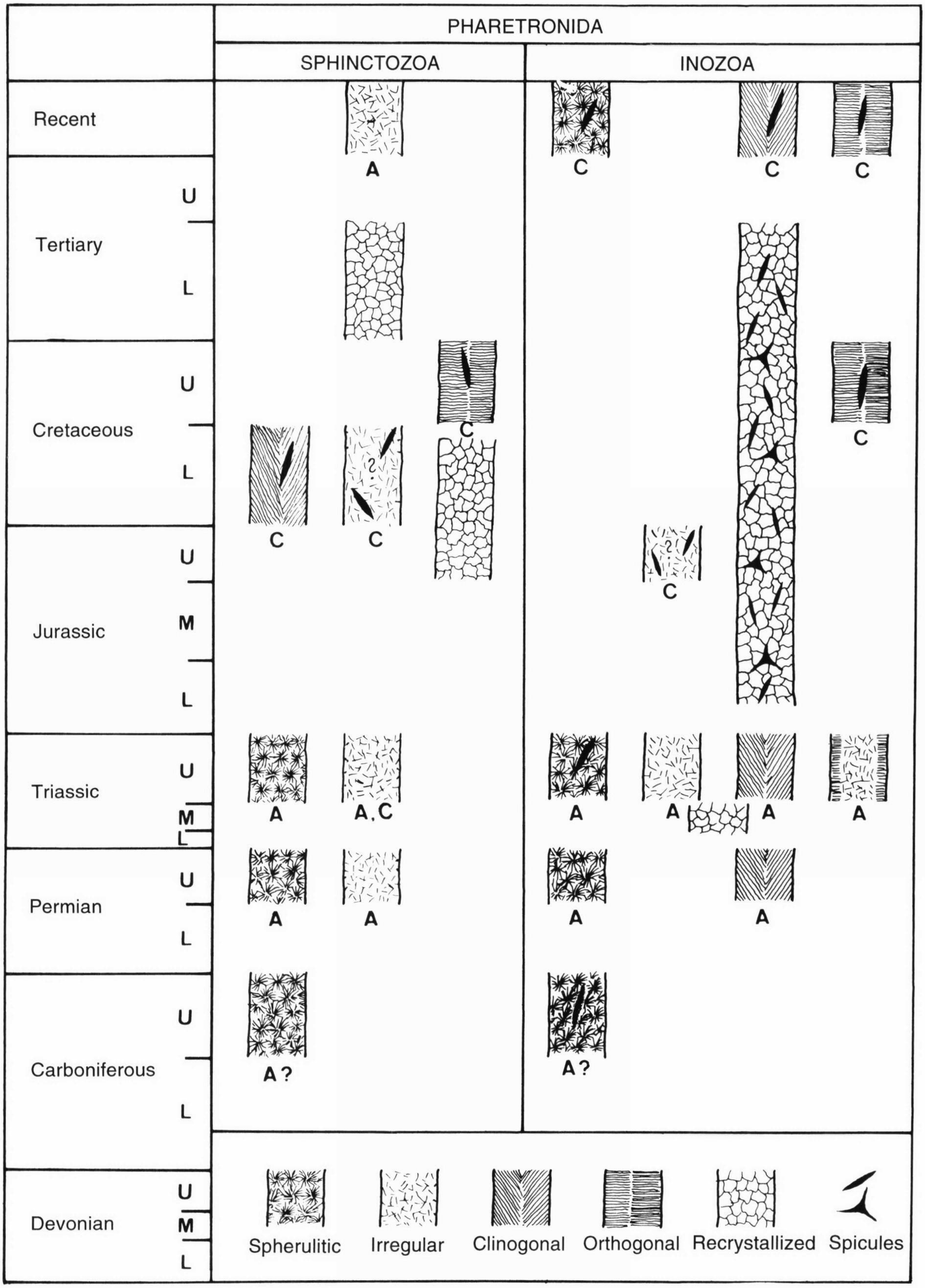

Figure 6. Distribution of microstructures and mineralogy in nonspicular calcareous sponges. Gaps shown in the symbols are actual breaks in the record where no data are available. A major shift from dominantly aragonitic skeletons in the Triassic to calcitic skeletons in the Jurassic and later sponges suggests a major change in composition of seawater; *A* = aragonite; *C* = Mg-calcite (adapted from Wendt, 1984).

Dolomite Alps of Italy. We have been unable to find spicules in Permian species originally included in the genus *Stellispongia* and have concluded that these earlier species are similar in gross morphology to the later sponges but are different in details of skeletal structure. Because of the presence of spicules in *Stellispongia* and *Sestrostomella* from the Triassic, these genera have been excluded from the Inozoida, but similar species of nonspiculate genera from the Permian have been included in new inozoid taxa.

POSSIBLE RELATIONSHIPS BETWEEN PALEOZOIC HETERACTINIDA, SPHINCTOZOA, AND INOZOIDA

Assemblages of calcareous sponges represented by the diverse collections from the Djebel Tebaga region of Tunisia document one of the great times of diversification of the group. Detailed analyses of earlier Permian and Carboniferous faunas are lacking in large part, so our conclusions about development of the order must remain somewhat conjectural.

Finks (1983, p. 59) noted that all of the Pennsylvanian and Permian inozoans observed by him, and many Triassic inozoans as well, have skeletal fibers or trabeculae composed of isodiametric spherulites. It is, in general, this group that is included here within the Inozoida. Finks (1983, p. 51) also noted that the oldest typical inozoans recognized by him occur in the Lower Permian Skinner Ranch Formation of Texas but that two still earlier groups of genera appear to be transitional between inozoan and sphinctozoan calcareous sponges and are known from the Desmoinesian Series from Oklahoma.

King (1933) described the new species *Maeandrostia tortacloaca* from the Graford Formation near Bridgeport, Wise County, Texas, and recorded the occurrence of the species in collections from two other Graford localities in the Wise County region, and from the Gaptank Formation in the Glass Mountains, west Texas, as well. King (1938) later included those sponges, along with two other very inozoid-looking new species, in the new genus *Fissispongia*. In the branching, subcylindrical, curved sponge, the wall is composed of irregular, vermiform, structureless fibers that define irregular meandering skeletal pores in that region between the porous spongocoel wall and the external surface, in a fashion distinctly inozoid in its skeletal character. These unsegmented forms have double spongocoels described as double-barrelled by King in his original description of *Maeandrostia tortocloaca*.

Finks (1983, p. 61) noted that most Pennsylvanian possible inozoid forms are unsegmented but that collections of sponges from the Pawnee Limestone of Oklahoma (Desmoinesian), as well as most Permian assemblages include forms composed of a series of conical segments, at least superficially resembling sphinctozoans. These sponges are therefore similar to *Imperatoria*, which has conical segments and also commonly has two discontinuous eccentric axial spongocoels that extend only part way through the sponge. Thus, sponges such as *Imperatoria* or *Bisiphonella* Wu, 1991 may be central to understanding early inozoid evolution because these sponges have skeletons made of spherulitic microstructure and have the other characteristics of Carboniferous genera, too. *Fissispongia* has a porous external wall with small tubular spines that may have been inhalant openings for the moderately coarsely trabecular skeleton, as figured by King (1933, pl. 7, fig. 1–4). Finks observed that the Carboniferous forms occur in shelf limestones and shales and that several types of *Fissispongia* in the Lower Permian appear to be important constituents of patch reefs. These forms superficially resemble *"Peronidella"*. Finks (1970, 1983) interpreted some of the sphinctozoans and inozoans as possibly having a common origin in the *Fissispongia-Maeandrostia* complex.

We now know that sphinctozoans extended far back into the Paleozoic, before the Carboniferous (Rigby and Blodgett, 1983; Rigby and Potter, 1986; de Freitas, 1987; Senowbari-Daryan, 1990), and that they were probably polyphyletic; therefore common origin of these two major groups in the late Paleozoic is improbable. The record is incomplete, but the nonspiculate inozoids could have evolved from the Carboniferous Des Moinesian-Missourian *Maeandrostia* and *Fissispongia* from a sphinctozoan lineage (Fig. 7) by loss of segmentation and shift from open-chambered forms into more complex forms with filling structures. Those filling structures may have become reticulate and developed into the dominant internal skeletal feature of the inozoids (Fig. 7).

Most sphinctozoans, if that group were looked to as the root for inozoans, have such simple structure that they are far removed as potential stem groups. The family Solenolmiidae Engeser, 1986, however, comprises porate sphinctozoans with reticulate filling structure and with one or more central spongocoel-like openings. Most of that family, however, are of Permian and Triassic age, leaving only the Middle Devonian *Hormospongia* Rigby and Blodgett, 1983, of the right age, i.e., from the pre-Carboniferous.

Rigbyspongia de Freitas, 1987, a genus in the family Cryptocoeliidae Steinmann, 1882, from the Upper Silurian of Canada, has a trabecular filling structure, but it, too, is far removed from the apparently later Carboniferous, early roots for the inozoid sponges. Senowbari-Daryan (1990, p. 172) noted that all of the then known Carboniferous sphinctozoan genera lack filling structures, so an obvious connection of the early to middle Paleozoic sphinctozoans to the later inozoids and inozoans must remain uncertain.

Rigby (1991), in a review of evolution of Paleozoic heteractinid calcareous sponges, noted that two of the general trends within heteractinids in the later part of the Paleozoic include the general reduction in numbers of rays in the calcareous spicules and an accompanying great increase in overgrowths of cement in some taxa, producing grotesque modifications of the skeleton. Rigby (1991, p. 90) hypothesized that, "triactines developed as dermal elements in early wewokellids and possibly became the

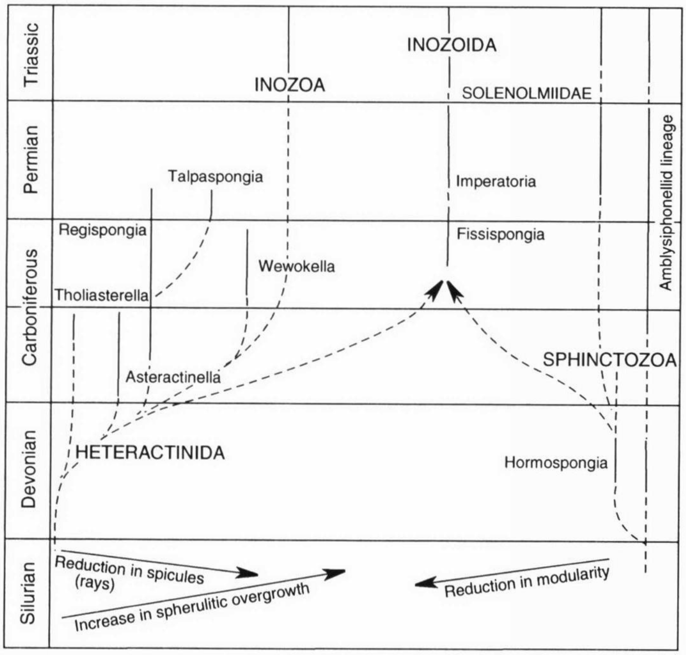

Figure 7. Possible relationships of inozoan, sphinctozoan, and heteractinid sponges to the inozoid sponges described here. Inozoids may have had one or more origins. Their early record and the record of stem transitions are too inadequate to be certain (adapted from Rigby, 1991; Finks, 1970).

dominant interior spicule in later forms, and perhaps developed as the principal spicule in later inozoans." Rigby thus inferred a potential stem or rootgroup for the triactine-bearing calcaronids of the Mesozoic and Cenozoic.

One might consider development of a parallel but separate lineage in which there was total reduction or loss of spicules, with the entire skeleton being composed of cement. In treating the biomineralization of corals and coralline sponges, Wendt (1990, p. 46, fig. 1; pl. 62, fig. 16) noted that spherulitic microstructure is common within the Heteractinida, based on his observations of Carboniferous fossils, presumably *Regispongia* or *Wewokella*. The spherulitic, aragonitic skeletons of the Inozoida may have derived from the massive cements or overgrowths developed in skeletons among the early and middle Carboniferous heteractinids, particularly in that lineage of *Regispongia, Wewokella,* and *Talpaspongia* (Fig. 7) that were grouped into the family Wewokellidae King (1943) by Rigby (1983, p. 79–83). Rigby (1991, p. 89) observed that had the inozoid sponges been derived from heteractinids, it would be a response of continuing a trend in spicule simplification and reduction of the early, multiple-rayed spicules of *Regispongia* and *Asteractinella* to the triactines of *Wewokella,* a trend continuing to the point where spicules were totally lost and the inozoids with aspiculate spherulitic skeletons developed (Fig. 7).

OCCURRENCES OF PERMIAN INOZOID SPONGES

Inozoid sponges occur worldwide within Permian reefs (Fig. 8) and are associated with other coralline sponges (sphinctozoans, sclerosponges, and demosponges) in communities with hydrozoans, bryozoans, algae, and other forms. Except for the sphinctozoans and *Tubiphytes,* a problematic organism, inozoid sponges are the most important frame builders of these Permian reefs. Sclerosponges also may be locally abundant, especially in the Permian deposits of Djebel Tebaga. Permian inozoid sponges have been reported from the Guadalupe and Glass Mountains of Texas (Girty, 1908a), Sicily (de Gregorio, 1930; Parona, 1933; Senowbari-Daryan and Di Stefano, 1988; Flügel, Di Stefano, and Senowbari-Daryan, 1991), Slovenia in northern Yugoslavia (Flügel, Kochansky-Devide, and Ramovs, 1984), Hungary (H. W. Flügel, 1973), from several localities in China (Deng, 1981, 1982a, 1982b, 1982c; Rigby, Fan, and Zhang, 1989; Wu, 1991; Rigby *et al.,* 1994), Thailand (Senowbari-Daryan and Ingavat-Helmcke, 1993, 1994), Oman (Weidlich, 1992; Weidlich and Senowbari-Daryan, 1996), and from the Djebel Tebaga area of southern Tunisia (Termier and Termier, 1955, 1977a, 1977b). The known paleogeographic distributions of Permian inozoid sponges are represented in Figure 8.

Table 1 lists the inozoid genera and species now known from Djebel Tebaga and the localities at which they were collected. Specimens of some genera, such as *Pseudohimatella, Intratubospongia,* and *Stellispongiella,* are abundant. The Upper Permian section in Djebel Tebaga provides the most diverse and abundant, known Permian sponge faunas of the world.

PROCESSES OF ENCRUSTATION, SEDIMENTATION, DIAGENESIS, AND PRESERVATION OF SPONGES IN DJEBEL TEBAGA

Most sponges from Djebel Tebaga that are embedded in rocks from bioherms or from rocks near the bioherms are encrusted by epibionts. Several thousand specimens of Permian sponges from Djebel Tebaga, including representatives of sphinctozoid, inozoid, and sclerospongid sponges, have been studied by the authors (see Senowbari-Daryan and Rigby, 1988, 1991). Outer surfaces of relatively few sponges are clean or free and exhibit no encrustations, but exteriors of most specimens are variously encrusted by different organisms.

The most common encrusting organism in Upper Permian reefs of Djebel Tebaga, as well as in other Permian reefs throughout the world, is *Archaeolithoporella* (Newell *et al.,* 1953; Babcock, 1977; Flügel, 1980, 1981; Flügel, Kochansky-Devide, and Ramovs, 1984; Senowbari-Daryan and Di Stefano, 1988; Fan, Rigby, and Qi, 1990; Razgallah and Vachard, 1991). In addition to *Archaeolithoporella,* the enigmatic fossil *Tubiphytes* Maslov, 1956, is one of the most abundant encrusting organisms reported in Permian reefs but not in our area. *Tubiphytes* should now be called *Shamovella* Rauser-Chernousova, 1951, according to Riding (1993; see also Senowbari-Daryan and Flügel, 1993). Other encrusting organisms, such as bryozoans, foraminiferids,

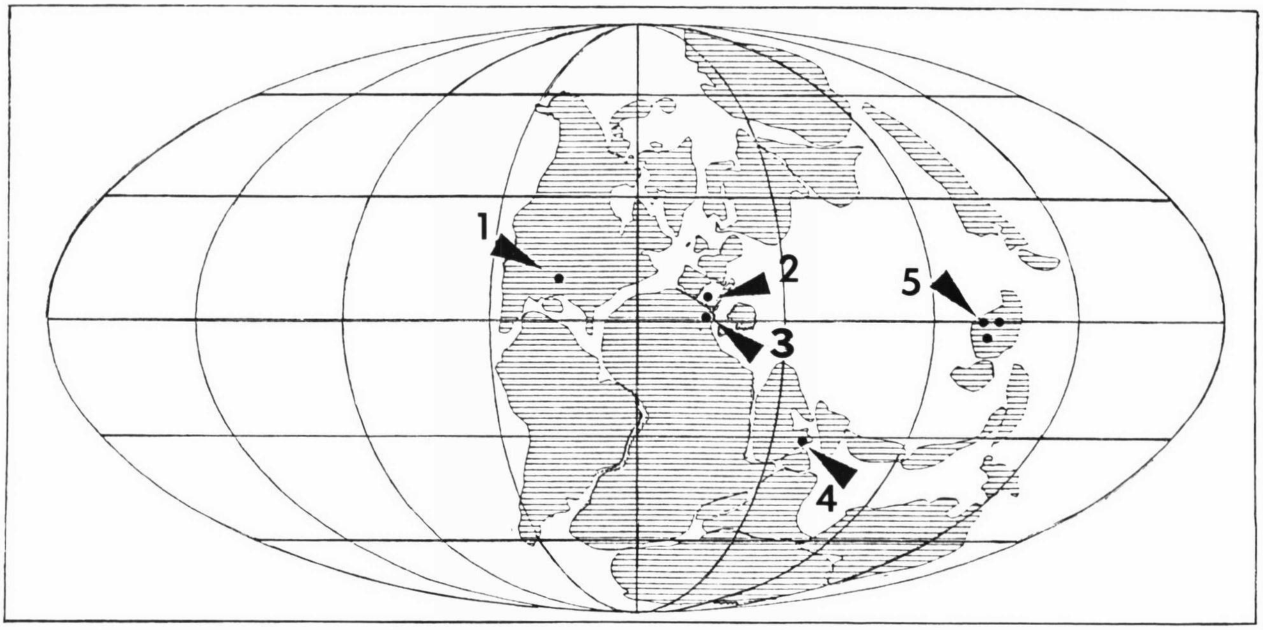

Figure 8. Distribution of major Permian sponge faunas showing their dominantly tropical position, plotted on a paleographical reconstruction of Late Permian distributions of land masses; *1,* Guadalupe Mountains (Capitan Reef), Texas and New Mexico, United States; *2,* Pietra di Salomone, Sicily, Italy; *3,* Djebel Tebaga, Tunisia, the fauna described, in part, herein; *4,* Ba'id area, Sultanate of Oman; *5,* Hubei and Guangxi provinces of southern China (base map from Scotese and McKerrow, 1990; figure adapted from Weidlich and Senowbari-Daryan, 1996).

worm tubes, and other sponges, are of minor importance compared to *Archaeolithoporella* and *Tubiphytes.* The Djebel Tebaga sponges are usually encrusted only by *Archaeolithoporella,* but successions of several encrustations by different organisms were also observed (Fig. 9–10).

Encrusting organisms among the sponges include some sphinctozoid sponges, e.g., *Parauvanella, Sollasia* (see Senowbari-Daryan and Rigby, 1988); inozoid sponges, e.g., *Prestellispongia lobata* (Parona, 1933) (see Plate 9.1 and Plate 13.4), and sclerospongid sponges, e.g., *Sphaerochaetetes* (see Gautret and Razgallah, 1987). With the exception of *Archaeolithoporella,* which usually coats entire sponges, all other organisms mentioned above grew on or encrusted only one side, probably the upper exposed surface of the sponge. Because of such encrustations, outer surfaces often appear nodular or laminated, or exhibit other more complex sculpture.

Only a few of those sponges that weather out of the inter-reef, marly beds and are not embedded in rock show encrustations by *Archaeolithoporella.* Most such free sponges are either not encrusted or are encrusted mainly by sclerosponges. Such relationships suggest that the small sponge and inter-reef, marly rocks document minor environmental differences. Perhaps free sponges and associated rocks accumulated in slightly deeper water or more turbid water below the zone where *Archaeolithoporella* could flourish. Sponges found in flank deposits associated with these small Djebel Tebaga bioherms also may have been buried rapidly, without enough time for extensive encrustation by *Archaeolithoporella.* Accumulations in depths below where *Archaeolithoporella* could thrive, however, seems more probable than very rapid burial to prevent it from encrusting many of these free sponges, because they are encrusted by sclerosponges or other organisms, such as the small sphinctozoid sponge *Sollasia* and bryozoans. These latter occurrences suggest a reasonably long period of exposure to encrusters in an environment where *Archaeolithoporella* was not common.

A generalized sequence of encrustation, diagenesis, and preservation of sponges in the Djebel Tebaga area is shown schematically in Figure 9.

Encrustation of some inozoid and sphinctozoan sponges by sclerosponges (see Senowbari-Daryan and Rigby, 1988, p. 207) may have started while the sponges were still alive. Some sponges apparently responded to such an attack by sclerosponges by formation of tubelike elements (exaules) out from the threatened ostia. Encrustations of sponges by *Archaeolithoporella* during the lifetime of the sponges generally cannot be demonstrated by similar physiologic responses, and *Archaeolithoporella*-encrusted sponges may have been dead.

Generally, two stages of encrustation of sponges from Djebel Tebaga can be recognized. The first stage usually is represented by sheets of sclerosponges, bryozoans, worm tubes, or perhaps other small sponges (see Pl. 13.2–13.3). The second stage is represented by crusts of *Archaeolithoporella,* which produce a nodular sponge surface (Pl. 13.1–13.3). Those sponges that are thickly encrusted by *Archaeolithoporella* generally do not show good preservation of the rigid skeleton.

A detailed description of successions of encrustation and of the different generations of encrusted organisms is the subject of a separate work; we present here only a short description and some examples with diagrams of characteristic succession (Fig. 9–10).

Preservation of sponges after death is influenced by encrusting organisms. These occur in two stages. The first encrusters are usually sclerosponges, and the second are examples of *Archaeolithoporella* (Fig. 9). Encrustations of the sponges protect them from mechanical and biological erosion as well as from dissolution, on one hand, but prevent matrix from filling voids between the skeletal fibers, on the other hand. As a result, the large interfiber voids are usually filled by sparry cement. Aragonite, dolomite, and calcite cements all occur in specimens in our collections. Scherer (1986) found six carbonate and three noncarbonate cement events recorded within sponge skeletons from Djebel Tebaga.

After the death of a sponge, it may have been transported by water movement and partly or totally destroyed by mechanical processes. Destruction during transportation does not seem to have been important in Djebel Tebaga occurrences because even partially abraded specimens are not common. Bioerosion by boring algae or fungi may be an important factor in local destruction of sponge skeletons (Scherer, 1986), but evidence of major bioerosion in the Tunisian sponges is limited.

Speed of burial may affect preservation of sponges. During such burial, voids within the skeleton were filled partly by sediment, or perhaps more commonly in Djebel Tebaga sponges, by yellow dolomite or Fe-calcite cement (Scherer, 1986). These cements show well in polished slabs. Such dolomite or Fe-calcite cements usually do not occur in the central parts of our sponges where the microstructure is commonly best preserved. Original openings in the central part of the skeleton are filled by transparent, sparry-calcite cement.

Figure 10 shows at least five generations that can be recognized in a sample of encrusting organisms studied in polished slabs. The pioneer generation of this succession is represented by a thalamid sponge, *Colospongia* (Fig. 10A). The first generation of encrusters (Fig. 10B) is represented by an undetermined organism (maybe an alga) and by the problematic organism *Permosoma*, a possible sclerosponge. These two organisms only partially encrusted the outer surface of the *Colospongia*. *Prestellispongia lobata* (Parona, 1933) is the third encruster, and it, too, partially encrusted the pioneer *Colospongia* and the first encrusting generation

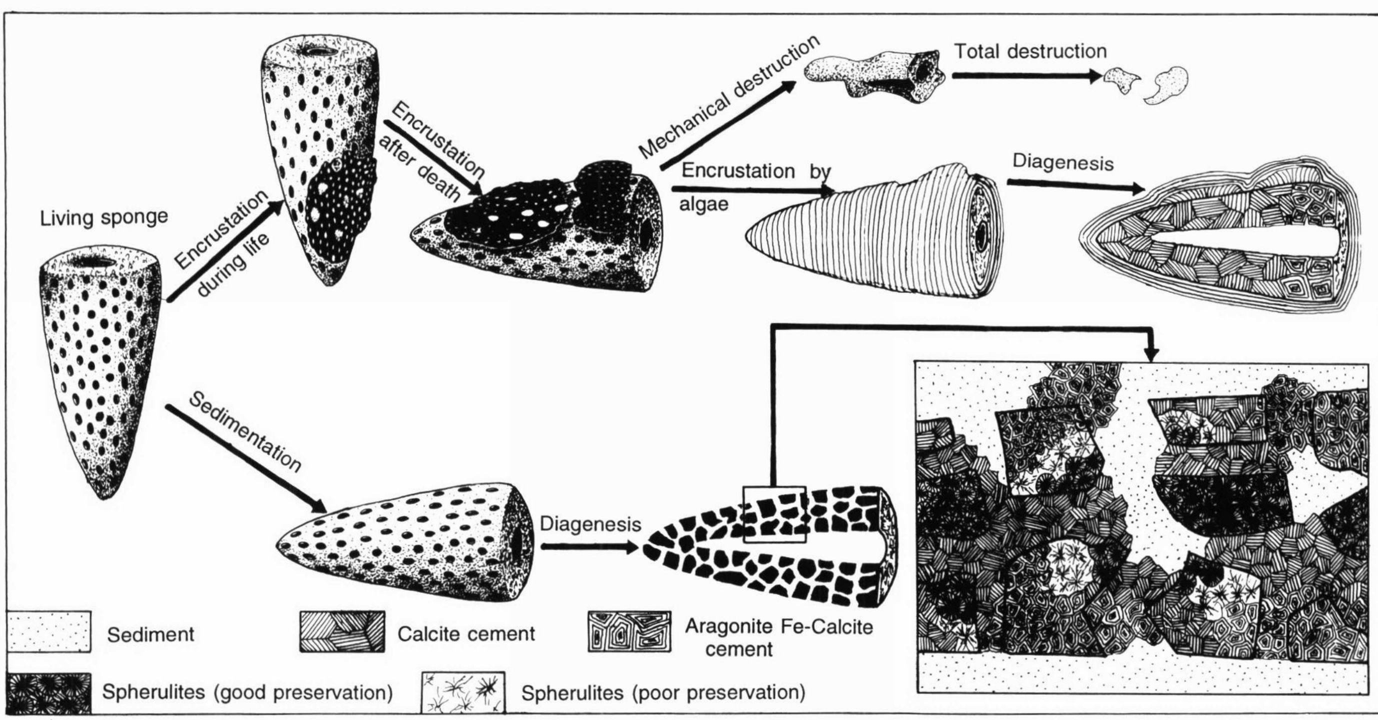

Figure 9. Diagram showing stages in diagenesis and destruction of fossil sponges in the Djebel Tebaga area. The original sponges may have been encrusted during life or after death by a variety of other sponges, algae, and miscellaneous organisms. In some beds of the area, thick coats of *Archaeolithoporella* obscured the sponges and locally prevented them from being mechanically destroyed. These sponges commonly underwent significant textural alteration and diagenesis. Where they were not protected and not buried in the marly sediments, the sponges may have been transported, abraded, and destroyed by mechanical processes. Other sponges, shown in the bottom of the diagram, were buried by the moderately rapid sedimentation and may have been preserved intact. They also underwent diagenesis, however, and common replacement by calcite or Fe-calcite. Various stages of diagenesis are commonly seen in single sponges at virtually every locality from which the specimens were collected.

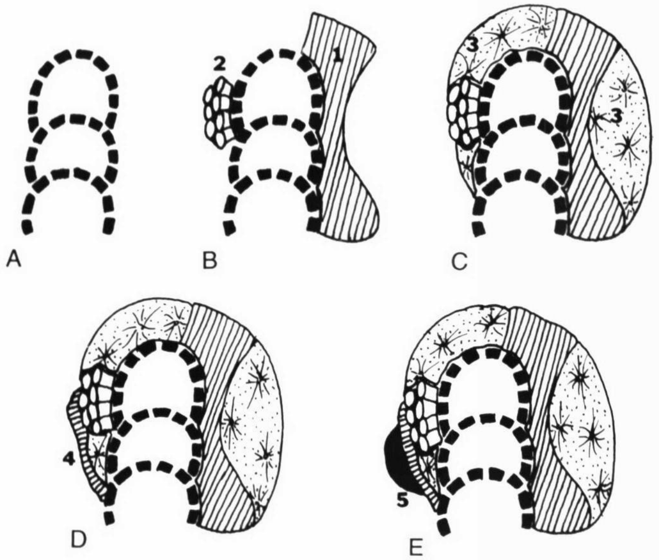

Figure 10. Encrustation succession of sponges in Upper Permian reefs of Djebel Tebaga. All figures are schematic and not to scale. *A,* The pioneer generation in the encrustation succession is represented by the thalamid sponge *Colospongia,* which was the substrate for subsequent encrustation by sponges or other organisms; *B,* the first generation of encrustation is represented by an undetermined organism (1), which may be algal, and the problematic and tubular organism called *Permosoma* (2). The time of encrusting could be the same or different for both organisms; *C,* after encrustation by algae and *Permosoma,* the next encrustation was by the prestellispongid (3), which overgrew both the pioneer host (*Colospongia*) and the encrusting algae and *Permosoma.* After this development, the pioneer putative colospongid was totally overgrown and could not be seen from the outside; *D,* a thin, sclerospongid sponge (4) next encrusted the substrate. It has very small tubes and partly or totally encrusted the *Permosoma* or the *Prestellispongia,* so that only the sclerosponge could be seen from the outside; *E,* finally, the last generation of encrustation (5) was a thin sheet of an undetermined organism, which grew over part of the sheet of the sclerosponge.

of algae and *Permosoma.* They combined to cover totally the *Colospongia* so that it is not recognizable from the outside (Fig. 10C). The skeleton associated with one of the multiple oscular systems in the prestellispongiid sponge (this species does not have a fixed shape) encrusts other organisms (see Pl. 9.1; Pl. 10.5, 10.7; and Pl. 13.4).

The next or third generation of encrusting organisms is represented by very thin sheets of a narrow-tubed sclerosponge. The tubule diameters are approximately 0.1 mm. The sclerosponge partially covered the sheets of both *Prestellispongia* and *Permosoma* (Fig. 10D). Finally, the sheets of the sclerosponge were at least partially covered by the last generation of encrusters, the additional laminae of another undetermined organism, possibly an alga (Fig. 10E).

CLASSIFICATION OF INOZOID SPONGES

Classically, composition of the spicular skeleton (calcite or silica), shape and arrangement of spicules, and the nature of the canal systems and growth forms have been used for classification of fossil sponges. Because spicular skeletons are lacking in almost all known Paleozoic and Triassic inozoid sponges, taxonomic classification of these sponges must be based on such features of the rigid skeleton as the nature and patterns of skeletal elements, presence or absence of a spongocoel, and presence or absence and nature of inhalant and exhalant canal systems. The lack of spicular skeletons in Paleozoic and Triassic inozoids is primary and is not a result of diagenesis. Following a short discussion of earlier proposed classifications of inozoans, including Triassic and Paleozoic inozoids, a classification will be proposed for inozoid sponges.

De Laubenfels (1955) was the first to develop a comprehensive classification of fossil inozoans in the order Pharetronida Zittel, 1878. He established six new families within this group and placed these, with the family Lelapiidae Dendy and Row, 1913, in the new suborder Chalarina. De Laubenfels (1955, p. 97) characterized the Chalarina as "having skeletal strands formed of spicules that are merely interlocked, entangled or joined side to side, not connected tip to tip." All other nonsegmented pharetronids were placed by him into the suborder Stereina de Laubenfels (1955, p. 99). The Stereina were characterized as having a "rigid skeleton formed by union of spicules at ray tips as in tetraclad lithistids (Demospongea) and dictyids (Hyalospongea)." The family-level classification of de Laubenfels was based on external morphology. At that level he did not take into consideration canal patterns and structure of the internal skeleton. As mentioned by Rigby *et al.* (1989), the growth form and external morphology of sponges are too plastic to be of major use for classification, certainly for classification above specific or generic levels.

The classification of Calcarea proposed by Burton (1963) was based on modern calcareous sponges and cannot be used for classification of fossil inozoan sponges. He used features not preserved in fossil sponges for differentiation of families. The Homocoeliidae and Heterocoeliidae cannot be consistently recognized in fossil sponges.

Wagner (1964a) tried to relate the classification of fossil inozoan sponges to the classification of recent sponges using the two families Minchinellidae Dendy and Row, 1913, and Elasmostomatiidae de Laubenfels, 1955, for fossil representatives. Wagner's classification was also based on the shape and arrangement of spicules. Because spicules have not been found in Paleozoic and Triassic representatives, Wagner's classification cannot be used for the taxonomy of sponges in our collections either.

Hurcewicz (1975) used some internal structures and took into consideration the classification of de Laubenfels (1955). She subdivided Jurassic inozoan sponges into four families, using those proposed by de Laubenfels (1955) and Dendy and Row (1913).

Dieci, Antonacci, and Zardini (1968), Dieci, Russo, and Russo (1974), and Bizzarini and Russo (1986) have proposed a classification of inozoid sponges based mainly on Upper Triassic sponges collected from the Cassian Formation in the southern Alps (Dolomites) of Italy. Their classification is based mainly on the presence or absence of axial spongocoel(s) and courses of the spongocoels and of exhalant and inhalant canals. Müller (1984) pointed out that the nonspicular skeleton (fiber structure) should be taken more into consideration in checking systematic importance of other structures. He also noted that the cortex (dermal layer in fossil sponges) may have a higher systematic value than had been considered previously. Müller's suggestion was based on Ziegler's (1964) observation that the occurrence of a cortex is connected with development patterns of the canal systems.

In addition to development of an axial spongocoel and pattern of canal system, Rigby, Fan, and Zhang (1989) considered variations in structure of the skeleton as important criteria for taxonomic differentiation of inozoid sponges.

Wu (1991) has classified and described the Permian inozoid sponges of China. Wu's classification, based on classifications of Dieci, Antonacci, and Zardini (1968) and Rigby, Fan, and Zhang (1989), is very theoretical; and apparently he did not take into consideration several other known inozoid genera and higher categories. Skeletal mineralogy and microstructure of the rigid skeleton have not been treated by Wu. In addition, documentation and descriptions of individual taxa are generally brief and nondiscriminating. Finally, several of Wu's new species have been previously described by other authors. In addition to the inozoid part of Wu's publication, other chapters of the paper should be reviewed carefully by specialists in those groups. We will deal with the inozoids in the systematic part of our contribution in this publication.

The canal system (spongocoel, osculum, and inhalant and exhalant canals) seems to allow classification of fossil Paleozoic and Triassic inozoid sponges without a spicular skeleton (Fig. 11). The basic classification of Triassic inozoid sponges proposed by Dieci, Antonacci, and Zardini (1968), Dieci, Russo, and Russo (1974), Russo (1981), and Bizzarini and Russo (1986) is used with modification for differentiation of the Permian inozoids of Djebel Tebaga. We consider the Permian and Triassic inozoid sponges that have spherulitic microstructure in common and that lack any spicular skeleton as a distinct major group. We distinguish these sponges from those with spicular skeletons that occur in some Triassic genera and in Jurassic and Cretaceous rocks. Our proposed artificial or form classification of inozoid sponges can be summarized as follows:

Class Calcarea Bowerbank, 1864.

A. Superorder Pharetronida Zittel, 1878.
Characterized by calcareous spicules of different types (mostly triactines) that are usually embedded within a rigid, segmented or not segmented skeleton composed of aragonite or calcite. Two groups may be distinguished, based upon whether the sponges are segmented or nonsegmented.

1. Rigid skeleton is segmented.
   a. Order Sphaerocoelida Vacelet, 1979 (Jurassic–Cretaceous).
   "Segmented pharetronids whose skeleton composed of neomorphic calcite (primary aragonite?). Spicular skeleton composed of calcareous spicules which are embedded within the rigid skeleton" (Senowbari-Daryan, 1990, p. 40).
   Note: As shown by Senowbari-Daryan (1990) and Reitner (1990), the Sphinctozoa (*sensu* Steinmann, 1882) is a polyphyletic group of sponges and should be subdivided into several groups and placed variously in the Archaeocyatha, Calcarea, Demospongea, Sclerospongea, and Hexactinellida.
2. Rigid skeleton is not segmented, with spicular skeleton embedded in rigid skeleton (Triassic–Holocene).
   a. Order Chalarina de Laubenfels, 1955.
   "Pharetronids having skeletal strands formed of spicules that are merely interlocked, entangled, or joined side-to-side, not connected tip-to-tip" (de Laubenfels 1955, p. 97).
   b. Order Stereina de Laubenfels, 1955.
   "Pharetronids with rigid skeleton formed by union of spicules at ray tips as in tetraclad lithistids (Demospongea) and dictyids (Hyalospongea)" (de Laubenfels, 1955, p. 99) (Jurassic–Holocene).

B. Superorder Aspiculata new superorder.
Characterized by a rigid skeleton composed of aragonite or perhaps calcite; skeleton totally lacks spicules; rigid skeleton may be segmented or not segmented.

1. Rigid skeleton is segmented.
   a. Order Permosphincta Termier and Termier, 1974.
   May include some sphinctozoid sponges (see Senowbari-Daryan, 1990, p. 44) (Cambrian–Triassic, Cretaceous?).
2. Rigid skeleton is not segmented.
   a. Order Inozoida new order.
   Nonsegmented, aspiculate sponges usually with aragonitic skeleton, but may also include forms with calcitic skeletons that lack spicules (Cambrian?, Devonian–Triassic?, Holocene?).

Steinmann (1882) originally included all nonsegmented sponges with a calcareous rigid skeleton within the Inozoa. Later investigations have shown that the inozoan species of Steinmann are variable. Although Jurassic to Cretaceous and some Triassic inozoan sponges have spicular skeletons, representatives of Paleozoic and most putative Triassic inozoans lack spicules. Lack of spicules in pre-Triassic inozoans is primary and not a result of loss through diagenesis. We also think that this group is not an evolutionary precursor to the pharetronids of Jurassic and Cretaceous ages. To express this we have separated at the ordinal level this Permian to Triassic group of sponges, which lacks spicules, from those Jurassic to Cretaceous pharetronids with spicules. The order Inozoida is proposed here for those nonsegmented Paleozoic and Triassic sponges with a rigid skeleton but without a spicular skeleton.

The occurrence of spicules in Permian inozoid sponges was reported by Wu (1991, p. 49) in *Acoelia ruida,* established by the same author. However, the relatively poor preservation of apparently the only collected specimen, which was illustrated in plate 8, figure 7 by Wu, does not confirm the preservation of spicules in this sponge. Nor was Wu sure about the nature of the trace or holes as spicules within the rigid skeleton of *Acoelia ruida* (Wu, 1991, p. 50, fig. 7).

Classification of Inozoida, new order.—For further subdivision of the Inozoida we have used as criteria the absence of a spongocoel and the presence of one or more spongocoel(s) and their position within the sponge body. Absence or presence and the distribution pattern of inhalant and exhalant canals are used to characterize subfamilies or genera (Fig. 11). Skeletons of all Inozoida of Permian and Triassic age, as presently known, are composed of aragonite. If calcitic Inozoida are discovered in the future, they should be included in this group but separated at some high level. The microstructure of Permian Inozoida cannot be used for systematic subdivision of this group at present because all investigated sponges have a spherulitic microstructure. Different microstructures, if discovered in Inozoida, should be used at a generic level within the different families. The spherulites may be arranged side by side, as observed in most Inozoida, or in other packing. For example, in *Sphaeropontia* new genus, the spherulites are regularly three-dimensionally arranged in space and connected to each other by beams (Pl. 68; Fig. 37).

Order Inozoida new order

A. Spongocoel and osculum absent.
Family Auriculospongiidae Termier and Termier, 1977a.

Exhalant or inhalant canals present or both absent. As discussed below in the systematic part of this paper, we have not found any spicules in our many specimens of *Auriculospongia,* the type genus of the family. This sponge cannot be placed in the Sclerospongia, as was suggested by Termier and Termier (1977a), because sclerospongiids are characterized by siliceous spicules within their rigid calcareous skeletons.

1. Exhalant canals present; inhalant canals absent.
Subfamily Auriculospongiinae new subfamily.
a. Sheetlike or palmate sponges; exhalant canals restricted to one side; inhalant pores to the other side.
Auriculospongia Termier and Termier, 1974.
b. Exhalant canals distributed irregularly over the entire sponge.
Cavusonella Rigby, Fan, and Zhang, 1989.
c. Exhalant canals are arranged radially to divergent upward.
Radiotrabeculopora Fan, Rigby, and Zhang, 1990.
2. Inhalant canals present; exhalant canals absent or not distinct.
Subfamily Daharellinae new subfamily.
a. Cylindrical sponges with circular or starlike ostia; a sievelike element common at the base of each ostium.
Daharella new genus.
3. Exhalant and inhalant canals absent.
Subfamily Spinospongiinae new subfamily.
a. Cylindrical or club-shaped sponges with skeleton of fibers and spine- or rodlike skeletal elements oriented radially and upwardly divergent in the sponge.
Spinospongia new genus.
Subfamily Acoeliinae Wu, 1991.
b. Cylindrical or club-shaped sponge composed of only skeletal fibers.
Acoelia Wu, 1991.
Elasmostoma Fromentel, 1860.
Blastina Zittel, 1878.
Ramospongia Wu, 1991.
Solutossaspongia Senowbari-Daryan and Ingavat-Helmcke, 1994.
Thallospongia new genus.

Wu (1991, p. 56) established the new family Acoeliidae for those inozoans without distinct inhalant and exhalant canals. In addition to the previously described genera *Elasmostoma* Fromentel, 1860, and *Blastina* Zittel, 1878, Wu (1991, p. 58–59) included two new genera in the family, the type genus *Acoelia* Wu and *Ramospongia* Wu. Both genera were described with only one species, and both are illustrated with only one thin section. The sections described as *Acoelia ruida* Wu, 1991 (1991, pl. 8.7) and *Ramospongia minor* Wu, 1991 (1991, pl. 9.3) could be sections of margins of other sponges. In our opinion these sections are not suitable for adequate description and determination of sponge genera and species, especially of inozoid sponges. In addition, we could find no significant differences between the illustrated sections of *Ramospongia minor* and *Elasmostoma aperiens* described as new species by Wu (1991, pl. 9, fig. 3, 8). We propose to limit the names *Acoelia* and *Acoelia ruida* to that specimen illustrated by Wu (1991) in his plate 8.7; to limit the name *Ramospongia minor* to the specimen he illustrated in his plate 9.3; and, finally, to limit the name *Blastina aperiens* to that specimen shown in his plate 8.2 and plate 9.8. We have re-

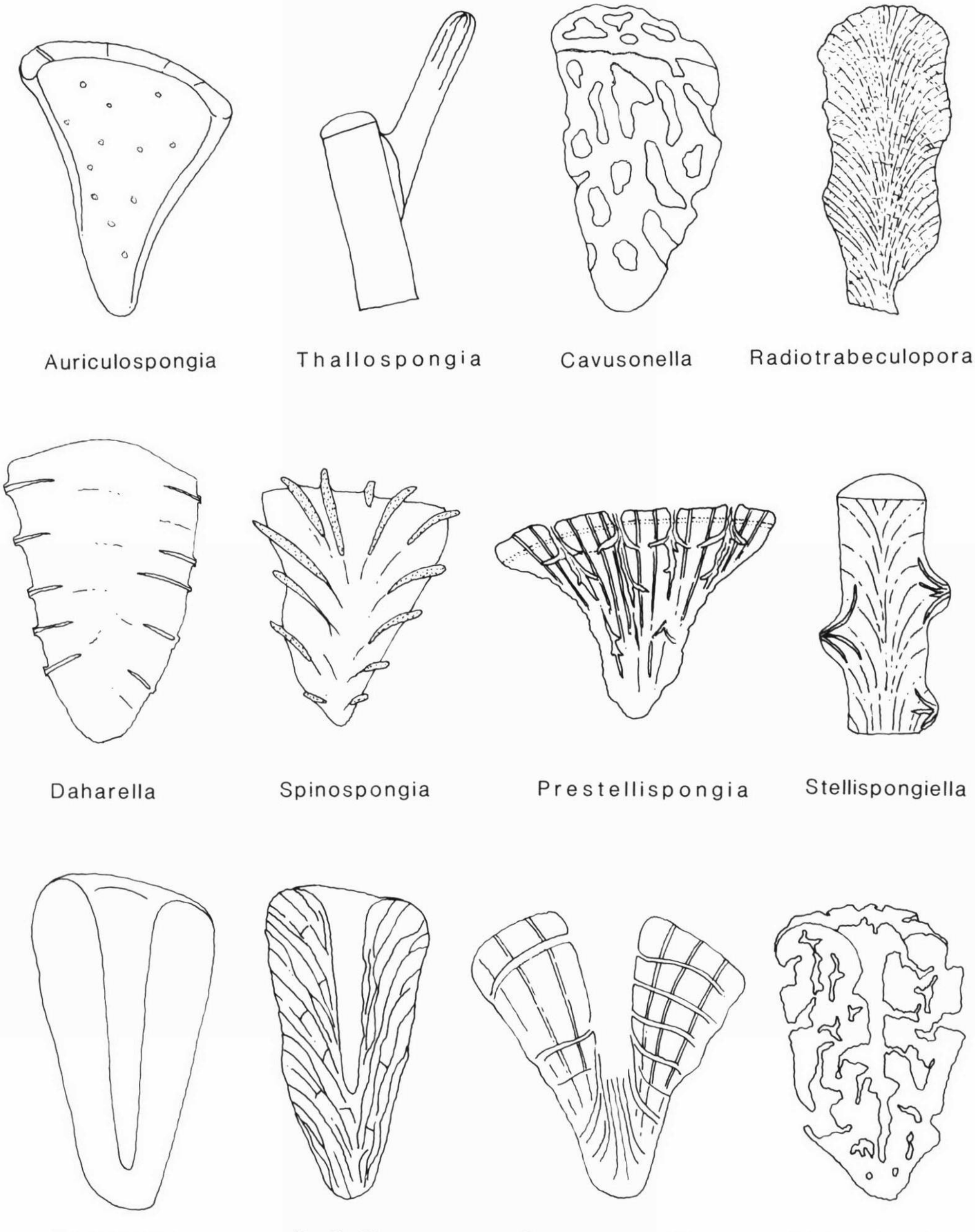

Figure 11. Generalized diagrams of skeletal structure, canal and spongocoel development, external form, and general appearance of genera of inozoid sponges described here from the Djebel Tebaga region of Tunisia. The genera, generally, are arranged parallel to their order of presentation in the section on systematic paleontology, reading left to right. Sketches are diagrammatic and not to scale.

tained the family Acoeliidae Wu, 1991, but as a subfamily for those inozoids that lack a major canal system and spongocoel.

4. Exhalant and inhalant canals present.

No known genus fits this theoretical slot.

B. Without deep spongocoel, but with one osculum or astrorhizal canal cluster on the summit or with several oscula or astrorhizae distributed over the sponge summit or its exterior.

Family Stellispongiellidae Wu, 1991.

1. Several openings extend as spongocoels into the sponge interior.

Subfamily Prestellispongiinae new subfamily.

Prestellispongia new genus.

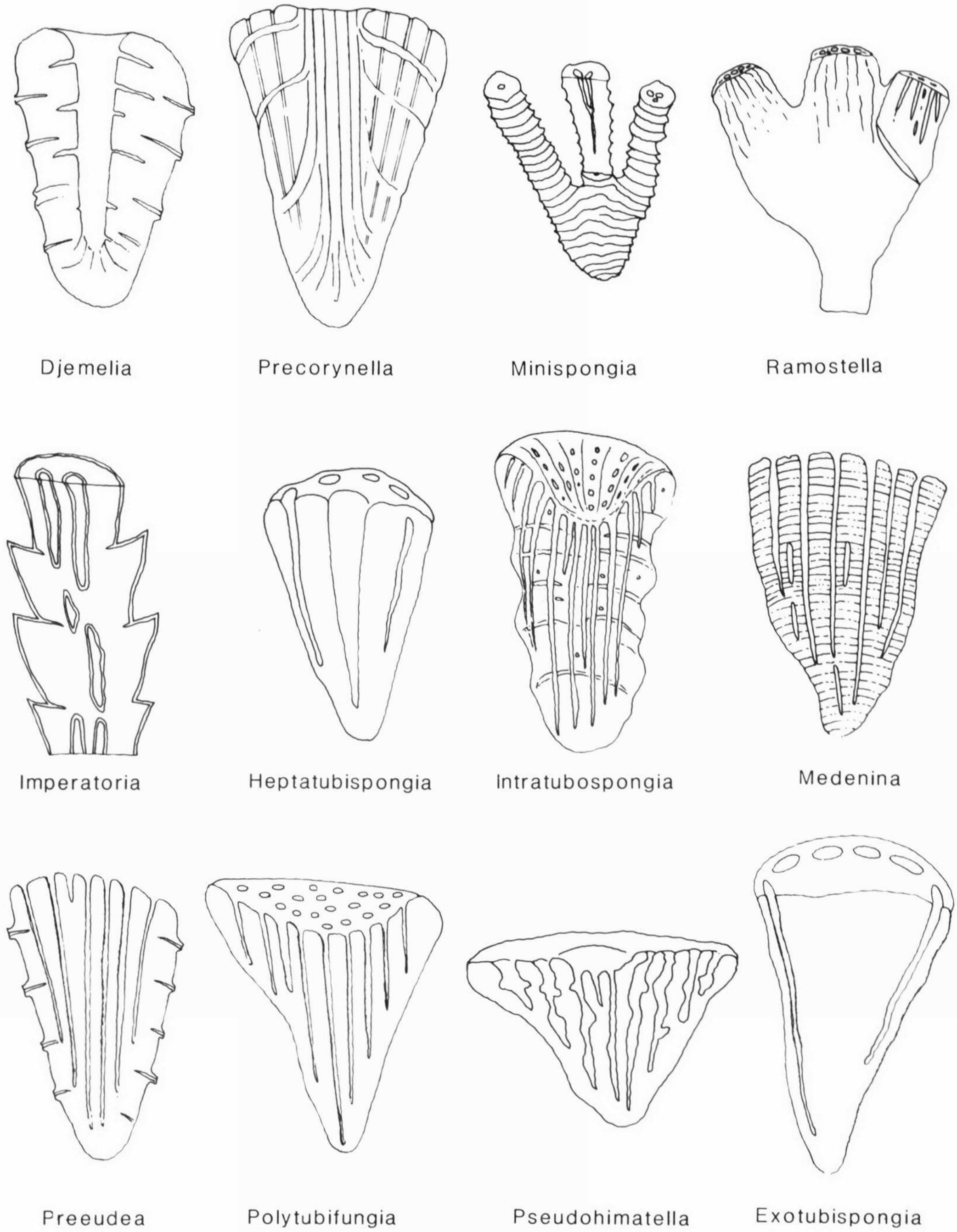

Figure 11. Explanation on facing page.

2. One or a few, large, shallow to obscure astrorhizal clusters situated on the summit or slopes of the massive sponge, at junctions of convergent tangential surface canals; oscula and spongocoel not developed.
Subfamily Estrellospongiinae new subfamily.
   a. Astrorhizae composed of several convergent surficial canals without well-developed, coarse exhalant openings in fibrous skeletal net at centers of convergence.
   Estrellospongia new genus.
3. Several starlike oscula composed of convergent canals with circular pores between canals on the exterior of sponge but that extend only short distances into the interior.

Subfamily Stellispongiellinae Wu, 1991.
a. Oscula starlike; may be situated on mamelonlike elevations or impressed in generally smooth surface of commonly ramose sponges.
Stellispongiella Wu, 1991.
C. An axial spongocoel or a bundle of axial spongocoels present.
Family Peronidellidae Wu, 1991.
1. Only an axial spongocoel present.
Subfamily Peronidellinae new subfamily.
a. Inhalant and exhalant canals absent.
1. Axial spongocoel passes essentially through the sponge; spongocoel without distinct wall; skeletal fibers irregular or reticulate.
Peronidella Hinde, 1893.
2. Spongocoel is limited to the upper part of sponge.
Brevisiphonella Russo, 1981.
Hodsia Moiseev, 1944.
3. Axial spongocoel passes essentially through the whole sponge; spongocoel without distinct wall; fibers are arranged radially upward and outward, and spaces between them look like tubes arranged radially upward, parallel to fibers.
Radiofibra new genus.
4. Axial spongocoel passes essentially through the sponge; spongocoel with a distinct wall; skeleton irregularly reticulate.
Maeandrostia Girty, 1908b.
b. Inhalant and exhalant canals present.
Subfamily Permocorynellinae new subfamily.
1. Axial spongocoel extends deeply into the interior of sponge; inhalant and exhalant canals are well developed as regular tubes.
Permocorynella new genus.
2. Axial spongocoel extends essentially through the sponge; inhalant and exhalant canals are developed as irregular tubes.
Saginospongia new genus.
3. Axial spongocoel extends essentially through the whole sponge; horizontal and branched in halant and exhalant canals occur in the sponge wall; spongocoel with discrete wall; inhalant pores with exaules.
Djemelia new genus.
2. Two or more axial spongocoels or cluster of coarse exhalant canals present.
Subfamily Precorynellinae Termier and Termier, 1977a.
a. Inhalant and exhalant canals present.
Precorynella Dieci, Antonacci, and Zardini, 1968.
Stallanella Bizzarini and Russo, 1986.
Paracorynella Wu, 1991.
b. Inhalant and exhalant canals absent.
Minispongia new genus.
Ramostella new genus.
c. Exhalant canals present; inhalant canals absent.
1. Screwlike or turriculate segments arranged one above the other; two or three axial canals present but discontinuous and do not extend deep into the interior or into segments.
Imperatoria de Gregorio, 1930.
Bisiphonella Wu, 1991.
3. Axial spongocoel present, with ring of several coarse longitudinal exhalant canals present near periphery.
Subfamily Heptatubispongiinae new subfamily.
a. Transverse inhalant and exhalant canals absent.
1. A relatively large axial spongocoel and 6 to 8 symmetrically arranged, longitudinal, peripheral spongocoels of exhalant canals in ring near the periphery that pass essentially through the whole sponge.
Heptatubispongia new genus.
D. Several spongocoels or oscula irregularly distributed throughout the whole sponge body.
Family Virgulidae Termier and Termier, 1977a (includes family Polysiphonellidae Wu, 1991 and family Paracorynellidae Wu, 1991).
1. Exhalant canals or spongocoels terminate in an upper large bowl-like depression or on rounded summit of the sponge.
Subfamily Virgulinae Termier and Termier, 1977a.
a. Inhalant canals absent; exhalant canals present.
Polysiphonella Russo, 1981.
Paracorynella Wu, 1991.
b. Inhalant and exhalant canals present.
Intratubospongia Rigby, Fan, and Zhang, 1989.
Medinina new genus.
Virgola de Laubenfels, 1955, *pro Virgula* Girty, 1908a.
2. Without a large osculum or depression on the summit, and with reticulate skeletons.
Subfamily Preeudeinae new subfamily.
a. Inhalant and exhalant canals absent.
1. Cylindrical sponges with several coarse spongocoels.
Grossotubenella Rigby, Fan, and Zhang, 1989.
2. Cylindrical sponge with exaulos-appearing inhalant pores.
Preeudea Termier and Termier, 1977a.
b. Fungiform sponge with numerous coarse exhalant canals.
Polytubifungia new genus.
c. Spherical sponge with several shallow oscula and inhalant canals.
Microsphaerispongia new genus.
3. Without a large osculum or depression on the summit and with fibers in vesicular-appearing skeleton.
Subfamily Parahimatellinae new subfamily.
Parahimatella new genus.

4. With a large osculum in the axial part of the summit of sponge; exhalant canals do not end in the osculum.

Subfamily Pseudohimatellinae new subfamily.

a. Exhalant canals present and inhalant canals absent or poorly defined.
Pseudohimatella new genus.

b. Exhalant canals absent, inhalant canals present.
No known genus yet discovered.

E. Without spongocoel, but with numerous upwardly divergent exhalant canals in skeleton of coarse, distinct spherulites connected by beams.
Family Sphaeropontidae new family.
Sphaeropontia new genus.

F. Without axial spongocoel, but with several peripheral, longitudinal, coarse exhalant canals or spongocoels.
Family Exotubispongiidae new family.
Exotubispongia new genus.

SYSTEMATIC PALEONTOLOGY

Class CALCAREA Bowerbank, 1864

Superorder ASPICULATA new superorder

Diagnosis.—Calcareous sponges lacking spicules but with rigid skeletons composed of aragonite or possibly calcite; usually unsegmented but rarely segmented.

Order INOZOIDA new order

Diagnosis.—Rigid skeleton not segmented, usually composed of aragonite but may include calcite; lacks spicules.

Family AURICULOSPONGIIDAE Termier and Termier, 1977a

Original diagnosis.—"Nous rangeons dans cette famille la genre *Auriculospongia* caractérisé par sa structure 'foliacée,' le squelette épais offrant d'un côté une surface inhalante et de l'autre une surface exhalante. Ce type écologique est connu chez de nombreux Calcisponges et Démosponges plus récents" [We include in this family, the genus *Auriculospongia,* which is characterized by its "foliate" structure, a thick skeleton, and with one side as the inhalant surface and the other as an exhalant surface. This ecologic type is known from numerous examples in recent calcisponges and demosponges] (Termier and Termier, 1977a, p. 29).

Discussion.—Termier and Termier (1977a) placed the family Auriculospongiidae into the order Ceratoporellida (Sclerospongiae Hartman and Goreau, 1972), an order characterized by possession of siliceous spicules within an aragonite basal skeleton. Termier and Termier (1977a, pl. 8, fig. 4; 1977b, pl. 1, fig. 8) figured two thin sections of *Auriculospongia auriculata* that are reported to show monaxon spicules within the rigid skeleton. The origin of the circular structures cited as spicules in their 1977a publication is most uncertain, and we could not see spiculelike structures in illustrations in their 1977b publication. The systematic affinity of the Auriculospongiidae to the demosponges or sclerosponges is uncertain. In fact, we could not find spicules in either *Auriculospongia auriculata* or in the new species *Auriculospongia perforata.* The rigid skeletons of both species, however, exhibit a spherulitic microstructure (see pl. 54.1–54.4 and compare Termier and Termier, 1977b, pl. 4, fig. 5; pl. 6, fig. 2).

Subfamily AURICULOSPONGIINAE new subfamily

Diagnosis.—Auriculospongiidae with exhalant canals on one side; without inhalant canals; interfiber spaces serving as inhalant openings.

Type genus.—*Auriculospongia* Termier and Termier, 1974.

Genus AURICULOSPONGIA Termier and Termier, 1974

Discussion and diagnosis.—The genus *Auriculospongia* was erected by Termier and Termier (1974, p. 247) without a diagnosis or description in a list of Sclerospongia, in a brief discussion of the Permian sponges of Djebel Tebaga from southern Tunisia. The complete citation is: ". . . *Auriculospongia* new genus *auriculata* Term. et Term. [(1955), p. 625, fig. 9a–b]," referring to their brief original description of *Phacellopegma auriculata* new species. One must thus assume that the diagnoses of the genus and species are the same. The original 1955 description is: "D'autres échantillons provenant aussi du Djebel Tebaga, sont auriformes, la face externe de l'individu offrant également des canaux anastomosés, à trace compliqué, la face interne élant parfois, mais non toujours, pourvenue d'une ornamentation plus simple, nous proposons pour ces échantillons le nom de *Phacellopegma auriculata* nov. sp. (fig. 9a–c)" [Other samples coming also from Djebel Tebaga are ear-shaped. The external face of the individual shows anastomosed canals with a complicated outline; the internal face often, but not always, is provided with a more simple ornamentation. We propose for these samples the name *Phacellopegma auriculata* new species (fig. 9a–c)].

This species was placed in *Auriculospongia* (Termier and Termier, 1977a, p. 30) because the sponges from Tunisia have a different skeletal structure. *Phacellopegma* is a lithistid demosponge (Finks, 1960, p. 60). *Auriculospongia,* at that time, was monospecific.

Type species.—*Phacellopegma auriculata* Termier and Termier, 1955.

AURICULOSPONGIA AURICULATA (Termier and Termier, 1955)

Plate 1.1–1.2; Plate 2.1–2.4, 2.10; Plate 44.1–44.2; Plate 54.1–54.2; Plate 71.1–71.2

Synonymy.—*Phacellopegma auriculata* Termier and Termier, 1955, p. 625, fig. 9a–b.

Auriculospongia auriculata Termier and Termier, 1974, p. 247; Termier and Termier, 1977a, p. 29–30, pl. 8, fig. 1–4; Termier and Termier, 1977b, pl. 4, fig. 5; pl. 6, fig. 1–2.

Diagnosis.—Sponges earlike to palmate above cylindrical base, with both inhalant and exhalant surfaces marked by tangential, moderately deep, and upwardly divergent furrows on exhalant side, but less deep and smaller in network of furrows on inhalant side. Skeletal fibers with dominant orientation parallel to direction of growth; fibers composed of spherulites approximately 40 μm in diameter.

Description.—Sponges with ear- to sheet- or handlike forms above cylindrical stem or base. Largest specimen (Pl. 1.1–1.2) with height of 130 mm and width of 80 mm, although sheets usually with lengths and widths of approximately 50 mm. Thicknesses of sheets usually depend upon the size of specimens and range from 5 to 20 mm. Characteristically exteriors of both sides show different ornamentations (Pl. 1.1–1.2; Pl. 2.1–2.2, 2.4, 2.10). One side striated with furrows oriented and branched radially toward top of sponge; furrows approximately 0.8 mm wide, and spaces between furrows usually 2 to 3 times wider than furrows. Some large pores up to 1 mm in diameter occur in furrows, but no pores observed in interfurrow areas. Areas between pores in furrows as well as interfurrow areas filled with reticular fibrous skeletal structure.

Other side characterized by network of furrows and interfurrow areas much smaller than on first side. Numerous pores less than 1 mm in diameter occur in furrows. Top of sheetlike sponge usually smooth, but in some the furrows from both sides connect over the top.

Thin sections made parallel and perpendicular to growth direction exhibit two different appearances of internal structure. The section perpendicular to growth direction (Pl. 71.2) shows skeletal fibers arranged irregularly (reticular type). No preferred direction of orientation of fibers is recognizeable. Interspaces between fibers circular, oval, irregular, or labyrinthic in section. Fibers have almost same widths or diameters as interfiber spaces; widths of fibers range from 0.15 to 0.25 mm.

Skeletal fibers have distinct orientations parallel to growth direction (Pl. 71.1) and spaces between fibers appear as tubes running parallel to growth direction. That part of section closest to surface of sponge has circular openings corresponding to exhalant openings or canals on surface of sponge.

Rigid skeleton of species lacks spicules but is composed of uniform spherulites, each approximately 40 µm in diameter (Pl. 54.1–54.2).

Discussion.—*Auriculospongia auriculata* (Termier and Termier, 1955) is a common sponge in Permian deposits of the Djebel Tebaga region, where it has been documented at 33 localities either in measured sections or in spot localities that were collected during the study. It is perhaps most common in the upper part of the sequence exposed on either flank of Merbah el Oussif, in the Section E or Section J areas. Palmate organisms, such as these species, are generally strongly oriented with reference to current directions, but because virtually all the specimens we recovered are fragments, we cannot reach conclusions about these aspects of the species's ecology.

Auriculospongia auriculata (Termier and Termier) is generally somewhat larger than the often associated *Auriculospongia perforata* new species and differs from that latter species in having both apparent incurrent and excurrent surfaces marked by furrows. The exhalant side is characterized by moderately deep, upwardly divergent, tangential furrows, in which the exhalant ostia are located. The inhalant surface, on the other hand, has a more or less irregular network of furrows that are less deep and usually smaller than on the excurrent side. *Auriculospongia perforata* new species may have radially anastomosing furrows on one side, but the opposite side is covered with a cortex with only fine perforations. These are the only prominent, palmate sponges in the Permian collections from Tunisia and, as such, are relatively easily identified, even in the field.

Material.—96 reference specimens.

Figured specimens.—USNM 463571–463577, from several localities.

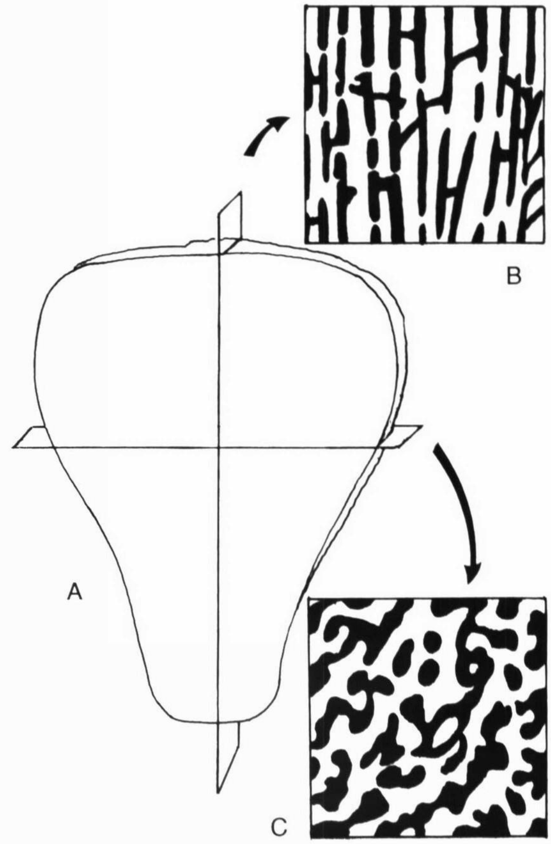

Figure 12. Arrangement of skeletal fibers within sheets of *Auriculospongia perforata* new species; *A*, club-shaped sheet of the sponge; *B*, section parallel to the growth direction shows fibers are arranged in lines parallel to the growth direction, with a few transverse fibers between them; *C*, section perpendicular to the growth direction and perpendicular to the section illustrated in *A* shows the fibers do not have a preferred direction but are arranged irregularly (schematic, not to scale).

Occurrence.—The numerous and widespread occurrences of this common species in the Djebel Tebaga area are tabulated in Table 1.

AURICULOSPONGIA PERFORATA new species

Plate 1.3–1.4; Plate 2.5–2.9; Plate 3; Plate 44.3–44.4; Plate 54.3–54.4; Plate 71.3–71.4; Figure 12

Diagnosis.—Sheet-, hand- or earlike sponges with ornamentation or canal development different on opposite sides; one side characterized by reticular fibrous structure,but other side with cortex with fine perforations. Without spongocoel or prominent exhalant or inhalant canals.

Description.—General growth form sheet-, hand- or earlike and with sizes like those of *Auriculospongia auriculata* (Termier and Termier, 1955). Specimens primarily small with heights to 15 mm and widths to 18 mm. Largest example (Pl. 3.6) 100 mm high and 120 mm maximum width. Holotype (Pl. 3.1–3.3) flat, heart-shaped, and 65 mm high and wide, in upper part; initial stemlike stage of holotype cylindrical but immediately grades to sheetlike

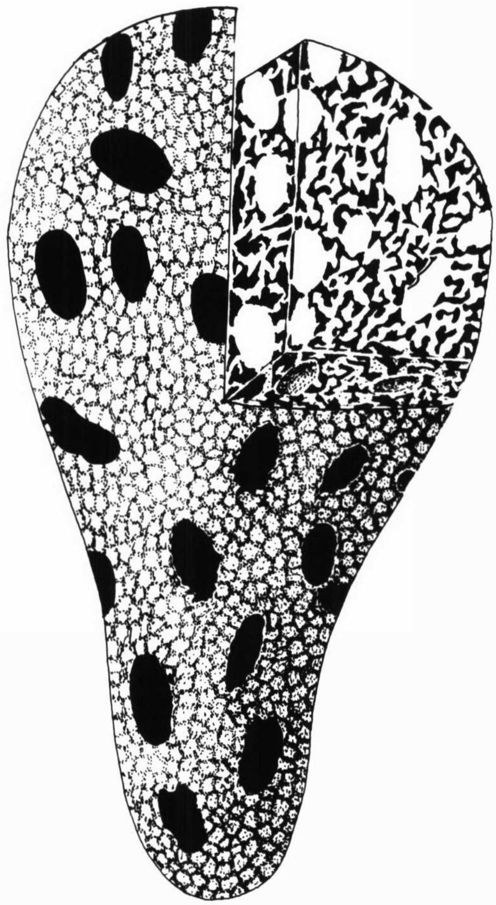

Figure 13. View of the exterior and three-dimensional section of the interior of *Cavusonella caverna* Rigby, Fan, and Zhang, 1989. The fibrous skeletal structure is marked by dotted points on the exterior surface but is black in the section. Large exhalant canals show as dark on the outside but white in the section. Connections between the large exhalant canals and openings in the skeletal structure are through skeletal pores between the skeletal fibers (not to scale).

structure in upper part. Thicknesses of sheets range from 5 to 15 mm; holotype 10 mm thick.

Two sides of sheets with different external appearance. One side, most probably the inhalant side, with cortex pierced by numerous small pores 0.15 to 0.25 mm in diameter. Other, presumably exhalant side, lacks cortex and only fibrous skeletal structure visible. Other sculpture, such as furrows characteristic of *A. auriculata,* lacking.

Two mutually perpendicular sections through sheets appear somewhat different. Vertical (longitudinal) section (Pl. 3.5; Pl. 71.4; Fig. 12B) with fibers of rigid skeleton arranged parallel to direction of growth and continue for long distances. Spaces between fibers appear like small longitudinal canals diverging toward exterior (Pl. 71.4). Fibers thin and range from 0.15 to 0.40 mm thick, but usually 0.25 mm in diameter. Spaces between fibers with essentially same dimensions. Fibers interrupted by pores that laterally connect spaces between fibers. Horizontal section perpendicular to vertical section (Pl. 3.4; Pl. 71.3; Fig. 12C) shows fibers irregularly arranged and 0.15 to 0.7 mm thick. Rigid skeletal fibers composed of densely packed spherulites that range from approximately 50 to 70 μm in diameter (Pl. 54.3–54.4).

Discussion.—*Auriculospongia perforata* differs from the type species *Auriculospongia auriculata* (Termier and Termier, 1955) in having radially anastomosed furrows on one side of the sheetlike skeleton. If present, however, the furrows in the new species are much smaller and more irregularly arranged than in *A. auriculata.* The perforated side of *A. perforata* corresponds to the inhalant side that has small, radially branched furrows in *A. auriculata.*

Material.—Whole sponges or fragments of 35 specimens.

Type specimens.—Holotype, USNM 463581, Pl. 3.1–3.3, Section G, bed 5; paratypes, USNM 463578–463587.

Occurrence.—This common species occurs in Section B, bed 1; Section C, bed 18; Section E, beds 14 and 26 and shale below Reef 3; Section I, bed 26 and shale below bed 3; Section J, bed 17, and at Spot Localities DJT-11 and 224-1976.

Etymology.—*Per,* through, by; *forates,* bored, Latin; in reference to the pores on one side of the sheetlike sponge.

Genus CAVUSONELLA Rigby, Fan, and Zhang, 1989

Original diagnosis.—"Cylindrical sponge with uneven to undulating exterior; interior pierced by coarse irregular openings, which may bifurcate upward and may make up to one-half sponge volume; sponge lacks prominent, continuous, longitudinal canals and continuous central spongocoel; skeleton of irregular fibers in loose upward and outward expanding pattern" (Rigby, Fan, and Zhang, 1989, p. 796).

Type species.—*Cavusonella caverna* Rigby, Fan, and Zhang, 1989.

Discussion.—Wu (1991) proposed the new genus *Tritubulistroma* and placed it in the hydrozoans. This genus, like many others in his work, was described with one species and is based upon only one thin section. The diagnosis of the genus and the characteristics given by Wu as diagnostic cannot be seen in the type thin section illustrated. In fact *Tritubulistroma* (as far as we can assess) is almost identical to the genus *Cavusonella.* Whether Wu's genus *Tritubulistroma* is a separate genus or a *Cavusonella* should be checked carefully by a researcher having access to the Chinese sponges.

CAVUSONELLA CAVERNA Rigby, Fan, and Zhang, 1989

Plate 4.6–4.8; Plate 21.1; Plate 44.7; Plate 55.1–55.4; Figure 13

Synonymy.—*Cavusonella caverna* Rigby, Fan, and Zhang, 1989, p. 796, fig. 12.1–12.3.

Original diagnosis.—"Cylindrical sponges, with uneven to undulating exteriors; interiors pierced by coarse irregular openings, which may bifurcate upward and may make up to one half sponge volume; sponges lack prominent continuous longitudinal canals and continuous central spongocoel; skeleton of irregular fibers in loose upward and outward expanding pattern" (Rigby, Fan, and Zhang, 1989, p. 796).

Description.—Cylindrical or subcylindrical to spoonlike sponges elliptical to slightly crescentic in cross section, with one side of sponge commonly depressed and slightly concave. Heights of three almost complete specimens range from 26 to 33 mm, with diameters between 11 mm and 13 mm in upper part.

Outer surface covered by numerous large openings (exhalant pores) of unwalled elliptical canals with long axes subvertical, parallel to sponge axis, and about 1 mm tall. Exhalant pores more regularly arranged on convex side than on concave side of sponge. Skeleton between openings appears to be granular.

Exhalant pores open as canals into interior but not in regular pattern. Canals about 0.5 to 0.8 mm in diameter and connected with interior canals by numerous pores. Skeleton between canals composed of reticular fibers that locally show radiate, upwardly and outwardly divergent pattern. Longitudinal section of figured specimen USNM 463589 (Pl. 21.1) shows irregular placement of coarse upwardly and outwardly divergent canals and horizontal interconnecting canals perforating regular skeletal net characteristic of species. Upwardly divergent, radial canals only moderately regular and unwalled perforations of net, although locally some coarse fibers occur at canal margins. Canals have open, porous walls connecting to skeletal pores between fibers. Irregularly developed, horizontal, interconnecting canals of same general proportions, 0.5 to 0.6 mm in diameter.

Skeleton shows generally upwardly and outwardly divergent structure in longitudinal section but forms reticulate, tubelike structures where the section is more tangential to principal fabric. Skeletal fibers range from 0.03 to 0.12 mm in diameter, with greatest dimensions in junctions of reticulate fibrous net, and thinnest elements in areas intermediate between junctions. Fibers define interconnected skeletal pores generally 0.16 to 0.20 mm in diameter. Pores more or less circular, so junction areas of tracts between adjacent pores swell into triangular elements. Where skeletal pores most tubelike, they appear moderately wavy or undulating and locally traceable 2 to 3 millimeters before being lost in reticulate skeletal net. In general, fabric of net remarkably uniform, even though interrupted by moderately coarse canals not in uniform pattern and spaced somewhat variably 1 to 3 mm apart.

Skeletal fibers in one specimen dense with pinpointlike microstructure of spherulites, approximately 60 to 100 μm in diameter. Internal structure of two other investigated specimens poorly preserved, so microstructure of those skeletons not determined. Longitudinal thin section also shows poor preservation of internal structure of holotype because of replacement of primary aragonitic skeleton by calcite or even dolomite. Poor preservation of skeleton has also resulted from crystallization of iron carbonate in spaces between fibers. Figure 13 shows external and three-dimensional internal views of *Cavusonella caverna* Rigby, Fan, and Zhang, 1989.

Discussion.—This species was first described and reported from Middle and Upper Permian reefs of China by Rigby, Fan, and Zhang (1989). Features and measurements of the Tunisian specimens correspond remarkably well with those of the types.

Material.—Eight specimens.

Figured specimens.—USNM 463588, Section J, bed 17; USNM 463589, Spot Locality T5; USNM 463590, Spot Locality 109-1976; USNM 480413, Spot Locality DJT-31.

Occurrence.—The relatively rare species has been found as a single specimen at each of the Spot Localities T5 and 143-1976, as two specimens from Spot Locality DJT-31, and as four specimens from Section J, bed 17.

Genus RADIOTRABECULOPORA Fan, Rigby, and Zhang, 1991

Synonymy.—*Tubulispongia* Wu, 1991, p. 35; *Flabelliscera* Wu, 1991, p. 36; *Gigantosclera* Wu, 1991, p. 38; *Gracilitubulus* Wu, 1991, p. 39; *Fugispongia* Wu, 1991, p. 39–40.

Original diagnosis.—"Coenosteum composed of many trabeculae, of various widths, that extend longitudinally and parallel to each other; trabeculae may merge into single coarse one, or a coarse one may split into two slender ones; skeletal openings between trabeculae have moderate range of diameters, many small pores irregularly interrupt trabeculae" (Fan, Rigby, and Zhang, 1991, p. 56).

Type species.—*Radiotrabeculopora xiangboensis* Fan, Rigby, and Zhang, 1991.

Discussion.—The outer surface, the pattern of perforation on the exterior, and the regular internal structure of *Radiotrabeculopora* look similar to the Carboniferous-Permian genus *Scheiia* Tschernyschew and Stepanov (1916). *Scheiia,* however, possesses a spicular skeleton and belongs to the tricranocladine demosponges (see Finks, 1960; Termier and Termier, 1978). *Radiotrabeculopora* lacks a spicular skeleton and has a rigid skeleton composed of aragonite with a spherulitic microstructure (see Pl. 56; Fig. 14).

Radiotrabeculopora was placed in the family Disjectoporiidae Tornquist, 1901 by Fan, Rigby, and Zhang (1991) and questionably referred to the Hydrozoa. However, the canal system and overall structural similarity with the sponge *Scheiia* is striking. These supposed hydrozoans described by Fan, Rigby, and Zhang (1991) are here included in the inozoid sponges.

Wu (1991, p. 29) proposed the new family Tubulispongiidae and included it in the new order Tubulospongiida within the new subclass Tubulospongia. Several new genera, including *Tubulispongia, Flabellisclera, Gigantosclera, Gracilitubulus,* and *Fungispongia,* were included

Table 3. Comparison of diagnostic features of *Radiotrabeculopora* and other Chinese Permian genera.

Species	Shape	Surface	Internal Structure	Wall between tubes	Micro-structure	Age and Horizon	Locality
Radiotrabeculopora	Columnar	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	Spherulitic	Middle Permian Maokou Formation	Xiangbo Guangxi
Tubilispongia	Columnar	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	Spherulitic	Middle Permian Maokou Formation	Xiangbo Guangxi
Flabellisclera	Conical	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	?	Middle Permain Maokou Formation	Xiangbo Guangxi
Gigantosclera	Columnar	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	Trabecular?	Middle Permian Maokou Formation	Xiangbo Guangxi
Gracilitubus	Columnar	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	Spherulitic	Middle Permian Maokou Formation	Xiangbo Guangxi
Fungispongia	Mushroomlike	Honeycombed perforated	Numerous tubes Upwardly divergent	Perforated	Spherulitic	Middle Permian Maokou Formation	Xiangbo Guangxi

in his new family Tubulispongiidae. The stratigraphic occurrences of all the mentioned genera as well as of *Radiotrabeculopora* described by Fan, Rigby, and Zhang (1991) are in the Middle Permian Maokou Formation of Guangxi province. Localities of all the mentioned genera are essentially identical and, according to numbers of the samples, they also came from essentially the same beds. Not only the stratigraphic age, locality, and horizon but also the sampling time and collectors of both suites, those published by Fan, Rigby, and Zhang (1991) and Wu (1991), are the same (Wu, 1991, p. 3).

After critical examination of figured specimens in both mentioned publications and the diagnoses given by Fan, Rigby, and Zhang (1991) of *Radiotrabeculopora* and of the other mentioned genera by Wu (1991), it is our opinion that all the questioned genera are synonymous. The main characteristics of these genera are summarized in Table 3. Species of *Tubulispongia, Flabellisclera, Gigantosclera, Gracilitubus,* and *Fungispongia* are moved to the genus *Radiotrabeculopora,* but the identity of Wu's species placed in the several genera should be checked again.

Occurrence.—Middle Permian Maokou Formation, Guangxi and Yunnan provinces; Upper Permian Changxing Formation, Guangxi and Hubei provinces, China, and Djebel Tebaga, Tunisia.

RADIOTRABECULOPORA cf. R. XIANGBOENSIS Fan, Rigby, and Zhang, 1991

Plate 5.11–5.13; Plate 7.11–7.12; Plate 27.9; Plate 44.8–44.9; Plate 56

Synonymy.—*Radiotrabeculopora xiangboensis* Fan, Rigby, and Zhang, 1991, p. 56–57, fig. 11.4, 12.8–12.10, 13.1, 13.4.

Emended diagnosis.—Skeleton of principally radially arranged, tubelike canals bounded by walls with varying thickness; inner part of skeleton essentially porous, but outer part massive with canal walls porous and appearing beaded, with most elements or tracts 0.2 to 0.3 mm in diameter; most canals approximately 0.5 mm in diameter; skeleton lacking concentric or horizontal layering, so generally ap-

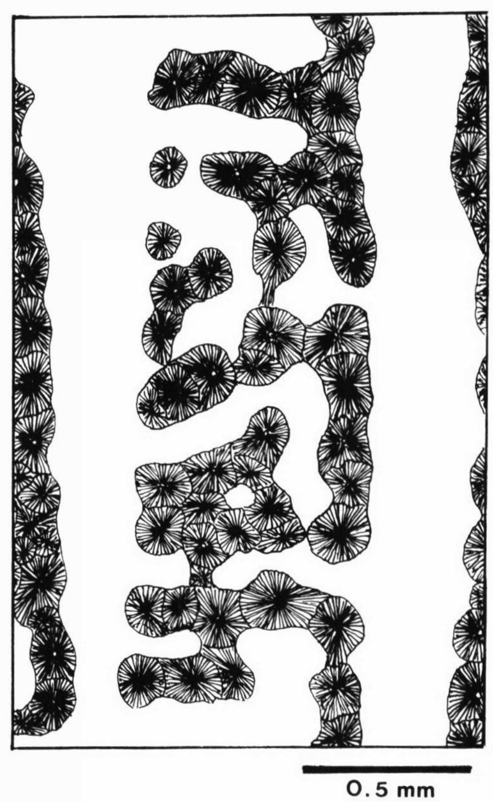

Figure 14. The arrangement of canals between the fibrous skeletal elements and of spherulites within the skeleton of *Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991 (Sample 28).

pears dominantly radial (modified from Fan, Rigby, and Zhang, 1991, p. 56).

Description.—These cylindrical to mostly club-shaped or massive sponges range up to 60 mm high and have diameters of up to 25 mm. Outer surface covered by circular, oval, polygonal, or irregular openings that correspond to interfiber spaces. Diameters of these openings were observable in specimens of *Radiotrabeculopora maokoui,* described below, but could not be seen in our specimens of this species.

Internal structure appears to be composed of numerous, more or less uniform, longitudinal, tubelike elements that diverge upward and outward toward sponge surface. These tubes are 0.2 to 0.4 mm in diameter and range up to 0.8 mm where branched. Walls around tubes usually 0.15 to 0.30 mm thick; tubes connected with adjacent tubes by numerous pores 0.1 to 0.4 mm in diameter. Arrangement of tubes and walls between tubes more irregular than in *Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991.

Some specimens show small, circular structures within walls of tubes when examined in a dissecting microscope. These show spherulitic microstructure of skeleton with spherulites 100 to 130 µm in diameter, as documented by examination of two specimens using scanning-electron microscopy.

Discussion.—In dimensions and arrangement of the skeletal elements, Tunisian specimens of this species correspond to those of *Radiotrabeculopora xiangboensis* Fan, Rigby, and Zhang (1991). That species was described from the Middle Permian Maokou Formation from Xiangbo (Guangxi) and Guangnan (eastern Yunnan), China.

Material.—42 specimens.

Figured specimens.—USNM 463616–463619, 463631.

Occurrence.—The species occurs in Section E, bed 1, Section E, beds 14, 26, and 27, and in the shales above and below Reef 3; Section G, bed 5; Section I, bed 2; Section J, bed 17, and in Spot Localities T3, T5, T6, 16A, 27A, and 143-1976.

RADIOTRABECULOPORA MAOKOUI
Fan, Rigby, and Zhang, 1991

Plate 5.6–5.10; Plate 7.15; Plate 21.2; Plate 45.1; Figure 14–15

Synonomy.—*Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991, p. 58, 60, fig. 13.2–13.3, 14.1–14.3.

Emended diagnosis.—Cylindrical to massive sponges with numerous upward-and-outward, radial canals defined by thin skeletal tracts; canals in the interior 0.1 to 0.3 mm in diameter but may expand radially to approximately 0.8 mm across; canal walls with numerous pores generally 0.2 to 0.4 mm across; tracts approximately 0.1 mm in diameter (modified from Fan, Rigby, and Zhang, 1991, p. 58).

Description.—Cylindrical to club-shaped sponges range up to 65 mm high and with diameters up to 30 mm. Spongocoel, as well as osculum, lacking.

Outer surface covered by numerous pores of different sizes. Large pores with diameters of 0.3 to 0.4 mm, spaced 0.1 to 1.0 mm apart. Pores and dimensions correspond to

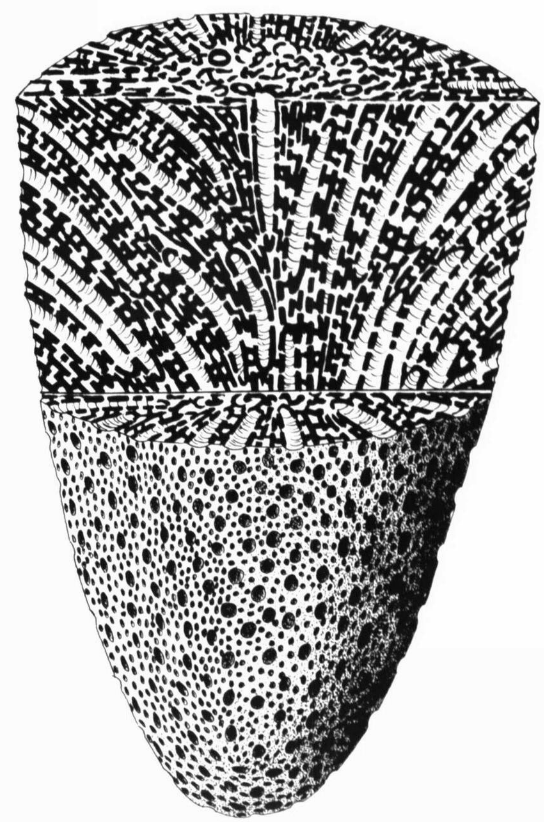

Figure 15. Reconstructions of longitudinal and transverse sections of *Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991. The large exhalant canals diverge upward within the sponge, but they appear as radially arranged openings in transverse sections, especially in the outer part of the sponge. In transverse sections the axial part appears composed mainly of fibers and only a few inhalant canals. Spaces between the canals are filled with fibers that are oriented upward and outward within the sponge, parallel to the exhalant canals. Small inhalant pores on the surface of the sponge extend inward as inhalant canals between the fibrous structures. In longitudinal section the large exhalant canals appear upwardly divergent, and the spaces between them are filled with skeletal fibers arranged parallel to the exhalant canals (schematic, not to scale).

tubes in sponge interior. Large tubes locally separated by thin wall only 0.1 mm thick, or elsewhere by thick tracts of skeleton with small pores. Smaller pores usually 0.15 to 0.25 mm in diameter, between larger pores. Small pores same as pores between walls of tubes.

Longitudinal section characterized by axial zone with numerous, small, vertical parallel canals that diverge water-jet-like toward upper periphery of sponge (Fig. 15). Diameters of canals relatively constant and range from 0.3 to 0.4 mm. Canals extend to surface and to summit where large exhalant openings located. Canals separated by thin wall 0.05 to 0.10 mm thick, which is pierced by numerous small pores approximately 0.05 mm in diameter.

Sponge wall or skeletal network between canals made of elongate elements or fibers, called trabeculae by Fan, Rigby, and Zhang (1991); fibers sometimes thick, usually 0.5 mm but range to 1.5 mm; where thick, small canals 0.1 mm in diameter, called pores by Fan, Rigby, and Zhang (1991), are oriented parallel to wall or to large tubes. Small pores or canals between fibers connected with others of same size and with larger canals by small pores 0.05 to 0.10 mm in diameter.

In transverse section, skeleton appears composed of irregularly to concentrically arranged network, pierced by radially arranged canals that extend to periphery of sponge.

Four specimens of species investigated with SEM (Sample 24, USNM 463625, 463628–463630); spicular skeleton lacking in all of them. All specimens have aragonite mineralogy and spherulitic microstructure; spherulites 100 to 150 µm in diameter and distinct from each other (Fig. 14).

Discussion.—*Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991, was described from the Upper Permian of China. The species is also moderately common in our collections from the Djebel Tebaga area, as somewhat finer-textured specimens than those included in *Radiotrabeculopora* cf. *R. xiangboensis* (Table 4). Larger pores in the sponges from Tunisia are only somewhat coarser than those in the type specimens from China, at least those in the interior of the skeletons from China. Therefore, our specimens are placed within the species with moderate confidence.

Specimens included in *Radiotrabeculopora maokoui* lack the reticulate skeletal structure that characterizes the somewhat coarser *Radiotrabeculopora reticulata,* as well, both in the specimens we have identified as the species from Djebel Tebaga and in the type specimens from China.

Material.—Seven specimens.

Figured specimens.—USNM 463625–463630, and 480396.

Occurrence.—The species occurs in Section I, in bed 5, and in the shale below bed 3, but west of the traverse; and at Spot Localities S7, 27A, and DJT-22.

RADIOTRABECULOPORA RETICULATA
Fan, Rigby, and Zhang, 1991

Plate 5.1–5.5; Plate 21.3; Plate 45.2; Plate 72.3–72.5

Synonymy.—*Radiotrabeculopora reticulata* Fan, Rigby, and Zhang, 1991, p. 60–61, fig. 15.1–15.5.

Emended diagnosis.—Skeleton massively obconical to massively subhemispherical, with skeleton of radial, subparallel, and prominent concentric tracts forming reticulate, even-textured pattern in section, but differentiated into inner and outer parts; inner part with laminae dominant; outer part with tracts mainly radial, with radial exhalant canals 0.4 to 0.9 mm across, mostly 0.5 mm across; skeletal tracts discontinuous and meandriform in inner part, with concentric laminate structures dominant in intermediate part, where canalled at porous walls; reticulate skeletal mesh characteristic of intermediate part of skeleton (modified from Fan, Rigby, and Zhang, 1991, p. 62).

Description.—This sponge is one of largest and most abundant inozoid sponges in Djebel Tebaga. Shapes of sponges range from massive to subspherical or conical. Individual specimens range up to 110 mm high and with diameters up to 70 mm; however, most specimens have diameters of approximately 25 mm. Most specimens of species recrystallized or encrusted by algae, thus nature of outer surfaces unknown. In some well-preserved specimens, however, surface covered by circular to oval or irregular pores of three different sizes (USNM 463624, Pl. 5.3–5.4). Largest openings 1.2 to 1.5 mm in diameter not abundant and separated 0.5 to 1.0 mm and more. Medium-sized pores occur between larger openings and usually 0.5 mm in diameter. Smallest pores 0.1 to 0.2 mm in diameter occur between fibers of skeleton and between medium-sized pores.

Skeletal fibers in central part of sponge have different arrangement from those in peripheral part. In transverse sections, fibers appear irregular in central part but arranged in concentric lines in peripheral part of skeleton (Pl. 5.2; Pl. 72.5). In longitudinal section, fibers look irregular but sometimes arranged in lines in central part of sponge. Arched structures bow upward toward summit of sponge and bend downward toward periphery of sponge. Both central and peripheral parts of skeleton pierced by relatively large tubes (1.0 to 1.5 mm in diameter) traceable to exterior of sponge where large openings located. Skeletal fibers relatively thick and range from 0.2 to 0.5 mm in diameter. Fibers separated by numerous small pores 0.15 to 0.75 mm in diameter.

Microstructure of specimen in Plate 5.4 investigated with scanning electron microscopy (Sample 2, USNM 463624). Skeleton composed of only vague spherulites 100 to 150 µm in diameter arranged side by side.

Discussion.—*Radiotrabeculopora reticulata* Fan, Rigby, and Zhang, 1991, is one of the largest sponges known from the Permian and is certainly one of the most common large forms in exposures at Djebel Tebaga (Table 4). The species is distinguished by the open, tubular outer part of the skeleton and an inner, more concentric laminate structure but with a reticulate transition zone in intermediate parts of the skeleton.

Material.—67 specimens.

Figured specimens.—USNM 463620–463621, 463623–463624, from Section G, beds 4–5; and USNM 463622 from Spot Locality S1.

Occurrence.—The species occurs widely in the Djebel Tebaga area. These occurrences are shown in Table 1.

RADIOTRABECULOPORA PATULA new species

Plate 6.1–6.2; Plate 21.4; Plate 48.6; Plate 63; Plate 77.6

Diagnosis.—Large mushroomlike sponges with several astrorhizal-like centers on upper surface producing ill-defined, shallow, oscular depressions that have only weak, shallow clusters of coarse, vertical, exhalant canals; clusters do not persist into interior, but isolated, prominent, coarse canals, 0.5 to 1.0 mm in diameter, cut coarse, broadly upwardly divergent, porous, linear fibers of skeleton; most tubelike canals 0.3 to 0.5 mm in diameter parallel fibers in dominant structure.

Table 4. Comparison of species of *Radiotrabeculopora* in the Tunisian collection, and those described from China by Fan, Rigby, and Zhang (1991) and Wu (1991); measurements in millimeters.

Species	Shape	Maximum height (H) and diameter (W)	Diameter of large canals	Diameter of small canals	Thickness of tube walls	Diameters of pores on the wall	Thickness of fibers
R. maokoui Fan, Rigby, and Zhang, 1991	Cylindrical to club-shaped	65 × 30	0.3–0.4	0.15–0.25	0.05–0.10	0.04–0.20	0.06–0.40
R. cf. *xiangboensis* Fan, Rigby, and Zhang, 1991	Cylindrical to massive	60 × 25	0.2–0.4, up to 0.8 where branched	0.08–0.40	0.15–0.3	0.06–0.25	0.1–0.4
R. reticulata Fan, Rigby, and Zhang, 1991	Largest; massive to obconical	100 × 70	1.0–1.5	0.1–0.2	0.1–0.3	0.15–0.75	0.2–0.5
R. elegans Fan, Rigby, and Zhang, 1991	Cylindrical; irregularly massive	20–26	0.1	0.6–0.12	—	0.10–0.34	0.1–0.4 rarely to 0.6
R. concentrica (Wu, 1991)	Large columnar, branched?	20–26	0.25–0.50	—	0.12–0.30	0.17–0.25	0.12–0.3
R. continua (Wu, 1991)	Columnar	20–25	0.25–0.50	—	0.10–0.30	0.075–0.200	0.10–0.30
R. discreta (Wu, 1991)	Conical or domed; columnar	10–15 × 15–16	0.17–0.30	—	0.17–0.30	0.12–0.25	0.17–0.30
R. patula n. sp.	Mushroomlike	45 × 90	0.5–1.0	0.3–0.5	?	0.1–0.3	0.2
R. deformis (Wu, 1991)	Columnar	50 × 35–37	0.15–0.37	—	0.05–0.20	—	0.05–0.20
R. perforatus (Wu, 1991)	Columnar	10–15	0.05–0.12	—	0.02–0.07	0.04–0.05	0.02–0.07
R. circularis (Wu, 1991)	Mushroomlike	32 × 10–14	0.25–0.62	—	0.12–0.25	0.15–0.30	0.12–0.25

Description.—Massive mushroomlike sponges increase in diameter rapidly upward from base of sponge, with diameter of only 10 mm, to approximately 90 mm; height only about 45 mm (Pl. 6.2).

Lower part of sponge generally smooth, showing only faint growth lines. Low radiate ridges produced by vertically arranged skeletal fibers and some coarse canals arranged parallel to lower surface and radial from near sponge base, evident where thin outer dermal layer weathered away.

Top of sponge domed, umbrellalike (Pl. 6.1–6.2), with four, ill-defined, shallow oscular depressions, 10 to 12 mm in diameter, toward which converge surficial shallow grooves 1.0 to 1.5 mm wide from periphery of sponge. Grooves curve irregularly and branch dichotomously away from centers. Ostia of large exhalant canals 0.5 to 1.0 mm in diameter concentrated in troughs of grooves but also occur as isolated openings across sponge top.

Pores or canals of three series: coarse, walled, vertical exhalant canals; intermediate, upwardly divergent, exhalant canals; and smaller skeletal pores, the latter two more or less parallel to the skeletal fibers and interconnected by lateral pores through the fibers.

Vertical and horizontal sections have rare, coarse canals that are essentially vertical, walled, exhalant openings that cut across dominant, upwardly divergent skeletal fabric and smaller canals; coarse canals extend up from lower part of sponge as isolated, unclustered canals. These canals widely distributed 1 to 5 mm apart in transverse sections.

Intermediate canals most common and 0.3 to 0.5 mm in diameter, with ostia common on upper surface; long major canals diverge upward from deep in sponge skeleton, parallel to skeletal fibers and smaller skeletal pores, as discontinuously walled, but porous, well-defined, openings. Canals range from side by side to 3 mm apart but common throughout skeleton. Smaller skeletal pores subpolygonal to circular, 0.1 to 0.3 mm across, in linear series in reticulate skeletal tracts between canals.

Skeleton reticulate but dominantly linear, of upwardly divergent, branching fibers, each generally 0.08 to 0.14 mm in diameter, both in upwardly elongate and cross-connected and interrupted or porous elements, but may thicken to as much as 0.24 mm in canal walls and in fiber junctions. Entire fabric relatively coarse among inozoids in collections.

Coarse skeletal fibers approximately 0.2 mm thick exposed over entire upper surface, both in grooves and between grooves.

Discussion.—Radiotrabeculopora patula new species is characterized by its mushroom shape and the distinctive three series of canals that contrast to the somewhat simpler canal patterns seen, for example, in *Radiotrabeculopora xiangboensis* Fan, Rigby, and Zhang, 1991, which has a moderately simple system of upwardly radiating canals, each approximately 0.5 mm in diameter. *R. xiangboensis* lacks the walled, vertical, coarse, exhalant canals characteristic of the mushroom-shaped species described here.

Radiotrabeculopora maokoui Fan, Rigby, and Zhang, 1991, similarly, has a somewhat less complex canal structure than *R. patula,* for in the Chinese species, the cylindrical to massive sponges have moderately simple canals, approximately 0.3 to 0.4 mm in diameter, that extend upward as parallel openings, much like the principal common canals in *R. patula.* In the latter species, however, they range somewhat coarser and may have a network of finer skeletal pores intervening between the major canals in structures not developed in *R. maokoui.*

Radiotrabeculopora reticulata Fan, Rigby, and Zhang, 1991 has a skeletal structure with prominent concentric tracts in early parts of the skeleton, a structure not developed in the mushroomlike sponge species described here. In addition, all three of the Chinese species lack the moderately large, walled, subvertical coarse exhalant canals that pierce the skeletal structure and are connected to the other canals only by pores through the walls in *R. patula.*

Sections of the fibrous skeleton are reminiscent of skeletons in species of *Radiofibra,* but that genus has a deep central spongocoel similar to that of *Peronidella,* but in a structure distinctly different from that of *Radiotrabeculopora patula.*

This species is superficially similar to *Precorynella ampliata* new species (Pl. 6.5–6.6), but differs from it by having several centers to which the irregularly curved and radially arranged, surficial, exhalant grooves converge from the periphery of the sponge. Also, *Radiotrabeculopora patula* has the coarse ostia of exhalant canals in troughs of the grooves not arranged side by side. It also has only weak clusters of those canals on the summit, and these clusters do not continue down into the body of the sponge, but rather only isolated coarse canals are traceable into the interior. *R. patula* also has a more pronounced upwardly divergent skeletal and smaller canal pattern and lacks the axial clusters of exhalant canals characteristic of *Precorynella.*

Material.—Two specimens.

Type specimens.—Holotype, USNM 480304, Pl. 6.1–6.2; Pl. 48.6, from Spot Locality 13B; paratype, USNM 480374, Section E, bed 27.

Occurrence.—Two specimens, one from Spot Locality 13B and one from Section E, bed 27, shale below CF-18a.

Etymology.—Patulus, Latin, broad, spread out; in reference to the abruptly expanded growth form of the species.

Subfamily DAHARELLINAE new subfamily

Diagnosis.—Auriculospongiids without exhalant canals but with inhalant canals. Spaces between fibers served as exhalant openings.

Type genus.—Daharella new genus.

Genus DAHARELLA new genus

Diagnosis.—Single or branched, cylindrical sponge without continuous central spongocoel or axial bundle of exhalant canals; outer surface with numerous circular or starlike ostia (inhalant pores) situated in elevated and tubelike elements. Sievelike plate may be developed in base of each ostium, which may continue as several small, inhalant tubes into interior; skeleton reticulate fibrous.

Discussion.—At first glance from the exterior, *Daharella* looks like the new genus *Djemelia* and *Preeudea* Termier and Termier, 1977a. *Djemelia,* however, has a continuous, central spongocoel, which is lacking in *Daharella. Preeudea* differs from *Daharella* by having several axial exhalant tubes. In addition, bases of ostia in *Daharella* have a sievelike plate, a structure lacking in *Djemelia* and *Preeudea.* Differences of the three genera are shown diagrammatically in Figure 16.

Type species.—Daharella ramosa new species.

Included species.—Daharella ramosa new species, *D. micella* new species, and *D. palmata* new species.

Etymology.—Dahar, named for the Dahar Escarpment beneath which exposures of the cuesta-forming Permian rocks of the Djebel Tebaga terminate.

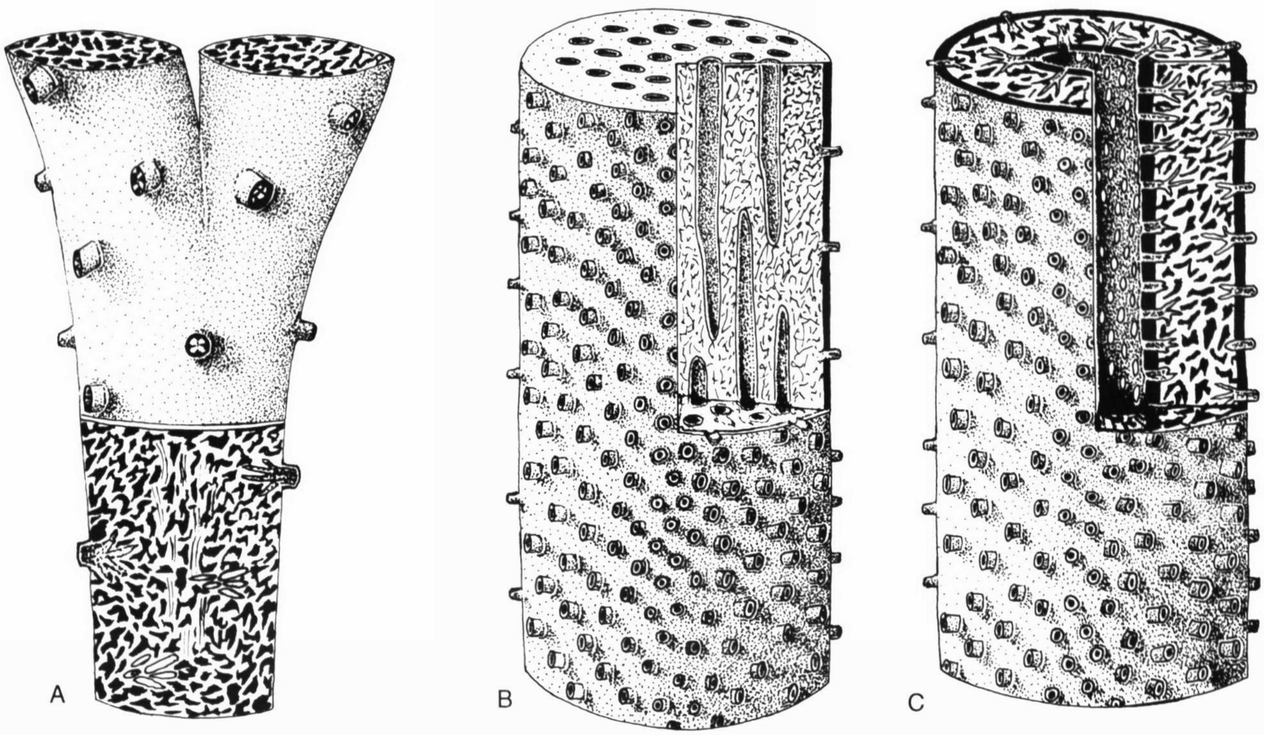

Figure 16. Structure differences between three similar-appearing genera of inozoid sponges; *A, Daharella* new genus lacks an axial spongocoel or bundle of exhalant canals. Water passes through large ostia into the interior of the sponge and leaves the sponge body through interfiber spaces. Small tubes may develop parallel to the axis of the sponge in the axial area, but they do not pass through the whole sponge; *B, Preeudea* has numerous vertical tubes that are parallel to the axis of the sponge. The canals are not limited to the axial area but are distributed throughout the sponge; *C, Djemelia* has only an axial spongocoel. The spongocoel wall has large openings of branched tubes that extend from ostia on the exterior into the thick wall of sponge (schematic, not to scale).

DAHARELLA RAMOSA new species

Plate 4.9–4.11; Plate 45.3; Plate 72.1–72.2; Plate 73.1, 73.3–73.6; Plate 77.7; Figure 16A

Diagnosis.—Cylindrical and branched stems with numerous, circular or starlike ostia on exterior; base of each ostium with sievelike plate pierced by several small pores that continue as canals into interior; ostia usually situated on elevated or tubelike elements; internal skeleton of reticulate fibers.

Description.—Cylindrical, slender sponges with diameters to 13 mm, may branch several times, near branching points may be 25 mm in diameter. Largest and most branched specimen is 80 mm high.

Exterior bears numerous circular to starlike ostia elevated or developed as small tubes; sievelike plate developed at base of each ostium with 4 to 6 pores that continue as small canals into interior of sponge (see Fig. 16a). Ostia up to 1.5 mm in diameter and defined by tube wall up to 0.5 mm thick. Relatively coarse porous skeleton, like that of internal skeleton, clearly recognizable between ostia.

Holotype (Pl. 4.11) branched but broken specimen 52 mm tall and 10 mm in diameter, expands to 20 mm across in branched part. Circular ostia, approximately 1.5 mm in diameter, with distinct elevated rims. Ostia in crudely linear arrangement in holotype, as in some other specimens. Polished surface of one side of holotype as well as some other specimens (USNM 463598 and 463600) (Pl. 73.3–73.5) shows very fine, irregular, upward and outward, jet-of-water arrangement of small, subcylindrical, tubelike canals in the axial part of the sponge, but such axial structure not uniformly well developed, for other specimens show only limited development of this structure (Pl. 73.1, 73.3–73.4, 73.6). On one polished specimen small bundles of canals can be traced a short distance from ostia into interior of sponge.

Where best developed on USNM 463600 (Pl. 73.5), small axial tubules 0.3 to 0.4 mm across diverge upward and outward through skeletal net as general pattern, not as long continuous tubes, but apparently only as localized interruptions in skeletal net, where characteristically traceable for only 1 to 2 mm before losing identity in somewhat irregular structure of skeleton. Prominent, moderately coarse, axial region may occupy about one-third diameter of sponge stem, but, outside of that, skeletal net becomes somewhat finer textured and coarse canals disappear or branch into fine, smaller, shorter, elongate segments between somewhat finer fibers of skeleton.

In interior, fibrous segments may be up to 0.1 mm in diameter in areas where not joined, but where joined may be up to 0.2 to 0.3 mm in diameter, as interruptions between upwardly divergent, coarse openings. Skeletal net of finer fibers generally 0.06 to 0.08 mm in diameter makes

Table 5. Characteristics of species of *Daharella* from Djebel Tebaga.

Species	Shape	Branching pattern	Ostia	Exaules
Daharella ramosa	Cylindrical	Dichotomous	Circular or starlike	Well developed
Daharella micella	Cylindrical small	Unbranched	Circular	Poorly developed
Daharella palmata	Cylindrical, palmate, sheet- or handlike	Fingerlike	Starlike	Not present

up much of outer half of skeleton. Fibers generally separate porous openings, 0.10 to 0.14 mm in diameter, in somewhat tubelike reticulate canals, up to 2.2 mm across, which apparently connect to ostia on surface. Outer half of skeleton considerably more reticulate than tubular in virtually all specimens.

A few upwardly arched, small, irregular openings form almost irregular horizontal series of canals, but openings discontinuous and appear to be only aligned pores interrupting more continuous, subvertical, longitudinal tracts that dominate skeleton. These upwardly arched areas may represent minor pulses in growth of sponge and may be only locally developed.

Small, sievelike plates at inner end of each exaules-type opening composed basically of regular skeletal net rather than distinctive separate structure.

Thin sections show dense, calcareous fibers generally replaced by microcrystalline spar so that in most areas microstructure completely obliterated; but some areas with irregular ghosts of probable spherulites, approximately 100 μm in diameter, where recrystallization has not been total.

Skeleton of sponge composed of very fine reticulate fibers and pierced by canals from ostia (Pl. 73.1, 73.3–73.6), but because fibers recrystallized, microstructure not preserved in specimen examined with REM.

Discussion.—Daharella ramosa, the type species, is characterized on the exterior by numerous, starlike ostia elevated on exaulos-appearing tubes reminiscent of similar structures in *Preeudea minima* Termier and Termier, 1977a, and *Daharella ramosa,* but *Daharella* lacks the numerous, vertical, coarse, exhalant tubes that characterize species of *Preeudea.*

Daharella ramosa is considerably coarser and a larger sponge than the tiny, cylindrical *Daharalla micella* new species, which also has only poorly developed, exaulos-like ostia on the exterior. *Daharella micella* is a cylindrical sponge only 2 to 5 mm across and contrasts with the larger *Daharella ramosa,* where unbranched cylindrical stems are up to 10 mm in diameter. *Daharella ramosa* contrasts with *Daharella palmata* new species in growth form, for the latter commonly developed sheet- or handlike skeletons on which exaules are lacking. Comparisons of the three known species of *Daharella* are given in Table 5.

Material.—34 specimens.

Type specimens.—Holotype, USNM 463593, Pl. 4.11, Section E, bed 27; paratypes, USNM 463591–463592, 463594–463598, 463600, and 480411.

Occurrence.—Daharella ramosa occurs at Djebel Tebaga, with one paratype from Spot Locality 160-1976 and four from Section J, bed 14; three from Section G, bed 16; three from Section E, bed 27, below shale below CF 18a; and one specimen from Section I, bed 26. An additional twenty reference specimens were collected from Section J, bed 14. The species is presently known only from Djebel Tebaga, Tunisia.

Etymology.—Ramosus, Latin, branched or branching; named for the branching stemmed habit of the sponge.

DAHARELLA MICELLA new species

Plate 4.12–4.14; Plate 45.4–45.5; Figure 17

Diagnosis.—Tiny, cylindrical, unbranched sponges with beaklike simple ostia. Bases of ostia without sievelike plates. Internal skeleton relatively coarse reticular fiber structure.

Description.—Tiny sponges 2 to 5 mm in diameter, holotype (Pl. 4.13) largest specimen, 15 mm tall, although total height unknown, because all specimens broken. Exterior with only a few ostia situated on elevated areas; diameters

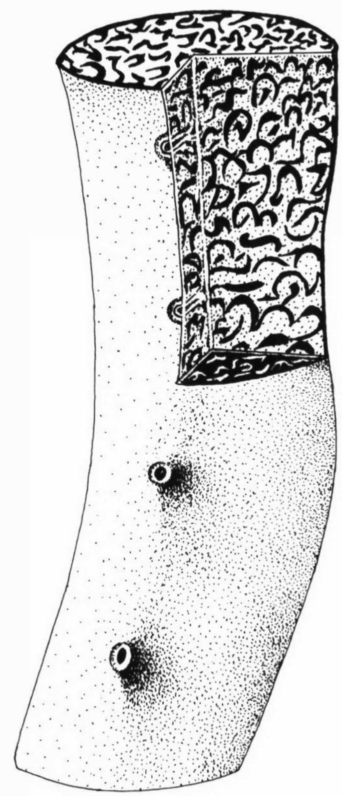

Figure 17. Reconstruction of *Daharella micella* new species showing the character of its exterior and its generalized internal canals and skeleton(schematic, not to scale).

of ostia range from 0.3 to 1.2 mm. Ostia linearly arranged on both sides of holotype, but other specimens do not show strong linear pattern. Exterior lacks other structures.

Interior of sponge filled with relatively coarse, reticulate fibrous skeleton. In longitudinal section, fibrous structure appears semicircular to crescentic with convex side oriented upward (see Fig. 17). Branched specimens not observed.

Poor preservation of specimen investigated by SEM did not allow determination of microstructure.

Discussion.—*Daharella micella* differs from *Daharella ramosa* in being a very small sponge, having only a few ostia, and lacking the sievelike plate at the base of each ostium. *D. micella* differs from *Daharella palmata* most distinctly in having a cylindrical rather than palmate growth form.

Material.—Three specimens.

Type specimens.—Holotype, USNM 463602, Pl. 4.13; Pl. 45.5, Spot Locality 203-1976; paratype, USNM 463601 from Spot Locality 27A.

Occurrence.—The rare species occurs as single specimens each at Djebel Tebaga Spot Locality 203-1976, Spot Locality 27A, and Section I, bed 17.

Etymology.—*Micella,* Latin, of small crumb, morsel or grain; in reference to the small size of the species in comparison to the type species *Daharella ramosa.*

DAHARELLA PALMATA new species

Plate 7.1–7.10; Plate 45.6; Plate 73.2

Diagnosis.—Sponges cylindrical, sheet- or handlike with fingerlike branches. Several small ostia grouped together to form starlike impressions; groups of ostia located on small elevations. Interior of sponge relatively coarse with irregularly arranged, fibrous structure.

Description.—Cylindrical to sheet- or handlike sponges to 40 mm high. Sponges cylindrical in initial stages but become more and more sheetlike and branching on upper part, like fingers on a hand (Pl. 7.3–7.5). Widths of sponge dependent on size of sheets but usually much wider in upper part than in lower.

Holotype (Pl. 7.3–7.4) handlike, with cylindrical base 4 mm in diameter, but becomes sheetlike and up to 20 mm wide and 3 mm thick in upper part. Palm branches fingerlike (Pl. 7.4) into 6 small stems, each approximately 5 mm in diameter (Pl. 7.3).

Exterior of cylindrical part of sponge and both sides of sheets bear several circular or starlike groups of 3 to 7 ostia. Diameters of individual ostia range from 0.30 to 0.55 mm, while that of groups range to 1.5 mm. Clusters of ostia usually located on small elevations. In addition to ostia groups, isolated oval openings occur in one specimen (Pl. 7.5). Whether these oval pores are primary or the result of borings or later diagenesis is uncertain. Spaces between groups of ostia on outer surface with additional numerous, irregularly shaped pores 0.10 to 0.25 mm in diameter, in general corresponding in size to interfiber spaces (Pl. 7.2, 7.5–7.6, 7.8–7.9).

Interior skeleton composed of irregularly or sometimes radially and upwardly divergent fibers 0.15 to 0.30 mm thick (Pl. 73.2). Fibers same thickness in interior and near exterior. Where fibers arranged radially and longitudinally, spaces between may appear as small canals, as for example on summit of holotype (Pl. 7.3). In USNM 463599, these canals usually 0.2 to 0.3, but locally to 0.5 mm in diameter. Spongocoel or other canal systems lacking. Where section cut in outer part of skeleton, fibers form more circular openings (Pl. 73.2, upper part).

Poor preservation of specimen investigated in SEM did not allow determination of microstructure of species.

Discussion.—*Daharella palmata* new species differs from the type species *Daharella ramosa* by having a bladed to palmate growth form, versus branching in the cylindrical *D. ramosa.* The pattern of branching is dichotomous in *D. ramosa* and fingerlike in *D. palmata.* Isolated ostia show strong development of exaules in *D. ramosa* but not in *D. palmata.*

D. palmata differs from *D. micella* in size, shape, branching pattern, and by having ostia grouped together. Differences and characteristics of the three species of *Daharella* from Tunisia are shown in Table 5.

Material.—35 specimens.

Type specimens.—Holotype, USNM 463604, Pl. 7.3–7.4; paratypes USNM 463599, 463603, 463605–643610.

Occurrence.—The species is moderately common at Spot locality 157-1976, the only locality where it has been found.

Etymology.—*Palmatus,* Latin, marked or shaped like the palm of the hand; in reference to the handlike growth form of some specimens of the species.

Subfamily SPINOSPONGIINAE new subfamily

Diagnosis.—Exhalant and inhalant canals not present; skeleton with prominent thornlike spines.

Type genus.—*Spinospongia* new genus.

Genus SPINOSPONGIA new genus

Diagnosis.—Cylindrical to club-shaped sponge without central canal or other coarse exhalant or inhalant canals; outer surface of sponge covered by spinelike elements that continue into interior and help form fibrous skeletal structure. Coarse openings developed between the spines. Interior filled with reticulate fibrous skeletal elements composed of spherulites.

Discussion.—*Spinospongia* is distinguished from other similar genera in the collections from Djebel Tebaga by development of prominent spinelike elements in the skeleton and by the lack of a spongocoel or major exhalant canals in the interior. *Spinospongia* is generally a steeply obconical to club-shaped sponge. It lacks the exaules and associated minor inhalant canals typical of *Daharella* and is not a bladelike or palmate form such as *Auriculospongia.*

Occurrence.—The genus is known only from the Djebel Tebaga area of Tunisia.

Type species.—*Spinospongia radiata* new species.

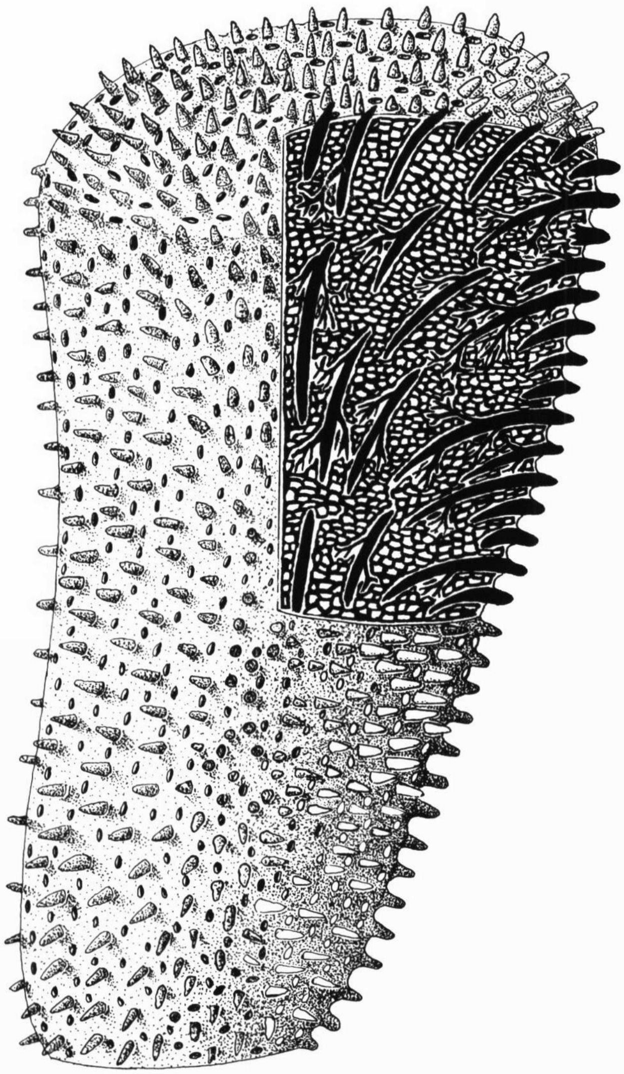

Figure 18. Outer morphology and longitudinal section through *Spinospongia radiata* new species. The section shows the arrangement of spinelike elements in axial and peripheral areas (schematic, not to scale).

Etymology.—*Spina,* Latin, thorn; *spongia,* sponge; named for spinelike skeletal elements exposed on the exterior of the sponges.

SPINOSPONGIA RADIATA new species

Plate 4.1–4.5; Plate 45.7; Plate 57.1–57.4; Plate 71.5–71.6, Figure 18–19

Diagnosis.—Diagnosis as for the genus.

Description.—Cylindrical to clublike holotype (Pl. 4.2–4.3) 49 mm high and 25 mm maximum diameter (because it was cut, it appears a little shorter and smaller) near top of sponge; other specimens to 90 mm tall and 30 mm maximum diameter, in upper part, above basal diameter of 19 mm, others as small as 35 mm tall and only 20 mm in diameter. One specimen (Pl. 4.1) overgrown by algae, but coarse external spines show as numerous sharp nodules and make surface rough (Fig. 18). Spines continue as rods into interior and in longitudinal section traceable, more or less, to axis of sponge (Pl. 71.5–71.6). Spines branch downward and inward several times, are inverted treelike, and lose their identity where merged into finer fibers that occupy interior of sponge (Fig. 18). Spines with concentric laminate structure in cross section, and cone-in-cone-like or water-jet-like structure in longitudinal section (Fig. 19). Spines 0.5 to 1.0 mm in diameter and more than 7 mm long. Spines have radial arrangement in transverse cross section of sponge, are convergent from periphery and disappear toward sponge axis (Fig. 18). Spines composed of spherulites 20 to 50 μm in diameter arranged side by side (Pl. 57.1–57.4).

Openings between spines have diameters of approximately 0.5 mm, as ostia to canals in interior of sponge.

Skeleton between spines composed of coarse, reticulate fibrous structures (Fig. 18–19; Pl. 71.5–71.6). Additional rodlike elements occur in center part of sponge but do not show any connection to coarse spines on outside, although their structure and size correspond to those of spines near the periphery. Figure 18 shows the skeletal construction of *Spinospongia radiata* new genus, new species, as well as the position and arrangement of spines and the structure of internal fibers.

Discussion.—Comparisons with similar genera in the Permian complex have been presented in discussion of the genus. The species is moderately rare, but is known principally in the middle part of the Permian sequence in the Merbah el Oussif area in the western Djebel Tebaga Permian outcrop belt.

Material.—Seven specimens.

Type specimens.—Holotype, USNM 463611, Pl. 4.2–4.3, Spot Locality S3; paratypes, USNM 463612–463615.

Occurrence.—This is a rare species at Djebel Tebaga; it is known from single specimens at each of Section C, bed 16; Section E, bed 27; Spot Locality S3, Spot Locality DJT 5 and Spot Locality 160-1976; and as two specimens from Section J, bed 17.

Etymology.—*Radius,* Latin, ray, rod, spoke; named for the prominent radial spines, as seen in transverse cross sections.

Subfamily ACOELIINAE Wu, 1991

Emended diagnosis.—Cylindrical to club-shaped inozoid sponges lacking spongocoel or major inhalant and exhalant canals in fibrous skeletal net.

Type genus.—*Acoelia* Wu, 1991.

Genus THALLOSPONGIA new genus

Diagnosis.—Branching, solid, twiglike sponges lacking major interior canal system in uniform, gently upwardly expanding skeletal net. Surface marked by subvertical, surficial canals converging to branch tip. Sponge lacks spongocoel or other significant canals.

Discussion.—Among the sponges from Djebel Tebaga, only the sponge included here essentially lacks an interior canal system and spongocoel. It lacks the spongocoel characteristic of the relatively finely textured *Peronidella* and lacks the prominent canals of *Preeudea* or even the discontinuous canals characteristic of *Imperatoria.* In addition, the branching, twiglike form and the surface sculpture of long, surficial tangential canals near the tip differentiate the genus from related forms.

Type species.—Thallospongia reticulata new species.

Etymology.—Thallus, Latin, branch; *spongia,* sponge; referring to the branched, solid, twiglike form of the genus.

THALLOSPONGIA RETICULATA new species

Plate 30.5–30.6; Plate 44.5–44.6

Diagnosis.—Relatively small branching sponges; branches 6 to 7 mm in diameter with smooth exterior, except for shallow, indented, vertical, surficial canals that converge toward summit of more or less complete, bullet-shaped tip. Skeleton with fine reticulation, gently upwardly and outwardly divergent from the axial region; surface lacks ostia. Ridges between surficial canal with only small skeletal pores.

Description.—Single branching holotype represents much of one complete branch and only base of another; stems 6 to 7 mm in diameter. Sponge fragment approximately 28 mm tall from broken base. Exterior generally smooth, except inscribed by 14 to 15 weakly indented, vertical, surficial grooves or canals, each 0.3 to 0.4 mm wide at maximum on upper, bullet-shaped tip, but decrease in width in zone of convergence on top and in lower part of sponge where traces become obscure. Canals indented maximum of 0.2 to 0.3 mm as relatively broad troughs, spaced essentially 1 mm apart and equally distributed around circumference of complete tip.

Ridges between canals marked by only fine skeletal pores 0.04 to 0.06 mm in diameter as circular to subpolygonal rounded openings in moderately dense dermal layer. Pores separated by network of short, rounded, reticular fibers 0.04 to 0.06 mm in diameter with pores essentially side by side. Skeleton upwardly and outwardly divergent net of uniform mesh, with skeletal pores generally 0.4 to 0.6 mm in diameter. Pores locally grouped in subradial, upwardly and outwardly diverging series which produce small, canal-like openings traceable for short distance in from dermal area, but such openings generally lost in skeletal net, where pores in interior have essentially same diameter, but are not in line. Skeletal fibers expand to as much as 0.08 mm in diameter at junctions in finely textured skeleton.

Discussion.—The genus *Acoelia* was proposed by Wu (1991, p. 57–58) for inozoans without a central cavity and inozoans that lack a canal system, but that genus is reported to include obconical sponges, in contrast to the distinctly ramose, subcylindrical, aspiculate sponges included in the new genus and species *Thallospongia reticulata. Acoelia ruida* Wu, 1991, the type and only species of that genus, apparently is a moderately large sponge with a diameter of up to 12 mm and a height of over 25 mm. Wu's specimens came from reefs of the Maokou Formation from Xiangbo, Longlin County, Guangxi, China. The single thin section of that form figured by him may be only a diagonal or tangential section and is inadequate for comparison with the more or less completely preserved sponge described here, although the reticulate net and thickness of the fibers are only slightly smaller than in the Tunisian species. Because of geographic and stratigraphic separation, as well as differences in growth form, however, we have elected not to include the Tunisian species in the Chinese genus.

Material.—One specimen.

Type specimen.—Holotype, USNM 480358, Pl. 30.5–30.6; Pl. 44.5–44.6, from Spot Locality 4A, Djebel Tebaga.

Occurrence.—The rare species is known only as a single specimen from Spot Locality 4A.

Etymology.—Reticulata, Latin, netlike; in reference to the very fine, uniform, netlike skeleton and dermal layer of the species.

Figure 19. Longitudinal section through four, spinelike elements in *Spinospongia radiata* new species and the skeletal fibers between the sponges. The spines branch several times and are treelike. These branches help produce the relatively loose skeletal fibers of the interior. The spines have a fine, lamellar or cone-in-cone-like structure and a microstructure composed of spherulites that are arranged side by side (see also Plate 57.1–57.4).

Table 6. Characteristics and measurements of species of *Stellispongiella* from Tunisia and *S. termieri* Wu, 1991, from China; measurements in mm; *w*, width; *h*, height; *S*, surface; *O*, exterior or outer region; *A*, axial region; *I*, intermediate region.

Species	Stem diameter	Spacing of astrorhizal areas or oscula	Surface sculpture	Oscula	Astrorhizal canals	Oscular canal diameter
S. termieri	5	6	Nodes	Indented in nodes	Discrete	0.5
S. bacilla	4–15	5–10	Nodes 6–8 w, 3–6 h	Indented in nodes	Discrete, no connection, but interdigitate tips	0.5 rare, 0.7–0.8 taper
S. insculpta	6–15 to palmate	6–10	Deep slits and depressions	Indented	Discrete; 2–3 mm long; simple	0.4–0.5 abrupt end
S. reticulata	6–12	6–10	Smooth	Indented	Branch and merge in network	0.6–0.8 2nd order, 0.4–0.5
S. parva	8–25 cylindrical branches	5–7	Smooth numerous small isolated oscula	Small, 4–6 w stacked, indented series	Discrete, branch 3–4 mm long	0.2–0.3
S. amplia	10–14	6–10	Smooth to low mounds	Shallow, indented, coarse	May or may not merge; nodes interconnected	0.8–1.0
S. porosa	15–18 circular 10 × 18 where oval	7–10	Low nodes 5–8 w, 1–2 h	Indented on nodes	May merge	0.6–1.0
S. tumida	15–16	10–15	Elevated canal traces and oscula	On ridges 0.25–0.30 h	Discrete	0.30–0.35 closely packed

Family STELLISPONGIELLIDAE Wu, 1991

Emended diagnosis.—Massive to hemispherical or obconical and stemlike sponges with one to several oscula or astrorhizal clusters of exhalant canals on upper surface; canal clusters may extend into skeleton but lack deep spongocoel; dense dermal layer may be developed on base; fibrous skeleton aspiculate, commonly reticulate, with fibers of spherulitic microstructure.

Discussion.—The sponges included in the family Stellispongiellidae Wu, 1991, were initially grouped in early stages of our work into the family Stellispongiidae de Laubenfels, 1955. Once it became apparent, through the work of Reitner (1992) and others, that Triassic and probably younger species of *Stellispongia* possess a spicular skeleton, it was not logical to group these aspiculate sponges with them at a family level. Some of the sponges described below are very similar morphologically to ones included earlier in the Stellispongiidae, but that similarity is interpreted as convergent development rather than indicating a phylogenetic relationship. We thus continue to group here those forms with stellispongiid morphology but with a spherulitic fibrous skeletal structure that lacks spicules.

Type genus.—*Stellispongiella* Wu, 1991.

Subfamily STELLISPONGIELLINAE Wu, 1991

Emended diagnosis.—Stellispongiellids in which starlike oscula of convergent excurrent canals may be situated on mamelonlike elevations or impressed into generally smooth surface; sponges commonly ramose.

Type genus.—*Stellispongiella* Wu, 1991.

Table 6. Continued.

Radial canal diameter and spacing	Axial canal diameter and pattern	Fiber diameter	Skeletal pore diameter	Number of oscular canals	Zonation of stem	Comments
—	—	0.07	0.5 w 0.5 h	2+	?	This species named by Wu (1991) is a synonym of *S. bacilla* (Termier and Termier)
0.15–0.25 12–15 mm²	0.10–0.12 and 0.25	0.03–0.07	0.05–0.06	10–14	A 1.5–2.0 I 2.5–3.0 O 2.0–3.5	Prominent mamelonlike nodes marked by astrorhizal canal systems
0.20–0.25 10–15 mm²	0.2–0.3 10° diverg.	0.02–0.10 0.1 S	0.08–0.15	4–8	A 3.0 I 2.0–2.5 O 2.0–2.5	Indented small oscula, separated by skeleton "wedges" in I & O zones between radial canals'
0.10–0.25 2–3 mm²	0.2–0.3 30–40° then to abrupt 90°	0.05–0.06 0.2 S	0.10 w	6–8	A 3.0 I 7–8 O 2.0	Reticulate net oscular canals; coarse, tubular, walled axial canals, regular spherulites
0.10–0.14 20 mm²	—	0.02–0.04 .04–.05 O	0.04–0.06	4–5, branch local to 25	0.30	Numerous small separated oscula on smooth stem
0.3–0.4 2 mm²	0.20–0.25 30° diverg.	0.2 0.08–0.15 S	—	5–7 wide and coarse	A 4.0	Low mounds, coarse surficial canals
0.2–0.5 5–6 mm 6 mm²	0.08–0.14 pinnate	0.15–0.20 0.04–0.06 S	0.06–0.08	7–14	A 4–6	Fine pinnate axial zone, long straight canals perpendicular to surfaces in outer zone, low nodes, porous skeleton outer zone
0.3–0.5 8–10 per 5 mm	Interior not preserved	0.2 0.1–0.3 O	Fine reticulate	6–10	?	Raised, ridged oscular canals

Genus STELLISPONGIELLA Wu, 1991

Emended diagnosis.—Cylindrical, stemlike to branching, or palmate to irregular encrusting sponges with numerous oscula uniformly distributed over stems, to which exhalant canals converge in stellate patterns; spongocoel lacking; oscula may be on nodes, on smooth stem, or impressed into stems; stem surface with numerous inhalant pores to short canals that may be lost in skeletal net or may lead to upwardly divergent axial canals, which connect to radial exhalant canals and ostia that may occur in tangential oscular canals or on the exterior between oscula; microstructure spherulitic.

Discussion.—Wu (1991, p. 65) proposed the new genus *Stellispongiella* with the type species his new species *S. termieri* and apparently restricted the species and genus to only those sponges with mamelons. He separated the ramose and cylindrical sponges from the more hemispherical and mushroomlike sponges, a separation with which we agree. We conclude, however, that the development of oscular areas on mamelons is a species characteristic and, consequently, we have broadened the definition of the genus to include other twiglike sponges that have oscula variously distributed over the sides of the stems and intervening pores of large radial canals. Comparisons of species are summarized in Table 6.

Stellispongiella is a common sponge in marly rocks throughout the Djebel Tebaga area. Its generally cylindrical fragments, covered with astrorhizal-like oscula and convergent exhalant canals, are distinct.

Occurrence.—*Stellispongiella* seems to be largely limited to the Permian section of Djebel Tebaga, Tunisia, except for the limited occurrence of possibly related *Stellispongia radiata* and *S. minor* reported by Rigby, Fan, and Zhang

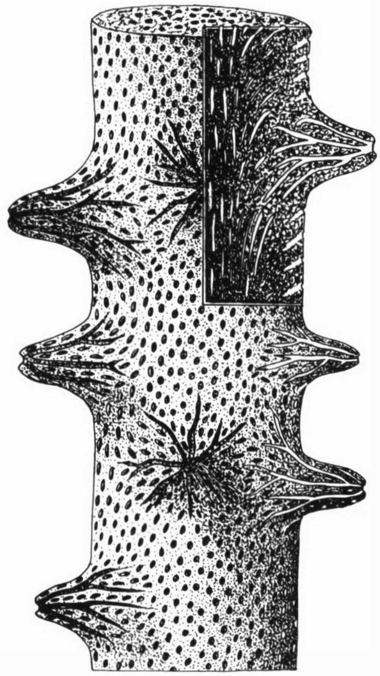

Figure 20. *Stellispongiella bacilla* (Termier and Termier, 1977a). The astrorhizal-like canal systems are located on mamelonlike elevations. As shown in longitudinal section, these canal systems extend as branched canals into the interior of the sponge. The axial area of the stem is characterized by several vertical and upwardly divergent tubes that may extend through the peripheral part as radial canals. The outside of the sponge exhibits numerous ostia of the exhalant canals (schematic, not to scale).

(1989, p. 728, 785) and *S. termieri* (now *S. bacilla* Termier and Termier, 1955), reported by Wu (1991, p. 65) from the Middle Permian Maokou Formation of Guangxi, China.

Type species.—*Stellispongia bacilla* Termier and Termier, 1955.

STELLISPONGIELLA BACILLA (Termier and Termier, 1955)

Plate 16.7–16.9; Plate 18.1–18.2; Plate 46.5; Plate 59.1–59.2; Figure 20

Synonymy.—*Stellispongia bacilla* Termier and Termier, 1955, p. 622–623, fig. 5a, e–f; Termier and Termier, 1973, pl. 1, fig. 4–5; pl. 2, fig. 1; Termier and Termier, 1977a, p. 34, pl. 7, fig. 2–3.

Stellispongia sp. Rigby, 1987, fig. 10.18M.

Stellispongiella termieri Wu, 1991, p. 65, pl. 9, fig. 6.

Emended diagnosis.—Cylindrical to ramose sponges, commonly with distinct nodes on which astrorhizal excurrent canal systems prominent; oscula or astrorhizae 5 to 10 mm apart, usually each with 10 to 14 indented convergent canals; radial canals 0.15 to 0.25 mm in diameter and 12 to 15 per mm^2; tangential astrorhizal canals distinct and only rarely merging with canals of adjacent astrorhizae; axial region lacks coarse excurrent canals in reticulate skeleton; tangential canals mostly 0.5 mm but may be as much as 0.8 mm wide; microstructure spherulitic.

Description.—Sponges generally cylindrical but may branch; stems with numerous oscula, commonly on prominent conical nodes several millimeters high and in diameter, includes fragments to 10 cm long, but most shorter. Basic stems 4 to 15 mm in diameter, with rounded mounds or conical nodes commonly 6 to 8 mm in diameter at base and may range to 3 to 4 mm high to rounded summits, but some up to 5 to 6 mm high in exceptional specimens. Nodes spaced 5 to 10 mm apart around circumference of cylindrical stems, but rarely nodes in irregular rows on opposite sides of the stem.

Peaks of nodes, where present, are centers of convergence of 10 to 14 tangential excurrent canals; outer or distal part of each may branch on basal slopes of mounds or in immediately surrounding areas but become straight subcylindrical in middle and upper parts of slopes. Some aberrant nodes with centers of convergence off peak and with irregular canal system.

Tangential excurrent canals approximately 0.5 mm wide but some to 0.7 to 0.8 also on some coarser specimens; canals essentially uniform width from near junction to base of node or outer edge of cluster, but narrow abruptly where branched and disappear into skeletal net. Canals generally impressed to approximately one-half width, but some almost slitlike, with depth being double the width with considerable variability. Lateral connections of canals from one osculum to adjacent ones very rare, although outer ends may alternate or interdigitate with those of adjacent oscula.

Ostia of radial canals pierce skeleton essentially at right angles to surface and occur on slopes within tangential excurrent canals, as well as in intercanal areas. Ostia generally 0.20 to 0.25 mm in diameter, smaller than canal widths so commonly one relatively central stacked radial series, although elsewhere two or three series may appear in zigzag arrangement along trough of tangential excurrent canals. In inner part of canals ostia more irregularly placed and not aligned, although canals essentially same size to slightly smaller, 0.15 to 0.25 mm across. Ostia generally circular and canals distinctly cylindrical where stacked; in intercanal areas, however, ostia may be more oval to rounded polygonal openings and spaced 12 to 15 per mm^2. Where aligned along troughs of tangential canals, ostia occur 2 to 3 per mm and commonly approximately 3 per mm in parallel series along margins of canals. No major cluster of axial excurrent canals in centers of zone of convergence as in some other species.

Three distinct zones of skeletal structure identified in vertical thin sections (Fig. 20); axial region with fine canals essentially vertical to gently upwardly divergent, intermediate region with canals sharply bent from subvertical to subhorizontal, and an outer region where dominant canals subradial and horizontal. In characteristic stem, approximately 14 mm in diameter, central axial region approximately 2.5 to 4.0 mm wide, intermediate zone approximately 2.5 to 3.0 mm wide, and the outer region or ring of somewhat more dense skeleton 3.0 to 3.5 mm wide.

In central axial region, vertical to gently divergent canals subpolygonal to subcircular and of at least two series;

larger ones more widely scattered and approximately 0.25 mm in diameter; smaller ones discontinuous, approximately 0.10 to 0.12 mm in diameter, and not common. Latter occur 5 or 6 per millimeter, measured normal to canal system.

Intermediate zone of divergence with gradational edges, skeletal structure with upward, jet-of-water pattern so single canal may diverge from axial region approximately 5 mm in distance of 8 to 9 mm with general curvature of 30 to 35° from axis to where skeletal structure and openings essentially horizontal and radial.

Skeletal structure in outer 3 mm crudely rectangular, with circular skeletal pores, 0.05 to 0.06 mm in diameter, bounded by fibers 0.03 to 0.06 mm in diameter and 0.06 to 0.08 mm long; 8 pores and fibers occur per millimeter, measured parallel to radial canals. Skeletal net essentially same texture at right angles to canals near margins of stem as well. Skeletal fibers with laminated pattern over nodes, with outward, radially expanding, skeletal fabric of fibers. Smaller radial canals that pierce main skeleton of nodes also roughly normal to node surfaces resulting in outwardly divergent pattern. Stacked canals of tangential excurrent system also with outward divergence as exposed on node surface. These appear as radially aligned openings in sections tangential to cylindrical stem of sponge and through nodes. Skeletal microstructure spherulitic with spherulites 40 to 70 µm in diameter and closely packed side by side (Pl. 59.1–59.2).

In transverse section of stem, Termier and Termier (1977a, pl. 7, fig. 5) showed six relatively large canals of vertical axial cluster embedded in smaller canals. Largest of these canals approximately 1 mm in diameter and others approximately 0.5 to 0.6 mm across. Latter somewhat oval in cross section, with long axes of most prominent ones essentially radial. These canals spaced 0.3 to 1.0 mm apart. Large canals somewhat larger than those in our specimens, where most larger canals are approximately 0.5 mm in diameter, although one axial opening is 0.7 mm across.

Discussion.—Termier and Termier (1977a) included at least two species within their *Stellispongia bacilla.* Those sponges with marked nodes, which they figured prominently (1977a, pl. 7, fig. 1–3), we retain as the type species, *Stellispongiella bacilla* (Termier and Termier, 1955). We describe the other species, represented by many specimens in our collection and included by them in *Stellispongia bacilla,* as *Stellispongiella insculpta* new species. In the latter species oscular areas are indented into an otherwise relatively smooth stem. It also has a skeletal structure somewhat different in proportions than that of typical *S. bacilla.*

Stellispongiella bacilla is generally finer textured than related forms and, most distinctively, it commonly has prominent nodes sculptured by indented convergent exhalant canals of the oscular system, canals that do not merge with canals of adjacent oscula. These nodes differentiate even small fragments from most other species of the genus, except *Stellispongiella porosa* new species, which also has nodal oscula but a considerably coarser canal structure. *Stellispongia reticulata* new species has a netlike system of interconnected surficial canals. Comparisons of species of *Stellispongiella* are shown in Table 6.

Material.—517 specimens.

Figured specimens.—USNM 480274–480276, Pl. 16.7–16.9; USNM 480277–480279, Pl. 18.1–18.2; USNM 480412, Pl. 46.5; USNM 480417, Pl. 59.1–59.2.

Occurrence.—The species is one of the most distinct, widespread, and common sponges in Djebel Tebaga. The 47 localities of its occurrence are shown in Table 1.

STELLISPONGIELLA INSCULPTA
new species

Plate 16.1–16.6, 16.10–16.11; Plate 21.14; Plate 46.6; Plate 80.5

Synonymy.—*Stellispongia bacilla* (pars) Termier and Termier, 1955, p. 622–623, fig. 5b–d; Termier and Termier, 1973, pl. 1, fig. 4–5; pl. 2, fig. 1; Termier and Termier, 1977a, p. 34, pl. 7, fig. 1 (*non* fig. 2–3).

Diagnosis.—Ramose to palmate sponges; smooth exterior lacking nodes but indented by deep slits of simple, commonly unbranched and separate, impressed, astrorhizal exhalant canal clusters 6 to 10 mm apart; clusters small with 4 to 8 distinct canals that do not merge with canals of adjacent astrorhizae; reticulate skeleton in axial region only gently divergent, but with abrupt divergence in outer region where radial canals 0.20 to 0.25 mm in diameter distributed 10 to 15 per mm^2, tangential canals to 0.4 to 0.5 mm wide; microstructure of irregular spherulites.

Description.—Cylindrical to branching or palmate-branched with cylindrical, fingerlike tips. Branches range 6 to 17 mm in diameter and vary from circular to elliptical. Palmate forms 6 to 8 mm thick with fingerlike cylinders that extend above. Most fossils preserved as fragments, but some with complete rounded tips. No complete base preserved in specimens at hand.

Exteriors of sponges smooth, except for indented or impressed inhalant canals in scattered oscular areas along both stems and blades. Oscula spaced 6 to 10 mm apart, center to center, with moderate uniformity although without geometric predictability. Oscular canals commonly expressed as deep slits of single, upwardly convergent canals, or as combined openings of several stacked convergent canals that produce deep grooves. Commonly with prominently parallel sides but may range to petaloid, with width varying to a maximum at approximate mid-distance. Surface expressions of canals usually short, 2 to 3 mm long, and straight to gently inosculating on surface, although some distinctly curved and many bifurcate either near convergent zone or in outer one-third of trace.

Generally 4 to 8 exhalant canals in convergent area, with some stems consistently containing ostia of 5 to 6 convergent canals. Others less regular, with regularity decreasing and canal lengths increasing as stem size increases. In small stems, canals 0.4 to 0.5 mm wide, nearly to where they end abruptly, where they may curve distally upward to surface or downward into interior.

Some oscular areas have skeletal boss in center of upwardly convergent canal cluster; others have openings of nearly vertical excurrent canals as separate elements. Canals from one oscular area do not merge with those of adjacent oscula and, in general, broad smooth area between oscula unmarked by horizontal canals.

Small vertical or radial canals with ostia between horizontal tangential ones, mostly 0.20 to 0.25 mm in diameter and commonly distributed 10 to 15 per mm^2 at surface. They may become more irregular 0.25 to 0.50 mm in from surface, and some may lose identity 1 or 2 mm in from dermal layer, but others traceable from axial zone of stem to exterior. These small canals bordered by skeletal fibers, approximately 0.02 to 0.10 mm across. Many such fibers with minute knobby surfaces, with knobs approximately 0.02 mm across, show particularly well on broader, more rounded surfaces of wider skeletal fibers.

Smaller skeletal pores only 0.08 to 0.10 mm across, scattered between coarser pores or canals with moderate regularity and occur about same number per square millimeter as larger openings. Small openings defined by somewhat narrower skeletal fibers in the surface layer where best preserved.

In vertical longitudinal section, three regions moderately well defined in skeletal structure; axial region with closely spaced canals essentially vertical to gently divergent, intermediate region where canals flex sharply and reticulate skeletal net fills between divergent openings, and outer region where canals dominantly radial and intervening areas filled with reticulate skeleton.

In axial, gently divergent area, canals appear tubular, porous, with moderately thin walls. Canals may originate either as inserted, gently expanding, conical openings, or some may arise by bifurcation of larger canals. Most canals 0.2 to 0.5 mm in diameter, but some rarely expand to 0.60 mm across. Larger canals with more vertically persistent elements, although no long continuous axial canals; some traceable for 4 to 5 mm in axial zone. All appearing to diverge and be replaced vertically in structure by other inserted or bifurcated canals. Canals diverging approximately 10° from vertical, across zone, and separated by thin porous spherulitic layers or walls approximately 0.10 mm thick. Walls commonly fairly straight and canals similarly relatively straight to edge of interior zone, where they flex moderately sharply outward.

Canals prominently curved upward and outward in intermediate zone and separated by wedges of reticulate skeletal fibers. Canals and more or less subparallel reticulate segments curve 60° to 70° where traced for 3 to 4 mm, and canals generally shift from virtually side by side to 0.2 to 0.3 mm apart in sections before they bend normal to surface into outer zone. Even in intermediate area, however, walls moderately distinct, porous, and somewhat beaded in their sections. Canals become subcylindrical in intermediate and outer parts, but expand upward from zones of insertion in inner part of skeletal structure. Differences in volume between divergent structures made up by insertion of reticulate skeleton. Walls of canals approximately 0.05 mm thick and perforated by common pores of essentially same diameter. Skeletal tracts or fibers parallel to canals somewhat more dominant in general appearance than those reticulate, cross-connecting segments. Most skeletal fibers in net between canals 0.06 to 0.10 mm in diameter and occur in segments 0.10 to 0.15 mm long. Where tracts of junctions occur, they are swollen to maximum diameter and generally define skeletal pores that appear subspherical to curved rectangular and 0.08 to 0.15 mm in diameter and occur in fairly regular, rounded, linear series.

Outer zone of skeleton characterized by canals generally arranged perpendicular to exterior surface and 2.0 to 2.5 mm thick; distinguished as zone of maximum penetration of radial, excurrent surficial canals of astrorhizal-like structures. Skeletal structure in outer part somewhat less beaded and more distinctly parallel to canals, producing somewhat more reticulate appearance, although radial elements still somewhat better defined than cross-bracing vertical elements. Skeletal elements here define skeletal openings essentially same size as in intermediate zone, although with somewhat more robust-appearing fiber segments, so entire structure of outer 0.2 to 0.4 mm of skeletal structure appears more tubular than in reticulate interior of skeleton. In this outer zone, 7 to 8 pores or fibers occur per millimeter, whether measured parallel to radial canals or at right angles and parallel to external surface.

Spherulites clearly defined within tracts in some better preserved specimens. Individual spherulites generally range 20 to 30 μm in diameter and spaced such that 2 to 4 occur per fiber width in intermediate part of segments where seen in cross section. They generally show as light dots in somewhat darker calcareous preservation.

Discussion.—Termier and Termier (1955, 1977a) included at least two distinct forms in their species *Stellispongia bacilla.* We retain that species name for the form with prominent nodes. The other common form, which lacks nodes or has only weak nodes and in which deeply and abruptly inscribed, convergent, excurrent canals are typical, we place in the new species *Stellispongiella insculpta.* The tangential surficial canals of *S. insculpta* do not merge to produce a net, as in *S. reticulata* new species, and the entire oscular system is considerably coarser than in *S. parva* new species. The inscribed canals immediately differentiate *S. insculpta* from *S. tumida* new species, where the coarse convergent canals occur on ridges. *S. porosa* new species is a similarly coarse sponge and lacks the finer, abruptly indented, oscular canals typical of *S. insculpta.*

Material.—99 specimens.

Type specimens.—Holotype, USNM 480271, Pl. 16.5; Pl.21.14; Pl. 80.5, Section I, bed 12; paratypes, USNM 463270, Pl. 46.6; 480266–480270, 480272–480273, Pl. 16.1–16.4, 16.6, 16.10–16.11.

Occurrence.—The species was collected from at least 32 localities in the Djebel Tebaga area (Table 1).

Etymology.—*Insculptus,* Latin, engraved; referring to the inscribed, often slitlike excurrent canals of the oscular system.

STELLISPONGIELLA RETICULATA
new species

Plate 17.1–17.3; Plate 21.15; Plate 46.7; Plate 79.4

Diagnosis.—Cylindrical to branching sponges with generally smooth exterior and indented net of 6 to 8 surface canals per astrorhizal exhalant cluster, clusters 6 to 10 mm apart, canals branch and merge with adjacent clusters; axial region with tubular, upwardly divergent canals, 0.2 to 0.3 mm in diameter, and lead to radial canals 0.15 to 0.25 mm in diameter; at surface tangential canals 0.5 to 0.6 mm wide; microstructure of regularly layered spherulites.

Description.—Cylindrical to branching cylindrical sponges with stems 6 to 12 mm in diameter and surface marked by several oscula, toward which converge relatively shallow, superficial, tangential canals that interconnect to produce irregular network on surface.

Oscular areas, or centers of convergence of canals, 6 to 10 mm apart around cylindrical to oval-sectioned stems, marked by 6 to 8 convergent tangential exhalant canals; first-order canals 0.6 to 0.8 mm wide and 0.4 to 0.5 mm deep, and second-order ones 0.4 to 0.5 mm wide and having shallow depressions. In general, tangential canals with relatively straight grooves for 3 or 4 mm but then merge with canals of adjacent oscula to form tangential net. Mounded intercanal areas range from small areas approximately 1 mm across to larger mounds 2 by 4 mm or larger that rise above canals.

Radial exhalant canals meet surface at high angles, the ostia of coarsest being 0.15 to 0.25 mm in diameter in bottom of grooves of branching tangential series with same width. Radial canals occur 2 to 3 per millimeter along canal grooves.

Somewhat smaller, equally numerous openings between larger ostia in grooves occur between relatively coarse skeletal fibers that stretch across bases of grooves. Most smaller ostia circular and approximately 0.10 mm in diameter.

Ostia of radial canals also occur on mounded areas between tangential canals and include two sets, one approximately 0.20 mm in diameter and other 0.10 mm in diameter; larger pores occur 4 or 5 per mm^2, and smaller ones 10 to 15 per mm^2. Both series grade down into numerous fine skeletal pores, 0.02 to 0.06 mm in diameter, that occupy almost one-half volume of outer 2 mm of skeleton.

Skeletal fibers on exterior most evident in canal grooves where they are approximately 0.05 to 0.06 mm in diameter at their thinnest; fibers thicken where merged with fibers at other angles. Coarse fiber segments approximately 0.25 to 0.35 mm long across floors of canals. Generally speaking, fibers in mounded areas approximately 0.02 mm in diameter to somewhat larger and generally producing finer fabric than in grooves. Fiber segments in principal skeleton 0.10 to 0.15 mm long, producing crudely rectangular skeletal fabric from upward and outward, jet-of-water nature of skeleton; upwardly and outwardly radial tracts cross connected by essentially concentric subtangential tracts to produce skeletal units approximately 0.1 mm^2. For example, approximately eight radial tracts occur per millimeter, measured around circumference on fractured end of holotype.

Two distinct skeletal zones evident in holotype; inner zone approximately 3 mm in diameter, consisting basically of small, axial tubules and irregular skeletal mesh, from which abruptly diverge radial skeletal tracts of outer zone, approximately 2 mm thick, of considerably more densely appearing and regularly reticulate skeleton around the stem.

In somewhat larger paratype, inner zone 7 to 8 mm in diameter of gently upwardly divergent axial tubules, but outer skeletal zone being still only approximately 2 mm thick. In longitudinal axial section of paratype, zones show well. In stem 10 to 12 mm in diameter, inner zone ranges 7 to 8 mm across, being composed of closely packed, subprismatic tubules 0.2 to 0.3 mm across, with most 0.25 mm across, defined by distinct walls of remarkably regularly placed spherulites. Walls of tubules range from 0.06 to 0.10 mm thick and generally moderately planar, although some curved; thicknesses increase upward. Walls perforated by openings 0.04 to 0.05 mm across that may occur in tubule corners or in midwall, and spaced 4 to 5 per millimeter, somewhat irregularly, measured vertically in single segments of walls.

Axial canals occur 3 to 4 per millimeter measured across axis. They diverge gently upward in interior, but swing 30° to 40° away from axis in outer part of inner zone, beyond which they curve abruptly into outer zone through additional 30° to 40° in approximately 2 mm, measured along length of canal, to nearly normal to surface at exterior. They may lose their identity in reticulate skeleton in outer part of net, where approximately 0.2 mm in diameter in ostia on surface.

Spherulites prominent in layers in distinct, three-dimensional, microreticulate fabric or grid work with layers of spherulites occurring approximately 3 per 0.1 mm, measured vertically, or 4 per 0.1 mm, measured horizontally in rectangular fabric. That rectangular microreticular fabric contrasts sharply with somewhat irregularly stacked spherulites of related species. Spherulites here approximately 20 μm in diameter with marked regularity.

Discussion.—*Stellispongiella reticulata* new species is characterized by its complexly interconnected and inscribed surficial excurrent canal system around the oscular areas. It also has larger and more distinctly walled tubules than other species in the genus. It has a regular microreticulate fibrous structure with very regular spherulites. *S. reticulata* lacks the nodes of *S. bacilla* and is considerably more coarsely canalled in the oscular cluster than *S. insculpta* and *S. parva* new species. Tangential oscular canals and clusters in *S. tumida* new species are more widely spaced and canals may merge, but those in *S. tumida* are on ridges rather than indented and do not form a network. *S. porosa* new species has coarser radial canals, a more distinctly porous outer part of the skeleton, and a finely pinnate, canalled axial region in addition to lacking the reticulate surficial canal system. *S. amplia* new species has interconnecting surficial canals, but they do not form a network and are coarser than those in *S. reticulata.*

Material.—29 specimens.

Type specimens.—Holotype, USNM 463648, Pl. 17.3; Pl. 46.7, from section G, bed 4; paratypes, USNM 463649, from the base of section H, north side of the hill; paratypes, USNM 463650–463651, from Spot Locality 13B, and a paratype, USNM 463652 from Section E, beds 26–27.

Occurrence.—The species occurs at 16 localities in the Djebel Tebaga area, as shown in Table 1.

Etymology.—*Reticulatus,* Latin, netted or netlike; in reference to the complex interconnected surficial canals on the surface of the cylindrical stems.

STELLISPONGIELLA PARVA
new species

Plate 17.4, 17.6; Plate 18.3–18.4, 18.7; Plate 46.8; Plate 60.3–60.4; Plate 79.3

Diagnosis.—Cylindrical to branching sponges with smooth exterior and numerous small, indented, and separated astrorhizal canal clusters; clusters 5 to 7 mm apart and 4 to 6 mm in diameter; canal tips separated from those of adjacent oscula; radial canals small, 0.10 to 0.14 mm in diameter, and up to 20 per mm^2; tangential canals to 0.2 to 0.3 mm wide and numerous, with up to 25 per cluster.

Description.—Cylindrical, branching sponges 8 to 25 mm in diameter, with numerous small oscular areas that may be locally encrusting. Oscular areas small, generally 4 to 6 mm in diameter across entire aureole of convergent tangential excurrent canals on surface of cylindrical sponges, with oscular centers spaced 5 to 7 mm apart. Approximately 10 canals converge toward center but bifurcate distally, sometimes trellislike; four to five main canals generally lying at center of oscular convergence where small, cross-shaped skeletal boss may occur between canals. Tangential canals approximately 0.2 to 0.3 mm wide and deep near center of convergence, but tapering distally; outer branches may be only 0.1 mm wide and deep before losing character as small depressions in skeletal net. Canal margins smooth walled, essentially one skeletal fiber thick. Canal tips do not merge with those of adjacent oscula, tips being commonly separated 2 to 3 mm.

Aligned and stacked excurrent canals open in bases of tangential grooves, with ostia side by side, separated by only one fiber; ostia generally 0.10 to 0.14 mm in diameter, with most 0.12 mm across. Canals cylindrical but may emerge into surficial tangential canals at angles to produce somewhat elliptical ostia, spaced approximately 5 per millimeter along groove. Fibers between pores 0.02 to 0.04 mm in diameter or wide. Ostia occupy essentially width of base of tangential convergent canals.

In longitudinal sections, these excurrent canals essentially parallel to exterior a few millimeters out from oscular centers but swinging sharply upward and outward, with those near center being J-shaped, with ends that rise vertically (radially) into centers of excurrent oscula. Canals with ostia 2 or 3 mm out from oscular centers emerging into radial canals at angles of approximately 30°, and showing gradual transition in toward center from 30° to vertical in smooth curve. Shift from emergence at 30° to vertical takes place in inner 1 mm of convergent canals. In transverse sections these canals stacked approximately 4 per mm, 2 to 3 mm out from center. They appear to be of uniform diameter and essentially subcylindrical for 3 to 4 mm then disappear in skeletal net 4 to 5 mm from oscular center.

Main outer skeleton pierced by probably inhalant canals, essentially perpendicular to outer surface; canals 0.10 to 0.15 mm in diameter, and numerous in interoscular areas where spaced 0.25 to 0.35 mm apart, center to center, or approximately 20 pores per mm^2 over entire surface. These canals traceable in cross sections for approximately 3 mm through thick, uniform, outer part of skeleton, but then curve downward into axial area and merge with relatively open skeletal net.

Skeletal fibers form regular net in outer 2.5 to 3 mm, where structure well defined; fibers generally uniform, 0.04 to 0.05 mm in diameter, around circular skeletal pores 0.04 to 0.06 mm in diameter. Most skeletal pores approximately 0.06 mm across and uniform as vertical and horizontal pores that interconnect openings in roughly rectangular fibrous skeleton in three-dimensional fashion. Most evident fibers essentially straight and radial or concentric and cross connected by essentially vertical fiber segments in outer 3 mm, but entire structure converges inward and downward into axial areas where skeleton not clearly preserved on available specimens. Skeletal microstructure spherulitic with closely packed spherulites approximately 30 µm in diameter.

Main outer skeleton locally blanketed by thin dermal layer, with irregular net 0.05 to 0.10 mm or 1 to 2 fibers thick; fibers irregularly vermiform and meandering with some angularity, yet relatively evenly textured; most 0.03 to 0.04 mm across but up to 0.08 mm in diameter at fiber junctions. This layer may partially mask inner, underlying regularly canalled areas of skeleton. Small skeletal pores 0.06 to 0.08 mm in diameter irregularly circular, rectangular, or polygonal in thin dermal layer.

Discussion.—*Stellispongiella parva* new species is distinguished by its numerous, isolated, small, surficial oscular areas. It lacks nodes on the smooth surface, unlike the prominent nodes of *S. bacilla* (Termier and Termier, 1955) and the less prominent ones on *S. porosa* new species. Other species also have much coarser oscular clusters and canals and lack the distinct separation of the small clusters that distinguishes *S. parva*. *S. insculpta* new species has small, isolated, indented oscular clusters; but those clusters usually have only a few stubby convergent canals in contrast to the many small, branched canals developed in *S. parva*.

Material.—Six specimens.

Type specimens.—Holotype, USNM 463653, Pl. 17.4, 17.6; Pl. 46.8; Pl. 60.3-60.4, from Spot Locality T8; paratypes, USNM 463656, from Spot Locality 9B; USNM 463655 from Spot Locality T5; paratype, USNM 463654 from Spot Locality 14A.

Occurrence.—Localities where the species occurs are shown in Table 1.

Etymology.—*Parvus,* Latin, little; in reference to the small, but numerous oscular areas on stems of the species.

STELLISPONGIELLA AMPLIA new species

Plate 17.7–17.8

Diagnosis.—Cylindrical to branching sponges with smooth to low-mounded exterior; with coarse, shallow, tangential canal clusters 6 to 10 mm apart; with 5 to 7 short canals, each 0.8 to 1.0 mm wide that may merge with those of adjacent clusters but not in net; radial canals 0.3 to 0.4 mm in diameter, and ostia 4 to 6 per mm^2; axial skeletal structure and canals diverge at 30° to 40° from axis; axial canals 0.2 to 0.3 mm in diameter.

Description.—Cylindrical, branched sponges with low, rounded mounds and numerous, coarse ostia with shallow, coarse, interconnecting canals. Centers of oscula 6 to 10 mm apart, each with 5 to 7 short, wide, tangential canals that converge to flattened centers. Such canals 0.5 to 0.8 mm wide may broaden away from centers of convergence, particularly evident on paratype with canals approximately 0.8 wide near center but slightly over 1.0 mm wide at outer ends that terminate abruptly. Canals may bifurcate in outer limits, be straight and single, or join those of other oscula 3 to 4 mm out from convergent centers. Canals shallow, broad depressions generally less than 0.5 mm deep, but most significantly shallower. Intercanal areas gently mounded.

Radial canals normal to surface and 0.3 to 0.4 mm in diameter, emptying into troughs of tangential series but only locally well defined on surface of somewhat altered holotype. Moderately large ostia occur 2 per millimeter, being most evident along troughs of tangential series and separated by single fibers 0.08 to 0.10 mm across.

In mounded intercanal areas, most prominent ostia 0.2 to 0.3 mm in diameter, occurring 4 to 6 per mm^2, although as many as 8 per mm^2 occur in some areas. These ostia of steep, radial canals that meet exterior essentially normally are characteristic of genus in general. Smaller skeletal pores 0.15 to 0.20 mm in diameter also occur in limited areas in very thin, locally developed, possible dermal layer of holotype. Pores occur 12 to 15 per mm^2 in small patches.

Interiors of both holotype and paratype not well preserved, but longitudinal section of paratype shows interior generally in two zones, as in other species of genus. Axial structure locally preserved, with skeletal elements principally vertical in axial zone approximately 4 mm in diameter. Moderately coarse fibers and canals, both 0.20 to 0.25 mm in diameter, although some segments of both only 0.10 mm across, perhaps cut tangentially. Some vertical tracts in interior 0.2 mm in diameter and canals at edge apppear to diverge upward and outward at 30° to 40° before being lost in coarsely recrystallized interior.

Outer 1 to 2 mm of skeleton with radial canals approximately normal to surface. Most such canals 0.2 to 0.3 mm in diameter as straight openings in outer 2 mm, but the inner extension lost in poorly preserved, intensely recrystallized sparry interior.

One small area of what appear to be ghosts of reticulate skeletal structure occurs in intermediate area between axial and outer zones. It suggests irregular reticulate skeleton without prominent canals, but that area very small and poorly preserved.

Details of interior skeletal structure must await discovery of additional, better preserved specimens for definition of finer skeletal and canal structure of interior.

Discussion.—*Stellispongiella amplia* new species is characterized by relatively coarse, excurrent canals and oscular areas. Tangential canals usually connect with those of adjacent oscula but do not form a network like that in *S. reticulata* new species. *S. tumida* also has coarse canals, but has tangential canals and oscular clusters on ridges rather than indented. Comparisons with other species have been treated in discussions of those species.

Material.—Two specimens.

Type specimens.—Holotype, USNM 463657, Pl. 17.8, and paratype, USNM 463658, Pl. 17.7, are from Spot Locality 13B.

Occurrence.—The species is known only from Spot Locality 13B.

Etymology.—*Amplius,* Latin, larger; in reference to the wide tangential excurrent canals of the oscular system.

STELLISPONGIELLA POROSA new species

Plate 17.5; Plate 18.6; Plate 46.9

Diagnosis.—Moderately large, ramose sponges with numerous low mounds with astrorhizal clusters 7 to 10 mm apart; approximately 10 indented canals on crests but up to 14 on slopes, canals commonly 0.6 mm wide but ranging to 1 mm wide, commonly not merging with adjacent canals; axial skeletal structure pinnate but tracts and canals bend abruptly to normal to surface in thick outer layer of skeleton. Outer layer porous.

Description.—Moderately large, cylindrical to branching stemlike sponges, with circular to oval cross sections; 15 to 18 mm in diameter where circular, and 10 by 18 mm where flattened to oval. Surface marked by numerous, low, conical, mounded oscula spaced 7 to 10 mm apart; low mounds 5 to 8 mm wide at base rise 1 to 2 mm above basic cylindrical stem.

Commonly 9 to 10 tangential canals converge onto crest of low domes, although 7 to 14 canals may occur on slopes. Most such canals approximately 0.6 to 0.8 mm across, although few rare ones to approximately 1.0 mm across. Canals generally taper distally from solid axial boss at crest of low mounds, but a few canals flare near base of cones, particularly where canals intersect or merge with tangential canals from adjacent oscula.

Ostia of radial canals in troughs of surficial tangential series to 0.40 to 0.45 mm in diameter; canals converge upward and inward toward solid boss of nonporous skeletal material at cores of convergent clusters. Bosses 1.0 to 1.5 mm in diameter contrast sharply to very porous other parts of skeleton. Some radial ostia elliptical, particularly evident where canals emerge at approximately 60° to surface. Canals commonly separated by only one skeletal fiber at surface so approximately two pores occur per millimeter along trough of tangential canals. Most tangential canals do not interconnect with those of adjacent oscula, but some do on all surfaces of flattened holotype.

Radial canals in areas between tangential canals generally straight, relatively cylindrical, and essentially normal to surface. Canals and ostia mostly 0.20 to 0.25 mm in diameter, although a few to 0.30 mm occur in distinctive outer layer, 2.5 to 5.5 mm thick. Canals numerous and spaced approximately 3 per millimeter, measured in almost any direction, or approximately 6 per mm^2 over entire surface outside tangential impressed canals. Radial canals flex sharply outward in dense, outer layer from porous axial area, where small canals diverge upward and outward.

Skeletal fibers in outer part of sponge variable, generally 0.10 to 0.20 mm wide between numerous ostia, but may thicken to 0.30 mm across in junction areas. Pores so numerous that skeletal fibers less than approximately 20 percent of volume, even in dense outer part.

Tracts between pores clearly made of smaller fibers, approximately 0.015 to 0.020 mm in diameter in some areas. Individual fibers approximately 0.1 mm long, merging at knots approximately 0.03 mm in diameter to produce reticulate microskeleton within somewhat thicker fibers that separate pores. Small reticulate fibers produce subrectangular skeleton around skeletal pores approximately 0.06 to 0.08 mm in diameter, so three fibers and two skeletal pores occur per 0.2 mm, measured across dominant reticulation of skeleton. These small skeletal pores essentially circular, being uniformly distributed and interconnecting with others at mutual right angles to produce rectangular, three-dimensional pores, although in very irregular and vague way. Net far from regular, right-angled reticulation seen in hexactinellids, and in some areas may appear hexagonal rather than rectangular around circular skeletal pores.

Longitudinal section of paratype shows skeleton subdivided into perhaps two main parts. Axial region characterized by canals that rise almost pinnately from sponge axis, in uniform, moderately wide zone. Outer zone 5 to 6 mm thick with outer canals essentially normal to exterior and extending parallel to skeletal structure to 5 to 6 mm in from sculptured surface. Canals in outer part well shown by matrix fills and most obvious ones 0.4 to 0.5 mm in diameter. Smaller skeletal structures obscure in middle and outer parts of skeleton.

Axial region approximately 2 mm across, with canals and skeletal tracts diverging approximately 30° from sponge axis near center, but bending more sharply outward in 4 to 5 mm thick zone in middle part of sponge. Coarse axial canals not clustered, but generally finely textured, 0.08 to 0.14 mm in diameter, with most approximately 0.10 mm across; separated by somewhat irregular skeletal fibers 0.06 to 0.12 mm across. These upwardly divergent skeletal fibers cross connected by short tracts 0.04 to 0.06 mm across to produce almost three-dimensional network. Upwardly divergent openings clearly dominant, and prominent horizontal divisions lacking.

Only locally are skeletal elements preserved in the intermediate area. These appear to swing an additional 30° to 40° to become virtually normal to outer surface for several millimeters in from exterior, but scattered evidence is not conclusive.

Details of microstructure are not preserved, but general dimensions of structures in interior are similar to those in moderately well-preserved exterior of holotype.

Discussion.—*Stellispongiella porosa* is characterized by a distinctly porous outer skeleton produced by numerous, relatively coarse, radial canals in the low nodes of the exterior. The species lacks a reticulate, surface-canal system as that in *S. reticulata* and the ridged canal and oscular system of the coarse *S. tumida.* Canals of the outer zone are distinctive in sections. Comparisons with the finely textured and nodose species are treated in discussions of those species. The fine, pinnate, axial skeletal structure and long, straight canals of the outer thick zone are distinctive.

Material.—29 specimens.

Type specimens.—Holotype, USNM 463659 from Spot Locality 216-1976, Pl. 17.5; paratypes, USNM 463660, from Section J, bed 26, and USNM 463661 from Section E, shale below Reef 3.

Occurrence.—Localities where the species occurs are shown in Table 1.

Etymology.—*Porosus,* Latin, full of holes; in reference to the numerous pores and the resulting porous nature of the skeleton.

STELLISPONGIELLA TUMIDA new species

Plate 18.5; Plate 47.1; Plate 60.1–60.2

Diagnosis.—Cylindrical to ramose sponges with 6 to 10 canals of astrorhizal clusters and cluster nodes weakly elevated above generally smooth surface, clusters 10 to 15 mm apart; radial canals 0.3 to 0.5 mm in diameter, closely packed.

Description.—Cylindrical to branched stems 15 to 16 mm in diameter and fingerlike, with fragments to 7 cm long with complete rounded tips but broken bases. Surface marked by generally elevated oscular areas, defined by 6 to 10 weakly elevated tangential convergent canal traces and separated 10 to 15 mm. Canal traces defined by raised ridges 0.25 to 0.30 mm high above stem surface; most traces highest near centers of convergence but lower radially. One oscular center slightly depressed. Tangential canal traces 0.30 to 0.35 mm wide and defined by fibers to 0.20 mm thick, somewhat thicker than in most fibers of skeleton. Generally 10 to 11 pores occur each 5 mm along tangential canal trace. Most pores in series circular but some elliptical, particularly in outer part of canal trace where smaller radial canals rise steeply and grade from approximately 60° in outer part to nearly vertical in inner part of oscular area.

Ostia of radial canals in interoscular areas mostly 0.4 mm in diameter and circular, but some to 0.5 mm in diameter and others rarely as small as 0.3 mm across. Ostia closely packed in crudely hexagonal arrangement being locally aligned but generally not; 8 to 10 pores occur per 5 mm in vertical or horizontal lines. Some openings weakly funnel-like and to 0.6 mm across, but circular pores in bases approximately 0.4 mm in diameter.

Fibers between canals in outer part of sponge mostly 0.1 to 0.2 mm wide, but some to 0.3 mm wide because of irregular canal spacing. Surfaces of fiber tracts between pores lumpy or minutely knoblike, with knobs 0.02 up to 0.06 to 0.08 mm across, with most approximately 0.6 mm in diameter. Fiber surfaces appear much like tracts in massive *Prestellispongia lobata* (Parona, 1933).

Somewhat oblique section through branching sponge shows internal structure not well preserved. Section shows reticulate skeletal structure of crudely upwardly and outwardly radiating fibers, 0.05 to 0.08 mm in diameter, that define open spaces 0.10 to 0.15 mm across, but with some irregularity. Outer parts of skeletal net composed of somewhat coarser segments up to 0.2 mm across in surficial zone, but markedly smaller than that in interior.

Microstructure spherulitic with closely packed spherulites 50 to 80 μm in diameter.

Discussion.—*Stellispongiella tumida* contrasts most obviously with other species of the genus in having traces of the convergent exhalant canal system elevated on the exterior. These systems are also coarser than in most other species of the genus. *S. tumida* lacks the prominent nodes of *S. bacilla* (Termier and Termier, 1955) and the complexly inscribed canal system of *S. reticulata* new species. *S. amplia* new species has coarse tangential canals of the scattered oscular clusters, but those canals are indented rather than raised; and it has clusters closer together than the widely spaced ones typical of *S. tumida* new species.

Material.—Two specimens.

Type specimens.—Holotype, USNM 463662, Pl. 18.5; Pl. 47.1, from west of Section I, but in a shale equivalent to Section I, bed 2, on the western end of Denguir, and one reference specimen, tentatively included in the species, from Spot Locality 10A.

Occurrence.—The species is known from only two localities, west of Section I and from Spot Locality 10A.

Etymology.—*Tumidus,* Latin, swollen; in reference to the elevated or swollen, astrorhizal-like excurrent canals and canal clusters.

Subfamily PRESTELLISPONGIINAE new subfamily

Diagnosis.—Massive to fungiform stellispongiellids in which one or several exhalant openings on summit extend as canal clusters into sponge; smaller inhalant canals commonly from upper surface and between canals of surficial, starlike, astrohizal clusters; skeletal structure regular reticulation to having longitudinally dominant fibers.

Type genus.—*Prestellispongia* new genus.

Etymology.—*Prae,* Latin, before *Stellispongia;* in reference to the occurrence of these sponges before *Stellispongia* of the Mesozoic.

Genus PRESTELLISPONGIA new genus

Diagnosis.—Irregularly hemispherical, mushroom-, or cauliflowerlike sponges with one to several starlike oscular clusters of excurrent canals on the summit and numerous vertical or longitudinal, smaller inhalant canals in intervening spaces; skeletal structure regular reticulation of small segments; microstructure spherulitic without spicular skeleton.

Discussion.—The genus *Stellispongia* was established by d'Orbigny (1849) based on the type species *Tragos stellatum.* That species was described by Goldfuss (1829) based on specimens from the Upper Cretaceous (Cenomanian) Essener Grünsand of northern Germany.

Reitner (1992) reported that the Goldfuss collection, including the type species of *Stellispongia,* is lost and is not available at the Institute of Paleontology, University of Bonn. A major question concerning the taxonomy of *Stellispongia* is whether the type species, *Stellispongia stellatum* (Goldfuss), possesses a spicular skeleton or not, and at this time we do not know. The Upper Triassic species *Stellispongia variabilis* (Münster, 1841) from the Cassian Formation of the Southern Alps, however, does possess a spicular skeleton of strongyles (Reitner, 1992). A second important question, then, concerns whether both the Triassic and Cretaceous species belong to the same genus or, as mentioned by Reitner (1992), whether they are different sponges grouped within the genus *Stellispongia.* This may be the reason de Laubenfels (1955) put sponges both with and without spicular skeletons into the family Stellispongiidae.

Sponges with spicular skeletons, described as *Stellispongia variabilis* (Münster) from the Upper Triassic (Carnian) Cassian Formation and morphologically similar sponges without spicular skeletons, such as those from the Permian section at Djebel Tebaga and from Sicily, cannot be grouped into the same genus or even into the same family. In our opinion there is no phylogenetic relationship between the aspiculate Permian and Triassic inozoids, on one hand, and the Jurassic-Cretaceous putative stellispongiid sponges on the other hand. Those Permian sponges described by Parona (1933) and Termier and Termier (1977a) with the same general appearance as *Stellispongia* but without spicular skeletons we propose to include in the new genus *Prestellispongia*.

Type species.—*Stellispongia lobata* Parona, 1933.

Etymology.—As for subfamily.

PRESTELLISPONGIA LOBATA (Parona, 1933)

Plate 8.1–8.3; Plate 9.1–9.5; Plate 10; Plate 11.6–11.7; Plate 13.4; Plate 21.5; Plate 43.4; Plate 58.1–58.2; Plate 79.5; Figure 21

Synonymy.—*Stellispongia lobata* Parona, 1933, p. 31, pl. 12, fig. 6–8; Termier and Termier, 1955, p. 621, fig. 4a–c; Termier and Termier, 1977a, p. 34, pl. 7, fig. 4, 6–7.

Emended diagnosis.—Irregularly obconical to lobate or mushroom-shaped sponge, summit with numerous star-shaped oscula 1 to 2 cm apart, upon which converge numerous, small, branched exhalant canals of astrorhizal systems; ostia of numerous radial canals (inhalant), with ostia 0.8 to 1.0 mm in diameter between astorhizal canals. Oscular areas with closely spaced exhalant canals. Skeleton a regular, almost laminate net of fine fibers.

Description.—Obconical to irregularly massive or subhemispherical in younger sponges, but cauliflowerlike or cake-platterlike, in older ones; forms to 5 to 6 cm high and 8 cm in diameter. Upper or excurrent surface usually moundlike, marked by multiple oscula or astrorhizal openings as small pits or low depressions spaced 1 to 2 cm apart, most approximately 1.5 cm apart; oscular pits 2 to 3 mm deep and 8 to 10 mm across, with rounded upper margins and somewhat irregularly rounded bases, into which empty vertical to steeply inclined and upwardly convergent exhalant canals in circular to elliptical clusters 2 to 4 mm across or long. Exhalant canals of central clusters approximately 0.8 mm in diameter, closely spaced and possibly becoming subprismatic; separated only 0.1 to 0.2 mm by fibers.

Upper surfaces marked by tangential, essentially horizontal, impressed canals that radiate 8 to 10 mm from oscular margin. Canals irregularly curved to straight and may be weakly branched distally; canals to approximately 0.8 mm wide near the osculum but generally narrow radially from oscular margin. Most impressed approximately one-half diameter into skeletal structure, although a few occurring as narrow slits to approximately 1 mm deep. Such canals generally related to exhalant system of single oscular pit not connected to radial canals of adjacent oscula.

Lower exterior of sponge marked by irregularly rugose growth lines 2 to 4 mm high, with rounded surfaces and indented impressions that suggest periodic pulses of growth. No marked cortex or dense dermal layer developed around

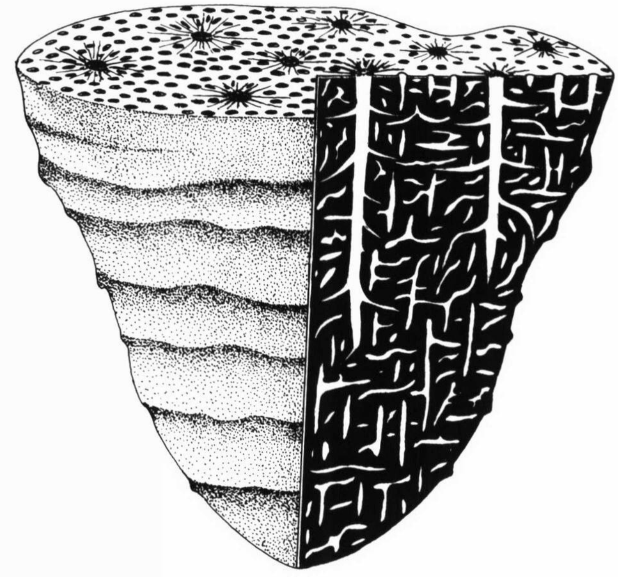

Figure 21. *Prestellispongia lobata* (Parona, 1933). The exterior or dermal layer of the sponge is smooth and without openings, but has growth lines. One to several starlike, tangential, exhalant canal systems surround each cluster of several exhalant canals. The interior of the sponge, as shown in longitudinal section, is characterized by horizontal canals and by two kinds of longitudinal canals that are differentiated by their size. The large canals connect to the oscula and the small canals to the inhalant pores on the summit of the sponge. Spaces between the canals are occupied by reticular or bubblelike skeletal fibers (schematic, not to scale).

base of conical sponges, but vertical beamlike rods approximately 0.10 mm in diameter irregularly discontinuous on surface. These rods spaced so that 5 to 6 occur per millimeter, measured horizontally around upper part of sponge where most pronounced.

Unclustered, vertical or upwardly divergent, tubelike canals pierce skeletal structure with relatively coarse ostia 0.5 to 0.8 mm in diameter, locally in steeply margined pits up to 1 mm wide at top. Ostia of radial canals 25 to 30 per 25 mm^2 and moderately uniformly spread, although without geometrically predictable position; locally appearing roughly aligned, but that being a function of spacing and not related to positions of radial canals or impressed oscula. Such vertical canals empty into impressed radiate tangential ones with same spacing and density as in flattened areas between impressed canals.

These vertical canals separated on upper surface by moderately dense, fibrous tracts irregularly 0.2 to 0.8 mm across but with most 0.5 to 0.6 mm across. Tracts between canals weather to minutely knobby irregular surface on exterior; produced by knobs on emergent upper ends of fiber segments 0.02 to 0.04 mm in diameter and separated by about same distance around irregular, small, circular skeletal pores 0.02 to 0.04 mm across.

Skeleton in vertical section appearing almost laminate-reticulate, 5 to 6 layers per millimeter, composed of fibers

0.02 to 0.06 mm in diameter, cross connected in rectangular pattern by vertical fibers of same dimensions and spacing; junctions swollen to 0.10 to 0.16 mm to produce beaded structure. Skeletal pores 0.08 to 0.10 mm, circular, and aligned. Interruptions and irregular growth may produce marked variations in regularity and produce dense layers in skeletons, some without significant pores, in otherwise porous open structure.

Discussion.—*Prestellispongia lobata* (Parona, 1933) is one of the more common sponges in the collection from Djebel Tebaga. It is also a form that is plastic and ranges from regularly obconical to highly irregularly massive and encrusting. It is distinguished by the sizes of its canals, dimensions of the astrorhizal clusters and their spacing, and the generally compound nature of the sponge. It differs from *Prestellispongia paula* new species by having much coarser vertical canals and astrorhizal and oscular canals, as well as larger, coarser, exhalant clusters. For example, relatively coarse ostia of the nearly vertical canals in the skeleton of *Prestellispongia lobata* range 0.5 to 0.8 mm in diameter, but are only 0.1 to 0.3 mm across in *Prestellispongia paula.*

Prestellispongia permica (Parona, 1933) differs from *Prestellispongia lobata* by having a single-domed or saucerlike upper surface, characteristically occupied by a single oscular depression, rather than the several depressions found in *Prestellispongia lobata.*

Prestellispongia scapulata new species is a vertically bladed or palmate form in typical development, in contrast to the obconical or irregularly massively obconical *Prestellispongia lobata.* In addition, *Prestellispongia scapulata* has relatively robust, stubby canals in the astrorhizal or oscular system, in contrast to the rather large, long canals in the multiple, starlike oscula of many canals characteristic of *Prestellispongia lobata.*

Material.—53 specimens.

Figured specimens.—USNM 480361–480371, 480397, 480419, and 480423, localities of which are given in explanations of Plates 8–11, 13, 21, 43, 58, and 79.

Occurrence.—In addition to occurring in Permian rocks of Sicily, the species is moderately common at several localities of Djebel Tebaga. These latter occurrences are shown in Table 1.

PRESTELLISPONGIA PERMICA (Parona, 1933)

Plate 12; Plate 21.8–21.9; Plate 45.9; Plate 78.1–78.2; Figure 22

Synonymy.—*Stellispongia permica* Parona, 1933, p. 30, pl. 12, fig. 1–5; Termier and Termier, 1955, p. 620, fig. 3; Termier and Termier, 1977a, p. 34, pl. 7, fig. 5.

Emended diagnosis.—Small, mushroomlike sponges with one or rarely more, regularly starlike, astrorhizal-like systems of tangential canals that converge toward depressed or domed, shallow osculum into which empty short, exhalant canals in closely packed clusters. Numerous small, circular ostia 0.2 to 0.4 mm in diameter occur between canals as well as in canals as openings of canals normal to surface and as second series that are normal to tangential series; fibrous skeleton between canals a regular net; microstructure spherulitic.

Description.—Mushroomlike sponges with pointed base to short stalk that expands abruptly upward. Only few specimens taller than diameter, most specimens being tabular with diameters greater than heights. Largest specimen 50 mm in diameter, but only 23 mm tall; smallest specimen 8 mm in diameter and 5 mm tall.

Lower outer or dermal surface of sponge characterized by clearly developed growth lines, but pores or other structures commonly lacking. Some show fine, parallel lines of loosely spaced, continuous, skeletal fibers, but nature obscure.

Summits of sponge walls usually arched, but few being concave; in both cases tops slope both down toward periphery and center of dome. Usually only one central, regular, starlike or astrorhizal-like system of canals, although some specimens with two or more (Plate 12.1); tangential, surficial canals radiate from depressed oscular center and branch toward periphery of dome. Numerous small circular ostia of vertical canals cover summit and occur between tangential canals as well as in canals.

Two internal series of canals developed. Larger exhalant canals 0.4 to 0.5 mm in diameter converge to form axial cluster, as seen in both transverse and longitudinal sections, where in latter sections canals curve upward and inward from lower outer part of skeleton. Smaller, generally upwardly divergent to vertical, straight canals meet summit surface at high angles or normal to surface and cross cut larger series in lower and outer, more peripheral part of skeleton. Smaller canals and ostia 0.2 to 0.3 mm in diameter, generally walled but elsewhere only perforations

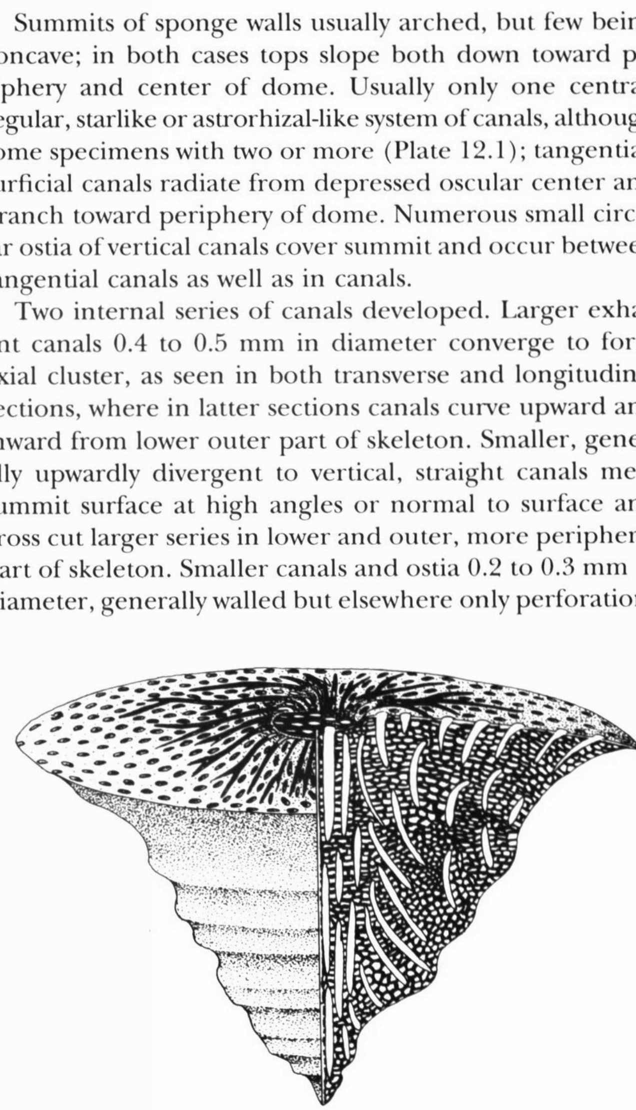

Figure 22. Reconstruction and longitudinal section of *Prestellispongia permica* (Parona, 1933). The section shows placement of canals within the interior of the sponge. Two kind of canals can be recognized. Exhalant canals are larger and end in the astrorhizal-like canals at the top of sponge. The abundant small canals serve as inhalant canals and open as small ostia on the top of sponge. Spaces between the tubes are filled with reticulate skeletal fibers. The outer surface is smooth, marked only by growth lines (schematic, not to scale).

through regular reticular skeleton. Canal walls perforated, 0.02 to 0.04 mm thick and essentially only one fiber thick; pores ranging from 0.04 to 0.08 mm but most about 0.06 mm in diameter and numerous.

In transverse cross sections, cut just under the edge of the summit, circular sections of larger, commonly walled, vertical exhalant canals concentrated in axial area or in radial rows between or in traces of tangential, convergent surficial canals.

Skeleton uniform net, fibers 0.04 to 0.05 mm in diameter but swell to 0.08 to 0.10 mm at junctions between skeletal pores, also being 0.08 to 0.10 mm in diameter but ranging from 0.04 to 0.12 mm in diameter, latter larger openings possibly locally aligning to produce short, intratract canals between larger, walled, canal series. Skeleton commonly with long, longitudinal to upwardly divergent fiber series, cross connected by irregularly spaced, transverse, short fibers in lower skeleton, but structure being more nearly laminate in upper part where transverse fibers are more prominent and regular. Skeleton with spherulitic microstructure.

Discussion.—The principal distinguishing characteristic of *Prestellispongia permica* (Parona, 1933) in the specimens from Tunisia is that the common, domed, or saucerlike upper surface of the summit characteristically is occupied by a single oscular depression into which converge tangential excurrent canals. The domed surface is marked by numerous small circular ostia of canals that are essentially normal to the surface and to the tangential canal series. In some respects the genus appears like a short *Precorynella,* except the horizontal, arched canals are considerably better developed in *Precorynella,* and the small canals normal to the surface are much better developed in *Prestellispongia permica.*

Estrellospongia grossa new species may appear to be somewhat similar, but it lacks the axial cluster of exhalant canals. In *Estrellospongia* the small canals normal to the upper surface are much finer and considerably more irregularly developed. *Estrellospongia* appears to have a considerably more irregular, less reticulate skeleton.

Prestellispongia paula new species has numerous, small, astrorhizal clusters and, as in *P. permica,* between these impressed canals the surface is perforated by numerous small canals normal to the upper surface. These small canals, however, are only 0.2 mm in diameter or less, in contrast to the somewhat larger, more prominent canals in *P. permica.* The two forms appear to have essentially the same regular skeletal net, however, filling the spaces between canal systems, but the small ostia of the canals normal to the surface do not appear as distinctly in rows in *Prestellispongia paula* as in *Prestellispongia permica.*

Material.—This species is one of the most abundant inozoan sponges in Djebel Tebaga; 337 specimens are included in our collection.

Figured specimens.—USNM 480280–480291, 480399, and 480421.

Occurrence.—The common species occurs widely in the Djebel Tebaga exposures. Occurrences are shown in Table 1.

PRESTELLISPONGIA PAULA new species

Plate 8.4; Plate 21.6–21.7; Plate 43.2–43.3, 43.5; Plate 45.8

Diagnosis.—Massive to irregularly obconical *Prestellispongia* with some numerous small, starlike oscular areas 6 to 9 mm apart, each with numerous, surficial, convergent, fine canals mostly 0.3 to 0.5 mm wide; ostia of numerous, small, radial or vertical canals 0.2 to 0.3 mm in diameter and between surficial canals.

Description.—Irregularly obconical to abruptly expanding in juvenile stages, some becoming undulate and cake-platterlike where upper part is a broadly expanded plate; upper surface generally weakly mounded to low-arcuate, convex upward; sponges range to irregular forms as much as 5 by 6 cm across in the upper, platterlike part of the sponge, and 3.0 to 3.5 cm high, with 2 to 3 cm, stalklike lower part; upper flared part 5 to 10 mm thick.

Upper surface with multiple, starlike oscula spaced 6 to 9 mm apart center to center, most approximately 7 mm apart; oscula appearing as gentle depressions to nearly flat, or on low mounds; where depressions develop they indent upper surface approximately 0.5 mm. Oscula generally ill-defined, convergent point of cluster of exhalant canals, clusters 2 to 3 mm in diameter, generally 8 to 10 occurring per oscular area, but number varying because outer edge of oscular area ill defined in nearly flat, upper surface.

Horizontal, tangential canals shallowly impressed, but moderately well defined around each oscular cluster; tangential canals 0.4 to 0.5 mm wide near oscular center but somewhat narrower distally. Canals generally straight but may bifurcate outward once or twice and become less well defined in outer half of astrorhizal star, where they are more shallow. Many canals traceable 3 to 4 mm from center of oscular area, but also extending considerable distance from osculum. No apparent lateral merger with canals of adjacent oscula. Tangential canals defined by depressions formed by ostia of aligned vertical canals as much as by general depressed area in skeleton.

Ostia of vertical canals common on surface and 0.1 to 0.3 mm across, but may be up to 0.4 mm across in bottoms of shallow, funnel-like pits. All ostia circular and spaced 5 or 6 per mm^2. Some appear to be crudely laterally aligned but, in general, position not geometrically predictable.

Ostia on surface separated by reticulate tracts 0.2 to 0.5 mm across, most approximately 0.3 mm across, at narrowest where ostia of vertical canals occur on opposite sides. Reticulate tract segments 0.04 to 0.06 mm in diameter and 0.10 to 0.15 mm long. Upper surfaces of tracts weather to minutely knobby or irregularly reticulate surface in which junctions of fibers form knobs or irregularities of various sizes, 0.02 to 0.10 mm across. Most tracts contain small, circular, skeletal pores that may make up to one-third of tract volume. These pores are 0.06 to 0.08 mm in diameter where clearly defined.

Dermal or lower surface of sponge rugose, moderately dense, and uniform with skeletal tracts as on upper surface; fewer incurrent pores, most 0.2 to 0.3 mm in diameter. No large ostia. Small skeletal pores 0.06 to 0.10 mm in diameter, generally circular, and separated by fibers 0.04 to 0.06 mm across. These fibers also with knobs at junctions. Most of lower part of sponge encrusted with other organisms.

Skeleton pierced by numerous vertical canals with circular cross sections 0.20 to 0.25 mm in diameter, although they may range up to 0.4 mm in diameter in unusual individuals. Canals uniformly spaced, 0.5 to 0.8 mm apart across entire upper surface, but occurring as linear clusters where they empty into bottoms of radial canals. Ostia of some vertical canals in conical, funnel-like, shallow pits up to 0.6 to 0.7 mm across. Overall impression of exterior is of moderately widely separated, small oscular areas separated by regular skeleton pierced by numerous vertical canals.

Internally, vertical canals subcylindrical in thin section and up to 5 mm long, although may be much longer where somewhat curvilinear and lost from plane of thin section. Interior canals 0.20 to 0.25 mm in diameter throughout, with irregular walls 0.06 to 0.08 mm thick but porous and discontinuous.

Horizontal canals occur throughout sponge and are 0.3 to 0.4 mm high or in diameter. They converge to present oscular areas or to abandoned oscular areas in interior in early stages of skeleton.

Skeleton appears rectangularly regular, almost laminate in some hemispherical specimens, to longitudinally regular with upwardly divergent tracts and horizontally connecting fibers of essentially the same dimensions and spacing. Fibers 0.02 to 0.08 mm in diameter with considerable irregularity, around skeletal pores 0.80 to 0.12 millimeter in diameter, again with moderate irregularity as seen in transverse sections. Structure considerably more regular in longitudinal sections; where fibers more continuous and pseudolaminate, regular structure more apparent, with 6 to 7 horizontal laminae per millimeter.

Paratype USNM 480424, from Spot Locality 27A, with canals and other features generally of the same size, although some vertical pores somewhat larger in the bigger sponge, which is 10 by 12 cm across in diameter on upper, platterlike part, with stalk approximately 2 cm high; upper platterlike part approximately 2 cm thick. Lower dermal layer markedly rugose with individual wrinkles 3 to 4 mm wide, some marked by rodlike clusters of spherulites as in holotype.

Discussion.—*Prestellispongia paula* new species has the general growth form of *P. lobata* (Parona, 1933) but has much finer vertical canals and astrorhizal or oscular canals and clusters. *Prestellispongia permica* (Parona, 1933) has only one or two oscular areas and has vertical, radial canals somewhat larger and more commonly aligned than similar canals in *Prestellispongia paula.*

Prestellispongia paula has oscular areas and tangential excurrent canals that, in fragments, could appear to be similar to those of *Prestellispongia insculpta* new species, but the latter species is ramose and, internally, has a much less regular skeletal structure and canal pattern.

Material.—69 specimens.

Type specimens.—Holotype, USNM 463637, Pl. 43.2–43.3; Pl. 45.8; paratypes, USNM 463638, 480398, and 480424.

Occurrence.—Holotype, Djebel Tebaga Spot Sample DJT-32; paratypes from Djebel Tebaga Spot Localities 144-1976 and 27A, and Section C, bed 16, and Section E, bed 27. Four reference specimens from Spot Locality DJT-13B, one from Spot Locality 160-1976, and one from the locality west of the house, west of the trail and of Section I, but in shale equivalent to bed 2 of Section I; all from the Tebaga Limestone.

Etymology.—*Paulus,* Latin, little; in reference to more finely textured canals and clusters than those in *Prestellispongia lobata* Parona, 1933.

PRESTELLISPONGIA SCAPULATA
new species

Plate 14; Plate 21.10; Plate 42.8; Plate 46.2; Figure 23

Diagnosis.—Scapulate, incipiently branched to club-shaped, branched sponges with osculum 1.0 to 3.0 mm in diameter, with 10 or more canals 0.6 to 0.8 mm in diameter on each node tip. Osculum with stubby, stellate appearance produced by upward convergence of exhalant canals. Long vertical to upwardly divergent inhalant canals, approximately 0.35 mm in diameter, numerous between oscula. Horizontal canals uncommon.

Description.—Scapulate, sheet-, or club-shaped sponges among rare species from Djebel Tebaga, with different sizes and shapes.

Complete holotype (USNM 480306; Pl. 14.1–14.2) with height of 48 mm, moderately thick, scapulate, with incipient branches somewhat mushroom-shaped in side view (Pl. 14.2) but thin and rectangular in top view (Pl. 14.1), 45 by 20 mm (in middle area).

Somewhat more scapulate paratype (USNM 480309; Pl. 14.7; Pl. 42.8) thinner and more sheetlike but branched on both sides at bottom. Largest of species in collection with height of 73 mm (now only 66 mm high because 7 mm were cut from base) and width of 53 mm at top, although only 20 mm wide at narrowest part of base. Sheet with maximum thickness of 10 mm at top (Pl. 42.8) but about 15 mm thick near base where large branches start. One side, opposite that shown in Plate 14.7, having coarse, vertical grooves that extend from top to base of sponge, producing branched appearance at top, with oscula located on small elevations.

Two branches at base of paratype (USNM 480309; Pl. 14.7; Pl. 42.8) diverge almost 90°, perpendicular to axis of

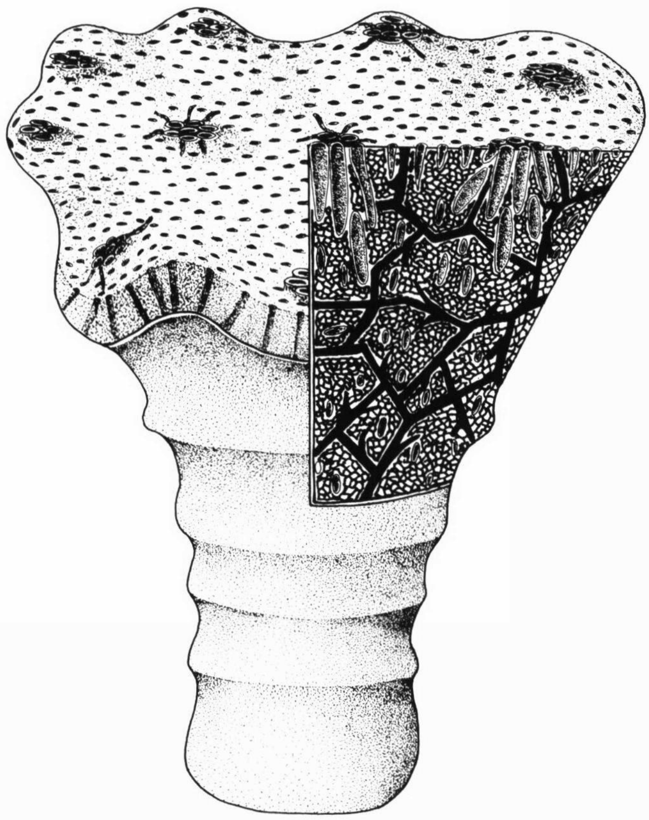

Figure 23. The exterior, summit, and longitudinal section of *Prestellispongia scapulata* new species. The outer surface is smooth and shows only growth lines. Several oscula composed of several individual openings occur on the summit, and some are on small elevations. Numerous, small inhalant pores cover the summit of the sponge between the oscula. The longitudinal section shows the tubular extension of individual openings of the oscula into the sponge. In addition, numerous small tubes corresponding to the inhalant tubes are also cut. The internal skeleton is composed of fibers of two different sizes that branch into smaller ones and produce a reticular structure that fills spaces between the large fibers and the various exhalant and inhalant canals (schematic, not to scale).

main stem; larger branch characterized by three oscula, each composed of several ostia at tip of main stem. Smaller branch broken. Some paratypes (Pl. 14.3–14.4) more mushroom- or club-shaped with heights of 30 to 40 mm and diameters of 20 to 25 mm at top, also included in species because of distinctive oscula.

Base and exterior of sponges relatively smooth, without pores or canal systems, but with ringlike growth lines. Small vertical grooves on exterior (Pl. 14.2, 14.7) of several internal canals exposed by weathering and removal of outer part of sponge. Distinct lines near tops of sponges separate perforated upper part from lower imperforate side, where growth lines developed (Pl. 14.2, 14.4–14.5, 14.7).

Summit of sponges characterized by several separated oscula, each on node tip of incipient branch, and each osculum 1 to 3 mm in diameter, composed of cluster of 10 or more inscribed small ostia 0.6 to 0.8 mm in diameter. Upward convergence gives stubby stellate appearance to osculum; more peripheral canals cut in longitudinal section appearing as grooves radiating from cluster and produce more starlike appearance.

Tops of sponges between oscula marked by ostia of numerous, small, vertical or longitudinal inhalant canals, each approximately 0.35 mm in diameter. These discontinuously walled canals common as upwardly divergent, long, regular openings. Horizontal canals of same general dimensions may be rarely developed.

Discussion.—The bladed, incipiently branched growth form, combined with the shallowly inscribed oscular structure on branch tips separate the species from the other obconical, hemispherical, or irregular species of the genus. These features, plus the rarity of horizontal canals and the well-developed, reticulate skeleton separate the species from more massive, branched species of *Permocorynella* and *Radiofibra* and from *Prestellispongia(?) fasciculata* new species.

Material.—Seven specimens.

Type specimens.—Holotype, USNM 480306, Pl. 14.1–14.2, Section G, bed 4; paratypes, USNM 480307–430308, from Section E, shale below Reef 3, and 480309 from Section E, shale above Reef 3.

Occurrence.—Five specimens from Section E, shale below Reef 3; one from Section E, in the shale 10 meters above Reef 3; and one specimen from Section G, bed 4.

Etymology.—*Scapulata,* Latin, like the shoulder blade or scapula; in reference to the general growth form of several specimens of the species.

PRESTELLISPONGIA BOLARIA
new species

Plate 13.5–13.8; Plate 21.11; Plate 46.1; Plate 58.3–58.4

Diagnosis.—Massive to irregularly nodose, clodlike, with several oscular clusters 10 to 15 mm apart; of mainly five, coarse, convergent, surficial, exhalant canals, the latter being irregularly branching; other surface with faint network; pierced by inhalant canals mainly 0.3 mm in diameter; skeleton upwardly and outwardly flaring, of moderately coarse, dominantly longitudinal fibers to 0.16 mm in diameter; cross connected irregularly by small fibers mainly 0.03 mm in diameter producing almost spinose appearance in sections; lacking major transverse canals in interior.

Description.—Sponges massive, irregularly and laterally lobate to low nodose, up to 45 mm across and 31 mm high in characteristic specimens. Each sponge with several oscular clusters 10 to 15 mm apart, with 2 to 5 canals; clusters generally on crests of nodes or mounds. Clusters surrounded by convergent, lateral surficial canals, mainly 0.5 mm but up to 0.6 mm wide, and about one-half that deep, occurring as 2 or 3 to 5 or 6 irregularly branching canals, most traceable to 4 to 5 mm from cluster, but some as far as 15 mm in irregularly sinuous courses through irregular, faint, surficial network.

Canals in clusters 0.5 to 0.8 mm in diameter may occur in bottom of separate, distinct, craterlike pits, 1.0 to 1.5 mm wide at the top and 1.0 to 1.5 mm deep. Longitudinal canals continue into interior as 0.5 to 0.8 mm wide walled tubes, essentially normal to surface, although steeply upwardly convergent canals may occur locally in outer part of skeleton. Some canals clearly traceable for 15 mm to intersections with canals from exterior and forming major openings in skeleton.

Numerous inhalant ostia 0.2 to 0.3 mm in diameter occur on surface as openings of abundant inhalant canals spaced approximately 1 mm apart and parallel to fibers in skeleton.

Skeleton upwardly and outwardly flaring network, dominated by longitudinal fibers that curve to meet surfaces of upper and lateral lobe nearly at right angles or at high angles. Longitudinal fibers 0.10 to 0.16 mm in diameter, with considerable irregularity, expand to as much as 0.2 mm across in junction areas with lateral, transverse fibers; latter fibers 0.03 to 0.06 mm in diameter, with most being 0.03 to 0.05 mm across in central part of sponge, but tapering abruptly from being somewhat thicker in the junction area, producing almost spinose appearance to longitudinal fibers. Lateral fibers generally discontinuous, connecting only adjacent longitudinal fibers. No common laminar effect in skeleton, which appears ladderlike.

Longitudinal skeletal pores 0.14 to 0.20 mm in diameter, cross connected by transverse pores 0.08 to 0.14 mm in diameter. Most of latter circular and 0.12 mm across and connecting longitudinal pores to somewhat coarser inhalant canals and coarse exhalant canals. Skeletal microstructure is spherulitic but not well preserved in specimen analyzed.

Discussion.—Prestellispongia bolaria new species is characterized by its irregularly nodose, lumpy, or clodlike form and its scattered, moderately obscurely defined, oscular clusters in a fairly coarsely fibrous, longitudinally dominated, skeletal net. *Prestellispongia lobata* (Parona, 1933) has a considerably finer skeletal net, more pronounced oscular clusters, and although of irregular shape, tends to be mushroomlike or irregularly steeply obconical. Inhalant openings on the upper surface of *P. lobata* are similarly considerably coarser than inhalant ostia in *Prestellispongia bolaria*, and exhalant openings in the clusters are considerably finer than in *Prestellispongia bolaria*.

Prestellispongia paula new species has radial or vertical canals of generally the same dimensions as those of *P. bolaria*, but *P. paula* lacks the moderately coarse canals that are the large openings in the oscular centers in *P. bolaria*. In addition, the skeleton of *P. paula* appears almost laminate in some hemispherical specimens and moderately finely rectangularly arranged rather than being the vertically dominated or longitudinally dominated skeleton seen in *P. bolaria*.

Material.—Two specimens.

Type specimens.—Holotype, USNM 480353, Pl. 13.5, 13.8; Pl. 21.11, Spot Locality DJT-8, Djebel Tebaga, paratype, USNM 480352.

Occurrence.—One specimen from Spot Locality DJT-8 and one from Section E, bed 27, shale below CF-18A.

Etymology.—Bolarion, Latin, lump or clod, diminutive; in reference to the irregular growth form of the species.

PRESTELLISPONGIA(?) FASCICULATA
new species

Plate 21.12; Plate 23.4–23.5; Plate 46.3

Diagnosis.—Branched sponges with shallow, oscular depressions and clusters of shallow, vertical exhalant canals 0.4 to 0.5 mm in diameter on branch tip, with convergent surficial canals; branch tips having polygonal to irregular skeletal pores 0.04 to 0.10 mm across as in interior; horizontal canals rare, obscure in interior; skeleton having vertically dominant fibers with short cross-connecting fibers, both approximately 0.06 mm in diameter; thin dermal layer dense.

Description.—Branched sponge species composed of several individual stems merged in lower part and in side view (Pl. 23.5), but stems distinct on top of sponge (Pl. 23.4) where individual stems range from 12 to 15 mm in diameter. Stems characterized by shallow oscular depression on summit of each; indistinct to clearly recognizable grooves of surficial exhalant canals converge toward depression from periphery of stem. These grooves 0.5 to 0.7 mm wide near center and narrow distally; grooves generally short, only 1 to 3 mm long.

Top of sponge between and around grooves covered by abundant polygonal to irregularly shaped openings, 0.3 to 0.4 mm in diameter, which correspond to vertical canals within rigid skeleton. Clusters of vertical canals in shallow oscular depressions, ranging from 2 to 4 mm across; ostia of canals 0.4 to 0.5 mm in diameter, canals short, extending only 2 to 3 mm below surface before becoming obscure and lost in reticulate skeleton. Short segments of similar, earlier canals parallel to vertical fibers scattered throughout skeleton. Horizontal canals obscure and occurring as rare, short openings 0.2 to 0.3 mm in diameter, normal to vertical canals and dominant skeletal fabric.

Skeletal pores 0.04 to 0.10 mm across, ranging from polygonal in smaller openings to circular in larger ones; pores commonly in ladderlike, vertical series in vertically dominated, reticular grid. Vertical fibers 0.02 to 0.20 mm with most 0.06 to 0.08 mm in diameter, cross connected by short horizontal fibers 0.04 to 0.06 mm in diameter and usually only 0.1 to 0.2 mm long, but rarely up to 1 mm long. Vertical fibers traceable to 2 to 3 mm before becoming obscure in net. Fibers on summit somewhat coarser than in interior and almost microdentate appearance on weathered surface produced by irregular cross sections of fibers and connections.

Side or bottom of sponge characterized by concentric ridges corresponding to growth lines (Pl. 23.5). No openings generally developed on side of sponge, for growth lines developed in thin, cortexlike layer from base to near top of individual stems; only branch tips do not show growth lines and are free of imperforate dermal layer.

Discussion.—Prestellispongia(?) fasciculata new species is most similar to *Permocorynella fruticosa* new species or *Radiofibra nodosa* new species in general growth form as a branched sponge, but *P. fruticosa* has oscular pits that extend into the sponge, toward which converge horizontal and upwardly curved canals that merge to form axial clusters, and has a fine reticulate skeleton in wide tracts, in contrast to the coarser, vertically dominant skeleton of *Prestellispongia(?) fasciculata.*

Radiofibra nodosa ranges in morphology from having an oscular pit to a shallow spongocoel and coarse canals in the interior and is moderately easily differentiated.

Material.—One specimen.

Type specimen.—Holotype, USNM 480302, Pl. 21.12; Pl. 23.4–23.5; Pl. 46.3, from Spot Locality T5.

Occurrence.—Spot Locality T5.

Etymology.—Fasciculatus, Latin, bundle; in reference to the clustered, branched form of the species.

Subfamily ESTRELLOSPONGIINAE new subfamily

Diagnosis.—Massive prestellispongiid lacking oscula and spongocoels but with one or several astrorhizal clusters of largely surficial, convergent exhalant canals on surface; lacking coarse openings in fibrous skeletal net.

Type genus.—Estrellospongia new genus.

Genus ESTRELLOSPONGIA new genus

Diagnosis.—Irregularly massive, hemispherical to lobate inozoid sponges; upper surface with one or rarely more astrorhizal systems of coarse, convergent, exhalant tangential canals; lacking coarse, vertical, exhalant canals in oscular ostia, but with numerous irregularly upwardly divergent canals in irregularly but prominently divergent skeletal net; microstructure spherulitic.

Discussion.—Estrellospongia lacks a major spongocoel, a cluster of exhalant tubes, or a widely separated series of coarse exhalant tubes which characterize several of the other sponges from Djebel Tebaga. The irregularly hemispherical or massive sponges are marked principally by a surficial tangential series of exhalant canals that converge toward an area near the crest of the sponge. Such a pattern is seen in smaller scale, and is somewhat more regularly developed within species of *Prestellispongia.* However, the other prominent coarse canal series of radial tubular elements and the cluster of axial canals that is commonly developed in *Prestellispongia* are not present in *Estrellospongia.* The latter genus also lacks the distinct, coarse, tubular skeletal structure of massive sponges such as those included in *Radiotrabeculopora* and so is easily differentiated from those forms. Because of its unique arrangement of canals and relatively regular beamlike fiber clusters of the skeleton, it is differentiated as a new genus.

Type species.—Estrellospongia grossa new species.

Etymology.—Estrella, Spanish for star; *spongia,* sponge; in reference to the coarse radial tangential canals on the upper surface of the sponge.

ESTRELLOSPONGIA GROSSA new species

Plate 11.5; Plate 15; Plate 21.13; Plate 30.10, 30.12; Plate 46.4; Plate 61.2; Plate 80.6

Diagnosis.—Irregularly massive, lobate, hemispherical sponges with generally domed surface marked by branched, convergent, tangential excurrent canals converging to one or more oscular areas, producing astrorhizal-like canal clusters. Tangential canals range to 2.0 mm wide and deep but become less prominent away from astrorhizal center. Areas between tangential canals perforated by ostia of small vertical or radial canals 0.2 to 0.4 mm in diameter as numerous, although not geometrically arranged openings. Skeleton fibrous, with irregularly low, sinuous beamlike fibers radially normal to surface. Lacks spongocoel, prominent clusters, or uniformly developed coarse exhalant canals. Microstructure of rigid skeleton spherulitic.

Description.—Irregularly massive to lobate hemispherical sponges, with surface marked by wide dendritic-appearing, convergent, tangential excurrent canals. Tangential canals converge to one or, in a few specimens, more oscular areas with number of oscular areas increasing as size increases. For example, in sponge approximately 5 cm in diameter or smaller generally only one oscular convergent area is evident, but there are 4 to 5 such centers preserved on sponges 7 to 8 cm in diameter, which are largest individuals of species.

Main tangential canals 1.7 to 2.0 mm wide in central convergent areas, where canals converge to shallow depressions 1 to 2 mm deep and to 4 mm wide, or to low elevated areas, so development of depressions or elevations not taxonomically significant. Canals narrow radially and may be only 0.5 mm wide at edge of upper surface that overhangs dense basal, dermal layer. Tangential canals floored by regular skeletal mesh but having no ostia of large vertical excurrent canals and no such ostia being evident in center of convergent canal system either.

Elevated areas between tangential canals may be 2 to 4 mm wide and somewhat longer; marked by small circular ostia of short radial canals 0.25 to 0.35 mm in diameter that open into circular or crudely prismatic pits up to 0.4 to 0.5 mm wide or in diameter. Ostia 3 to 5 per mm^2, spaced approximately 2 per mm, whether measured parallel to or at high angles to tangential canals. In vertical sections, canals irregularly and slightly sinuous and of moderately uniform diameter, with pronounced walls that appear almost rodlike. Outside diameters of walled canals 0.30 to 0.45 mm, with most being 0.30 to 0.35 mm in diameter, with irregular walls; sometimes ragged appearing, 0.04 to 0.10 mm thick, around smooth, tubelike openings commonly 0.20 to 0.25 mm in diameter. A few pores, 0.04 to 0.06 mm in diameter perforate generally solid canal walls, but some loss of pores may have resulted from diagenesis and thickening of the wall.

Fibers well defined in longitudinal section and on exterior in surficial canals. Fibers 0.02 to 0.03 mm wide on the exterior but locally expand to approximately 0.08 mm in diameter in junction areas, although most junctions are only 0.05 to 0.06 mm in diameter. Some junctions appear beamlike, with several with fiber clusters radially arranged and normal to skeletal surface in transverse sections. Appearance, however, results from linear, moderately regular, reticular, ladderlike fibers rather than from beams.

Entire skeleton reticulate with vertical to upwardly divergent, somewhat sinuous fibers dominant locally and cross connected by shorter, less regularly spaced fibers. Vertical fibers parallel to canals and 0.06 to 0.08 mm in diameter as rodlike elements traceable for 1 to 2 mm before being lost in regular skeletal structure. Cross-connecting, short fibers 0.04 to 0.06 mm in diameter, spaced 4 to 6 per millimeter along ladderlike structure to produce skeletal pores 0.06 to 0.14 mm in diameter, with most about 0.10 mm across, even where oval and vertically elongate. Skeletal microstructure spherulitic but not well preserved in analyzed specimens.

Some larger specimens with basal layer show skeleton of distinct, radial, small rods, spaced 4 to 5 per millimeter measured around the circumference of the sponge, these being aligned, somewhat thickened clusters, not beams. Basal layer generally ill defined.

Crests of elevated, intercanal areas on upper surfaces armored by dense dermal layer 0.2 to 0.3 mm thick, where fibers characteristically thickened to 0.2 mm across, approximately ten times the width of normal fibers in interior skeleton. Most thickened tracts approximately 0.1 mm thick around circular ostia. In cross section, canals of these ostia are subcircular and traceable for at least 1 mm into skeletal net but then losing identity in moderately open, porous, skeletal fabric of reticulate fibers. Similarly, small canals evident in floors of tangential canals also traceable in irregular fashion 0.5 to 1.0 mm into skeletal net, essentially as interfiber openings but soon losing identity as discrete openings in reticulate open skeletal fabric of interior of sponges.

Specimen investigated with SEM poorly preserved but spherulites still recognizable in rigid skeleton (Plate 61.2).

Discussion.—Comparisons with similar sponges have been treated in discussion of the genus.

Material.—31 specimens.

Type specimens.—Holotype, USNM 463639, Pl. 15.1; paratypes, USNM 463640–463647, Pl. 15.2–15.10; USNM 480400, Section E, bed 27; figured reference specimen, questionably of species, USNM 480360, Pl. 30.10 and 30.12, Spot Locality 48.

Occurrence.—Two specimens from Djebel Tebaga Spot Locality DJT-13; four from Djebel Tebaga Spot Locality 13B; one from Section E, bed 11; seven from Section E, bed 27 in the shale 20 feet below CF 18A; one from Section G, bed 4; two from Spot Locality T6; four from Spot Locality 216-1976; and three large specimens from Djebel Tebaga Spot Locality 27; plus possibly 4 small, button-like specimens, including one from Djebel Tebaga Spot Locality 48 that is questionably placed in the species.

Etymology.—*Grossa,* Latin, big, coarse, thick; in reference to the coarse canals of the large astrorhizal systems.

Family PERONIDELLIDAE Wu, 1991

Emended diagnosis.—Sponges in which excurrent system consists of only a spongocoel or a cluster of several coarse canals in axial region of sponges; water system of *Peronidella*- or *Precorynella*-type (modified from Wu, 1991, p. 56).

Type genus.—*Peronidella* Hinde, 1893.

Subfamily PERONIDELLINAE Wu, 1991

Diagnosis.—Sponges with axial spongocoel but lacking inhalant and exhalant canals.

Type genus.—*Peronidella* Hinde, 1893.

Genus PERONIDELLA Hinde, 1893

Synonomy.—(*pro Peronella* Zittel, 1878, *non Peronella* Gray, 1855).

Original diagnosis.—"Einfach oder durch Knospung ästig; Einzel-Individuen cylindrisch dickwandig; Scheitel gewölbt, seltener eben, in der Mitte mit engem, kreisrundem Osculum der röhrenförmigen Magenhöhle, welche mit nahezu gleichbleibendem Durchmesser die ganze Länge des Schwammkörpers bis in die Nähe der Basis durchbohrt. Einströmungscanäle fehlen. Wand der Magenhöhle und Oberfläche porös. Aussenseite entweder nackt oder an der Basis, zweilen auch bis in die Nähe des Scheitel mit dichter, concentrisch runzeliger Epidermis überzogen. Das Skelet besteht aus meist groben, wurmförmig gekrümmten, anastomosirenden Fasern, die ein wirres Gewebe bilden" [Single or branched through budding; individual specimens cylindrical, thick walled; summit arched, rarely flat, in the middle occurs a round osculum of the tubular spongocoel, which extends with nearly unchanged diameter for the entire length of the sponge body from the vicinity of the base. Inhalant canals lacking. Wall of the spongocoel and upper surface porous. Exterior either naked or secondarily coated on the base and up to the summit with a thick, concentrically wrinkled epidermis. The skeleton is composed mostly of large, vermiform, round, anastomosing fibers that form a confused net] (Zittel, 1878, p. 30, 120).

To the diagnosis given by Zittel we add that the skeleton of *Peronidella* is composed of aragonite, and its microstructure is spherulitic.

Type species.—*Spongites pistilliformis* Lamouroux, 1821.

Included species.—*Peronidella pistilliformis* (Lamouroux, 1821); and the Permian species *P. magna* new species; *P. multiosculata* new species; *P. rigbyi* Senowbari-Daryan, 1991; *P. baloghi* Flügel, 1973; *P. beipeiensis* Rigby, Fan, and Zhang, 1989; *P. regulara* Rigby, Fan, and Zhang, 1989; and the additional Chinese species *P. gravida* Wu, 1991; *P. labiaformis* Wu, 1991; *P. unicoeliala* Wu, 1991; and *P. recta* Hinde, 1893 (as cited by Wu, 1991). Additional Triassic species include *Peronidella loretzi* (Zittel, 1878); *P. rosetta* Dieci, Antonacci, and Zardini, 1968; and *P. subcaespitosa* (Münster, 1841).

Discussion.—As pointed out in the diagnosis by Zittel (1878) no spicules have been observed in *Peronidella*. Because the type species is represented by a Triassic type and it does not possess a spicular skeleton, we use that generic name for our sponges. Jurassic and Cretaceous species included in *Peronidella*, however, have a spicular skeleton composed of diactines, triactines, and tetractines (de Laubenfels, 1955; Wagner, 1964a; Hurcewicz, 1975, p. 266). For that reason the sponge species previously grouped into *Peronidella* should be subdivided into at least two different genera. The new name *Paronadella* (in honor of C. F. Parona, who described the Permian inozoid sponges from the Sosio Valley in Sicily) is proposed for those Jurassic-Cretaceous sponges that have a spicular skeleton composed of di-, tri-, and tetractines not united with calcareous cement (see Hurcewicz, 1975, p. 266). The Jurassic species *Peronidella proramosa* Hurcewicz, 1975 is the selected type species of the genus *Paronidella.* The diagnosis and proposal of *Paronadella,* as a new genus, are presented later in this paper following treatment of species of *Peronidella.*

Hinde (1893) changed the name *Peronella* of Zittel (1878) to *Peronidella* because *Peronella* was preoccupied by the echinoderm *Peronella* Gray, 1855.

PERONIDELLA MAGNA new species

Plate 19.1–19.2; Plate 21.16; Plate 47.2; Plate 58.5–58.6

Diagnosis.—Large *Peronidella* with relatively wide spongocoel that may be annulated as with outside of sponge. Thin cortex may occur around spongocoel.

Description.—Collected specimens range significantly in size, with largest 40 mm in diameter and 95 mm tall and smallest only 15 mm in diameter and 40 mm tall. All specimens with annulated exteriors, although outer surfaces of our specimens partly or intensely weathered and most not showing outer pores or ostia of sponge. Very small pores, about 0.2 mm diameter, cover outer surface of two specimens.

Wide and deep spongocoel, usually more than half width of sponge, extends deep into sponge (see Table 7). Spongocoel also shows annulation more or less parallel to outside profile of sponge. In comparison to diameter of sponge, sponge wall appears relatively thin, generally less than one quarter the width of whole sponge, but thicknesses vary depending upon diameters of sponges (Table

Table 7. *Peronidella magna* n. sp.; measurements in millimeters.

Number	Diameter of sponge	Diameter of spongocoel	Thickness of wall	Height of sponge
2	40	22 (55%)	5–10	95
2	19	13 (68%)	3–4	52
2	15	8 (53%)	4–6	40
2	16	7 (44%)	3–4	40
2	25	13 (52%)	5–6	30
1	23	11 (48%)	6	64
1	14–18	9–11 (60–66%)	3–4	60

7). Thin, differentiated gastral layer observed on most specimens around spongocoel (Pl. 19.2), but nature of that thin layer uncertain. It ranges from 0.1 to 0.3 mm thick in various specimens and appears moderately dense, although perforated by small pores of essentially the same size as skeletal pores in regular net, but in other areas appearing virtually imperforate.

Principal skeletal net made of regular, moderately robust elements in irregular tracts 0.14 to 0.24 mm in diameter that surround pores 0.12 to 0.22 mm in diameter, with most pores being 0.18 to 0.20 mm in diameter and occurring as circular openings where seen in cross section. Pores unite into a three-dimensional, roughly rectangular grid with openings swelling to as much as 0.35 mm in diameter at junctions of more or less horizontal and vertical openings. Aligned horizontal pores in one area and some vertical pores elsewhere locally give lineation to fabric on microscale, but that is not persistent. Larger canals not developed in very regular skeletal net. Some sections show crude vertical structure to skeleton, particularly where cut somewhat obliquely. Skeletal microstructure spherulitic, with spherulites appproximately 100 µm in diameter.

Skeleton lacks well-developed external cortex or differentiated external layer, although many specimens coated with massive dense algae; where algal layer not developed, uniform skeletal net shows essentially same dimensions as in sections of interior.

Discussion.—Specimens of the species in our collections include some of largest sponges with a spongocoel known from Djebel Tebaga, but apparently Termier and Termier (1977a) did not find representatives of the species there.

Several species of *Peronidella* are known from the Triassic and Permian in the literature (Dieci, Antonacci, and Zardini, 1968; Rigby, Fan, and Zhang, 1989; Wu, 1991). The previously described Permian species of *Peronidella* are *Peronidella baloghi,* from Hungary, described by Flügel (1973), and *Peronidella beipeiensis, Peronidella regulara,* and *P. parva* (=*P. rigbyi* Senowbari-Daryan, 1991) described by Rigby, Fan, and Zhang (1989) from the Middle to Upper Permian of China. Wu (1991) described other species from the same localities and horizons as described by Rigby, Fan, and Zhang (1989). Wu's species include *P. gravida, P. labiaformis, P. minicoeliaca, P. recta recta* Hinde, and *P. recta grossa.* The identities of all species described as separate species by Wu or their affiliation to the known species described by Rigby, Fan, and Zhang (1989) should be checked carefully. As shown in Table 8, however, the sizes and other characteristics of Wu's species are identical with those described by Rigby, Fan, and Zhang (1989).

The main features of the Permian species of *Peronidella* are compared with the new species in Table 8.

Several of the specimens were apparently broken off so that they were buried horizontally, parallel to stratification. Some show well-developed geopetal structures with crystalline, geode-like voids developed in the up-arched parts of annulations within the spongocoel, openings that were not filled by the fine matrix.

Table 8. Permian species of *Peronidella;* measurements in millimeters; *F,* Flügel, 1973; *R,* Rigby, Fan, and Zhang, 1989; *W,* Wu, 1991; *H,* Hinde, 1893; *S,* Senowbari-Daryan, 1991.

Species	Diameter of sponge	Diameter of spongocoel	Thickness of wall	Ratio of diameters of spongocoels to sponges
P. baloghi (F)	40 × 55	12 × 18	14	30%–36%
P. beipeiensis (R)	6.8–21.0	1.5–9.0	2–7	22%–44%
P. regulara (R)	12–38	2–10	4.5–9.0	17%–40%
P. rigbyi (S)	4–6	1.2–2.0	1.5–2.5	abt. 30%
P. magna n. sp.	14–40	7–22	3–10	44%–66%
P. digitata n. sp.	6–11	1.0–1.5	2–5	17%–30%
P. multiosculata n. sp.	5	1–2 (0.2–0.6)	1.5	18%–23%
P. gravida (W)	8.5	2.3–5.0	1–2	27%–59%
P. labiaformis (W)	4–10	0.75–1.00 (2.4–2.8)	0.4–0.8	10%–25%
P. minicoeliaca (W)	13–21	3.75	4.8–5.7	18%–29%
P. recta recta (H)	3.6–4.7	1.0–2.3	1.5–2.3	28%–50%
P. recta grossa (W)	3.6–4.7	1.0–1.8	1.0–1.5	28%–38%

Material.—14 specimens.

Type specimens.—Holotype, USNM 463663, Senowbari-Daryan collection, Pl. 19.1; Pl. 21.16; Pl. 47.2; paratypes both from Section J, bed 7, (thin section), USNM 463664, Pl. 19.2; and USNM 480422, Pl. 58.5–58.6.

Occurrence.—Localities where the species was collected are shown in Table 1.

Etymology.—*Magnus,* Latin, large or great; referring to the relatively large size of the species.

PERONIDELLA(?) sp. cf. P. MAGNA new species

Plate 19.3; Plate 37.9, 37.11–37.12

Description.—Largest fragment of this sponge 45 mm high, with outer diameter of 35 mm; very wide spongocoel with diameter of 23 to 27 mm. Exterior of sponge and spongocoel clearly annulate, and internal and external annulations at same levels in skeleton (Pl. 19.3). Sponge wall relatively thin, only 3 to 6 mm thick, and similar to other species of *Peronidella;* wall of fine skeletal fibers with dominantly vertical orientation. Outer surface of sponge bears some pores approximately 0.3 mm in diameter (Pl. 19.3). On side where pores developed or recognizable, sponge partially overgrown by another smaller sponge (Pl. 19.3), which shows same perforation pattern. Theoretically, sponge could have been encrusted by another pore-bearing organism; sponge wall on this side approximately double thickness that of other side, but extensions of skeletal pores through wall indicate that they belong to sponge.

Skeletal dimensions essentially like that of *Peronidella magna* with pores and skeletal tracts 0.15 to 0.30 mm across in moderately regular pattern, but major canals lacking in skeleton. Exhalant pores aligned in margin of spongocoel to produce moderately strong vertical orientation to skeleton. Pores on exterior somewhat larger, 0.3 to 0.5 mm in diameter, separated by skeletal tracts 0.1 to 0.2 mm across. These ostia do not continue as canals into interior, however. Porous skeleton reticulate locally, appearing almost rectangular in regularity of spacing of skeletal pores and skeletal segments. Prominent horizontal or vertical canals lacking within relatively thin walls of sponge.

Discussion.—The sponge is similar to *P. magna* but differs from all other specimens described as *P. magna*, especially by development of distinct pores on the surface of the sponge. The assignment of this species to *Peronidella* is uncertain.

Material.—Three figured specimens.

Figured specimens.—USNM 463665, from the shale below bed 3 of Section I, east of Section E, and 480410 from Section J, bed 17.

Occurrence.—One figured specimen from the shale below bed 3 of Section I, and one figured specimen and one reference specimen, USNM 463666, from Section J, bed 17.

PERONIDELLA MULTIOSCULATA new species

Plate 19.8–19.11; Plate 20.4, 20.6; Plate 47.3; Plate 52.1; Plate 61.4–61.6

Synonymy.—*Hikorocodium* sp. Driggs, 1977, p. 44–52, fig. 10C–D, and 11C.

Diagnosis.—Tiny, twiglike sponges with 3 to 6 spongocoels; oscula may be locally oriented radially to produce starlike pattern. Inhalant and exhalant canals lacking; fine reticulate fibrous skeleton developed around spongocoel.

Description.—Individual branches of multi-branched, bushlike sponge usually approximately 5 mm in diameter; branching pattern in which several branches arise from one point typical of species. Second-order branches diverge immediately from first-order ones following same pattern (Pl. 20.6). First- and second-order branches have same diameter as main stem. Holotype 15 mm high, with 6 branches that diverge from common point (Pl. 20.4, 20.6); whole specimen with diameter of 15 mm in upper part.

Three to six distinct oscula situated on summit of each branch stem and commonly arranged radially, producing starlike opening. Diameters of whole oscular complex range between 1 and 2 mm. Individual oscula 0.2 to 0.6 mm in diameter. Proportion of width of spongocoel complex to whole stem ranges between 18 and 23 percent.

Walls around spongocoels to 1.5 mm thick, composed of finely reticulate fibrous structure. Fibers range from 0.05 to 0.06, most being 0.06 to 0.07 mm thick. Fibers form regular net that surrounds pores of basically two sizes: larger pores 0.10 to 0.14 mm across and perhaps short segments of only junction area of regular skeletal pores, which predominantly range from 0.06 to 0.08 mm in diameter, in general occurring as circular openings in skeletal structure.

Fiber segments circular in cross section where bounding pores occur but becoming somewhat irregularly rectangular and swelling to approximately 0.1 mm in diameter in junctions, but with considerable irregularity. Overall appearance of skeletal net regular and uniform, although without geometric predictability. Pores and fibers each occupy about one-half volume within the skeleton. Inhalant and exhalant canals lacking. Skeletal microstructure spherulitic with closely packed aragonitic spherulites 60 to 100 μm in diameter.

Dimensions of specimen pictured in Plates 19.10 and 19.11 differ from other available specimens. Individual branches of this specimen about 8 mm in diameter, and spongocoel complexes about 4 mm across. Oscula on summits of branches are next to large osculum, and because of radial arrangement, produce starlike pattern. All other features of this specimen correspond to those of other specimens, but because it is distinctly larger, assignment to *P. multiosculata* is uncertain.

Discussion.—*P. multiosculata* new species differs from most other Permian species of *Peronidella* by having many branches and especially by its several oscula and spongocoels (Table 8).

One of the additional distinctive features of the sponge is its relatively fine skeletal net, considerably finer textured than either of the other species included within *Peronidella*. This fine texture is evident both in sections across the branches and in the relatively small pores on the exterior. Pores of both dimensions, like those seen in the interior, show on the relatively smooth, fine-textured surface of the sponge, but even these large pores do not appear to connect to major canals within the walls of the small species. These pores are irregularly distributed over the surface as well as within the interior of the sponge, although they tend to be somewhat more common on the upper, rounded tips of the branches, and are most characteristically developed in the holotype. They are essentially lacking in the very fine, uniform textures of the paratypes.

Material.—Four specimens.

Type specimens.—Holotype, USNM 463667; and paratype USNM 480401, from Spot Locality 21A; paratypes, USNM 463668, from Spot Locality CF18, and USNM 463669, from Spot Locality T5.

Occurrence.—Two specimens from Spot Locality 21A and one specimen each from Spot Locality CF-18 and T5.

Etymology.—*Multus,* Latin, much or more; *osculum,* Latin, little mouth; because of the several oscula on the summit of each branch.

PERONIDELLA DIGITATA new species

Plate 19.4–19.6; Plate 47.4; Plate 52.2

Diagnosis.—Branched to digitate palmate *Peronidella,* with branches 6 to 11 mm in diameter and with single, narrow, spongocoel in each branch; skeletal fibers coarse and irregularly radial.

Description.—Multibranched, palmate, medium-sized sponges; holotype (Pl. 19.5–19.6) largest specimen with broken height of 40 mm, and branched dichotomously and fingerlike from single point. Diameters of individual branches in holotype range from 6 to 8 mm (Pl. 19.5), but branches of other specimens range from 6 to 11 mm in diameter.

Relatively narrow spongocoel, 1.0 to 1.5 mm in diameter, passing through individual branches, as observed in longitudinal section, and bounded by relatively thick walls up to 2.5 mm thick, but thickness somewhat variable, dependent upon diameter of stem and spongocoel. Wall formed by skeletal fibers with coarse, moderately irregular, radial arrangement; fibers relatively thick and ranging from 0.15 to 0.20 mm in diameter, swollen at junctions. Walls lacking canals. Skeletal pores range from 0.14 to 0.30 mm in diameter with most approximately 0.25 mm in diameter and arranged in irregular although dominantly horizontal, interconnected series.

Discussion.—Most Permian species of *Peronidella* are unbranched. For example, *Peronidella magna* new species, described here, is a steeply obconical species; and it is many times the size of the moderately small *Peronidella digitata* new species. At the other extreme, *Peronidella rigbyi* Senowbari-Daryan, 1991 is a tiny sponge only a few millimeters in diameter and is clearly separable from the branched, intermediate-sized species described here. *Peronidella multiosculata* new species is a branching species of the genus present in collections from Djebel Tebaga, but that sponge is a tiny, twiglike form with a cluster of multiple spongocoels on the summit of each branch. The holotype of that branched species is only 15 mm tall, and the branches are only 8 mm in diameter maximum. There seems little reason for confusion of the species. Comparisons with other Permian species of *Peronidella* are given in Table 8.

Material.—Six specimens.

Type specimens.—Holotype, USNM 480414, Plate 19.5–19.6, and paratypes USNM 463669–463670, from Spot Locality T5.

Occurrence.—Three type specimens from Spot Locality T5; three additional specimens from Spot Locality DJT-11 are also considered as probable representatives of the species.

Etymology.—*Digitatus,* Latin, having fingers or appearing digitate; in reference to the form of the branched species.

PERONIDELLA RIGBYI Senowbari-Daryan, 1991

Plate 11.3; Plate 47.5

Synonymy.—*Peronidella parva* Rigby, Fan and Zhang, 1989, p. 789–790, fig. 9.7–9.8 (*non Peronidella parva* Nutzubidze, 1964).

Peronidella rigbyi Senowbari-Daryan, 1991, p. 405.

Original diagnosis.—"Small, branching(?), cylindrical *Peronidella,* stems 4 to 6 mm in diameter with tubular spongocoel 1.2 to 2.0 mm across; skeletal fibers generally 0.2 mm across and skeletal canals of essentially the same dimensions; well-defined gastral layer and dermal armor" (Rigby, Fan, and Zhang, 1989, p. 789).

Description.—Single small specimen of species occurs in collection as broken fragment approximately 9 mm long, with a maximum diameter of 3.2 mm at oscular rim; broken base with essentially same diameter. Sponge somewhat annular and gently curved cylinder.

Skeleton pierced along entire length by cylindrical spongocoel 1.2 to 1.3 mm in diameter. Differentiated canals lacking in thin walls composed of relatively robust skeletal fibers 0.08 to 0.15 mm in diameter that form moderately coarse net around skeletal pores, 0.15 to 0.22 mm across. Skeletal pores may form short, linear series that commonly appear to be circular in cross section. Skeletal fibers generally expanded at spongocoel wall to produce somewhat more dense but very porous gastral layer. Dermal layer not well developed.

Discussion.—The species was initially differentiated by Rigby, Fan, and Zhang (1989, p. 789–790) based on specimens from the Permian of China. The species is certainly among the smallest representatives of *Peronidella* in the Paleozoic, and, as was noted in the original description and discussion, it is much smaller than the associated species of the genus known from the Permian of China. Wu (1991, p. 61–64) proposed several species of *Peronidella,* but these, too, are larger or more irregularly shaped forms than the small cylindrical *Peronidella rigbyi* Senowbari-Daryan, 1991. Dimensions of the other species of the genus known from the Paleozoic are given in Table 8.

Material.—One specimen.

Figured specimen.—USNM 480375, Spot Locality 4A.

Occurrence.—One specimen from Spot Locality 4A.

Genus PARONADELLA new genus

Diagnosis.—Sponge single or branched, cylindrical with spongocoel that passes nearly through whole sponge. Inhalant and exhalant pores or canals lacking, but with interconnected interfiber spaces within sponge wall. Spicular skeleton composed of di-, tri-, or tetraclones not united with calcareous cement.

Type species.—*Peronidella proramosa* Hurcewicz, 1975.

Etymology.—In honor of C. F. Parona, who described the Permian inozoid sponges from the Sosio Valley, Sicily.

Genus RADIOFIBRA new genus

Diagnosis.—Cylindrical to subcylindrical sponges, branched in few specimens, all with very narrow, deep, central spongocoel. Interior fibrous skeleton with poorly defined arrangement in transverse cross sections but having upwardly divergent, jet-of-water arrangement in longitudinal section. Spaces between fibers appear as canals that diverge upward and outward toward periphery. Short lateral canals may also occur. Microstructure of rigid skeleton composed of spherulites.

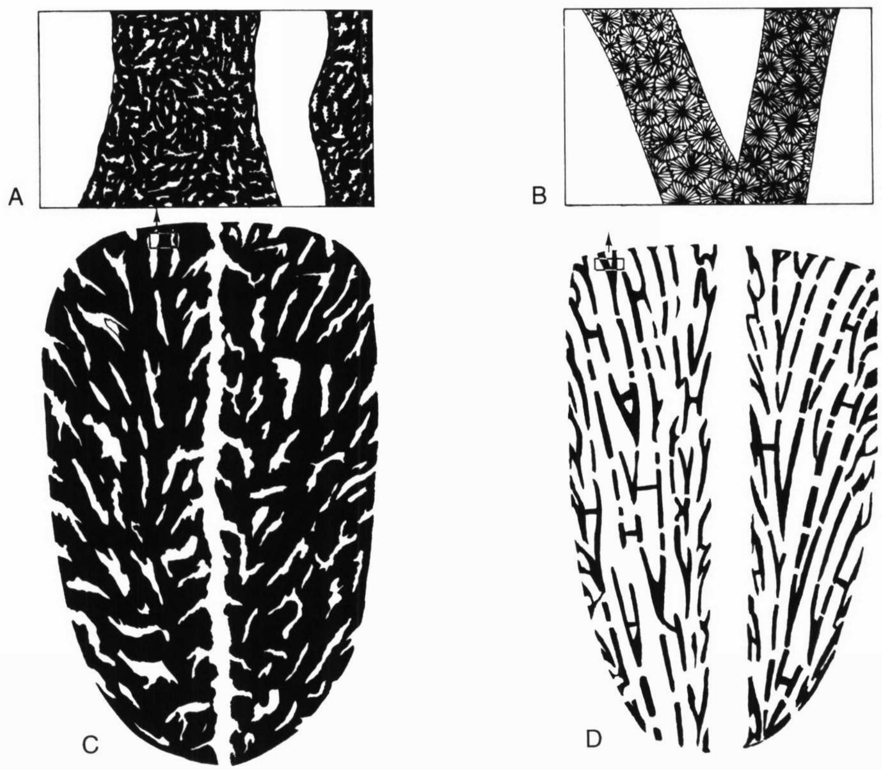

Figure 24. Longitudinal sections through *Saginospongia* new genus (*C*) and *Radiofibra* new genus (*D*) show the differences between the rigid skeleton of the two genera. The strands of *Saginospongia* are subdivided into smaller fibers (*A*) and show a vermipore structure. The strands of *Radiofibra* are composed of partially packed spherulites (*B*). In *Radiofibra* the skeletal fibers are also preferentially oriented parallel to the sponge axis (schematic, not to scale).

Discussion.—*Radiofibra* is very similar to *Peronidella* but differs from the latter by having a clearly defined, upwardly divergent skeletal and pore structure that resembles canals in longitudinal section (see Fig. 24). In *Peronidella* the fibers have a reticular arrangement.

Radiofibra may look somewhat like *Djemelia* as well, but *Djemelia* commonly has an outer dermal layer with numerous ostia, many of which occur on exaules, tubelike structures that are not developed in *Radiofibra.* In addition, *Djemelia* has a reticular, fibrous skeleton rather than one of simple, upwardly divergent, elongate fibers.

Permocorynella may appear somewhat similar from the exterior, but *Permocorynella* has prominent horizontal, upwardly arched canals in addition to the upwardly and outwardly radiating structure in the walls of the sponge. These walls in *Permocorynella* have a very fine, fibrous, skeletal structure in contrast to the relatively gross fibers and pores in *Radiofibra*. Differences between *Radiofibra* and *Saginospongia* are treated in discussion of the latter genus.

Type species.—*Radiofibra lineata* new species.

Etymology.—*Radiatus,* Latin, rayed, beaming radially; *fibra,* fiber; in reference to the radially arranged fibrous skeleton.

RADIOFIBRA LINEATA new species

Plate 20.1–20.3; Plate 22.7–22.9; Plate 47.6; Plate 54.5–54.6

Diagnosis.—Cylindrical to subcylindrical sponges with rough exterior produced by coarse fibers that internally show jet-of-water arrangement in longitudinal section around a relatively narrow, deep, central spongocoel. Skeletal fibers 0.2 to 0.8 mm in diameter and usually separated by 0.5 mm but range up to 1.2 mm apart, producing prominent upward and outward, canal-like structure.

Description.—Unbranched cylindrical to subcylindrical sponges with maximum diameters between 16 and 28 mm; largest specimen is holotype, 22 mm in diameter and 70 mm tall, a broken specimen whose original height was certainly more than 70 mm.

Outer surface of sponge rough, produced by irregularly arranged, coarse fibers visible to naked eye except where covered by sheets of encrusting chaetetids and skeleton only partly visible. Outer surface does not show any particular arrangement of fibers in either of the four type specimens.

Internal fibers of rigid skeleton show jet-of-water arrangement in longitudinal section, with fibers diverging upwardly and outwardly from margin of axial spongocoel toward periphery. Individual fibers arranged in lines about 1 mm apart and resembling walls of canals with separation between lines regular or parallel for distances of more than 20 mm. Lateral fibers connect dominantly vertical ones. Thicknesses of vertical fibers range from 0.2 to 0.8 mm, fibers being separated by small openings up to 1.2 mm in diameter but usually 0.5 mm across.

In transverse sections, fiber structure irregularly arranged or with poorly defined radial pattern. Skeletal microstructure aragonitic spherulitic, with spherulites approximately 100 μm in diameter.

Narrow central spongocoel, 2 to 4 mm in diameter, passes nearly through sponge, but lacks distinct wall. Spongocoel connected with openings in sponge wall by numerous small and irregularly arranged pores that correspond to skeletal pores between fibers.

Discussion.—Radiofibra lineata has a considerably coarser skeleton, composed of principally vertical fibers, than most other inozoid sponges. It contrasts with *Radiofibra delicata* new species in having considerably coarser skeletal fibers and a coarser-appearing skeleton in general. *Radiofibra lineata* also lacks the radiating, starlike canal pattern seen in *Radiofibra delicata.* Comparisons with other Permian sponges with which the genus and species might be confused have been treated under discussion of the genus.

Material.—Seven specimens.

Type specimens.—Holotype, USNM 463675, Pl. 20.1–20.2; Pl. 47.6, Section G, bed 4; paratypes, USNM 480350, from Section G, bed 4; USNM 463676, from Section I, bed 2; and USNM 480395, from Section E, bed 27.

Occurrence.—Djebel Tebaga, four specimens from Section G, bed 4; one specimen from Section I, bed 2; and two from Section E, bed 27.

Etymology.—Lineatus, Latin, of a line; referring to the linear fibrous structure of the skeleton.

RADIOFIBRA DELICATA new species

Plate 22.1–22.6; Plate 47.7; Plate 52.3–52.4; Plate 62.1–62.3

Diagnosis.—Single or branched sponges with cylindrical to subcylindrical shapes, commonly annulate; narrow central spongocoel passes nearly through whole sponge. Skeletal fibers fine and arranged as in *Radiofibra lineata* in longitudinal section, but with few large exhalant canals that converge on spongocoel and lead between irregularly arranged fibers. Outer surface of sponge with very fine circular or polygonal ostia.

Description.—Diameters of cylindrical to subcylindrical species range from 10 to 27 mm; some specimens branched. Holotype is broken specimen 27 mm in diameter and 25 mm tall.

Outer surface of most specimens shows annulation, although not developed in type species, *Radiofibra lineata.* Outer surface covered by small circular or polygonal openings 0.12 to 0.35 mm in diameter.

In longitudinal section, spongocoel and arrangement of skeletal fibers resemble those in *Radiofibra lineata,* fibers and spaces between them being much finer. Fibers usually 0.04 mm thick but range to maximum diameter of 0.2 mm and branch upward and toward periphery; fibers very regularly spaced in outer part.

Fibers have irregular reticular structure in transverse sections, as in *Radiofibra lineata,* but also show poorly defined radial pattern. Starlike canal system clearly developed around spongocoel, with radial canals branched toward periphery. Starlike canal system not observed in *Radiofibra lineata.* Diameters of canals 0.8 mm.

Specimens of this species generally recrystallized, but microstructure of rigid skeleton locally preserved, composed of spherulites 50 to 70 μm in diameter.

Discussion.—Radiofibra delicata differs from *R. lineata* by having a much finer fibrous skeletal structure, by homogenous perforation of the outer surface, and by the starlike canal system radially arranged around the spongocoel.

Material.—Nine specimens.

Type specimens.—Holotype, USNM 463671, Pl. 22.3–22.4; Pl. 62.1–62.3, Section J, bed 25; and paratypes, USNM 463672–463673, Section G, bed 4, and USNM 463674 from Spot Locality DJT-8.

Occurrence.—Djebel Tebaga, one specimen from Section C, bed 16; two from Section G, bed 4; two from Section G, bed 5; two from Section J, bed 17; one from Section J, bed 25; and one from Spot Locality DJT-8.

Etymology.—Delicatus, Latin, dainty, soft; in reference to the small size of the species.

RADIOFIBRA NODOSA new species

Plate 23.3; Plate 47.9; Plate 52.5; Plate 61.1

Diagnosis.—Branched to massive, nodular sponges, each branch with shallow spongocoel into which irregularly vertical canals empty; parallel canals with ostia on upper surface limited by coarse, uneven, but dominantly upwardly divergent skeletal fibers; transverse canals rare or obscure in coarse, irregular skeleton.

Description.—Holotype (Pl. 23.3) with diameter of about 8 cm and height of approximately 5.5 cm, composed of several branches each about 1.5 cm in diameter and differentiated at tip from central massive sponge. Summit of each branch with osculum to spongocoel 1.0 to 1.5 mm in diameter, with obscure to moderately well-developed and radially arranged, short, convergent grooves 0.2 to 0.5 mm wide of canals around oscula. Spongocoel shallow, irregularly walled; upwardly convergent exhalant canals 0.4 to 0.5 mm in diameter open in irregular base in porous, coarsely fibrous skeletons.

Canals and skeletal pores irregular in interior and gradational in coarse, porous skeleton; canals generally coarse, 0.4 to 0.7 mm in diameter, and more tubular and continuous; skeletal pores commonly irregularly polygonal to rounded, 0.1 to 0.4 mm across. Canals usually upwardly divergent with circular ostia on branch slopes and crests as well as in intervening depressions. Some ostia in craterlike pits that may be circular to irregularly polygonal. Horizontal or transverse canals locally developed, short, 0.2 to 0.6 mm in irregular diameter, mainly upwardly and outwardly cross connected, or may curve upward to become longitudinal, but transverse canals not major elements in skeleton.

Skeletal fibers range irregularly 0.1 to 0.4 mm across, mainly upwardly and outwardly divergent in variable patterns; may appear sinuous, beaded and lumpy to porous, uneven; without common, regular, cross-connecting fibers. Skeletal microstructure of specimen examined in SEM poorly preserved, but small spherulites 30 μm in diameter still recognizable.

Discussion.—*Radiofibra nodosa* new species differs from other species of the genus in its compound growth form and relatively shallow spongcoels. Its skeleton is considerably coarser textured than that of *Radiofibra delicata* new species and is much more irregular and less distinctly canalled than the type species *Radiofibra lineata* new species.

Radiofibra nodosa is externally similar to *Permocorynella fruticosa* new species. The latter has a fine, reticulate, regular skeleton rather than the coarse, irregular, fibrous skeleton of *R. nodosa*. *Permocorynella ampliata* is also a branched compound species in the Djebel Tebaga collection, but it has a finer, reticulate, though vertically dominant skeleton and well-defined transverse canals.

Material.—One specimen.

Type specimen.—Holotype, USNM 480301, Pl. 23.3; Pl. 47.9; Pl. 52.5, from Section G, bed 5.

Occurrence.—One specimen from Section G, bed 5, 100 meters north of CF-53.

Etymology.—*Nodosus,* Latin, full of knots or swellings; in reference to nodular or irregular lumpy growth form of the sponge.

RADIOFIBRA INORDINATA new species

Plate 30.2, 30.9; Plate 47.8; Plate 52.6; Plate 55.5–55.6; Plate 62.4–62.5

Diagnosis.—Irregularly branched to palmate sponges with irregular narrow axial spongocoels in each branch, with ostia at tips of branches near centers of convergence of prominent, vertical, surficial canals; axial canals few, 0.5 to 0.8 mm in diameter, narrowing at depth; surface marked by prominent subparallel surface canals up to 1.1 mm wide that converge to summit of tips or to blade crests; convergent exhalant canals to 0.6 mm in diameter as transverse openings; inhalant pores and canals in two series, larger ones being 0.2 to 0.4 mm in diameter as ostia on ridges between and in surficial canals.

Description.—Moderately rare sponges with irregular growth, laterally radiate to irregularly vertically palmate. Holotype with radiate cluster of branches to 20 mm long and 15 to 18 mm wide at base, cluster approximately 65 mm wide and 25 mm high as distinctly digitate sponge. Paratype bladed and palmate to 45 mm high but with broken base, but only 20 mm thick, with branches 15 to 20 mm wide to 10 mm thick and 10 mm high on palmate base.

Both type specimens marked by surficial canals or grooves, 0.4 to 1.1 mm wide and up to 0.5 mm deep at maximum. Numbers of grooves dependent upon size of stems or branches, up to 12 grooves on smaller branches and up to 18 on larger branches. Branches spaced 0.3 to 2.0 mm apart with flat ridges between. Grooves irregularly sinuous to nearly straight, roughly radial downslope; a few branch distally, but most being unbranched traces. Groove lengths range 2 to 3 mm in a few and up to 20 mm long on some of larger branches. Locally, grooves are walled over to become internal canals. Grooves gradually narrow and shallow distally from the branch tips.

Ostia 0.5 to 0.8 mm in diameter clustered side by side only locally in grooves of coarse, exhalant canals. Generally, such openings and inhalant ostia scattered.

Convergent exhalant canals unwalled and 0.5 to 0.6 mm in diameter, transverse to principal fibrous skeleton and generally curving upward into spongocoel margins, but elsewhere same size canals curving downward, as though functioning as separate exhalant openings onto lateral slopes of sponge.

Inhalant openings of two series: finer, generally skeletal pores 0.10 to 0.15 mm in diameter and irregular; and somewhat coarser canals, 0.2 to 0.4 mm in diameter showing on both surface and in fibrous interior where smaller openings occur in intimate, vermiculate association as both transverse and longitudinal openings in skeletal structure.

Skeleton irregularly upwardly and outwardly divergent, relatively coarse, with reticulation having upwardly divergent fibers dominant. Fibers 0.08 to 0.10 mm in diameter, away from canals as smooth, curvilinear elements defining skeletal pores, 0.10 to 0.15 mm in diameter; as circular, laterally connected openings in cross section, but forming porous, irregularly vermiculate structure thoughout the sponge. Fibers with spherulitic microstructure, with spherulites ranging 60 to 70 μm in diameter.

Discussion.—*Radiofibra inordinata* new species is probably most similar to *Radiofibra nodosa* new species in its generally complex, branched forms but differs from that much more compact species in having greatly reduced numbers of canals in the axial clusters, prominent surficial grooves on all of the branches, and a well-defined inhalant canal system.

Radiofibra delicata new species has a considerably finer-textured skeleton and a more simple, ramosely branched, growth form. *Radiofibra lineata* new species, the type species, is a cylindrical to subcylindrical sponge with very coarse fibers arranged in regular, upwardly expanding, jet-of-water arrangement, as seen in longitudinal section, and a more tubelike arrangement than that of *Radiofibra inordinata.*

To some degree the species may appear somewhat similar to a very coarse *Stellispongiella bacilla* (Termier and Termier, 1955), but the relatively coarse, fibrous skeleton in the species described here contrasts sharply with the more delicate, fine, reticulate skeleton of that species.

Material.—Two specimens.

Type specimens.—Holotype, USNM 480356, Spot Locality S1, Djebel Tebaga, Pl. 30.2, 30.9; Pl. 47.8; Pl. 52.6; paratype, USNM 480376, from the same locality.

Occurrence.—Djebel Tebaga Spot Locality S1 is the only locality from which the species is currently known.

Etymology.—Inordinatus, Latin, not arranged, disorderly, or irregular; referring to the somewhat irregular growth form demonstrated particularly by the holotype.

Subfamily PERMOCORYNELLINAE new subfamily

Diagnosis.—Axial spongocoel extends virtually through sponge; inhalant and exhalant canals present as regular or irregular tubes.

Type genus.—Permocorynella new genus.

Genus PERMOCORYNELLA new genus

Diagnosis.—Spherical, mushroom-, or club-shaped sponge with one or two oscula in summit, usually extending as spongocoel deep into sponge; starlike and radially arranged grooves may surround osculum. Several vertical exhalant canals in base of sponge terminate at base of spongocoel (see Fig. 25). Horizontal inhalant canals well defined near periphery of sponge; exhalant canals end in spongocoel. Additionally, upwardly and outwardly divergent canals may occur as exhalant canals. Inhalant pores on exterior of sponge may be arranged in vertical or horizontal lines. Dermal or outer lower surface of mushroom-shaped specimens without pores but with distinct growth lines. Relatively fine skeletal fibers fill in regular to reticulate net space between canals. Skeletal mineralogy originally primarily aragonite with spherulitic microstructure.

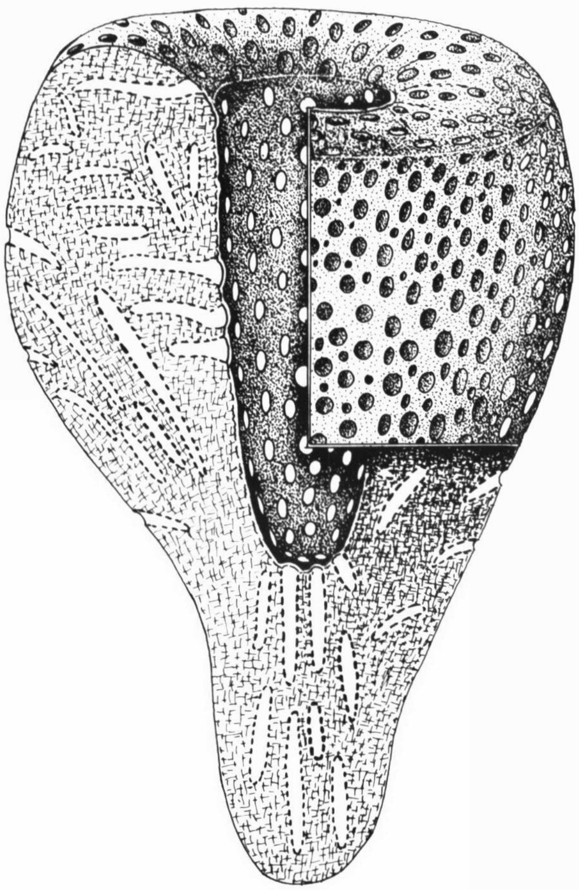

Figure 25. View of the exterior and interior of *Permocorynella ovoidalis* (Parona, 1933). The sponge has an axial spongocoel that continues toward the base as a bundle of exhalant tubes. Exhalant and inhalant canals and other vertical tubes are well developed (schematic, not to scale).

Discussion.—Corynella is a typical Jurassic to Upper Cretaceous sponge. The genus was established by Zittel (1878, p. 35), who noted the occurrence of rodlike and triactine spicules in species of the genus. Later workers have mentioned the occurrence of diactine and triactine spicules in Jurassic species of *Corynella* (Hinde, 1893; Wagner, 1964a, 1964b; Hurcewicz, 1975). No spicules are known to occur in species of Triassic and Permian *"Corynella"*, however, and we have grouped these species into the new genus *Permocorynella.*

"Corynella" was first reported from Permian rocks by Parona (1933). The species *Corynella ovoidalis* was described by Parona (1933) from Sicily, is characterized by only one axial canal or spongocoel, and certainly appears to have the form of *Corynella. Corynella crysanthemum,* described by Parona (1933) from the Permian of Sosio Valley, Sicily, was placed in *Precorynella* by Termier and Termier (1977a), for it has an axial bundle of canals as is typical of the genus *Precorynella* Dieci, Antonacci, and Zardini (1968).

All Permian and Triassic species included here have been previously assigned to the genus *Corynella* Zittel, 1878. Zittel (1878, p. 36) gave a list of Triassic sponge species he included in *Corynella.* However, the affiliation of all the species listed by Zittel (1878, p. 36) and those described by later workers should be checked again.

Some specimens of *Permocorynella* may appear to be similar to the sphinctozoan *Preverticillites,* where the unbranched exhalant canals are regular and give a pseudochambered appearance in longitudinal section. Upwardly divergent canals that interrupt the regularity are characteristic of *Permocorynella.* They cut across several skeletal units that appear to be chambers. In transverse sections radial canals are common openings in *Permocorynella.*

Type species.—Corynella ovoidalis Parona, 1933.

Etymology.—Named for *Corynella*-like appearance of inozoid sponges occurring in the Permian and Triassic.

PERMOCORYNELLA OVOIDALIS (Parona, 1933)

Plate 24; Plate 25; Plate 27.1, 27.5, 27.8; Plate 28.7–28.9; Plate 48.1; Plate 52.7; Plate 74.2–74.5; Figure 25

Synonymy.—Corynella ovoidalis Parona, 1933, p. 36, pl. 8, fig. 15–16.

Diagnosis.—Pear- or club-shaped sponges with single cylindrical to funnel-like, deep spongocoel that extends to near base of sponge. Spongocoel extends upward from bundle of vertical exhalant canals at base; canals connect to inhalant canals that pierce sponge walls and pass upward in jet-of-water pattern to ostia on exterior; skeleton between canals very finely fibrous. Canals connected with intercanal skeletal openings between fibers by very small pores. Exterior with ostia.

Description.—Pear- or club-shaped, rarely umbrellalike, ranging from 10 to 45 mm in diameter. Smallest specimen in Tunisia collection 15 mm and largest one 50 mm high. Characteristic specimen of species with maximum diameter of 21 mm in middle and diameter of 15 mm at top, with incomplete height of 31 mm.

Umbrellalike specimens usually with smooth bases, but pear-shaped ones irregular to rough. Exterior with numerous ostia 0.2 to 0.8 mm in diameter.

Relatively narrow spongocoel extends upward into funnel-shaped osculum. Deep spongocoel begins near base above several vertical exhalant tubes, with diameters up to 0.8 mm, that extend up through lower quarter of sponge. Spongocoel diameter varies as diameter of whole sponge and ranges from 2 to 8 mm in our specimens. Spongocoel not defined by distinct gastral wall.

Relatively thick walls around spongocoel perforated by canals of two orientations; first set includes radial inhalant and exhalant canals that generally parallel top of sponge wall and rise upward from exterior to spongocoel; canals may branch. Second set subvertical and diverge upward and outward from spongocoel to exterior, and generally perpendicular to exhalant or inhalant canals. Diameters of both canal sets almost same and range from 0.3 to 0.6 mm. Walls of both canal sets pierced by very small pores with diameters of approximately 0.8 mm. Spaces between canals filled by very fine, fibrous structure. Microstructure spherulitic but poorly preserved in available sections. Figure 25 shows the main characteristics of *Permocorynella ovoidalis* (Parona).

Discussion.—*Permocorynella* is a relatively abundant sponge in Djebel Tebaga and is also moderately common in Middle Permian deposits of the Sosio Valley in Sicily. Apparently *Permocorynella* is rare among sponges in the Permian reefs of China. Rigby, Fan, and Zhang (1989) described only one questionably identified species of *Permocorynella* (there described as *Corynella*) from Upper Permian reefs of the Changxing Formation in Guangxi.

Permian *Permocorynella ovoidalis* (Parona) was the first species of *Corynella* described from the Permian. Deng (1982a, p. 248, pl. 2, fig. 1A–C) described *Corynella gusongensis* from the Lower Permian of southwestern China. Deng (1990, p. 317–318, 319–320, pl. 1, fig. 2A–C), however, also described the new genus and species *Corynospongia tubuliforma*, perhaps from the same Lower Permian locality in southern Sichuan. These appear to be similar or even the same species. The family affinity of *Corynospongia* is uncertain.

Material.—82 specimens.

Figured specimens.—USNM 463681–463691, 480262–480265, 480333–480336, 480379, 480394, and 489395, from several localities, as noted in explanations of Plates 24–25, 27–28, 48, 52, and 74.

Occurrence.—The species occurs widely, in 21 localities in Djebel Tebaga (Table 1) and in the Sosio Valley in Sicily.

PERMOCORYNELLA OSCULIFERA new species

Plate 26.1–26.11; Plate 48.2; Plate 52.8

Diagnosis.—Club-shaped to conical sponges, each with one or two shallow spongocoels or oscula on summit and restricted to upper part of sponge, not extending deeply into sponge. Exhalant canals 0.4 to 0.6 mm in diameter arch upward to spongocoel or osculum, and surficial furrows converge in astrorhizal-like pattern on summit. Pores of two sizes numerous on outer surface, with larger ostia locally in horizontal rows as openings to horizontal canals. Interior of sponge characterized by prominent subhorizontal to upwardly arched, convergent, exhalant canals interrupting regular, upward and outward but reticulated skeletal fibers; fibers paralleled by small canals 0.15 to 0.20 mm in diameter that diverge upward toward periphery of sponge.

Description.—Conical or club-shaped sponges ranging 12 to 70 mm high, with diameters of 12 to 39 mm. Holotype a club-shaped specimen 70 mm tall and with maximum diameter of 36 mm at the top, but only 9 mm wide at its base. Holotype and some smaller specimens with annulated exterior.

Outer surface with abundant pores of two sizes. Larger pores or ostia circular to elliptical or sometimes crescentlike, with diameters commonly approximately 0.7 mm, but ranging from 0.5 to 0.9 mm. Larger pores generally distributed irregularly on exterior but also may be arranged in horizontal lines around sponge. Smaller pores represented by interfiber spaces generally circular, elliptical, or polygonal in outline with diameters of 0.10 to 0.25 mm.

Summit of sponge characterized by relatively shallow spongocoel to narrow osculum, up to 8 mm in diameter in larger specimens, but narrower in smaller specimens. Osculum elliptical in holotype measuring 5 by 10 mm. Some specimens with two oscula on summit.

Top of sponge flat to moderately arched. Several furrows of astrorhizal-like canals converge from periphery of sponge toward oscula; furrows approximately 0.5 mm wide and 0.3 mm deep. Furrows a surficial expression of upwardly arcuate canals prominent in interior of sponge.

Osculum does not continue far down into sponge as deep spongocoel but restricted to upper part and may extend to maximum of 20 mm, as observed in one specimen (Plate 26.1). Earlier stages filled by skeleton and canals of exhalant system.

Bundle of exhalant canals or tubes, each 0.4 to 0.5 mm in diameter, extends irregularly from near base of sponge up to osculum. These vertical canals parallel in axial part but converge from periphery in lower and intermediate parts of sponge. Other series of prominent, subhorizontal to upwardly arched canals 0.4 to 0.6 mm in diameter, converging radially from periphery, with ostia on exterior, and open as exhalant pores in spongocoel walls. Very small canals 0.15 to 0.20 mm in diameter occur parallel to and between large canals and end as small interfiber pores on the exterior. Walls between canals 0.05 to 0.10 mm thick and pierced by numerous small pores 0.05 to 0.15 mm in diameter. Walls of large canals also with similar size pores.

Fibers of the skeleton form prominent, uniform net that expands upward. Fibers appear more continuous longitudinally and spaced uniformly 0.15 to 0.20 mm apart; cross connected by less prominent and more discontinuous horizontal fibers spaced 0.20 to 0.25 mm apart; fibers spool-like, thin in midsegment but expanding in intersections to 0.10 to 0.14 mm across. Fiber junctions expand at margins of horizontal canals up to 0.15 to 0.20 mm and locally form porous walls. Microstructure spherulitic but poorly preserved in type specimens.

Discussion.—The external appearance and dimensions of this sponge are similar to *Heliospongia finksi* Termier and Termier, but *Permocorynella osculifera* lacks a deep axial spongocoel and has a different pattern of large canals within the interior of the sponge. In addition, *Heliospongia* is a demosponge, and no spicular skeleton has been found in *Permocorynella osculifera* new species.

Permocorynella osculifera new species differs from *Permocorynella ovoidalis* Parona, 1933 by having a distinctly shallower spongocoel and generally being more steeply obconical. The convergent subhorizontal canal sets in *P. ovoidalis* are somewhat coarser, but, perhaps more significantly, *Permocorynella ovoidalis* has much more prominent and coarser, upwardly and outwardly diverging canals, essentially at right angles to the upwardly arched horizontal series so prominent in *Permocorynella osculifera*. Canals of this set, parallel to the upwardly and outwardly divergent, reticulate skeletal structure, are only one-half or one-third the size in *Permocorynella osculifera* that they are in *Permocorynella ovoidalis*.

Material.—Six specimens.

Type specimens.—Holotype, USNM 463635, Plate 26.7–26.9, Section E, shale below Reef 3; paratypes 463632–463634, 463636, from localities as shown in explanations of Plates 26, 48, and 52.

Occurrence.—Djebel Tebaga, two specimens from Spot Locality 204-1976, two from Spot Locality 21A-23A, and two from Section E, shale below Reef 3.

Etymology.—*Osculum*, Latin, little mouth; *fero*, bear or carry; named for the presence of one or two small oscula on the summit of the sponge.

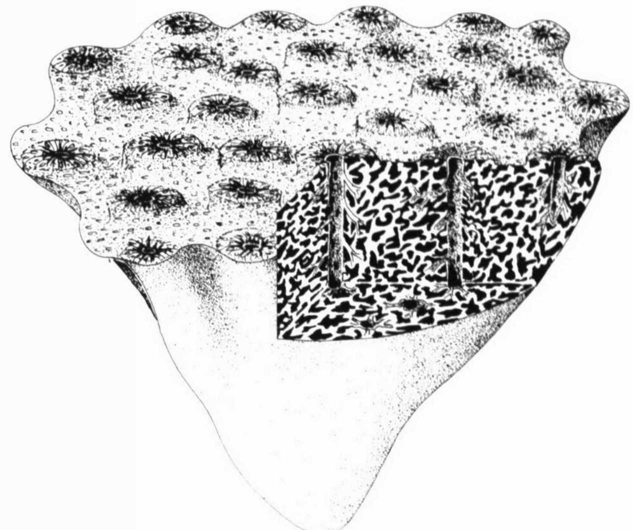

Figure 26. View of the side and summit of *Permocorynella fruticosa* new species, which appears as one colony but is composed of several stems that are recognizable only where separated at the summit of the colony. Each stem has an osculum, which is the opening of a small, deep spongocoel that extends downward from the oscular margin (see longitudinal section). Radially arranged grooves extend from the spongocoel margin toward the periphery of individual stems. The exterior is smooth and does not have any perforations, but the summit is covered by numerous inhalant pores. The skeleton is composed of reticularly arranged skeletal fibers (not to scale).

PERMOCORYNELLA FRUTICOSA
new species

Plate 23.1–23.2; Plate 48.3; Plate 65.3; Figure 26

Diagnosis.—Large, globular to massively branched sponges, with stems 1.0 to 1.5 cm in diameter diverging from common base. Each with osculum 2.0 to 3.5 mm in diameter at upper end of shallow spongocoel, into which converge inner ends of essentially radial canals that swing upward or rise vertically into spongocoel; inhalant canals 0.3 to 0.5 mm in diameter. Numerous vertical, walled canals 0.3 to 0.5 mm in diameter occur between radial, horizontal series that may be vertically aligned in outer part of sponge. Skeleton fine, regularly uniform, fibrous net.

Description.—Species includes some of largest inozoid sponges collected from Djebel Tebaga. Globular to massively obconical sponges composed of several branches that grew upward and radiated more or less from common point at base. Holotype (Pl. 23.2) with diameter of approximately 6 cm and height of about 5 cm, composed of more than 25 branches, each approximately 1.0 to 1.5 cm in diameter. Largest paratype 14 to 15 cm across and 9 cm long. Stems closer together in central area, ranging from 1.0 to 1.7 cm apart, with separations greatest in outer part of cluster where depressions between branches also deepest and most distinct.

Each stem with circular to oval osculum 2.0 to 3.5 mm in diameter situated on highest point of summit, as upper end of walled and well-defined, though shallow, spongocoel to 5 mm deep (Pl. 23.1). Lower part commonly with star-like transverse sections produced by radially arranged, convergent, transverse canals, that appear as grooves around oscula on immature summits of branches. Reconstruction showing characteristics of species in longitudinal and transverse section illustrated in Figure 26.

Radial canals may converge toward osculum from periphery, but upper branches generally lacking such surficial canals. Where such canals absent, may have been buried in skeleton by dermal layer, such canals being developed in sponge interior. Where present, as on some branches in paratype, canals 0.2 to 0.5 mm wide near osculum, extending 1 to 2 mm radially where narrow and shallow. These canals in interior curve upward from horizontal to meet spongocoel either vertically, in center, or at 45° to 60° to spongocoel wall or its trend. These walled canals generally 0.4 to 0.5 mm high in upper part of interior, where well preserved.

Summits of individual stems, as well as spaces between them, covered by numerous small inhalant ostia 0.3 to 0.5 mm in diameter, ostia may occur in bottoms of V-shaped or craterlike pits, up to 0.7 mm wide at upper edges, that may be up to 0.5 mm deep, where dermal layer well developed on upper surface. These canals walled and extending vertically down into skeleton. Segments of such canals occur near base but probably not continuous from surface; ostia not in regular pattern.

Outer lower or dermal surface of sponge with coarse growth lines traceable around sponge. No pores evident in this surface. However, some indistinct vertical lines correspond to radiate fibrous structures of rigid skeleton.

Skeleton composed of relatively fine, reticulate, skeletal fibers in regular network with spherulitic microstructure, in which spherulites about 30 µm in diameter; fibers generally 0.08 to 0.10 mm thick on regular basis. Vertical dominance of skeletal fibers hardly recognizable, for network mainly regular, almost rectangular, athough vertical lines occurring locally on lower outer surface of fibrous origin. Skeletal pores generally circular and 0.10 to 0.15 mm in diameter; may appear linear, triangular, or rectangular in junction area and up to 0.2 to 0.3 mm across. General pattern one of regularity.

Discussion.—*Permocorynella fruticosa* new species includes some of the largest inozoid sponges collected from Djebel Tebaga. These massive, branched sponges contrast with most other species in the collection in having that growth form but are somewhat similar to *Radiofibra nodosa* new species. That species of *Radiofibra* is less distinctly branched, although nodose, and has a skeleton of very coarse, upwardly and outwardly divergent fibers, in contrast to the skeleton of fine, uniform, reticulate fibers that characterizes *Permocorynella fruticosa.*

Prestellispongia(?) fasciculata new species also has a somewhat similar growth form, but *Prestellispongia(?) fasciculata* new species has only rare horizontal canals, in contrast with the very common horizontal canals that characterize the species of *Permocorynella. Prestellispongia(?) fasciculata* new species has a skeleton of vertically dominant fibers, with short cross-connecting fibers, in contrast with the more or less fine, regular, uniform reticulate skeleton in *Permocorynella fruticosa. Prestellispongia* species, in general, lack or have only obscure, shallow spongocoels, in contrast to the moderately deep and well-defined spongocoels in *Permocorynella.*

Material.—Three specimens.

Type specimens.—Holotype, USNM 480300, Pl. 23.2; Pl. 48.3, Spot Locality DJT-23; paratype USNM 480299, from Section G, bed 5.

Occurrence.—Two specimens from Section G, bed 5, and one from Spot Locality DJT-23.

Etymology.—*Fruticosus,* Latin, bushy; in reference to the branched, clumped, or bushlike growth form of the species.

PERMOCORYNELLA TUBEROSA new species

Plate 19.7; Plate 20.5, 20.7; Plate 48.7; Plate 52.9–52.10

Diagnosis.—Small, branched, and low to more or less horizontally branched, radially lobate sponges with smooth dermal layer. Each stem or branch with one or more starlike clusters of exhalant canals of osculum to narrow spongocoel, 0.5 to 0.6 mm in diameter. Skeleton of reticulate fibers 0.03 to 0.04 mm in diameter that diverge distally, with upwardly and outwardly divergent fibers dominant in outer part of skeleton. Skeletal pores 0.04 to 0.06 mm in diameter.

Description.—Relatively small, low, horizontally to irregularly radially branched to tuberose-appearing sponges, each with several stems, 13 in holotype (Pl. 20.3), but only 5 or 6 in paratype (Pl. 19.7), branches in both being initiated from a single point. Stems mutually attached at base, but easily recognized by distinct branch tips on summit or periphery of sponge (Pl. 20.7). Each branch with separate, starlike osculum on tip.

Oscula of holotype (Pl. 20.7) usually having only one opening per stem, extending as spongocoels into sponge. Faint convergent grooves extending from outer edge toward osculum producing starlike appearance. Diameters of oscula approximately 1 mm, and that of whole, starlike, tangential canal clusters up to 4 mm, but spongocoel in interior 0.5 to 0.6 mm in diameter as porous-walled openings, to which moderately rare exhalant canals 0.2 to 0.3 mm in diameter converge.

Oscula of paratype (Pl. 19.7) with 5 to 8 individual openings, each 0.3 to 0.5 mm in diameter, where tip of sponge broken so internal exhalant canals exposed. Arrangement of those ostia produces starlike appearance to osculum. Only one starlike osculum with several such openings observed in holotype where tips not broken and where finely textured dermal layer more consistently preserved. Longitudinal section of paratype with divergent exhalant canals in skeleton, but ostia of canals not developed in dermal layer.

Skeleton immediately interior to fine, dermal layer locally exposed, with skeletal pores 0.12 to 0.25 mm in diameter on paratype, but dermal layer and main skeletal net as in holotype. Summit and exterior of holotype and much of paratype smooth, but with abundant small pores 0.04 to 0.06 mm in diameter, separated by reticulate fibers 0.02 to 0.04 mm across, with essentially pore and fiber dimension of exterior skeletal net, also being regular and finely textured with upwardly divergent structure. Interior skeletal pores 0.05 to 0.06 mm in diameter and with moderate alignment normal to dermal surface in outer part of skeleton, defined by fibers that elongate consistently upward and outward, cross connected by shorter fiber segments; longitudinal fibers traceable to 1 mm before being lost in net.

Discussion.—Branched radiate growth form of the species is distinct among the Permian inozoan sponges from Tunisia. It contrasts to the massive, more upward growth form of *Permocorynella fruticosa* new species. In addition, the distally divergent, linear skeletal makeup of *Permocorynella tuberosa* contrasts to the more regular, reticulate, fine skeletal structure of the globular *Permocorynella fruticosa.* Both have well-defined spongocoels, but dimensions of the canals and those spongocoels are different.

Peronidella multiosculata new species might appear superficially similar in some views, but *Peronidella* lacks prominent canals in the regular interior skeleton and differs in that respect from all species of *Permocorynella* where canals are prominent.

Material.—Two specimens.

Type specimens.—Holotype, USNM 480310, Pl. 20.5, 20.7; Pl. 48.7; Pl. 52.9-52.10; Spot Locality DJT5; paratype, USNM 480311, equivalent to shale below bed 3 of Section I, but west of traverse.

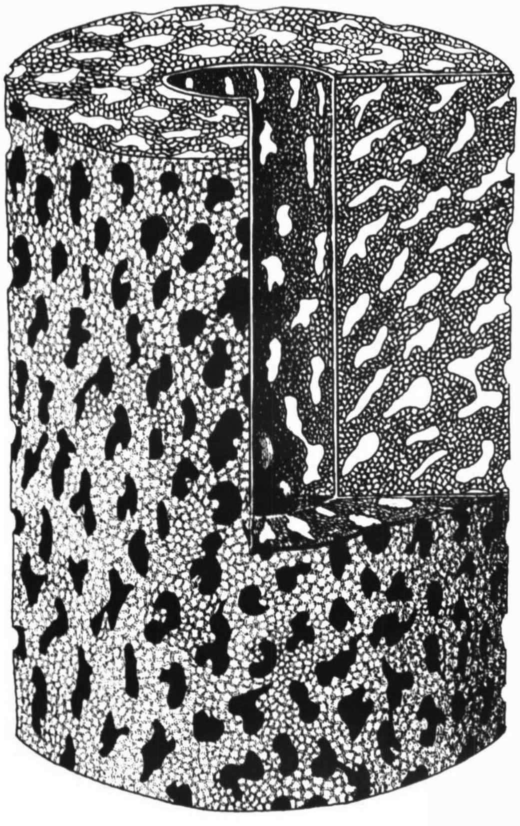

Figure 27. Exterior and generalized internal structure of *Saginospongia angusta* new species. Large openings on the exterior are shown as dark areas. The reticular skeleton between the large pores contains small, interfiber pores (schematic, not to scale).

Occurrence.—One specimen from Spot Locality DJT5; and one from the shale below bed 3 of Section I, but west of Section I and east of Section E.

Etymology.—*Tuberosa,* Latin, full of lumps or protuberences; calling attention to the irregular growth form of the species.

Genus SAGINOSPONGIA new genus

Diagnosis.—Possibly cylindrical to branched sponges with deep spongocoel in coarse, massive skeleton with radial pattern in transverse cross section, but having upwardly expanding, jet-of-water pattern in longitudinal section. Massive internal skeleton composed of very fine, reticulate, or sievelike elements. Microstructure uncertain.

Discussion.—*Saginospongia* looks very similar to *Radiofibra,* and the two could be easily confused. Both genera have a deep, central spongocoel and similar arrangements of skeletal fibers in both transverse and longitudinal section that is produced by similar arrangements of skeletal pores. The internal skeleton of *Saginospongia,* however, is composed of very fine reticular or sievelike fibers. These fine structures are lacking in *Radiofibra.* Additionally, the microstructure of *Radiofibra* is spherulitic, which was not observed in *Saginospongia.* Differences of the two genera are shown schematically in Figure 24.

Type species.—*Saginospongia angusta* new species.

Etymology.—*Sagina,* Latin, fish net; in reference to netlike or reticulate skeleton.

SAGINOSPONGIA ANGUSTA new species

Plate 22.10–22.11; Plate 48.8; Figure 27

Diagnosis.—Possibly cylindrical or branched sponges with coarse, massive, internal skeleton composed of very fine, reticulate or sievelike, fibrous structure. Narrow spongocoel with starlike cross section passes through sponge. Spaces between coarse, massive internal elements appear radially arranged in transverse section, but with upwardly expanding, jet-of-water pattern in longitudinal section.

Description.—Only two specimens of species found in our collection; holotype a branched specimen, 65 mm tall and with basal diameter of 30 mm and maximum diameter of 40 mm near top (Pl. 22.10). Branches defined by longitudinal furrows on exterior, but not separable in interior; one branch about 22 mm and other only 18 mm in diameter. Paratype is smaller specimen or only fragment 22 mm tall and 11 mm in diameter with same canal and skeletal characteristics as holotype. Outer surface rough, corresponding to coarse fibers and skeletal pores between them.

Interior with coarse, massive fibers 0.5 mm to 1.5 mm thick. Spaces between fibers small or narrow and arranged with jet-of-water structure in longitudinal sections, but with radial appearance in transverse sections.

Massive or coarse skeleton composed of very fine, fibrous, reticular structure visible only with microscope (see Fig. 27).

Axial spongocoel 1.2 mm in diameter passing through sponge body, and radially arranged interfiber spaces ending at spongocoel. Interfiber spaces branched toward periphery, with starlike appearance. Interfiber spaces arranged in jet-of-water pattern, in longitudinal section. Skeletal fibers recrystallized; microstructure of fibers unknown.

Discussion.—Comparisons with genera that appear similar have been treated in discussions of the genus. *Saginospongia angusta* new species can be differentiated from *Saginospongia porosa* by the relatively coarse canal and fiber tracts produced in the latter species. *Saginospongia porosa* is a very coarsely porous form that appears, from the outside, much like *Cavusonella caverna* Rigby, Fan, and Zhang, 1989.

Material.—Two specimens.

Type specimens.—Holotype, USNM 463677, Pl. 22.10; Pl. 48.8; paratype, USNM 463678, both from Section G, bed 5.

Occurrence.—Two specimens from Djebel Tebaga, Section G, bed 5, 100 meters north of CF53.

Etymology.—*Angustus,* Latin, narrow, tight, slender, thin; in reference to the relatively thin fibers of the skeleton.

SAGINOSPONGIA POROSA new species

Plate 11.4; Plate 22.12; Plate 48.9; Plate 52.11; Plate 75.1–75.3

Diagnosis.—Single sponge with coarse, massive, fibrous skeleton. Outer surface bears irregularly shaped openings of large dimensions. Axial spongocoel passes nearly through sponge; internal skeleton lacks predictable pattern in transverse or longitudinal sections.

Description.—Well-preserved holotype (Pl. 11.4; Pl. 22.12; Pl. 75.1–75.3), 53 mm tall and 28 mm in diameter in upper part, but only 22 mm in diameter in lower part; base broken. Sponge club shaped, with slight exterior annulation. One fragmental paratype 20 mm in diameter and 29 mm tall, fractured vertically, showing characteristics of spongocoel. Third reference specimen, a smaller fragment, showing only large openings and skeleton between them.

Exterior with oval to slitlike or irregularly shaped openings corresponding to ostia in irregular distribution on sponge surface. Ostia generally 1 mm in diameter; however, slitlike openings may be to 5 mm long and approximately 1 mm wide. Coarse, irregular, rigid skeletal tracts on exterior 1 to 3 mm wide fill spaces between openings.

Spongocoel approximately 7 mm in diameter in holotype and paratype, passing essentially through whole sponge. Naturally weathered paratype shows details of spongocoel and canal pattern where inhalant and exhalant ostia oval or irregular in outline; inhalant ostia 0.5 to 1.5 mm wide and in diameter, may occur in compound slits 4 to 5 mm long that include up to 4 to 5 ostia. Slits irregular to 1 to 2 mm deep. Exhalant ostia opening into spongocoel and 0.5 to 1.0 mm in diameter, not in slits but only poorly arranged in crude vertical series.

Somewhat more common smaller openings, 0.2 to 0.4 mm across, occur in inner part of skeleton as openings between tracts and larger exhalant ostia. Skeletal tracts on exterior and interior with essentially same general dimensions in moderately regular reticulate skeleton, individual fiber tracts being somewhat curvilinear around more or less circular pores. Dominant horizontal or vertical structure in alignment of either skeletal pores or tracts lacking.

Skeletal pores range 0.06 to 0.14 mm in diameter, but most openings 0.08 to 0.10 mm across and generally circular where small, but more irregular and elongate where somewhat larger, perhaps as junctions of interconnecting pores. Individual skeletal fibers range from 0.02 to 0.07 mm in diameter, with most being 0.04 to 0.05 mm across, expanding to as much as 0.10 mm across in junction areas between skeletal pores. Rigid skeleton between irregularly arranged canals composed of very thin, fibrous structures. Holotype investigated with SEM, but recrystallization has obscured skeletal microstructure.

Discussion.—The exterior of this sponge resembles *Cavusonella caverna* Rigby, Fan, and Zhang, 1989, but spaces between inhalant canals in *Cavusonella* are much longer than in *Saginospongia porosa* new species. In addition, the spongocoel that occurs in *Saginospongia porosa* is lacking in *Cavusonella. S. porosa* differs from *Saginospongia angusta* by having a much coarser skeleton and irregularly placed and much larger epirhyses or canals in the sponge wall. In addition to the irregular arrangement of skeletal strands, the wide spongocoel separates *S. porosa* from the type species, *S. angusta.*

Material.—Two, well-preserved specimens, the holotype and paratype, and two fragments.

Type specimens.—Holotype, USNM 463679, Pl. 11.4; Pl. 22.12; Pl. 75.1–75.3, Section G, bed 5; paratypes, USNM 463678, Section G, bed 5, and USNM 463680, Spot Locality 160-1976.

Occurrence.—Merbah el Oussif, three specimens from Section G, bed 5, at CF53; and one from Spot Locality 160-1976.

Etymology.—*Porosus,* Latin, full of holes; in reference to the large ostia on the exterior.

SAGINOSPONGIA CRATERIA new species

Plate 35.9–35.11; Plate 49.1; Plate 52.12

Diagnosis.—*Saginospongia* with moderately sized spongocoel and steeply obconical form perforated by coarse, irregular canals; exterior marked by numerous craterlike, coarse ostia up to 4 mm in diameter, which connect to prominent, irregularly horizontal canals that lead to irregularly sinuous vertical canals in general axial area. Broad skeletal tracts of uniform but not geometrically predictable fibers, and skeletal pores in fine net characteristic of genus.

Description.—Holotype steeply obconical, cylindrical sponge with upper oscular rim well preserved, base broken; sponge 38 mm high, expands upward from broken base 14 mm in diameter, to maximum diameter of approximately 24 mm at upper oscular rim.

Summit penetrated by irregular spongocoel, approximately 10 mm deep and 6 to 7 mm wide at oscular margin;

upper walls 8 to 10 mm thick near well-developed spongocoel. Vertical canals irregularly developed and with irregular courses in the middle third of diameter and parallel to axial region in lower sponge. Horizontal, irregularly radial, inhalant canals in outer part of sponge wall connect to vertical axial exhalant canals. Canals 2.0 to 2.5 mm in diameter in midwall and separated by skeletal tracts 2 to 3 mm across in interior. Canals with circular cross sections in interior. Volcanic, craterlike pits up to 4 mm in diameter and 2 to 3 mm deep marking exterior and making up more than half of surface area, leading to canals 1 to 2 mm in diameter, where circular, or 1 by 3 mm across, where vertically elongate and oval in the inner part of the outer skeleton. Craterlike pits may merge to produce 8-shaped or triangular, irregular clusters, separated by skeletal tracts 1 to 3 mm across that may have either bulletlike cross sections or steep, V-shaped, ridged, skeletal tracts at exterior; 2 to 3 irregularly arranged ostia occur per centimeter. Interior canals make up about one-half volume and, within tracts, skeletal pores make up about one-half volume of fine tracts.

Skeletal tracts in interior, 1 to 3 mm across, composed of fine, regular, curvilinear skeletal fibers 0.06 to 0.08 mm across, with circular cross sections in areas between pores, but swollen to somewhat rounded rectangular and up to 0.10 mm in diameter at junctions. Skeletal net uniform but not in predictable geometric fashion.

Skeletal pores between fibers in tracts range from 0.06 to 0.12 mm in diameter, most being 0.06 to 0.08 mm in diameter, with circular cross sections to interconnected pore system. Such pores occur 8 to 10 per millimeter, vertically, horizontally, or diagonally, in fine skeletal net that is characteristic of genus.

Ghosts of faint spherulites, 10 to 20 µm in diameter, locally preserved in thin sections but not observable in scanned sections.

Discussion.—*Saginospongia angusta,* the type species of the genus, has a somewhat finer texture and generally a more regular, predictable, jet-of-water-type pattern in the skeletal canals, which in the type species are less than half the diameters of coarse openings in *Saginospongia crateria.* The exterior of *Saginospongia angusta* is marked by relatively small openings, in contrast to the coarse, craterlike openings in *Saginospongia crateria.*

Saginospongia porosa has a prominent, deep, axial spongocoel and a somewhat more coarsely canalled skeleton than seen in the type species but significantly finer texture than in the very coarse, robust *Saginospongia crateria.* Exterior ostia of canals in *Saginospongia porosa* are irregularly oval to interconnected and somewhat linear, in contrast to the distinct, pitlike openings in *Saginospongia crateria,* which is the coarsest-textured species of the genus known to date. Skeletal tracts of all three known species of the genus, however, are composed of essentially the same style of skeletal net and with elements of essentially the same dimensions within their tracts.

Material.—Two specimens.

Type specimens.—Holotype, USNM 480372, Pl. 35.9–35.11; Pl. 49.1; Pl. 52.12; and unfigured paratype, USNM 480373; both from Section G, bed 5.

Occurrence.—Two specimens from Djebel Tebaga, Section G, bed 5, 100 meters north of CF-53.

Etymology.—*Crateria,* Latin, cup or crater; in reference to the distinctive cratered sculpture of the sponge exterior.

Genus DJEMELIA new genus

Diagnosis.—Single or branched, cylindrical to club-shaped sponge with axial spongocoel passing through whole sponge. Outer surface covered with numerous ostia, some of which occur on exaules. Ostia lead into branched tubes that pass into reticular fibrous skeleton of wall. Spongocoel with distinct wall with well-developed exhalant canals leading to spongocoel (see Fig. 16C).

Discussion.—The exterior of *Djemelia* is similar to that of *Daharella* new genus or *Preeudea* Termier and Termier (1977a). *Djemelia,* however, differs from both of those genera by possessing an axial spongocoel. Structural differences in these three externally similarly appearing sponges are shown in Figure 16.

A diagnosis of *Djemelia* is similar or almost identical to the diagnosis of *Eudea* given by Zittel (1878, p. 26). *Eudea,* however, was established by Lamouroux (1821) with the type species *Eudea clavata* from the Upper Jurassic (Bathonian). Although no spicules have been described from either species of *Eudea* (see Hurcewicz, 1975, p. 242) and although the genus has been described from the Triassic Cassian Formation in the Dolomite Alps (Zittel, 1878; Dieci, Antonacci, and Zardini, 1968), *Eudea* is a typically Jurassic genus. We do not think that *Eudea* ranges from the Permian to the Upper Jurassic. We think the genus did not last through the two major extinction events, one at the Permian-Triassic and the other at the Triassic-Jurassic boundary, when many sponges and other taxa became extinct. We establish the new genus *Djemelia* for those Permian-Triassic inozoid sponges that are similar in appearance to the Upper Jurassic genus *Eudea.* We suggest that all species of *Eudea* previously described from the Triassic Cassian Formation be moved to the new genus, *Djemelia,* although we are not sure about the affiliation of Upper Triassic species to the Permian genus.

Type species.—*Djemelia amplia* new species.

DJEMELIA AMPLIA new species

Plate 29.7–29.11; Plate 37.10; Plate 75.4–75.6

Diagnosis.—Cylindrical to steeply obconical sponges with walled axial spongocoel that passes essentially through whole sponge; numerous ostia on outer surfaces on ends of small tubes or elevations (exaules). Some branched inhalant-exhalant canals converge from periphery and open through wall of spongocoel; reticular fibrous skeleton fills inner part of sponge between canals.

Description.—Cylindrical to conicocylindrical sponges with diameters from 7 to 20 mm; holotype (Pl. 29.7) bro-

Table 9. Specimens of *Djemelia amplia* n. sp., measurements in millimeters; *H*, holotype; *, including surrounding wall.

Height of sponge	Diameter of sponge	Diameter of spongocoel	Diameter of ostia canals*	Diameter of inhalant canals	Diameter of exhalant canals
20	18	5	1.0–1.4	0.4–0.6	0.4–0.8
30	15	4	1.0	0.4–0.6	—
29	10	4	0.6–0.8	0.2–0.4	—
36	20	10	1.0–1.5	0.6–0.8	0.4–0.8
22	20	—	0.9–1.1	0.4–0.5	—
30	10	2.5	0.6–0.8	0.4–0.5	—
27	7	1.5	0.5–0.6	0.3–0.4	—

ken specimen 20 mm high and 18 mm in diameter. All other specimens of species in collection also fragments but some nearly complete, 30 mm high and expanding upward from broken base 4 mm in diameter to complete oscular margin with diameter of 14 mm.

Outer surface of sponge covered by numerous, relatively large ostia, each on node up to 1.5 mm in basal diameter and up to 1 mm high, with elevated rim, or situated at end of small tube (exaulos). Ostia connect to small and short tubes (exhalant canals) that open into interspaces between skeletal fibers around spongocoel. Diameters of ostia of inhalant and exhalant canals and measurements of other features are given in Table 9.

Axial spongocoel passes nearly through whole sponge and ranges from 10 to 15 mm in diameter, depending upon diameter of sponge. Spongocoel walled, with wall approximately 1 mm thick and pierced by exopores mostly about 0.5 mm in diameter in both holotype and one paratype. Exopores virtually side by side, producing coarsely cellular layer of wall; cells separated by thick fibers up to 0.2 to 0.3 mm thick. Inhalant-exhalant canals converge toward spongocoel from periphery in cross sections of holotype.

Skeleton relatively fine reticulate fibrous structure. Fibers generally diverging gently upward and outward from walled surface of spongocoel, meeting surface at angles of approximately 30°. Fibers discontinuous and cross connected, forming loose reticulate structure, and spaced 3 to 4 per millimeter. Fibers range from 0.04 to 0.12 mm but generally 0.06 to 0.08 in diameter; both dominantly vertical and radial segments often curved and discontinuous. Skeletal pores 0.2 to 0.3 mm in diameter and net relatively porous. A reconstruction in Figure 16c with longitudinal and transverse cross sections of *Djemelia amplia* new genus, new species shows our interpretation of relationships of skeletal fibers, as well as of inhalant and exhalant canals. Poorly preserved specimen examined with SEM shows only poorly preserved spherulitic microstructure.

Discussion.—Comparisons of the large *Djemelia amplia* with the smaller, finely textured *Djemelia mediala* new species and *Djemelia nana* new species are discussed in treatment of those species. Their comparisons are shown in Table 10.

Material.—Ten specimens.

Type specimens.—Holotype, USNM 463692, Spot Locality S7, Pl. 29.7; 37.10; paratypes, USNM 463693–463695, Pl. 29.8–29.11, and USNM 480328–480329, Pl. 75.4–75.5, localities of which are shown in explanations of Plates 29 and 75.

Occurrence.—Three specimens from Djebel Tebaga Spot Locality S7; two from Spot Locality DJT-11; three from Section G, bed 4, and two from Section E, shale below Reef 3.

Etymology.—*Amplius,* Latin, larger; named for the large diameter of the sponge compared to other species of *Djemelia* that occur at Djebel Tebaga.

DJEMELIA MEDIALA new species

Plate 32.7–32.11; Plate 37.10; Plate 49.2; Plate 52.13

Diagnosis.—Cylindrical sponges, annulate in some specimens, with outer surface covered by numerous small ostia not located on exaules; narrow spongocoel passes nearly through sponge; interior skeleton reticulate, fibrous.

Description.—Cylindrical sponges with diameters of 3 (holotype, Pl. 32.7–32.8; Pl. 49.2) to 6 mm. All available specimens broken, so complete heights unknown, but most fragments range from 20 to 23 mm; holotype only 15 mm high. Some specimens show weak outer annulation.

Outer surface with or without dermal layer but having numerous small pores or ostia with diameters that range from 0.13 to 0.40 mm, but most usually 0.2 to 0.3 mm across. Ostia not situated on extended elements (exaules) and generally not showing elevated rims, but where der-

Table 10. Species of *Djemelia* described from Upper Permian reefs of Tunisia; measurements in millimeters.

Species	Diameter of sponge	Diameter of spongocoel	Diameter of ostia	Exaules
D. amplia	7–20	1.0–1.5	0.5–1.5	Well developed
D. mediala	3–6	1–2	0.13–0.40	Lacking
D. nana	2–5	0.5–0.8	0.15–0.22	Weakly developed

mal layer present, low rims 0.05 mm wide and high developed. Ostia or pores arranged side by side, and make sponge appear as porate sphinctozoan (Pl. 32.7, 32.10). Distances between ostia or pores limited, only about 0.2 mm.

Narrow spongocoel 1 to 2 mm in diameter passes virtually through whole sponge. Dense spongocoel wall perforated by horizontal tubular canals, about same size as ostia in outer surface, that extend to spongocoel or gastral surface (Pl. 32.8). Inner part of sponge filled with reticular fibrous skeleton, with moderately coarse fibers 0.15 to 0.25 mm across. Fine fibers in tracts in moderately dense spongocoel wall generally 0.01 to 0.02 mm in diameter. Some areas show vertical dominance of reticulation in midwall; others near spongocoel with horizontal-radial dominance; most variable or irregular. Because of recrystallization, spherulites of rigid skeleton poorly preserved.

Discussion.—This species could be confused with some species of *Peronidella,* but *Peronidella* does not have these kinds of ostia on the outer surface. *Djemelia mediala* is differentiated from *Djemelia amplia* by its small size and finely textured skeletal elements, especially by the lack of exaules on the surface of the sponge. Differences between the three species of *Djemelia* are summarized in Table 10.

Material.—Six specimens.

Type specimens.—Holotype, USNM 463700, Spot Locality 13B, Pl. 32.7–32.8; Pl. 49.2; and paratypes, USNM 463701–463702, from Spot Locality 127-1976; 463703 from Spot locality 122-1976, Pl. 32.9–32.11; and 480402, Pl. 52.13, from Section G, bed 5.

Occurrence.—All known specimens are from the Djebel Tebaga area, one specimen from Spot Locality 13B; two from Spot Locality 122-1976; two from Spot Locality 127-1976; and one from Section G, bed 5.

Etymology.—*Medialis,* Latin, middle or in the middle; named for the medium size of sponges of the species compared with the other species of the genus *Djemelia.*

DJEMELIA NANA
new species

Plate 29.1–29.6; Plate 48.5; Figure 28

Diagnosis.—Single to branched, cylindrical or weakly club-shaped sponges of small size; outer surface covered by dermal layer with numerous ostia that have elevated rims (exaules); narrow spongocoel with distinct wall passes through sponge; interior of sponge occupied by fine, reticulate, fibrous skeleton.

Description.—Tiny, single, or branched sponge 2 to 5 mm in diameter, with maximum heights of nearly complete fragments to 18 mm. Holotype club-shaped with beginning of branching at top; basal diameter of 3 mm expands to 6 mm where branching starts (Pl. 29.1–29.2). Narrow, obscurely walled spongocoel 0.5 to 0.8 mm in diameter passes nearly through whole sponge. Outer surface covered by dermal layer with numerous small ostia

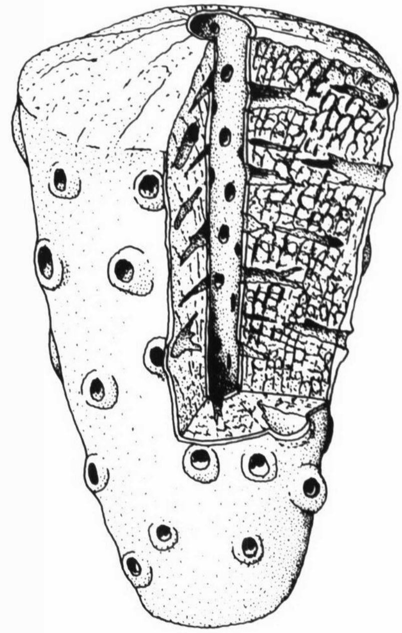

Figure 28. Section through *Djemelia nana* new species shows the arrangements of the fibers in longitudinal and transverse cross sections. The concave side of skeleton fibers shows a preferred upward direction within the sponge. Ostia extend as small inhalant tubes into the sponge interior (schematic, not in scale).

with diameters of 0.15 to 0.22 mm and short rims (exaules), walls of exaules extending to 0.5 mm from outer surface and ranging to 0.1 mm thick.

Skeleton fine reticulate fibrous structure, with 6 to 8 fibers per millimeter, as seen in longitudinal sections; longitudinal fibers diverge upwardly and outwardly 15° to 20° from sponge surface, cross connected irregularly by short, radial fibers of same general size. Skeletal pores up to 0.20 to 0.25 mm across; internal pores more or less horizontal, up to 0.5 mm in diameter.

Discussion.—*Djemelia nana* is almost the same size as *Djemelia mediala* but differs by having much smaller ostia on the outer surface. In addition, ostia in *D. mediala* do not have elevated rims, which are clearly developed in *D. nana* and *D. amplia. D. nana* is differentiated by its smaller size from *D. amplia* (see Table 10).

Material.—Eight specimens.

Type specimens.—Holotype, USNM 463696, Spot Locality DJT-10, Pl. 29.1–29.2; Pl. 48.5; and paratypes 463697–463699, Pl. 29.3–29.6, from Section I, bed 5, Spot Locality 143-1976 and from Senowbari-Daryan collection, respectively.

Occurrence.—Djebel Tebaga, one each from Spot Locality DJT-10; Spot Locality 127-1976 and 143-1976; one from Section G, bed 5 (CF-53); two from Section I, bed 5; and two in collections of Senowbari-Daryan.

Etymology.—*Nanus,* Latin, dwarf; named for the very small size of the species when compared with other species of *Djemelia.*

Subfamily PRECORYNELLINAE
Termier and Termier, 1977a

Emended diagnosis.—Sponges in which two or more axial spongocoels or cluster of coarse axial exhalant canals present; inhalant and exhalant canals present or absent.

Discussion.—Termier and Termier (1977a, p. 45) originally defined the family Precorynellidae as "Formes proches des Virgulidés mais où la cavité spongocoelienne est formée de tubes subaxiaux fasciculés, parallèles entre eux, chacun prolongeant un tube radiaire" [Forms near the virgulids but where the spongocoel is formed of bundles of subaxial tubes, parallel among themselves, each a continuation of a radial tube]. We have modified their definition to include some sponges without the prominent convergent inhalant canals and have treated that latter development as being of generic importance.

Type genus.—*Precorynella* Dieci, Antonacci, and Zardini, 1968.

Genus PRECORYNELLA
Dieci, Antonacci, and Zardini, 1968

Original diagnosis.—"Spugna sia semplice sia aggregata. Individui singoli cilindriformi, a pera o subsferici. Strato dermale basale inspessito. Osculo abbastanza ampio, imbutiforme, con, in genere, solchi radiali. Zona assiale occupata da gruppi di corti canali efferenti che si sovrappongono più o meno irregolarmente gli uni sugli altri; canali afferenti leggermente obliqui verso il basso; canali efferenti laterali arcuati verso il basso e verso l'esterno" [Sponge either single or aggregate. Single individuals cylindrical to pear-shaped or subspherical. Dermal layer thickened basally. Osculum fairly wide, funnel-like, with generally radial grooves or canals. Axial zone occupied by a group of exhalant (corti) canals and in upper opening are more or less irregularly united to themselves or to one another; inhalant canals slightly oblique toward the base; lateral exhalant canals arcuate toward the base or toward the exterior] (Dieci, Antonacci, and Zardini, 1968, p. 126).

Discussion.—*Precorynella* is separated from *Corynella* and *Permocorynella* by development of a prominent, deep, axial spongocoel in the latter genera, in contrast to the axial cluster of canals that extend to near the summit in *Precorynella.* Both have generally upwardly arcuate, transverse, inhalant canals cutting across the upwardly expanding, finely reticulate skeletal structure and have inhalant canals that are generally parallel to the fibrous, expanding, skeletal structure, as smaller openings than the upwardly arcuate and central exhalant canals of the cluster.

Type species.—*Cnemidium pyriformis* Klipstein, 1843.

PRECORYNELLA CRYSANTHEMUM (Parona, 1933)

Plate 28.1–28.4; Plate 49.3; Plate 64; Plate 76.1–76.2, 76.4–76.5

Synonymy.—*Corynella crysanthemum* Parona, 1933, p. 33, pl. 11, fig. 1–8; Termier and Termier, 1955, p. 24, fig. 7a–c. *Precorynella crysanthemum* (Parona, 1933), Termier and Termier, 1977a, p. 46.

Emended diagnosis.—Relatively small, broadly obconical to pyriform or fig-shaped sponges with summit capped by shallow osculum or spongocoel; upper surface with radial grooves of convergent arcuate exhalant canals; axial cluster of coarse exhalant canals, 0.5 mm in diameter, extending to summit from near the base, enlarged by addition of upflexed interior ends of upwardly arcuate, transverse canals. Downwardly sloping, inhalant canals approximately 0.3 mm across; in periphery, more or less parallel to upwardly and outwardly expanded, fibrous, reticulate skeleton.

Description.—Obconical to mushroomlike sponges with central spongocoel missing or very shallow below rounded osculum. Specimens in collection 39 to 45 mm high, expanding broadly upward from essentially complete base 6 to 7 mm in diameter to maximum diameter of 39 mm at top of rounded walls and oscular margin. Height of best preserved specimen approximately 26 mm, with shallow depression of osculum 10 mm wide and 5 mm deep.

Axial cluster of exhalant canals extends upward as more or less vertical element in skeleton from near base, 20 to 22 mm below oscular margin. These canals having circular cross section, 0.6 to 0.8 mm in diameter, with distinct walls 0.10 to 0.15 mm thick in the upper part and being somewhat thinner, 0.06 to 0.12 mm thick, in the lower part. Vertical canal cluster of inner and upper extensions of upwardly arched, transverse canals extending as inhalant openings from prominent ostia on exterior. Ostia 0.4 to 0.6 mm in diameter spaced 0.15 to 1.0 mm apart, locally in horizontal rows, as well as in crude vertical rows, in moderately aligned canal system. These upwardly arched, transverse canals also 0.6 to 0.8 mm in diameter and walled by abruptly thickened tips of fibers cut across by openings.

Skeleton expands upward and outward, with long, longitudinal fibers dominant and cross connected at irregular intervals by transverse fibers to produce microreticulate structure; cross connections spaced at irregular intervals except in vicinity of upwardly arched inhalant canals. Skeletal pores prominent as openings parallel to longitudinal radiating fibers; longitudinal pores 0.10 to 0.14 mm in diameter also cross connected by horizontal pores 0.06 to 0.08 mm in diameter. Skeletal pores defined by fibers 0.08 to 0.12 mm in diameter and locally may appear somewhat beaded in longitudinal sections.

Downwardly arched inhalant canals lacking in peripheral area of sponge, and coarse canals parallel to skeletal fibers also absent such as characterize most species of *Precorynella.* Skeletal microstructure spherulitic, with spherulites 50 to 70 µm in diameter but with details not well preserved in type specimens.

Material.—Three figured specimens and two somewhat questionable specimens.

Figured specimens.—USNM 480380, Pl. 28.1–28.2; Pl. 49.4, Section G, bed 9; USNM 480342–480343, Pl. 76.1–76.2, Section G, bed 5; and USNM 480344–480345, Pl. 76.4–

76.5, Section I, bed 12; two questionable reference specimens, USNM 480381, Pl. 28.3–28.4; Pl. 64.3–64.5, Section G, bed 5, and USNM 480415, Pl. 64.1–64.2.

Occurrence.—One specimen from Section G, bed 9, from shale 33 m below CF-65 in the pass; three specimens (including two thin sections of one specimen) from Section G, bed 5, 100 m north of CF-53; and one (two thin sections) from Section I, bed 12.

PRECORYNELLA VIRGOSA new species

Plate 27.2–27.3; Plate 49.4; Plate 52.14

Diagnosis.—Small, branched, *Precorynella,* each branch having axial exhalant canal cluster 3 to 4 mm across, of 20 to 35 canals, each 0.3 to 0.4 mm in diameter, toward which converge branched, radial canals to 0.4 mm in diameter, as horizontal to upwardly arched, lateral series. These canals flex upward at inner ends to merge with axial cluster. Longitudinal exhalant canals 0.15 to 0.30 mm in diameter radiate upward in skeleton and crosscut arched series; all canals with porous walls; intervening skeletal net irregular, vermiform reticulation of fibers 0.04 to 0.05 mm in diameter around pores 0.06 to 0.10 mm across; net without dominant direction.

Description.—Holotype small, branched sponge, quadrate appearance from above, 20 by 27 mm across on complete summit; base 4 mm in diameter and essentially complete. Sponge appears somewhat double-bladed with two branches capping each blade, which are 7 to 10 mm wide, but narrowing medially to a width of 6 mm to define individual branches. Blades extend 7 to 8 mm above common depression marked by horizontal lateral canals, suggesting early axial cluster in center of depression established before branching.

Axial clusters of canals in each branch 3 to 4 mm in diameter and each cluster composed of 25 to 35 canals that empty into shallow tip depression, up to 1 mm deep. Depression with irregular edges because of varying numbers of upwardly convergent, lateral canals. Ostia of individual vertical canals 0.3 to 0.4 mm in diameter, generally circular but faintly subprismatic where crowded side by side. Canal clusters extend at least 6 to 7 mm into skeleton as coherent structures.

Summit marked by grooves of radial convergent canals, each approximately 0.4 mm in diameter at cluster edge but 0.3 mm across where branched in distal parts. Similar canals walled in interior and produce upwardly arched convergent system that parallels former position of rounded upper walls. These canals steeply ascend in peripheral part, arch to become subhorizontal in midwall, but then curve slightly downward only to flex sharply upward in axial region to form steep or vertical exhalant canals, in pattern typical of genus.

Inhalant canals longitudinal to upwardly radiating in upper part of sponge, but downwardly descending in lower part of sponge, 0.15 to 0.30 mm in diameter, as straight tubular openings, approximately normal to upwardly arched, radial horizontal series. Ostia of inhalant canals 0.2 to 0.5 mm apart on summit.

Lower dermal exterior with three series of ostia; largest 0.3 mm in diameter as openings to horizontal, arched series, generally spaced 0.5 to 1.0 mm apart; smaller ostia, approximately 0.2 mm in diameter, between descending, inhalant canals, spaced 0.5 to 1.0 mm apart with most approximately 0.5 mm apart. Small intervening ostia 0.10 to 0.15 mm in diameter, spaced 0.2 to 0.4 mm apart in moderately dense skeletal net, may open into inhalant canals or moderately enlarged skeletal pores. All canals with porous walls, 0.03 to 0.04 mm thick, perforated by pores 0.04 to 0.08 mm in diameter, with most approximately 0.04 mm across where connected to skeletal pores.

Skeleton irregular, nonlinear mesh of fibers 0.04 to 0.05 mm in diameter, with short curved segments. Intervening skeletal pores, 0.06 to 0.10 mm in diameter, as circular, vermiform, interconnected openings in fine, reticular net.

Discussion.—*Precorynella crysanthemum* (Parona, 1933) is a relatively small, broadly obconical to pyriform sponge rather than a branched species and with only a few moderately coarse axial canals in the exhalant cluster. Somewhat more similar species of *Precorynella* are branching forms like *Precorynella* cf. *P. clavosa* (Laube, 1865) and *P. auriformis* Dieci, Antonacci, and Zardini, 1968, from the Upper Triassic of the St. Cassian region of northern Italy. The first form, in general, has fewer exhalant canals and a much coarser dermal layer, produced by coarser inhalant canals and a moderately coarse, longitudinally dominant, fibrous skeleton. *P. auriformis* has considerably fewer canals in the axial cluster, and they extend less deeply into the skeleton and are also coarser openings. Most other branching sponges within the collections from Tunisia have either prominent axial spongocoels or lack the arched lateral canals and inhalant canals characteristic of the species described here.

Material.—One specimen.

Type specimen.—Holotype, USNM 480392, Pl. 27.2–27.3; Pl. 49.4; Pl. 52.14; Section G, bed 4.

Occurrence.—Section G, bed 4 of Djebel Tebaga.

Etymology.—*Virgosa,* Latin, bushy or full of twigs; in reference to the branched structure of the sponge.

PRECORYNELLA DIFFUSA new species

Plate 30.3–30.4; Plate 49.5; Plate 52.15; Plate 65.4–64.5

Diagnosis.—Club-shaped, small sponges with canal patterns typical of genus, with moderately widespread, though weakly clustered, vertical exhalant canals 0.5 to 0.7 mm in diameter, some of which extend to near base, but others with upturned ends of moderately rare, horizontal to arched, convergent canals. Vertical or longitudinal, small, inhalant openings, 0.2 to 0.3 mm in diameter, crosscut horizontal series or converge downward in lower part of sponge. Canals walled. Surface exterior marked by prominent, long grooves, some extending from near base to edge of rounded summit, where they are faint; summit generally lacks radial system. Skeletal net of fine reticulate fibers, irregularly vermiform, although locally dominant longitudinally; fibers 0.04 to 0.08 mm in diameter around skeletal pores 0.06 to 0.10 mm in diameter, which in a few places may form short, anastomozing, beaded canals.

Description.—Holotype club-shaped sponge, 31 mm high, expanding upward from broken base, 5 mm in diameter, through stalk 20 mm high to upper barrel-shaped part of sponge. Latter formed above abrupt expansion as subcylindrical section, 13 to 14 mm in diameter and 10 mm high, which extends to rounded summit. Summit lacks osculum but contains 8 to 10 ostia of weakly clustered vertical canals, 0.5 to 0.8 mm in diameter, in central region.

Exterior marked by prominent, slightly sinuous to anastomosing, longitudinal, surficial canals; some traceable from near base to edge of rounded summit, but summit lacks radial groove system. Grooves most prominent in upper, barrel-like part of sponge where 0.5 to 0.7 mm wide and most continuous and unbranched, but become abruptly 0.3 to 0.5 mm wide near base of the barrel and continue to narrow toward base, where some of most continuous still 0.2 to 0.3 mm wide. Grooves separated by ridges of variable widths, to 1.5 mm wide, with considerable irregularity; separation decreases toward base where grooves tend to converge.

Ostia 0.2 to 0.4 mm in diameter occur on summit and as coarsest openings on sides, where they occur only as openings in troughs of vertical grooves and commonly 1 to 2 mm apart vertically. Finer ostia, 0.1 to 0.2 mm in diameter, more common on lateral slopes, principally in grooves where spacing is 0.2 to 0.5 mm apart. Few fine ostia of series also occur in ridges between grooves but rarely because most openings being only skeletal pores.

In longitudinal section, major axial canal clusters continuing from summit virtually to base as walled openings, 0.5 mm in diameter, with somewhat sinuous trends but becoming straighter toward base; separated to 1 mm in upper part but generally closer.

Essentially horizontal, upwardly arched, convergent canals common only in upper part where they flex upward to form loose cluster 5 mm in diameter. Canals rise steeply in outer peripheral part, arch, and become subhorizontal in middle part of the wall but bend sharply upward to continue as vertical, axial, exhalant canals. Smaller, vertical to upwardly divergent inhalant canals, 0.2 to 0.3 mm in diameter, with moderately straight courses, crosscut horizontally arched canals and most prominent in upper part of sponge, but may curve inward and down in outer one-quarter of lower stalk.

Skeletal structure generally fibrous, irregular reticulation in outer part, but somewhat more longitudinally dominant and parallel to canals in upper and axial parts of sponge, particularly in lower stalk. Vertical fibers 0.06 to 0.08 mm in diameter, even where reticulation more vermiculate, generally cross connected by horizontal fibers 0.04 to 0.06 mm in diameter. Pores defined by skeletal fibers generally 0.06 to 0.10 mm in diameter, commonly locally aligned to produce short, beaded-appearing canals to 1 mm long in skeletal interior, but pores generally moderately regularly arranged openings in tracts between canals. Microstructure possibly spherulitic but poorly preserved in holotype (Pl. 65.4–65.5).

Canals of walls 0.04 to 0.08 mm thick, with most approximately 0.06 mm thick; all porous with openings generally same size as skeletal pores to somewhat smaller. Such perforations with spacing somewhat more irregular than skeletal pores, but walls obviously open to porous skeleton between canals.

Discussion.—*Precorynella diffusa* new species contrasts sharply with the small branched *Precorynella virgosa* new species in growth form and in dimensions of canals, for *P. diffusa* has ostia of vertical, exhalant canals, 0.5 to 0.8 mm in diameter, in the moderately ill-defined and widely separated cluster, whereas *P. virgosa* has up to 35 tightly clustered canals with ostia only 0.3 to 0.4 mm in diameter. Interior canals are similarly much coarser in *Precorynella diffusa* than in the smaller, branched species.

Wu (1991, p. 59) described the new species *Precorynella dendroidea* as a branched sponge in which the vertical exhalant canals range 0.3 to 0.5 mm across, and are considerably finer openings than the 0.5 to 0.8 mm wide ostia in *Precorynella diffusa.* The species also differ in their growth forms. Because only a single thin section of the Chinese species is known, it is difficult to contrast surface sculpture and other features.

Precorynella crysanthemum (Parona, 1933) includes obconical to mushroomlike sponges with only a shallow, rounded, oscular impression on the summit. *P. crysanthemum* has a tight axial cluster of canals, each 0.6 to 0.8 mm in diameter, within the general range of those seen in *P. diffusa,* but having prominent, inhalant openings 0.4 to 0.6 mm in diameter, openings that are considerably coarser than the inhalant canals in *P. diffusa.* In addition, such openings are common in areas between converging canals on the summit and elsewhere in tracts around the periphery in *P. crysanthemum.* Such ostia are not seen in the small *Precorynella diffusa.*

Precorynella capitata (Münster, 1841) has a tight, dense, axial cluster of exhalant canals in a shallow oscular pit, but also has prominent, coarse canals on ridges between the moderately pronounced, radially convergent canals, characteristic of the system.

Precorynella pyriformis (Klipstein, 1843) may be steeply obconical to club-shaped, but it also has a tightly compact axial cluster of exhalant canals and prominent, aligned ostia of other canal series on the exterior.

Material.—One specimen.

Type specimen.—Holotype, USNM 480357, Pl. 30.3–30.4; Pl. 49.5; Pl. 52.15; Pl. 65.4–65.5, Section E, shale below Reef 3.

Occurrence.—Only one specimen is known, and it came from Section E, shale below Reef 3 in the western part of Djebel Tebaga.

Etymology.—*Diffusus,* Latin, spread out, dispersed, or extended; in reference to the relatively loose cluster of axial exhalant canals on the rounded summit of the sponge.

PRECORYNELLA ROBUSTA
new species

Plate 7.13–7.14; Plate 28.5–28.6; Plate 52.16

Diagnosis.—Cylindrical to steeply obconical *Precorynella* with prominent axial cluster of exhalant canals, each approximately 0.8 mm in diameter. Radially convergent canals multibranched and not in regularly stacked series. Coarse, vertical, longitudinal canals, 0.5 to 0.6 mm in diameter, and smaller openings 0.3 to 0.4 mm in diameter, continue full length of fragment as tubular, walled openings. Skeleton moderately coarsely porous with irregular fibers; exterior essentially lacking prominent ostia, but surface covered with skeletal pores and relatively coarse fibers.

Description.—Steeply obconical, subcylindrical sponges; available fragment 30 mm high and with maximum diameter of 31 mm at summit, which has shallow, wide, oscular depression; maximum 3 to 4 mm deep, below irregular undulating rim. Exterior smooth, weakly annulate, marked locally by short, fine, vertical canals approximately 0.2 mm wide and in segments 3 to 4 mm long, which appear largely as aligned, irregular, skeletal pores. Rare larger canals, 0.4 to 0.5 mm in diameter, traceable for a few millimeters, rise upward and inward to form walled canals in interior. Most of surface with only irregularly circular to subprismatic skeletal pores, approximately 0.2 mm across, limited by fiber sections.

Shallow axial cluster of approximately 30 canals well developed in bottom of oscular depression, individual canals round to subprismatic, with most 0.8 mm in diameter, but range 0.6 to 1.1 mm across, locally oval in transverse sections where probably cut diagonally across steeply ascending canals. Some ostia merged or branched so 8-shaped in sections.

Radially convergent canals exposed in oscular depression and evident in transverse and longitudinal sections. Such canals arch upward in outer periphery, become subhorizontal, and then flex upward sharply near border of axial cluster to parallel or merge with other exhalant canals in axial cluster. Canals near cluster 0.5 to 0.6 mm wide and high, 0.4 to 0.5 mm across in first-order branches, and 0.2 to 0.3 mm across in second-order branches; latter common in outer part, but rarely extending to edge, where sponge wall generally made of skeletal fibers and skeletal pores, with but few canals. Fifteen to 20 traces of convergent canals evident in transverse sections and in one-half of oscular depression exposed at top. Such canals less evident in polished base.

Area between convergent, subhorizontal canals with prominent, long, vertical canals probably as inhalant openings, generally of two series. Coarser openings 0.5 to 0.6 mm in diameter, with most approximately 0.5 mm in diameter and 1 mm apart, may extend for full length of available fragment. Smaller openings, 0.4 mm or slightly smaller in diameter, spaced approximately 0.5 mm apart, also extend considerable distances, vertically within skeleton.

All canals walled with only few pores; walls generally 0.06 to 0.08 mm thick, but with considerable irregularity where walls merge with thick fibers of skeleton.

Skeleton mainly vertically dominant, with vertical fibers irregularly 0.06 to 0.08 mm, but with great variation; cross connected by fibers somewhat smaller or same general size, defining irregularly circular or spherical pores, 0.15 to 0.20 mm in diameter. Finer subprismatic to rounded prismatic pores generally 0.05 to 0.10 mm across, but with great variation and irregularity. Although much of skeleton shows prominent vertical lineation, many of broader tracts with irregularly reticulate to vermiform fibers and pores. Microstructure spherulitic, but not well preserved in type specimens.

Discussion.—Among the species of *Precorynella* included in collections from Djebel Tebaga, the one most closely similar in coarseness of skeleton and texture is *Precorynella crysanthemum* (Parona, 1933), but that species is generally an obconical form with numerous, prominent, horizontal to upwardly arched canals and with prominent ostia 0.4 to 0.6 mm in diameter on the exterior in horizontal rows or crude vertical rows. Such openings are not present in *Precorynella robusta.* Vertical exhalant canals of the axial cluster are approximately the same size in the two species, as are proximal ends of the arched convergent series, but those lateral canals are not branched as extensively in *Precorynella crysanthemum* as they are in the prominent fashion seen in *Precorynella robusta.* There is considerable difference in canal patterns of the species as well. The cluster of axial canals is readily traceable through nearly the full height of *Precorynella crysanthemum* but is only prominent in the upper part of the holotype of *Precorynella robusta.*

Material.—One specimen.

Type specimen.—Holotype, USNM 480393, Pl. 7.13–7.14; Pl. 28.5–28.6; Pl. 52.16, Section G, bed 5.

Occurrence.—Only the single specimen from Section G, bed 5, 100 m north of CF-53, is in the collection.

Etymology.—*Robustus,* Latin, hard and strong; in reference to the robust fibers in the coarser skeleton of the species.

PRECORYNELLA AMPLIATA
new species

Plate 6.5–6.6; Plate 43.6; Plate 48.4

Diagnosis.—Large broadly obconical sponges with axial clusters of coarse exhalant canals, each 0.6 to 0.8 mm in diameter at base of shallow, oscular depression. Canals extend upward from near base. Smaller canal series, 0.04 to 0.05 mm and 0.2 to 0.4 mm in diameter, parallel and locally transect upwardly divergent, coarse, skeletal fibers 0.06 to 0.10 mm in diameter; canal pattern typical of genus.

Description.—Large, massive, obconical sponges with diameter of 90 mm at summit, but only 12 mm near broken base. Diameter of sponge increased rapidly during growth; upper surface with shallow, oscular depression.

Exterior of specimen (Pl. 6.6) relatively smooth with only indistinct, small, vertical grooves that correspond to small, upwardly divergent, long skeletal pores or canals, exposed by weathering. Opposite side of obconical lower part (Pl. 43.6) with variety of encrusting epifauna. Base of sponge broken, 12 mm across, exposing a few pores 0.5 mm in diameter in fibrous skeleton.

Summit of holotype (Pl. 6.5) with broad shallow oscular depression 15 to 20 mm across and 10 mm deep; outer limits ill defined by broad, rounded, slope-of-wall crests. Axial cluster of walled, coarse, vertical exhalant canals empties into base of shallow oscular depressions, cluster extends upward from near base of sponge. Canals of clusters with round sections, separated by distinct wall or tracts of skeletal fibers. Canals generally upward extension of arched, radially convergent canals of lower part of sponge. Coarse canals with walls 0.2 mm thick; smaller canals with walls 0.08 to 0.12 mm thick. Partly covered by algal laminae and minor worm tubes, such as those illustrated in Plate 43.6. Unencrusted area with many shallow grooves, 1.0 to 1.5 mm wide near osculum but only fractions of millimeter deep, convergent toward oscular depression and traceable from periphery of sponge. Grooves branch dichotomously outward several times (Pl. 6.5).

Numerous ostia of upwardly convergent, relatively large, exhalant canals approximately 0.7 mm in diameter, occur closely spaced in troughs of some grooves, especially near crest of arched walls, and scattered elsewhere in skeleton. These are upwardly arched, coarse canals that cut across generally upwardly divergent fabric of fibrous skeleton.

Smaller ostia 0.4 to 0.5 mm in diameter occur in fibrous skeleton between grooves as openings of upwardly divergent canals that are generally parallel to structure of fibrous skeletons; may have been inhalant. Still smaller circular openings are skeletal pores 0.2 to 0.4 mm across, as openings in moderately coarse skeleton.

Skeleton upwardly flaring, divergent, fibrous structure; fibers in interior 0.06 to 0.10 mm in diameter, but may be expanded up to 0.10 to 0.15 mm thick in dermal area on summit. Fibers define generally polygonal pores 0.06 to 0.10 mm across in interior and on summit. Dominant fibers are upwardly divergent and cross connect shorter fibers throughout.

Discussion.—*Precorynella ampliata* new species has canals and skeletal structures coarser than those in *Permocorynella ovoidalis* (Parona, 1933) or *P. osculifera* new species. It also differs from those species in its broadly obconical form, in contrast to club-shaped or steeply obconical-cylindrical in those species. *R. ampliata* also has a moderately more complex canal system.

Chainlike, small chambers of the small, multichambered thalamid sponge, *Sollasia ostiolata* Steinmann occur as encrusters on the holotype (Pl. 43.6). *Sollasia* is an abundant sponge in Permian reefs in Djebel Tebaga (see Senowbari-Daryan and Rigby, 1988). Additionally, many worm tubes, some bryozoans, and other undetermined fossils are attached on sponge surfaces. Apparently, this side represents the upper side of the sponge on the sea bottom. The stable position of the sponge is with encrusted side upward.

Material.—One specimen.

Type specimen.—Holotype, USNM 480303, Pl. 6.5–6.6; Pl. 43.6; Pl. 48.4, from Section G, bed 5.

Occurrence.—One specimen from Section G, bed 5, 100 meters north of CF-53.

Etymology.—*Ampliatus,* Latin, enlarge or increase; referring to the broadly obconical, upwardly expanding form of the species.

Genus MINISPONGIA new genus

Diagnosis.—Tiny, dichotomously branched, cylindrical sponge with one to several united or parallel spongocoels. Ringlike exterior annulations, or ridges, may merge in zigzag fashion. Outer surface without perforations. Skeletal fibers reticulate.

Discussion.—*Minispongia* is one of the very small inozoids from the Djebel Tebaga region of Tunisia. It is differentiated from most other genera in the collections by the prominent, annular, sharp ridges that mark its exterior. This exaggerated sculpture is not known in other sponges, particularly small sponges, in the Permian. Some small forms that may have been encrusted by algae produce an irregularly sculptured surface, but not the well-defined ring-like annulations or sharply crested ridges distinctive of *Minispongia.*

Peronidella multiosculata new species is also a tiny, branched, twiglike sponge with multiple spongocoels that locally may produce a starlike pattern, as in *Minispongia,* but the small *Peronidella* lacks the distinctive surface sculpture of *Minispongia.*

Type species.—*Minispongia carinata* new species.

Etymology.—*Minimus,* Latin, least; *spongia,* sponge; named for the very small size of sponge.

MINISPONGIA CARINATA new species

Plate 29.12–29.18, Plate 51.8; Figure 29

Diagnosis.—Tiny cylindrical to branched sponges with 1 to 3 deep spongocoels in starlike pattern in relatively coarse, reticular, skeletal structure; prominent ringlike annulation or ridges around sponge characteristic; such sharp ridges may merge in zigzag fashion for short distances on exterior but do not mark internal structural differences.

Description.—Tiny branched sponge, one of smallest sponges in Djebel Tebaga collections; stem diameters range 2 to 5 mm across, and heights to 15 mm. Holotype (Pl. 29.12) with maximum diameter of 5 mm at upper end and

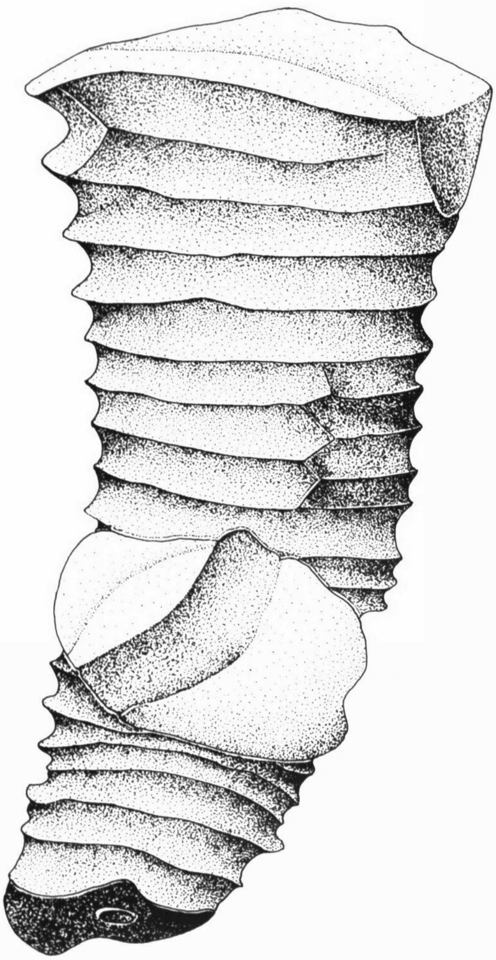

Figure 29. An outer view of *Minispongia carinata* new species, holotype. The exterior of the sponge is marked by ridged, ringlike elements that may be interconnected in zigzag patterns. The inner part of the sponge is filled with reticular skeletal fibers. The summit of the sponge is covered by algae or cement and does not show an osculum, but the bottom is characterized by a large opening. One or two oscula are located on the summit of the paratypes (schematic, not to scale).

basal diameter of only 2.5 mm in 15 mm tall sponge. External ringlike horizontal sharp ridges typical; ridges may locally merge in zigzag fashion for short distances (Pl. 29.12, 29.18). Ornamentation appears unique to this species in Djebel Tebaga. Ostia or other kinds of large openings not evident on exterior, but small skeletal pores, 0.06 to 0.08 mm in diameter, locally occur in rows between fibers or skeletal tracts of same general proportions, to produce tiny nodular or beadlike surface of both ridges and troughs.

One, two, or three spongocoels, 0.2 to 0.5 mm in diameter, occur and may be united in some areas to produce starlike appearance in cross sections; clusters less than 1 mm in diameter; openings pass vertically nearly through sponge (Pl. 29.15–29.16). Spongocoels not walled but connected to interfiber openings in sponge wall, which has coarsely reticular, fibrous skeleton.

Specimens of species usually recrystallized and specimen examined with SEM poorly preserved but with spherulitic microstructure still recognizable.

Discussion.—This small sponge has been compared to other small species in the collection in discussion of the genus.

Material.—13 specimens.

Type specimens.—Holotype, USNM 463704, Spot Locality 302–1976, Pl. 29.12, Figure 29; paratypes, USNM 463705–463710, Pl. 29.13–29.18, from Section E, shale below Reef 3 and from Spot Localities DJT-23 and 300-1976, respectively.

Occurrence.—Djebel Tebaga, one specimen each from Spot Locality 300-1976 and 302-1976, four from Spot Locality 204-1976, one each from Spot Localities DJT11, 23A, and 27A, plus four from Section E, shale below Reef 3, but the small species is much more common than these few specimens would indicate.

Etymology.—*Carinatus,* Latin, keeled; in reference to the sharp horizontal ridges that are characteristic of the exterior of the species.

Genus RAMOSTELLA new genus

Diagnosis.—Cylindrical to branched, small sponges, with general axial cluster of moderately coarse, exhalant canals in fine, reticulate, upwardly and outwardly expanding, skeletal network; lacks transverse canals other than moderately coarse skeletal pores. Upper surface marked by longitudinal surficial grooves that converge toward canal cluster on summit, but undulating and subparallel some distance down along cylindrical flanks. Microstructure spherulitic.

Discussion.—The new genus, in longitudinal section, is possibly most similar to basal parts of *Permocorynella,* but *Ramostella* lacks the prominent transverse canals characteristic of that genus. *Polytubifungia* has many broadly spaced canals throughout the skeleton but has a moderately coarsely fibrous skeleton instead of the finely reticulate one seen in *Ramostella.* The spongocoel is lacking, as are the coarse inhalant ostia characteristic of *Preeudea,* for example, or of the lower parts of *Djemelia.* The canals are not peripherally situated as in *Heptatubispongia* or in *Exotubispongia.* Because of this, a new genus is erected herein.

Type species.—*Ramostella stipulata* new species.

Etymology.—*Ramos,* Latin, branched; *stella,* star; referring to the somewhat radiate character of the canals on the summit of the branched sponge.

RAMOSTELLA STIPULATA new species

Plate 30.11, 30.13; Plate 49.6; Plate 61.3

Diagnosis.—Cylindrical to branched-palmate forms; summit marked by numerous small ostia 0.6 to 0.8 mm across of vertically sinuous to curved, exhalant canals that penetrate to near base of sponge as walled, tubular openings. Summit exterior and upper flanks marked by prominent, subparallel, somewhat sinuous grooves that converge toward summit. Skeletal net fine, but moderately open and porous.

Description.—Three specimens included in species range from palmate, branched holotype, in which incipient branches occur at the summit, to two subcylindrical paratypes. Branched holotype essentially complete, 34 mm high and 25 mm wide, but only 6 to 7 mm thick through palmate lower part. Three branches extend 3 to 5 mm above common bladed base as subcylindrical structures; cylindrical, immediate base of sponge broken.

Paratypes generally cylindrical fragments 7 to 10 mm in diameter and 22 to 25 mm high. One of these with well-preserved, dome-shaped tip of branch but with broken base; other with broken top and bottom.

Summit marked with numerous ostia, 0.6 to 0.8 mm in diameter, may occur in somewhat crater-like depressions up to 1 mm wide. Ostia generally separated 0.3 to 0.5 mm by tracts of fine, reticulate skeleton. Ostia openings of somewhat parallel, though sinuous to curved, exhalant canals in interior; canals commonly walled, tubular, maintaining essentially same diameter to near base, or may taper slightly toward base, but in interior may be separated by as few as two fibers, which define what appears as double wall where tubes are side by side.

Skeletal structure and canal patterns gently upwardly divergent, so canals and somewhat elongate fibers may diverge 10° to 20° from axis. Divergence particularly pronounced in smaller canals locally developed between larger openings. Smaller ostia of these canals, 0.2 to 0.3 mm in diameter, relatively rare on exterior surface.

Surface smooth except for vertical grooves, marked only by a few ostia of smaller canals and skeletal pores between moderately well-preserved fibers.

Fibrous skeleton composed of curvilinear to somewhat elongate elements, 0.03 to 0.04 mm in diameter but may range up to 0.06 mm thick in junction areas. Fibers define skeletal pores 0.08 to 0.14 mm in diameter, with most approximately 0.12 mm across. Locally, pores elongated to produce small canals of essentially pore diameter.

Walls of coarse exhalant canals may be up to 0.06 mm thick locally, but some of that may be enlargement by diagenesis, because such thick walls occur in areas where other skeletal fibers similarly thickened, beyond that seen in best preserved parts of skeleton. Microstructure spherulitic, with spherules 30 to 40 µm in diameter based on one specimen, probably of species.

Discussion.—Comparisons with related or similar genera have been presented above in discussion of the genus.

Material.—Four specimens.

Type specimens.—Holotype, USNM 480354, Section I, bed 5, Pl. 30.11, 30.13; paratypes, USNM 480377 and one unfigured paratype, USNM 480378, both from Section G, bed 4; and one specimen probably of the species, USNM 480418, from Spot Locality 299-1976.

Occurrence.—Djebel Tebaga, one specimen from Section I, bed 5; two from Section G, bed 4; and one from Spot Locality 299-1976.

Etymology.—*Stipulata,* Latin, branched, small; referring to the generally branched form typical of the species, as exemplified by the holotype.

Genus IMPERATORIA de Gregorio, 1930

Discussion.—*Imperatoria* was erected by de Gregorio (1930, p. 39, pl. 19, fig. 9–16) for spiral-looking sponges from the Middle Permian of the Sosio Valley in Sicily. The genus was later redescribed by Parona (1933, p. 4a, pl. 10, fig. 5–9), who placed it in the thalamid sponges. Later workers placed *Imperatoria* in different groups of thalamid sponges. De Laubenfels (1955) included it in the Celyphiidae; and Seilacher (1962), Ott (1967), Termier and Termier (1977a), and Rigby and Potter (1986) placed it in the Sebargasiidae. The generalized vertical section published by Ott (1967, fig. 5), however, does not correspond to the actual internal structure of types of *Imperatoria.* For example, internal segmentation is lacking in *Imperatoria,* and, therefore, it cannot be a thalamid sponge. *Imperatoria* has now been placed in the inozoid sponges (see Aleotti, Dieci, and Russo, 1986; Senowbari-Daryan and Rigby, 1988; Senowbari-Daryan, 1990). The superficial segments of *Imperatoria* and especially of *Imperatoria voluta* new species most probably represent growth pulses.

Wu (1991) described a new inozoid sponge with two exhalant tubes from the Middle Permian Maokou Formation of China as *Bisiphonella cylindrata.* Senowbari-Daryan and Ingavat-Helmcke (1994) have reported the new species *B. tubulara* from uppermost Permian reef limestone from Thailand. Cross sections of *Bisiphonella* are essentially identical with those of species of *Imperatoria,* especially with *Imperatoria voluta* (see Pl. 31.4–31.5, 31.13). In such cross sections, *Imperatoria* cannot be differentiated from *Bisiphonella* by the development of two tubes or by their discrete walls. The loosely packed and radially arranged skeletal fibers in some specimens (Pl. 31.6), however, may help to differentiate the two genera. Segmentation of *Bisiphonella* was not mentioned in Wu's description. The holotype of *B. cylindrata* (Wu, 1991, pl. 7, fig. 5) shows some segmentlike structures, however, which could indicate the assignment of *Bisiphonella* to *Imperatoria.* The distinctness of *Bisiphonella* and its detailed appearance or formation in longitudinal sections should be checked carefully by researchers with access to the Chinese sponges.

IMPERATORIA MARCONII de Gregorio, 1930

Plate 31.14

Synonymy.—*Imperatoria marconii* de Gregorio, 1930, p. 39, pl. 19, fig. 9–16; Parona, 1933, p. 41, pl. 10, fig. 5–9; *non Imperatoria marconii* Termier and Termier, 1955, fig. 2C; Termier and Termier, 1977a, p. 42 (no illustration); Senowbari-Daryan, 1990, pl. 33, fig. 6–7.

Description.—Sponge with screwlike or spiral to turriculate appearance from side, composed of several upwardly expanding segments, each characterized by flattened ramp on its upper surface; ramps oblique to axis of sponge and generally rise distally (Pl. 31.14). Internal segmentation lacking. Only specimen found at Djebel Tebaga 40 mm high with maximum diameter of 20 mm, composed of 4 or 5 segments with spiral-appearing ramps; segments 6 to 8 mm high. No other structures visible on exterior.

Recrystallization largely destroyed internal structure so detailed features of interior unknown. Poorly defined vertical canals extend through segments of sponge fragments, with space between canals filled with fine, reticulate, fibrous skeletal structure. Bottom segment, in fragmental specimen in Plate 31.14, exhibits two canals in longitudinal section, each approximately 1.5 mm in diameter, with canals limited to lower segment. Each segment probably possesses such canals, but they do not extend into other segments.

Very finely porous dermal layer as described for *Imperatoria(?) fistulata* new species also developed, with segment ramps built of this dense dermal layer. Fibers in interior range 0.04 to 0.08 mm in diameter; they define round skeletal pores 0.10 to 0.18 mm in diameter; in regular network with general dominance of upwardly and outwardly divergent, fiber segments, with inner part more or less parallel exhalant tubes but outer part 45° to 50° from axial trends; fibers may parallel lower slopes of turriculate segments but meet ramp at high angles.

Discussion.—*Imperatoria marconii* de Gregorio, 1930, is much larger than the smaller species *Imperatoria voluta* new species. In addition, *Imperatoria voluta* has regularly developed segments and is not branched. *I. marconii* contrasts with *Imperatoria(?) fistulata* new species in lacking the exaulos-bearing ostia so typical of that moderately common species and in having both horizontal and vertical canals. The turriculate or spiral screwlike appearance in side view is characteristic of species of the genus, but it is particularly well developed in *Imperatoria marconii* in specimens from Sicily.

Material.—One figured specimen.

Figured Specimen.—USNM 463711, Pl. 31.14, Spot Locality T8.

Occurrence.—This species of *Imperatoria* is rare in Djebel Tebaga, for only a single, moderately well-preserved specimen occurs in our collection from Spot Locality T8.

IMPERATORIA VOLUTA new species

Plate 31.1–31.6, 31.8–31.9, 31.13; Plate 49.7; Plate 53.1; Figure 30

Synonymy.—*Imperatoria marconii* de Gregorio. Termier and Termier, 1955, p. 617, fig. 2c; Termier and Termier, 1977a, p. 42 (no illustration).

Diagnosis.—Small species of *Imperatoria* with turriculate construction but internal segmentation lacking; top of each segment with horizontal ramp with sharp upper edge; spongocoel lacking, but each segment usually bears two small oscula on summit, oscular extensions of two short tubes limited to individual segments. Numerous small pores in outer dermal wall. Internal structure composed of reticular fibers.

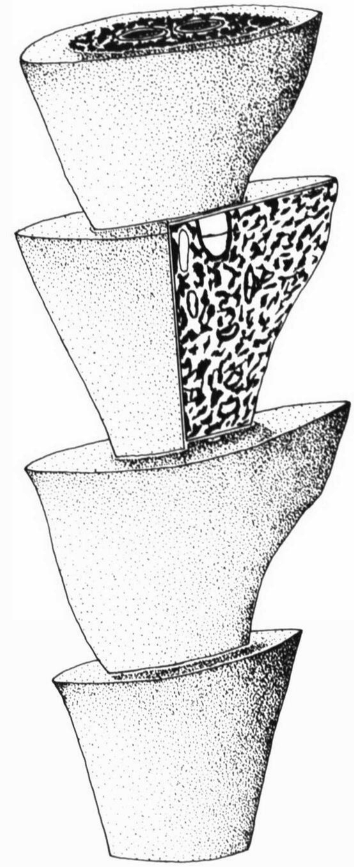

Figure 30. Reconstruction and section through a segment of *Imperatoria voluta* new species; the segmentlike elements are arranged one above the other but oblique to the axis of the sponge. Two small oscula occur on the summit of each element but do not extend through the sponge. They are limited only to the upper part of the each segment. Perforations of the dermal layer are not shown (schematic, not in scale).

Description.—Tiny, turriculate sponge with maximum diameters of 13 mm, but usually 5 to 8 mm across; fragment heights dependent upon numbers of segments; for example, one with 6 segments 27 mm high, another with 4 segments only 19 mm high. Holotype (Pl. 31.5–31.6) of 3 turriculate elements 14 mm high, with maximum diameter of 7 mm in middle part of sponge. Skeletal segments generally 5 mm high, but range 3 to 8 mm. Each segment element with upper horizontal ramp with sharp, outer, keel-like edge. Ramps usually slope inward toward axis of sponge. No branched specimens were found.

Two small oscula, 1 mm in diameter, occur at summit of most specimens, surrounded by coarse fibrous structure (Pl. 31.4–31.5, 31.13). Oscula not connected to long canals or spongocoels, for neither developed in species. Internal structure consists of coarsely reticulate fibers in relatively open structure. Fibers 0.04 to 0.08 mm thick where fine and around subprismatic pores, 0.2 to 0.4 mm across in longitudinal sections. Elsewhere fibers coarser, to 0.2 mm across, and pores smaller. General skeletal structure open and porous between walled canals. Skeletal microstructure spherulitic, but not well preserved in type specimens.

Dense outer layer of sponge, as well as upper ends of segments (not visible in all specimens), with numerous side-by-side, small, circular to polygonal pores, 0.08 to 0.15 mm in diameter separated by fibers 0.04 to 0.06 mm across. Interpretation of appearance of exterior, internal structure, and positions of two small oscula shown in Figure 30.

Discussion.—The relatively rare new species *Imperatoria voluta* was included in *Imperatoria marconii* by Termier and Termier (1955, 1977a). The small size, regular development of segments, and lack of branching, however, suggest that these sponges should be considered as a new species of the genus *Imperatoria. Imperatoria voluta* differs from *I. marconii* and *Imperatoria(?) fistula* new species by its small size and lack of exaulos-bearing ostia on the outer surface. Differentiation of *Imperatoria voluta* and the similar sponge *Bisiphonella cylindrata* Wu (1991) from the Middle Permian of China has been discussed under remarks concerning the genus *Imperatoria.*

Material.—22 specimens.

Type specimens.—Holotype, USNM 463715, Spot Locality 206-1976, Pl. 31.5–31.6; and paratypes, USNM 463712–463714, 463716–463719 on Pl. 31.1–31.4, 31.8–31.9, 31.13; Pl. 49.7; and USNM 480403 on Pl. 53.1, from Sections C, E, I, and J, and Spot Locality T9.

Occurrence.—Two specimens from Spot Locality S7; two from Spot Locality T9; one from Spot Locality 206-1976; three from Section C, bed 16, below the star-coral bed; six from Section E, bed 27, shale below CF-18a; two from Section E, shale below Reef 3; one from Section I, shale below bed 3, west of traverse; two from west of pass, west of traverse in equivalent of bed 2 of Section I; one from Section J, bed 17; and two from Section J, bed 26.

Etymology.—*Voluta,* Latin, spiral; named for the helical or spiral growth form of the species.

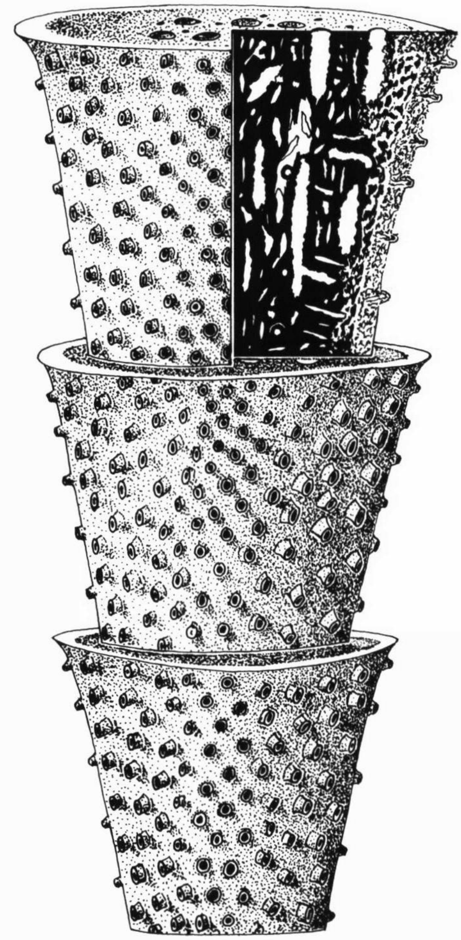

Figure 31. *Imperatoria(?) fistulata* new species. The youngest element shows the dermal layer and the coarse, reticulate layer between the dermal layer and the interior of the sponge (not to scale).

IMPERATORIA(?) FISTULATA new species

Plate 31.7, 31.10–31.12; Plate 33.19–33.20; Plate 49.8; Plate 53.2; Figure 31

Synonymy.—*Imperatoria* sp. Senowbari-Daryan, 1990, pl. 33, fig. 8.

Diagnosis.—Medium-sized *Imperatoria(?)* with turriculate construction, in which each bowl-like segment bears horizontal ramp across its summit; spongocoel lacking but each segment with one to several, irregularly arranged, longitudinal internal canals. Finely porous dermal layer clearly developed, extending over summit ramp of each segment. Numerous ostia with elevated rims (exaules) occurring over outer surface. Internal structure irregular but with both vertical and horizontal canals.

Description.—Turriculate sponges up to 30 mm in diameter; complete heights unknown because all specimens only fragmental; holotype of two turriculate-looking, segmentlike elements 15 mm high and 18 mm in diameter in upper part, and 11 mm in lower part; total fragment 30 mm high.

Well-preserved, unbranched fragments with outer surface covered by numerous ostia, 0.8 to 1.5 mm in diameter, each with elevated rim of short exaulos so appear as ruptured pustules. Extensions of ostia pass through dermal layer but end in fibrous interior.

Thin sections show finely porous dermal layer, 0.3 to 1.0 mm thick, traceable across summit of each segment, and forming upper edge of each external segment. Dermal layer of wall 0.3 to 0.5 mm thick grades into finely and irregularly reticulate layer that surrounds coarse, fibrous, inner part of sponge (see Fig. 31). Sponge interior characterized by horizontal and vertical tubes. Horizontal ones about 0.6 mm in diameter, usually smaller than vertical ones, with diameters of 0.8 to 1.5 mm. Spaces between tubes filled by coarse, irregularly fibrous skeleton. Outer 3 to 4 mm curvilinear net with fibers 0.05 to 0.10 mm in diameter, around pores 0.2 to 0.3 mm in diameter; grades to coarse fibers 0.20 to 0.25 mm in diameter; intermixed with fine fibers as in outer part, between walled transverse canals, 0.4 to 1.0 mm in diameter, and coarser vertical exhalant canals. Entire net and canal system appears irregular in orientation and size of elements.

Holotype (Pl. 31.7, 31.11) with outer surface, like paratypes, covered by pustular ostia, but irregular internal structure of holotype only moderately well preserved, but generally like that in paratypes. Exhalant tubes well developed in paratypes figured in Plate 31.10 and 31.12, and shown in Figure 31, but short and discontinuous in section of holotype (Pl. 31.7).

Discussion.—The genus *Imperatoria* and especially the species *Imperatoria(?) fistulata* new species, could be easily confused with the genus *Intratubospongia,* the latter an abundant sponge in collections from Djebel Tebaga. *Imperatoria(?) fistulata,* however, can be distinguished from *Intratubospongia* by having ostia on the outer surface, a dermal layer around the sponge, a coarse internal structure, and lack of growth lines, which are typical of specimens of *Intratubospongia* or *"Virgula"* of earlier papers on the fauna.

Imperatoria(?) fistulata differs from *Imperatoria marconii* de Gregorio by having exaulos-bearing ostia on the outer surface, presence of horizontal and vertical canals, and development of a dermal layer, as shown in Figure 31.

Exaulos-bearing ostia, which occur in *I.(?) fistulata,* were observed in neither the type species, *I. marconii,* nor in *I. voluta.* This feature makes the assignment of this species to *Imperatoria* uncertain, although probable.

Imperatoria seems to be an endemic sponge of the western Tethyan realm. Apart from occurrences in the Sosio Valley, Sicily, and at Djebel Tebaga, Tunisia, no other localities are known. However, *Imperatoria* is not an abundant sponge at Djebel Tebaga.

Material.—13 specimens.

Type specimens.—Holotype, USNM 463720, Pl. 31.7, 31.11, Section E, shale below Reef 3; and paratypes USNM 463721–463723, Pl. 31.10, 31.12; Pl. 33.19–33.20; Pl. 49.8; and USNM 480404, Pl. 52.2; from Section E, bed 15 and shale below Reef 3; and Section I, beds 2 and 5.

Occurrence.—Djebel Tebaga, three specimens from Section E, bed 15; three from Section E, shale below Reef 3; three from Section I, bed 5; and four from beds equivalent to bed 2 of Section I, but west of the section; and in the Sosio Valley, Sicily.

Etymology.—*Fistulatus,* Latin, with pipes; referring to the horizontal and vertical tubes in the interior of the sponge.

Subfamily HEPTATUBISPONGIINAE
new subfamily

Diagnosis.—Axial spongocoel present with several coarse longitudinal exhalant canals regularly spaced in one ringlike layer near periphery.

Type genus.—*Heptatubispongia* new genus.

Genus HEPTATUBISPONGIA
new genus

Diagnosis.—Cylindrical to branched sponge with relatively large axial canal or spongocoel, and usually seven but in some specimens with as few as six or as many as eight or more collateral vertical canals located near periphery of sponge. Outer surface bears a few ostia. Internal structure characterized by relatively coarse reticulate fibers. Growth lines prominent on exterior.

Discussion.—Comparisons with other similar sponges are discussed below in treatment of the type species.

Type species.—*Heptatubispongia symmetrica* new species.

Etymology.—*Hepta,* Greek, seven; *tubus,* Latin, pipes; *spongia,* sponge; named because most specimens of the species have an outer ring of seven, collateral, tubelike canals parallel to the main axial spongocoel.

HEPTATUBISPONGIA SYMMETRICA
new species

Plate 33.9–33.16; Plate 49.9

Synonymy.—*Graminospongia girtyi* (Parona) Termier and Termier, 1977b, pl. 8, fig. 1.

Diagnosis.—Cylindrical to branched sponges with axial main spongocoel and 6 to 8 symmetrically arranged, collateral vertical canals located near periphery of sponge. Relatively coarse reticular fibrous skeletal structure fills between canals. Outer surface may be weakly annulated and growth lines clearly developed in some specimens. A few ostia occur in outer surface. Ostia may unite to form larger openings.

Description.—Cylindrical to branching sponges with stems that range 4 to 7 mm in diameter. Holotype (Pl. 33.10–33.11) approximately 4 mm in diameter and 20 mm tall; largest specimen branched and 30 mm tall, although all specimens broken, so total original heights cannot be determined. One specimen weakly annulated, but others not; all with growth lines on outer surface in thin, but dense, otherwise smooth or finely textured dermal layer. Ostia 0.2 to 0.3 mm in diameter generally lack rims on exterior of dense dermal layer (Pl. 33.15, lower part), may unite in some specimens. Where ostia not evident, perhaps obscured by weathering, encrustations, or covered by recrystallized dermal layer.

Species characterized by walled axial main spongocoel, with diameters that range 0.4 to 0.8 mm; spongocoel extends virtually through sponge; walls 0.06 to 0.09 mm thick. Additional 6 to 8 collateral walled vertical canals arranged in ring near periphery; canals symmetrically and evenly spaced in skeleton around main spongocoel, walls 0.04 to 0.06 mm thick. Diameters of collateral canals 0.2 to 0.4 mm, about half the size of axial spongocoel. Complete summit with central osculum and collateral canals at base of vertical grooves. Polished surface on one side of paratype shows collateral canals may branch upwardly in interior of sponge. Skeletal network between canals reticulate, but with upwardly and outwardly arched general pattern. Fibers 0.1 to 0.2 mm diameter around pores generally about 0.1 mm in diameter. Short inhalant canals 0.2 to 0.3 mm in diameter connect ostia to exhalant canals and skeletal pores. Inhalant canals generally arch upwardly and inwardly.

Discussion.—This relatively rare sponge was described as *Graminospongia girtyi* (Parona) by Termier and Termier

(1977b, pl. 8, fig. 1), but the sponge illustrated in plate 8, figure 1 by Termier and Termier does not have the internal or external structure of that species and is included here in *Heptatubispongia.*

Openings in pustular elements on the exterior are typical of *Graminospongia* (see Senowbari-Daryan and Rigby, 1988) and *Exotubispongia* new genus, but such pustules or nodes are totally lacking in *Heptatubispongia. Graminospongia girtyi* (Parona) is a thalamid sponge and has only a single spongocoel. In transverse section, however, the small chambers of *Graminospongia* could be confused with the collateral canals of *Heptatubispongia,* but the number of chambers around the spongocoel in *Graminospongia* is much higher than the 6 to 8 canals in *Heptatubispongia.* In addition, spaces between chambers in *Graminospongia* are represented by chamber walls, but in *Heptatubispongia* they are filled by the reticulate skeleton, which allows these two genera to be easily differentiated in transverse sections.

Heptatubispongia also occurs in Lower Permian boulders within the Lercara Formation in the Sosio Valley of Sicily and in the Upper Carboniferous Auernig beds in the Alps (unpublished data from B. Senowbari-Daryan).

Material.—Four specimens.

Type specimens.—Holotype, USNM 463724, Pl. 33.9–33.12; Pl. 49.9; and paratypes, USNM 463725–463726, Pl. 33.13–33.15, all came from Section G, bed 5.

Occurrence.—Djebel Tebaga, four specimens from Section G, bed 5, at CF 53.

Etymology.—*Symmetros,* Greek, in measure with, proportional, corresponding part for part; named for the symmetric arrangement of collateral exhalant canals around the axial canal.

HEPTATUBISPONGIA(?) cf. H. SYMMETRICA new species

Plate 32.12–32.13; Plate 53.3

Description.—One specimen of this striking species in our collection may belong to *Heptatubispongia symmetrica.* Sponge with height of 30 mm and diameter of approximately 7 mm, a little larger than specimens included in *Heptatubispongia symmetrica* above. Main axial spongocoel and six collateral vertical canals evident (Pl. 32.13). Reticular skeletal fibers between canals correspond in size and orientation to those of *H. symmetrica.* Outer surface of specimen covered by numerous, well-developed ostia, each approximately 0.25 mm in diameter (Pl. 32.12).

Discussion.—Numerous ostia that cover outer surface of this specimen were not observed in specimens included above in *H. symmetrica.* The few ostia evident in type specimens of that species could be a result of weathering and perhaps even this well-preserved specimen should be included in the type species.

Material.—One specimen.

Figured specimen.—USNM 463727, equivalent to bed 2, Section I, west of traverse.

Occurrence.—One specimen from west of the house, west of the trail, and west of Section I but in beds equivalent to bed 2.

HEPTATUBISPONGIA(?) sp.

Plate 30.1, 30.8

Description.—Single specimen of moderately coarsely preserved small sponge with basic canal pattern of *Heptatubispongia,* with prominent axial spongocoel and perhaps 10 collateral, walled, vertical canals in ring near the periphery and exposed in moderately well-preserved tip. Sponge fragment 25 mm tall and 6 to 7 mm in diameter, broken at base of stemlike subcylindrical form. Upper tip somewhat bullet-shaped or hemispherical, pierced by central tubular spongocoel 1.0 to 1.2 mm in diameter and surrounded by ring of canals each 0.5 to 0.7 mm in diameter, although locally oval in section and somewhat longer than that radially. Surface marked by low vertical ribs and grooves, approximately 2 mm apart trough to trough, somewhat irregularly grooved over canals in dense dermal layer.

Discussion.—Although the small, stemlike sponge has a central axial spongocoel surrounded by a ring of collateral canals well exposed in the tip, these 9 or 10 canals are much larger and separated by more massive skeletal material than in *Heptatubispongia symmetrica* new species, where the ring of outer canals usually includes only 6 to 8 canals that are only 0.2 to 0.3 mm in diameter. The central spongocoel is also nearly twice the diameter in this questionable specimen as in type specimens of *Heptatubispongia symmetrica.* This specimen is tentatively placed in *Heptatubispongia,* however, because of the distinctive canal pattern, but it differs significantly from *Heptatubispongia symmetrica* new species, the type species of the genus, and the other small specimen tentatively classified as *Heptatubispongia* cf. *H. symmetrica.*

Material.—One specimen.

Figured specimen.—The single figured specimen, USNM 480355, Pl. 30.1, 30.8, from Section I, bed 5.

Occurrence.—Djebel Tebaga, one specimen from Section I, bed 5.

Family VIRGULIDAE Termier and Termier, 1977a

Synonyms.—Includes Paracorynellidae Wu, 1991, and Polysiphonellidae Wu, 1991.

Emended diagnosis.—Obconical or cylindrical to massive or irregularly spherical sponges that contain numerous longitudinal spongocoels throughout whole sponge, or radial where spherical; may include axial tubes or clusters of exhalant canals; summit may range from domed to concave with pronounced depression; inhalant canals absent or present and where present, more or less horizontal.

Type genus.—*Virgula* Girty, 1908a.

Subfamily VIRGULINAE Termier and Termier, 1977a

Original diagnosis.—"Les membres de cette [sub] famille sont caractérisés par un réseau stromatoporoïde du même type que celui des Disjectoporidés, mais avec une morphologie centralisée. La présence de spherolithes y a été observée. La forme est verticale, plus ou moins conique, pourvue de planchers horizontaux légèrement convexes. Les tubes ont deux dispositions pouvant coexister: les unes divergent en éventail vers une structure astrorhizaire unique; tendant vers la présence d'un gastrocoele, les autres sont subhorizontaux, aboutissant à la surface externe par des pores" [The members of this (sub)family (Virgulinae) are characterized by a stromatoporoid net of the same type as that in the disjectoporids, but with a centralized morphology. The presence of spherulites has been observed. The form is vertical, but more or less conical, provided with horizontal slightly convex floors. The tubes have two coexistent arrangements: one diverges fanshaped toward a single astrorhizal structure, extending toward the gastrocoel; the others are subhorizontal, ending at the exterior as pores] (Termier and Termier, 1977a, p. 31).

Discussion.—The genus *Virgula* (renamed to *Virgola* by de Laubenfels, 1955, because of homonymy with *Virgula* Simpson, 1900) was established by Girty (1908a, p. 73), who described two species, *V. neptunia* and *V. rigida,* and one variety, *V. rigida,* var. *constricta* from Permian rocks of the Guadalupe Mountains, Texas, USA. The internal structure of the type species, *V. neptunia* (Girty, 1908a, pl. 7, fig. 11–12, see also de Laubenfels, 1955, p. 54, fig. 3), is composed of a reticular, meshlike, fibrous structure and does not show any internal tubes or canals. Girty (1908a, p. 73) noted, however, that "there is in some specimens a tubular cloaca extending part way through the center of the sponge, but this has not been demonstrated as a permanent feature." This note of Girty indicates that apparently a few intermittent canals are developed in the axial part of *Virgola neptunia.* The external appearance of the type species was not described nor figured. The internal structure of *V. rigida* was not described by Girty (1908a, p. 74) "but seems to be same as in *V. neptunia.*"

The systematic position of the genus *Virgola* is controversial. De Laubenfels (1955) placed *Virgola* with some question into the tetracladine demosponges. However, Finks (1960, p. 93) placed *Virgola* with pharetronid calcisponges. Termier and Termier (1977a) saw some relationship between *Virgola* and *Disjectopora* Waagen and Wentzel (1887), although Termier and Termier also pointed out similarities between *Virgola* and *Precorynella,* which is also an abundant sponge at Djebel Tebaga. Termier and Termier (1977a) established the Family Virgulidae, which was placed into the order by them.

Another questionable species of *Virgola* was described by Gerth (1927, p. 21–22, pl. 4, fig. 8, 8a; pl. 6, fig. 11) from the Permian of Timor as *"Virgula"? malayica.* The species from Timor, as represented by Gerth (1927, pl. 6, fig. 11), appears to be a demosponge.

Type genus.—*Virgula* Girty, 1908a.

Genus INTRATUBOSPONGIA Rigby, Fan, and Zhang, 1989

Synonyms.—*Virgola* de Laubenfels, 1955, *partim, pro Virgula* Girty, 1908a, *partim. Paracorynella* Wu, 1991; *Paristellispongia* Wu, 1991.

Original diagnosis.—"Cylindrical to subcylindrical or club-shaped sponge with many longitudinal, walled exhalant canals, 0.5–0.6 mm across; canal walls 0.1–0.2 mm thick and coarsely perforate with pores 0.1 mm across that are openings of fine inhalant canals, 0.12–0.17 mm across; skeletal fibers generally 0.05–0.07 mm across" (Rigby, Fan, and Zhang, 1989, p. 790).

Discussion.—Rigby, Fan, and Zhang (1989, p. 79) erected the new genus *Intratubospongia* for sponges from the Permian reefs of south China. They included four new species (*I. typica, I. tenuiperforata, I. multisiphonata,* and *I. minima*) in the new genus *Intratubospongia.* The type species of the genus, *I. typica,* is essentially identical to *V. osiensis* (de Gregorio). Also, *Intratubospongia multisiphonata,* which was described from transverse and oblique sections by Rigby, Fan, and Zhang (1989), represents the same species.

De Gregorio (1930, p. 42, pl. 16, fig. 1–4) described the species *Cystiphyllum osiensis* from the Permian of Sosio Valley, Sicily. This sponge was redescribed by Parona (1933) and placed in the genus *Virgola* de Laubenfels, 1955 (=*Virgula* Girty). Parona (1933, p. 17–18, pl. 4, fig. 1–5) described another species of the genus from the same locality as *"Virgula" bifida,* but it has an internal skeletal and an external appearance different from that of *Virgola osiensis* (de Gregorio). *Virgola osiensis* has the canal and skeletal pattern of *Intratubospongia.* All three species (*V. osiensis, I. typica,* and *I. multisiphonata*) are considered here to represent the same species. The species name *osiensis* has priority and becomes the type species of the genus.

Wu (1991) proposed the new family Paracorynellidae with only the new type genus *Paracorynella,* and its single species, *P. flexa.* The genus appears very similar to *Intratubospongia* Rigby, Fan, and Zhang, 1989, and diagnoses of both genera are almost identical. We cited the original diagnosis of *Intratubospongia* above, and the following is the original diagnosis of *Paracorynella* Wu to show their essential identity. "Sponge single or compound. Skeletons cylindrical or hemispherical, with a canal system consisting of aporrhyses, multicloaca, and multi-osculum. Fibers arranged into regular or irregular lattice" (Wu, 1991, p. 64). Comparisons of the diagnoses of both genera (*Paracorynella* and *Intrabutospongia*), as well as the illustrated thin sections from Rigby, Fan, and Zhang (1989) and Wu (1991) confirm the identity of the genera. *Paracorynella* Wu is a synonym of *Intratubospongia* Rigby, Fan, and Zhang.

The identification of *Intratubospongia flexa* (=*Paracornyella flexa* Wu) as a separate species or its affiliation to described species of the genus *Intratubispongia* should be examined by a researcher with access to the critical Chinese thin sections.

The genus *Paristellispongia* Wu, 1991 with type species *P. parallela* also should be put into synonymy with *Intratubospongia.* The original diagnosis of *Paristellispongia* is: "Sponges single or compound. Skeletons generally subspherical in form, with a canal system consisting of ostia, epirrhyses and a multiosculum (possibly in a cloaca depression). The epirrhyses consist of tubes vertical, straight, and subparallel to each other. The aporrhyses converge to the multiosculum. In compound forms, there is more than one multiosculum. From each multiosculum a group of aporrhyses radiates downwards. Fibres arranged into regular or irregular lattice" (Wu, 1991, p. 71).

A comparison of diagnoses of *Paristellispongia* and *Paracorynella* with *Intratubispongia* makes it difficult to recognize differences between these three genera. Also the illustrated thin sections of these genera are almost identical. Such small differences between the three genera and in sponges in general do not, in our opinion, justify establishment of a new genus.

We also observe that the characteristics of the genus *Paristellispongia* as given by Wu, for example, or the diagram of the canal system in *Paristellispongia* shown by him in his figure 21 cannot be seen in the photographic illustrations. Wu may have had access to other and unfigured specimens or thin sections that show the characteristics of *Paristellispongia* better than the illustrated specimens, but because these are not published, the documentation of *Paristellispongia* does not justify establishing a new genus for this sponge. *Paristellispongia* is here considered an additional synonym of *Intratubospongia* Rigby, Fan, and Zhang.

The sponge described as *Stellispongia* cf. *S. manon* by Wu (1991, p. 69, pl. 9, fig. 12) and *Stellispongia* sp. (specimen on the upper part growing on a species of *?Cavusonella caverna* Rigby, Fan, and Zhang, 1989) also seems to be representative of *Intratubospongia.*

At present, the following are species of the genus *Intratubospongia* Rigby, Fan, and Zhang, 1989: *I. osiensis* (de Gregorio, 1930) (synonyms: *I. typica* Rigby, Fan, and Zhang, 1989, *I. multisiphonata* Rigby, Fan, and Zhang, 1989); *I. bifida* (Parona, 1933) (the identity of this species should be proven); *I. minima* Rigby, Fan, and Zhang, 1989; and *I.? tenuiperforata* Rigby, Fan, and Zhang, 1989 (this species may not belong to *Intratubospongia*). Those species in the very similar genus *Virgola* de Laubenfels, 1955 (=*Virgula,* Girty, 1908a) include *V. neptunia* (Girty, 1908a); *V.? rigida rigida* (Girty, 1908a); *V.? rigida constricta* (Girty, 1908a); and *V.? malayica* (Gerth, 1927) (most probably belongs to the demosponges; see Finks, 1960).

INTRATUBOSPONGIA OSIENSIS (de Gregorio, 1930)

Plate 32.1–32.6; Plate 34; Plate 50.1–50.2; Plate 53.4; Plate 66.1–66.4; Plate 76.3; Plate 77.1–77.5

Synonymy.—*Cystiphyllum osiensis* de Gregorio, 1930, p. 42, pl. 16, fig. 1–4.

Virgula osiensis (de Gregorio). Parona, 1933, p. 16, pl. 2, fig. 10–11; Termier and Termier, 1955, pl. 626, fig. 8a–c; Termier and Termier, 1977a, p. 32, pl. 11, fig. 7–8; Termier and Termier, 1977b, p. 63, fig. 5.

Virgula bifida (Parona). Termier and Termier, 1955, p. 626, fig. 8d; Termier and Termier, 1977a, p. 32, pl. 12, fig. 5–6.

Virgula sp. Termier and Termier, 1955, p. 626, fig. 8e–f; Termier and Termier, 1977a, p. 32; Termier and Termier, 1977b, p. 63, fig. 4; pl. 5, fig. 8, pl. 7, fig. 2.

Intratubospongia typica Rigby, Fan, and Zhang, 1989, p. 790–792, fig. 11.1–11.3, 11.5, 11.7.

Intratubospongia multisiphonata Rigby, Fan, and Zhang, 1989, p. 790–792, fig. 10.5, 10.10, 12.10.

Description.—Cylindrical to club-shaped or steeply obconical sponges; most specimens with annulate exterior and appear composed of segmentlike elements one above the other (Pl. 32.2; Pl. 34.2), as in Permian genus *Imperatoria* de Gregorio, also a moderately common sponge at Djebel Tebaga. Typically, specimens of *I. osiensis* with prominent ringlike growth lines throughout height of sponge (Pl. 34.2, 34.4, 34.6, 34.8, 34.12, 34.14). Outer surface of sponge formed by fine, reticular fibers approximately 0.05 mm in diameter and with small pores 0.03 to 0.08 mm in diameter between the fibers. Large openings lacking on outer surface.

Summit of each sponge marked by bowl-shaped, calyxlike depression into which open numerous exhalant canals (Pl. 32.3, 32.6; Pl. 34.5, 34.7, 34.11, 34.13) 0.5 to 1.0 mm in diameter distributed throughout sponge. Prominent bowl-like summit depressions range to 10 mm deep; numerous septalike ridges and separate furrows, as in *Precorynella,* extend from edge of the bowl down into hollow, producing coral-like appearance (Pl. 32.3; Pl. 34.10–34.11, 34.13). Widths and depths of furrows range up to 10 mm. Most but not all specimens with such furrows well defined. Numerous excurrent openings located in furrows.

Upper edge of bowl composed of dense skeletal material up to 1 mm thick. This part of skeleton, being made by dermal layer composed of fiber structures, does not contain large exhalant openings.

Interior of sponges characterized by numerous, longitudinal, parallel, and irregularly spaced canals throughout (Pl. 76.3; 77.1–77.5). Canals generally 0.8 to 1.0 mm in diameter but range 0.6 to 1.2 mm in diameter and open in distinct ostia at top of sponge. In addition, several horizontal inhalant canals 0.5 to 0.8 mm in diameter extend from smaller pores in dermal layer into axial part of sponge (Pl. 77.1, 77.5). These larger inhalant canals do not pierce dermal layer, which is 0.1 to 0.8 mm thick. Concentration of longitudinal exhalant canals in axial part of sponges (Pl. 77.1) is variable and not a diagnostic, specific feature, although used earlier by Rigby, Fan, and Zhang (1989) to differentiate the new species *I. multisiphonata.*

Spaces between longitudinal exhalant canals and horizontal inhalant canals filled by relatively regular reticulation of skeleton fibers (Pl. 77.3–77.4). Thicknesses of fibers relatively constant, ranging from 0.5 to 0.8 mm. Diameters of interfiber pores range from 0.7 to 1.4 mm.

Two specimens of *Intratubospongia osiensis* investigated using scanning electron microscopy. Sample 1 recrystallized and no microstructure preserved; second sample (USNM 480346; Pl. 66.1–66.4) with rigid skeleton composed of well-preserved spherulites, approximately 30 µm in diameter. Termier and Termier (1977a) earlier pointed out spherulitic microstructure of *Intratubospongia,* called *Virgola* by them.

Discussion.—Sizes of complete sponges, details of skeletal elements, and the nature of the calyxlike summit depression vary greatly in this species. The range of distribution of the longitudinal exhalant canals, whether irregularly and widely spaced throughout the sponge or with some concentration in the axial region, is also great and does not allow separation of the species *I. multisiphonata,* as was done by Rigby, Fan, and Zhang (1989). The species are synonyms. The larger size and greater height of the sponge does not require recognition of two species, as was done by Termier and Termier (1977a) when they erected the species *V. bifida* on the basis of size differences. All the species described by Termier and Termier (1955, 1977a) are included here within *I. osiensis* (de Gregorio). The identity of species described as *Paracorynella flexa, Paristellispongia parallelica, Stellispongia* cf. *manon,* and *Stellispongia* sp. by Wu (1991), whether as separate species or affiliated to *Intratubospongia osiensis* (de Gregorio), should be considered carefully after investigation of Wu's collections or by collecting new specimens from the Chinese Permian localities. They are likely to be synonyms.

Material.—Over 750 specimens of *Intratubospongia osiensis* from numerous localities document the species as the most abundant inozoid sponge in the Permian section at Djebel Tebaga.

Figured specimens.—USNM 480237–480247, 480316–480320, and 480346, from Section E, beds 14, 17, and 27, and shale below Reef 3; Section I, bed 2 and shale below bed 3 to west; Section J, bed 18, and Spot Localities 21A, 22A, 16A, S-7, DJT-16, and 204-1976.

Occurrence.—As noted earlier, the external appearance of *Virgola rigida* (both *V. rigida rigida* and *V. rigida constricta*) described from the Permian of the Guadalupe Mountains by Girty (1908a) is the same as *I. osiensis* (de Gregorio). *V. rigida* could belong to *Intratubospongia.* Reinvestigation of Girty's specimens (1908a) is necessary. The occurrence of the genus in the Guadalupe Mountains is suggested.

The genus *Intratubospongia* and the species *I. osiensis,* in particular, occur in Middle and Upper Permian reefs in South China. It does not seem to be as abundant there, however, as in Djebel Tebaga or in Sicily, although it has been described as several genera from Chinese collections. The genus seems to be restricted to the Middle and Upper Permian.

INTRATUBOSPONGIA OBSCURA new species

Plate 6.3–6.4; Plate 50.3; Plate 53.5; Plate 65.1–65.2

Diagnosis.—Irregularly annulate columnar sponges with faint, shallow oscular areas, to which converge obscure surficial canals. Ill-defined axial clusters of vertical exhalant canals in shallow oscular depression about 10 mm across. Ostia of vertical or longitudinal exhalant canals mostly 0.5 mm in diameter, irregularly spaced over summit, between ostia of much more common, smaller, inhalant canals 0.2 to 0.3 mm across. Canal walls tubular. Skeletal net regularly rectangular, with vertical fibers dominant. Lacks spongocoel and transverse canals. Skeletal microstructure spherulitic.

Description.—Holotype irregularly cylindrical, annulate; sponge at least 45 mm high, but with broken base; with oval to rounded-quadrate transverse section 28 by 45 mm across, extending upward from cylindrical round base 20 to 25 mm across. Exterior with prominent, deep annulations and rounded ridges, marking pulses of growth. Irregular, thin, dermal layer developed principally on lower parts of rounded annulate bulges. Two faint and shallow oscular depressions, approximately 10 mm across and 1 to 2 mm deep on summit, to which converge a few obscure grooves of exhalant canals, approximately 0.5 mm wide and discontinuous and shallow.

Surfaces between surficial canals marked by ostia of both inhalant and exhalant canals and skeletal pores. Exhalant canals largest openings in skeleton, ranging 0.4 to 0.6 mm wide on summit, with most approximately 0.5 mm in diameter as round, irregularly porous-walled openings that extend into interior as tubular canals, parallel to skeletal structure. Most continuous exhalant canals traceable 8 to 9 mm from summit before becoming obscured in skeleton or curved away from available longitudinal section. Shallow canals of summit cluster generally do not extend far into interior. Exhalant canals on summit and in interior, 1 to 2 mm apart.

Round inhalant ostia on summit, 0.2 to 0.3 mm in diameter, abundant with 10 to 12 per mm^2 on upper surface. Canals commonly separated only by one skeletal fiber and traceable as continuous tubular openings several millimeters down into regular skeletal net. Other parallel openings continue irregularly into interior.

Moderately coarse, vertically aligned skeletal pores circular and 0.10 to 0.14 mm in diameter, occurring as tubular openings parallel to longitudinal fibers and coarser canals. Horizontal skeletal pores, circular and 0.08 to 0.12 mm in diameter, interconnect vertical pores in moderately regular rectangular pattern between porous canals. Transverse canals lacking, but skeletal pores provide lateral connection; sometimes locally short openings up to 0.5 mm long in rectangular net but do not form consistent linear series.

Skeletal structure essentially upwardly and outwardly expanding with vertical fibers dominant. Upward divergence on lateral margins generally 20° to 30° from axis, but fibers locally diverge to 60° from axis in lateral bulges of annular layers. Fibers 0.08 to 0.10 mm in diameter, with circular cross sections, and expanding in junctions to approximately 0.14 mm across. Vertical fibers most nearly continuous and forming longitudinal, dominant, upwardly and outwardly expanding skeleton; fibers arranged essentially normal to upper and lateral surfaces of sponge at the time fibers were formed. Skeletal microstructure spherulitic, with spherulites 60 µm in diameter.

Growth pulses marked in interior by more dense layers, upwardly arched and essentially parallel to present summit surface; layers 0.1 to 0.2 mm thick, of fibers expanded to 0.2 mm in diameter. Dense layers irregularly spaced 3 to 5 mm apart and continue laterally to crests of rounded, lateral bulges of growth lines or annulations on exterior.

Discussion.—*Intratubospongia osiensis* (de Gregorio, 1930) is a very common sponge in collections from Djebel Tebaga and has an interior canal and skeletal structure somewhat like that in the species described here. Specimens of *I. osiensis,* although variable, generally have bowl-shaped, calyxlike depressions on their summits instead of the massive, upwardly arched summit seen here. Canals in the interior of *Intratubospongia obscura* are considerably smaller than the longitudinal exhalant canals in *I. osiensis.* In addition, *I. osiensis* has horizontal inhalant canals, in contrast to the lack of such canals in *I. obscura. I. osiensis* appears to lack the small inhalant canals that are parallel to the exhalant series in *I. obscura,* although the general skeletal structure of the two species appears to be essentially the same dimensions and character.

Some species of *Prestellispongia* have obscure, ostial development and transverse tangential, surficial grooves somewhat similar to *Intratubospongia obscura,* and several *Prestellispongia* species have prominent, vertical canals that pierce the skeleton and are of essentially the same diameter as the large exhalant canals seen here. *Prestellispongia lobata* (Parona, 1933), for example, has vertical canals that range 0.5 to 0.8 mm in diameter and skeletal pores that range 0.08 to 0.10 mm in diameter, like those in the relatively finely textured net seen here in *Intratubospongia obscura. Prestellispongia lobata,* however, lacks the second series of canals that appear to be inhalant openings 0.2 to 0.3 mm in diameter and, in general, has considerably more well-defined astrorhizal-like clusters on summits of the sponges. The nature of those structures and differences in the canal development separate the genera and species.

Prestellispongia paula new species is a smaller species in which the coarsest vertical canals are 0.2 to 0.3 mm in diameter, considerably finer than the prominent canals in *I. obscura* described here. In addition, *Prestellispongia paula* has numerous, well-defined, small, starlike oscular clusters, structures that are not developed in *Intratubospongia obscura.* Horizontal canals are common throughout the interior of the skeleton in *Prestellispongia paula* and are not developed at all in *Intratubospongia obscura.*

Material.—One specimen.

Type specimen.—Holotype, USNM 480305, Pl. 6.3–6.4; Pl. 50.3; Pl. 53.5; Pl. 65.1–65.2, Spot Locality DJT-27, Djebel Tebaga.

Occurrence.—The only known specimen, the holotype, is from Djebel Tebaga Spot Locality DJT-27.

Etymology.—*Obscura,* Latin, dark or indefinite; in reference to the obscure oscular depressions and convergent surficial canals on the summit of the sponge.

Subfamily PREEUDINAE new subfamily

Diagnosis.—Virgulid sponges without large osculum or depression on summit.

Type genus.—*Preeudea* Termier and Termier, 1977a.

Genus PREEUDEA Termier and Termier, 1977a

Original diagnosis.—"*Preeudea* se présente comme *Eudea,* mais sans tube axial et avec de nombreux tubes aquifères verticaux" [*Preeudea* appears like *Eudea* but without an axial tube and with numerous vertical water-bearing tubes] (Termier and Termier, 1977a, p. 33).

Discussion.—Comparison of diagnoses of *Eudea* Lamouroux (1821, p. 46, see also Zittel, 1878, p. 26; Dieci, Antonacci, and Zardini, 1968, p. 141) and *Preeudea* Termier and Termier, 1977a, indicate that *Eudea* is characterized by a single axial spongocoel, whereas *Preeudea* has several vertical tubes. From the diagnosis of *Preeudea* given by Termier and Termier (1977a, p. 33), however, it is not clear whether the tubes are concentrated in the axial part or distributed throughout the whole cross section. Outer surfaces of representatives of both genera are covered by ostia with elevated rims. *Eudea* has an irregularly reticular skeletal structure, but other structures are lacking. The internal structure of *Preeudea* was not described by Termier and Termier (1977a), but we add some information to their short diagnosis of this genus, below, concerning the internal structure of the genus and position of internal canals in *Preeudea.*

Three types of sponges with the same external appearance as *Preeudea* occur in our collections, including *Preeudea,* *Daharella,* and *Djemelia* (see Fig. 16). Exteriors of all three are covered by ostia with elevated rims. The sponges are clearly separated, however, by differences in canal patterns and presence or absence of one or several axial tubes. Cylindrical or club-shaped sponges with numerous axial or broadly distributed tubes are here included in *Preeudea* Termier and Termier, 1977a. Those with only an axial spongocoel are included in *Djemelia* new genus, and those without any spongocoel or coarse vertical exhalant canals are placed herein in the new genus *Daharella.*

PREEUDEA MINIMA Termier and Termier, 1977a

Plate 33.1–33.8; Plate 50.5; Plate 53.6

Synonymy.—Jereopsis? Termier and Termier, 1955, p. 629, fig. 10a.

Preeudea minima Termier and Termier, 1977a, p. 33, pl. 11, fig. 6.

Description.—Largest specimen of species in our collection 18 mm in diameter, 18 mm high, and subspherical. Other specimens generally cylindrical, with smallest 7 mm in diameter and tallest one 38 mm high. Outer surfaces of all specimens with dense dermal layer perforated by numerous ostia 0.9 to 1.2 mm in diameter, with elevated rims and spaced 1 to 5 mm apart (Pl. 33.1, 33.4–33.5, 33.8). Canals do not branch in interior, unlike similar canals in *Eudea.*

About 30 vertical, walled, tubelike canals, with diameters of 0.4 to 1.0 mm, occur in individual sponges, but numbers vary depending on sizes of sponges. Canals may be largely concentrated in axial area in some specimens (Pl. 33.2) but distributed throughout whole sponge in other specimens (Pl. 33.3, 33.5, 33.7). Canal walls generally about 0.04 mm thick but may range up to 0.08 mm thick and perforated by common pores 0.02 to 0.04 mm in diameter to connect with skeletal pores of net. Spaces between canals range from 0.2 to 1.2 mm across and filled by very fine net of fibers, irregularly 0.02 to 0.08 mm in diameter, around circular or oval pores, generally 0.04 to 0.08 mm in diameter. Net with obscure inhalant canals and large pores 0.2 to 0.3 mm in diameter, occurring as irregular open segments generally more or less horizontal but usually ill-defined in open but fine, porous skeleton. Skeletal microstructure spherulitic.

Discussion.—Description of this species by Termier and Termier (1977a) is insufficient, for they gave neither dimensions of the sponge nor its elements. According to the magnification given by them (1977a, p. 107), their only figured specimen of *Preeudea minima* (Termier and Termier, 1977a, pl. 11.6) should have a diameter of about 5 mm. Our specimens, however, are much bigger than that, up to 18 mm in diameter and height. Comparisons with similar sponges have been discussed in treatment of the genus.

Material.—Six specimens.

Figured specimens.—USNM 463733–463736, 480211, Pl. 33.1–33.8; Pl. 50.5; Pl. 53.6, from Section E, shale below Reef 3; Section G, beds 4, 5, and Section J, bed 17; plus Spot Locality T8.

Occurrence.—Preeudea minima is not an abundant sponge at Djebel Tebaga. Specimens collected include one from Section G, bed 4; one from Section G, bed 5, 100 m north of CF53; one from Section J, bed 17; one from Spot Locality T8, and two from Section E, shale below Reef 3.

Genus MEDENINA new genus

Diagnosis.—Single or branched, club-shaped, perhaps annulate sponge with numerous, longitudinal, exhalant canals densely packed side by side in central part, but numbers of canals decrease, and distances between them increase toward periphery. Horizontal canals developed between tubes and in peripheral part. Both canal walls and walls of horizontal elements pierced by numerous small pores. Skeletal microstructure spherulitic.

Discussion.—Several genera of inozoans have a bundle or bundles of vertical to subvertical exhalant canals: *Sestrostomella* Zittel, 1878; *Precorynella* Dieci, Antonacci, and Zardini, 1968; *Stollanella* Bizzarini and Russo, 1986; *Intratubospongia* Rigby, Fan, and Zhang, 1989; and *Grossotubenella* Rigby, Fan, and Zhang, 1989. Differences between these genera and their characteristics are shown in generalized diagrams in Figure 11. The first three genera mentioned above are each characterized by a bundle of axial canals; their other canals are not distributed throughout the sponge as they are in *Medenina.* The new genus differs from *Intratubospongia* and *Grossotubenella* mainly by development of horizontal canals in the peripheral part of the sponge.

Medenina may be most similar to *Intratubospongia* Rigby, Fan, and Zhang, 1989, described from the Middle to Late Permian reefs of China, for both have exhalant canals that decrease in number toward the periphery of the sponge. Spaces between canals in *Intratubospongia,* however, are filled by a fine, reticulate structure; and the horizontal elements that characterize *Medenina* are missing. In addition to the horizontal elements, perforations in canal walls and horizontal elements of *Medenina* are different from those in *Intratubospongia* Rigby, Fan, and Zhang (1989). The other genera mentioned above are easily separated from the new genus by differences in canal patterns, as noted.

Type species.—Medenina laterala new species.

Etymology.—Named after the community of Medenine, which is near Djebel Tebaga in southern Tunisia.

MEDENINA LATERALA new species

Plate 35.1–35.8; Plate 50.4; Plate 78.3–78.6; Figure 32

Diagnosis.—Diagnosis as for genus.

Description.—Club-shaped single or branched sponges of variable size, with smallest being 5 mm in diameter and 23 mm high and largest (holotype, Pl. 35.1–35.2) being 33 mm diameter and 65 mm high. Some paratypes with annulate growth, but holotype shows only weak annulation.

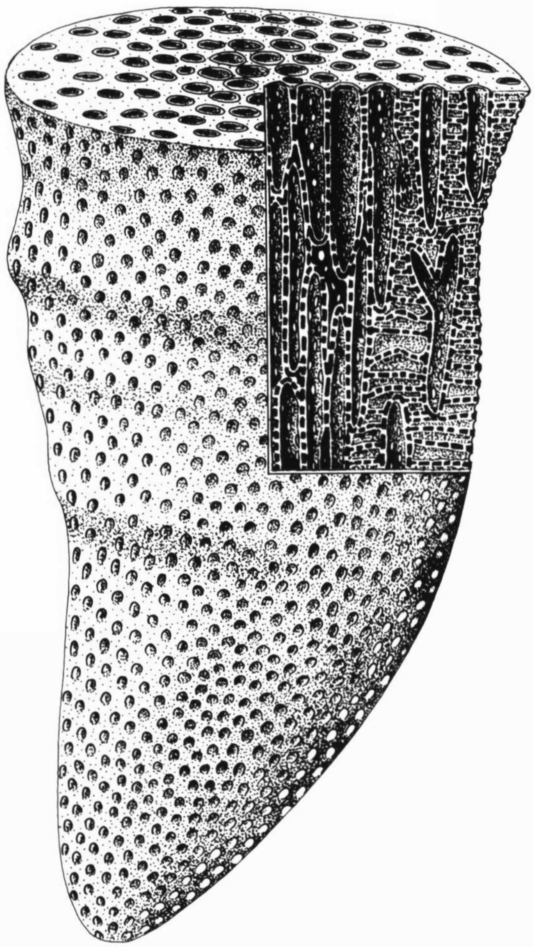

Figure 32. A reconstruction of *Medenina laterala* new species. The vertical section shows the loosely packed vertical canals near the periphery of the sponge and horizontal skeletal elements between them. Both walls of the canals and the horizontal elements have numerous small pores. The transverse cross section shows exhalant tubes concentrated in the axial area of the sponge (schematic, not to scale).

Species characterized by central, longitudinal bundle of long, walled, exhalant canals 0.6 to 1.0 mm in diameter that pass nearly through sponge. Canals parallel to sponge axis in central part but curve upwardly and inwardly toward axial cluster in outer part (Pl. 78.3–78.4), where canals may merge upwardly. Canals in axial cluster densely packed side by side, with perforated walls 0.4 to 1.0 mm thick and no fibrous skeleton between them (Pl. 78.4). Toward periphery, numbers of canals decrease, and distances between them increase up to 2 mm. Horizontal skeletal fibers and pores visible between canals in longitudinal sections in outer part, but limited in central area of axial cluster. Larger pores between horizontal fibers in interior connected by numerous small openings 0.2 to 0.4 mm in diameter (Pl. 78.5). Distances between horizontal elements range from 0.1 to 0.4 mm, elements being 0.08 to 0.40 mm thick.

Outer part of skeleton with dominantly gently arched, horizontal inhalant canals, 0.4 to 0.6 mm diameter, separated by perforated walls generally 0.1 to 0.2 mm thick but thicker in upper part of larger sponges where canals also somewhat larger. Outer part 1 to 4 mm thick, with thickness of outer, horizontally canalled part generally increasing upward and as diameter of sponge increases. Pores in all canal walls 0.1 to 0.2 mm in diameter, but walls not profusely porous, although pores do connect all adjacent canals.

Dermal layer to 0.3 mm thick, somewhat more dense than interior skeleton, characterized by numerous side-by-side small pores with diameters 0.2 to 0.3 mm and with rounded nodelike terminations of skeletal fibers of same general dimensions. Exterior locally obscure because of weathering or encrustation by algae. Microstructure of specimen investigated with SEM poorly preserved but spherulites still recognizable.

Top of holotype (Pl. 35.1) and of some paratypes with depression (osculum) to 10 mm in diameter, but other paratypes without depression. Figure 32 shows characteristics of the exterior and interior of *Medenina laterala* new species.

Discussion.—Comparisons with similar sponges have been made in treatment of the genus.

Material.—Twelve specimens.

Type specimens.—Holotype, USNM 463728, Spot Locality 21A-23A, Pl. 35.1–35.2; and paratypes, USNM 463729–463732, Pl. 35.3–35.7; and USNM 480313–480315, Pl. 78.2–78.5, from Section E, bed 29a, Section J, beds 17 and 25, and Spot Locality T5.

Occurrence.—*Medenina laterala* is a moderately abundant sponge at Djebel Tebaga. Four specimens at Spot Locality 143-1976; one at Spot Locality T5; three at Spot Locality DJT-8; one from Spot Locality DJT 21A-23A; one from Section E, bed 29e; and two from Section J, bed 17 at the button locality.

Etymology.—*Lateralis,* Latin, of the side; referring to the lateral structure of the outer part of the sponge.

Genus POLYTUBIFUNGIA new genus

Diagnosis.—Mushroom-shaped sponge without large, deep, spongocoel but with numerous coarse exhalant canals that pass vertically through sponge and distributed throughout entire sponge; very fine fibrous skeletal net between tubelike canals. Inhalant canals lacking or ill defined. Ostia characteristically with raised rims on outer surface; growth lines clearly developed.

Discussion.—*Polytubifungia* appears, at first glance, like some sclerosponges represented by several species in the Djebel Tebaga collection. *Polytubifungia* is differentiated from these fossils by possession of ostia on the outer surface and by the fibrous skeleton between the tubes.

The general shape of the sponge, with ostia on the summit, is like that of *Parahimatella* new genus, but *Polytubifungia* differs from that genus by lacking prominent coarse oscula on the summit and also by having ostia on the outer surface of the sponge. The new genus differs from similar sponges, for example the typically Triassic genera *Leiofungia* Fromentel, 1860, or *Leiospongia* d'Orbigny, 1849 by having widespread, vertical, exhalant canals throughout its skeleton and by development of prominent ostia. *Polytubifungia* is similar to *Polysiphonella* Russo (1981) because both have numerous vertical canals that pass through the whole sponge but they are different because *Polytubifungia* has exaulos-bearing ostia on the outer surface and lacks the coarse, horizontally arranged canals developed in *Polysiphonella. Polysiphonella* also has an irregular microstructure rather than a spherulitic one.

Type species.—*Polytubifungia maxima* new species.

Included species.—*Polytubifungia maxima* new species; *P. minima* new species.

Etymology.—*Poly,* Latin, several; *tubus,* pipe; *fungus,* mushroom; in reference to the many canals in the mushroom-shaped sponge.

POLYTUBIFUNGIA MAXIMA new species

Plate 36.1–36.18, 36.23; Plate 50.6; Plate 53.7–53.8; Plate 59.3–59.5; Plate 74.1, 74.6; Figure 33

Synonymy.—*Leiospongia* sp. Termier and Termier, 1977b, fig. 3.

Diagnosis.—Mushroom-shaped sponge with numerous relatively large, vertical, generally unwalled, exhalant canals up to 0.6 mm in diameter, large in comparison to those in *Polytubifungia minima* new species; canals separated by relatively coarse, fibrous skeletal structure. Ostia on outer surfaces typically with elevated rims (exaules). Growth lines clearly developed.

Description.—Sizes of mushroom-shaped species variable; holotype (Pl. 36.11–36.12) largest of 47 collected specimens with diameter of 40 mm and height of 20 mm, but perhaps originally about 10 mm higher before base broken. Upper surface of holotype, as well as most other specimens, with central depression and with ostia of numerous, relatively coarse, exhalant canals 0.4 to 0.6 mm in diameter. These vertical canals traceable through much of sponge, with intervening spaces filled with skeletal net.

Exterior of holotype and other type specimens characterically with ostia 0.4 to 0.8 mm in diameter that may be arranged in horizontal lines around sponge (Pl. 36.2, 36.8, 36.12; Fig. 33). Walls around ostia about 0.08 mm thick and typically with elevated rims (Pl. 36.16, 36.18). Growth lines clearly developed (Pl. 36.12, 36.16). Although other specimens of species much smaller, they show same characteristics as holotype; smallest specimen 10 mm in diameter and 11 mm high; tallest specimen 34 mm high.

Fibers of skeletal net relatively robust, ranging from 0.08 to 0.14 mm but most approximately 0.10 mm in diameter around pores 0.10 to 0.25 across; pores interconnected in short canal-like segments 0.2 to 0.3 mm across as seen in transverse sections, but longer segments in longitudinal sections, parallel to more continuous longitudinal fibers, traceable 2 to 3 mm. Locally skeleton almost ladderlike in regularity of fiber structure. Well-defined horizontal canals not developed, but pulses in growth defined by horizontal zones of somewhat more dense skeleton produced by fiber enlargement. In one paratype where zonation well developed, pulses irregularly 2 to 4 mm apart. Figure 33 shows exterior and internal characteristics of species.

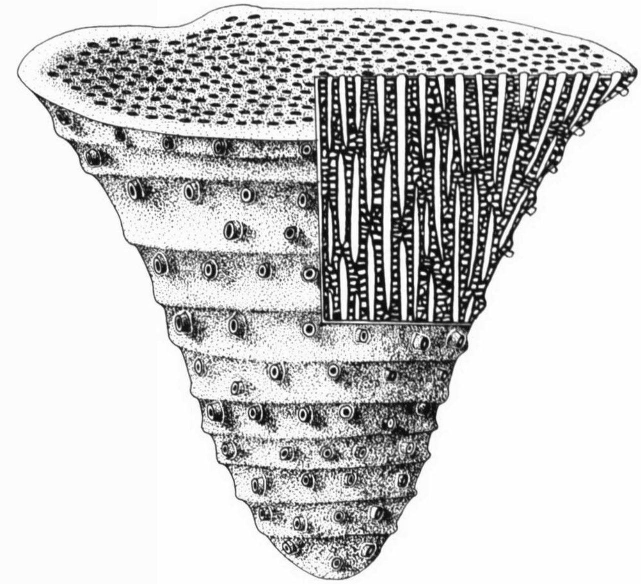

Figure 33. *Polytubifungia maxima* new species. The outside of the sponge is covered by ostia, which have a rim and are situated near the periphery around the sponge. The exterior is also characterized by annulations marking growth stages of the sponge. The top of sponge shows numerous pores that continue as tubes down into the interior of the skeleton. Spaces between the tubes are filled by fibrous skeletal structure (schematic, not to scale).

Discussion.—Apparently this species was described as *Leiospongia* sp. by Termier and Termier (1977a, p. 32) without an illustration, so we are not able to comment on the identity of that sponge. However, Termier and Termier (1977b, p. 62, fig. 3) gave a reconstruction of their *Leiospongia* sp., which is essentially identical to *Polytubifungia maxima* described here. This sponge cannot be placed in *Leiospongia,* however, for that sponge lacks ostia, a canal system, and oscula (see Zittel, 1878, p. 47; Dieci, Antonacci, and Zardini, 1968, p. 102, 110–111). In addition, Dieci, Russo, and Russo (1974) considered the *Leiospongia* of Triassic age to be a sclerosponge, but we could not find any trace of spicules in *Polytubifungia.* In contrast to *Polytubifungia, Leiospongia* has a penicillate skeletal microstructure (Dieci, Russo, and Russo, 1974).

Material.—40 specimens.

Type specimens.—Holotype, USNM 480215, Spot Locality 4A, Pl. 36.11–36.12; paratypes, USNM 480216–480225 and 480425, Pl. 36.1–36.10, 36.13–36.18, 36.23; USNM 480331–480332, Pl. 74.1, 74.6, and USNM 480416, Pl. 59.3–59.4 from Sections B, E, and I, and from Spot Localities 4A, CF24, 27A, and 160-1976.

Occurrence.—Localities where the species occurs in the Djebel Tebaga region are shown in Table 1.

Etymology.—*Maximus,* Latin, greatest; named for the large size of this species in comparison to *Polytubifungia minima* new species.

POLYTUBIFUNGIA MINIMA new species

Plate 36.19–36.22; Plate 50.7; Plate 53.9

Diagnosis.—Small, mushroomlike *Polytubifungia* with fine vertical canals and fibers between them, much finer than in type species *P. maxima;* ostia on exterior lack elevated rims; growth lines poorly developed.

Description.—Small species of genus with maximum upper diameters in obconical sponges of 11 to 19 mm. Holotype (Pl. 36.19, 36.22) with maximum upper diameter and height both 11 mm. Summit depressed on all specimens and edge of top clearly recognizable. Numerous small ostia visible on top and continuing as canals down into interior of sponge. Diameter of these canals and ostia range from 0.08 to 0.20 mm, with most being about 0.1 mm in diameter. Canals spaced 0.1 to 0.2 mm apart with spaces between filled by very fine, reticular, fibrous structure.

Outer surface with numerous, small ostia 0.1 to 0.2 mm in diameter; ostia lack elevated rims such as developed in *Polytubifungia maxima.* Growth lines poorly developed. Skeletal fibers 0.04 to 0.06 mm in diameter where not affected by diagenesis, but where affected may be up to 0.08 mm in diameter. Fibers define skeletal pores 0.08 to 0.10 mm in diameter. These generally arranged in linear series, about 0.12 to 0.14 mm apart, between longer longitudinal fiber segments, commonly occurring 1 to 2 series per tract between vertical exhalant canals, which are commonly bounded by parallel longitudinal skeletal fibers. Exhalant canals not walled.

Characteristics of canals, fibers between canals, dimensions of ostia, and other characteristics of paratypes correspond with those of holotype.

Discussion.—*Polytubifungia minima* differs from *Polytubifungia maxima* by being smaller and having smaller exhalant canals and spaces between the canals, finer skeletal fibers and, especially, smaller ostia that lack elevated rims.

Material.—Three specimens.

Type specimens.—Holotype, USNM 480212, Pl. 36.19, 36.22; Pl. 50.7; Section B, bed 1, and paratypes USNM 480213–480214, Pl. 36.20–36.21, from Spot Locality 14A.

Occurrence.—Both species of *Polytubifungia* represent small and relatively rare sponges within the bioherms of Djebel Tebaga. *Polytubifungia* is known only from the Permian of Djebel Tebaga. One specimen of this species has been found at Section B, bed 1 and two specimens found at Spot Locality 14A.

Etymology.—*Minimus,* Latin, least; named for the small size of the sponge and its canal and skeletal elements.

Genus MICROSPHAERISPONGIA new genus

Diagnosis.—Spherical sponge with several relatively shallow spongocoels distributed over surface of sponge, with dermal layer perforated by numerous small openings. Internal skeletal structure composed of relatively coarse skeletal fibers of reticular type.

Discussion.—These small, spherical to irregular, hemispherical sponges appear to be unique among the numerous sponges in collections at Djebel Tebaga. At first glance, the rimmed, shallow oscular areas in *Microsphaerispongia* may appear like they have a sieve plate, as in *Daharella ramosa* new species, but *Daharella ramosa* is a relatively large cylindrical or branched sponge. Ostia in *Daharella ramosa* appear starlike, with 4 to 6 pores of continuous, small canals that extend into the interior, in a structure unlike that seen in the small sponge here, where only the moderate reticulation is apparent in openings of ostia. Species of both *Preeudea* and *Djemelia* also have rimmed ostia or exaules, but these are also large, conical forms with either major axial clusters of exhalant tubes or a deep spongocoel, structures that are not present in *Microsphaerispongia.*

Type species.—*Microsphaerispongia polyarteria* new species.

Etymology.—*Micro,* Greek, small; *sphaera,* Greek, ball, globular; because of the small size and spherical shape of the sponge.

MICROSPHAERISPONGIA POLYARTERIA new species

Plate 37.5–37.8; Plate 50.8

Diagnosis.—Tiny, spherical sponge with several exhalant canals (spongocoels) that do not extend deeply into sponge interior. Oscula with low rims distributed over whole sponge surface; entire dermal layer also perforated by small pores. Skeletal fibers of sponge interior relatively coarse and reticular. Fiber structure between canals arranged vertically.

Description.—These globular to egg-shaped sponges commonly attached to fragments of other sponges, ranging in diameter up to 14 mm. Smallest specimen has diameter of 10 mm, medium-sized specimen a diameter of 11 mm, and largest one (holotype) a diameter of 14 mm. Spherical holotype (Pl. 37.8) attached to fragment of another inozoid sponge has seven, relatively large, exhalant ostia of short canals that extend only about 1 mm into sponge. Canals distributed over whole sponge exterior. Ostia with low rims. Inner diameters of canals (ostia) range 1.5 to 3.5 mm. Bases of large canals seem to be where several small canals or interfiber openings are located in skeletal net.

Radially arranged skeletal fibers within canals mainly vertical. Dermal layer or cortex approximately 0.35 mm thick blankets exterior, but pierced by numerous, small and uniformly distributed pores 0.1 mm in diameter. Where dermal layer missing, skeletal fibers exposed as relatively coarse elements about 0.6 mm thick and of reticulate type.

One of paratypes (Pl. 37.6–37.7) shows almost same characteristics as holotype described above, but sponge and ostia slightly smaller. This paratype having nine ostia with separation less than in holotype.

Smallest specimen with five small ostia, each approximately 1 mm in diameter, three connected by groove or alternatively, the result of weathering. In addition to these five ostia, specimen also with large canal or osculum 3.5 mm in diameter (Pl. 37.5). Base of osculum or canal exposes polygonal outlines of several possible tubes that extend into sponge and represent pores between skeletal fibers. This specimen, like holotype, attached to fragment of another sponge.

Discussion.—Comparisons have been discussed in treatment of the genus.

Material.—Three specimens.

Type specimens.—Holotype, USNM 480226, Section E, bed 14, Pl. 37.8; and paratypes 480227–480228, Pl. 37.5–37.7, from Spot Locality T6.

Occurrence.—Two specimens from Spot Locality T6; and one specimen from Section E, bed 14.

Etymology.—*Poly,* Greek, many; *arteria,* Greek, artery; in reference to the several canals of each ostium on the surface of the sponge.

Subfamily PSEUDOHIMATELLINAE new subfamily

Diagnosis.—Virgulids with large osculum in axial part of summit; exhalant canals do not end in osculum but open across summit.

Type genus.—*Pseudohimatella* new genus.

Genus PSEUDOHIMATELLA new genus

Diagnosis.—Club-shaped to mushroomlike, sometimes pearlike sponge without axial spongocoel but with several coarse, long vertical canals distributed throughout entire sponge body; canals circular to polygonal or irregular in cross section, with generally one or sometimes two or more large osculumlike depressions occurring almost in axial position; however, depression not upward extension of spongocoel; rigid skeleton between canals fine fibrous net. Lower exterior dermal surface with limited to well-developed, fine to coarse growth lines.

Discussion.—This species was described as *Himatella pauciporata* by Parona (1933, p. 37, pl. 6, fig. 8–9) based on specimens from the Permian of the Sosio Valley in Sicily. It was redescribed from Tunisian sponges by Termier and Termier (1977a, p. 33, pl. 8, fig. 5–6) as *Himatella meandrina* new species. The species has significantly different internal and external structures from those seen in *Himatella,* however, and, in addition, the new genus lacks an axial spongocoel.

The new genus *Pseudohimatella* differs from *Himatella* Zittel, 1878, in the following ways.

1. *Pseudohimatella* lacks an axial spongocoel, as mentioned also by Parona (1933, p. 37); an axial spongocoel is lacking in sponges described as *Himatella pauciporata* as well as in *Himatella meandrina* (see Termier and Termier, 1977a, p. 32).

2. *Pseudohimatella* has numerous vertical canals that are parallel to the axis of sponge (see also Parona, 1933). Such canals are not present in *Himatella* (see Zittel, 1878).

3. *Pseudohimatella* lacks horizontally thickened and irregularly spaced skeletal fibers, such as are typical in *Himatella* (see Zittel, 1878; Dieci, Antonacci, and Zardini, 1968).

Type species.—*Himatella pauciporata* Parona, 1933.

Etymology.—*Pseudo,* Greek, lie, false; *Himatella,* the genus that appears most similar to the new genus.

PSEUDOHIMATELLA PAUCIPORATA (Parona, 1933)

Plate 38; Plate 39.3–39.6; Plate 40.2–40.3; Plate 50.9; Plate 51.1–51.2; Plate 53.10; Plate 67; Plate 79.1–79.2, 79.6–79.7; Figure 34

Synonymy.—*Himatella pauciporata* Parona, 1933, p. 37, pl. 6, fig. 8–9.

Himatella sp. Termier and Termier, 1955, p. 625, fig. 7–9.

Himatella meandrina Termier and Termier, 1977a, p. 33, pl. 8, fig. 5–6.

Diagnosis.—See diagnosis of genus.

Description.—Abundant sponges, usually mushroomlike or club-shaped but may be pearlike. Maximum diameters of sponges range 8 to 78 mm near top, with heights of 8 to 45 mm. Characteristic specimen with maximum diameter of 25 mm and height of only 10 mm; another has diameter of 8 mm and height of 25 mm. Summit of sponge usually convex with central depression where osculum situated but some specimens with gently domed summits.

One or more round to oval oscula usually 3 mm in diameter, in depressions in center of top. Some specimens

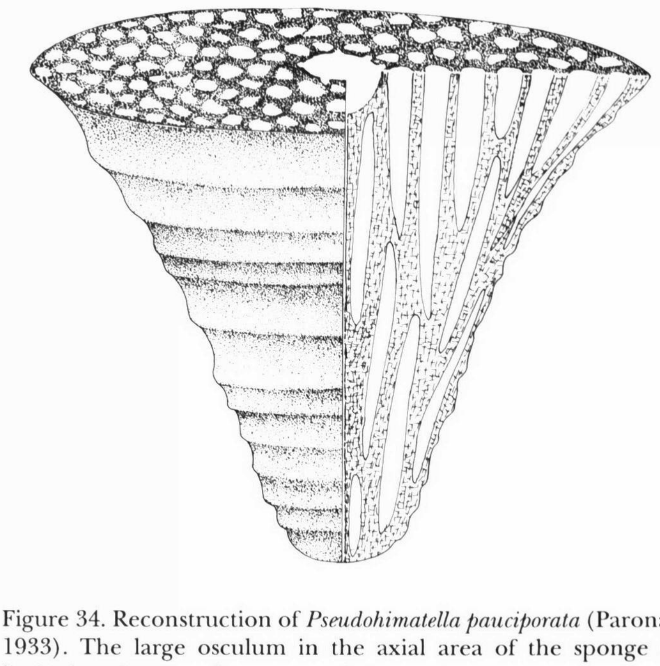

Figure 34. Reconstruction of *Pseudohimatella pauciporata* (Parona, 1933). The large osculum in the axial area of the sponge is limited to the top of sponge and does not pass as a spongocoel deep into the sponge. Only exhalant(?) tubes are developed; inhalant pores and tubes lacking. The lower exterior surface of the sponge does not show perforations but exhibits well-developed growth lines (not to scale).

with two or more oscula irregularly placed on summit. Oscular openings do not continue as spongocoels deeply into sponge. Numerous irregular round, oval, or polygonal openings 0.5 to 1.0 mm in diameter or across occur around oscula as upper ends of vertical exhalant canals that are traceable through much of sponge body, even though locally irregular and vermiform. Sections of canals also show in broken bases of some sponges (Pl. 38.3–38.4). Exhalant canals on summit separated by skeletal tracts, 0.5 to 1.2 mm across on which microreticulate skeleton shows as numerous small nodes and depressions about 0.1 mm across.

Lower or outer surface of sponge commonly with clearly defined growth lines in dense dermal layer, where preserved, with obscure pores up to 0.10 mm in diameter defined by fibers about 0.02 mm thick, but layer commonly recrystallized and structure obscure; one paratype with dense aporose dermal layer marked by fine growth lines.

Transverse thin sections, from 2 mm beneath edge of top, show canals, usually with circular cross sections, with diameters less than 1 mm and separated by skeletal tracts. A few specimens show cross-connecting, horizonal, inhalant canals leading into vertical exhalant ones.

Rigid skeleton between canals is fine, reticular, fibrous structure. Skeletal net of tracts with fine uniform reticulation of fibers 0.04 to 0.08 in diameter with most 0.05 to 0.06 mm in diameter around skeletal pores, 0.06 to 0.12 but most approximately 0.10 mm in diameter and traceable 2 to 3 mm, producing moderately regular local areas, although not regular and ladderlike. Skeletal microstructure spherulitic with spherulites 30 to 100 µm in diameter (Plate 67.1–67.6).

Discussion.—Shapes of this relatively abundant sponge, whether club-shaped, mushroomlike, or pearlike, cannot be used to separate different species as was done by Termier and Termier (1977a) when they established the species *Himatella meandrina* based on its expanded, mushroomlike form. Features of our Tunisian specimens correspond to those of *Pseudohimatella pauciporata,* as the species was described by Parona (1933) from the Permian of Sicily. *Pseudohimatella pauciporata* (Parona) and *Pseudohimatella meandrina* (Termier and Termier, 1977a) are conspecific.

As mentioned above, some specimens have two or more oscula on the sponge summit. We see this as variation within a single species and have included all these morphotypes in the species *Pseudohimatella pauciporata* (Parona).

Material.—208 specimens.

Figured specimens.—USNM 480248–480256, 480258–480260, 480340–480341, 480405, 480420–480422 from Section G, bed 4; Section J, bed 17; Spot Localities S5, DJT-15 and DJT-17, 157-1976, and Senowbari-Daryan collections.

Occurrence.—This is one of the widely distributed species in the Djebel Tebaga exposures. Those occurrences are shown in Table 1, which documents distributions of the inozoid sponges reported here.

Subfamily PARAHIMATELLINAE new subfamily

Diagnosis.—Inozoid sponges characterized by skeletons of fibers composed of coarse spherulites and with fibers arranged into vesiculate-appearing network; skeleton with numerous oscula of deep, widespread spongocoels on upper surface.

Discussion.—Comparisons with similar sponges are treated in discussion of the type genus.

Type genus.—*Parahimatella* new genus.

Genus PARAHIMATELLA new genus

Diagnosis.—Broadly obconical, flaring, mushroomlike or annulate subcylindrical sponges without major axial spongocoel, but with oscula of numerous smaller spongocoels across surface; spongocoels with vertically walled openings extending deeply into skeleton to where excurrent canals converge toward their bases or flanks; distinct, small, vertical inhalant openings extend from surface down into skeleton; skeleton vesiculate or of bubblelike chambers arranged in either vertically stacked series or en echelon between canals, each chamber with 1 to 2 interpores and those adjacent to canals with 1 to 2 lateral pores; wall coarsely spherulitic; rodlike elements, possibly foreign, common throughout.

Discussion.—These sponges were first included by us in *Pseudohimatella pauciporata* (Parona, 1933), based on their general exterior appearances. Once the skeletal structure became evident, however, it was clear these sponges are unrelated to *Pseudohimatella* and probably belong elsewhere. *Pseudohimatella* has a very fine reticulate skeletal network that makes up the relatively massive tracts between canals. Such a network is not apparent here in the thick, spherulite-dominated, platelike or bubblelike skeleton.

Parahimatella has some general structure in common with *Lemonea* Senowbari-Daryan, 1990, a genus of sclerosponges, as interpreted by Senowbari-Daryan (1990, p. 147–153) and described from examples from the Guadalupe Mountains of Texas. The vesicular or cell-like sponge is perforated by one or more, deep spongocoels with linear rowlike chambers radially oriented around the spongocoels, in a structure much more regular and coarser than that seen in *Parahimatella.* In addition, the linear spongocoels in *Lemonea* may be compound structures in which several exhalant tubes occur in the walled cylindrical clusters that perforate the chambered skeleton. This contrasts sharply with the isolated, undivided, moderately deep spongocoels in *Parahimatella* that are open and tubular through much of their extent but are formed by convergent canals that lead laterally and upwardly into the base and lower parts of the tubular openings. Most verticillitid and permosphinctid sponges are distinctly more regular and open textured, with beadlike, caplike, or broad chambers, in contrast to the distinctly vesicular or bubblelike cellular structure of *Parahimatella.*

Type species.—Parahimatella vesiculata new species.

Etymology.—Para, Greek, beside or nearly; *himatella,* named for superficial similarity to *Himatella.*

PARAHIMATELLA VESICULATA new species

Plate 11.1–11.2; Plate 39.1–39.2, 39.7; Plate 40.1, 40.4–40.5; Plate 51.9; Plate 53.15–53.16; Plate 69; Plate 70

Diagnosis.—Broad, expanding obconical to steeply annulate, obconical sponges up to 60 to 70 mm in diameter, in which numerous oscula 2 to 3 mm across occur in summit, spaced 1 cm apart; oscula separated by coarse, vesicular-appearing skeleton, perforated by numerous smaller vertical canals 0.6 to 0.7 mm in diameter; interior skeleton vesicular, of chambers 0.4 to 0.6 mm high and generally 1 mm but up to 2 mm across, with upwardly arcuate interwalls; each chamber perforated by 1 to 2 interpores in interwall and 1 to 2 pores laterally into inhalant and exhalant canals; rodlike structures locally common in thin sections but not evident in scanning images in spherulitic wall; with spherulites 20 to 30 μm in diameter in rows.

Description.—Several specimens of species in collection range from broadly obconical forms 70 to 90 mm wide and 33 mm high to annulate subconical form 62 mm high and 25 by 30 mm. Upper surface generally shallow depression but may be gently arched. Lower exterior annulate with prominent growth lines. Dense dermal layer generally imperforate but where thin on annulate crests may be interrupted by inhalant pores 0.05 mm in diameter.

Upper surface perforated by numerous, tubular, walled openings ranging from 1.6 to 3.0 mm in diameter, but commonly 2.0 to 2.5 mm across as cylindrical to slightly conical openings. Upper surface with scattered, irregular, discontinuous, transverse lateral canals as convergent short grooves to spongocoel openings. Spongocoels range from 5 to 20 mm apart, with most 10 mm apart. Spongocoels in longitudinal section extend to 15 mm deep in broad, mushroomlike forms or virtually through sponge in more steeply obconical forms; openings with walls 0.2 to 0.4 mm thick at surface but somewhat thinner at depth.

Secondary lateral canals converge onto each spongocoel as walled openings within skeleton; canals essentially horizontal for most of trace but swinging abruptly upward to merge with spongocoel. Lateral canals 0.8 to 1.0 mm in diameter near spongocoel, branching irregularly radially to second-order openings 0.4 to 0.5 mm in diameter and occasionally into tertiary openings 0.2 to 0.3 mm across.

Vertical, probably inhalant canals abundant and 0.6 to 0.7 mm in diameter; such canals 1 to 2 mm apart with walls 0.1 to 0.2 mm thick. These and walls of larger canals perforated by round, scattered pores 0.08 to 0.16 mm in diameter, with most being 0.1 to 0.2 mm in diameter. These pores lead from bubblelike chambers through canal walls and may occur in vertically linear series, essentially 1 to 2 pores per bubble or chamber.

Bubblelike chambers arranged either in vertically stacked series, where canals are close together, or offset en echelon where less confined, chambers having strongly curved upper interwalls and rounded lateral slopes. Chambers 0.4 to 0.6 mm high at maximum arch, with most being 0.4 to 0.5 mm high. Chamber interwalls 0.04 to 0.12 mm thick, most being 0.08 to 0.10 mm thick with some lateral variation even within single interwall. Interwalls perforated by 1 to 2 pores 0.08 to 0.10 mm in diameter so that super- and subjacent chambers interconnected. No filling structures developed.

Fragments of rodlike structures occur in matrix within chambers and canals, being incorporated in calcareous walls where possibly foreign, for they could not be found in numerous surface studies by scanning electron microscopy of seven specimens, even when spherulites well preserved. Largest fragments approximately 0.04 mm in diameter and at least 0.6 to 0.7 mm long, most being somewhat smaller, 0.01 to 0.02 mm at maximum diameter, and at least 1 mm long as seen in thin section.

Bulk of interwalls and canal walls of coarse, parallel-stacked spherulites, 0.02 to 0.03 mm in diameter. Spherulite rows generally normal to wall surface; normal to light band that marks midwall between chambers.

Discussion.—Comparisons to similar-appearing sphinctozoan and inozoid sponges have been presented in discussion of the genus above.

Material.—Five specimens.

Type specimens.—Holotype, USNM 480261, Locality 157-1976, Pl. 39.1–39.2; Pl. 51.9; paratypes, USNM 480257–480258, and 480361, from Section G, bed 4; Spot Locality DJT-24; and Spot Locality T-1-201, respectively.

Occurrence.—One specimen from Section G, shale in bed 4; one from Spot Locality DJT-24; one from Spot Locality 21A-23A; one from Spot Locality 157-1976; and one from Senowbari-Daryan collection T-1-201.

Etymology.—Vesiculata, Latin, provided with blister or pustules; in reference to the vesiculate nature of the skeleton.

Family SPHAEROPONTIIDAE new family

Diagnosis.—Sponges characterized by skeleton composed of regularly three-dimensionally spaced spherulites arranged as sphaeroclones in *Astylospongia,* with spherulites with beams that articulate with adjacent spherulites.

Discussion.—Rigid skeletons of almost all inozoid sponges described from Djebel Tebaga localities are composed of spherulites. These spherulites are commonly small and regularly arranged, one beside the other, or perhaps locally arranged in rows to form the rigid skeleton. Such arrangements contrast sharply with the three-dimensionally arranged, very coarse spherulites developed in *Sphaeropontia* new genus, which are isolated but connected

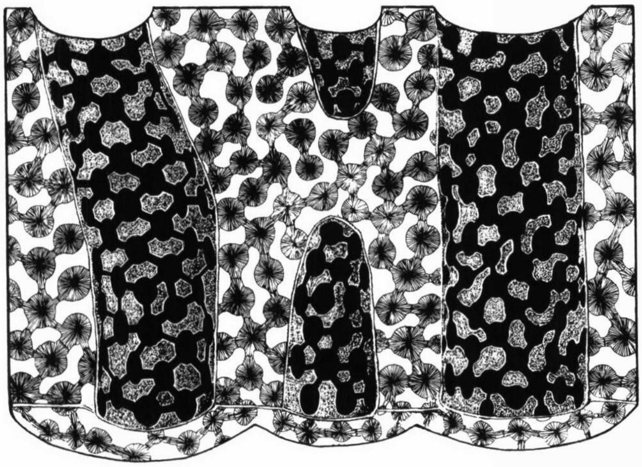

Figure 35. Vertical section through *Sphaeropontia regulara* new species shows the skeleton composed of individual spherulites, which are connected to adjacent ones by beams, produced by prolongation of aragonitic needles. Spaces between individual spherulites correspond to interfiber spaces. Those adjacent to the inner wall of tubes are shown by a darker tone (schematic, not to scale).

to each other by beams, to form a solid rigid skeleton in a unique arrangement among the sponges from Djebel Tebaga.

Arrangements of the spherulites in space and their interconnection with beams or rays are at least superficially similar to skeletal patterns within the lithistid suborder Sphaerocladina Schrammen, 1910, and within the family Astylospongiidae Zittel, 1877. Genera in that family are characterized by spherical spicules in which there is a swollen centrum from which radiate several rays on one side. These rays articulate in handlike expansions to center of adjacent spicules and produce an interlocking, three-dimensionally fused, skeletal net. Such a skeleton characterizes such genera as *Astylospongia* Roemer, 1860, and the similarity in element size and three-dimensional relationships is so striking between the sponges here included in the new family Sphaeropontiidae and the astylospongiids as to raise some questions about their relationships. It raises questions about the mineralogy of the skeleton in *Sphaeropontia* and the possible aragonitic nature of spicules in the Astylospongiidae. The spherulites are composed of radiating aragonite needles within *Sphaeropontia* and are primary structures produced by the sponge. Hence, we have included the genus within the Inozoida. Whether the Astylospongiidae have a convergent structural style and were initially siliceous or were calcareous sponges and have been mistakenly placed within the Lithistida Schmidt, 1870, is yet to be determined. They are the subject of a continuing investigation because at least the gross similarities are striking, and each genus included within the family (Rigby, 1986, p. 33–35) will need to be reexamined.

Type genus.—Sphaeropontia new genus.

Genus SPHAEROPONTIA new genus

Diagnosis.—Conicocylindrical to steeply obconical, relatively small sponges with skeleton composed of spherulites of more or less uniform size from base to summit. Relatively large exhalant canals diverge outward and upward. Spongocoel not developed. Smaller inhalant canals usually subhorizontal in the outer part, curving upward and outward in interior, connecting parallel with or parallel to exhalant series; microstructure spherulitic.

Discussion.—The skeletal structure of *Sphaeropontia* is unique among known sponges from the Permian. No other sponge in our collections have such coarse spherulites, nor spherulites arranged in the three-dimensional network characteristic of the genus and species, as noted in discussion of the new family above.

Type species.—Sphaeropontia regulara new species.

SPHAEROPONTIA REGULARA new species

Plate 37.1–37.4; Plate 51.7; Plate 68; Plate 80.1–80.4; Figure 35–36

Diagnosis.—Steeply obconical to conicocylindrical; small sponges up to 20 mm in diameter with skeletons composed of uniformly sized and spaced, coarse spherulites 0.10 to 0.20 mm in diameter interconnected with relatively short massive rays, mostly 0.04 to 0.06 mm long and with a similar diameter. Spherulites not arranged in radiating or linear series but relatively uniformly packed in regular net. Skeleton perforated by relatively coarse, upwardly divergent exhalant canals, up to 1.1 mm in diameter, throughout sponge. These canals cross connected by inhalant canals up to 0.3 mm in diameter that may be essentially horizontal in peripheral part of skeleton but upwardly divergent in central part.

Description.—Three relatively small specimens occur in the collection. Holotype cylindrical fragment 66 mm long and with somewhat irregular diameter of 17 to 21 mm. Main skeletal interior surrounded in paratypes by dense wall 0.7 to 1.2 mm thick of what appears to be radially fibrous calcite. Original features of wall not certain, for both paratypes are encrusted by algae, and there is no clear separation of that laminate structure from relatively massive walls of sponge.

Sponge lacks spongocoel in fragments, broken both top and bottom, so neither basal tip nor summit of sponges known. Skeleton perforated by major exhalant canals that diverge upward and outward in jet-of-water pattern, although locally in paratypes somewhat irregular pattern present where canals become principally subparallel in middle two-thirds of sponge. These canals range from 0.5 to 1.1 mm in diameter, with most being 0.7 to 0.9 mm in diameter. These unwalled openings are only interruptions in regular skeletal net, most of them appearing to be 0.7 to 0.8 mm across and with circular cross sections in weathered bases and summit. Canals separated by uniform skeletal tracts generally 0.5 to 0.6 mm across, although some tracts may be as small as one spherulite series across, but most being tracts 5 to 6 spherulites wide.

Shorter inhalant canals, prominent as upwardly divergent openings in skeleton, ranging up to 0.2 to 0.3 mm in diameter; canals vertical in middle part of skeleton but curving outward to become essentially subhorizontal in outer millimeter. They subparallel coarse, exhalant series and locally merge or interconnect with coarser exhalant series.

Skeleton of coarse, interconnected, relatively uniformly sized spherulites. Throughout skeleton spherulites spaced 5 to 6 per millimeter, where measured horizontally or vertically, in moderately uniform, although not geometrically predictable, packing. Spherulites spherical, not spinose, and 100 to 250 µm in diameter, with most being 100 to 120 µm across, with general tendency for smaller ones to occur in what appear to be spaces opened in expanding skeletal structure.

Spherulites cross connected to adjacent ones by short, relatively massive rays or beams. These connecting rays range from 20 to 80 µm long, with most being approximately 40 to 60 µm long. They flare in both directions where they terminate or contact adjacent spherulites, but being commonly 40 to 60 µm in diameter, in general narrow area between flaring ends. Where cross-connecting beams best preserved, some show characteristic taper from spherulites of origin, where they may be 30 µm in diameter. Some show junctions in midray and taper from both origins. They narrow distally to approximately 20 µm across before flaring in articulation to surface of adjacent spherulite.

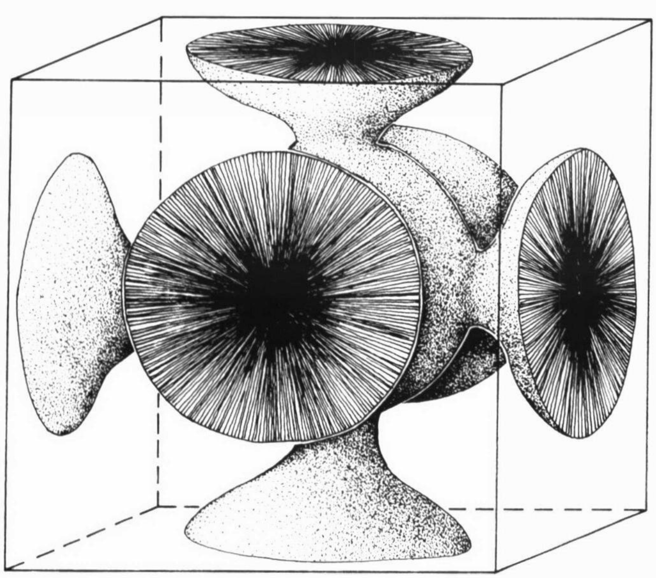

Figure 36. Reconstruction and connection pattern of spherulites in *Sphaeropontia regulara* new species. Aragonite needles of the spherulites are shown by radially arranged lines that extend outward from the center to the outer surface (schematic, not to scale).

Spherulites placed so that circular skeletal pores uniformly developed throughout skeleton. Pores 0.04 to 0.06 mm in diameter, occurring as openings between subparallel beams, but becoming somewhat larger voids between moderately widely placed spherulites.

Skeletal net in all specimens has undergone diagenesis, for many spherulites appear hollow and formed of shells that range up to 80 µm thick, around central small openings 20 to 60 µm in diameter.

Fine details best preserved where spherulites embedded in iron carbonate matrix. Where in crystalline calcite cement, skeletal structures somewhat enlarged by diagenesis. In these latter areas radially aragonitic, needlelike preservation is most apparent.

Discussion.—Comparisons with at least superficially similar genera within the Astylospongiidae and with other sponges have been presented above under discussion of the family. Once the skeletal structure is evident, however, the species and genus are not likely to be confused with other sponges known from the Permian.

Material.—Only three specimens of the species are known from Djebel Tebaga.

Type specimens.—Holotype, USNM 480321, Pl. 37.3; Pl. 80.1–80.4; from Section G, bed 5; paratypes, USNM 480230, from Section E, bed 27, shale below CF-18A and USNM 480229, from Section J, bed 17. Thin sections, USNM 480322–480323, were cut from the holotype, USNM 480321.

Occurrence.—Djebel Tebaga, one specimen each from Section G, bed 5; Section E, bed 27; and Section J, bed 17.

Etymology.—*Regularis,* Latin; according to rule, referring to the regular uniform structure of the skeleton.

Family EXOTUBISPONGIIDAE new family

Diagnosis.—Inozoids with several vertical, exhalant, tubelike canals forming part of periphery in outer part of sponge, with the inner part filled with a reticular fiber structure. Outer surface with numerous small openings arranged either in vertical lines, along canals, or irregularly.

Type genus.—*Exotubispongia* new genus.

Genus EXOTUBISPONGIA new genus

Diagnosis.—Tiny, cylindrical, or branched sponges with several vertical, tubelike canals arranged in ring near periphery of sponge; lacking central spongocoel; inner part of skeleton relatively coarse, upwardly divergent reticulate fibrous structure. Canals connected to exterior by numerous small pores, which may occur in little, pustular elevations arranged either in lines on vertical ribs, irregularly along vertical tubelike canals, or irregularly over dermal surface. Additional large openings may also occur.

Discussion.—The manner of construction of the skeleton in *Exotubispongia* differs significantly from other known inozoid sponges. In other associated inozoids with multiple vertical canals, usually one or several of them are situated in the axial part, as a canal bundle, or are distributed throughout the whole sponge and pierce the fibrous skeleton of the sponge body. In the distinctive *Exotubispongia,* the vertical canals are situated uniformly near the periphery of the sponge inside a fairly thick wall, and fibrous skeleton fills the inner area. *Exotubispongia* is considered as the type genus of the new family Exotubispongiidae.

The skeletal microstructure is unknown because the rigid fibers of all specimens examined are recrystallized.

Type species.—Exotubispongia pustulata new species.

Etymology.—Exo, Greek, out of, without; *tubus,* Latin, pipe; *spongia,* sponge; named for common, vertical, tubelike canals situated near periphery of the sponge.

EXOTUBISPONGIA PUSTULATA new species

Plate 33.17–33.18; Plate 41; Plate 51.3; Plate 53.12; Figure 37

Synonymy.—Graminospongia sp. Termier and Termier, 1977a, p. 36–37, pl. 9, fig. 5.6 (not *Coelocladia* as cited on p. 107).

Diagnosis.—Tiny branched *Exotubispongia* with numerous small porous pustules aligned in vertical rows or ribs over subdermal vertical canals.

Description.—Some of smallest sponges known from Djebel Tebaga; largest specimen with diameter of 5 mm and smallest only 2 mm in diameter. All specimens broken, and tallest fragment 18 mm high; holotype 11 mm high and 3 mm in diameter.

At first sight, sponges appear as cylindrical rods with outer ornamentation of vertical parallel lines, but lines mark narrow ridges or ribs and furrows. Ribs composed of aligned, small, hemispherical, pustular elements about 0.2 mm in diameter, each with a small outer pore, as illustrated in Figure 37. These pores 0.08 mm in diameter may be associated with additional openings only 0.3 mm in diameter on some specimens (Pl. 33.17; Pl. 41.1, 41.5–41.6). Elevated ribs may branch in upper parts of sponge where newly arisen ribs parallel others.

Transverse sections show about 15 relatively large, cylindrical, tubelike canals 0.2 to 0.3 mm in diameter situated near periphery of sponge (Pl. 41.7) (number dependent upon diameter of sponge). Ribs of exterior over tubes and their numbers mutually correspond. Pores from pustular outer elements open into vertical canals (Pl. 41.1–41.2, 41.5–41.6).

Canals defined by walls 0.1 to 0.2 mm thick that separate tubes from each other and from reticulate fibrous skeleton that fills interior of sponge. Outer dense wall 0.2 to 0.3 mm thick envelops sponge. Transverse and longitudinal sections show fibrous, inner skeletal structure with appearance of small, circular, or polygonal openings, but longitudinal sections show upwardly divergent reticular structure. Longitudinal fibers 0.08 to 0.10 mm in diameter diverge upwardly 10° to 15° from axis in jet-of-water pattern, cross connected by horizontal fibers of same diameters, spaced to define round to vertically elongate, oval, skeletal pores 0.10 to 0.14 mm in diameter, approximately 4 per millimeter vertically along longitudinal series and 4 to 5 series per millimeter horizontally. Peripheral canals connected to skeletal pores of interior skeleton by numerous pores. Figure 37 shows simplified reconstruction, with peripheral vertical canals and skeletal fibers in same general area. Small pores on pustular elements shown only in one line.

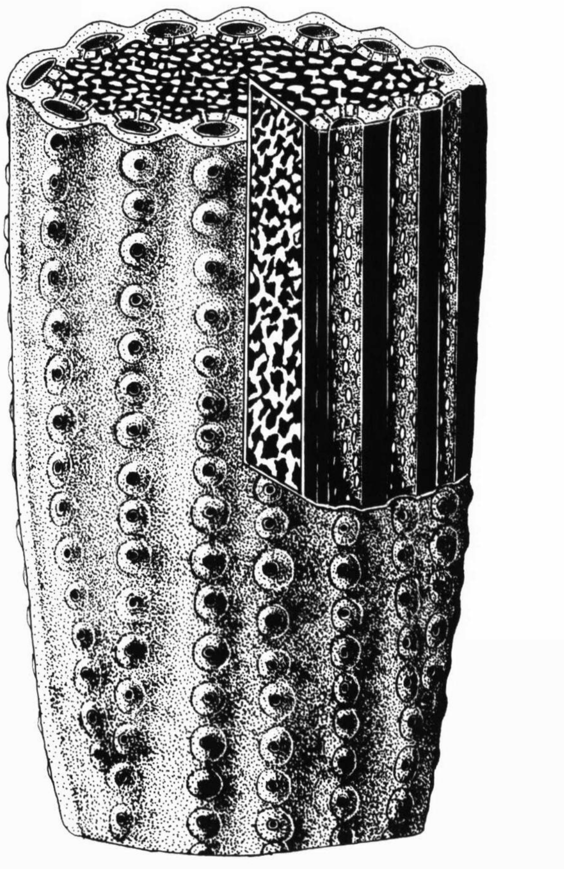

Figure 37. *Exotubispongia pustulata* new species. Reconstruction shows the exterior, as well as a three-dimensional section of the interior. Longitudinal exhalant canals occur near the periphery of the sponge and are interconnected by numerous pores. Interspaces between the fibrous skeletal structures occupy much of the interior part of the sponge. Vertical canals are connected to the exterior by large oscula situated in pustular nodes. The ostia are commonly arranged in lines above the tube wall, but they also may be situated between tubes. The inner area of the sponge is filled with reticular skeletal fibers (schematic, not to scale).

Discussion.—This species was described by Termier and Termier (1977a, p. 36–37, pl. 9, fig. 3–4) as *Graminospongia* sp. (*Coelocladia* sp. on p. 107). Senowbari-Daryan and Rigby (1988, p. 194) placed it in *Graminospongia girtyi* (Parona). Certainly both of these species look very similar from the outside. The pustular elements, however, are situated irregularly in *Graminospongia girtyi* and not in the regularly aligned pattern typical of *Exotubispongia*. In addition *Graminospongia* is a thalamid sponge, and openings in the outer wall lead into the small discrete chambers in the interior. An axial spongocoel, so clearly developed in *Graminospongia,* is not present in *Exotubispongia.*

Exotubispongia pustulata is also easily separable from *Coelocladia* Girty (1908b), a sponge that also has pustular elements on its exterior. Pustules on *Coelocladia* are not linearly arranged as are those in *Exotubispongia pustulata.* In addition *Coelocladia* has an axial, cylindrical to funnel-shaped spongocoel (see Finks, 1960) and radial tubes, which are lacking in the new genus.

Material.—Fourteen specimens.

Type specimens.—Holotype, USNM 480231, Section G, bed 5, Pl. 33.17; and paratypes USNM 480232–480236, Pl. 33.18; Pl. 22.1–22.9, and paratype USNM 480406, Pl. 53.12; from Section E, shale below Reef 3; Section E, bed 5; Section G, bed 5; and Spot Localities DJT-11 and 204-1976.

Occurrence.—Specimens in the collection include seven from Section G, Bed 4; one from Section E, bed 15; one from Section E, shale below Reef 3; four from Spot Locality DJT-11; and one from Spot Locality 204-1976.

Etymology.—*Pustulatus,* Latin, blister-, bubble- or pimplelike; named for the small pustular-appearing nodes on the exterior of the sponge.

EXOTUBISPONGIA VIRGULATA new species

Plate 30.7; Plate 51.4; Plate 53.11

Diagnosis.—Small, cylindrical, branched sponge lacking spongocoel, but with several vertical, tubelike, exhalant canals up to 0.3 by 0.5 mm across in ring near periphery; exterior smooth, lacking small, pustular elevations, but perforated by small pores 0.1 to 0.2 mm in diameter in irregular pattern.

Description.—Holotype branched, with one complete branch 15 mm long and one broken branch 2 to 4 mm long, each approximately 3 mm in diameter, and circular to irregularly oval or quadrate in cross section. Complete branch terminates in bullet-shaped tip into which traces of vertical peripheral canals form slits, each 0.10 to 0.15 mm wide and indented up to 0.5 mm from periphery, near where slits covered to form lower circular to radially oval elongate canals.

Surface irregularly annulate but generally smooth, marked only by pores of incurrent openings generally 0.2 mm in diameter, but ranging from 0.1 to 0.3 mm across, as circular to slightly polygonal openings bounded by fine fibers of skeletal net.

Broken base and cut transverse section of shorter branch show vertical canals moderately uniformly spaced and 0.2 to 0.3 by 0.4 to 0.5 mm across, with long dimensions of oval cross sections radial. Vertical canals connected to exterior by regular skeletal pores without pronounced ostia.

Skeleton generally upwardly and outwardly divergent net of coarse fibers which define skeletal pores 0.04 to 0.08 mm in diameter, with most approximately 0.06 mm across, where circular, and up to 0.08 mm in long dimensions where oval. Skeletal fibers generally 0.02 to 0.04 mm but may range to 0.08 mm across, although some enlargement may be result of diagenesis.

Discussion.—*Exotubispongia virgulata* new species is included in the genus *Exotubispongia* because of the distinctive development of the more or less uniformly spaced, subperipheral, vertical canals in the netlike skeleton. *E. virgulata* contrasts to the type species, *Exotubispongia pustulata,* in lacking the pustular rows of pores developed in vertical lines on the exterior of ribs that are concurrent with the vertical, tubelike canals just interior to them. Instead, it has a smooth, irregularly porous dermal net.

Material.—One specimen.

Type specimen.—Holotype, USNM 480359, Pl. 30.7; Pl. 51.4; Pl. 53.11, Spot Locality 4A.

Occurrence.—The holotype, the only known specimen in the collection, was collected from Djebel Tebaga Spot Locality 4A.

Etymology.—*Virgulatus,* Latin, twiglike or branched; in reference to the small, branched, smooth form of the species.

Class DEMOSPONGEA Sollas, 1875
Order EPIPOLASIDA Sollas, 1888
Family HELIOSPONGIIDAE Finks, 1960
Genus HELIOSPONGIA Girty, 1908b

Emended diagnosis.—"Large, cylindrical to flabellate, branching sponge, with thick body wall and relatively narrow cloaca; skeletal net relatively dense and tracts thick; horizontal tract layers strongly down turned about periphery; dermal layer essentially absent; large prosopores frequently stellate; large apopores circular; approximately as large as prosopore and commonly arranged in vertical and horizontal rows" (Finks, 1960, p. 43).

Remarks.—The genus *Heliospongia* is known from Carboniferous and Permian age rocks in the United States (Girty, 1908b; King, 1933, 1943; Finks, 1960) and from the Permian of Tunisia (Termier and Termier, 1977a) (Table 11).

Deng (1982c) described sponges referred to the genus *Heliospongia* from the Permian of Wuxian, Jiangsu, China, and the new species *Heliospongia? houchangensis* from the Permian of Ziyun, Guizhou, China. The specimen designated *Heliospongia* sp. (Deng, 1982c, p. 712, pl. 1, fig. 7) is represented by only a cross section and does not show the definitive characteristics of the genus. *Heliospongia* shows in transverse cross section typical exhalant canals that extend into the axial spongocoel. The specimen figured by Deng has the typically fibrous skeletal structure of the genus *Peronidella* and most probably belongs to that genus. The specimen named *Heliospongia? houchangensis* by Deng (1982c, p. 712, pl. 1, fig. 8) is not completely preserved and does not allow much to be said about its affinity to *Heliospongia* or any other sponge genus. The occurrence of

Table 11. Characteristics of species of *Heliospongia* from the Carboniferous and Permian of USA and Djebel Tebaga. The Chinese species of *Heliospongia* sp. and *Heliospongia houchangensis* described by Deng (1982a) are not considered in this table. All measurements are in millimeters; *D,* diameter of sponge; *DS,* diameter of spongocoel; *PP,* prospores or inhalant pores; *AP,* apopores or exhalant pores; *PBP,* diameter of small pores between prosopores; *TC,* thickness of network elements between canals; *RAP,* distance of the rows of apopores; *DIC,* diameter of inhalant canals; *DEC,* diameter of exhalant canals; L, length.

										Spicule size	
	D	DS	PP	AP	PBP	TC	RAP	DIC	DEC	D	L
H. ramosa	8–23	2–7	0.5–0.9	1	0.2	0.9–1.2	2–3	?	?	0.010–0.037	0.24–0.50
H. excavata	12–45	2–7	0.2–1.0	0.4–1.3	?	1.2–2.4	1–2	?	?	0.024–0.036	0.24–0.50
H. vokesi	25–125	9–50	0.5–2.0	0.5–1.8	0.1–0.6	0.3–1.2	1.2–4.0	0.5–2.0	0.5–2.0	0.120–0.036	0.12–0.48
H. finksi	8–30	2.5–7.0	0.3–0.6	0.5	0.10–0.15	0.2	1.5	0.35–0.60	0.35–0.60	0.003	0.05?

Heliospongia within Permian deposits of China is, therefore, uncertain.

Type species.—Heliospongia ramosa Girty, 1908b.

Other included species.—Heliospongia excavata King, 1933; *Heliospongia vokesi* King, 1943; *Heliospongia finksi* Termier and Termier, 1977a; *Heliospongia? houchangensis* Deng, 1982c.

HELIOSPONGIA FINKSI
Termier and Termier, 1977a

Plate 27.4, 27.6–27.7; Plate 42.1–42.7; Plate 51.5–51.6; Plate 57.5–57.6; Plate 66.5–66.8; Plate 81

Synonymy.—?Aulocospongia sp. Termier and Termier, 1955, p. 628.

Hyalospongia undetermined, Termier and Termier, 1955, p. 625, fig. 10f–h.

?Heliospongia vokesi Finks, 1970, p. 48.

Heliospongia finksi Termier and Termier, 1977a, p. 35–36, pl. 9, fig. 1–2; Termier and Termier, 1978, pl. 1, fig. 2.

Description.—Single or branched, cylindrical to club-shaped, relatively abundant species. Diameters of individual stems range 8 to 30 mm. Outer surface may be annulate and pierced by relatively large openings 0.3 to 0.6 mm in diameter (Pl. 42.7), but most specimens weathered so exterior not well preserved (Pl. 42.2, 42.5). Some specimens with openings in vertical lines (Pl. 42.7). Relatively narrow osculum 2.5 to 7.0 mm in diameter on summit, with osculum being 16 to 30 percent of diameter of whole stem.

Deep spongocoel extends to near base of sponge. One specimen, 65 mm tall, lacks spongocoel in only 12 mm near base of sponge. In branched specimens, spongocoels almost parallel in upper part but connection of spongocoels of branches with main stem not observed. Spongocoels lack distinct gastral layer of wall.

Numerous gastral ostia or exhalant pores 0.35 to 0.60 mm in diameter, arranged in horizontal rows 1.5 mm apart. Pores also arranged in crude, vertical rows as openings of horizontal exhalant canals. Exhalant canals connect to inhalant canals of same general diameter. Inhalant pores on exterior of similar diameter.

Spaces between canals filled with netlike structure with elements 0.2 mm thick. Small pores 0.1 to 0.3 mm in diameter fill spaces between skeletal elements. Openings in net connected with inhalant and exhalant canals as well as with spongocoel by small pores approximately 0.1 mm in diameter.

Three specimens of species examined in SEM, two being recrystallized and neither spicular skeleton nor traces of spicules preserved. Third specimen shows skeletal details in tracts of skeleton between exhalant and inhalant canals composed of small monaxon heloclone or rhizoclone spicules oriented concentrically around small spaces within network (Pl. 66.5–66.8). Diameters of spicules almost uniformly 3 µm. Spicules embedded in irregular-appearing structure or organic cement. Similar arrangements of spicules around pores also known from *Heliospongia excavata* (see Finks, 1960, pl. 2, fig. 8).

Discussion.—Heliospongia finksi was originally described as "*?Aulacospongia* sp." or "Hyalosponge undetermined" by Termier and Termier (1955). Finks (1960, p. 48–49) placed the sponge with *Heliospongia vokesi* King, which is characterized by large dimensions of the sponge and sponge elements. Dimensions and characteristics of *Heliospongia* species are summarized in Table 11, and distribution of the common species is shown in Table 1.

Material.—94 specimens in our collections.

Figured specimens.—USNM 480292–480298, USNM 480324–480327, from Section E, bed 27; Section G, bed 4;

Section J, bed 17; and Spot Localities T2, 14A, 16A, CF24, and 144-1976; and Senowbari-Daryan collections.

Occurrence.—*Heliospongia finksi* Termier and Termier, 1977a, occurs in several localities in Permian rocks of Djebel Tebaga, as listed in Table 1.

Class HEXACTINELLIDA Schmidt, 1870
Subclass HEXASTEROPHORA Schulze, 1887
Order LYSSACINOSA Zittel, 1877
Superfamily BRACHIOSPONGIOIDEA Finks, 1960
Sponge indet.

Plate 43.1; Plate 53.13–53.14

Description.—Only one specimen in our collection showing naturally weathered, probably exhalant surface.

Sheetlike or tabular and probably saucerlike sponge, 2.2 to 3.2 cm thick, possibly having grown laterally over substrate. Large sponge at least 12 cm across, but may have been much larger, our sample being only a fragment of a large sponge. One side of fragment with tapered rounded edge that appears to be original margin or growing edge 15 to 20 mm thick.

Circular skeletal openings more common in that part of fragment away from probable growing edge and markedly oval to elongate openings in 3 to 4 cm close to edge. These elongate openings with greatest dimensions more or less parallel to probable edge. Surface of sponge (Plate 43.1) shows numerous, circular to oval openings or parietal gaps 2.5 to 5.0 mm in diameter or 2.0 to 2.5 by 5.5 to 6.5 mm where oval. These openings extend about 5 mm into sponge before being filled with matrix or subdivided by smaller skeletal tracts.

Tracts between large openings 1 to 3 mm thick and with bulletlike cross sections where thin, but arched where thick. These tracts contain smaller, circular openings that range from 0.5 to 2.9 mm in diameter, with most approximately 1 mm in diameter. Such openings common and up to 1 mm apart in rows in midtract where tracts are wide or in tract junctions between large parietal gaps. They may occur as single or multiple openings in tract junctions. Large openings locally subdivided by narrow tracts 0.5 to 1.0 mm wide, 2 to 3 mm below sponge surface and form inner circular pores 2 to 3 mm in diameter, but some large gaps not so subdivided.

Tracts between outer pores composed of minute spicules 0.04 to 0.06 mm in diameter and possibly 1 mm long, that appear as a thatch of parallel spicules, parallel to tract margins as exposed on surface. Spicules probably long, needlelike monaxons or rhabdodiactines, but nature impossible to confirm. Smooth-rayed hexactines of variety of sizes occur in sections of interior tracts with ray junctions preserved in thin section. Spicules range from tiny, barely discernable ones with rays less than 0.02 mm in diameter and less than 0.5 mm long to large ones with ray diameters to 0.2 mm. The latter with preserved ray sections 2 to 3 mm long, with little taper, so originally probably several times longer. Most abundant hexactines with basal ray diameters of 0.04 to 0.06 mm and ray lengths of at least 2.0 to 2.5 mm. Hexactines irregularly oriented and spaced in tracts, except for coarsest ones with rays vaguely concentrated at two or three levels in skeleton. Rays mainly parallel to upper surface. Orientations of other rays uncertain. No hexactines observed on tract surfaces.

Openings through sponge with irregular sizes and courses, but appear to be only 1 to 2 mm across with much irregularity. Boring organisms and diagenesis have obscured structural details. Numerous small pores on tract crests between large openings do not extend deep into sponge interior.

Discussion.—The sponge most closely resembles *Carphites plectus* Finks, 1960, in general appearance. The large gastral openings of that species are separated by a thatch of small spicules with long rays that, in sections, might appear like the Tunisian sponge. Such a pattern is suggestive, but details are not preserved in our sponge. The coarser spicules in the sponge described here might be analogous to the coarse pentacts in *C. plectus* and related species. Spicule overgrowths, such as characterize spicules of *Dododerma, Stioderma,* or *Pileolites* described by Finks (1960), are absent from the Tunisian sponge.

Material.—One specimen.

Figured specimen.—USNM 480312, Pl. 43.1; Pl. 53.13–53.14, Spot Locality S1.

Occurrence.—Djebel Tebaga, Spot Locality S1, collected by N. D. Newell, 1973.

ACKNOWLEDGMENTS

Financial support for field work in Tunisia for Rigby and his associates came from NSF Grant Gf 32510-X to the University of South Carolina and from departmental research funds from Brigham Young University. Assistance of the staff of the University of South Carolina Geology Project in Tunisia, under direction of William Kane, is greatly acknowledged. Field expenses for Senowbari-Daryan were covered by grants from the Deutsche Forschungsgemeinschaft during his stay at the University of Münster, 1983 (Project Se 416-1). Deutsche Forschungsgemeinschaft also supported the present research program (Evolution of reefs, Project F142/49, subproject "Revision of Sphinctozoans, Inozoans of Permian reefs, Tunisia"), Institute of Paleontology, Erlangen University (Professor Dr. E. Flügel).

B. J. Kowallis of the Department of Geology, Brigham Young University, assisted in detailed bed-by-bed mapping of the Permian rocks of Djebel Tebaga in 1976, and helped assemble the massive collection of fossil sponges and other fossils from the area. C. J. Collum helped prepare polished sections and specimens for thin section. J. R. Mortensen (Provo) printed some of the photographs from negatives made by Rigby, and Mrs. L. Neuferd and Ch. Sporn printed photographs from negatives made by Senowbari-Daryan (Erlangen). W. E. Miller, former Chairman, and D. T.

Griffin, present Chairman of the Department of Geology, Brigham Young University, both made research space and equipment readily available, so the project could be completed. F. D. Bosworth helped prepare part of the collection and did much needed repair on some of the preparation equipment. L. T. Bird, E. Cohen, and C. Cohen helped prepare specimens, constructed illustrations and tables, and typed numerous revisions of the manuscript. Continued support and interest of N. D. Newell of the American Museum of Natural History is much appreciated, as is the interest and support of our many colleagues at the Institute of Paleontology, Erlangen University, and the Department of Geology at Brigham Young University. A Brigham Young University Alumni Foundation Maeser Research Award to Rigby partially supported the USA part of our joint study, and funding granted in supported research by B. J. Ott through the College of Physical and Mathematical Sciences was also very helpful in carrying out our project. Residents of the rural communities of Medenine, Halk el Djemel, Nouveau Toujane, and Saikra in the Djebel Tebaga region were very helpful and assisted in our fieldwork in many ways. To all of these people and institutions, we express our gratitude. C. W. Stock and an unknown reviewer provided critical and helpful suggestions. Finally we express our thanks to the editorial staff of the Paleontological Institute of The University of Kansas, especially R. L. Kaesler, Jill Hardesty, Karen Renteria, Jane Kerns, and Elizabeth Brosius.

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Plates

Plate 1

1–2. Auriculospongia auriculata (Termier and Termier, 1955), USNM 463571, Spot Locality 299-1976; *1,* inhalant side of large specimen shows relatively small, irregularly arranged pores and a few larger mounded ostia on the right; such ostia may have developed to counter overgrowth by algae, ×1; *2,* exhalant side of specimen characterized by prominent system of upwardly divergent tangential furrows in which the exhalant pores are concentrated, ×1.——*3–4. Auriculospongia perforata* new species, paratype, USNM 463578, Section J-C, Locality CF24; *3,* inhalant side of broken specimen with dermal layer preserved on right but weathered away on the left where internal structure of fibrous skeleton is exposed, ×2; *4,* exhalant side of broken specimen shows coarse skeletal structure, ×2.

Plate 2

1–4, 10. Auriculospongia auriculata (Termier and Termier, 1955). *1–2,* figured specimen, USNM 463572, Section G, bed 5, CF-53; *1,* finely textured, furrowed inhalant(?) side of specimen; furrows irregularly distributed and small pores located between and in the furrows, ×1; *2,* exhalant side with relatively large furrows oriented radially and upward on the sponge; large ostia are located in the furrows, ×1; *3, 10.* USNM 463573, Section E, bed 27; *3,* finely textured inhalant side shows characteristic distribution of small furrows and pores, ×1; *10,* exhalant side of small but thick, leaflike specimen; coarse tangential furrows and their distribution, ×1; *4,* USNM 463574, Section E, bed 27; characteristic exhalant, coarsely canalled surface of small, leaflike paratype, ×1.——*5–9. Auriculospongia perforata* new species; *5–6,* paratype, USNM 463579, Section G, bed 5; *5,* exhalant side shows coarse, fibrous skeletal structure in the upper part; lower part of sheet is covered by algae, ×1; *6,* inhalant side shows thin dermal layer with small pores in middle part, but dermal layer is weathered from upper part where coarse, internal, fibrous structure is evident, ×1; *7–9,* paratype, USNM 463580, Spot Locality 36-1976; *7,* summit view of specimen shows the same skeletal structure as side views, ×2; *8,* exhalant side lacks prominent canal differentiation and could be weathered surface but some radially arranged fibers are visible in upper part; opposite side shown in Plate 2.9, ×2; *9,* inhalant(?) side of specimen is characteristically finely textured, ×2.

Plate 3

Auriculospongia perforata new species. *1–3,* holotype, USNM 463581, Section G, bed 5, 100 m north of CF 53; *1,* view of exhalant or gastral side of leaf-shaped sheet sponge shows the moderately fine and irregularly arranged tangential canals, ×1; *2,* view of the summit, gastral surface to right, ×1; *3,* inhalant or dermal side of holotype shows small inhalant pores over the entire surface, ×2; *4–5,* paratype, USNM 463582, Section G, bed 5, 100 m north of CF 53; *4,* exhalant side of fragmental specimen in which reticular structure of skeletal fibers shows in natural weathered section, ×1; *5,* inhalant side shows arrangement of fibers parallel to sheet surfaces in natural section, ×1; *6–7,* paratype, USNM 463583, Spot Locality 36-1976; *6,* exhalant or gastral surface with moderately sized, circular ostia in coarse fibrous skeleton with only rudimentary tangential canals, ×1; *7,* finer textured inhalant or dermal surface, ×1; *8,* paratype, USNM 463584, Spot Locality 4A; dermal(?) side of a large specimen with branched, fingerlike upper part; specimen is covered by algae and sclerosponges so inhalant and exhalant pores are indistinct, ×1.

Plate 4

1–5. Spinospongia radiata new species; *1,* paratype, USNM 463612, Spot Locality S3; outer view of a club-shaped paratype; skeletal rods are especially visible as small points on the lower part of the sponge, ×1; *2–3,* holotype, USNM 463611, Spot Locality S3; *2,* side view; rounded obconical form is typical; tips of skeletal rods show as light points; small openings between the rods do not pass as canals into the interior of the sponge, ×2; *3,* summit shows the lack of a spongocoel, ×2; *4–5,* paratype, USNM 463613, Spot Locality DJT-5; *4,* side view of a relatively small sponge, top to right; skeletal rods are visible as light points, ×1; *5,* rounded summit with protruding, spinelike skeletal rods that show as light gray dots with dark pores between them. Whether the cluster of large pores is a primary oscular opening or produced by boring organisms is uncertain, ×2.——*6–8. Cavusonella caverna* Rigby, Fan, and Zhang, 1989; *6,* figured specimen, USNM 463588, Section J, bed 17; side view of figured specimen; relatively large exhalant pores and coarse texture are clearly developed, ×2; *7,* figured specimen, USNM 463589, Spot Locality T5; side view of a well-preserved specimen; small inhalant pores occur on ridges between the large exhalant pores, ×2; *8,* figured specimen; USNM 463590, Spot Locality 109-1976; side view, ×2.——*9–11. Daharella ramosa* new species; *9,* paratype, USNM 463591, Spot Locality 160-1976; side view of branched paratype are exhalant pores with a distinct edge are clearly visible, ×2; *10,* paratype, USNM 463592, Section J, bed 14; side view of simple paratype shows typical skeletal elements and rimmed ostia, ×2; *11,* holotype, USNM 463593, Spot Locality 160-1976; side view of branched but broken specimen in which exhalant pores have distinct rims, ×1.——*12–14. Daharella micella* new species; *12,* paratype, USNM 463601, Spot Locality 27A; side view shows two large exhalant pores, each with a moderately developed rim, ×5; *13,* holotype, USNM 463602, Spot Locality 203-1976; side view shows twiglike sponge with several relatively small exhalant pores, each with a moderately developed edge, ×5; *14,* paratype, USNM 463601, Spot Locality 27A; three exhalant pores, ×5.

Plate 5

1–5. Radiotrabeculopora reticulata Fan, Rigby, and Zhang, 1991; *1,* figured specimen, USNM 463620, Section G, bed 4; side view of a weathered, cylindrical specimen that shows numerous inhalant pores over the sponge surface, ×1; *2–3,* figured specimen, USNM 463622, Spot Locality S1; *2,* broken cross section of specimen; large exhalant canals are radially arranged and are most evident on the outer part of the wall, ×4; *3,* side view shows small inhalant and large exhalant pores, internal structure shown in Plate 72.3, ×1; *4,* figured specimen, USNM 463624, Section G, bed 5; side view of a broken specimen shows numerous small inhalant and large exhalant canals, ×1; *5,* figured specimen, USNM 463621, Section G, bed 4; side view of subcylindrical sponge; large exhalant pore in lower center, other openings mainly inhalant pores, ×1.——*6–10. Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991; *6,* figured specimen, USNM 463625, Spot Locality S7; side view of a fragment of a conicocylindrical specimen with numerous large exhalant and smaller inhalant pores on the exterior, ×2; *7,* figured specimen, USNM 463626, Section I, shale below bed 3; side view of subcylindrical specimen in which large exhalant and smaller inhalant pores are clearly differentiated, ×2; *8,* figured specimen, USNM 463628, Spot Locality S7; side view of specimen with expanded base of attachment and cylindrical form, ×2; *9–10,* figured specimen, USNM 463627, Section I, bed 5; *9,* summit view, ×1; *10,* side view of club-shaped specimen shows large exhalant pores and numerous small inhalant pores, ×1.——*11–13. Radiotrabeculopora* cf. *R. xiangboensis* Fan, Rigby, and Zhang, 1991; *11–12,* figured specimen, USNM 463616, Section E, beds 26-27; *11,* side view of a spherical specimen intergrown with other sponges. The exterior, as well as the summit, shows the large exhalant pores and numerous inhalant pores between them, ×2; *12,* reverse side and summit of spherical specimen showing the characteristic pore patterns and growth form, ×2; *13,* figured specimen, USNM 463618, Section B, bed 1; side view of a club-shaped annulate specimen with large exhalant pores and smaller inhalant pores, ×2.

Plate 6

1–2. Radiotrabeculopora(?) patula new species, holotype, USNM 480304, Spot Locality 13B; *1,* summit of massive, mushroomlike sponge with four centers of converging, surface, excurrent canal grooves and clusters of exhalant canals with smaller inhalant pores in intervening area, ×1; *2,* side view with faint vertical structure in dermal layer, marked more prominently by growth lines, ×1.——*3–4. Intratubospongia obscura* new species, holotype, USNM 480305, Spot Locality DJT-27; *3,* summit view with two obscure oscular areas of canal convergence; coarse exhalant ostia and fine inhalant ostia scattered over summit, ×2; *4,* side view of irregular subcylindrical sponge with exaggerated growth annulae; vertical skeletal fibers show where thin dermal layer not developed or weathered away, ×2.——*5–6. Precorynella ampliata* new species, holotype, USNM 480303, Section G, bed 5; *5,* summit with shallow spongocoel or osculum toward which converge branched, surficial, exhalant canals; sponge partially encrusted with worm tubes and other epibionts; ostia of aligned, vertical exhalant canals show prominently in radial rows; smaller ostia occur scattered in fibrous skeleton, ×1; *6,* side view of obconical sponge with faint growth lines and upwardly divergent skeletal fibers, ×1.

Plate 7

1–10. Daharella palmata new genus, new species, all specimens from Spot Locality 157-1976; *1–2,* paratype, USNM 463603; *1,* summit shows the interior of the sponge filled by fibrous skeletal structure and canals, ×2; *2,* side view in which the exterior is characterized by several ostia where canals are grouped to form a bundle and ostia are located on small elevations, ×2; *3–4,* holotype, USNM 463604; *3,* view of the summit with fingerlike branches, ×2; *4,* side view shows the fingerlike branches and handlike shape of the sponge; ostia are grouped together, ×2; *5,* paratype, USNM 463605; side view shows fingerlike branching and groups of ostia located on small elevations; some single and oval ostia are also present, ×2; *6,* paratype, USNM 463607; side view shows groups of ostia located on small elevations; the sponge had started to branch in the upper part, ×2; *7,* paratype, USNM 463606; side view of an unbranched(?) paratype; groups of ostia and the fibrous structure show on the exterior, as well as in the interior of the broken base of the sponge, ×2; *8,* paratype, USNM 463608; side view of a broken specimen shows starlike groups of ostia, some located on elevations, ×2; *9,* paratype, USNM 463609; small fragment shows a group of ostia on an elevation, ×2; *10,* paratype, USNM 463610; side view shows initiation of branching in the upper part; starlike ostia show well, ×1.——*11–12. Radiotrabeculopora* cf. *R. xiangboensis* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 463631, Section E, shale below Reef 3; *11,* view shows summit covered with exhalant pores, ×2; *12,* side view shows exhalant pores on the upper part and the internal structure in the lower part of sponge, ×2.——*13–14. Precorynella robusta* new species, holotype, USNM 480393, Section G, bed 5; polished surface with low contrast in yellow and brown, iron-stained preservation; *13,* transverse section 5 to 6 mm below sponge crest shows numerous vertical, walled exhalant canals in an axial cluster, with common horizontal convergent canals; smaller, long, vertical, probably inhalant, canals occur in the outer part of the sponge between radial canals, ×2; *14,* vertical section shows coarse canals of the axial cluster, some as upturned inner ends of horizontal canals; long, possibly inhalant vertical canals show in upper left, ×2.——*15. Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, figured specimen, 1991, USNM 463629, Spot locality 27A; side view shows the large exhalant pores (and canals on the upper part) and small inhalant pores between the exhalant pores, ×2.

Plate 8

1–3. Prestellispongia lobata (Parona, 1933), figured specimen; *1–2,* USNM 480369, equivalent to bed 2 in Section I, but west of traverse; *1,* summit of specimen bears several starlike exhalant openings and numerous small inhalant openings between them; basal side is shown in Plate 9.1, ×2; *2,* side view of specimen showing low-domed shape of sponge, attached on other sponges at the base, ×2; *3,* figured specimen, USNM 480370, Spot Locality DJT-21; summit of specimen with exhalant tubes of overgrown sponge, in massive skeletons, ×1.——*4. Prestellispongia paula* new species, paratype, USNM 463638, Spot Locality 144-1976; summit exhibits several starlike exhalant openings and numerous inhalant pores between them, ×2.

Plate 9

1–5. Prestellispongia lobata (Parona, 1933); *1,* figured specimen, USNM 480369, Section I, equivalent to bed 2; showing overgrown sponges and bivalves; bottom of specimen pictured in Plate 8.1, ×2; *2,* figured specimen, USNM 480371, Section J, bed 5; massive sponge overgrown on a variety of other inozoid and sphinctozoid sponges; normally developed astrorhizae are obscure around two large oscula, ×1; *3,* figured specimen, USNM 480367, Section B, bed 1; hemispherical form with four moderately well-defined astrorhizal clusters around oscula, ×2; *4–5,* figured specimen, USNM 480368, Section B, bed 1; *4,* summit of irregular mushroom-shaped sponge illuminated to emphasize three principal, deeply indented, oscula, ×2; *5,* summit illuminated to emphasize ostia of radial canals that perforate much of the areas between oscula and surficial tangential canals, ×2.

Plate 10

1–7. Prestellispongia lobata (Parona, 1933); *1, 4,* figured specimen, USNM 480366, Spot Locality 27A; *1,* summit of the specimen shows several astrorhizal-like exhalant canals, with several exhalant openings grouped in the center of each cluster; irregular growth on the left was caused by other sponges which have partially overgrown the *Prestellispongia,* ×2; *4,* side view shows very irregular, almost branched growths produced by encrusting organisms, ×2; *2, 7,* figured specimen, USNM 480364, Section E, bed 27; *2,* summit of relatively small mushroomlike specimen exhibiting two, well-preserved astrorhizae and numerous inhalant pores between them; nodular area in the right is produced, in part, by a small sponge partially overgrown by *Prestellispongia;* light lines on the summit of the sponge are small tubes produced by worms or bryozoans, which are also abundant on the lower surface of the sponge, ×2; *7,* side view shows broad, obconical form and prominent growth lines; the irregular linear features on the sponge surface are produced by encrusting worm tubes, ×2; *3, 6,* figured specimen, USNM 480363, Section E, bed 27; *3,* side view of specimen shows irregular growth; the two distinct growth stages are marked by deeply developed interruptions in the middle part that helps produce irregularity; the irregular growth of the second stage was partially caused by another sponge which has overgrown the *Prestellispongia,* ×2; *6,* summit of specimen shows three, well-developed astrorhizae and growth distorted by overgrown organisms, ×2; *5,* figured specimen, USNM 480365, Spot Locality CF18; summit of globular obconical specimen shows well-preserved astrorhizae and inhalant pores between them, ×1.

Plate 11

1–2. Parahimatella vesiculata new species, paratype, USNM 480361, Senowbari-Daryan collections; *1,* summit of figured specimen shows several astrorhizal-like exhalant canal clusters. Several ostia are located in the center of each cluster, ×2; *2,* side view shows the two major pulses of growth, marked by deeply developed annulations that help produce the characteristic sponge shape, ×2.——*3. Peronidella rigbyi* Senowbari-Daryan, 1991, figured specimen, USNM 480375, Spot Locality 4A; side view shows relatively coarse limonite that replaced skeleton of the tiny sponge; osculum to the deep spongocoel shows at the top, ×10.——*4. Saginospongia porosa* new species, holotype, USNM 463679, Section G, bed 5; summit of fragment shows partial spongocoel at left center; coarse skeletal tracts separate coarse irregular canals, ×2.——*5. Estrellospongia grossa* new species, paratype, USNM 463646, Spot Locality 27A; side view of globular specimen exhibiting well-preserved astrorhizae and inhalant pores between them, ×4.——*6–7. Prestellispongia lobata* (Parona, 1933), figured specimen, USNM 480362, Spot Locality S1; *6,* summit of an obconical specimen exhibiting five, well-preserved astrorhizae and numerous inhalant pores between them, ×2.5; *7,* side view shows weak annulations and prominent growth lines; lower part overgrown with algal crusts and worm tubes, ×1.5.

Plate 12

1–17. Prestellispongia permica (Parona, 1933); *1–2,* figured specimen, USNM 480280, Spot Locality 21A-23A; *1,* specimen which has two starlike, exhalant(?) furrow systems; inhalant pores are located between furrows, ×2; *2,* side view of broadly obconical specimen with smooth exterior marked by growth lines, ×2; *3–4,* figured specimen, USNM 480281, Spot Locality 27A; *3,* summit with single radial furrow system, ×2; *4,* side view of steeply obconical specimen; dermal layer shows only growth lines, ×2; *5,* figured specimen, USNM 480285, Spot Locality 160-1976; summit view of specimen with deeply weathered furrow system and prominent inhalant pores, ×2; *6–7,* figured specimen, USNM 480282, Spot Locality 27A; *6,* summit view of specimen has two starlike exhalant canal systems with canals that radiate as furrows, ×2; *7,* side view of mushroomlike specimen, dermal layer shows only growth lines, ×2; *8,* figured specimen, USNM 480287, Spot Locality 13B; summit view of specimen shows well-preserved, branching furrows, as well as widespread inhalant and more nearly axial exhalant pores, ×2; *9,* figured specimen, USNM 480284, Spot Locality 27A; summit view of a platelike specimen, only 7 mm thick, with uniform radial furrow system, ×2; *10–11,* figured specimen, USNM 480288, Spot Locality S7; *10,* summit view with large inhalant pores between radial furrows, ×2; *11,* side view of the specimen typically shows only fine growth lines in dermal layer, ×2; *12–13,* figured specimen, USNM 480289, Spot Locality S7; *12,* summit of specimen with typical shallow osculum and starlike exhalant grooves, ×2; *13,* side view of the obconical specimen with weathered dermal layer that shows only a few deep growth lines, ×2; *14,* figured specimen, USNM 480291, Section E, bed 14; summit view of almost spherical specimen shows deep exhalant canals in multibranched furrows, ×2; *15,* figured specimen, USNM 480286, Spot Locality 160-1976; summit view of platelike specimen, only 5 mm thick, which shows characteristic canal system of the species, ×2; *16,* figured specimen, USNM 480286, Spot Locality 160-1976; summit view of platelike specimen, only 5 mm thick, in which exhalant(?) furrows are well preserved, ×2; *17,* figured specimen, USNM 480290, Spot Locality S7; summit view of mushroom-shaped specimen, only 13 mm high, with regular radial canals, ×2.

PLATE 13

1–3. Encrusted sponges, possibly *Stellispongiella; 1,* USNM 480407, Spot Locality S7; sponge encrusted by nodular *Archaeolithoporella,* ×2; *2,* USNM 480408, Section G, bed 4, shale above CF55; sponge coated by algae, with attached *Colospongia* and worm tubes, ×2; *3,* USNM 480409, Section I, bed 5; sponge coated with irregular *Archaeolithoporella* and trace of soft-bodied, attached form, ×2.——*4. Prestellispongia lobata* (Parona, 1933), figured specimen, USNM 480371, Section J, bed 5; coarse *Prestellispongia lobata* (Plate 9.2) at base, overgrown on a variety of other sponges, including *Prestellispongia paula* new species (*S*), *Intratubospongia* sp. (*i*); *Peronidella* sp. (*p*), *Ramospongia(?) reticulata* (*R*), and several sclerosponges including *Permosoma permotessellata* (Parona, 1933) (*T*), and chaetetids (*C*), with other debris, ×1.——*5–8. Prestellispongia bolaria* new species; *5, 8,* holotype, USNM 480353, Spot Locality DJT-8; *5,* side view of laterally lobate sponge, upper part marked by reticulate canals, lower parts partially encrusted, ×2; *8,* summit view with coarse exhalant canals in oscular clusters with convergent surficial astrorhizal system; areas between reticulate canals dotted with numerous fine skeletal pores, ×2; *6–7,* paratype, USNM 480352, Section E, bed 27; *6,* side view shows area of reticulate canals on summit and smoother lower part with fine skeletal pores partially obscured by encrustations, ×2; *7,* summit view of irregular lobate sponge with several oscular areas marked by coarse, deep exhalant canals; area between marked by surficial reticulate canal system with numerous, fine inhalant ostia and finer skeletal pores between canals, ×2.

PLATE 14

1–7. Prestellispongia scapulata new species; *1–2,* holotype, USNM 480306, Section G, bed 4; *1,* summit shows several well-defined oscula located on small elevations; each osculum is composed of a group of exhalant openings; spaces between oscula are pierced by numerous, small, inhalant pores defined by the skeletal fibers, ×2; *2,* side view shows lower exterior of the sponge is characterized by ringlike growth lines and is separated by a distinct line from the upper part, which has several oscula with pores between them, ×2; *3–4,* paratype, USNM 480307, Section E, shale below Reef 3; *3,* summit of specimen shows restricted exhalant area with starlike oscula and with exhalant pores clearly shown between them, ×2; *4,* side view of specimen shows restricted exhalant area at the top; exhibits some indistinct growth lines, ×2; *5–6,* paratype, USNM 480308, Section E, shale below Reef 3; *5,* side view shows two oscula with associated radial grooves and smaller exhalant ostia; only growth lines show on the side, ×2; *6,* summit shows characteristic oscula and small exhalant pores between them, ×2; *7,* paratype, USNM 480309, Section E, shale above Reef 3; side view of specimen whose summit is shown in Plate 42.8, with small vertical grooves that correspond to the inhalant canals in internal structure and are exposed by weathering of the dermal layer that has growth lines, ×2.

PLATE 15

1–8, 9, 10–11. Estrellospongia grossa new species; *1,* holotype, USNM 463639, Spot Locality DJT-27; summit with radially arranged furrows that are multibranched toward the periphery and downward on the sponge, ×2; *2,* paratype, USNM 463640, Spot Locality DJT-27; summit shows the arrangement of surficial canals characteristic of the species, as in Plate 15.1, ×2; *3,* paratype, USNM 463642, Section G, bed 4; summit of a small specimen showing typical, multibranched surficial furrows and pores between them, ×2; *4,* paratype, USNM 463641, Spot Locality DJT-27; summit of a small specimen showing the characteristic pattern of radial furrows, ×2; *5–6,* paratype, USNM 463643, Spot Locality 13B; *5,* summit of well-preserved sponge; multibranched canal furrows are arranged almost symmetrically, ×2; *6,* bottom of specimen shows that furrows on the summit do not extend over the side of the sponge, so only growth lines are visible, ×2; *7–8,* paratype, USNM 463644, Spot Locality T6; *7,* summit of the specimen, ×2; *8,* side view of sponge with radial furrows; with visible growth lines similar to other specimens; the surficial canal furrows are limited to the summit of the sponge, ×2; *9,* paratype, USNM 463647, Section E, bed 27; summit of large specimen, ×1; *10,* paratype, USNM 463645, Spot Locality S13; summit of a specimen with radially arranged furrows that are multibranched toward the periphery and downward on the sponge, ×1; *11,* paratype, USNM 463646, Spot Locality 27A; summit of a specimen with the same characteristics as other specimens of the species, ×2.

PLATE 16

1–6, 10–11. Stellispongiella insculpta new species; *1,* paratype, USNM 480266, Section G, bed 5; side view of branched specimen in which the relatively small astrorhizal-like exhalant canal systems are located in depressions; individual radial slits may be branched at their tips but do not interconnect, ×2; *2,* paratype, USNM 480267, Section G, bed 5; side view of cylindrical specimen with numerous, small, inhalant pores between astrorhizal-like canals over the whole sponge surface, ×2; *3,* paratype, USNM 480268, Section J, bed 17; side view of cylindrical sponge with oval cross section; surface with canal clusters and abundant inhalant pores; upper part covered by a thin sheet of sclerosponge, ×2; *4,* paratype, USNM 480270, Section E, shale below Reef 3; side view of a relatively small specimen shows fingerlike branched slits at ends of well-preserved, exhalant canals, ×2; *5,* holotype, USNM 480271, Section I, bed 12; side view of a relatively large specimen with characteristic canal clusters and inhalant pores, ×2; *6,* paratype, USNM 480272, Spot Locality 13B; side view of a palmate specimen with fingerlike branches with characteristic canal clusters, ×2; *10,* paratype, USNM 480273, Section E, shale below Reef 3; side view of a specimen exhibits the radially arranged slits as well-preserved, exhalant canal clusters, ×2; *11,* paratype, USNM 480269, Section J, bed 16; side view shows the same characteristics of indented and separated astrorhizal clusters, ×2.——*7–9. Stellispongiella bacilla* (Termier and Termier, 1955); *7,* figured specimen, USNM 480274, Section G, bed 5; side view of well-preserved specimen with large astrorhizal-like exhalant clusters located on mamelonlike elevations; the canal slits of astrorhizal-like exhalant system branch dichotomously; small inhalant pores are abundant between exhalant canals, ×2; *8,* figured specimen, USNM 480275, Section E, bed 27; side view of a large specimen with prominent mamelonlike elevations where exhalant canals are well developed on slopes, ×1; *9,* figured specimen, USNM 480276, Section G, bed 5; side view of a specimen shows the coarse, radial, exhalant elevations with astrorhizal canals that almost merge, ×2.

PLATE 17

1–3. Stellispongiella reticulata new species; *1,* paratype, USNM 463650, Spot Locality 13B; side view of a large specimen; exhalant canals (astrorhizal systems) are located in depressions; branches of astrorhizae merge at tips and produce a surficial net of slits; exhalant pores are located in slits but inhalant pores and openings of radial canals occur between slits, ×2; *2,* paratype, USNM 463649, Section H, base; side view of a multibranched specimen shows the branched astrorhizal net; function of the two large openings is uncertain, ×2; *3,* holotype, USNM 463648, Section G, bed 4; side view of a twiglike specimen; the astrorhizal net is well preserved, ×2.——*4, 6. Stellispongiella parva* new species, holotype, USNM 463653, Spot Locality T8; *4,* side view of branched(?) holotype; radial slits of small astrorhizae are thin and are not grown together, ×1; *6,* small pores of radial canals are dark, circular, small openings between starlike astrorhizae in enlarged side view of holotype, ×2.——*5. Stellispongiella porosa* new species, holotype, USNM 463659, Spot Locality 216-1976; side view; large astrorhizae are located on moderately elevated mamelons; slits of astrorhizae merge at tips; pores of radial canals occur between the astrorhizae, ×2.——*7–8. Stellispongiella amplia* new species; *7,* paratype, USNM 463658, Spot Locality 13B; side view of a weathered, branched specimen on which the astrorhizal systems are only moderately well preserved, ×2; *8,* holotype, USNM 463657, Spot Locality, 13B; side view of the broken specimen; astrorhizae with wide slits occur on low elevations and are almost grown together; pores of radial canals are well developed between the astrorhizae, ×2.

PLATE 18

1–2. Stellispongiella bacilla (Termier and Termier, 1955); *1,* figured specimen, USNM 480277, Section I, bed 12; cylindrical sponge with low-mounded astrorhizal systems, ×2; *2,* figured specimen, USNM 480278, Section I, bed 12; branched sponge with astrorhizal systems on low nodes, ×2.——*3–4, 7. Stellispongiella parva* new species; *3,* paratype, USNM 463654, Spot Locality 14A; cylindrical specimen with small astrorhizae, ×2; *4,* paratype, USNM 463655, Spot locality T-5, ×1.5; *7,* paratype, USNM 463656, Spot Locality 9B, ×2.——*5. Stellispongiella tumida* new species, holotype, USNM 463662, Section I, bed 2; cylindrical branched sponge with swollen traces of excurrent canals of astrorhizal systems and very coarse inhalant ostia, ×2.——*6. Stellispongiella porosa* new species, paratype, USNM 463661, Section E, shale below Reef 3; branched cylindrical form with typical inhalant and exhalant systems, ×1.

PLATE 19

1–2. Peronidella magna new species; *1,* holotype, USNM 463663, Senowbari-Daryan collection; side view shows coarse annulation in the dermal layer, perforated by numerous very small inhalant pores, ×1; *2,* paratype, USNM 463664, Section J, bed 17; summit view shows a wide spongocoel that has a diameter approximately the same as the wall thickness that passes through the whole sponge; the spongocoel seems to have a thin wall; the skeleton is composed of a fibrous net without major exhalant or inhalant canals; the exterior is covered by algae, ×1.——*3. Peronidella(?)* sp. cf. *P. magna* new species, figured specimen, USNM 463665, Section I, shale below bed 3; traverse west of section and pass; side view of a broken specimen partially overgrown by smaller sponge; the larger sponge of concern here shows distally annulated exterior and has relatively large and well-defined inhalant ostia more widely separated than in specimen in Plate 19.1; a wide spongocoel passes through the sponge and is surrounded by a wall only 5 mm thick, ×1.——*4–6. Peronidella digitata* new species; *4,* paratype, USNM 463670, Spot Locality T5; summit view of a dichotomously branched specimen shows the relatively narrow spongocoels and a thick sponge wall of reticulate fibers around them, ×2; *5–6,* holotype, USNM 480414, Spot Locality T5; *5,* summit view of the multibranched holotype, ×2; *6,* side view of the multibranched holotype in which the dermal surface is relatively smooth and the inhalant pores, which correspond to interfiber spaces, are widespread numerous openings, ×2.——*7. Permocorynella tuberosa* new species, paratype, USNM 480311, shale equivalent to bed 3 of Section I, but west of traverse; side view of an irregularly lobate, discoidal sponge with several branches; each rounded branch tip is characterized by an osculum composed of 5 to 8 individual circular openings; broken branch in lower center shows the dense dermal layer and irregular canals in the interior; top is to the left; compare with Plate 20.7, ×2.——*8–11. Peronidella multiosculata* new species; *8–9,* paratype, USNM 463668, Sections E-F, CF18; *8,* summit view of specimen in which the summit of each branch has a starlike osculum; branches diverge from a single level, ×5; *9,* side view of the specimen in which the dermal layer is characterized by a very fine, fibrous structure and small interfiber spaces, ×5; *10–11,* paratype, USNM 463669, Spot Locality T5; *10,* summit view of the specimen in which large openings of exhalant canals are visible around the spongocoel on the left branch, ×5; *11,* side view of specimen shows dichotomous branches, ×5.

PLATE 20

1–3. Radiofibra lineata new species; *1–2,* holotype, USNM 463675, Section G, bed 4; *1,* exterior showing coarse skeletal net on weathered surface, apparently lacking a dermal layer, ×2; *2,* polished longitudinal section of side opposite Plate 20.1, showing matrix-filled, narrow, axial spongocoel and coarse, upwardly divergent skeletal fibers defining tubelike canals, ×2; *3,* paratype, USNM 480395, Section E, bed 27; exterior of conicocylindrical sponge shows characteristic coarse skeletal net and stalklike base, ×2.——*4, 6. Peronidella multiosculata,* holotype, USNM 463667, Spot locality 21A; *4,* summit view of a multibranched specimen; the summit of each branch bears an osculum composed of 3 to 5 individual openings, ×5; *6,* side view shows two levels of branching, ×5.——*5, 7. Permocorynella tuberosa* new species, holotype, USNM 480310, Spot Locality DJT-5; *5,* side view shows platelike growth form and dermal layer on the lower surface; oscula occur on branch tips, ×1; *7,* summit view of an irregularly low, radiate to lobate specimen with several branches, each with a spongocoel from oscula on the tips; compare with Plate 19.7, ×1.

PLATE 21

Photomicrographs of polished surfaces of sponges from the Djebel Tebaga showing skeletal textures and interior structures in the several species. Contrast is low because the polished surfaces generally show only intermediate shades of gray and locally photograph dark where the skeletal structure and matrix are preserved as translucent calcite. All photographs were taken with the surface wet by a thin film of glycerine, diluted with water.——*1. Cavusonella caverna* Rigby, Fan, and Zhang, 1989, figured specimen, USNM 463589, Spot Locality T5; general relatively uniform, fine, reticulate skeleton interrupted by common large canals distributed throughout the skeleton, as seen in medial longitudinal section, ×10.——*2. Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 480396, Spot Locality DJT-22; upward and outward divergence of relatively coarse, skeletal elements and canals; here with canals filled with reddish matrix that shows dark gray in the longitudinal medial section, ×10.——*3. Radiotrabeculopora reticulata* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 463622, Spot Locality S1; part of a longitudinal section with top toward the right showing irregular, discontinuous, and meandriform to spinous skeletal elements, with pinkish matrix between light gray elements of the skeleton that have an irregular, reticulate structure characteristic of the species, ×10.——*4. Radiotrabeculopora(?) patula* new species, paratype, USNM 480374, Section E, bed 27; more or less transverse horizontal section shows the moderately delicate fibers of the skeleton and the irregular open texture, characteristic of the species and genus, with moderately large canals and skeletal pores filled with light matrix, ×10.——*5. Prestellispongia lobata* (Parona, 1933), figured specimen, USNM 480397, Section E, shale beneath Reef 3; regular reticulate skeletal structure, in which horizontal elements or fibers are dominant, is characteristic of the species, with skeleton perforated by segments of both horizontal and vertical canals, in large part filled with translucent calcite, ×10.——*6–7. Prestellispongia paula* new species, paratype, USNM 480398, Section C, bed 16; *6,* vertical section through spongocoel showing convergence of moderately large, subhorizontal exhalant canals on the right, and subparalleled by vertical, probably inhalant, canals on the left; fine, regular, skeletal mesh appears as dark transparent elements in the upper part and as light gray elements in the lower right, ×10; *7,* vertical section of the interior part of the skeleton showing uniform reticulate network, as seen in an area where the matrix is translucent calcite in the center, ×10.——*8–9. Prestellispongia permica* (Parona, 1933), figured specimen, USNM 480399, Spot Locality 27A; *8,* vertical section through part of the sponge, away from the spongocoel, showing the vertically aligned, subhorizontal, convergent exhalant canals as large, clear-calcite openings, which appear dark, interrupting the regular skeletal mesh preserved in clear-calcite matrix; minor horizontal convergent exhalant canals show near the left margin and near the bottom; the regular skeleton is characteristic of the genus, ×10; *9,* vertical section through the central convergent area where numerous exhalant canals merge into a vertical series near the base of the spongocoel. The regular, skeletal mesh shows between the canals in the translucent calcareous preservation, ×10.——*10. Prestellispongia scapulata* new species, paratype, USNM 480307, Section E, shale below Reef 3; vertical section showing smaller, apparently inhalant, vertical canals piercing the moderately uniform skeletal net, in which vertical fibers appear dominant over horizontal ones; entire skeletal net interrupted by dense areas, apparently marking pulses of growth of the sponge skeleton. Light dots near the bottom are where the skeleton appears at the surface of the glycerine-wet section. Most of the rest of the view is where the skeleton is preserved in translucent calcite matrix, ×10.——*11. Prestellispongia bolaria* new species, holotype, USNM 480353, Spot Locality DJT-8; vertical section showing moderately coarse skeletal structure, characteristic of the species, with vertically dominant fibers, cross connected by smaller, horizontal, short elements and with the entire structure pierced by coarse, walled canals, ×10.——*12. Prestellispongia(?) fasciculata* new species, holotype, USNM 480302, Spot Locality T5; vertical section showing dominance of fine, vertical fibers in the skeleton, in part preserved with translucent calcite cement in the only moderately well-preserved structure, ×10.——*13. Estrellospongia grossa* new species, paratype, USNM 480400, Section E, bed 27; vertical section shows characteristic skeletal structure with some coarse, vertical fibers, cross connected by small, horizontal units; coarse vertical fibers paralleled by small inhalant canals, pulses of growth marked by subhorizontal dense zones, ×10.——*14. Stellispongiella insculpta* new species, holotype, USNM 480271, Section I, bed 12; vertical, medial section showing upward-and-outward divergence of the principal skeletal fibers from a moderately open, coarse, axial area to more massive, finer textured skeleton in zone of divergence, ×10.——*15. Stellispongiella reticulata* new species, paratype, USNM 463651, Spot Locality 13B; more or less transverse section showing convergent, coarse exhalant canals in the moderately coarsely fibrous skeleton, with iron-stained and dark matrix filling the walled canals and skeletal pores, ×10.——*16. Peronidella magna* new species, holotype, USNM 463663, Senowbari-Daryan collection; vertical section of the wall showing the reticulate, relatively coarse skeletal network uninterrupted by canals, in a structure characteristic of the species and genus, ×10.

PLATE 22

1–6. Radiofibra delicata new species; *1–2,* paratype, USNM 463672, Section J, bed 17; *1,* view showing relatively fine skeletal structure and canal pattern around central starlike spongocoel, ×2; *2,* side view showing numerous fine inhalant ostia on obconical sponge, ×2; *3–4,* holotype, USNM 463671, Section J, bed 25; *3,* side view of weakly annulate cylindrical form with numerous irregular inhalant ostia, ×2; *4,* view showing uniform texture of skeleton and canals around small central spongocoel, ×2; *5–6,* paratype, USNM 463673, Section G, bed 4 shale; *5,* side view of branched form, ×2; *6,* summit view of branched form with spongocoel well defined in tip of the large branch, ×2.——*7–9. Radiofibra lineata* new species; *7,* paratype, USNM 480350, Section G, bed 4; side view of weakly annulate sponge with numerous fine inhalant pores in dense dermal layer, and coarser openings in weathered interior at the top, ×1; *8–9,* paratype, USNM 463676, Section I, base of bed 2; *8,* side view showing relatively coarse inhalant canals in the cylindrical sponge, ×2; *9,* summit view showing moderately coarse skeletal structure around cylindrical spongocoel, ×2.——*10–11. Saginospongia angusta* new species; *10,* holotype, USNM 463677, Section G, bed 5, scan sample 3; side view of incipiently branched, coarse-textured sponge with coarse ostia in the thick wall and finer ostia and skeletal tracts between branches; summit essentially complete, ×2; *11,* paratype, USNM 463678, Section G, bed 5; side view of coarsely canalled, weakly annulate sponge, ×2.——*12. Saginospongia porosa* new species, holotype, USNM 463679, Section G, bed 5; coarse canals and broad irregular skeletal tracts in the obconical sponge, ×2.

Plate 23

1–2. Permocorynella fruticosa new species; *1,* paratype, USNM 480299, Section G, bed 5; summit of a massive and branched sponge; each branch has an osculum from which a canal system spreads radially on the tip; numerous small inhalant pores can be seen between furrows on individual stems, ×1; *2,* holotype, USNM 480300, Spot Locality DJT-23; summit of a massive spherical sponge showing several branches or individuals (?), each without a deep spongocoel; relatively large inhalant pores can be seen between oscula, ×2. ——*3. Radiofibra nodosa* new species, holotype, USNM 480301, Section G, bed 5; spherical to irregularly shaped sponge mass composed of several sponges, each characterized by an osculum on the tip and radial furrows of an astrorhizal system; numerous inhalant pores are visible between the furrows and astrorhizae, ×1.——*4–5. Prestellispongia(?) fasciculata* new species, holotype, USNM 480302, Spot Locality T5; *4,* summit of a large sponge with individual stems characterized by a large astrorhizal-like system of exhalant canals; irregular inhalant pores occur between the furrows of the astrorhizae on the smooth stems, marked elsewhere only with growth lines, ×1; *5,* basal view shows the exterior marked only by growth lines, ×1.

Plate 24

1–11. Permocorynella ovoidalis (Parona, 1933); *1–2,* figured specimen, USNM 463681, Section E, bed 15; *1,* summit view with prominent deep central spongocoel and ostia of longitudinal canals that end on the summit, ×2; *2,* side view shows weathered dermal layer with closely spaced inhalant pores, ×2; *3–4,* figured specimen, USNM 463682, Section E-F, CF18; *3,* summit view shows furrowed exhalant canals and ostia of longitudinal canals; the spongocoel is partially filled by matrix, ×2; *4,* side view in which radial canals extend down one-third of sponge height; inhalant ostia on ridges between furrows, ×2; *5,* figured specimen, USNM 463683, Spot Locality DJT-5; diagonal view of specimen shows mainly coarse inhalant pores and deep axial spongocoel, ×2; *6–7,* figured specimen, USNM 463684, Section B, bed 1; *6,* summit view shows deep axial spongocoel, ×2; *7,* side view of conicocylindrical specimen shows prominent inhalant pores, ×2; *8,* figured specimen, USNM 463685, Spot Locality T5; summit view shows a deep axial spongocoel and the radial exhalant and inhalant canals, as well as aligned ostia of longitudinal tubes in the sponge wall, ×2; *9,* figured specimen, USNM 463686, Section J, bed 17; summit view of specimen with two spongocoels; the larger one extends deeply into the interior of the sponge, but the smaller one is limited to the top and may mark an initial stage of branching; exhalant canals extend into the spongocoels; ostia of inhalant and longitudinal canals are prominent, ×2; *10–11,* figured specimen, USNM 463687, Senowbari-Daryan collection; *10,* summit view with deep axial spongocoel, ×2; *11,* side view of short hemispherical specimen; common inhalant ostia on the exterior side; the base lacks pores and has only growth lines, ×2.

Plate 25

1–8. Permocorynella ovoidalis (Parona, 1933); *1,* figured specimen, USNM 463688, Spot Locality DJT-31; summit view of a specimen shows deep spongocoel and well-developed inhalant pores and coarser aligned exhalant canals, ×2; *2,* figured specimen, USNM 463689, Section J, bed 17; side view shows inhalant pores distributed over the whole dermal surface, ×1; *3,* figured specimen, USNM 463690, Spot Locality S7; fractured surface shows inside of spongocoel with exhalant pores in vertical parallel rows; the cylindrical spongocoel extends deeply into the sponge body, ×2; *4, 7,* figured specimen, USNM 480262, Section G, bed 4; *4,* view of the summit shows a prominent deep spongocoel and coarse, irregularly spaced, exhalant pores and finer inhalant pores, ×2; *7,* side view of conicocylindrical specimen with irregular pores in the weathered exterior, ×2; *5,* figured specimen, USNM 480265, Section G, bed 4; side view of weakly annulate cylindrical specimen, with irregularly spaced and placed inhalant and exhalant pores, ×2; *6,* figured specimen, USNM 480263, Spot Locality 9B; side view of annulate conical sponge that shows prominent variation in diameters and apparent rejuvenated upper parts; all with irregular inhalant and exhalant pores, ×2; *8,* figured specimen, USNM 480264, Section G, top of bed 4; natural section shows cylindrical spongocoel and prominent upwardly and outwardly divergent coarse exhalant canals, particularly in the lower section through the wall, ×2.

Plate 26

1–11. Permocorynella osculifera new species; *1–2,* paratype, USNM 463632, Spot Locality 21A-23A; *1,* summit with radially convergent inhalant and exhalant canals around osculum at top of the walls; relatively wide osculum extends into the sponge but does not form a spongocoel through the whole sponge, ×2; *2,* side view shows distinct inhalant pores arranged in lines around the sponge, ×2; *3–4,* paratype, USNM 463633, Spot Locality 204-1976; *3,* summit view shows osculum is relatively shallow and limited to the summit of the sponge, ×2; *4,* side view shows inhalant pores in the fibrous skeleton, ×2; *5–6,* paratype, USNM 463634, Section E, shale below Reef 3; *5,* summit shows the osculum is relatively small and limited to the top of sponge, ×1; *6,* side view shows inhalant pores are starlike and irregularly distributed over the entire dermal surface, ×1; *7–9,* holotype, USNM 463635, Section E, shale below Reef 3; *7,* polished surface of axial longitudinal section showing curved, upwardly convergent subhorizontal canals in outer part, becoming subvertical near axis, and upwardly and outwardly divergent regular skeletal structure with smaller pores parallel to skeletal fibers, ×2; *8,* view of summit in which osculum is offset, not axially, perhaps because a branch may have started on the right; a large furrow leads to that side, ×1; *9,* side view shows inhalant canals arranged in distinct lines, especially in the upper part of the dermal layer, ×1; *10–11,* paratype, USNM 463636, Spot Locality 21A-23A; *10,* summit view shows two oscula in the axial part, ×1; *11,* side view shows inhalant pores arranged in irregular lines, traceable around the sponge, especially evident on the upper part, ×1.

Plate 27

1, 5, 8. Permocorynella ovoidalis (Parona, 1933); *1, 8,* figured specimen, USNM 480394, Spot Locality S1; *1,* side view shows weakly annulate but generally smooth exterior, perforated by abundant inhalant ostia, ×2; *8,* summit view with slightly oblique osculum and radial canals with abundant ostia of upwardly radiating canals, ×2; *5,* figured specimen, USNM 480262, Section G, bed 5; summit view shows central osculum of deep spongocoel, radial canals, and circular ostia of vertical to upwardly radiating canals in fibrous net, ×2.——*2–3. Precorynella virgosa* new species, holotype, USNM 480392, Section G, bed 4; *2,* summit view shows many aligned exhalant ostia in shallow osculum at tip of four main branches; branch at lower left has been cut, ×2; *3,* side view showing common base and two principal branches, numerous inhalant ostia show on otherwise smooth sides, ×2.——*4. Heliospongia(?) finksi* Termier and Termier, 1977a, figured specimen, USNM 480298, Section J, bed 17; side view of the exterior shows prominent inhalant ostia, ×2.——*6–7. Heliospongia finksi* Termier and Termier, 1977a, figured specimens; *6,* USNM 480293, Spot Locality 14-A; side view of specimen showing branching in annulate sponge, ×2; *7,* USNM 480297, Section G, bed 4; summit view shows deep central spongocoel with walls partially encrusted by algae; specimen has been cut, ×2.——*9. Radiotrabeculopora* cf. *R. xiangboensis* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 463619, Section E, shale above Reef 3; side view of branched specimen with abundant inhalant ostia, ×2.

Plate 28

1–4. Precorynella crysanthemum (Parona, 1933); *1–2,* figured specimen, USNM 480380, Section G, bed 9; *1,* summit of specimen shows several openings of exhalant canals, visible in the center; the radially arranged inhalant canals can be seen on the top of sponge, ×2; *2,* side view of specimen, ×2; *3–4,* figured specimen, USNM 480381, Section G, bed 5; *3,* summit of specimen, ×2; *4,* side view of specimen shows a depression that indicates incipient branching of the sponge, ×2.——*5–6. Precorynella robusta* new species, holotype, USNM 480393, Section G, bed 5; *5,* summit of specimen, ×2; *6,* side view of specimen, ×2.——*7–9. Permocorynella ovoidalis* (Parona, 1933); *7,* USNM 480379, Spot Locality DJT-21; side view showing irregular growth in steeply obconical specimen, ×2; *8–9,* USNM 463691, Spot Locality 9B; *8,* upper and inner part of specimen shows numerous exhalant pores of the spongocoel, cut from upper part of specimen shown in Plate 28.9, ×2; *9,* side view of exterior of specimen, ×2.

Plate 29

1–6. Djemelia nana new species; *1–2,* holotype, USNM 463696, Spot Locality DJT-10; *1,* summit of holotype shows spongocoel to right and characteristic fine fibrous skeletal structure, ×5; *2,* side view shows distinct rimmed ostia, ×5; *3–4,* paratype, USNM 463697, Section I, bed 5; *3,* summit shows the axial spongocoel is surrounded by relatively coarse, fibrous skeleton, ×5; *4,* side view shows weakly annulate cylindrical form, ×5; *5,* paratype, USNM 463698, Spot Locality 143-1976; side view of a branched specimen shows pustular ostia on the outer surface, ×3; *6,* paratype, USNM 463699, Senowbari-Daryan collection; side view of well-preserved paratype shows rimmed ostia in small sponge, ×5.——*7–11. Djemelia amplia* new species; *7,* holotype, USNM 463692, Spot Locality S7; side view shows the pustular ostia with elevated edges; cross section illustrated in Plate 37.10, ×1; *8,* paratype, USNM 463694, Section E, shale below Reef 3; side view shows ostia with moderately elevated rims and fine fibrous skeleton between ostia, ×2; *9–10,* paratype, USNM 463693, Spot Locality DJT-11; *9,* view of the summit shows the relatively wide spongocoel, now largely filled by matrix, ×2; *10,* side view shows moderately aligned and rimmed ostia, ×2; *11,* paratype, USNM 463695, Section G, bed 4; side view partially covered by algae in lower part, ×2.——*12–18. Minispongia carinata* new species; *12,* holotype, USNM 463704, Spot Locality 302-1976; side view shows horizontal, dermal ridges, which are partly grown together in a zigzag pattern; part of axial spongocoel is visible in broken base, ×5; *13,* paratype, USNM 463705, Section E, shale below Reef 3; side view of a branched paratype shows characteristic annulated dermal surface, ×5; *14,* paratype, USNM 463707, Spot Locality 300-1976; side view of branched paratype with distinctive dermal sculpture, ×5; *15,* paratype, USNM 463706, Section E, shale below Reef 3; view of summit shows single axial spongocoel and fibrous skeleton around it, ×5; *16–17,* paratype, USNM 463708, Spot Locality DJT-23; *16,* view of top shows a spongocoel composed of three, more or less separated tubes, ×5; *17,* side view of specimen that branched twice, dichotomously; the well-developed annulate ridges are partly grown together and form a zigzag ridge near the bottom, ×5; *18,* paratype, USNM 463710, Section E, shale above Reef 3; side view with ridges grown together in a zigzag pattern, ×5.

Plate 30

1, 8. Heptatubispongia(?) sp., figured specimen, USNM 480355, Section 7, bed 5; *1,* summit view shows central spongocoel and grooves of lateral canals, ×5; *8,* side view shows complete tip and lateral canal grooves on tip, ×3.——*2, 9. Radiofibra inordinata* new species, holotype, USNM 480356, Spot Locality S1; *2,* side view shows irregular growth form and prominent surface grooves typical of the species, ×2; *9,* view of the tip of one branch with characteristic surface sculpture, canals, and pores, ×2.——*3–4. Precorynella diffusa* new species, holotype, USNM 480357, Section E, shale below Reef 3; *3,* side view shows prominent longitudinal surficial canals and club-shaped form, ×2; *4,* top view shows clustered, larger exhalant canals and upper ends of surficial canals around periphery, ×2. ——*5–6. Thallospongia reticulata* new species, holotype, USNM 480358, Spot Locality 4A; *5,* side view shows branched form, ×2; *6,* radial grooves of tip and the dense skeleton, ×4.——*7. Exotubispongia virgulata* new species, holotype, USNM 480359, Spot Locality 4A; side view of small branched sponge with surficial grooves of lateral canals typical of the species and genus, ×2.——*10, 12. Estrellospongia(?) grossa* new species, reference specimen, USNM 480360, Spot Locality 48; *10,* top view, ×5; *12,* side view, ×5.——*11, 13. Ramostella stipulata* new species, holotype, USNM 480354, Section I, bed 5; *11,* top view showing clusters of exhalant ostia on summits of the three, short branches, ×2; *13,* side view showing triangular, palmate appearance above cylindrical base; three short branches at top, marked by irregular surficial grooves but lacking ostia of inhalant canals, ×2.

Plate 31

1–6, 8–9, 13. Imperatoria voluta new species; *1,* paratype, USNM 463712, Section C, bed 16, shale below the star-coral bed, side view composed of four complete segments and a new partial segment at the top; because the segments are arranged obliquely, one above the other, the sponge has a screwlike side view; dermal surface of the sponge has numerous small and obscure inhalant pores, ×2; *2,* paratype, USNM 463713, Spot Locality T9; side view of a specimen composed of 6 segments shows general vertical decrease in element size in turriculate sponge, ×2; *3,* paratype, USNM 463714, Section I, shale below bed 3 but west of traverse; side view of small specimen composed of 4 segments, ×2; *4,* paratype, USNM 463718, Section J, bed 26; summit view of a specimen with two small oscula in the axial part of the segment, ×4; *5–6,* holotype, USNM 463715, Spot Locality 206-1976; *5,* summit view with two characteristic, small, adjacent oscula in the relatively coarse fibrous skeletal structure, ×4; *6,* side view of the small specimen composed of only 3 segments, ×2; *8,* paratype, USNM 463716, Section J, bed 17; side view of small specimen with 4 segments, ×4; *9,* paratype, USNM 463717, Section E, shale below Reef 3; side view of small specimen with 3 segments, ×4; *13,* paratype, USNM 463719, Section E, bed 27; top shows two small oscula in summit, ×4.——*7, 10–12. Imperatoria(?) fistulata* new species; *7, 11,* holotype, USNM 463720, Section E, shale below Reef 3; *7,* top view; dark line is saw cut made to prepare longitudinal sections, ×4; *11,* side view shows numerous elevated exaules on exterior of turriculate sponge, ×2; *10,* paratype, USNM 463721, Section E, bed 15; side view of a turriculate specimen with prominent exaules, ×2; *12,* paratype, USNM 463722, Section I, bed 5; side view, ×2.——*14. Imperatoria marconii* de Gregorio, 1930, figured specimen, USNM 463711, Spot Locality T-8; side view, ×2.

Plate 32

1–6. Intratubospongia osiensis (de Gregorio, 1930); *1–2,* figured specimen, USNM 480239, Section E, shale below reef 3; *1,* summit view shows numerous exhalant pores distributed across the whole sponge summit; this specimen does not have a bowl-like summit depression, perhaps because of weathering. It was cut to observe the internal structure, ×1; *2,* side view shows a smooth dermal layer, except for exaggerated growth lines forming weak annulations, ×1; *3–4,* figured specimen, USNM 480247, Spot Locality 204-1976; *3,* summit view shows radially arranged furrows and exhalant pores located in a bowl-like spongocoel depression, producing a coral-like appearance, ×2; *4,* side view of the specimen shows the dermal surface of the sponge is smooth in detail, but with prominent growth line annulations and encrustation, ×2; *5–6,* figured specimen, USNM 480245, Section J, bed 18; *5,* side view of club-shaped specimen shows prominent growth lines on the surface of the sponge, ×4; *6,* summit view shows exhalant pores located in a characteristic bowl-like spongocoel depression; radially arranged furrows are faint traces, ×1.5.——*7–11. Djemelia mediala* new species; *7–8,* holotype, USNM 463700, Spot Locality 13B; *7,* side view shows the characteristic openings over the outer surface of the sponge, ×2; *8,* summit shows the osculum and relatively coarse skeletal fibers, ×4; *9,* paratype, USNM 463701, Spot Locality 127-1976; side view shows the numerous and well-preserved openings without exaules, ×5; *10,* paratype, USNM 463702, Spot Locality 127-1976; side view of a specimen exhibiting densely packed ostia without exaules, ×5; *11,* paratype, USNM 463703, Spot Locality 122-1976; side view of a specimen that shows the same external characteristics as the other types, ×5.——*12–13. Heptatubispongia(?)* cf. *H. symmetrica* new species, figured specimen, USNM 463727, Section I, bed 2, equivalent to west of traverse, pass and house; *12,* outer surface exhibiting ostia characteristic of *Djemelia,* but it differs from *Djemelia* by having the several concentrically arranged tubes shown in cross section in Plate 32.13; this canal pattern is characteristic of *Heptatubispongia symmetrica* new species (see Plate 33.9–33.16), but the outer surface of *Heptatubispongia* is smooth and does not show prominent ostia. The assignment of this specimen to both genus and species is uncertain, ×2; *13,* summit of specimen shows six exhalant outer canals arranged in a ring, typical of *Heptatubispongia,* ×4.

Plate 33

1–8. Preeudea minima Termier and Termier, 1977a; *1, 3,* figured specimen, USNM 463733, Section E, shale below Reef 3; *1,* exterior of cylindrical specimen in which the relatively large ostia are only partly open because the sponge is partially covered by algae, ×2; *3,* top of specimen showing extensive canals, ×2; *2,* figured specimen, USNM 463734, Section G, bed 4; top of a spherical specimen shows a bundle of small, tubular, axial spongocoels, ×2; *4–5,* figured specimen, USNM 463735, Section J, bed 17; *4,* exterior of specimen with relatively large ostia in the dense dermal layer, ×2; *5,* top view of the specimen with a cluster of tubular axial spongocoels, ×2; *6–7,* figured specimen, USNM 463736, Section G, bed 5; *6,* characteristic exterior with inhalant ostia on the side, ×2; *7,* base of the sponge with well-developed exhalant canals, ×2; *8,* figured specimen, USNM 480211, Spot Locality T8; exterior view in which exhalant canals and prominent inhalant ostia are rimmed on the side; growth lines are present in the dense dermal layer on the top and exhalant canals show on the top of sponge, ×2.——*9–16. Heptatubispongia symmetrica* new species, all type specimens are from Section G, bed 5; *9–12,* holotype, USNM 463724; *9,* side view of branched specimen showing growth form and weakly annulate growth lines, ×2; *10,* summit of left branch above, as shown in Plate 33.9, showing the minor, axial, central exhalant canals and symmetrically arranged, collateral, vertical canals near the periphery, ×4; *11,* base of sponge, as shown in Plate 33.9, with typical ring of exhalant canal near periphery and radial canals around central spongocoel, as in right branch, ×8; *12,* summit of right branch, as shown in Plate 33.9, with characteristic canal pattern, ×5; *13–14,* paratype, USNM 463725; *13,* summit with typical canal pattern, ×9; *14,* side view showing weakly annulate growth form and dense dermal layer, ×2; *15–16,* paratype, USNM 463726; *15,* summit view showing typical canal development, ×5; *16,* side view of curved cylindrical specimen, ×2.——*17–18. Exotubispongia pustulata* new species; *17,* USNM 480231, Section G, bed 5; side view of a holotype starting to branch in the upper part; pustular elevations with small pores arranged in lines, ×5; *18,* paratype, USNM 480232, Section E, shale below Reef 3; side view of a small and branched specimen; pustular elevation with small pores are typical, ×5.——*19–20. Imperatoria(?) fistulata* new species, USNM 463723, Section I, bed 2 equivalent, west of traverse and pass; *19,* view into upper osculum shows multiple small exhalant pores, ×2; *20,* side view shows characteristic growth form but with ill-defined exaules on weathered surface, ×2.

PLATE 34

1–14. Intratubospongia osiensis (de Gregorio, 1930); *1–2,* figured specimen, USNM 480237, Section E, shale below Reef 3; *1,* view of branched specimen in which the branches are clearly separated on the right; each branch has several coarse exhalant pores distributed throughout the skeleton, ×1; *2,* side view of specimen appears as though two individuals grew together, but the interior does not show clear separation; growth lines mark the dermal surface, ×1; *3–4,* figured specimen, USNM 480238, Section E, shale below Reef 3; *3,* summit view shows exhalant pores located in a bowl-like depression that has a small boss in the axial part, ×1; *4,* side view shows well-expressed growth lines in the dermal layer, ×1; *5–6,* figured specimen, USNM 480241, Section J, bed 17; *5,* summit view shows exhalant pores irregularly distributed in the bowl-like spongocoel, ×1; *6,* side view of cylindrical specimen on which growth lines are clearly shown, ×1; *7–8,* figured specimen, USNM 480242, Spot Locality S7; *7,* summit view shows numerous exhalant pores exposed in bowl-like depression; a starlike furrow system is developed in the left part, ×2; *8,* side view of specimen with smooth dermal surface, except for prominent growth lines, ×1; *9–10,* figured specimen, USNM 480243, Section I, shale below bed 3, on transverse, west of pass and house; *9,* side view shows three distinct major pulses of growth, ×1; *10,* summit view of bowl-like depression shows an astrorhizal-like exhalant canal system and numerous exhalant pores, ×1; *11–12,* figured specimen, USNM 480244, Section J, bed 18; *11,* summit view in which the spongocoel is relatively deep and shows radially arranged furrows with numerous exhalant pores, ×2; *12,* side view of partially encrusted specimen, ×2; *13–14,* figured specimen, USNM 480246, Section E, bed 14; *13,* summit view shows radially arranged furrows and exhalant pores located in a bowl-like spongocoel, ×2; *14,* side view of obconical specimen in which the weathered dermal layer shows some nearly surficial(?), vertical exhalant tubes extending from near the base of the sponge, ×2.

PLATE 35

1–8. Medinina laterala new genus, new species; *1–2,* holotype, USNM 463728, Spot Locality 21A-23A; *1,* view of the summit of branched specimen; numerous small exhalant pores are located in large depressions on the summit of each branch, ×2; *2,* side view of the exterior shows branched form and weak annulations, ×2; *3,* paratype, USNM 463729, Section E, bed 29a; summit of a weathered specimen showing small exopores, ×2; *4–5,* paratype, USNM 463730, Section J, bed 17; *4,* summit of specimen, one half of which shows numerous exhalant pores, ×2; *5,* side view of annulate, steeply obconical specimen shows aligned inhalant pores in the weathered upper part of the sponge, ×2; *6, 8,* paratype, USNM 463732, Section E, bed 29a; *6,* photomicrograph shows rounded nodes of exterior dense dermal layer, ×6; *8,* side view of a weakly annulate specimen showing the outer structure of the sponge, ×1; *7,* paratype, USNM 463731, Spot Locality T5; side view of a specimen with a weathered upper part which shows the horizontally arranged elements, ×2.——*9–11. Saginospongia crateria* new species, holotype, USNM 480372, Section G, bed 5; *9,* summit view or partial transverse weathered section showing open spongocoel as depression on the left and the thick wall pierced by craterlike canals, ×2; *10,* side view of coarsely pitted exterior, with thick, intervening tracts with fine, reticulate skeleton; bases of ostia pits commonly matrix filled, ×2; *11,* polished vertical section of upper part shows partially excavated spongocoel and filled coarse canals; darker gray, separated by lighter gray, massive, skeletal tracts of fine, reticulate skeleton, ×2.

PLATE 36

1–18, 23. Polytubifungia maxima new genus, new species; *1–2,* paratype, USNM 480216, Section I, bed 2, west of traverse, trail, and house; *1,* view of summit shows the numerous exhalant ostia, ×2; *2,* side view of specimen shows coarse inhalant pores in horizontal lines on the exterior of the sponge, ×2; *3–4,* paratype, USNM 480217, Spot Locality 4A; *3,* summit view with the oscula partly obscured on the left, ×2; *4,* side view with exterior marked by nodes of inhalant ostia, ×2; *5–6,* paratype, USNM 480219, Section B, bed 1; *5,* summit with numerous exhalant ostia in laterally flattened sponge, ×2; *6,* side view of specimen with some inhalant ostia evident, even on lower, stalklike part, ×2; *7–8,* paratype, USNM 480220, Section B, bed 1; *7,* summit view with well-defined, coarse, excurrent ostia, ×1; *8,* side view shows growth lines and inhalant pores in characteristic dermal layer, ×2; *9,* paratype, USNM 480425, Spot Locality 4A; summit of a specimen in which exhalant ostia are partly covered by algae(?), ×2; *10,* paratype, USNM 480221, Spot Locality 160-1976; summit shows numerous oscula distributed across the entire top of the sponge, ×2; *11–12,* holotype, USNM 480215, Spot Locality 4A; *11,* summit of sponge with shallow oscular depression in which numerous exhalant ostia are apparent, ×1; *12,* oblique side view of sponge with growth lines and numerous incurrent ostia arranged in lines parallel to the growth lines in dense dermal layer, ×1.5; *13,* paratype, USNM 480222, Section E, bed 14; summit of a well-preserved specimen shows closely arranged ostia, ×2; *14,* paratype, USNM 480223, Section E, bed 14; summit in which ostia are located in a bowl-like depression, ×2; *15–16,* paratype, USNM 480218, Spot Locality 4A; *15,* summit with coarse ostia, triangular shape probably a result of crowding during growth, ×1; *16,* side view shows characteristic growth lines and rimmed inhalant ostia, ×2; *17–18,* paratype, USNM 480224, Spot Locality CF24; *17,* summit of only gently depressed specimen shows numerous exhalant ostia, ×1; *18,* view of the bottom and sides shows rimmed outlines of ostia of tubes that pass vertically through the whole sponge, ×2; *23,* paratype, USNM 480225, Spot Locality CF24; summit view with numerous ostia located in a bowl-like depression, ×2.——*19–22. Polytubifungia minima* new species; *19, 22,* holotype, USNM 480212, Section B, bed 1; *19,* side view shows the numerous small ostia and obconical form of the species, ×2; *22,* summit view with prominent oscular depression with numerous small exhalant canals, ×2; *20–21,* paratype, USNM 480213, Spot Locality 14A, 20; *20,* side view shows very small ostia and faint fine growth lines, ×2; *21,* summit shows shallow oscular depression and small ostia, ×2.

Plate 37

1–4. Sphaeropontia regulara new species; *1–2,* paratype, USNM 480229, Section J, bed 17; *1,* summit view shows the numerous small exhalant openings, ×2; *2,* side view of steeply obconical specimen that has been weathered and has detail obscured, ×2; *3,* holotype, USNM 480321, Section G, bed 5; summit of specimen exhibiting numerous outwardly divergent exhalant openings; exhalant canals in the center are vertical, parallel to the axis of the sponge, and their diameters are smaller than those in the peripheral part, ×2; *4,* paratype, USNM 480230, Section E, bed 26; polished slab of recrystallized specimen in which only the lower part exhibits well-preserved skeletal structure of small sphaeroclones, ×2.——*5–8. Microsphaerospongia polyarteria* new species; *5,* paratype, USNM 480227, Spot Locality T6; view of an exhalant opening showing diagnostic sievelike plate, ×5; *6–7,* paratype, USNM 480228, Spot Locality T6; *6,* enlargement shows spherical form with prominent, rimmed oscula as starlike openings, ×5; *7,* spherical, small specimen shows typical form and canal patterns, ×2; *8,* holotype, USNM 480226, Section E, bed 14; view of subspherical growth form and characteristic rimmed oscula, ×1.——*9, 11–12. Peronidella(?)* sp. cf. *P. magna* new species, figured specimen, USNM 480410, Section J, bed 17; *9,* photomicrograph of gastral surface shows skeletal pore distribution and somewhat diagenetically altered, intervening skeletal tracts, ×5; *11,* vertical interior in naturally weathered section shows large spongocoel and thin walls, without major canals; aligned skeletal pores marking gastral surface, ×2; *12,* exterior with moderate annulations and surface with large, skeletal pores of coarse, reticulate skeleton, details obscured by diagenesis, ×2.——*10. Djemelia amplia* new species, holotype, USNM 463692, Spot Locality S7; cross section of the holotype, whose side view is illustrated in Plate 29.7; the relatively wide spongocoel with radially arranged exhalant canals is characteristic, ×2.

Plate 38

1–11. Pseudohimatella pauciporata (Parona, 1933); *1–2,* figured specimen, USNM 480248, Spot Locality DJT-15; *1,* summit view of club-shaped sponge shows two large exhalant openings and numerous, coarse, exhalant pores, ×2; *2,* side view shows smooth dermal surface, except for prominent annulations and weak growth lines, ×2; *3,* figured specimen, USNM 480255, Section G, bed 4; broken and weathered base of figured specimen shows outlines of tubes and coarse, fibrous structure between them, ×2; *4,* figured specimen, USNM 480249, Spot Locality DJT-17; deeply weathered base of another figured specimen shows coarse exhalant tubes and fibrous skeletal structure, ×2; *5,* figured specimen, USNM 480250, Section J, bed 17; summit view shows a single, central osculum and possible inception of one or possibly two more oscula on the lower left edge, ×2; *6–7,* figured specimen, USNM 480252, Spot Locality S-5; *6,* summit view shows central osculum and surrounding coarse exhalant pores, ×2; *7,* side view that shows dense dermal layer is smooth but marked by growth lines, ×2; *8–9,* figured specimen, USNM 480251, Section J, bed 17; *8,* side view of club-shaped specimen shows the dermal layer of the sponge is coarsely annulate and has prominent growth lines, ×2; *9,* summit view with outlines of inhalant canals that show a radial pattern, ×2; *10–11,* figured specimen, USNM 480253, Section J, bed 17; *Pseudohimatella pauciporata(?)* (Parona, 1933); *10,* top view shows inhalant pores are regularly arranged around the osculum; radial furrows converge to the single osculum, ×2; *11,* side view shows that growth lines and some longitudinal tubes are visible on the steeply obconical sponge, particularly in the upper part, ×2.

Plate 39

1–2, 7. Parahimatella vesiculata new species; *1–2,* holotype, USNM 480261, Spot Locality 157-1976; *1,* side and bottom view of sheetlike and irregularly depressed sponge has a smooth dermal layer, marked only by well-developed growth lines, ×1; *2,* summit shows numerous circular oscula, 1 mm deep, distributed irregularly over the entire summit; the coarse, fibrous skeletal structure and small inhalant pores are evident between oscula, ×1; *7,* paratype, USNM 480257, Section G, bed 4; summit in which exhalant pores are partly covered by algae, but they are well preserved in the lower part; side view is shown on Plate 40.1, ×2.——*3–6. Pseudohimatella pauciporata* (Parona, 1933), figured specimens; *3–4,* USNM 480259, Spot Locality DJT-13; *3,* basal view of figured specimen which is mushroom-shaped and shows growth lines and minor annulations; dermal layer pierced by numerous circular inhalant ostia, ×7; *4,* summit view with numerous oscula 1 mm deep in coarsely fibrous skeleton, ×1.25; *5,* figured specimen, USNM 480254, Section J, bed 17; summit view of mushroomlike specimen shows the large axial osculum 1 mm deep in the sponge interior; numerous inhalant pores are well preserved around the osculum, ×2; *6,* figured specimen, USNM 480256, Senowbari-Daryan Collection; summit of a mushroom-shaped specimen shows an osculum in the central part and another new one on the lower periphery; circular, oval, and irregular inhalant pores are well preserved, ×2.

PLATE 40

1, 4–5. Parahimatella vesiculata new species; *1,* paratype, USNM 480257, Section G, bed 4; side view of specimen shown in Plate 39.7; distinct outer annulation, ×2; *4, 5,* paratype, USNM 480258, Spot Locality DJT-24; *4,* side view of specimen with well-developed growth lines but with opposite side and edges encrusted by algae, ×1; *5,* summit of specimen; somewhat rimmed and with prominent oscula in coarse fibrous skeleton, ×1.——*2–3. Pseudohimatella pauciporata* (Parona, 1933), USNM 480260, Section J, bed 17; *2,* view of the summit shows several oscula, coarse skeletal fibers, and inhalant pores, ×2; *3,* side view of the mushroom-shaped sponge principally shows annulations and well-developed growth lines, ×2.

PLATE 41

1–9. Exotubispongia pustulata new species; *1–4,* paratype, USNM 480233, Spot Locality DJT-11, SEM photomicrographs; magnifications indicated by scale bars on figures; *1,* skeletal surface; walls of peripheral vertical tubes are pierced by numerous pores; *2,* enlargement of part of the upper center of Plate 41.1 shows ridgelike outer walls of two tubes of inhalant pores; *3,* lower part of the same specimen with slightly flared base, with bent tubes extending to near the base; *4,* enlargement of center of Plate 41.2 shows slightly elevated rim of one of the outer pores; *5, 7,* paratype, USNM 480234, Spot Locality 204-1976; *5,* side view of a cylindrical sponge shows pustular elevations with small pores arranged in straight vertical lines, ×5; *7,* summit view in which vertical tubes are exposed near the periphery of the sponge, ×5; *6,* paratype, USNM 480235, Spot Locality DJT-11; side view of cylindrical specimen similar to that in Plate 41.5, ×5; *8–9,* paratype, USNM 480236, Section G, bed 5; *8,* summit of specimen shows the reticular, internal, fibrous skeletal structure, ×5; *9,* side view shows well-preserved pustular elevations with pores, ×5.

PLATE 42

1–7. Heliospongia finksi Termier and Termier, 1977a; *1,* figured specimen, USNM 480292, Spot Locality T2; side view shows basal part that lacks inhalant pores but shows growth lines; inhalant pores are arranged in longitudinal lines in the upper part, especially on the right side, ×2; *2,* figured specimen, USNM 480293, Spot Locality 14A; side view of two upper branches that show weak annulation, ×1; *3–4,* figured specimen, USNM 480294, Spot Locality 144-1976; *3,* side view shows distinct inhalant ostia located in crude longitudinal lines, ×2; *4,* summit shows a prominent narrow spongocoel in one branch; similar central openings present but obscure in other branches, ×2; *5–6,* figured specimen, USNM 480295, Section E, bed 27; *5,* side view shows the weak annulation of the exterior and obscure inhalant ostia, ×2; *6,* summit shows deep central spongocoel, ×2; *7,* figured specimen, USNM 480296, Sch 32, Senowbari-Daryan collection; well-preserved inhalant ostia located in longitudinal lines (SCAN, sample 20), ×1.——*8. Prestellispongia scapulata* new species, paratype, USNM 480309, Section E, shale above Reef 3; summit of specimen whose side view is shown in Plate 14.7; individual openings of oscula and inhalant pores between the oscula, ×2.

PLATE 43

1, Hexactinellid sponge, figured specimen, USNM 480312, Spot Locality S1; platelike fragment shows probable original margin on lowermost part where openings are more consistently elongate; rounded parietal gaps are separated by porous tracts composed of thatch of spicules, ×1.——*2–3, 5. Prestellispongia paula* new species; *2–3,* holotype, USNM 463637, Spot Locality DJT-32; *2,* summit showing numerous fine clusters of exhalant canals in irregular, broadly obconical form, ×1; *3,* oscular side view showing rapid upward expansion of the sponge with coarse growth lines in the dense dermal layer on the lower surface, ×1; *5,* paratype, USNM 463638, Spot Locality 144-1976; bottom of specimen shown in Plate 8.4; irregular, mushroomlike growth of the sponge, ×2.——*4. Prestellispongia lobata* (Parona, 1933), figured specimen, USNM 480370, Spot Locality DJT-21; bottom of specimen pictured in Plate 8.1; shows growth of the *Prestellispongia* (*p*) over several other sponges (*s1–s3*), ×1.——*6. Precorynella ampliata* new species, holotype, USNM 480303, Section G, bed 5; reverse side of specimen shown in Plate 6.6; with attached *Sollasia* (*s*) and encrusting algae, ×1.

PLATE 44

Photomicrographs of exteriors of fossils from the Djebel Tebega region of Tunisia.——*1–2. Auriculospongia auriculata* (Termier and Termier, 1955), figured specimens; *1,* USNM 463573, Section E, bed 27; relatively finely textured, moderately smooth, inhalant side of the specimen with relatively small inhalant pores as dark matrix fill, ×10; *2,* USNM 463574, Section E, bed 27; prominent upwardly divergent tangential canals are separated by irregular nodes of fibrous skeleton in which skeletal pores are dark, subprismatic openings between light fibers; exhalant pores are large circular openings generally in the troughs of the surficial canals, ×10.——

3–4. Auriculospongia perforata new species; *3,* paratype, USNM 463583, Spot Locality 36-1976; exhalant surface shows moderately coarse skeletal tracts that are light gray, surrounding darker, matrix-filled exhalant depressions on the gastral surface; recrystallization has obscured the net within the skeletal tracts, ×10; *4,* paratype, USNM 463579, Section G, bed 5; inhalant surface with well-preserved dermal layer near the base, in which weakly rimmed inhalant ostia perforate the moderately fine layer; that dermal layer removed from the upper part, which shows tractlike internal skeleton generally recrystallized but with microreticulate net preserved in eroded surface of some tracts, particularly in the upper left; canals and skeletal pores are filled with dark matrix, ×10.——*5–6. Thallospongia reticulata* new species, holotype, USNM 480358, Spot Locality 4A; *5,* transverse section shows prominent, fine skeletal net and lack of prominent canals or spongocoel in uniform skeleton, ×10; *6,* exterior showing weakly indented subvertical surficial canals, with ridges between essentially lacking coarse ostia but perforated only by fine skeletal pores between uniform skeletal net, ×10.——*7. Cavusonella caverna* Rigby, Fan, and Zhang, 1989, figured specimen, USNM 463589, Spot Locality T5; exterior showing moderately uniform skeletal net in coarse tracts that separate coarse canals characteristic of the exterior and interior of the sponge, ×10.——*8–9. Radiotrabeculopora* cf. *R. xiangboensis* Fan, Rigby, and Zhang, 1991, figured specimens; *8,* USNM 463619, Section E, shale above Reef 3; moderately large exhalant tube shows in the upper left, surrounded by intermediate-sized inhalant canals and less regularly rounded, small, skeletal pores between tracts of skeleton, ×10; *9,* USNM 463616, Section E, bed 26-27; weathered exterior shows largest openings as inhalant pores to canals and smallest openings as skeletal pores between moderately regular skeletal fibers, ×10.

PLATE 45

Photomicrographs of exteriors of naturally weathered surfaces of sponges from the Djebel Tebaga region of Tunisia.——*1. Radiotrabeculopora maokoui* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 463629, Spot Locality 27A; generalized exhalant area showing widely distributed, moderately coarse exhalant openings; intermediate-sized inhalant openings, and smaller inhalant openings bounded by skeletal tracts, which here show a relatively well-preserved, finely reticulate structure within the skeletal tracts, ×10.——*2. Radiotrabeculopora reticulata* Fan, Rigby, and Zhang, 1991, figured specimen, USNM 463622, Spot Locality S1; moderately large exhalant canal in the lower left, with intermediate-sized inhalant openings between tracts of the skeletal fibers, here in moderately regular reticulate net, characteristic of the species, ×10.——*3. Daharella ramosa* new species, paratype, USNM 480411, Section I, bed 26, two, coarsely rimmed, circular exhalant openings perforate relatively uniform skeletal net of fine fibers in uniform reticulation around inhalant openings and skeletal pores, ×10.——*4–5. Daharella micella* new species; *4,* paratype, USNM 463601, Spot Locality 27A; prominent, coarse, exhalant openings in characteristic fine skeletal net, here encrusted with worm tubes and nodular algae, ×10; *5,* holotype, USNM 463602, Spot Locality 203-1976; middle part of cylindrical specimen shows exauloslike exhalant openings in moderately fine dermal layer with fine inhalant openings; dermal layer weathered away in lower central part, which shows moderately coarse internal skeletal net; surface encrusted with nodular algae, ×10.——*6. Daharella palmata* new species, paratype, USNM 463609, Spot Locality 157-1976; two rimmed exhalant clusters elevated slightly above regular, uniform skeletal net with intermediate-sized, round, inhalant openings and somewhat finer skeletal pores in the net, ×10.——*7. Spinospongia radiata* new species, paratype, USNM 463613, Spot Locality DJT-5; prominent radial spines as light elevated areas in the moderately open skeletal net, perforated by round, inhalant openings, with skeletal fibers outlining polygonal skeletal pores over most of the surface, ×10.——*8. Prestellispongia paula* new species, holotype, USNM 463637, Spot Locality DJT-32; darker, matrix-filled canals converge toward exhalant clusters in the lower right and beyond the border in the upper left; circular inhalant openings mark ridges between the canals; light areas are of moderately coarse, skeletal net that outlines skeletal pores between ostia of canals, ×10.——*9. Prestellispongia permica* (Parona, 1933), figured specimen, USNM 463286, Spot Locality 160-1976; upper or gastral surface of saucerlike form with dark, matrix-filled, convergent canals as part of axial cluster and ostia to smaller vertical canals normal to the tangential series, probably as inhalant series; with finer, subprismatic skeletal pores defined by light fibers of uniform, reticulate skeleton, ×10.

PLATE 46

Photomicrographs of naturally weathered exteriors of several sponges from the Permian of Djebel Tebega, Tunisia.——*1. Prestellispongia bolaria* new species, paratype, USNM 480352, Section E, bed 27; moderately fine skeletal net interrupted in reticulate fashion by network of surficial, tangential, exhalant canals that locally mark the surface away from oscular clusters; coarser skeletal elements are tips of long fibers that meet the surface at high angles, ×10.——*2. Prestellispongia scapulata* new species, paratype, USNM 480308, Section E, shale below Reef 3; reticulate skeleton interrupted by moderately coarse exhalant openings in the upper right and by round, smaller, inhalant openings and prismatic, small skeletal pores defined by the light skeletal fibers over most the rest of the surface, ×10.——*3. Prestellispongia(?) fasciculata* new species, holotype, USNM 480302, Spot locality T5; moderately irregular, almost spinose-appearing skeletal net of fibers that are light gray, around inhalant ostia, as larger circular openings, and subprismatic skeletal pores within tracts between the canals, ×10.——*4. Estrellospongia grossa* new species, paratype, USNM 463644, Spot locality T6; moderately coarse fibers, characteristic of the species and genus, well exposed in grooves of surficial exhalant canals; ridges between marked by inhalant openings and irregular subpolygonal skeletal pores between coarse fibers, ×10.——*5. Stellispongiella bacilla* (Termier and Termier, 1955), figured specimen, USNM 480412, Spot Locality DJT-14; moderately coarse, reticulate skeletal net shows in both the tangential convergent exhalant canal grooves and ridges between on the mamelonlike nodes characteristic of the species; smaller inhalant openings occur on ridges between the grooves, ×10.——*6. Stellispongiella insculpta* new species, paratype, USNM 463270, Section E, shale below Reef 3; moderately fine clusters of tangential exhalant canals, appearing dark at bottom and top, as do finer inhalant ostia defined as circular dark openings in the light skeletal net, ×10.——*7. Stellispongiella reticulata* new species, holotype, USNM 463648, Section G, bed 4; irregular network of tangential surficial canals mark the surface; smaller inhalant ostia prominent on the nodes as well as locally within the exhalant groups; larger exhalant ostia generally occur in the groove traces; skeletal fibers light gray, forming moderately coarse, uniform net, ×10.——*8. Stellispongiella parva* new species, holotype, USNM 463653, Spot Locality T-8; surface marked by moderately widely spaced, small, convergent astrorhizal-like clusters of exhalant canals; area between of moderately uniform fine skeletal net interrupted by small inhalant openings of canals essentially normal to the upper surface, ×10.——*9. Stellispongiella porosa* new species, paratype, USNM 463661, Section E, shale below Reef 3; coarse, convergent, surficial exhalant canals of two clusters show partially in the upper left and lower right, with moderately coarse reticulate skeleton between marked by coarse pores of inhalant canal series, ×10.

Plate 47

Photomicrographs of naturally weathered exteriors of several sponge species from the Permian rocks of the Djebel Tebaga region of Tunisia.——*1. Stellispongiella tumida* new species, holotype, USNM 463662, West of Section I, in shale equivalent to bed 2; ridged or swollen traces of convergent exhalant canals of starlike cluster show in the upper part into which feed exhalant canals; area between marked by moderately coarse inhalant ostia in coarse skeletal net, ×10.——*2. Peronidella magna* new species, holotype, USNM 463663, Senowbari-Daryan collection; uniform, coarse, skeletal pores defined by relatively robust fibers, characteristic of almost rectangular skeletal structure lacking canals, characteristic of the species and genus, ×10.——*3. Peronidella multiosculata* new species, paratype, USNM 463668, Spot Locality CF-18; fine, uniform texture lacks major ostia, but with small skeletal pores defined by fine fibers of net that characterize the species, ×10.——*4. Peronidella digitata* new species, paratype, USNM 463669, Spot Locality T5; exterior with irregular, small- to moderate-sized skeletal pores defined by coarse, almost spinose-appearing fibers of skeletal net; diagenesis has affected the preservation locally, ×10.——*5. Peronidella rigbyi* Senowbari-Daryan, 1991, figured specimen, USNM 480375, Spot Locality 4A; small specimen characterized by prominent, moderately coarse fibrous net lacking ostia of major canals but with comparatively coarse skeletal pores, ×10.——*6. Radiofibra lineata* new species, holotype, USNM 463675, Section G, bed 4; coarse fibers of skeletal net around large openings that were probably exhalant and smaller openings that were probably inhalant, in the coarse, linear, fibrous structure, ×10.——*7. Radiofibra delicata* new species, paratype, USNM 463672, Section G, bed 4; moderately fine fibrous skeleton, with small circular or polygonal ostia or pores defined by somewhat recrystallized fine skeletal fibers, ×10.——*8. Radiofibra inordinata* new species, holotype, USNM 480356, Spot Locality S1; pronounced to discontinuous surficial exhalant canals in finer reticulate skeleton, ×10.——*9. Radiofibra nodosa* new species, holotype, USNM 480301, Section G, bed 5; coarsely porous skeleton shows on left and is blanketed by possible dermal layer on right, ×10.

Plate 48

Photomicrographs of naturally weathered surfaces of several sponge species in the Permian rocks of Djebel Tebaga.——*1. Permocorynella ovoidalis* (Parona, 1933), figured specimen, USNM 463686, Section J, bed 17; ostia of moderately coarse inhalant canals are circular, coarse, matrix-filled depressions that interrupt moderately fine skeletal net; surficial tangential canals in the lower center and upper right lead toward the summit and osculum, ×10.——*2. Permocorynella osculifera* new species, paratype, USNM 463632, Spot Locality 21A-23A; circular inhalant canals interrupt a more irregular fibrous skeletal net in which skeletal pores are relatively coarse, ×10.——*3. Permocorynella fruticosa* new species, holotype, USNM 480300, Spot Locality DJT-23; inhalant ostia interrupt relatively finely textured tracts in which subprismatic skeletal pores are defined by fine skeletal fibers, ×10.——*4. Precorynella ampliata* new species, holotype, USNM 480303, Section G, bed 5; moderately coarse exhalant openings occur individually or as loose clusters in fibrous skeletal net; somewhat finer inhalant canals and even smaller skeletal pores occur between the fibers, ×10.——*5. Djemelia nana* new species, holotype, USNM 463696, Spot Locality DJT-10; side view of small sponge with prominent ostia with elevated rims and with fine reticulate skeleton between, ×10.——*6. Radiotrabeculopora(?) patula* new species, holotype, USNM 480304, Spot Locality 13B; isolated, but common, coarse exhalant openings are irregularly scattered in the coarse prismatic, fibrous skeletal net, which contains smaller inhalant openings and coarse interfibrous skeletal pores, ×10.——*7. Permocorynella tuberosa* new species, holotype, USNM 480310, Spot Locality DJT-5; fine skeletal net of the exterior uninterrupted by major ostia, but with encrusting worm tubes toward the top, ×10.——*8. Saginospongia angusta* new species, holotype, USNM 463677, Section G, bed 5; moderately coarse ostia and canals defined by broad skeletal tracts of finely reticulate skeleton with fairly irregular coarse structure, ×10.——*9. Saginospongia porosa* new species, holotype, USNM 463679, Section G, bed 5; relatively massive skeletal tracts surround irregular coarse canals and ostia characteristic of the species; skeletal tracts with reticulate but moderately coarse skeleton, ×10.

Plate 49

Photomicrographs of the exteriors of sponges from the Djebel Tebaga region of Tunisia.——*1. Saginospongia crateria* new species, holotype, USNM 480372, Section G, bed 5; thick skeletal tracts of fine, uniform net define walls of deep, craterlike openings in the exterior that are characteristic of the species, ×10.——*2. Djemelia mediala* new species, holotype, USNM 463700, Spot Locality 13B; moderately small ostia of inhalant canals in the uniform exterior, ×10.——*3. Precorynella crysanthemum* (Parona, 1933), figured specimen, USNM 480380, Section G, bed 9; coarse openings are inhalant ostia of essentially horizontal canals; skeletal tracts between with subprismatic skeletal pores defined by coarse fibers of the skeletal net, ×10.——*4. Precorynella virgosa* new species, holotype, USNM 480392, Section G, bed 4; relatively finely textured skeletal net pierced by small ostia of inhalant canals; upper part of figure shows a cut surface made during preparation of the specimen, ×10.——*5. Precorynella diffusa* new species, holotype, USNM 480357, Section E, shale below Reef 3; upper margin of lateral slope shows relatively coarse skeletal fibers and skeletal pores, evident both in troughs of surficial tangential exhalant grooves and on ridges between the grooves; inhalant ostia relatively fine in the lower part, but somewhat coarser in the upper part of the slope; large opening near the top is an exhalant ostium on the tip of the sponge, ×10. ——*6. Ramostella stipulata* new species, paratype, USNM 480377, Section G, bed 4; upper part of lateral slope with irregular subvertical surficial grooves, in which the skeletal structure of coarse fibers shows moderately well, interrupted by circular coarse exhalant openings in troughs of the grooves; finer skeletal pores show both in grooves and on ridges between, ×10.——*7. Imperatoria voluta* new species, paratype, USNM 463712, Section C, bed 16; moderately fine irregular skeletal structure uninterrupted by ostia, but with fairly coarse prismatic to rounded, skeletal pores on the lower flank of one of the segmentlike parts of the sponge, ×10.——*8. Imperatoria(?) fistulata* new species, paratype, USNM 463722, Section I, bed 5; somewhat irregular surface marked only by rare, moderately coarse, inhalant ostia interrupting regular skeletal net exposed on uneven exterior, ×10.——*9. Heptatubispongia symmetrica* new species, holotype, USNM 463724, Section G, bed 5; moderately fine exterior in small sponge lacks ostia but with irregular, light-colored skeletal pores surrounded by darker fibers of the skeleton, ×10.

Plate 50

Photomicrographs of naturally weathered exteriors of several species of sponges collected from the Permian rocks of Djebel Tebaga.——*1–2. Intratubospongia osiensis* (de Gregorio, 1930), figured specimens; *1,* USNM 480242, Spot Locality S7; weakly annulate exterior with fine, uniform skeletal net unperforated by ostia of canals, ×10; *2,* USNM 480247, Spot Locality 204-1976; upper lateral surface somewhat weathered, showing prominent vertical tubular structures and coarse skeletal fibers and pores visible in troughs, as well as between the coarse exhalant openings in the somewhat finer inhalant openings in the skeletal structure, ×10.——*3. Intratubospongia obscura* new species, holotype, USNM 480305, Spot Locality DJT-27; side of specimen with moderately coarse inhalant ostia and a skeletal net with very coarse skeletal fibers, ×10.——*4. Medenina laterala* new species, paratype, USNM 463732, Section E, bed 29A; micronodose, dense exterior produced by rounded tips of outwardly divergent skeletal fibers, ×10.——*5. Preeudea minima* Termier and Termier, 1977a, figured specimen, USNM 463734, Section G, bed 4; rimmed, coarse, exhalant openings are moderately uniformly spread; microstructure of intervening skeleton largely recrystallized, ×10.——*6. Polytubifungia maxima* new species, paratype, USNM 480220, Section B, bed 1; upper slope shows prominent rimmed ostia and annulate growth form; lower part with prominent fibers of the skeleton exposed where dermal layer exposed by weathering, ×10.——*7. Polytubifungia minima* new species, holotype, USNM 480212, Section B, bed 1; smaller inhalant ostia perforate relatively dense dermal layer of the tiny sponge; ostia with lower rims, ×10.——*8. Microsphaerispongia polyarteria* new species, paratype, USNM 480228, Spot Locality T6; scattered coarse exhalant ostia are the large openings; smaller inhalant openings and numerous skeletal pores outlined by light, skeletal fibers of net are characteristic of species and genus, ×10.——*9. Pseudohimatella pauciporata* (Parona, 1933), figured specimen, USNM 480251, Section J, bed 17; micronodose, broad skeletal tracts characterize the regular skeletal net interrupted by deep, coarse ostia, ×10.

Plate 51

Photomicrographs of naturally weathered exteriors of several species of sponges except for Plate 51.7, which is a polished surface. ——*1–2. Pseudohimatella pauciporata* (Parona, 1933), figured specimens; *1,* USNM 480254, Section J, bed 17; microsculpture of dense dermal layer of lower exterior, possibly a result of growth influenced by tidal cycles; laminated surface uninterrupted by canals, but some skeletal fibers and pores show between some growth lines, ×10; *2,* USNM 480251, Section J, bed 17; upper surface shows prominent, inhalant ostia separated by micronodose skeletal fibers characteristic of the genus and species, ×10.——*3. Exotubispongia pustulata* new species, paratype, USNM 480235, Spot Locality DJT-11; side view of the small specimen shows tiny pustules aligned above canals, where the dermal layer has not been broken; those canals show in the interior of the sponge in the upper part where the dermal layer has been removed; small ostia occur in crests of the pustules, best exposed in the upper part, ×10.——*4. Exotubispongia virgulata* new species, holotype, USNM 480359, Spot Locality 4A; exterior of small branching sponge, with uniform inhalant ostia in fine skeletal net, but perforations irregular and not aligned, ×10.——*5–6. Heliospongia finksi* Termier and Termier, 1977a, figured specimens; *5,* USNM 480293, Spot Locality 14A; moderately weathered exterior shows moderately large inhalant ostia in coarse skeletal net; an object in the lower left was overgrown by the sponge, ×10; *6,* USNM 480298, Section J, bed 17; interior of the spongocoel wall, exposed by grinding polished surface of the smooth lateral margin; with exhalant ostia moderately aligned in the cylindrical spongocoel, both horizontally and vertically; much of the skeletal microstructure has been destroyed by diagenesis, ×10.——*7. Sphaeropontia regulara* new species, paratype, USNM 480230, Section E, bed 27; polished surface view into nearly transparent carbonate preservation showing spherical spherulites, cross connected by rays, and with skeletal structure interrupted by the vertical exhalant canals, ×10.——*8. Minispongia carinata* new species, paratype, USNM 463708, Section E, shale below Reef 3; small microannulate specimen with dense walls and with a broken transverse section showing irregular reticulation of the fine skeleton in the interior of the sponge, ×10.——*9. Parahimatella vesiculata* new species, holotype, USNM 480261, Spot Locality 157-1976; coarse bubblelike openings in the skeleton between the coarse exhalant canals are exposed on the weathered upper surface of the sponge, ×10.

Plate 52

Photomicrographs of polished surfaces of sponges from the Djebel Tebaga showing skeletal textures and interior structures in several species. Contrast is low because the polished surfaces generally show only intermediate shades of gray and locally photograph dark where the skeletal structure and matrix are preserved as translucent calcite. All photographs were taken with the surface wet by a thin film of glycerine diluted with water.——*1. Peronidella multiosculata* new species, paratype, USNM 480401, Spot Locality 21A; vertical medial section with reticulate skeleton best shown in the lower right and with multiple canals characteristic of the species in the upper center, ×10.——*2. Peronidella digitata* new species, paratype, USNM 463670, Spot Locality T5; transverse section showing in the center a moderately large, central spongocoel in part dark with limonite stains; skeletal pores and fibers radiate from the spongocoel uninterrupted by major canals, in a structure characteristic of the genus, ×10.——*3–4. Radiofibra delicata* new species, paratype, USNM 463674, Spot Locality DJT-8, *3,* subvertical, slightly diagonal section showing upwardly and outwardly divergent coarse canals separated by smaller dark fibers in an open, skeletal structure characteristic of the species, ×10; *4,* transverse section showing the irregular skeletal fibers and irregular interconnection of the generally upwardly and outwardly divergent canals of the species, ×10.——*5. Radiofibra nodosa* new species, holotype, USNM 480301, Section G, bed 5; longitudinal section near one of the node tips, showing relatively coarse, upwardly and outwardly divergent canals separated by moderately coarse skeletal fibers, here shown light gray, but with black limonite clusters scattered throughout. The large opening on the left may be a spongocoel that extends moderately deeply into the skeleton, ×10.——*6. Radiofibra inordinata* new species, holotype, USNM 480356, Spot Locality S1; longitudinal section of a node showing a deep but narrow spongocoel in the right center and vertically aligned, convergent exhalant canals in transverse section in the fibrous skeletal net, ×10.——*7. Permocorynella ovoidalis* (Parona, 1933), figured specimen, USNM 480379, Spot Locality DJT-21; vertical section shows moderately deep, open spongocoel in the upper right, toward which converge upwardly arched, inner ends of exhalant canals, with smaller inhalant canals oriented at right angles to the exhalant ones and seen best in the lower left, interrupting the moderately regular reticulate skeleton, ×10.——*8. Permocorynella osculifera* new species, paratype, USNM 463633, Spot Locality 204-1976; vertical section shows reticulate uniform skeleton and transverse sections of exhalant horizontal canals, particularly evident in the upper right, ×10.——*9–10. Permocorynella tuberosa* new species, holotype, USNM 480310, Spot Locality DJT-5; *9,* vertical section on a small node showing deep, central spongocoel with laterally convergent, horizontal exhalant canals that pierce the reticulate skeleton, ×10; *10,* vertical section shows vertical inhalant canals piercing the uniform skeletal net, in part preserved as impressions in the clear calcite matrix, ×10.——*11. Saginospongia porosa* new species, paratype, USNM 463678, Section G, bed 5; transverse section showing the irregular serpentine canals, characteristic of the sponge, separated by wide skeletal tracts of the fine net, ×10.——*12. Saginospongia crateria* new species, holotype, USNM 480372, Section G, bed 5; vertical section of low contrast showing wide canals with dark matrix fill separated by broad tracts of fine, reticulate skeleton, ×10.——*13. Djemelia mediala* new species, paratype, USNM 480402, Section G, bed 5; somewhat diagonal, longitudinal section showing central spongocoel in the upper part, toward which converge moderately small canals that pierce the very fine, reticulate skeleton shown in long sections in the central part but transversely in the somewhat tangential sections in the lower part, ×10.——*14. Precorynella virgosa* new species, holotype, USNM 480392, Section G, bed 4; with top to the left, through part of the axial cluster of exhalant canals in the lower left, and showing convergent exhalant canals in the lower and upper right, with transverse inhalant canals in the upper left, all in the moderately fine, reticulate skeleton, ×10.——*15. Precorynella diffusa* new species, holotype, USNM 480357, Section E, shale beneath Reef 3; vertical section shows moderately coarse, reticulate skeletal structure, with dominant subvertical elements cross connected by shorter, irregular, horizontal units and with skeleton pierced by upwardly convergent canals, shown best on the right, and somewhat interconnecting canals in the upper and left center, ×10.——*16. Precorynella robusta* new species, holotype, USNM 480393, Section G, bed 5; transverse section showing the coarse, exhalant canals of the axial cluster in the upper left and smaller inhalant canals as walled openings piercing the moderately coarse skeletal net in the lower right, ×10.

Plate 53

Photomicrographs of polished surfaces of sponges from the Djebel Tebaga showing skeletal textures and interior structures in several species. Contrast is low because the polished surfaces generally show only intermediate shades of gray, and locally photograph dark where the skeletal structure and matrix are preserved as translucent calcite. All photographs were taken with the surface wet by a thin film of glycerine diluted with water.——*1. Imperatoria voluta* new species, paratype, USNM 480403, Spot Locality T9; vertical section showing relatively coarse skeletal structure, with lack of a continuous central spongocoel, although central, vertical canals are evident in the upper part, ×10.——*2. Imperatoria(?) fistulata* new species, paratype, USNM 480404, Section E, shale beneath Reef 3; vertical section of part of the deeply annulate margin shown on right, with prominent, irregular reticulate skeletal structure interrupted by upwardly arcuate to horizontal canals, ×10.——*3. Heptatubispongia(?)* cf. *H.symmetrica* new species, figured specimen, USNM 463727, Section I, bed 2; vertical section near the summit showing a prominent, more or less central spongocoel and obscure lateral canals in the gray surface with little contrast; reticulate skeleton only moderately well shown, ×10.——*4. Intratubospongia osiensis* (de Gregorio, 1930), figured specimen, USNM 480238, Section E, shale below Reef 3; general transverse section showing cross sections of numerous canals in the fine skeletal net, ×10.——*5. Intratubospongia obscura* new species, holotype, USNM 480305, Spot Locality DJT-27; longitudinal section showing long, prominent tubes characteristic of the structure of the species, separated by moderately coarse skeletal fibers, ×10.——*6. Preeudea minima* Termier and Termier, 1977a, figured specimen, USNM 463736; longitudinal section shows vertically walled canals separated by somewhat irregular skeletal net, ×10.——*7–8. Polytubifungia maxima* new species, paratype, USNM 480217, Spot Locality 4A; *7,* longitudinal section showing numerous exhalant canals and moderately coarse skeletal net between; white spots in the upper part are highlights reflected from the curved, glycerine-wet surface, ×10; *8,* transverse section showing uniform spacing of numerous, coarse exhalant canals that cut moderately coarse skeleton, ×10.——*9. Polytubifungia minima* new species, paratype, USNM 480214, Spot Locality 14A; vertical section showing numerous, small, exhalant canals in fine skeleton, with part of saucerlike summit at the top, ×10.——*10. Pseudohimatella pauciporata* (Parona, 1933), figured specimen, USNM 480405, Spot Locality 21A-23; vertical section showing coarse, open canals separated by wide tracts of moderately coarse, reticulate skeleton, ×10.——*11. Exotubispongia virgulata* new species, holotype, USNM 480359, Spot Locality 4A; longitudinal section of the upper part of a small stem, showing prominent vertical canals in moderately coarse skeleton; reticulate fibrous skeleton lacks an axial spongocoel, ×10.——*12. Exotubispongia pustulata* new species, paratype, USNM 480406, Section G, bed 5; longitudinal section showing moderately coarse skeletal structure lacking a central spongocoel, ×10.——*13–14,* Hexactinellid sponge indeterminate, figured specimen, USNM 480312, Spot Locality S1, irregular hexactines (arrows) range from robust specimens, as in Plate 53.13 (×10), to moderately long-rayed spicules, as in Plate 53.14, ×10.——*15–16. Parahimatella vesiculata* new species, paratype, USNM 480361, Senowbari-Daryan collection; *15,* impression of rodlike structures (arrow) are embedded in the skeletal tracts made of rows of spherulites that show as light gray short bands particularly prominent in the upper part of the figure, ×10; *16,* rodlike structures (arrows) occur in dark gray skeletal tracts between coarse chamberlike canals that are filled with transparent carbonate, ×10.

Plate 54

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–2. Auriculospongia auriculata* (Termier and Termier, 1955), Sample 21, USNM 463577, Spot Locality 224-1976, SEM photomicrographs; *1,* the rigid skeleton is composed of spherulites, each 40 µm in diameter; *2,* enlargement of part of Plate 54.1 shows one of the spherulites about 40 µm in diameter.——*3–4. Auriculospongia perforata* new species, Sample 6, USNM 463585, Section E, shale below Reef 3, SCAN photomicrographs; *3,* the rigid skeleton shows skeletal fibers composed of densely packed spherulites; *4,* enlargement of part of Plate 54.3 shows several spherulites, each approximately 60 µm in diameter, a little larger than those in *Auriculospongia auriculata* Termier and Termier.——*5–6. Radiofibra lineata* new species, Sample 1, USNM 480350, Section G, bed 4, SEM photomicrographs; *5,* view of skeletal fibers that are made of large spherulites approximately 100 µm in diameter; *6,* enlargement of part of Plate 54.5 shows several spherulites with poor preservation.

Plate 55

1–4. SEM photomicrographs of the microstructure of the fibrous skeleton of *Cavusonella caverna* Rigby, Fan, and Zhang, 1989, Sample 1, USNM 480413, Spot Locality DJT-S-1; magnifications indicated by scale bars on figures; *1,* overview of the reticular skeletal fibers (dark) and the sparry calcite cement in the interfiber spaces; *2,* enlargement of Plate 55.1 shows skeletal fibers with recognizable spherulites up to 100 µm in diameter; *3,* enlargement of Plate 55.2 showing the spherulites, 60 µm in diameter, arranged beside each other; *4,* enlargement of Plate 55.3 shows one of the spherulites, 60 µm in diameter, adjacent to another of the same size.——*5–6.* SEM photomicrographs of *Radiofibra inordinata* new species, Sample 46B, USNM 480376, Spot Locality S1; *5,* view of a part of skeleton shows poorly preserved, aragonitic, spherulitic microstructure, with spherulites approximately 50 to 70 µm in diameter; *6,* view of two or possibly three recognizable aragonite spherulites, each about 70 µm in diameter.

Plate 56

1–5. SEM photomicrographs of the microstructure of *Radiotrabeculopora* cf. *R. xiangboensis* Fan, Rigby, and Zhang, 1991, Sample 2, USNM 463616, Section E, beds 26-27; magnifications indicated by scale bars on figures; *1,* overview of the skeleton with interfiber spaces filled with coarse, sparry calcite cement (dark areas); *2,* enlargement of Plate 56.1 shows the large spherulites, up to 120 µm in diameter, in detail; *3,* individual spherulites reach a diameter of 150 µm in this part of the skeleton; *4,* enlargement of Plate 56.3 shows a large spherulite and the radially arranged aragonite needles, in detail; *5,* enlargement of Plate 56.1 exhibits the individual spherulites, each about 130 µm in diameter, densely packed and side by side.

Plate 57

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–4. Spinospongia radiata* new species, Sample 11, USNM 463614, Section E, bed 27; *1,* photomicrograph shows a skeletal rod (outlined by dashed lines); *2,* enlargement of Plate 57.1 shows that the spines or rods are composed of densely packed spherulites; *3,* enlargement of Plate 57.2 shows spherulites are densely packed and approximately 30 µm in diameter; *4,* enlargement of one spherulite of Plate 57.3 shows detailed structure and arrangement of the aragonite needles that compose the spherulites.——*5–6. Heliospongia finksi* Termier and Termier, 1977a, Sample 20, USNM 480296; concentric ridgelike arrangement of monaxon spicules around a cement-filled inhalant pore (in the upper right corner of figure; see also Plate 66.5–66.8); *6,* view of an inhalant pore with concentrically arranged monaxon spicules.

PLATE 58

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–2. Prestellispongia lobata* (Parona, 1933), Sample 6, USNM 480423, Spot Locality 13B; *1,* view of rigid skeleton that has relatively large exhalant canals in reticulate fibrous structure and interspaces between fibers; *2,* enlargement of Plate 58.1 shows the poorly preserved, fibrous structure in which only hemispherical structures with aragonitic needles are visible.——*3–4. Prestellispongia bolaria* new species, Sample 43, USNM 480352, Section E, bed 27; spherical aggregates of small pyrite crystals replaced some of the coarse sparry calcite cement between fibrous skeleton. Such spherical aggregates were also observed in skeletons of other sponges; *4,* enlargement of Plate 58.3 exhibits the individual, idiomorphic pyrite crystals densely packed one beside the other.——*5–6.* SEM photomicrographs of the microstructure of *Peronidella magna* new species, Sample 15, USNM 480422, Section J, bed 17; *5,* partially recrystallized skeleton exhibits large spherulites up to 100 µm in diameter, densely packed beside one another; *6,* enlargement of Plate 58.5 shows one spherulite with recognizable aragonite needles.

PLATE 59

SEM photomicrographs of microstructure; magnifications indicated by scale bars on figures.——*1–2. Stellispongiella bacilla* (Termier and Termier, 1955); *1,* Sample 11B, USNM 480417, Section I, bed 7; the aragonitic spherulites, 40 to 70 µm in diameter, are arranged beside each other; *2,* enlargement of Plate 59.1 shows the spherulites and the radially arranged aragonitic needles in detail.——*3–5.* Microstructure of *Polytubifungia maxima* new species, paratype, Sample 28, USNM 480416, Section B, bed 1; *3,* overview of numerous tubes cut in cross section showing recrystallized tube walls and irregularly arranged fibers between them; inorganic cement characterized by large crystals; *4,* enlargement of Plate 59.3 shows the recrystallized tube walls, as well as the fibers between them; *5,* interfiber spaces of sponges are sometimes sites of preservation of small fossils. Illustrated here is a miliolid foraminifer dissolved out by treatment of the sponge skeleton with Titriplex-III. The chamber interior is marked by inorganic cement of large crystals; the wall of the foraminifer is characterized by very small micritic crystals.

PLATE 60

SEM photomicrographs of microstructure of the fibrous skeletons; magnifications indicated by scale bars on figures.——*1–2. Stellispongiella tumida* new species, Sample 14, USNM 463662, Section I, equivalent to bed 2 west of traverse; *1,* overview exhibiting the relatively well-preserved spherulites, 60 µm in diameter, packed beside each other; *2,* enlargement of Plate 60.1 shows two spherulites with clearly recognizable aragonite needles.——*3–4.* Microstructure of the skeleton of *Stellispongiella parva* new species, Sample 12, USNM 463653, Spot Locality T8; *3,* the relatively well-preserved spherulites are approximately 30 µm in diameter and packed one beside the other; *4,* view similar to Plate 60.3 shows spherulites of 30 µm in diameter.

PLATE 61

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1.* Microstructure of *Radiofibra nodosa* new species, Sample 47, USNM 480301, Section G, bed 5; poorly preserved spherulites, most of which are approximately 50 µm in diameter.——*2.* Microstructure of *Estrellospongia grossa* new species, Sample 10B, USNM 463639, Spot Locality DJT-27; poorly preserved spherulites, up to 30 µm in diameter, are still recognizable.——*3.* Microstructure of *Ramostella stipulata(?)* new species, Sample 32, USNM 480418, Spot Locality 299-1976; relatively well-preserved argonitic spherulites arranged one beside the others.——*4–6.* Microstructure of *Peronidella multiosculata* new species, Sample 16, USNM 463671, Spot Locality T5; *4,* overview of the fibrous skeleton of *Peronidella multiosculata* new species shows the excellent preservation of aragonitic spherulites, which have a hollow internal part. Idiomorphic crystals of quartz were precipitated in the interiors of some spherulites (Sample 16); *5,* enlargement of Plate 61.4 exhibiting one well-preserved spherulite approximately 70 µm in diameter with an idiomorphic quartz crystal precipitated in the hollow central part of a spherulite; *6,* enlargement of Plate 61.4 shows two well-preserved spherulites with clearly recognizable aragonite needles and hollow central areas.

PLATE 62

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–3.* Microstructure of *Radiofibra delicata* new species, holotype, Sample 17, USNM 463671, Section J, bed 25; *1,* overview of the reticular fibrous skeleton, dark gray in the figure; *2,* enlargement of Plate 62.1 shows the relatively large spherulites arranged side by side; *3,* enlargement of Plate 62.2 shows detail of individual spherulites approximately 60 µm in diameter.——*4–5.* Microstructure of *Radiofibra inordinata* new species, Sample 46B, USNM 480376, Spot Locality DJT-S-1; *4,* view of the densely packed, fibrous structure and interfiber spaces (dark); *5,* enlargement of Plate 62.4 shows the small spherulites approximately 60 µm in diameter, composed of aragonitic needles.

PLATE 63

SEM photomicrographs of the microstructure; magnifications indicated by scale bars on figures.——*1–5. Radiotrabeculopora(?) patula* new species. All figures from specimens from Sample 42, USNM 480374, Section E, bed 27; *1,* overview of the reticular skeletal fibers and coarse sparry calcite cement between them; *2,* enlargement of Plate 63.1 shows the microstructure of the skeletal fibers composed of different sizes of aragonitic spherulites 60 to 120 µm in diameter, arranged beside each other; *3,* enlargement of Plate 63.2 shows two relatively well-preserved spherulites about 110 µm in diameter; *4,* the skeletal fibers show spherulites surrounded by several (here three) thin layers of organically precipitated carbonate (possibly a secondary skeleton). Such layers were observed only in this species; *5,* enlargement of Plate 63.4 shows the relatively small spherulites, approximately 60 µm in diameter, with the surrounding organically precipitated layers of carbonate.

PLATE 64

SEM photomicrographs of the microstructure; magnifications indicated by scale bars on figures.——*1–5. Precorynella crysanthemum* (Parona, 1933), Section G, bed 5; *1–2,* Sample 33, USNM 480415; *1,* view of the poorly preserved skeleton showing spherulites 50 to 70 µm in diameter; *2,* view like that of Plate 64.1 showing spherulites that are partly dissolved and destroyed; *3–5,* Sample 56, USNM 480381; *3,* view of skeletal fibers with poorly preserved spherulites, each about 60 µm in diameter; *4,* moderately preserved spherulites with oval sections in skeletal fiber, spherulites with long axis of approximately 60 µm; *5,* enlargement of Plate 64.4 shows two of the better preserved spherulites in more detail.

PLATE 65

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–2.* Microstructure of *Intratubospongia obscura* new species, Sample 54, USNM 480305, Spot Locality DJT-27; *1,* overview of the fibrous skeleton and interfiber areas, the latter of coarse sparry calcite cement (dark areas); *2,* enlargement of Plate 65.1 shows the microstructure composed of spherulites approximately 60 µm in diameter, packed one beside the other.——*3.* SEM photomicrographs of the microstructure of *Permocorynella fruticosa* new species, Sample 49, USNM 480300, Spot Locality DJT-5; only moderately preserved spherulites, each about 30 µm in diameter.——*4–5.* Microstructure of *Precorynella diffusa* new species, holotype, Sample 51, USNM 480357, Section E, shale below Reef 3; *4,* overview showing dark gray canals and lighter gray reticular fibrous structure between the canals; *5,* enlargement of skeletal fibers and part of upper end of elliptical canal in upper right of Plate 65.4 shows the poorly preserved, possibly spherulitic microstructure in the skeletal fibers.

PLATE 66

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–4. Intratubospongia osiensis* (de Gregorio, 1930), figured specimen, Sample 33, USNM 480346, Section E, bed 27; *1,* fibrous skeletal structure, composed of densely packed spherulites, with darker gray calcite cement between fibers; *2,* enlargement (middle section of Plate 66.1) shows a few spherulites, each approximately 30 µm in diameter, and the calcite cement (upper part) precipitated between the fibrous structure; *3,* enlargement of one spherulite shown in Plate 66.2 shows details and aragonite needles; *4,* other spherulites within the skeleton of the same specimen.——*5–8. Heliospongia finksi* Termier and Termier, 1977a, figured specimen, Sample 20, USNM 480296, Sch 32, Senowbari-Daryan collection; *5,* parts of the spicular skeleton with exhalant pores between, filled by calcite cement; *6,* enlargement of the middle part of Plate 66.5 shows individual monaxon spicules, arranged almost parallel to one another; *7,* view of two inhalant pores surrounded by concentrically arranged monaxons each approximately 50 µm long; *8,* enlargement shows round, inhalant pores in the central part of Plate 66.7 and the curved monaxon spicules around the pore filled by calcite cement.

PLATE 67

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–6,* microstructure of the skeletal fibers of *Pseudohimatella pauciporata* (Parona, 1933), Sample 30C, USNM 480258, Spot Locality DJT-24; *1,* overview of the fibers shows the spherulitic microstructure of the skeleton, partially replaced by idiomorphic crystals of quartz. Some crystals or crystal aggregates were also precipitated in the interfiber space; *2,* view of a well-preserved spherulite, 70 µm in diameter, with an idiomorphic quartz crystal precipitated in the axial area of the spherulite; *3,* enlargement of Plate 67.1 showing the well-preserved spherulites, about 80 µm in diameter, and the interfiber spaces with crystal aggregates; *4–6,* spherulites that are partly replaced by idiomorphic crystals of quartz.

PLATE 68

SEM photomicrographs of skeletal fibers; magnifications indicated by scale bars on figures.——*1–8. Sphaeropontia regulara* new species, Sample 28, paratype, USNM 480230, Section E, bed 27; *1,* view of the skeleton shows large spherulites, some up to 250 µm in diameter, spatially arranged and connected to neighboring spherulites by beamlike elements; *2,* enlargement of the central part of Plate 68.1 shows the large spherulites, the structures that connect them to adjacent spherulites, and the aragonite needles; *3,* enlargement of Plate 68.2 shows one spherulite approximately 200 µm in diameter and its connection to an adjacent one; *4–5,* several spherulites and their interconnecting, beamlike elements; *6,* large spherulites, 150 µm in diameter, and beamlike elements with junction lines that show beams are formed by extension of aragonite needles from both spherulites; *7,* enlargement of Plate 68.4 shows connection of neighboring spherulites by beamlike elements; *8,* view of the skeleton shows both spatial and linear arrangements of the spherulites.

PLATE 69

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–5.* Microstructure of *Parahimatella vesiculata* new species, Sample 55, paratype, USNM 480261, Spot Locality 157-1976; *1,* overview of the rigid skeleton exhibits small, cystlike elements up to 1 mm in diameter; *2,* walls of cystlike elements are 50 to 100 µm thick and are composed of large, locally elliptical spherulites, approximately 80 µm in diameter; *3,* enlargement of Plate 69.2 shows a spherulite 90 by 120 µm in size; *4,* enlargement of Plate 69.2 exhibits densely packed spherulites; *5,* enlargement of Plate 70.4 shows an aragonitic crystal in the center of a spherulite.

Plate 70

SEM photomicrographs; magnifications indicated by scale bars on figures.——*1–5.* microstructure of *Parahimatella vesiculata* new species, Sample 55, USNM 480261, Spot Locality 157-1976; *1,* overview of the rigid skeleton showing a large exhalant canal and coarse skeletal fibers, surrounded by light lines produced by large calcite crystals, at boundaries between the matrix and skeleton; *2,* enlargement of Plate 70.1 shows the large exhalant canal bounded by skeletal fibers composed of spherulitic microstructure. Boundaries between the sponge and sediment are marked by large crystals, appearing as light lines. The nuclei of some spherulites are replaced by large crystals of aragonite (see Plate 70.4); *3,* enlargement of Plate 70.2 shows the large spherulites, 80 to 100 µm in diameter; *4,* the boundary between the sponge skeleton and the interfiber spaces is marked in the center by large dolomite crystals that grew into the sponge skeleton. Some spherulites also show idiomorphic crystals in the right-central part (see Plate 69.5); *5,* some large spherulites, 60 to 80 µm in diameter, exhibit the replacement process represented by small crystals in centers of the spherulites.

Plate 71

Photomicrographs of sponges in plain light.——*1–2. Auriculospongia auriculata* (Termier and Termier, 1955); *1,* thin section 69, UNSM 463576, Section E, shale below Reef 3; longitudinal section shows skeletal fibers are oriented parallel to the direction of growth; spaces between the fibers appear as small tubes, ×1.5; *2,* thin section 70, USNM 463577, Section E, shale below Reef 3; transverse section, normal to growth direction and to Plate 71.1; skeletal fibers arranged irregularly but with a dominantly vertical appearance, ×3.5.——*3–4. Auriculospongia perforata* new species; *3,* thin section 79, USNM 463586, Spot Locality 4; cross section, transverse to growth direction and normal to Plate 71.4; skeletal fibers arranged irregularly and with a reticular appearance, ×3.5; *4,* thin section 80, USNM 463587, Spot Locality 4; longitudinal section normal to Plate 71.3 shows skeletal fibers arranged parallel to the growth direction; spaces between them appear as small tubes, ×3.5.——*5–6. Spinospongia radiata* new species, thin section 58, USNM 463615, Section J, bed 17; *5,* enlargement of part of section shows spinelike elements (*S*), that diverge upward and outward within the sponge; exterior depressions between spines appear as small pores; these spaces between the spines are filled internally with bubblelike, fibrous skeletal tracts, ×7; *6,* longitudinal section shows differences in appearance of matrix between the fibers in the central part (calcite) and peripheral parts (iron carbonate); arrow indicates area where upwardly diverging, spinelike elements are recognizable, ×1.5.

Plate 72

Photomicrographs of sponges in plain light.——*1–2. Daharella ramosa* new species; *1,* thin section 78, USNM 463596, Section J, bed 14; longitudinal section exhibiting the reticular fibrous skeletal structure and the large exhalant tubes that end in ostia on the exterior of the sponge, ×3.5; *2,* thin section 76, USNM 463594, Section J, bed 14; longitudinal section shows the arrangement of fibers and the tubes between them, ending at the exterior of the sponge, ×3.5.——*3–5. Radiotrabeculopora reticulata* Fan, Rigby, and Zhang, 1991; *3,* thin section 62, USNM 463622, Spot Locality S1; longitudinal section shows the internal structure of the same specimen shown in outer view in Plate 5.3; the interior of the sponge is recrystallized, but some tubes are still recognizable, ×2; *4,* thin section E29e, USNM 463623, Section E, bed 29e; longitudinal to oblique section shows some large tubes and concentrically arranged fiber structures, ×2; *5,* thin section 67, USNM 463622, Section E, shale below Reef 3; cross section of the same specimen illustrated in Plate 72.3 (compare Plate 5.2–5.3); the axial part of the sponge is strongly recrystallized, but the tubes are still recognizable in the peripheral part of the sponge, ×3.5.

Plate 73

Photomicrographs of sponges in plain light.——*1, 3–6. Daharella ramosa* new species, all from the equivalent of Section I, bed 2, west of traverse; *1,* thin section 91, USNM 463597, Section I, shale of bed 2, west of pass; longitudinal section through a branched specimen (the right branch is broken) shows the reticular fibrous skeletal structure and canals (see arrows) that extend from inhalant ostia into the sponge interior, ×2; *3–4,* thin section 92, USNM 463598, Section I, shale of bed 2, west of pass; *3,* longitudinal section shows the fibrous structure essentially parallel to axis of sponge, ×3.5; *4,* enlargement shows the arrangement of the fibrous structures within interior of sponge, ×7; *5,* thin section 94, USNM 463600, Section I, shale of bed 2, west of pass; longitudinal section shows fibrous structure and upwardly divergent tubes; arrow points to ostium (exhalant opening) of convergent exhalant canals, ×3.5; *6,* thin section 77, USNM 463595, Section J, bed 14; longitudinal section shows upwardly divergent and horizontally arranged canals; arrows point to ostia of exhalant canals, ×3.5.——*2. Daharella palmata* new species, thin section, 93, USNM 463599, Spot Locality 157-1976; longitudinal section through specimen exhibiting upwardly diverging canals and the reticular fibrous skeletal structure, ×3.5.

Plate 74

Photomicrographs of sponges in plain light.——*1, 6. Polytubifungia maxima* new species; *1,* paratype, thin section 72, USNM 480331, Spot Locality 27A; longitudinal section exhibiting bowl-like depression in top of sponge and large tubes that extend into sponge parallel to axis of sponge; spaces between tubes are filled with reticulate skeletal fibers; openings in tubes are connected to spaces between fibers by interfiber pores, ×7; *6,* thin section, USNM 480332, Spot Locality 27A; cross section of a poorly preserved specimen showing the vertical tubes as circular openings, ×3.5.——*2–5. Permocorynella ovoidalis* (Parona, 1933), figured specimens; *2,* thin section 28, USNM 480333, Section E, shale above Reef 3; longitudinal section of a flat specimen showing initiation of the spongocoel; the vertical tubes end in the spongocoel; horizontal inhalant and exhalant canals are also well shown; spaces between tubes are filled with fine reticular skeletal fibers, ×3; *3,* thin section 29, USNM 480334, Section E, shale above Reef 3; transverse cross section of half of the specimen whose longitudinal section is illustrated in Plate 74.2; because it is from the base of sponge, a spongocoel is not developed; however, the circular outlines of numerous upwardly diverging exhalant canals are evident, ×3; *4,* thin section 25, USNM 480335, Spot Locality DJT-31; longitudinal section through basal part of sponge shows numerous vertical exhalant canals; horizontal inhalant canals are also visible, ×3.5; *5,* thin section 24, USNM 480336, Spot Locality DJT-31; cross section of half of specimen in Plate 74.4; the section is cut where the axial canals start (crescentlike section in the middle part of the right side); horizontal inhalant and exhalant tubes are well illustrated, ×3.5.

Plate 75

Photomicrographs of sponges in plain light.——*1–3. Saginospongia porosa* new species, thin section BA, USNM 463679, Section G, bed 5; *1,* longitudinal section through the holotype shows relatively wide spongocoel and coarse skeletal fibers, as well as coarse interfiber spaces in wall of sponge; fibrous structure around spongocoel is much finer than elsewhere in wall; primary aragonitic skeleton was replaced by needlelike crystals, which seem to be gypsum, ×2; *2,* enlargement of Plate 75.1 shows fine fibers around spongocoel and small white crystals, apparently gypsum, ×7; *3,* enlargement of Plate 75.1 shows skeletal tracts as light gray and canals filled by dark gray matrix, and fine fibers around the spongocoel, ×7.——*4–5. Djemelia amplia* new species; *4,* paratype, thin section 68, USNM 480328, Section E, shale below Reef 3; longitudinal section through a specimen, whose transverse section is illustrated in Plate 75.5; interior of poorly preserved sponge, but with a spongocoel that contains some ostracode shells and detrital grains (*1*); they produce a geopetal structure (*2*), indicating that the skeleton shown in the left side of the picture was up; only this originally upper side was overgrown, first by some light-appearing organism (algae) and later by *Archaeolithoporella* crusts (*3*); because of overgrowth by algae or *Archaeolithoporella,* the outer surface of the sponge appears nodular, corresponding to the large exaulos-bearing ostia, ×3.7; *5,* paratype, thin section 67, USNM 480329, Section E, shale below Reef 3; transverse cross section shows the poorly preserved sponge with only loose internal skeletal fibers and the spongocoel in the center, ×7.——*6. Djemelia amplia(?)* new species, thin section 83, USNM 480330, Section E, bed 29e; longitudinal section through a poorly preserved specimen shows spongocoel, spongocoel wall (outlined by double lines on both sides), and skeletal fibers in sponge wall; interior of spongocoel filled with secondary filling structure corresponding to skeletal fibers within sponge wall. An ostium is cut on the outer surface (upper center), ×3.3.

Plate 76

Photomicrographs of sponges in plain light. *1–2.*——*Precorynella crysanthemum(?)* (Parona, 1933); *1,* thin section 30, USNM 480342, Section G, bed 5; longitudinal section of a specimen whose cross section is illustrated in Plate 76.2; sponge with numerous vertical exhalant canals; many more canals occur in center than in areas near periphery of sponge; numerous inhalant canals and pores also well developed, ×3.5; *2,* thin section 31, USNM 480343, Section G, bed 5; transverse cross section of the same species in Plate 76.1; exhalant as well as inhalant canals are well shown, ×3.5.——*3. Intratubospongia osiensis* (de Gregorio, 1930), thin section 38, USNM 480346, Section I, bed 2, equivalent west of traverse and house; longitudinal section exhibits the upwardly divergent and relatively large canals and fine skeletal fibers between them, ×2.——*4–5. Precorynella crysanthemum* (Parona, 1933); *4,* thin section 33, USNM 480344, Section I, bed 12; longitudinal section shows deep osculum, in left center, and exhalant canals that terminate in the osculum, as well as those that occur in wall of sponge, ×3.5; *5,* thin section 32, USNM 480345, Section I, bed 12; cross section of the specimen in Plate 76.4; cut near the base where the exhalant canals end, ×7.

Plate 77

Photomicrographs of sponges in plain light.——*1–5. Intratubospongia osiensis* (de Gregorio, 1930), figured specimens; *1,* thin section 50, USNM 480316, Spot Locality 22; longitudinal section with upwardly divergent tubes concentrated in axial part; spaces between the tubes are filled with reticular to bubblelike structures, ×2; *2,* thin section 51, USNM 480317, Spot Locality 22; transverse section of specimen illustrated in Plate 77.1, ×3.5; *3,* thin section 41, USNM 480318, Spot Locality 21, longitudinal section shows numerous upwardly divergent canals most common in the axial area, ×2.3; *4,* thin section 44, USNM 480319, Spot Locality 21; transverse section of specimen whose longitudinal section is shown in Plate 77.3; circular outlines of canals show well, ×3.5; *5,* thin section T-2/3/1, USNM 480320, Senowbari-Daryan collection; longitudinal section shows the annulation (growth stages) and internal structure; the canals branch dichotomously toward the periphery of the sponge, top to left, ×2.——*6. Radiotrabeculopora(?) patula* new species, thin section 20, USNM 480374, Section E, bed 27; transverse section showing skeletal fibers and pores and exhalant canals, ×5.——*7. Daharella ramosa* new species, thin section 76, USNM 463594, Section J, bed 14; longitudinal section showing upwardly divergent skeletal and canal structure; upwardly divergent fibers are cross connected by shorter fibers, ×3.5.

Plate 78

Photomicrographs of sponges in plain light.——*1–2. Prestellispongia permica* (Parona, 1933); *1,* thin section 1, USNM 480421, Spot Locality DJT-15; transverse section showing small convergent clusters of exhalant canals in reticulate fibrous skeletal net, ×5; *2,* thin section 23, USNM 480424, Section E, bed 27; longitudinal section showing an exhalant canal cluster and upwardly convergent canals cutting the regular skeletal net, ×5.——*3–6. Medenina laterala* new species, all thin sections and figures are from the same specimen from Section J, bed 25; *3, 6,* thin section 46, USNM 480314, Section J, bed 25; *3,* longitudinal section shows parallel vertical canals and horizontally oriented walls which are pierced with small pores; arrow shows position of area shown in Plate 78.6, ×2; *6,* enlargement of Plate 78.3, but reversed left to right; vertical canals with horizontal walls between canals; both horizontal walls and walls of canals pierced by numerous pores, ×10; *4,* thin section 45, USNM 480313, Section J, bed 25; longitudinal section of opposite side of cut from section illustrated in Plate 78.3; shows the same skeletal and canal characteristics, ×2; *5,* thin section 47, USNM 480315, Section J, bed 25; transverse section shows vertical canals in cross section; many more canals occur in the axial area than in the peripheral part; many canals have partly common walls but some are isolated with their own walls, ×3.5.

Plate 79

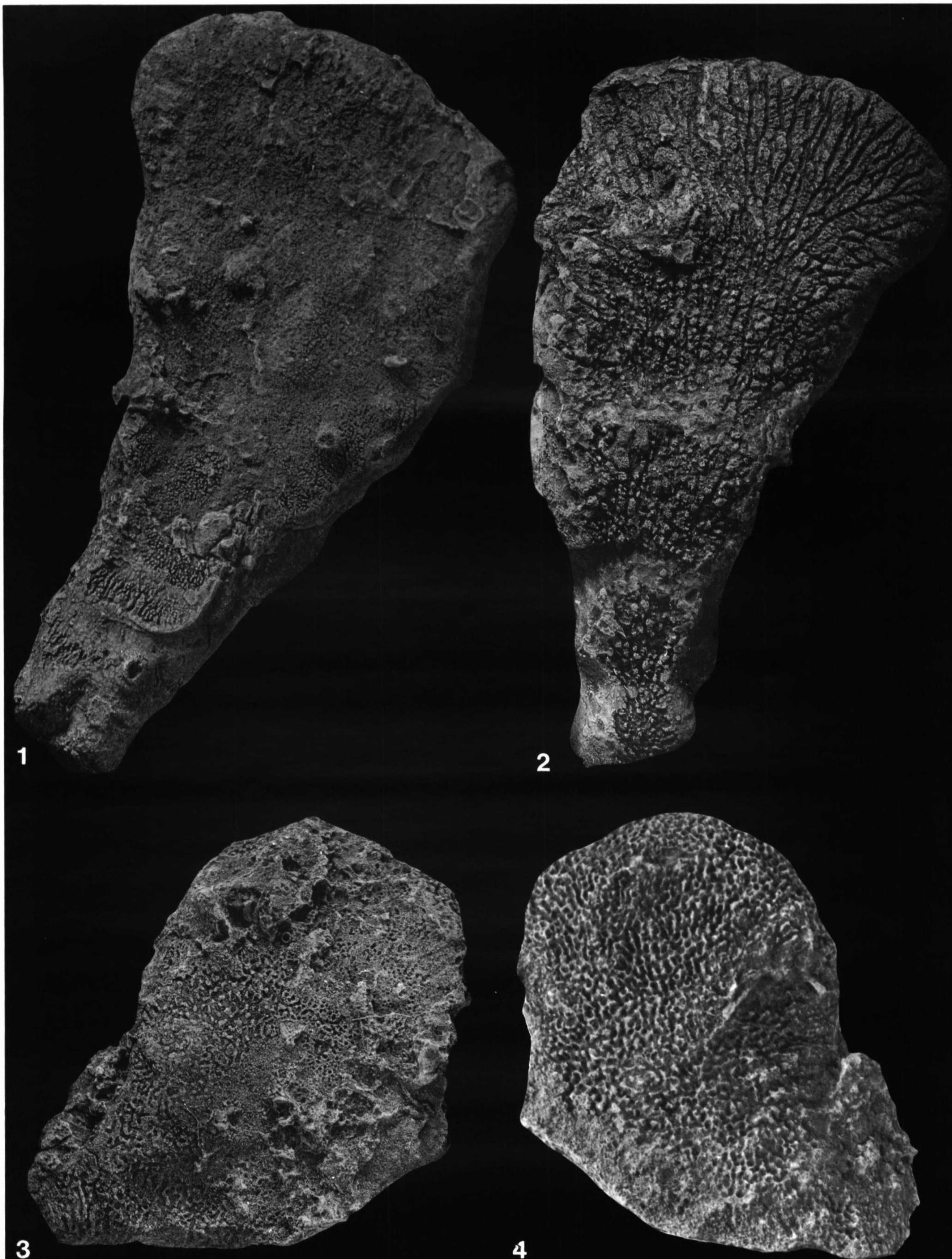
Photomicrographs of sponges in plain light.——*1–2, 6–7. Pseudohimatella pauciporata* (Parona, 1933); *1,* thin section 8, USNM 480422; transverse cross section exhibiting large exhalant canals and relatively fine reticular skeletal fibers between canals; section cut in middle part of sponge; spongocoel, which is limited to the top of the sponge, was not cut in this section, ×3; *2,* thin section 7, USNM 480420; transverse section with well-preserved skeletal net in tracts between canals, ×3; *6,* thin section 65, USNM 480340, Senowbari-Daryan collection; transverse section similar to Plate 79.1 showing canals in less well-preserved skeletal net, ×3; *7,* thin section 66, USNM 480341, Senowbari-Daryan collection; longitudinal section of specimen whose transverse section is shown in Plate 79.6; numerous exhalant tubes and fine reticular skeletal fibers between them, ×3.——*3. Stellispongiella parva* new species, thin section T-8, USNM 463563, Spot Locality T8; longitudinal section showing fine skeletal net interrupted by two exhalant canal clusters on right, with interior of stem with largely obscure skeletal structure, ×5.——*4. Stellispongiella reticulata* new species, paratype, thin section 133, USNM 463651, Spot Locality 13B; longitudinal section showing upwardly and outwardly divergent skeletal structure and canal pattern, ×5.——*5. Prestellispongia lobata* (Parona, 1933), thin section 26, USNM 480419, Spot Locality 216-1976; longitudinal section shows moderately coarse but reticulate skeleton interrupted by exhalant canal cluster in upper right, ×5.

Plate 80

Photomicrographs of sponges in plain light.——*1–4. Sphaeropontia regulara* new species, holotype, USNM 480321, Section G, bed 5, 100 m north of CF-53; *1, 3,* thin section 65A, USNM 480322; *1,* transverse cross section of holotype shows numerous upwardly divergent canals distributed throughout sponge; small dots in tracts between canals are spherulites, arrow points to area shown enlarged in Plate 80.3, ×4; *3,* enlargement of Plate 80.1; small light dots represent spherulites, ×15; *2, 4,* thin section 65B, USNM 480323, Section G, bed 5; *2,* longitudinal section of holotype shows numerous upwardly divergent canals separated by skeletal tracts of essentially the same dimensions as canals, arrow points to area shown enlarged in Plate 80.4, ×2; *4,* enlargement of Plate 80.2; canals filled with calcite cement (left to right orientation); spaces between canals are filled with individual spherulites, either connected directly with adjacent ones or by elongate beams where slightly more distant, ×18.——*5. Stellispongiella insculpta* new species, holotype, thin section I-12, USNM 480271, Section I, bed 12; longitudinal section showing deeply indented exhalant canals, now filled with dark matrix, cutting across moderately coarse skeleton, ×5.——*6. Estrellospongia grossa* new species, thin section 34, USNM 463642, Section G, bed 4; transverse section showing unclustered radial canals in moderately uniform skeleton which also lacks central openings, ×5.

Plate 81

Photomicrographs of sponges in plain light.——*1–4, 5?. Heliospongia finksi* Termier and Termier, 1977a, figured specimens; *1–2,* thin section 32, USNM 480324, Senowbari-Daryan collection; *1,* longitudinal section, see Plate 42.7 for outer view; the narrow spongocoel is cut in the upper part of the sponge, where upwardly divergent exhalant canals can be seen; circular outlines of the exhalant pores are arranged in lines and are easily recognized in the lower part of the sponge, arrow points to area shown enlarged in Plate 81.2, ×2; *2,* enlargement of lower part of Plate 81.1 shows the exhalant pores arranged in lines, reversed left to right; spaces between canals are filled with reticular-appearing structures, ×8; *3,* thin section 86, USNM 480325, Spot Locality 16A; transverse section of the specimen whose longitudinal section is illustrated in Plate 81.4; faint, radially arranged inhalant and exhalant canals, ×3.5; *4,* thin section 85, USNM 480326, Spot Locality 16A; longitudinal section shows spongocoel cut marginally, but recognizable in the left part; the reticular structure is recognizable where interfiber spaces are filled with calcite cement (light gray in picture), ×2; *5,* thin section 54, USNM 480327, CF24, shale below oncolite beds of Section J; longitudinal section which cuts the deep spongocoel; because of differences in internal structures, the affiliation of this sponge to *H. finksi* is uncertain, ×2.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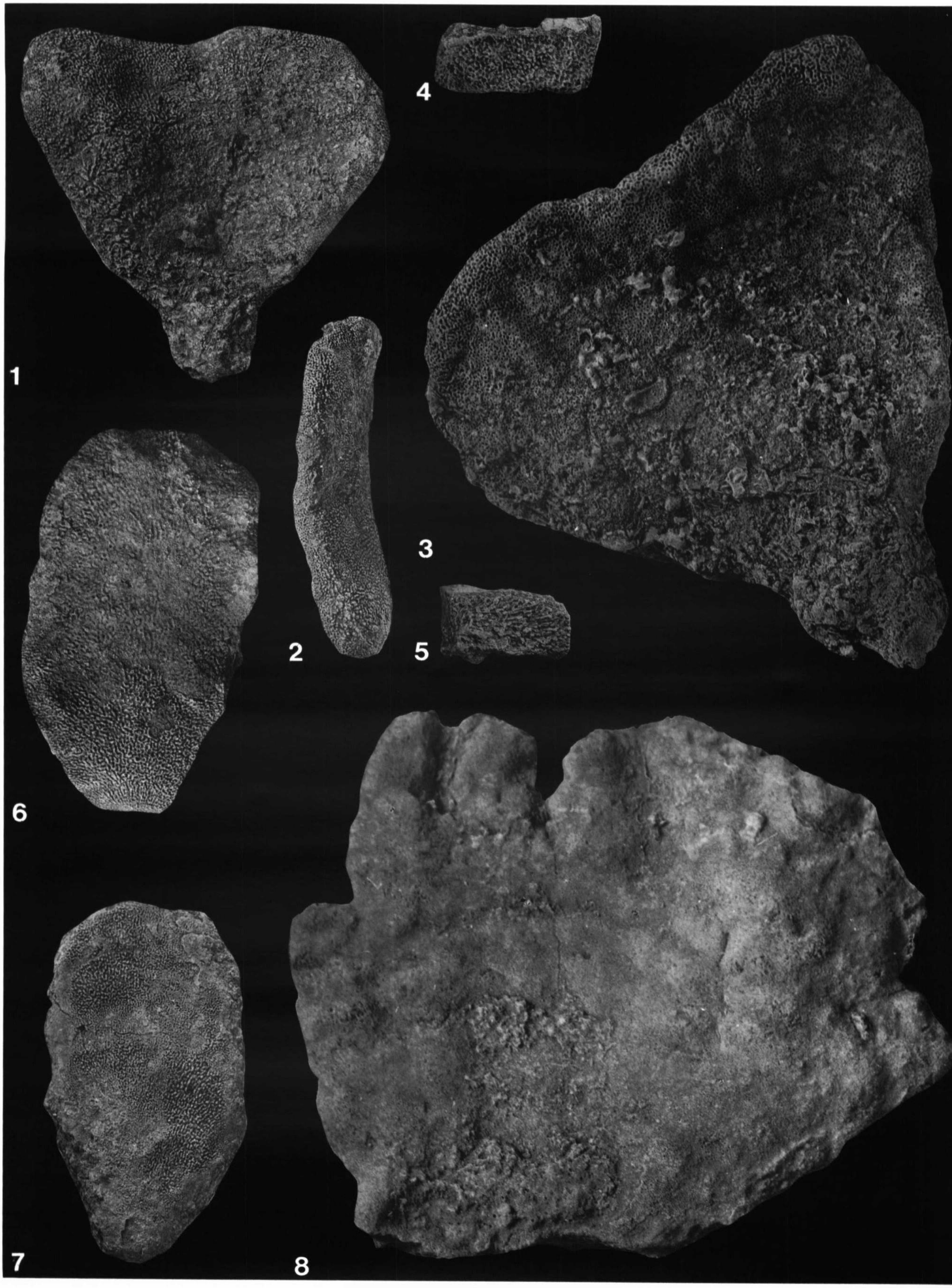

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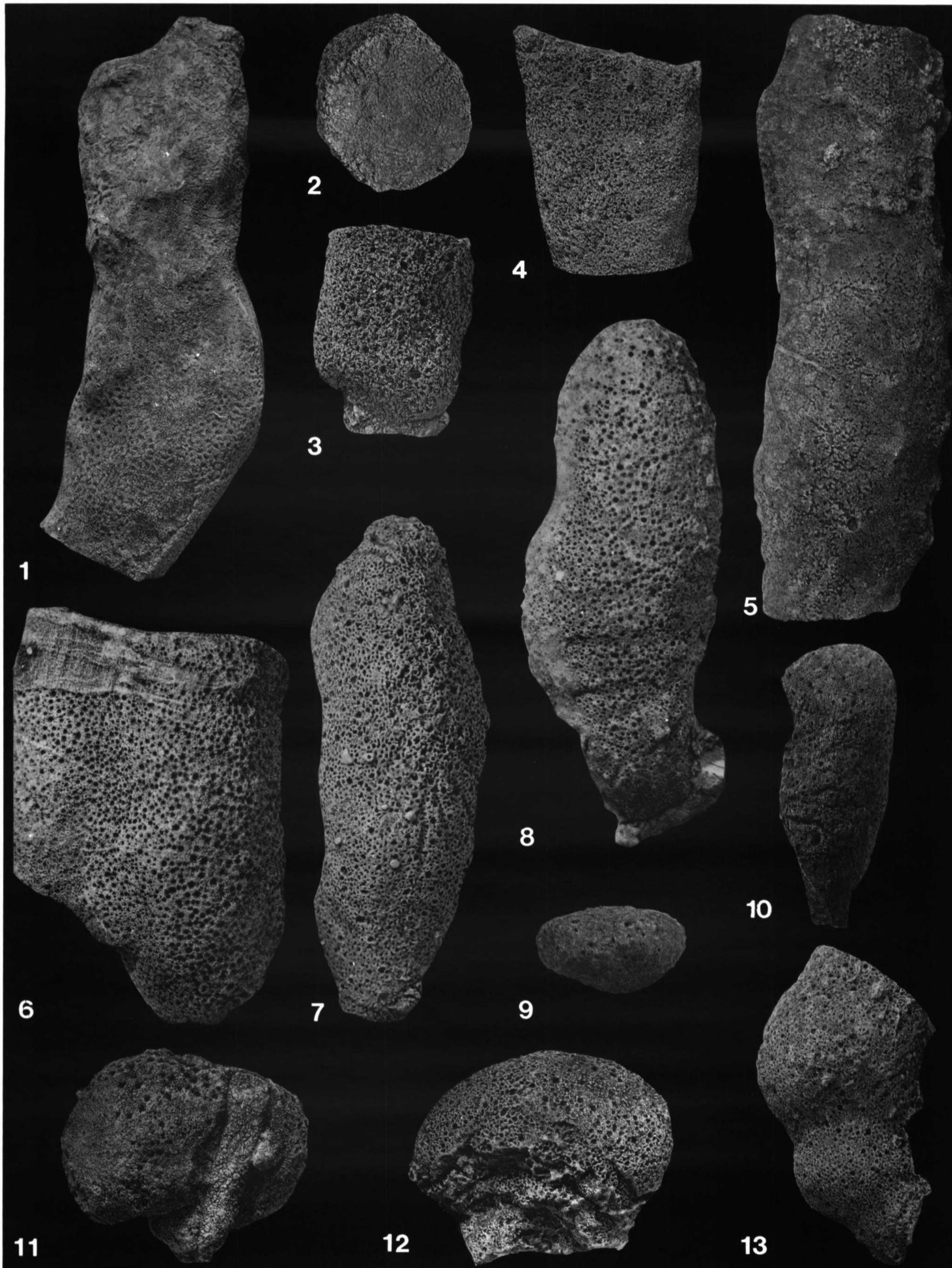
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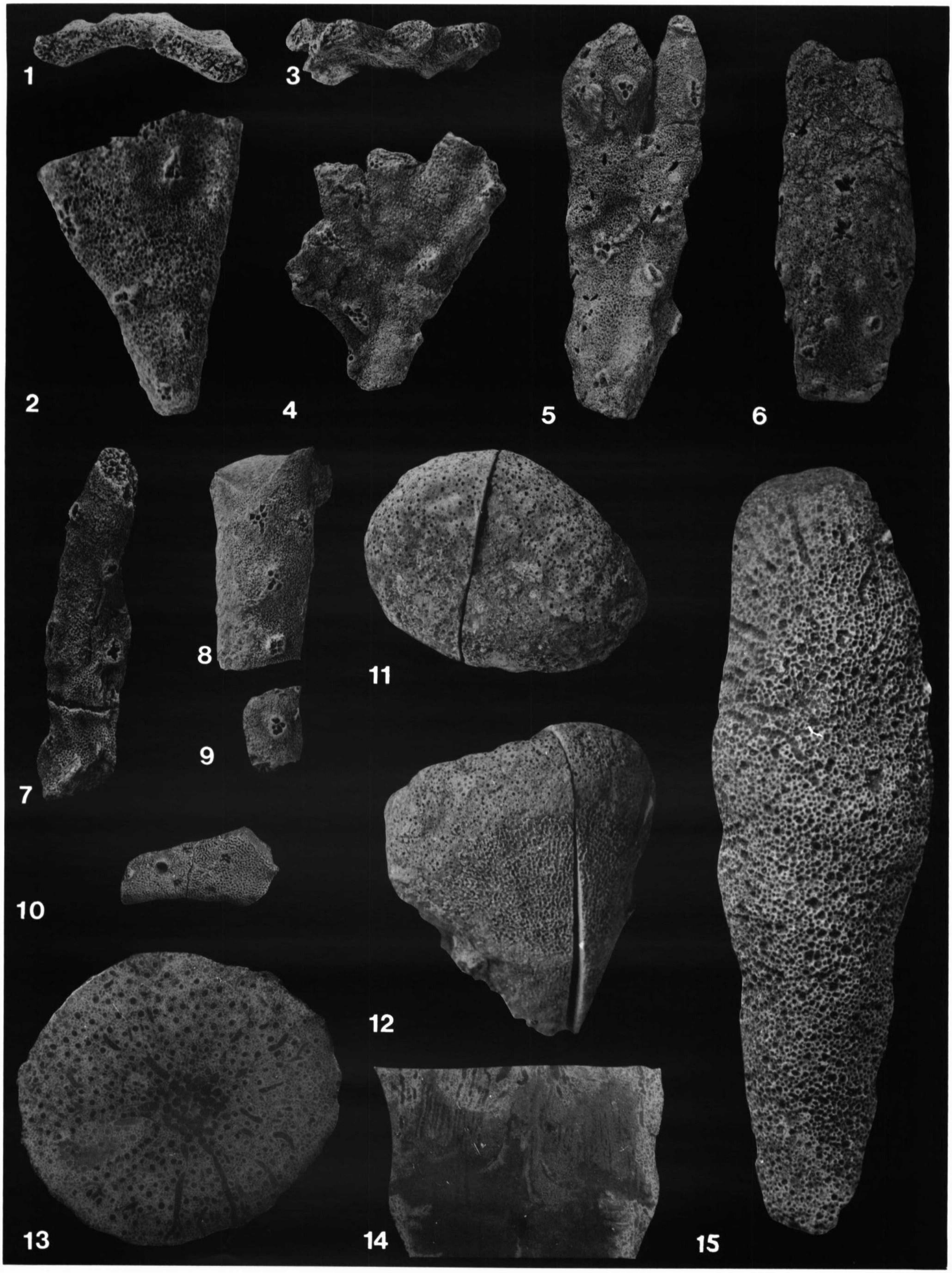
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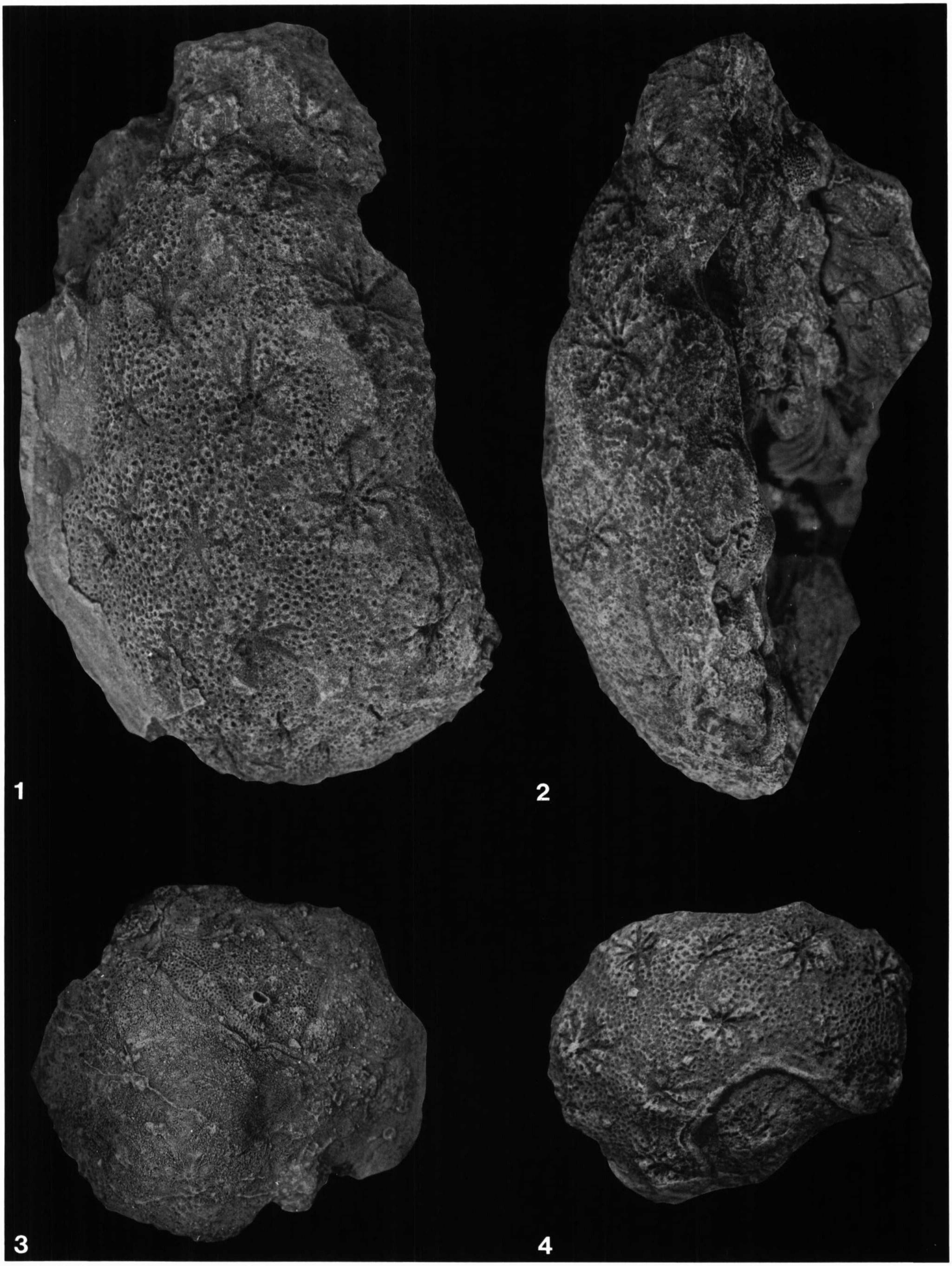

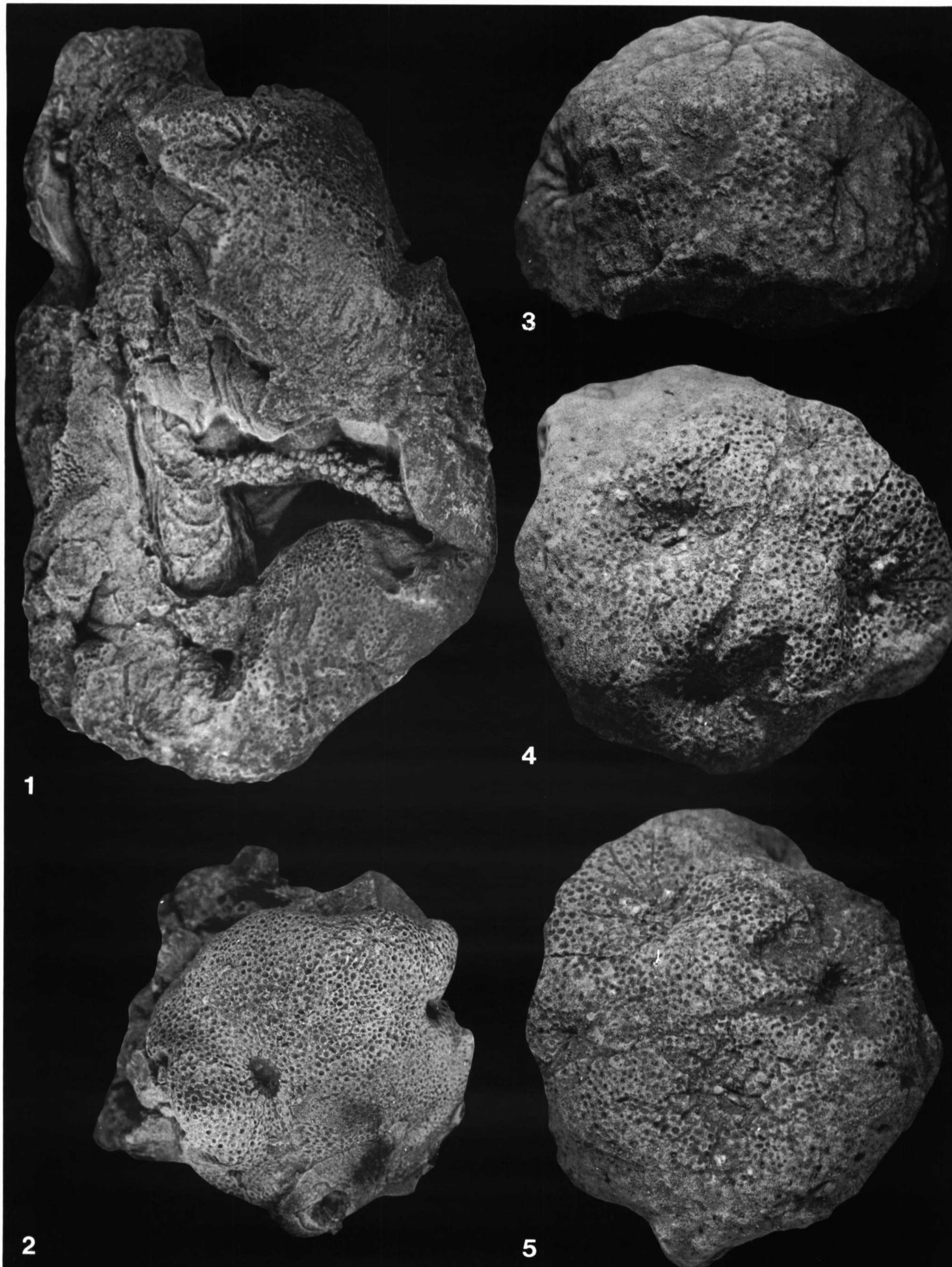
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PLATE 10


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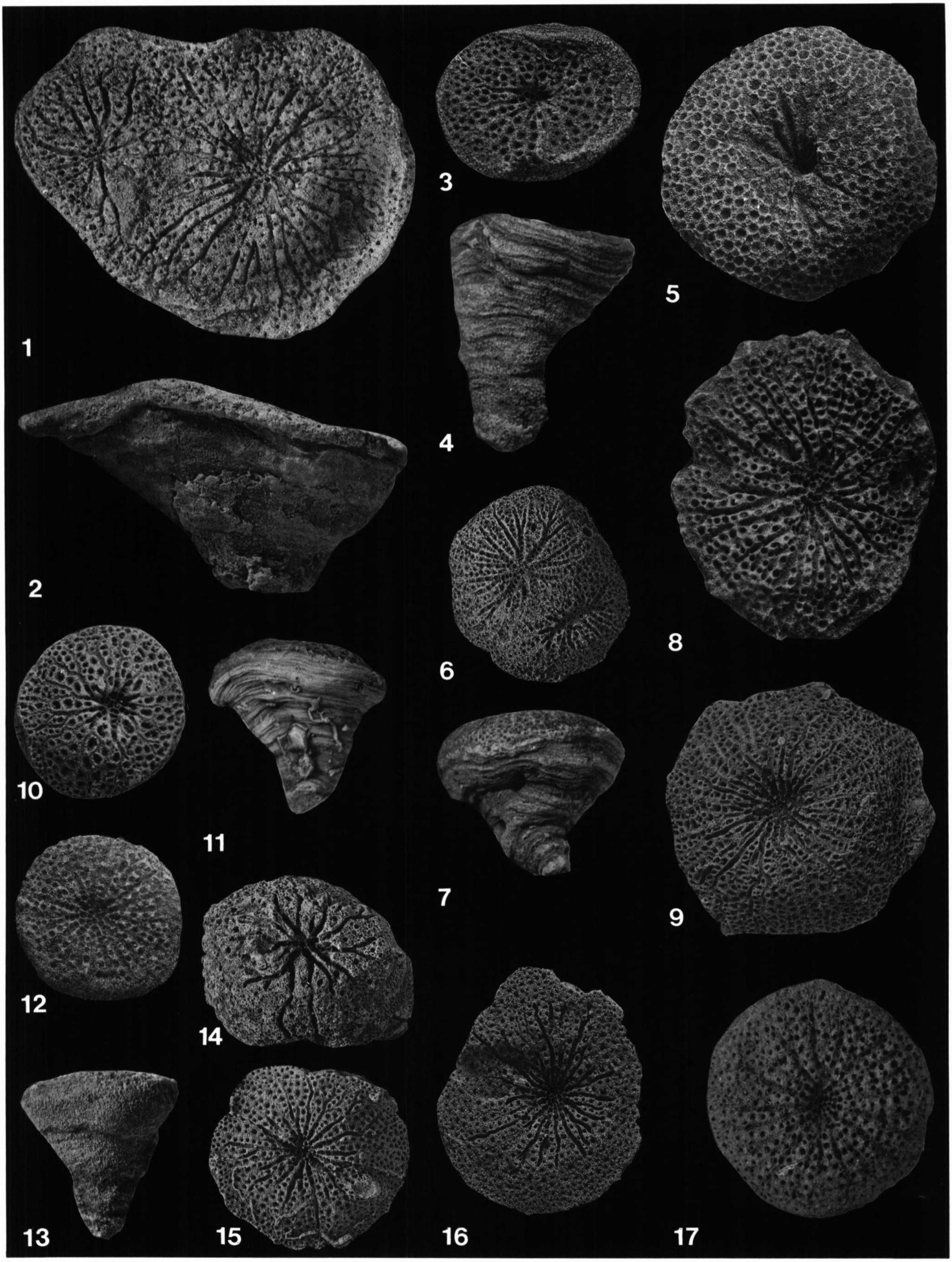
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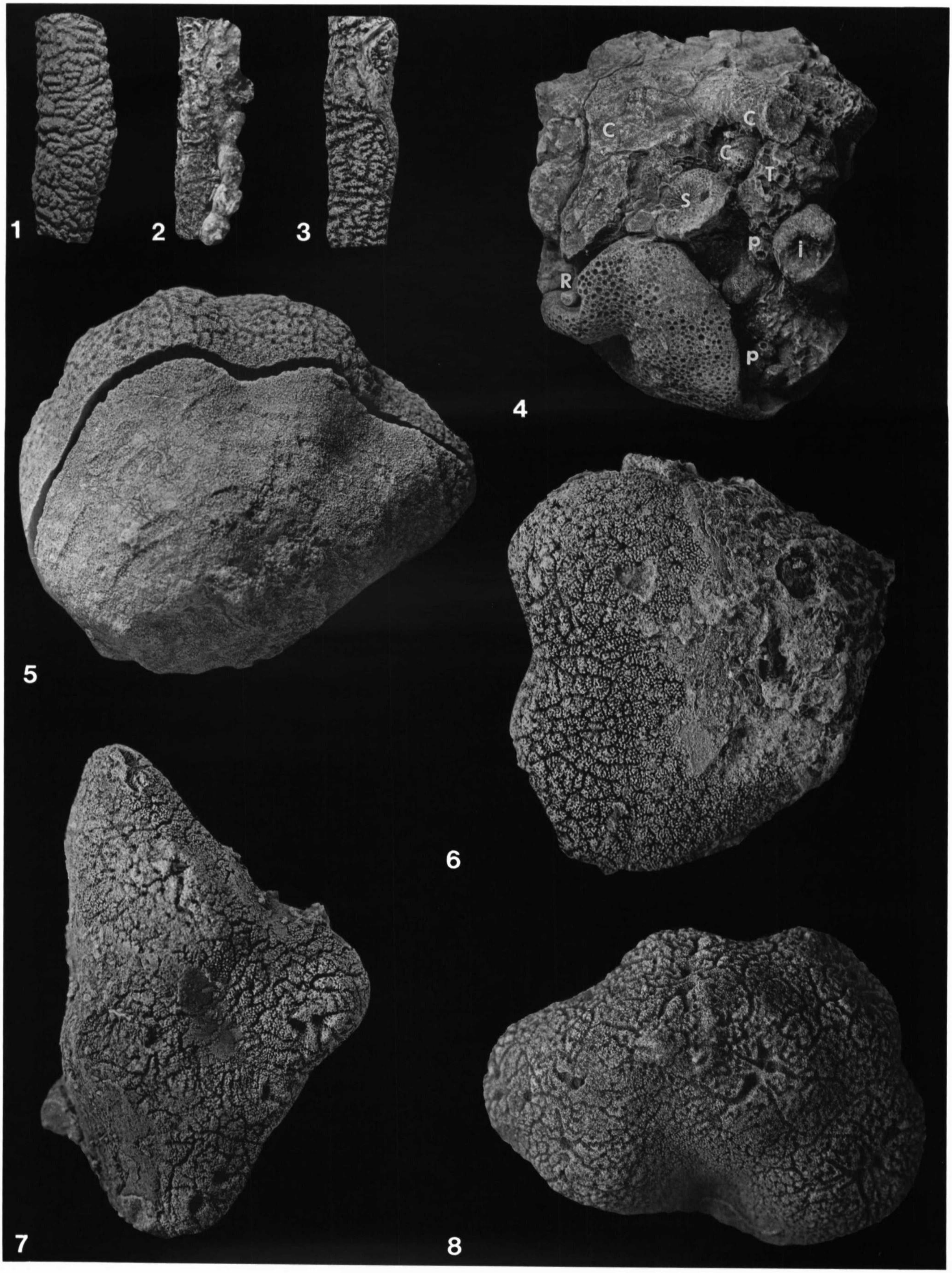
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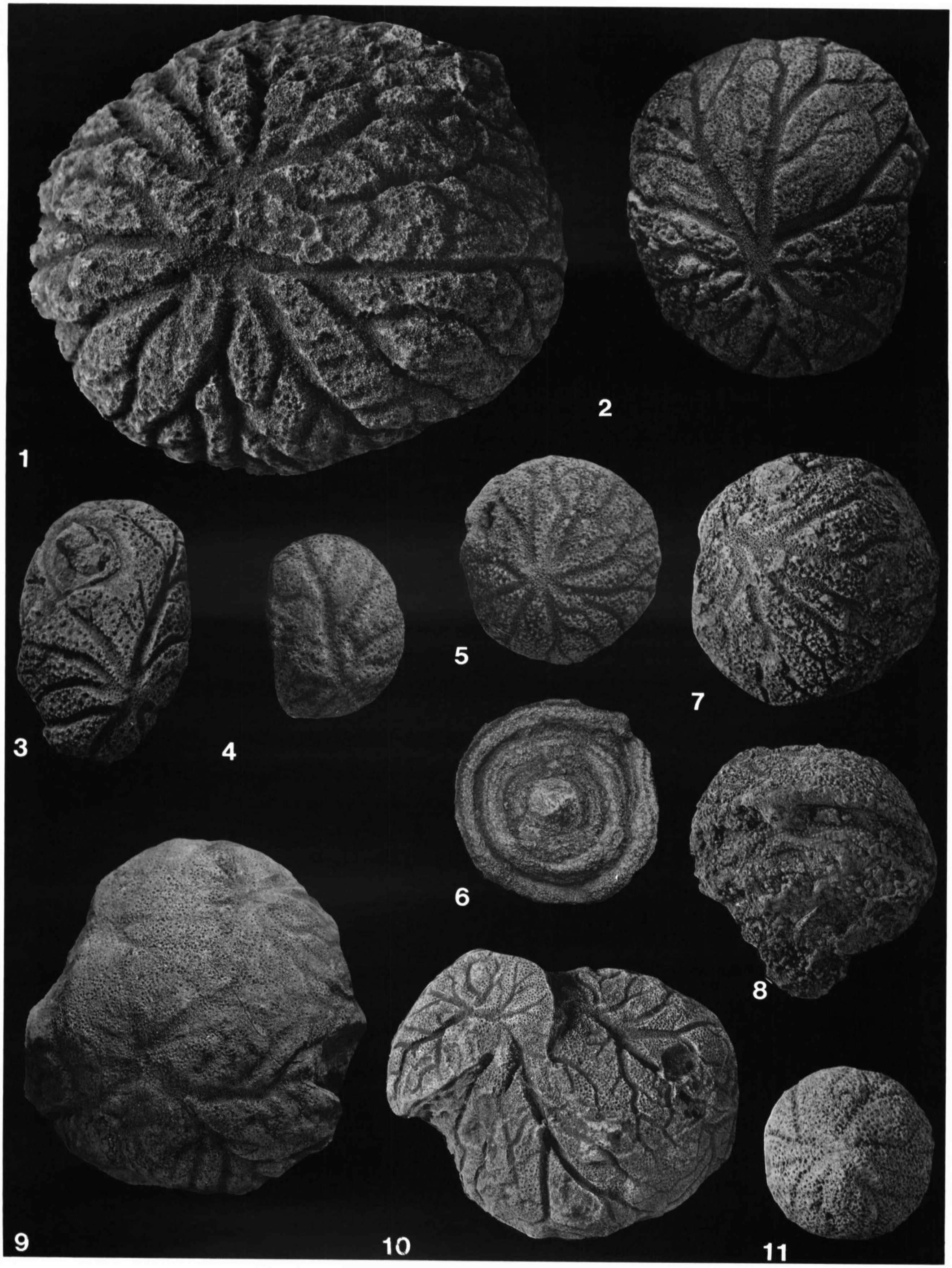

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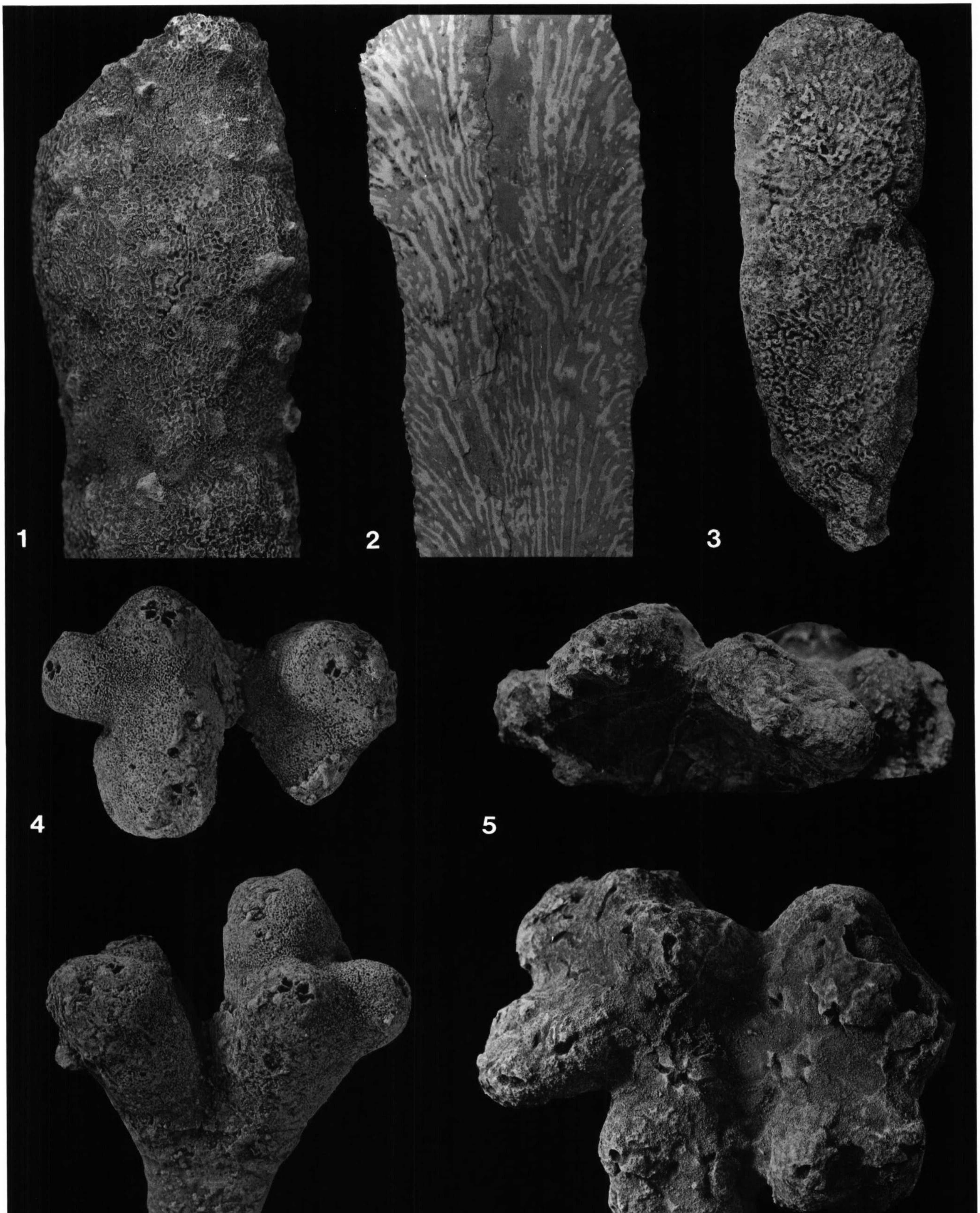

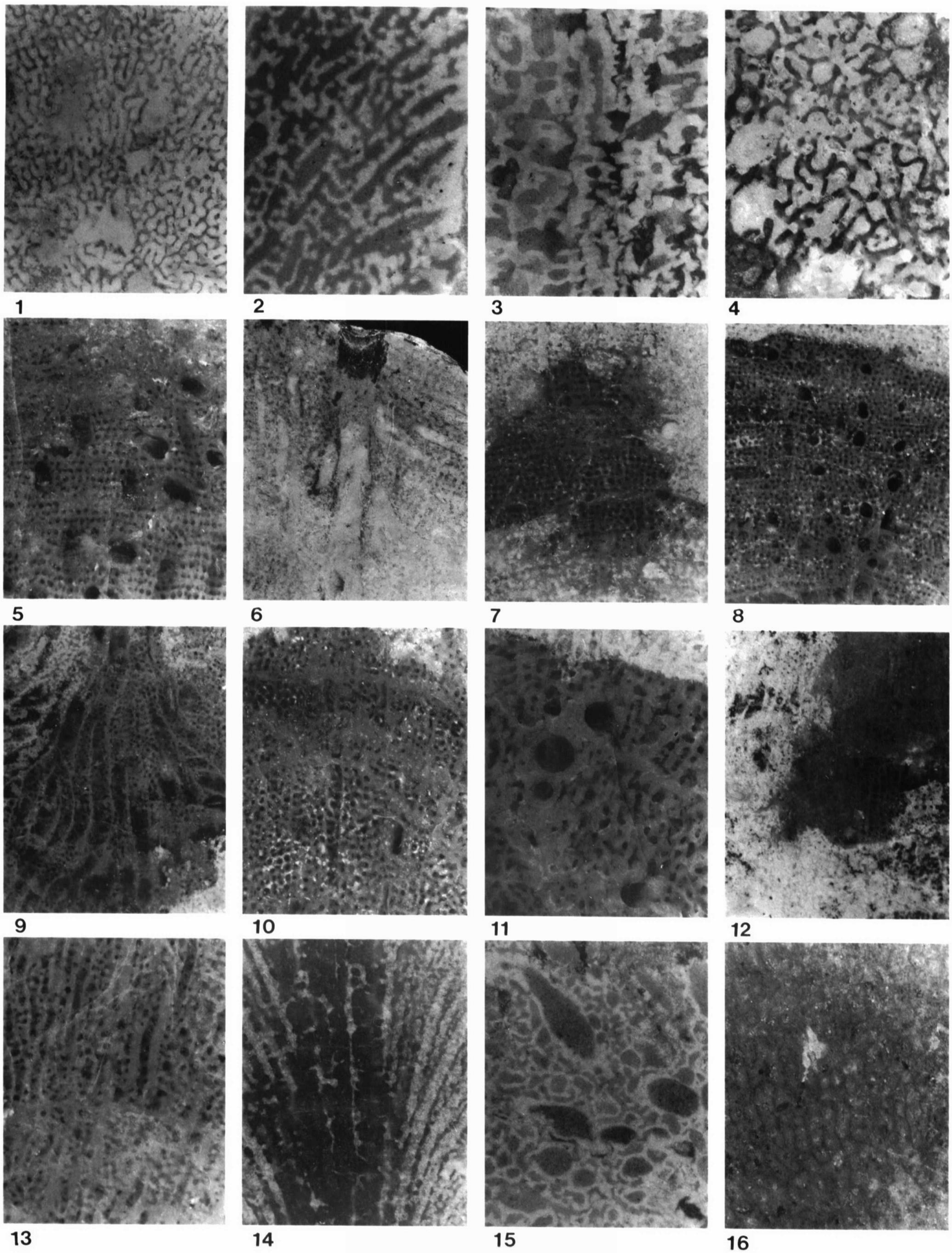
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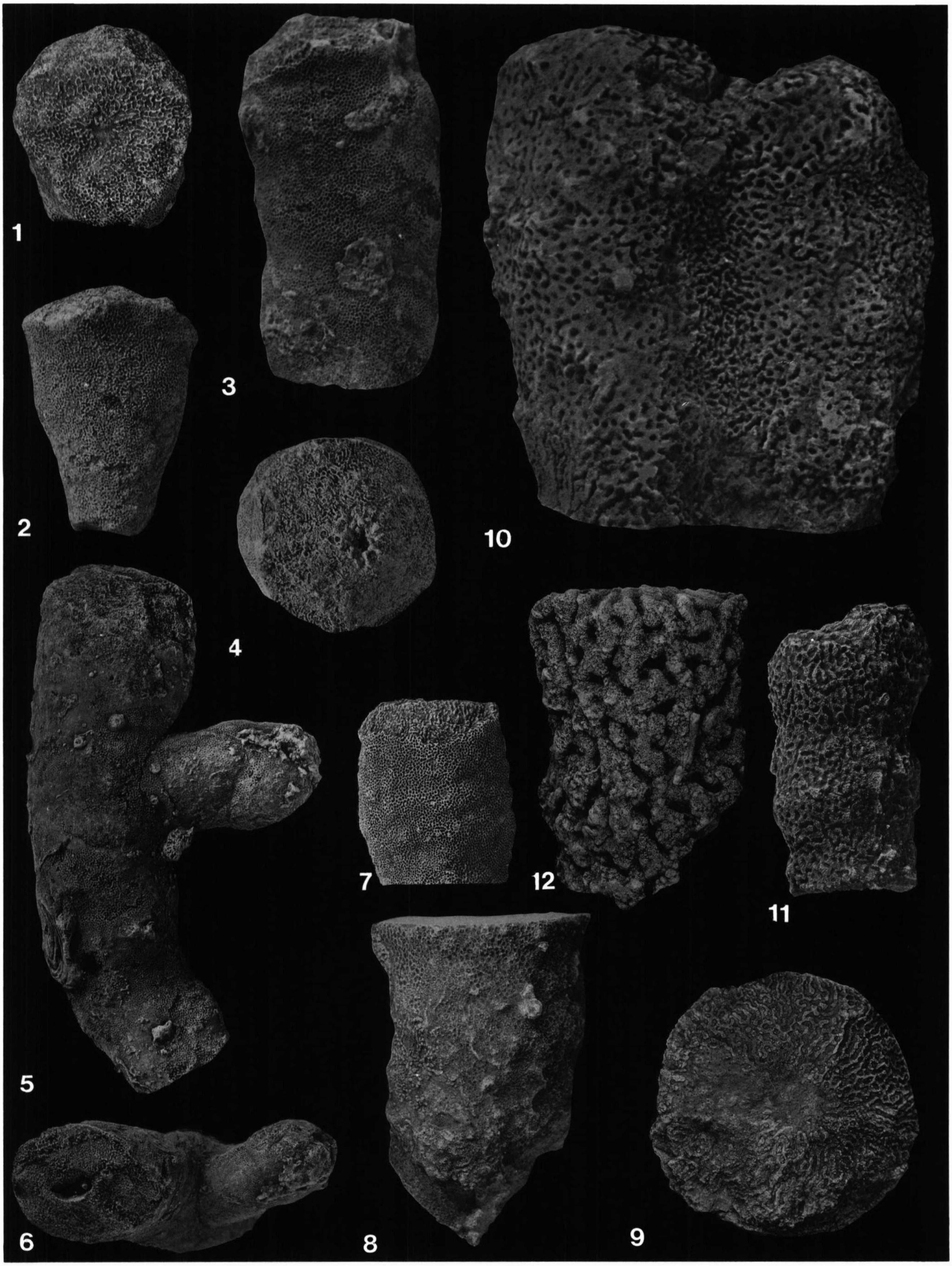
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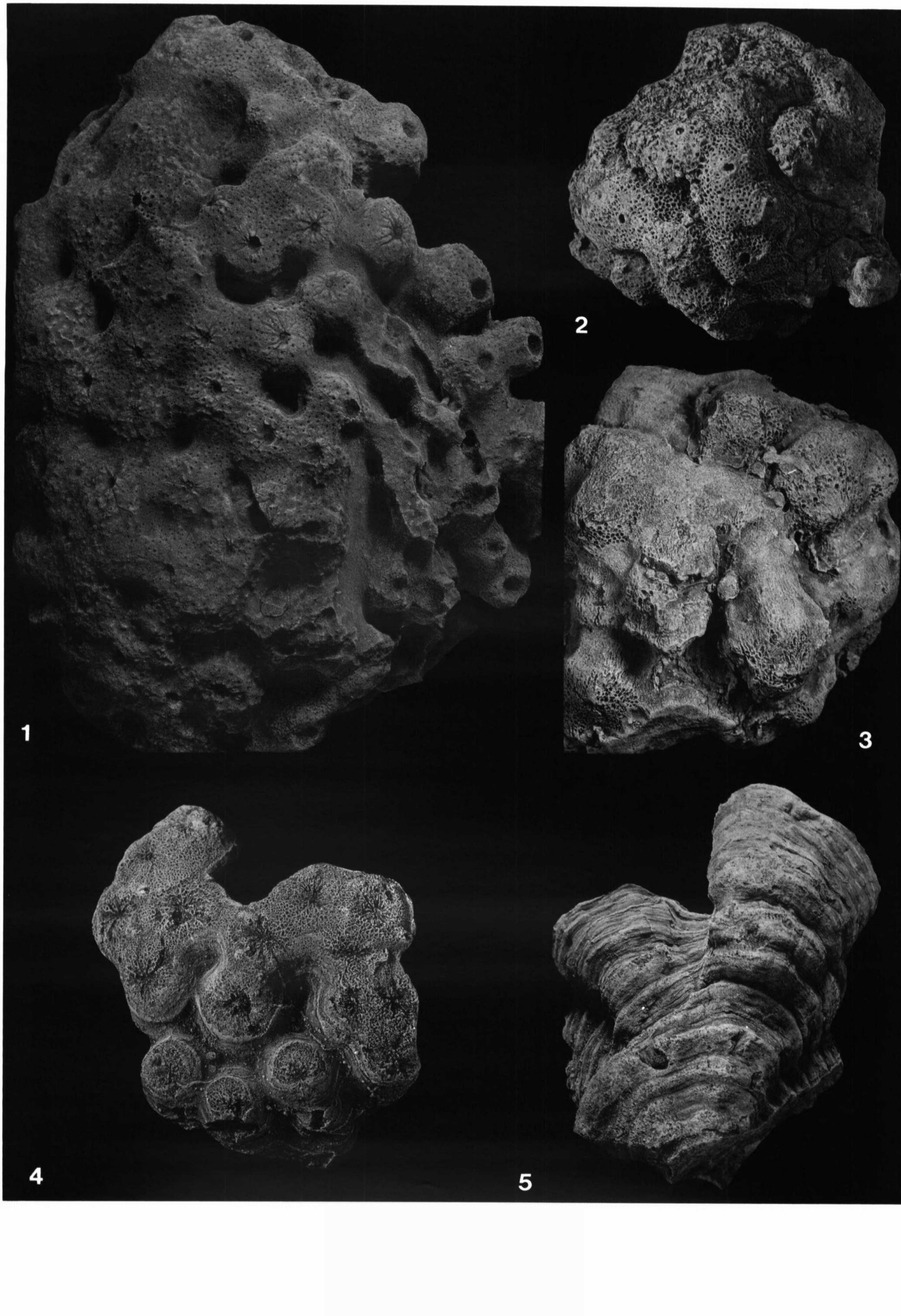
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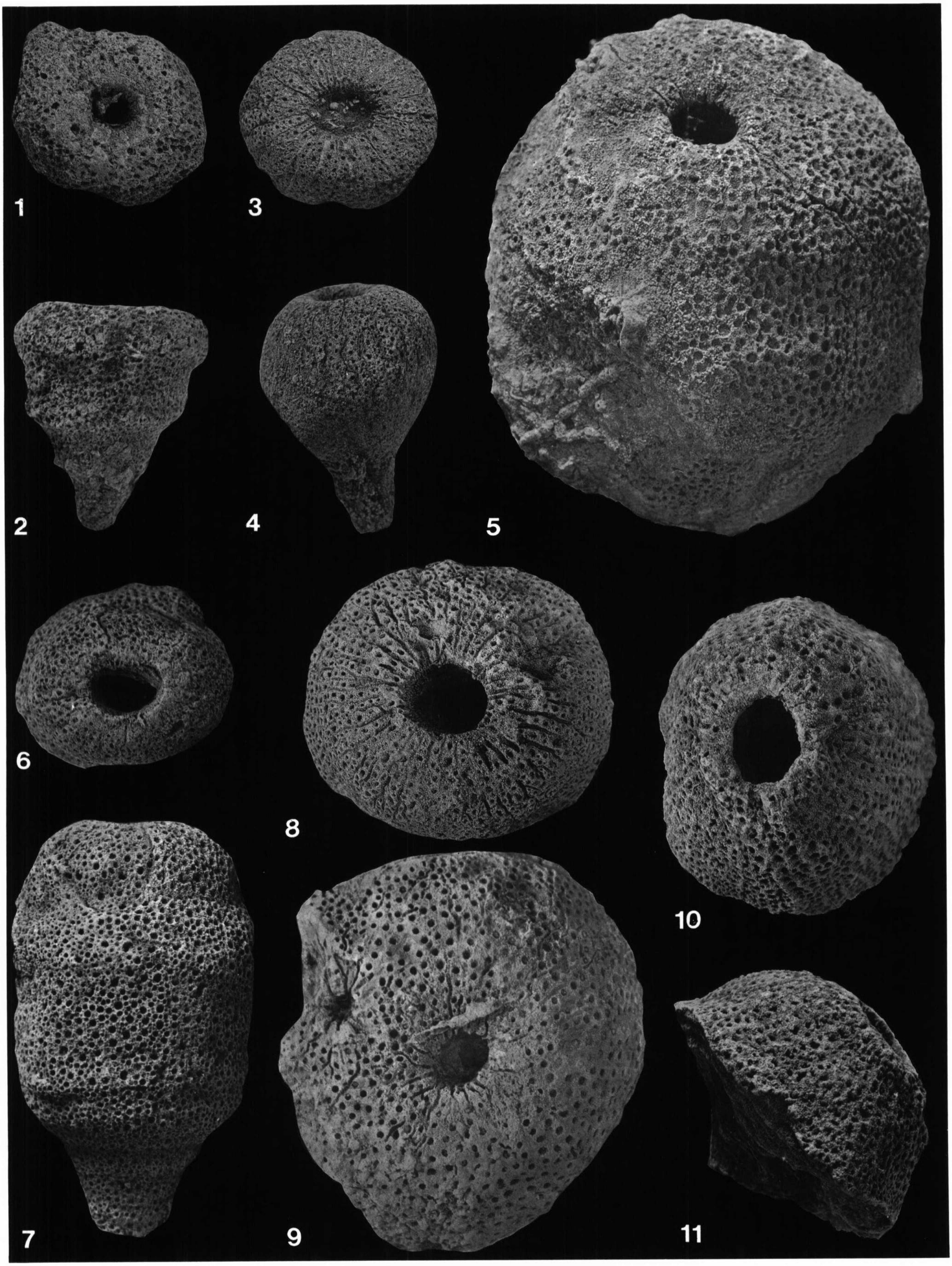
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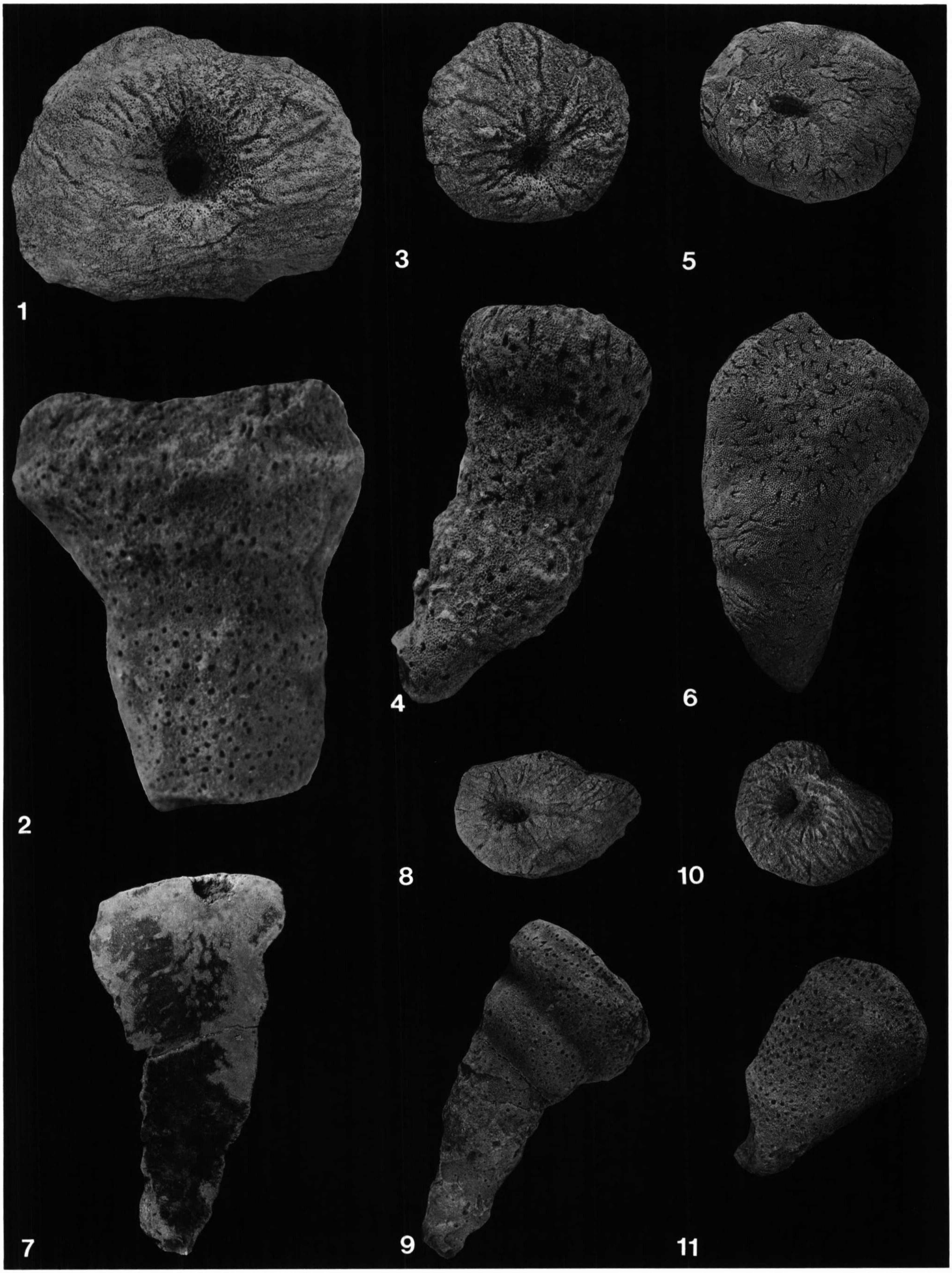
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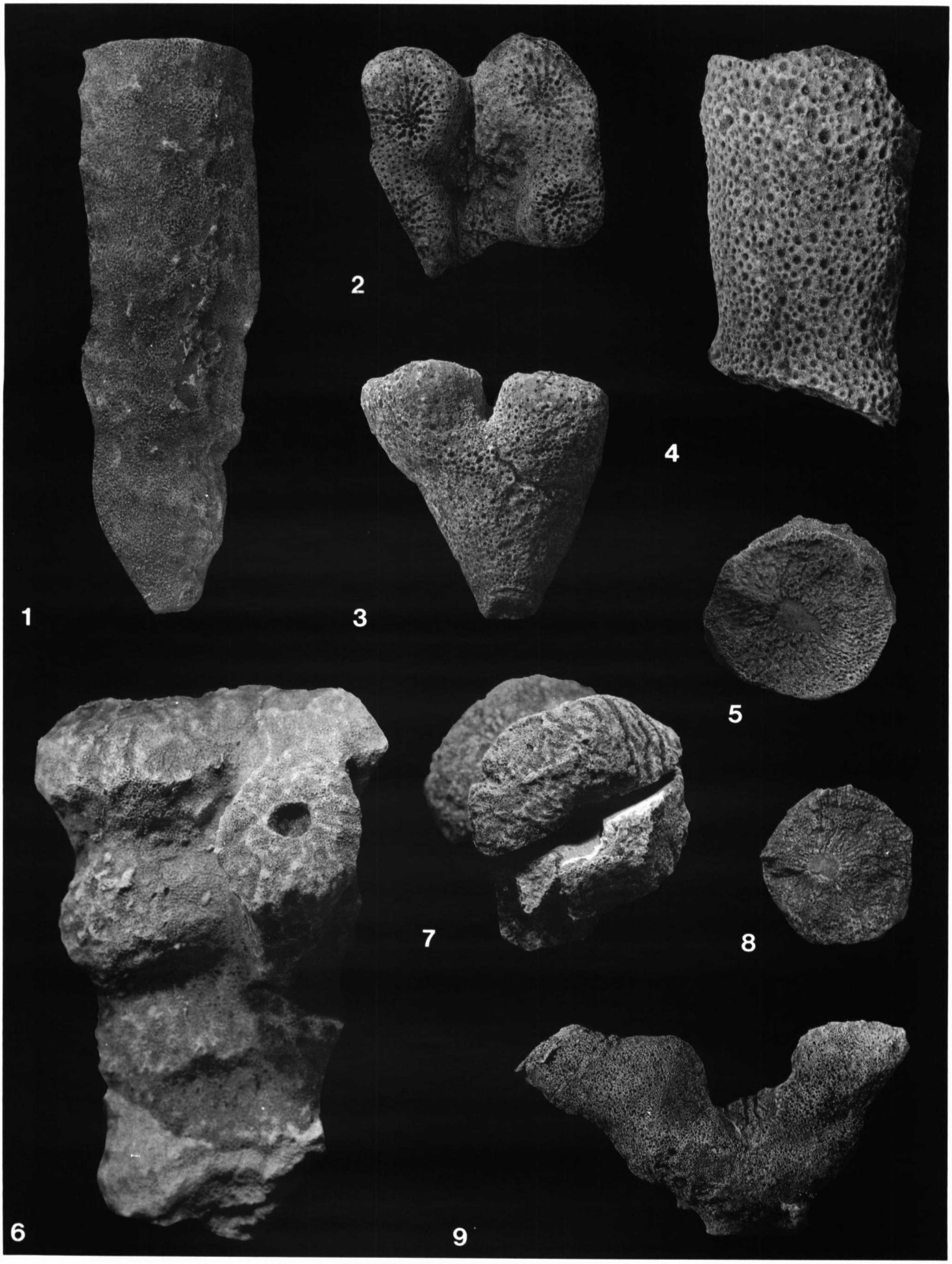

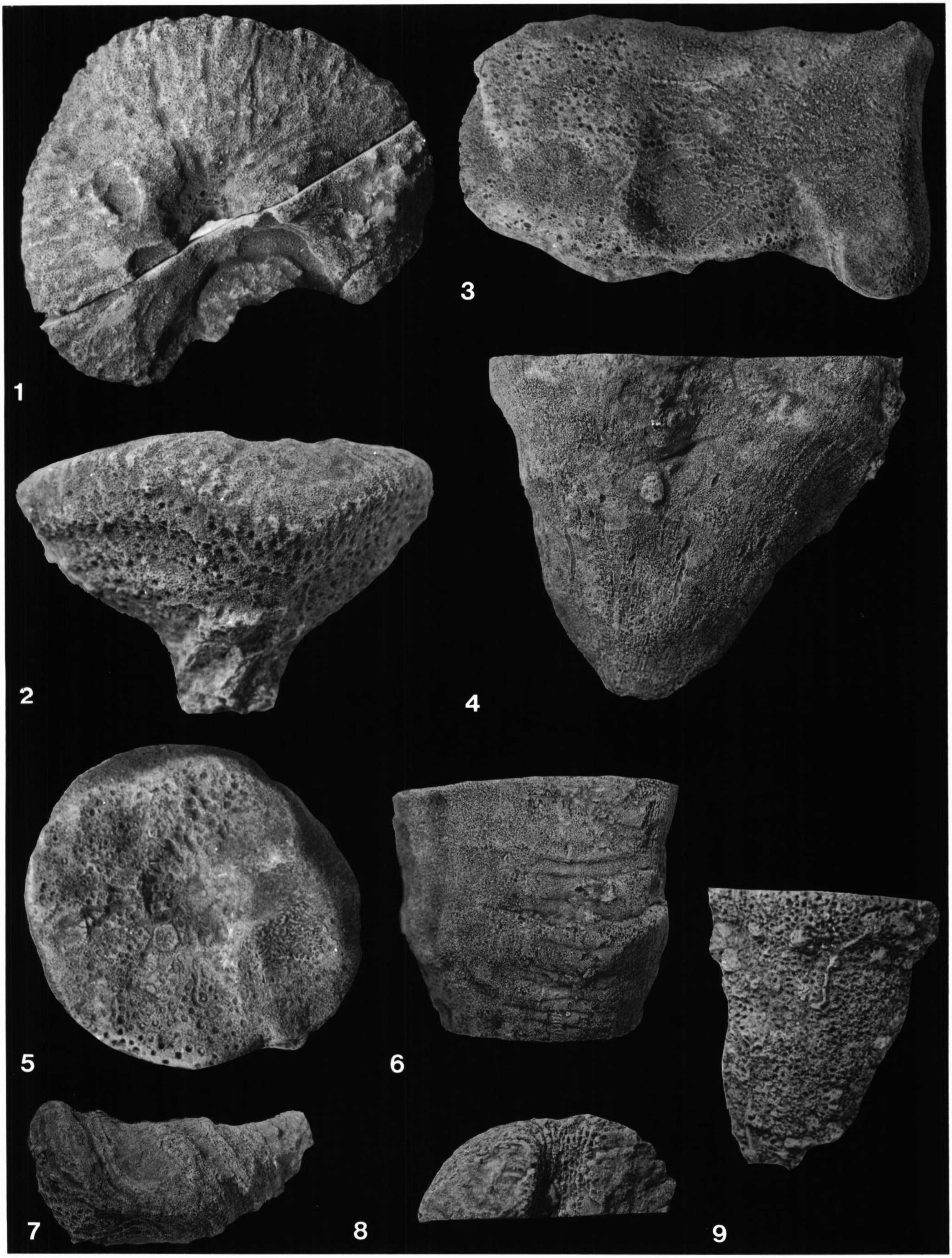
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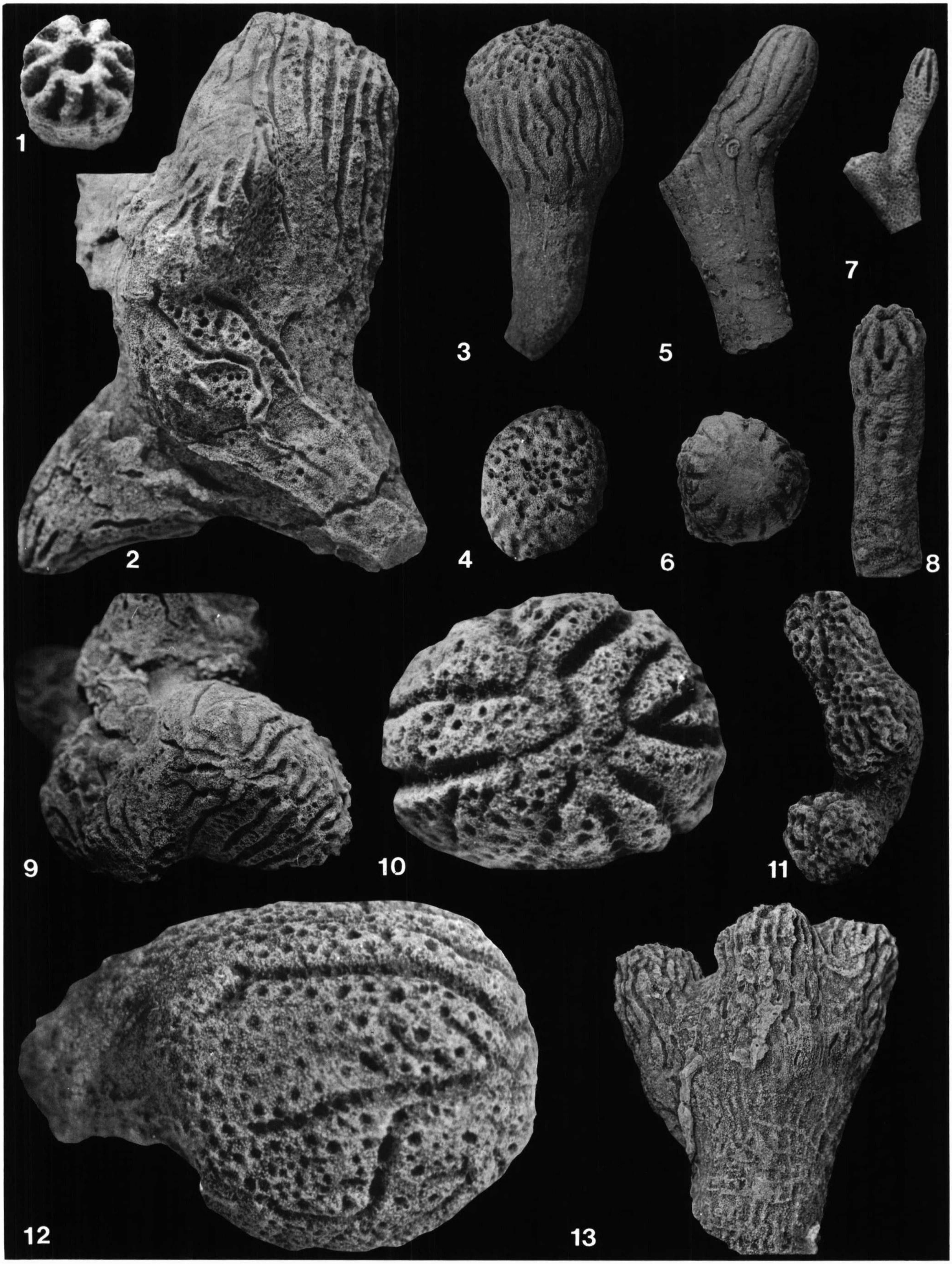
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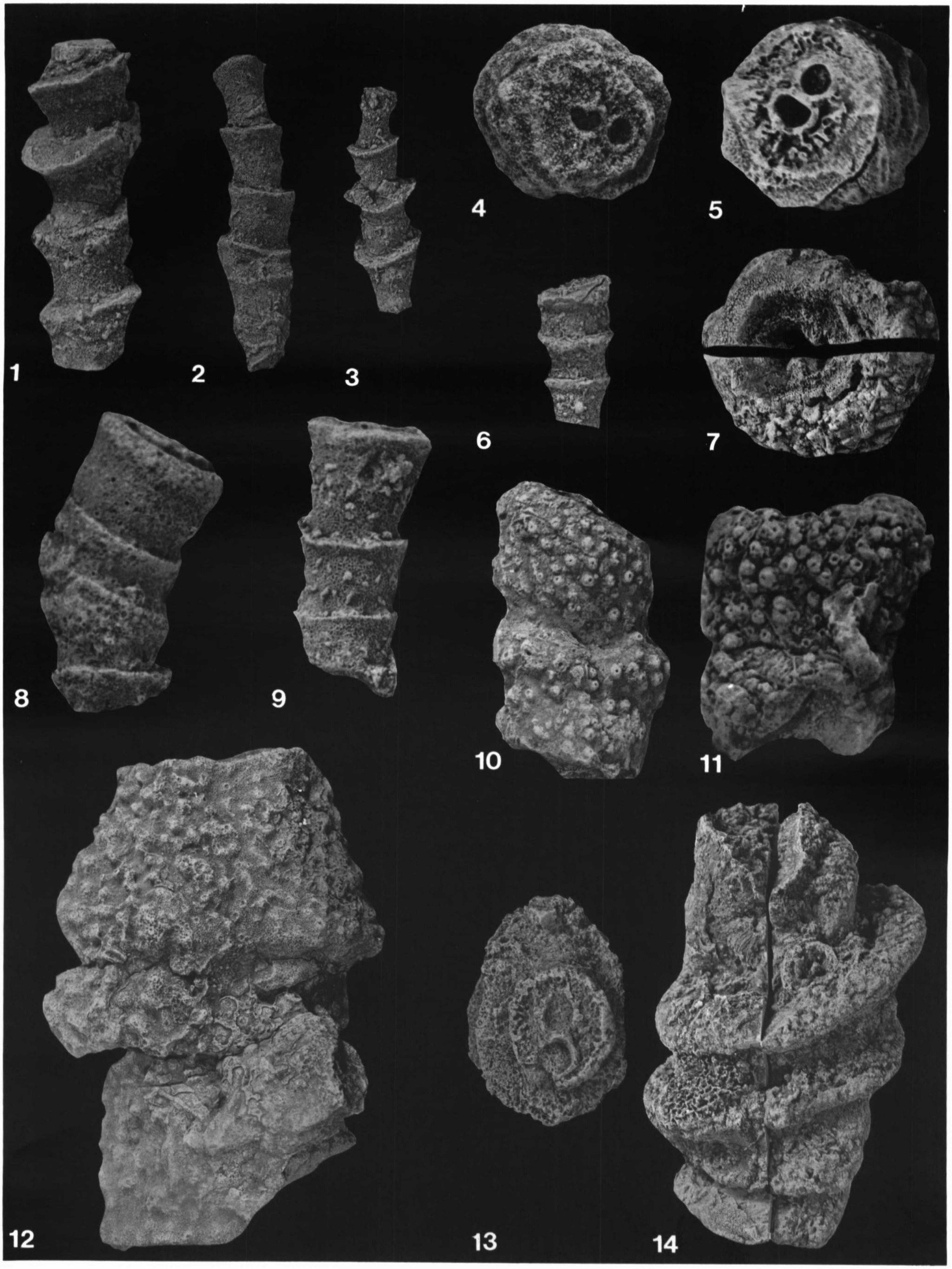
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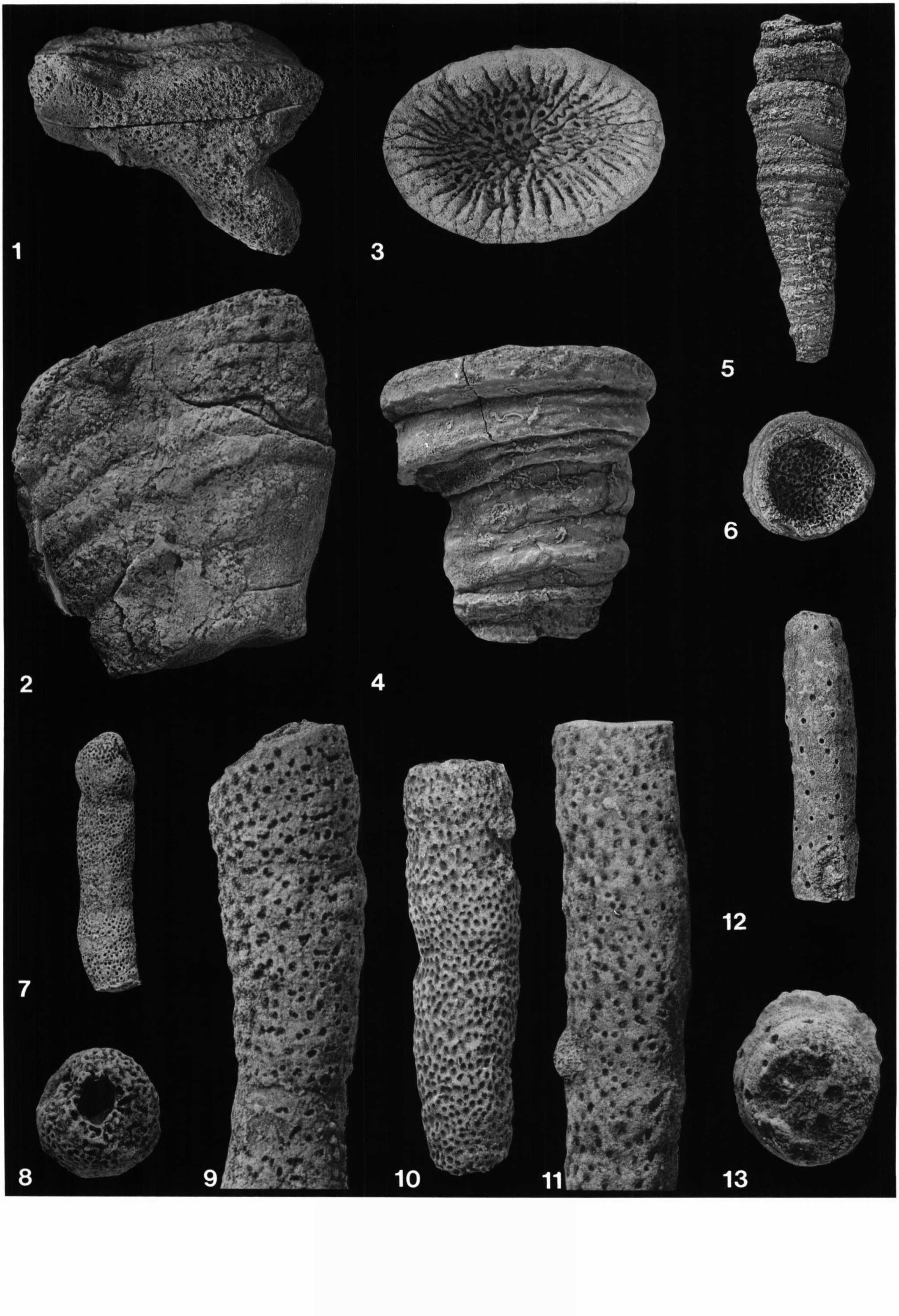


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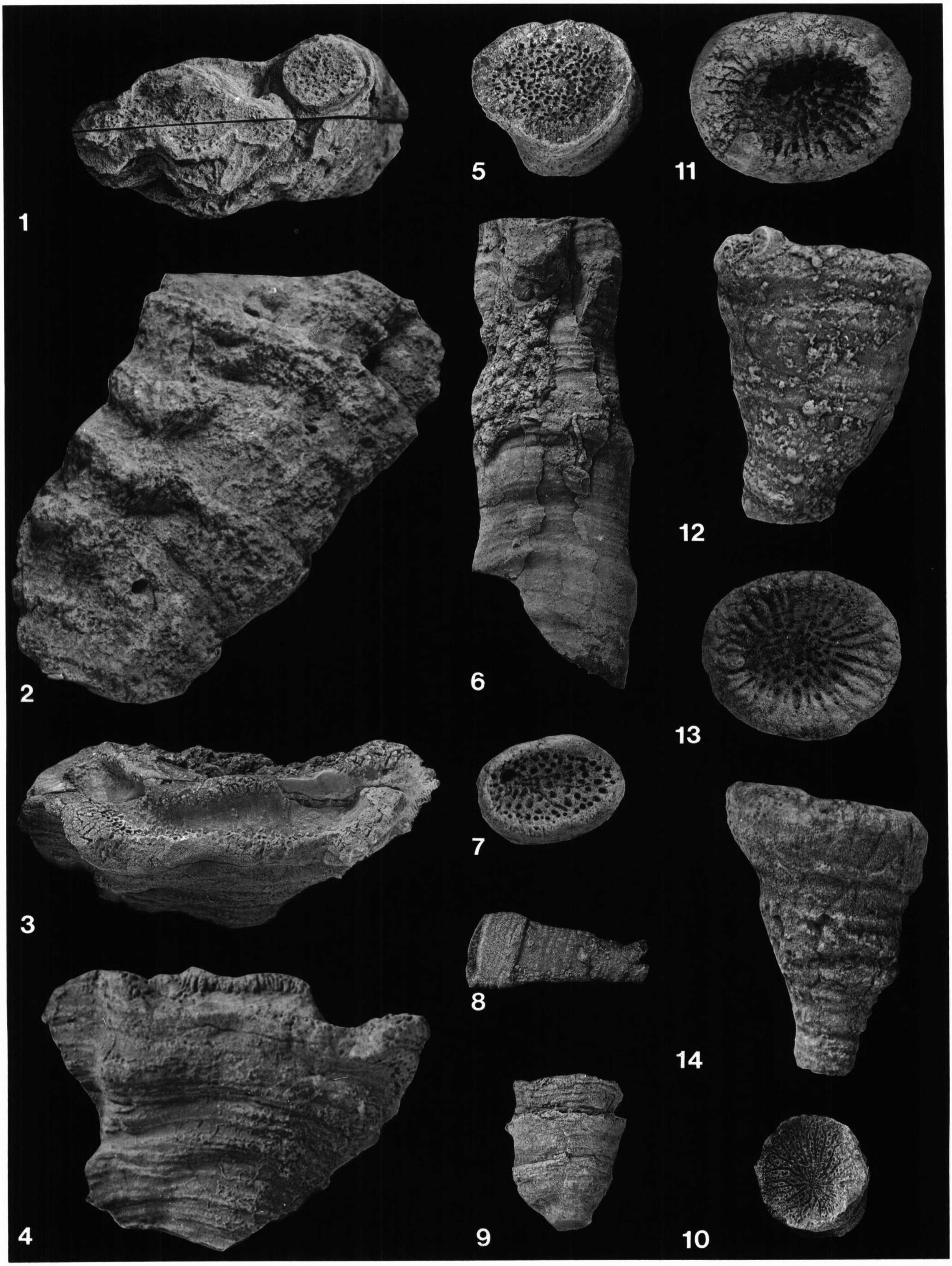
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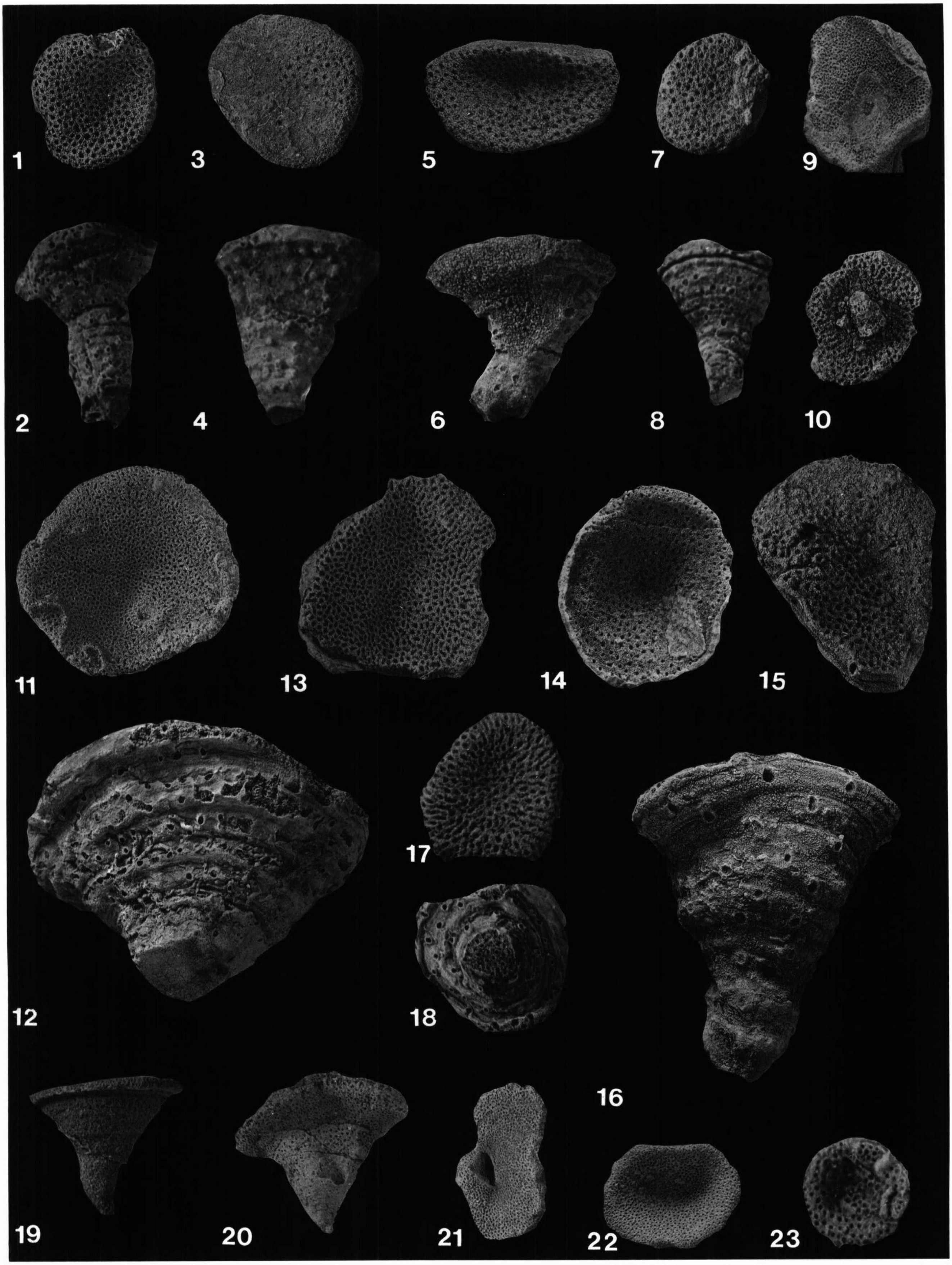
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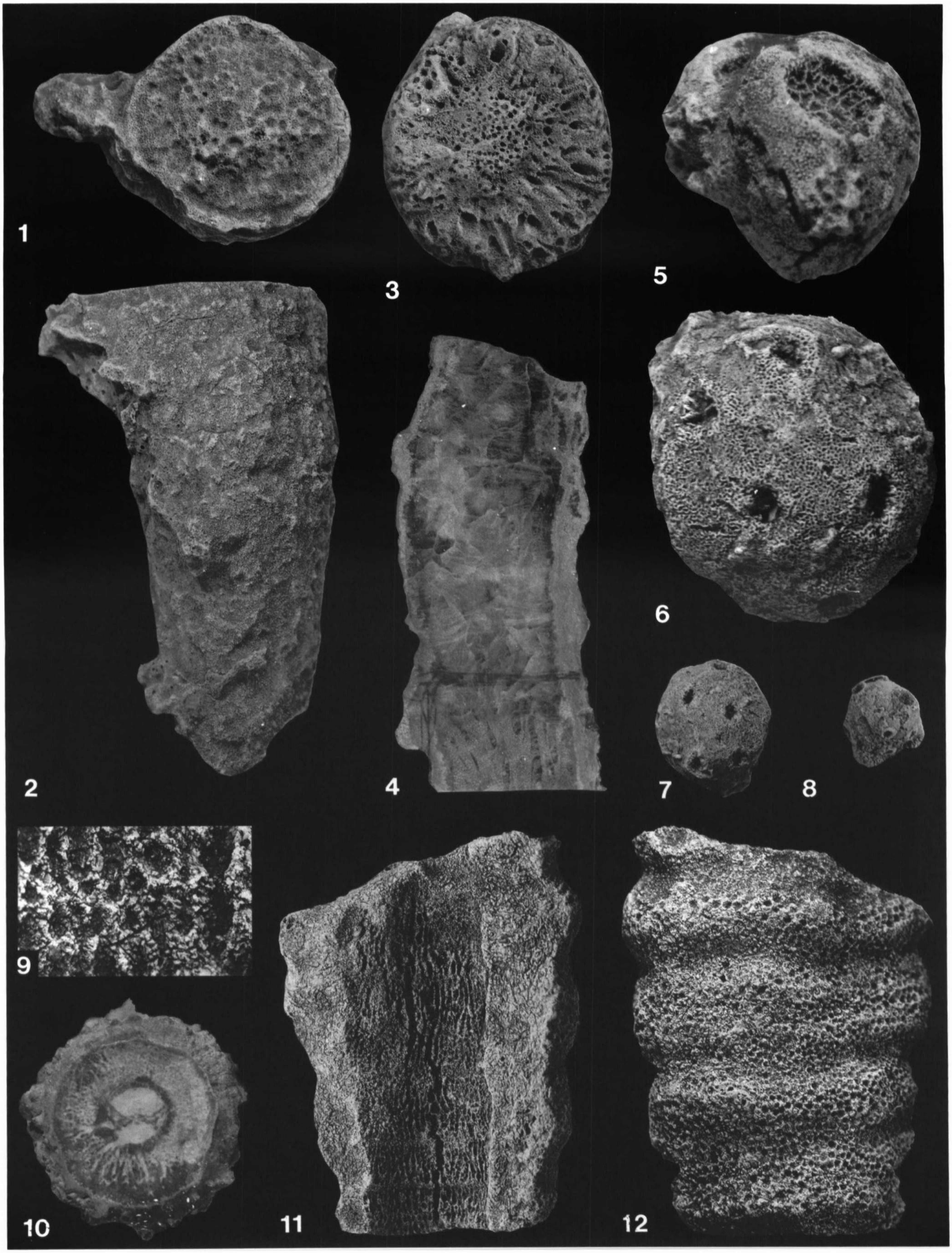
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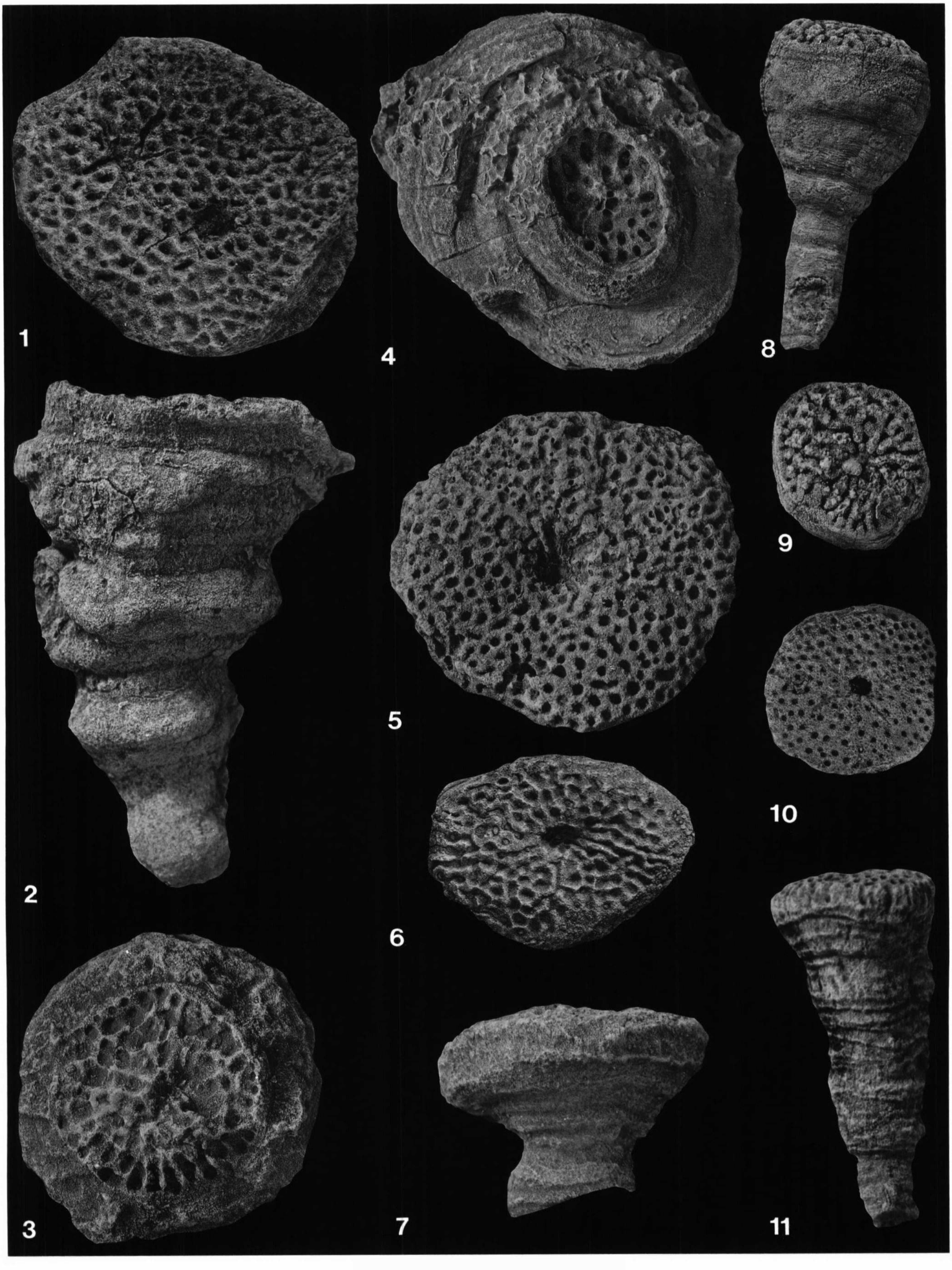
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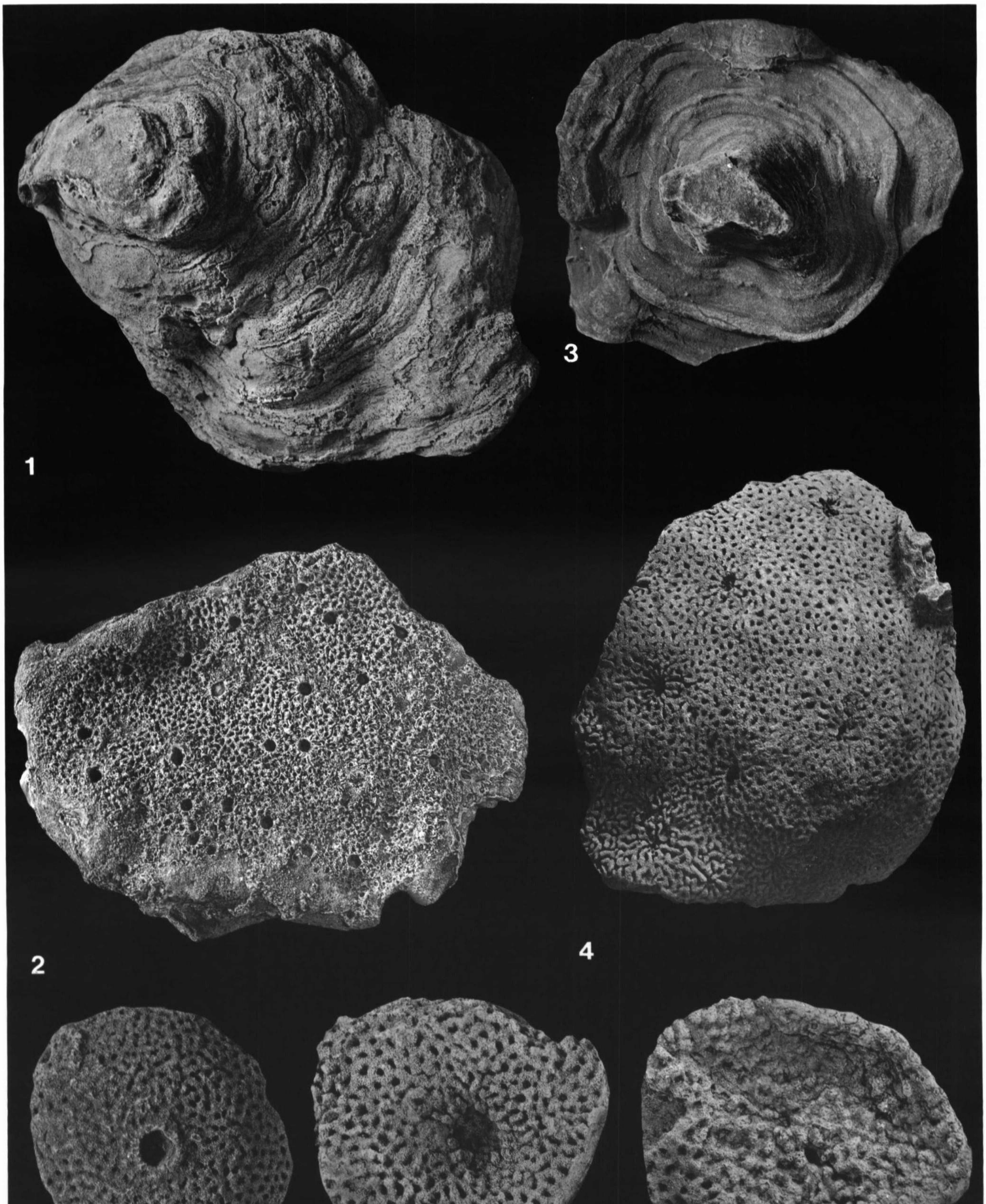
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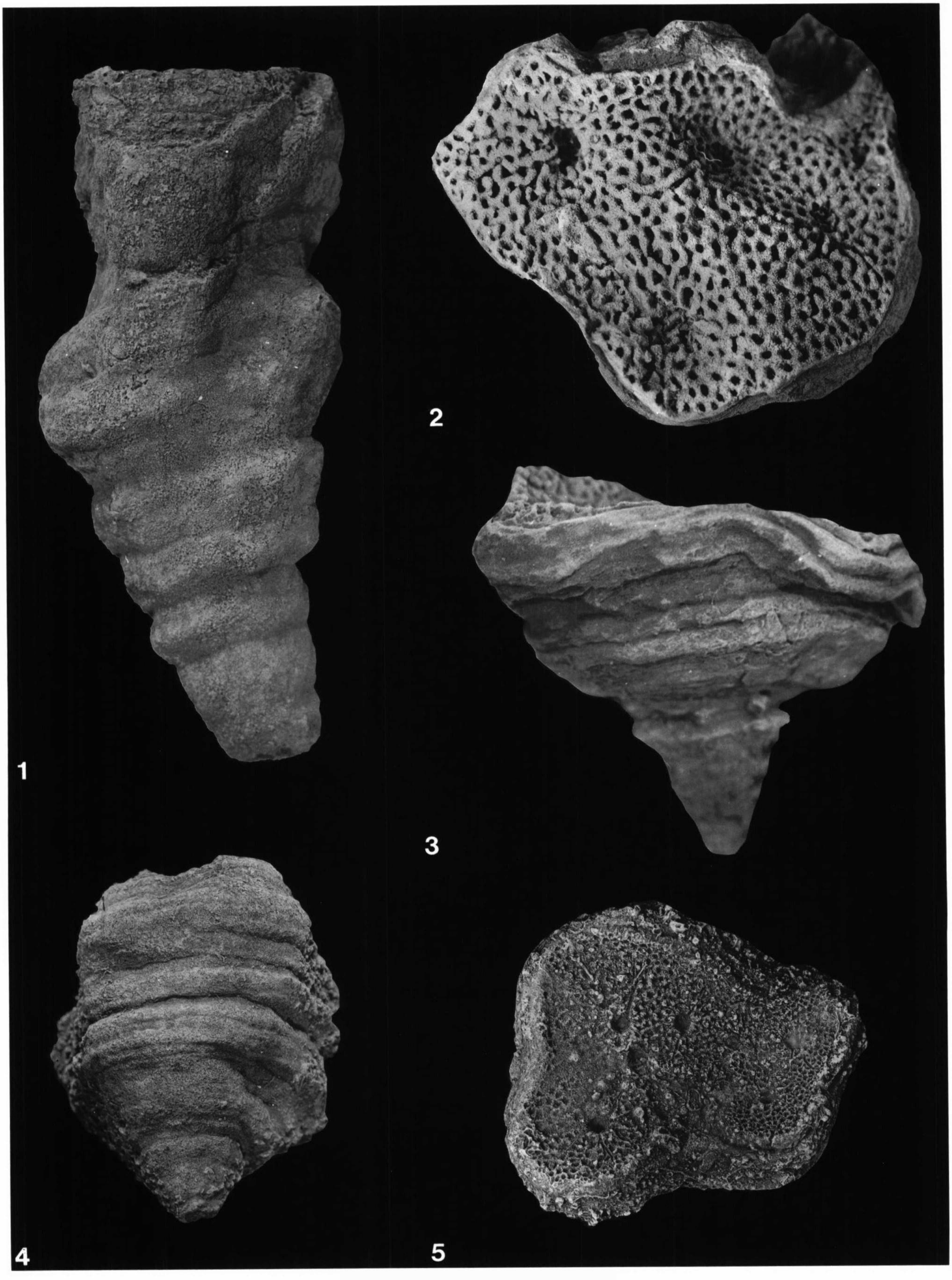
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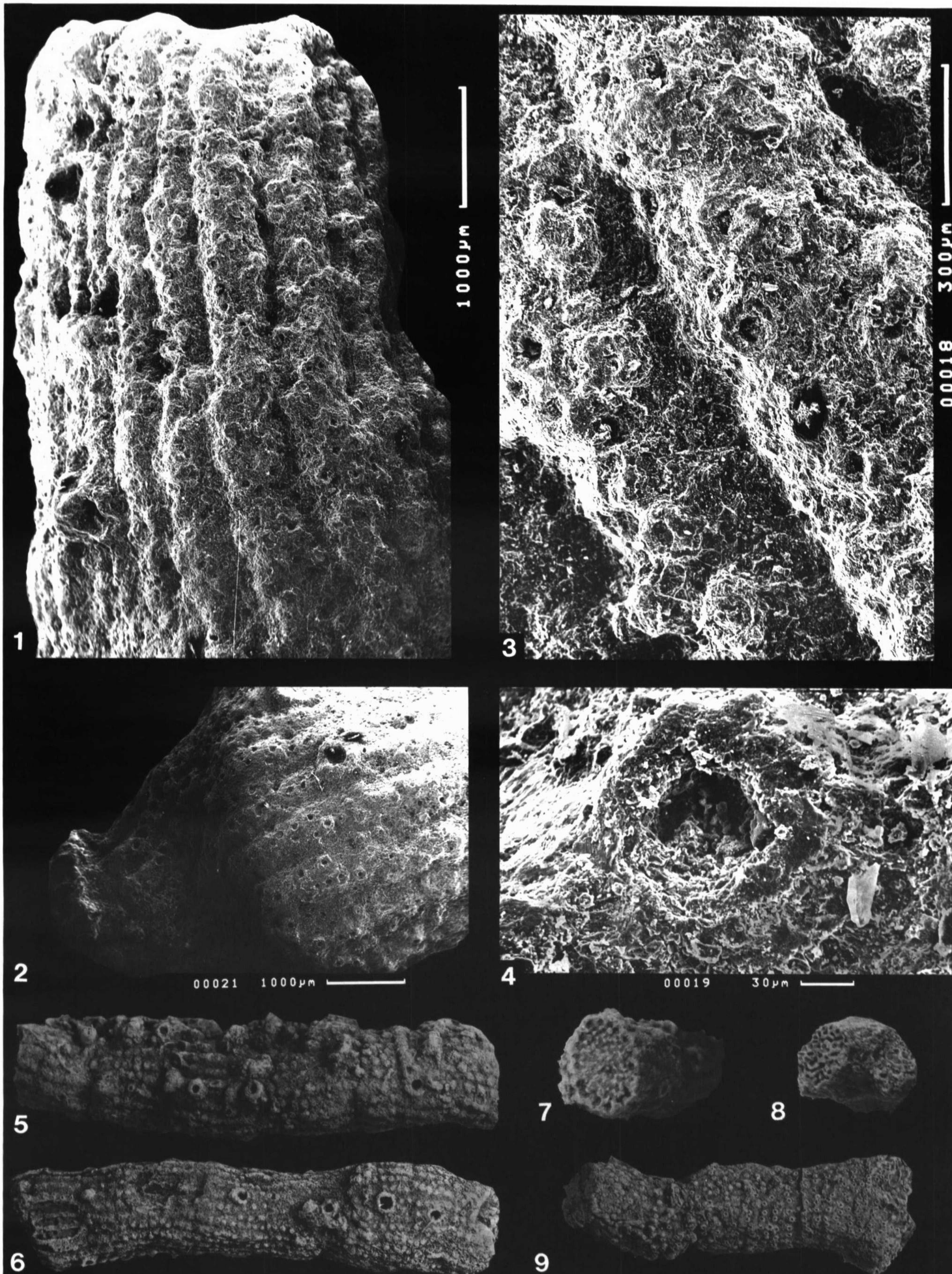
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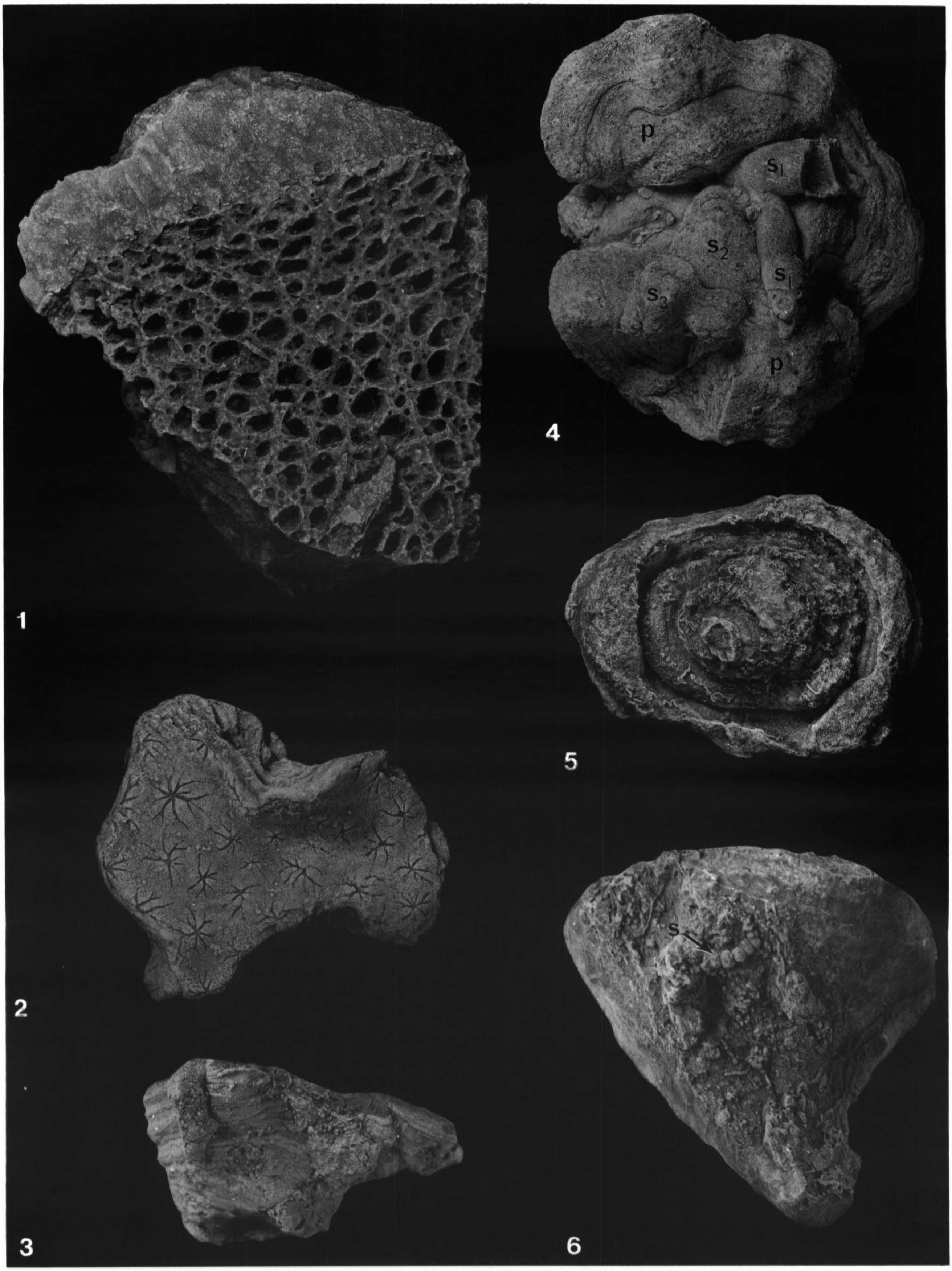
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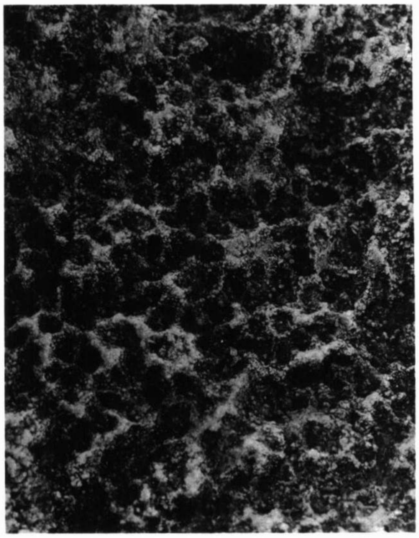

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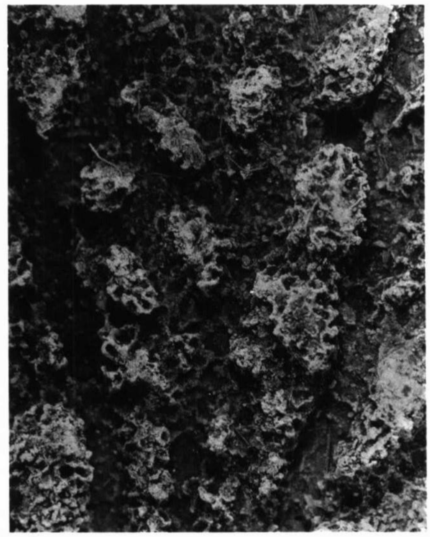

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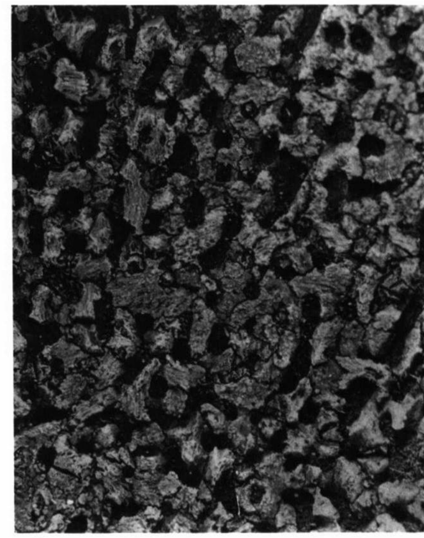

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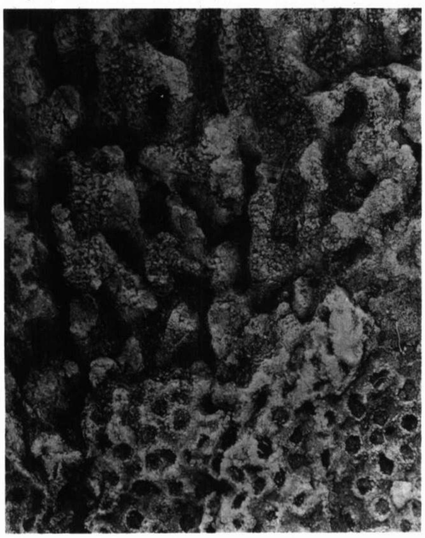

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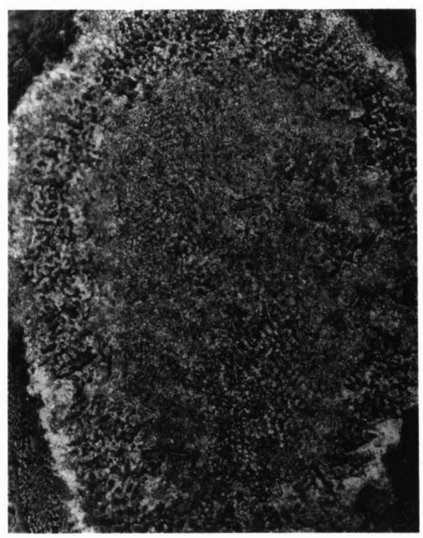

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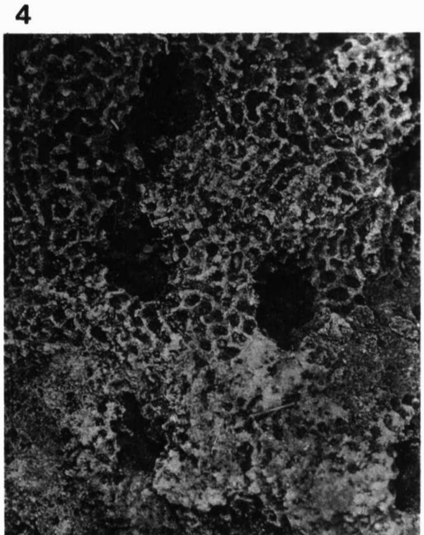

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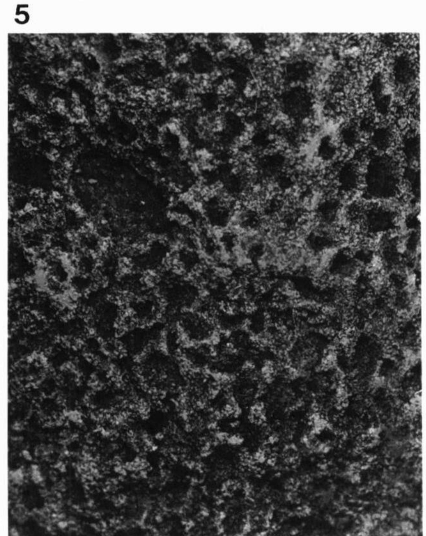

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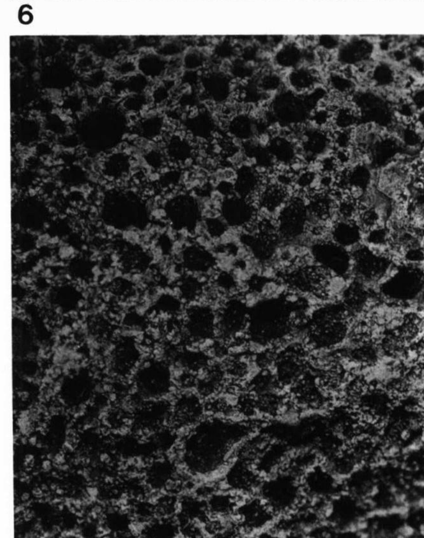

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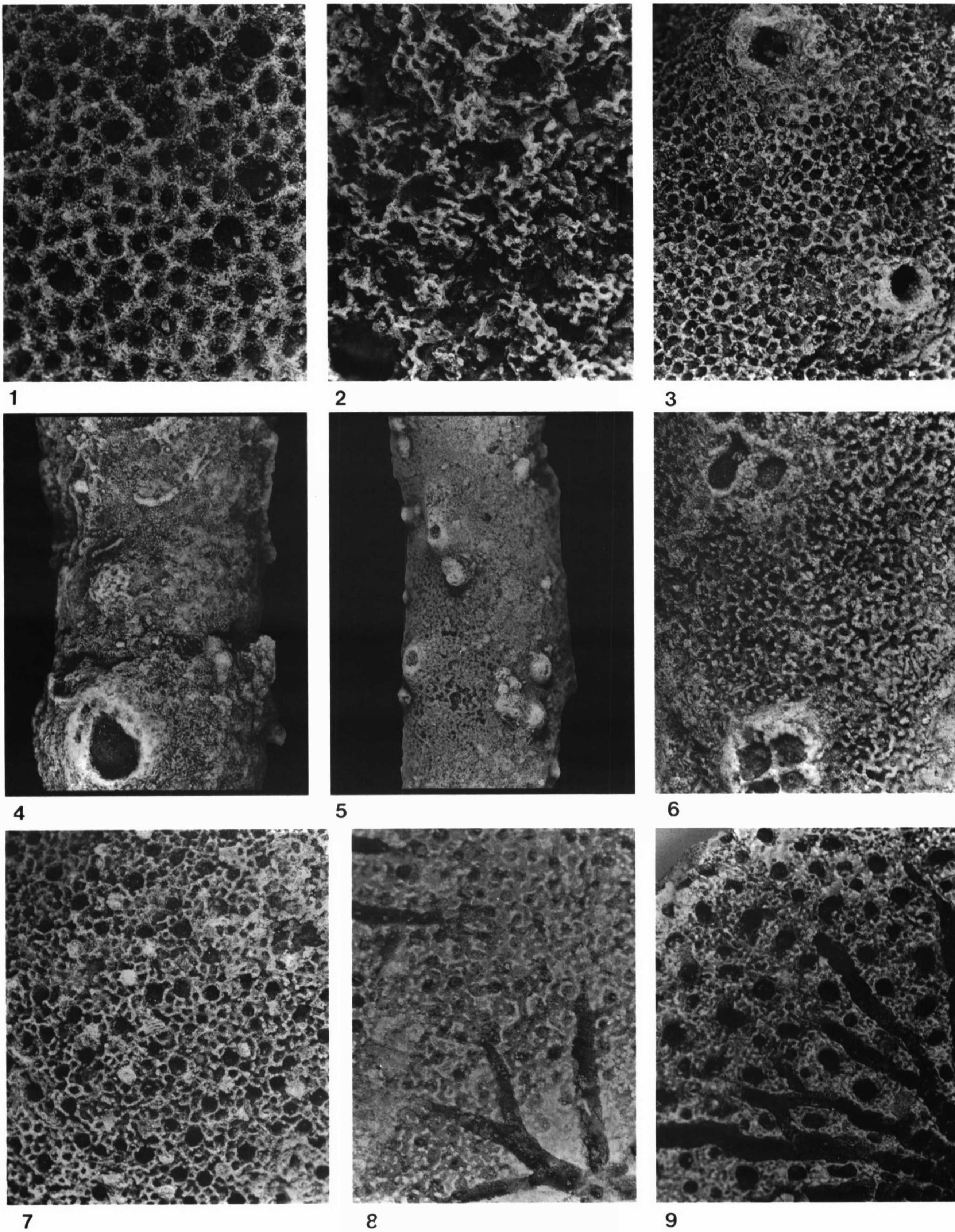
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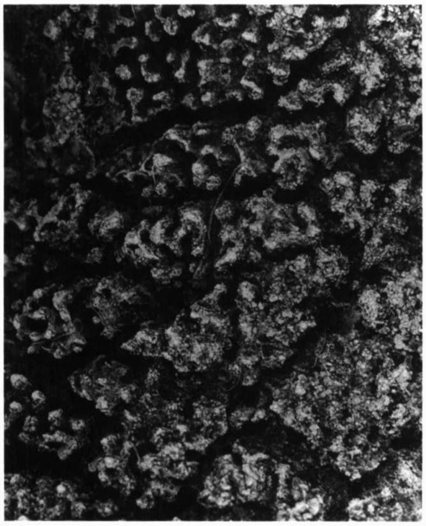
PLATE 46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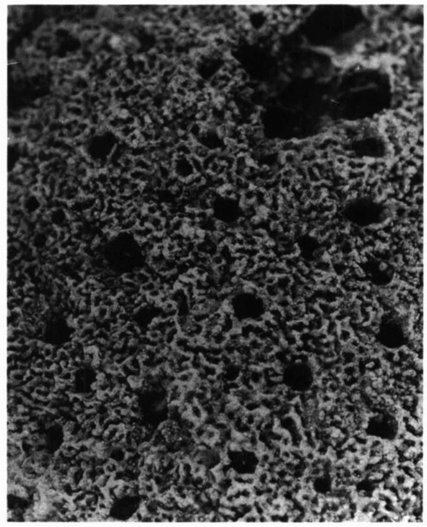
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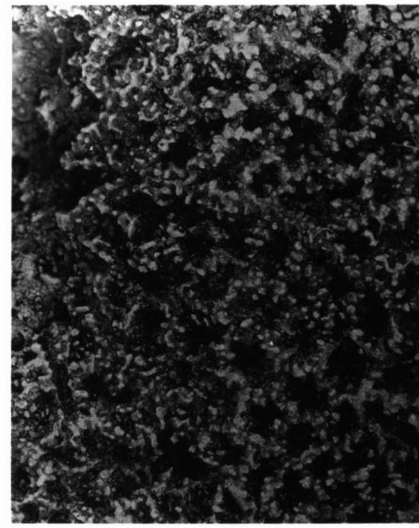
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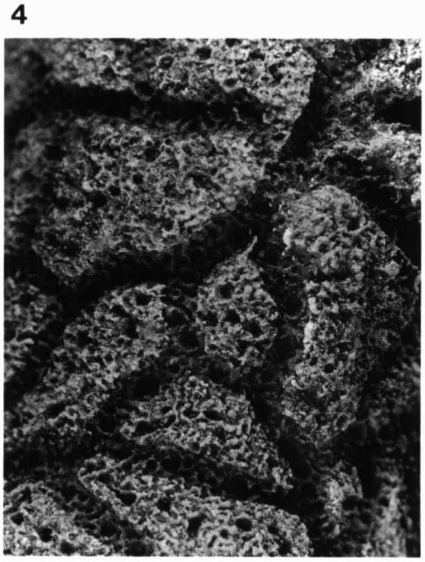
6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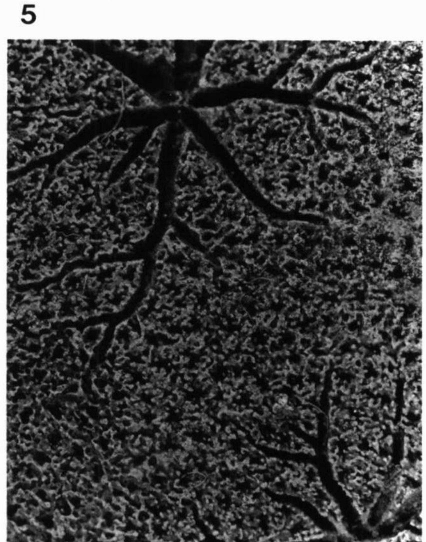
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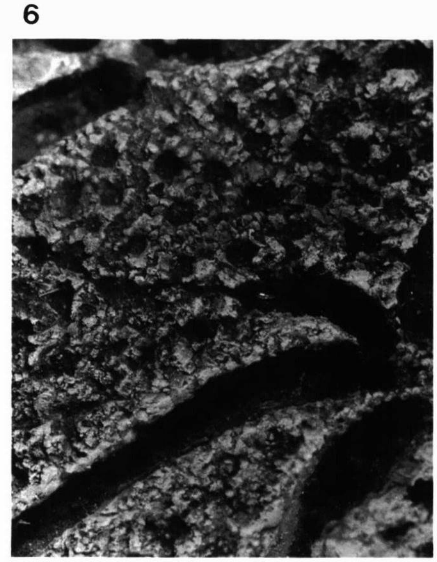
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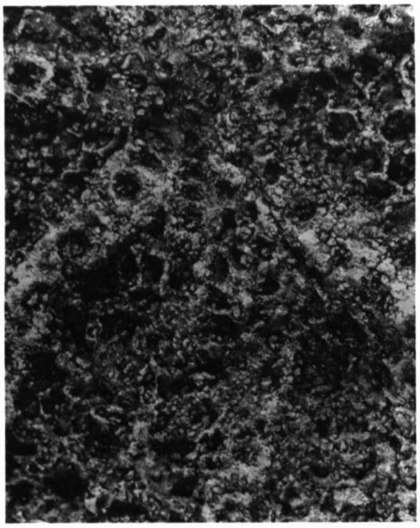

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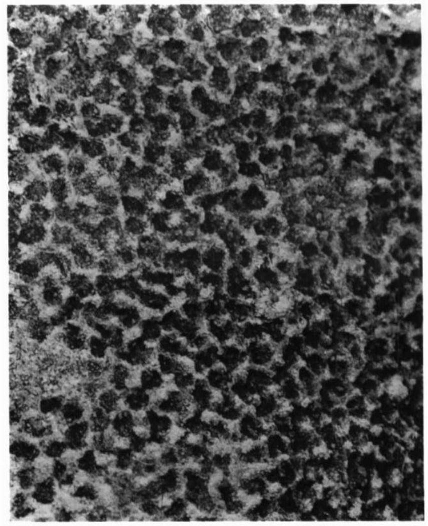

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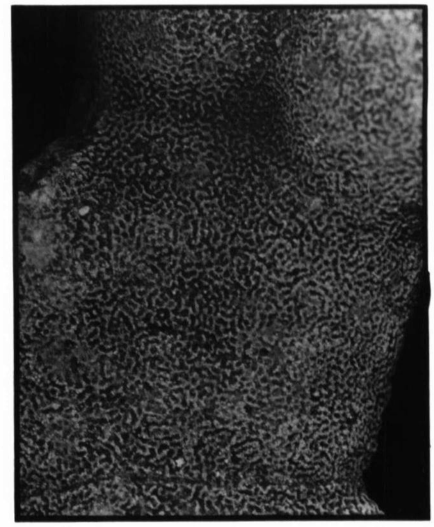

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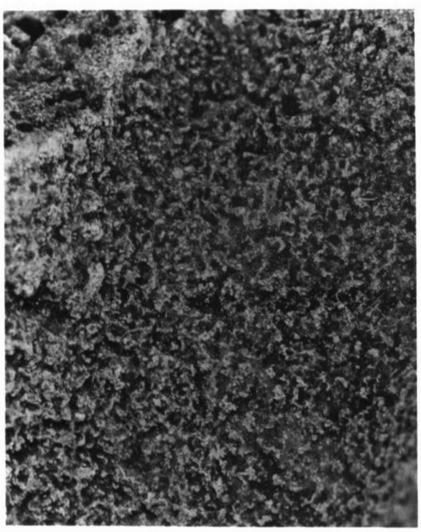

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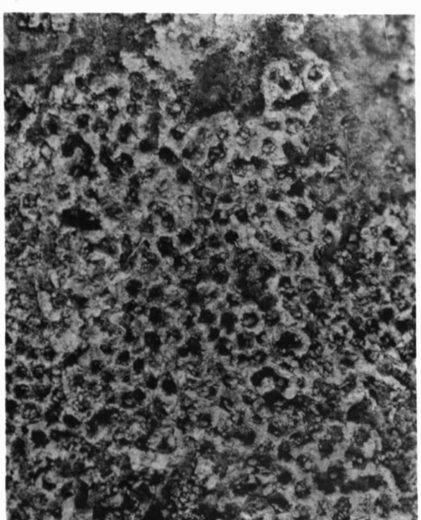
6



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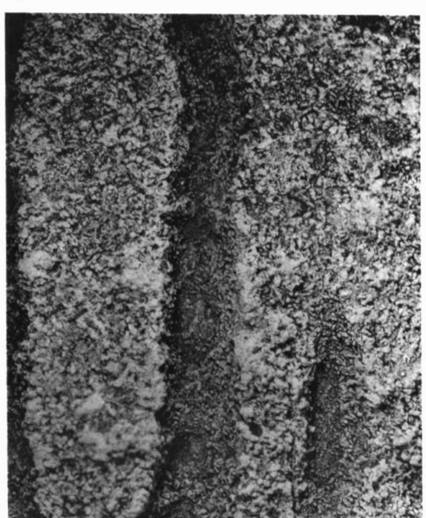

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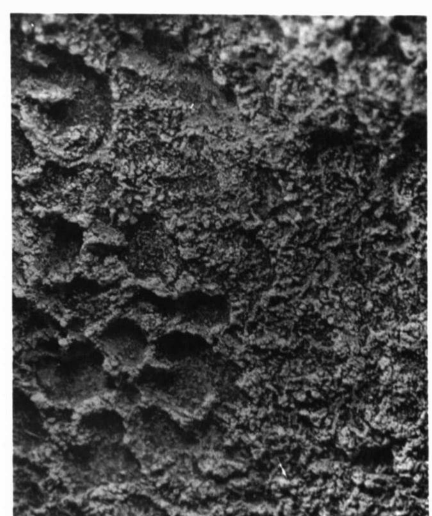
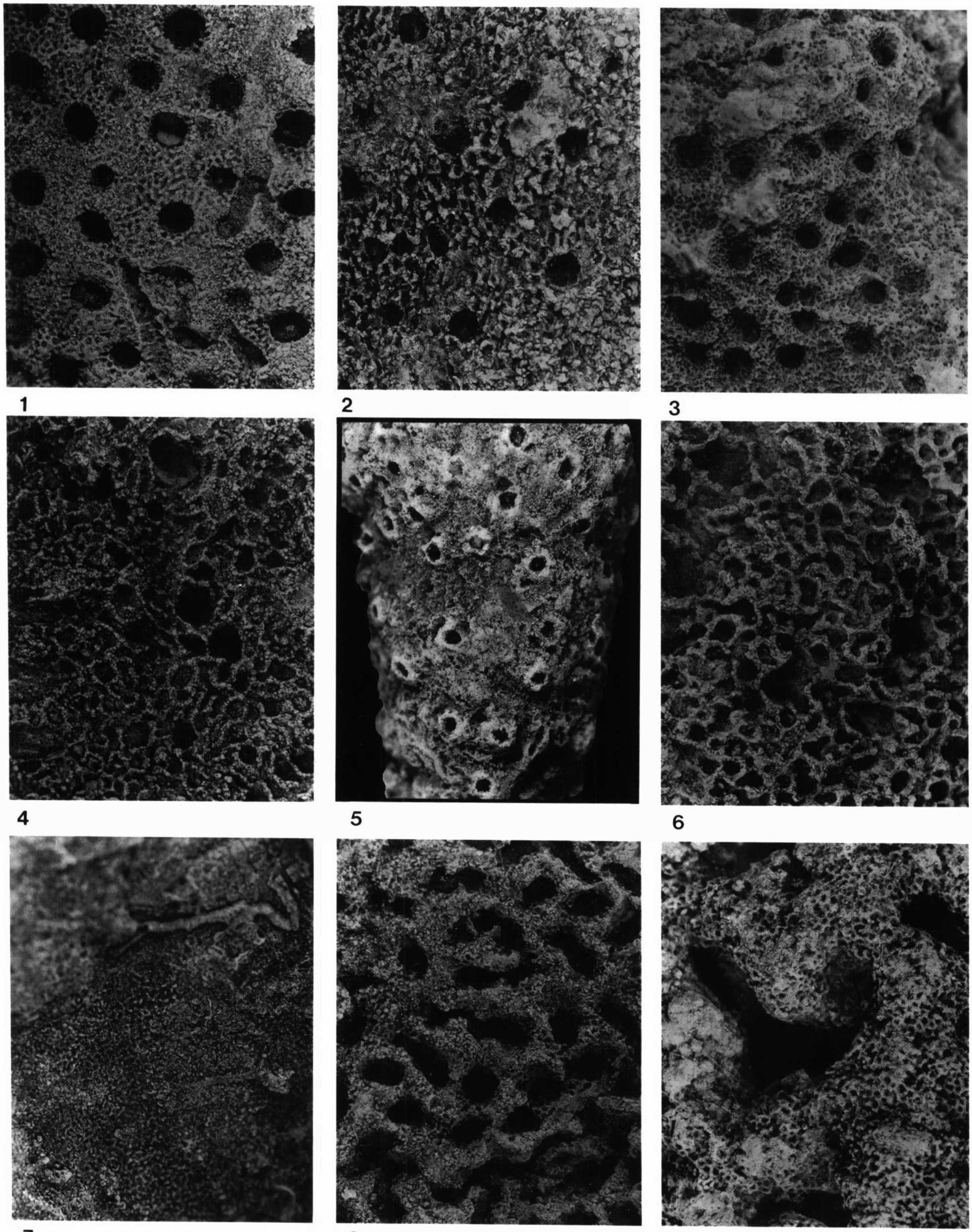
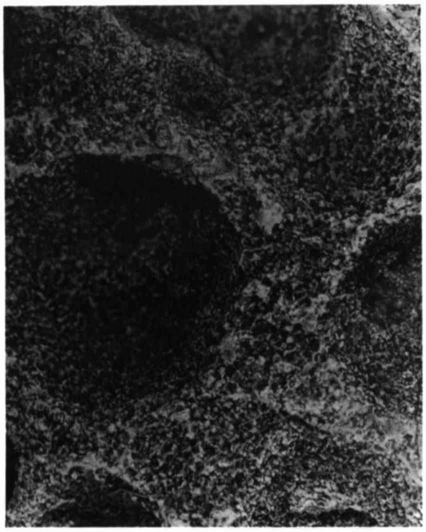


9

PLATE 48





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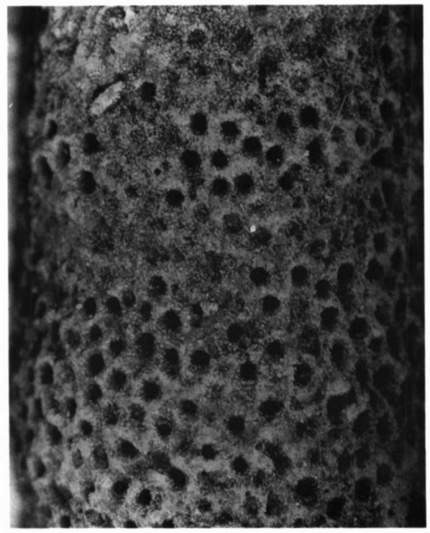

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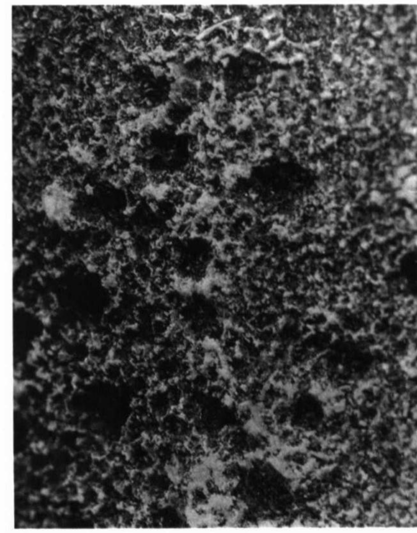

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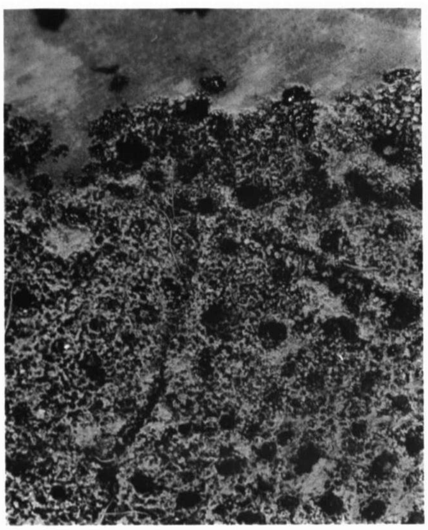

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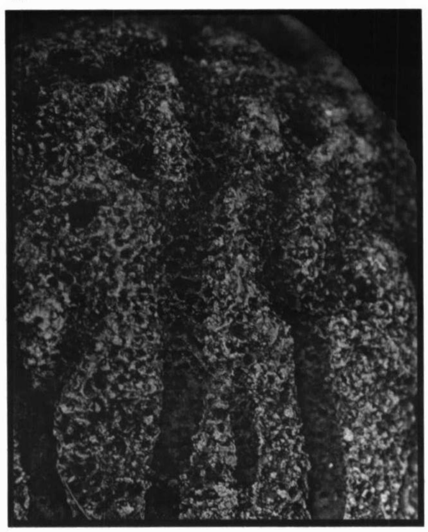

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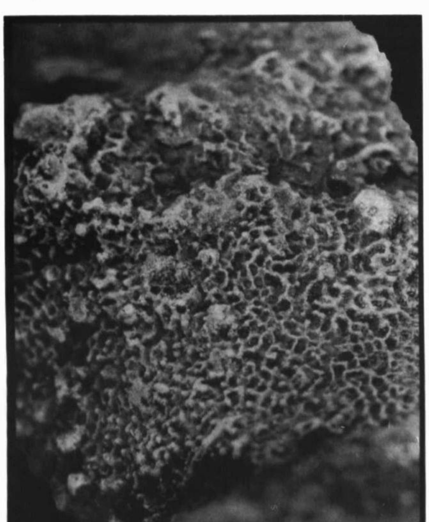
6



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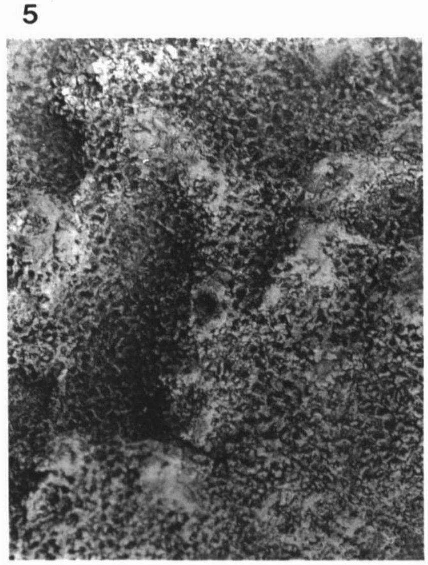
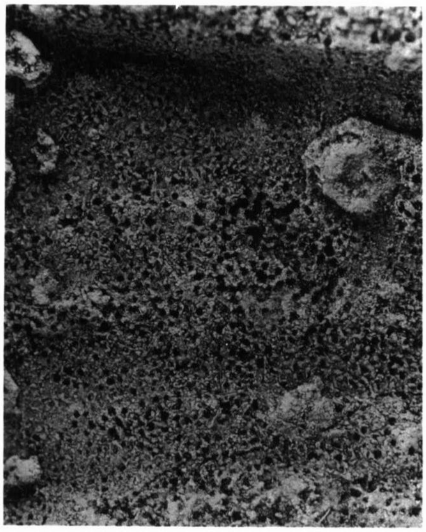


8

9

PLATE 50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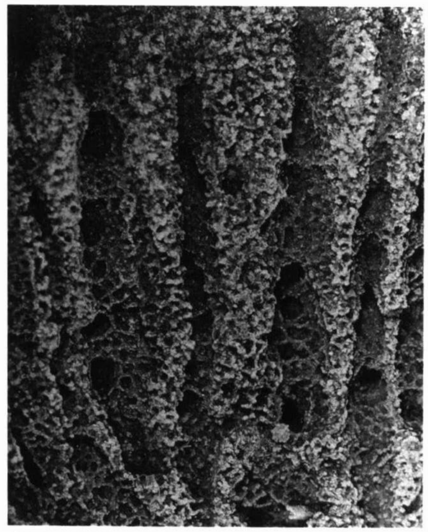
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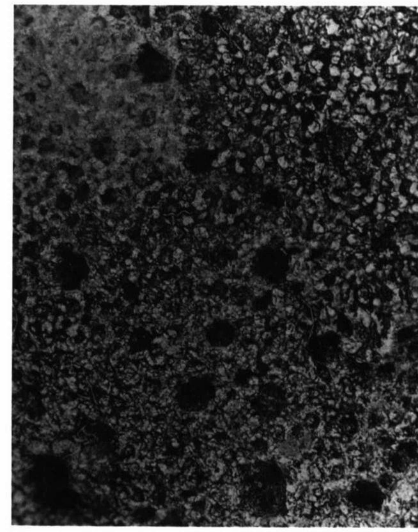
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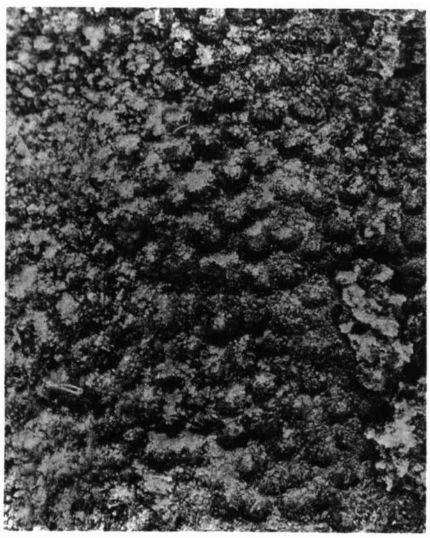
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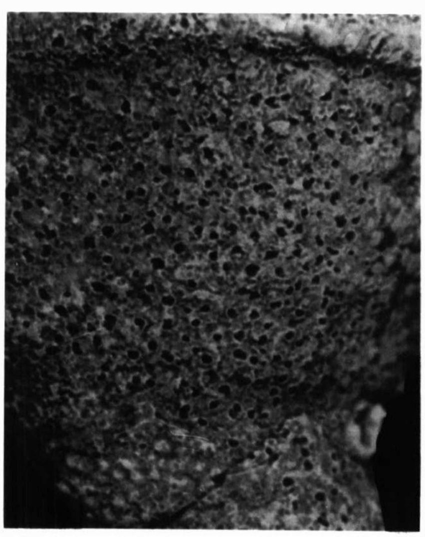
5


6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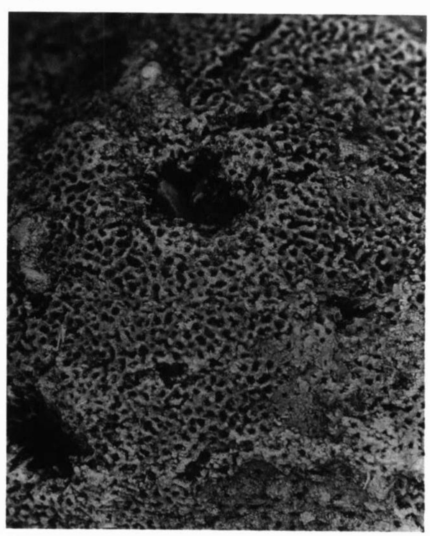
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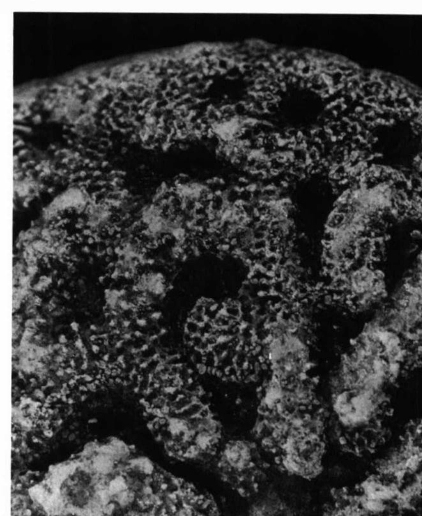
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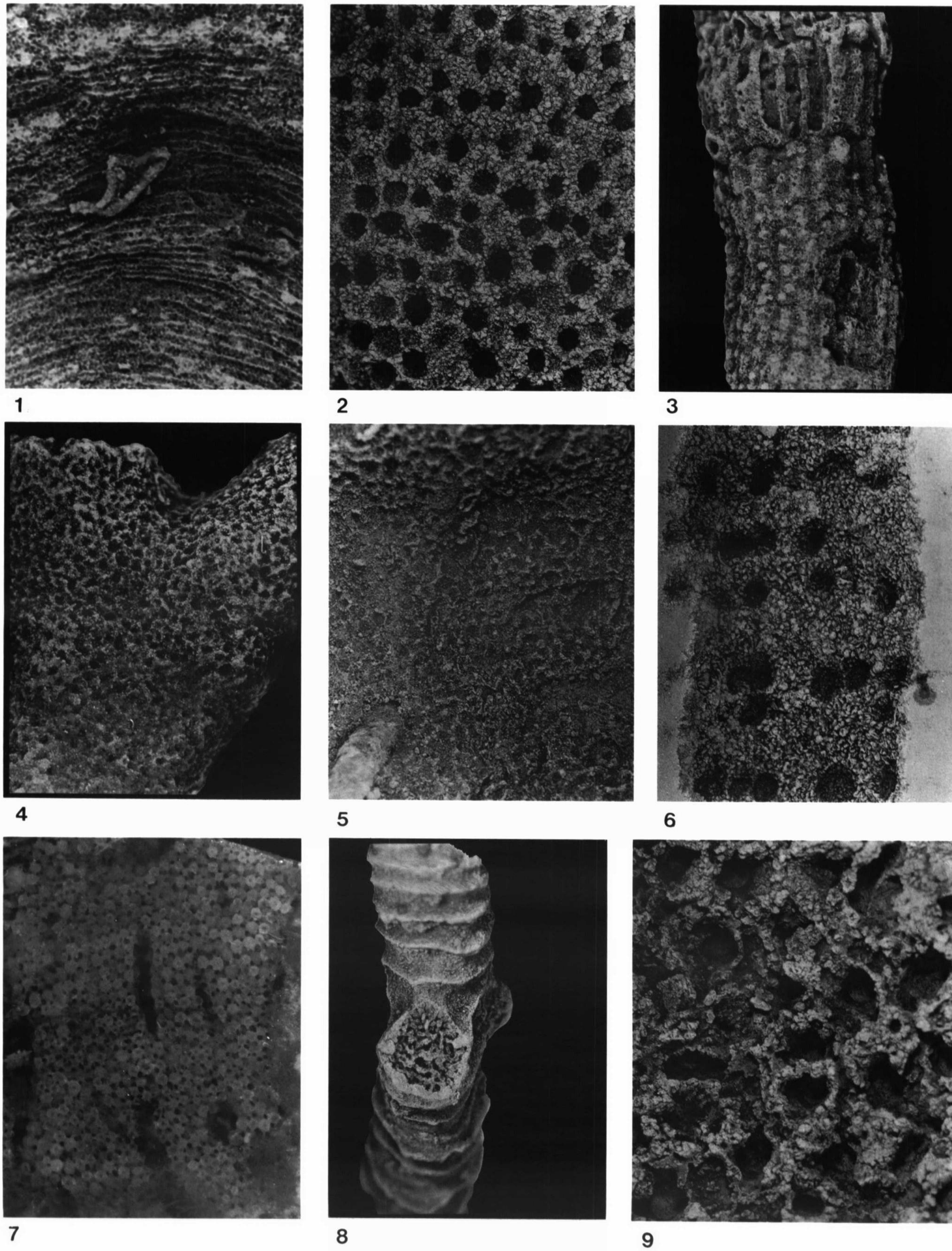
1
2
3
4
5
6
7
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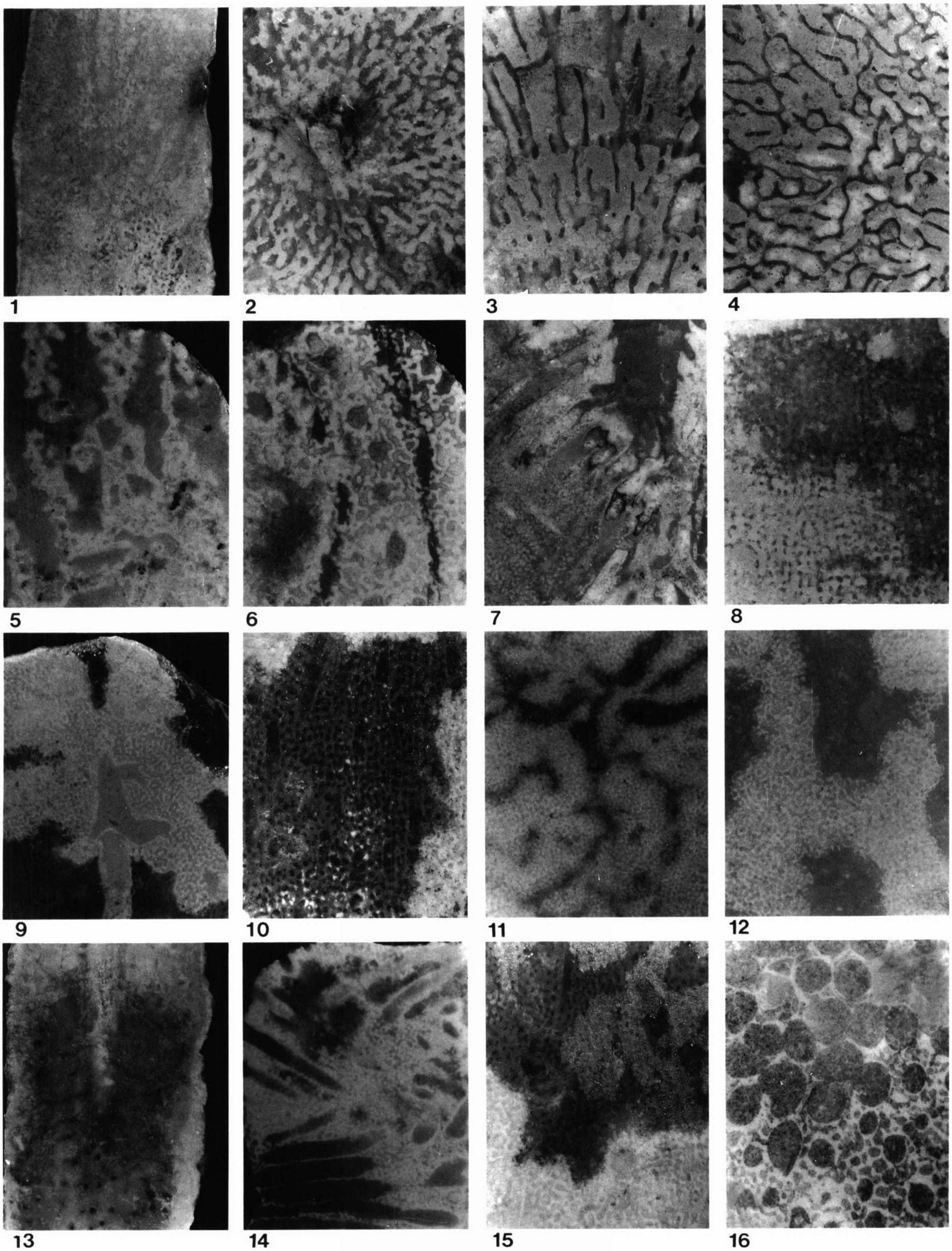
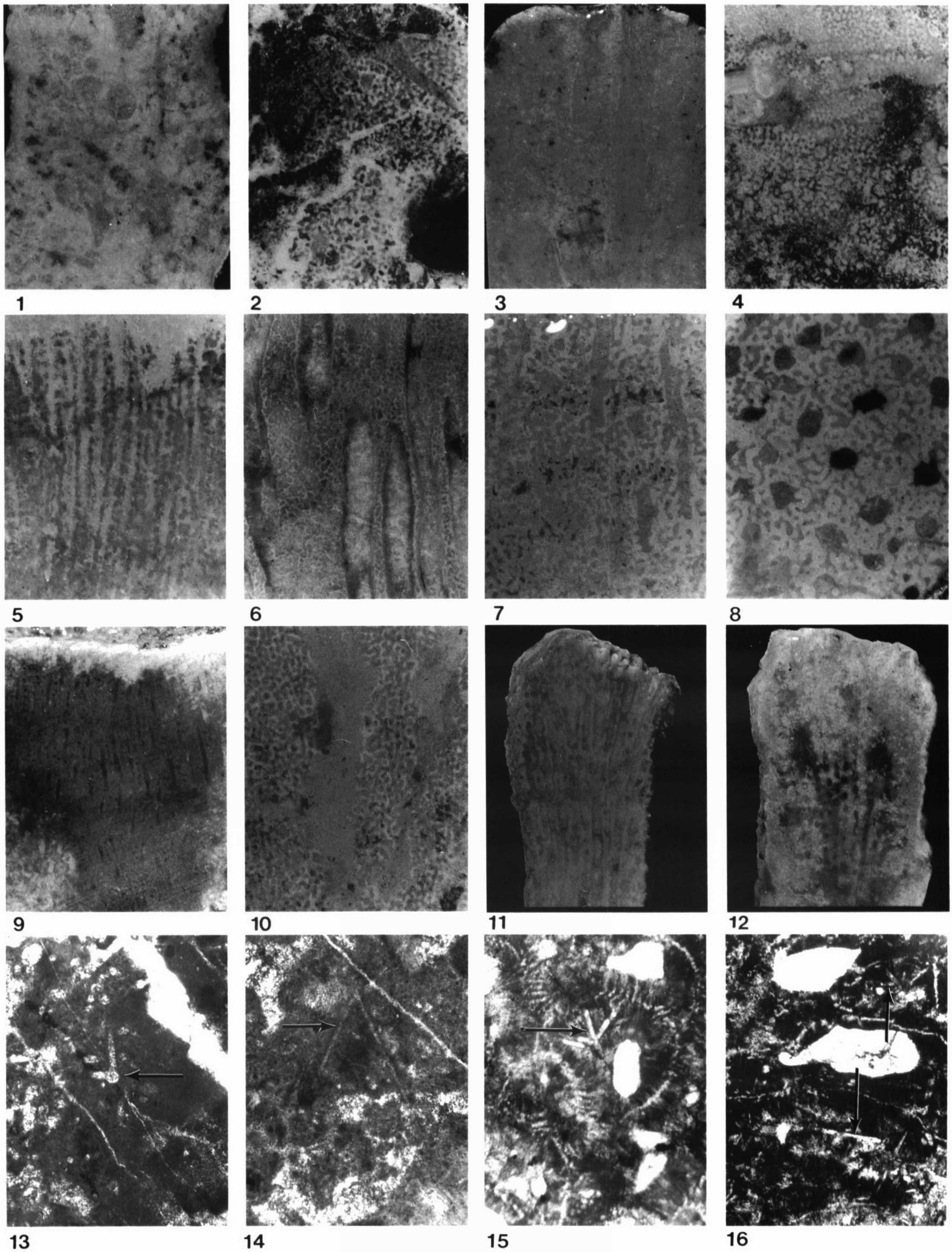
9

PLATE 52




1
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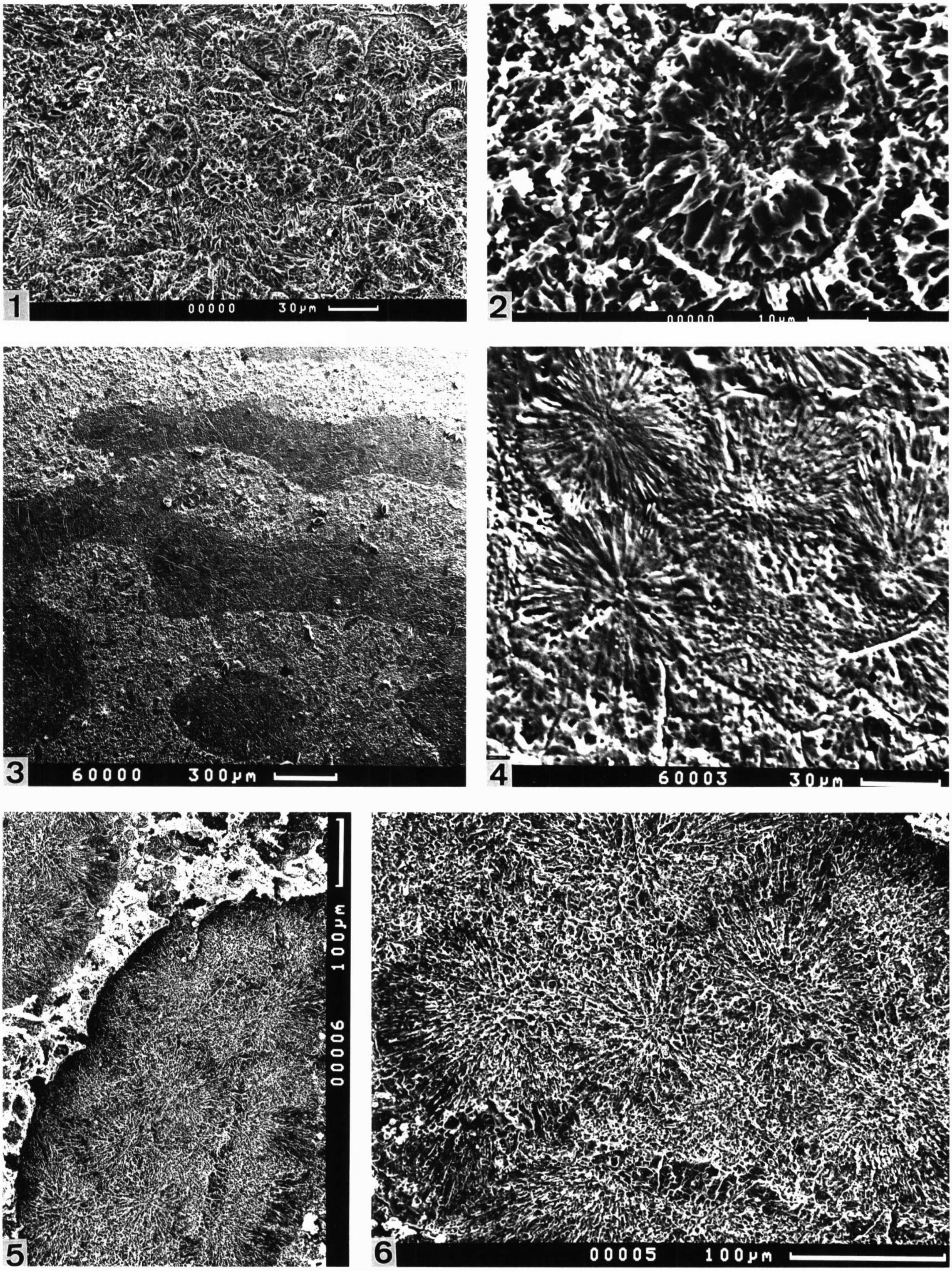
3
4
5
6
7
8
9
10
11
12
13
14
15
16


1
00000 30µm
2
3
60000 300µm
4
60003 30µm
5
00006 100µm
6
00005 100µm

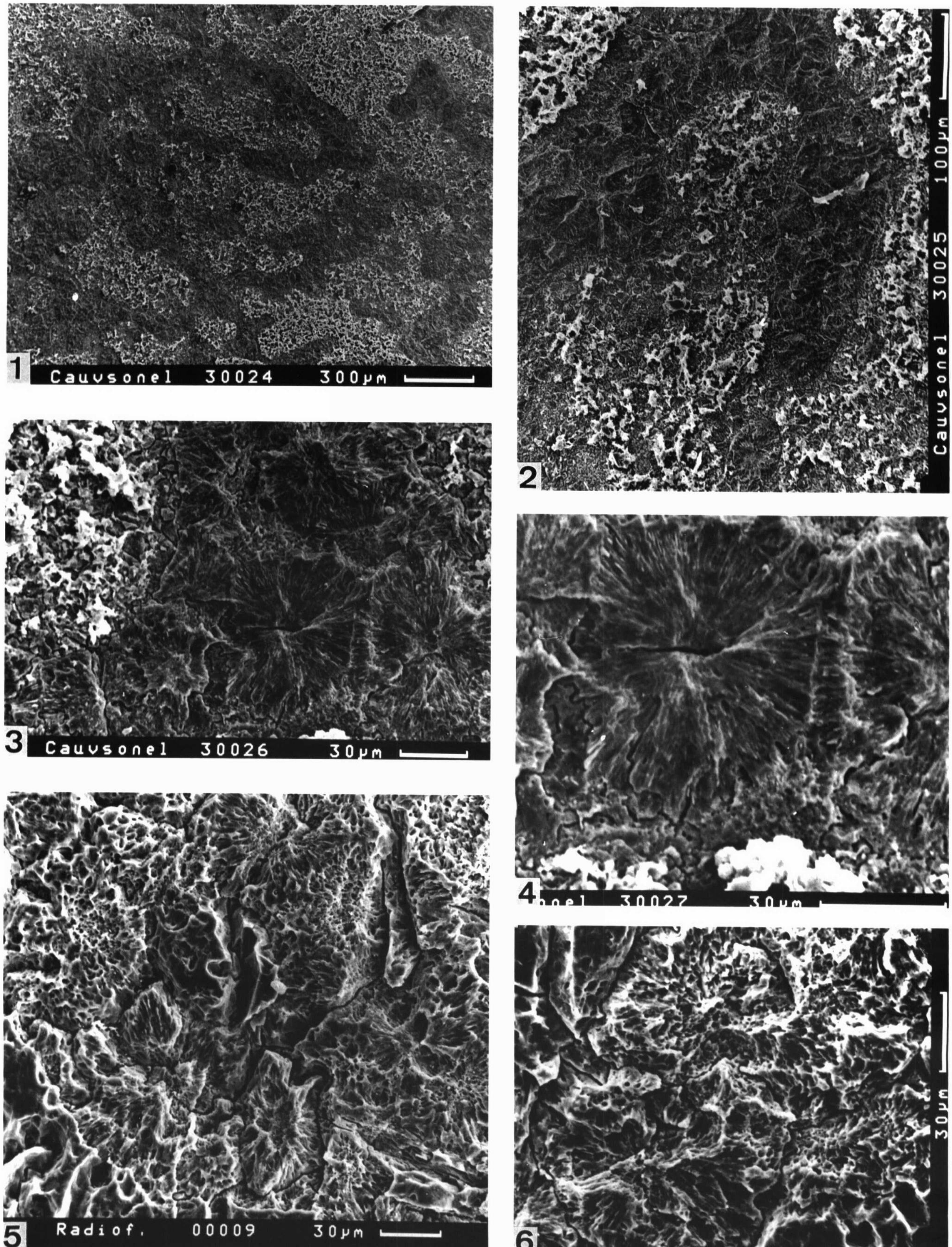
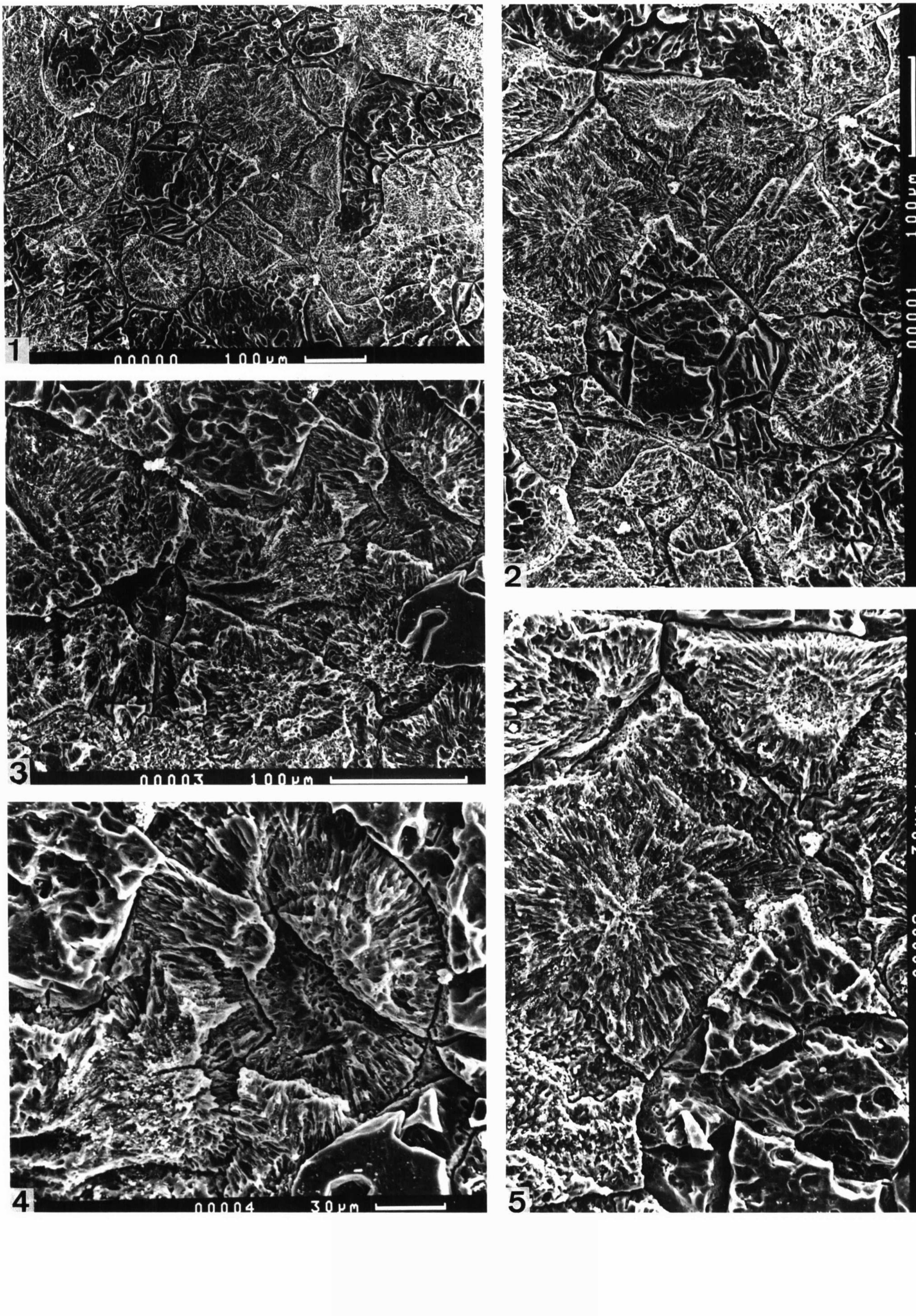

1
Cauvsonel 30024 300µm
2
Cauvsonel 30025 100µm
3
Cauvsonel 30026 30µm
4
30027 30µm
5
Radiof. 00009 30µm
6
30µm

PLATE 56


1
00000 100µm
2
00001 100µm
3
00003 100µm
4
00004 30µm
5
00002 30µm

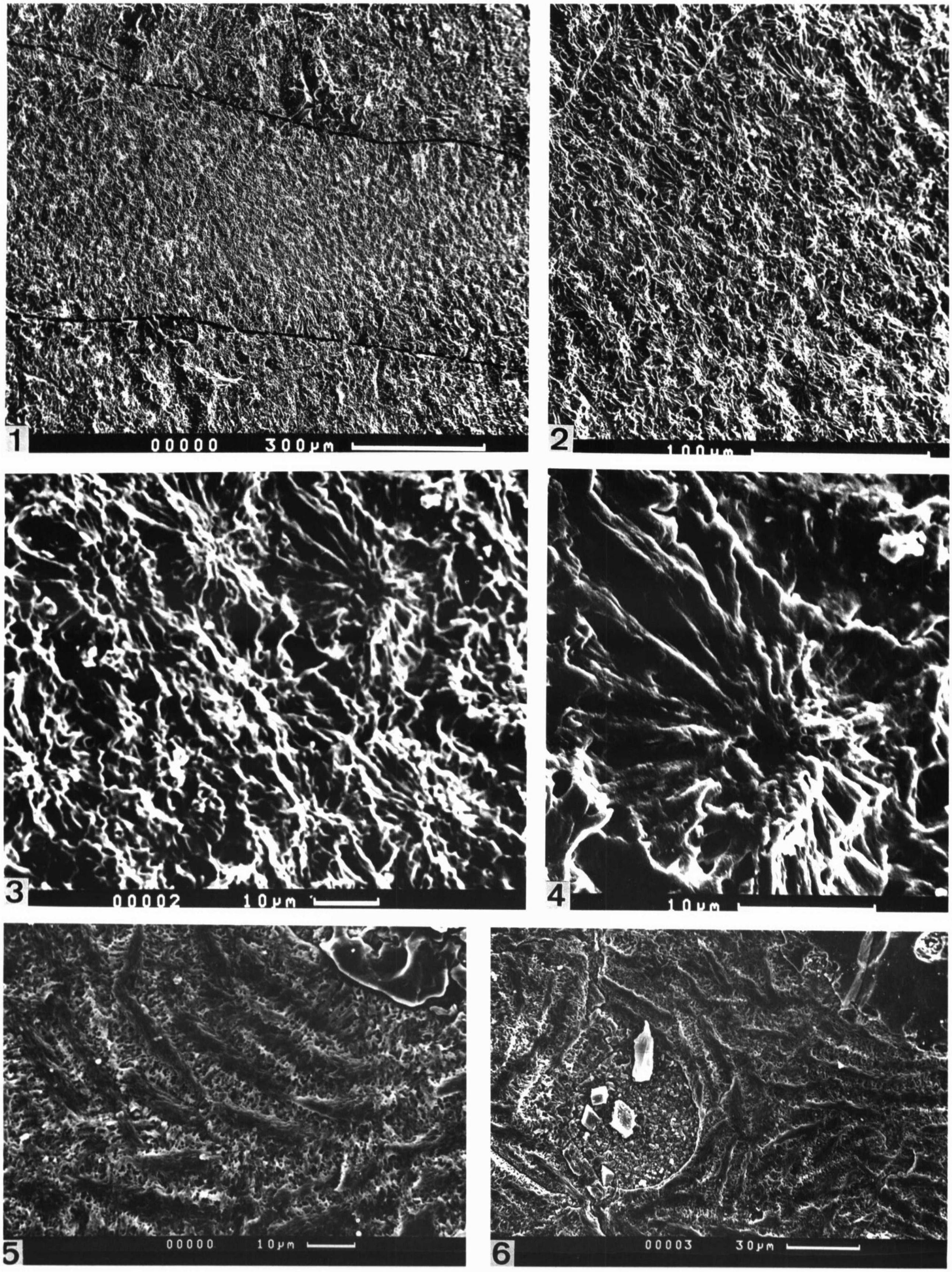
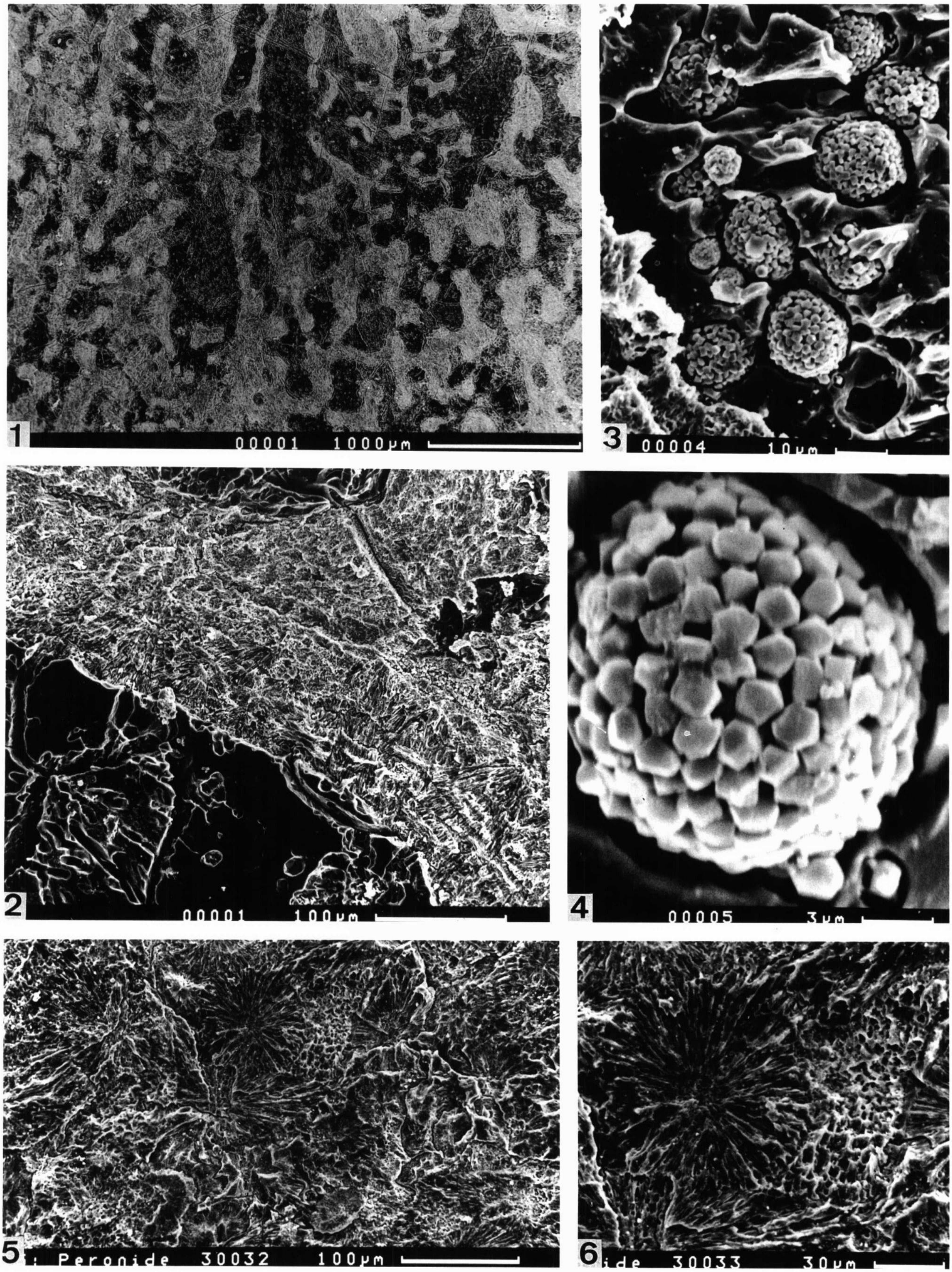

1
00000 300µm
2
100µm
3
00002 10µm
4
10µm
5
00000 10µm
6
00003 30µm

PLATE 58


1
00001 1000µm
3
00004 10µm
2
00001 100µm
4
00005 3µm
5
: Peronide 30032 100µm
6
ide 30033 30µm

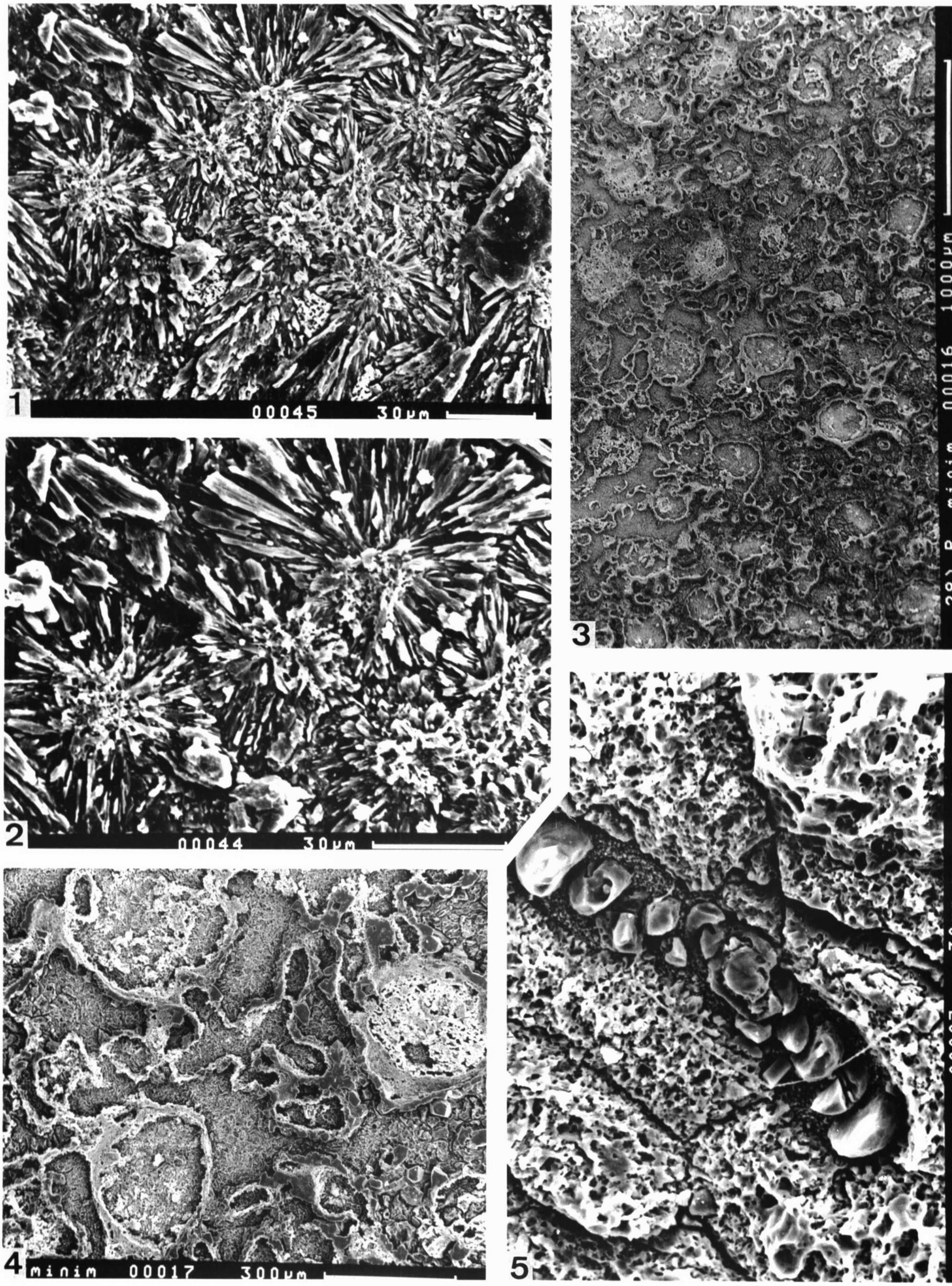
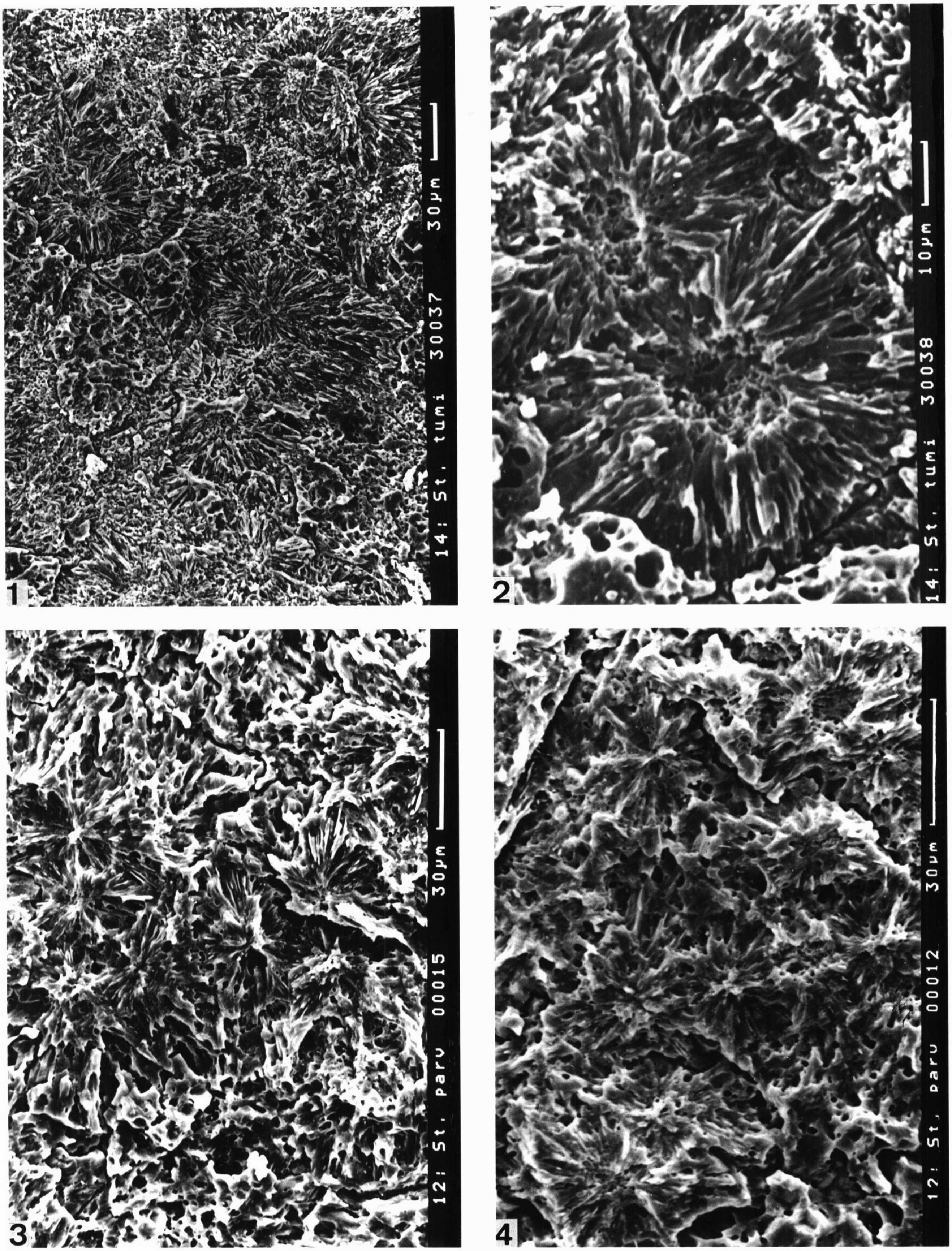
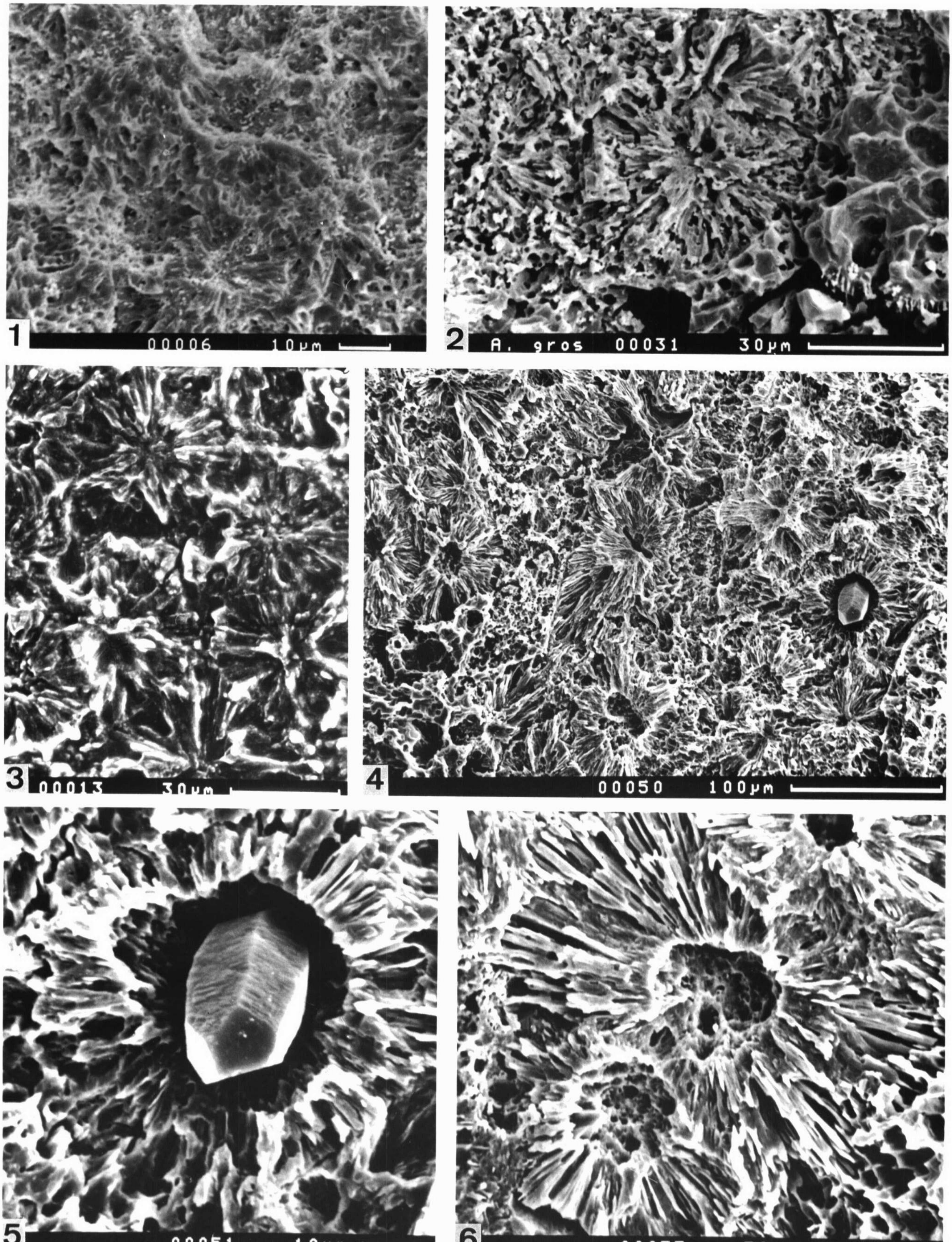
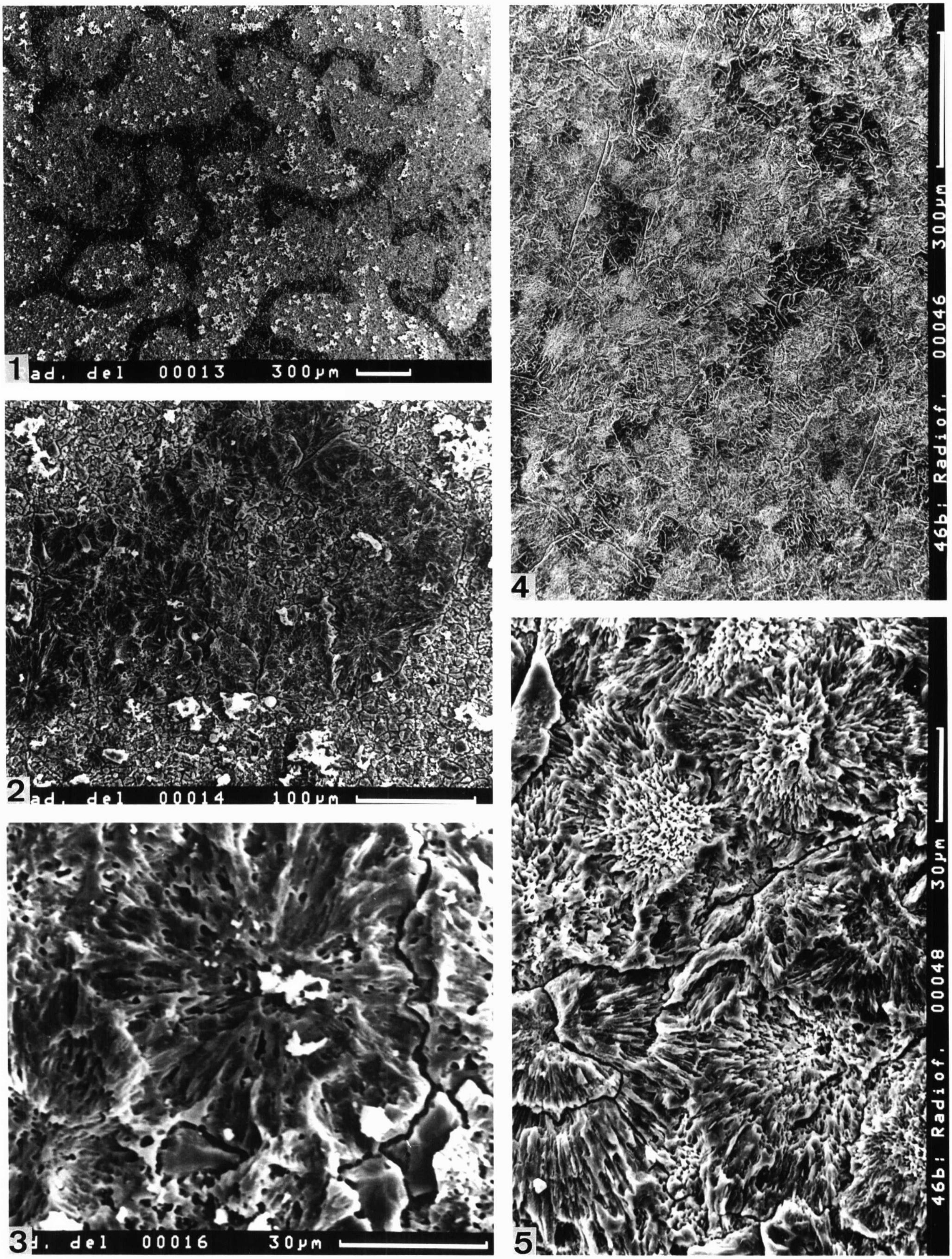

1
00045 30μm
2
00044 30μm
3
28) P. minim 00016 1000μm
4
minim 00017 300μm
5
00007 30μm

PLATE 60


1
14: St. tumi 30037 30µm
2
14: St. tumi 30038 10µm
3
12: St. parv 00015 30µm
4
12: St. parv 00012 30µm


1
00006 10µm
2
A. gros 00031 30µm
3
00013 30µm
4
00050 100µm
5
00051 10µm
6
00053 30µm


1
ad. del 00013 300µm
2
ad. del 00014 100µm
3
d. del 00016 30µm
4
46b: Radiof. 00046 300µm
5
46b: Radiof. 00048 30µm

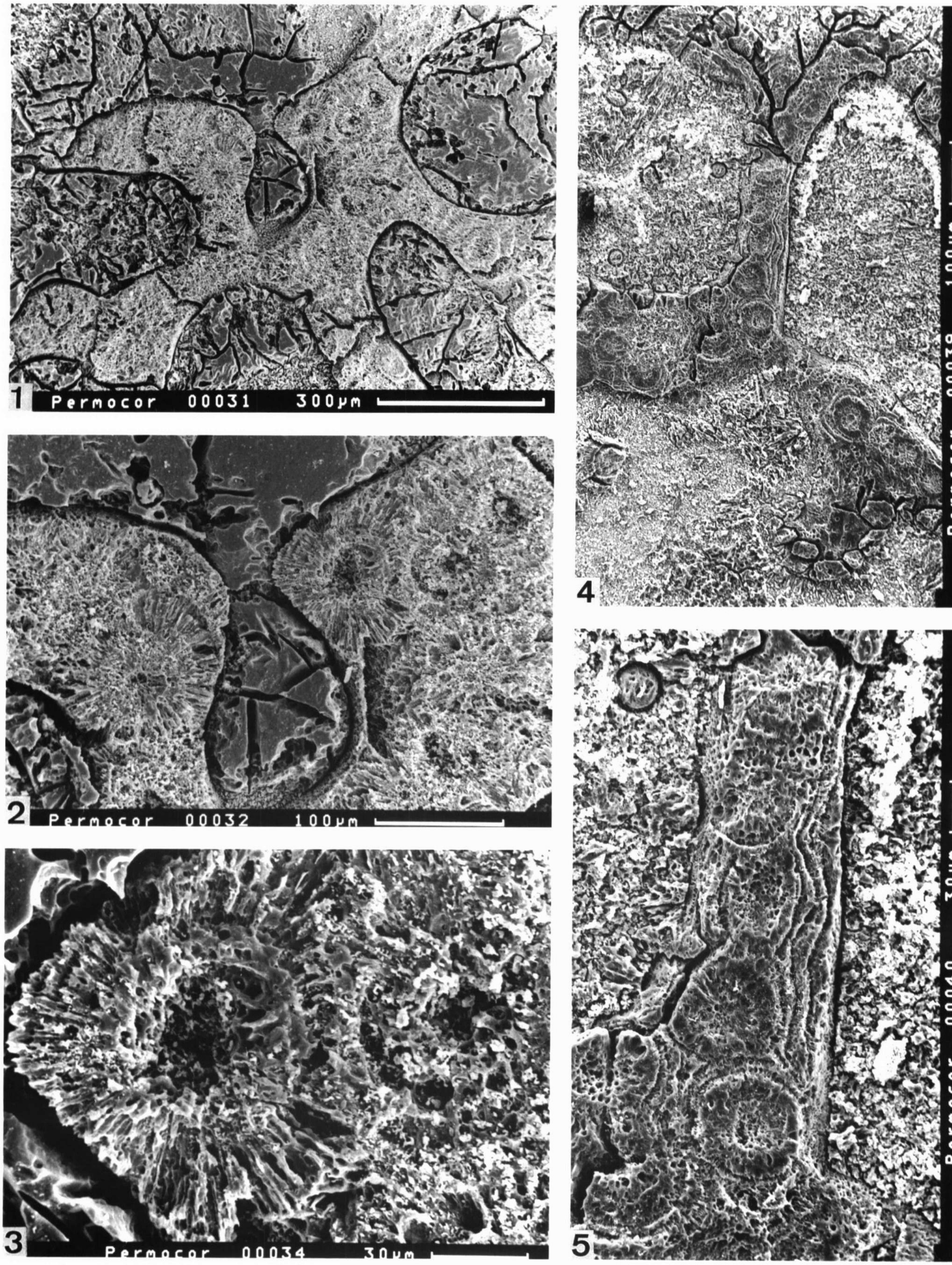
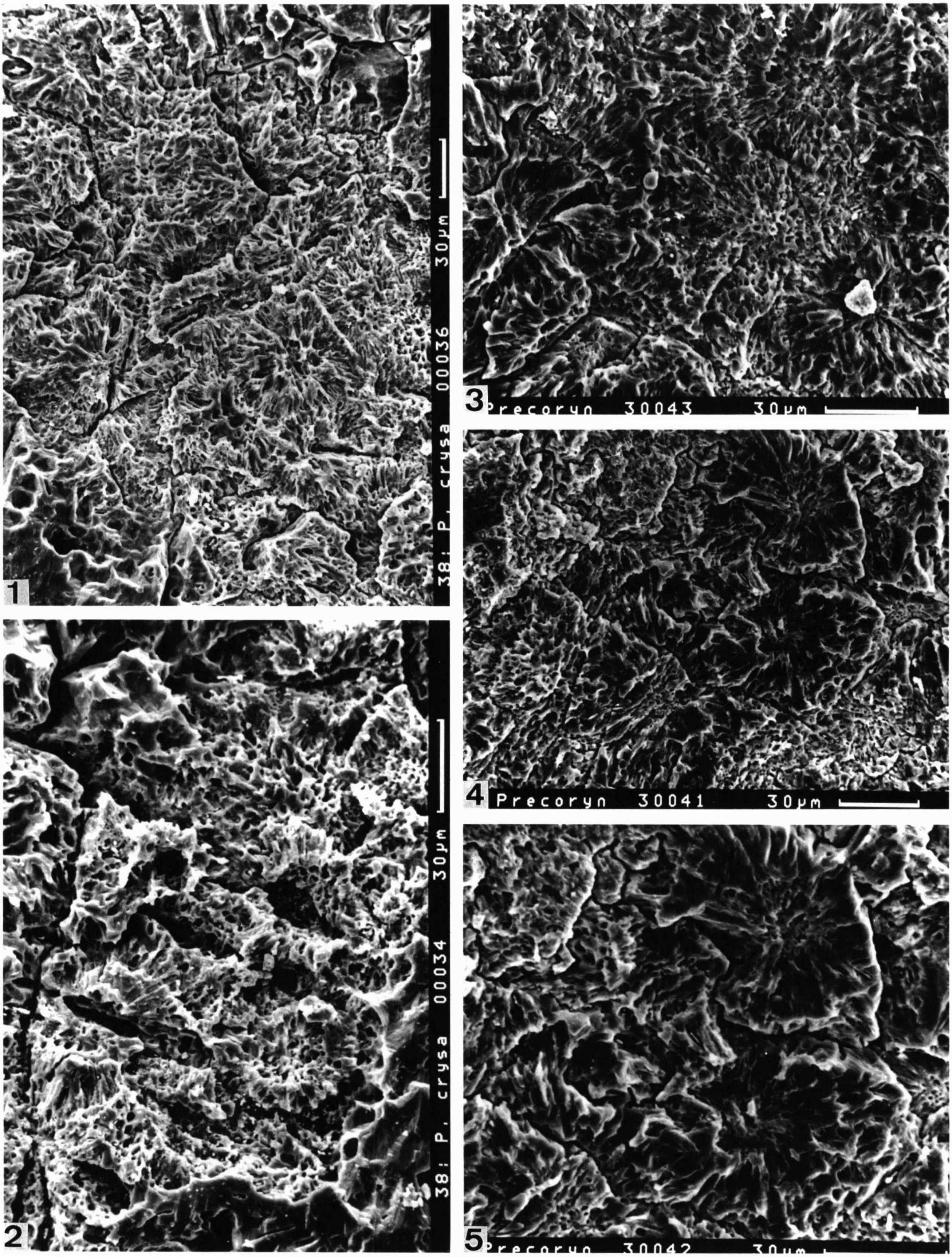
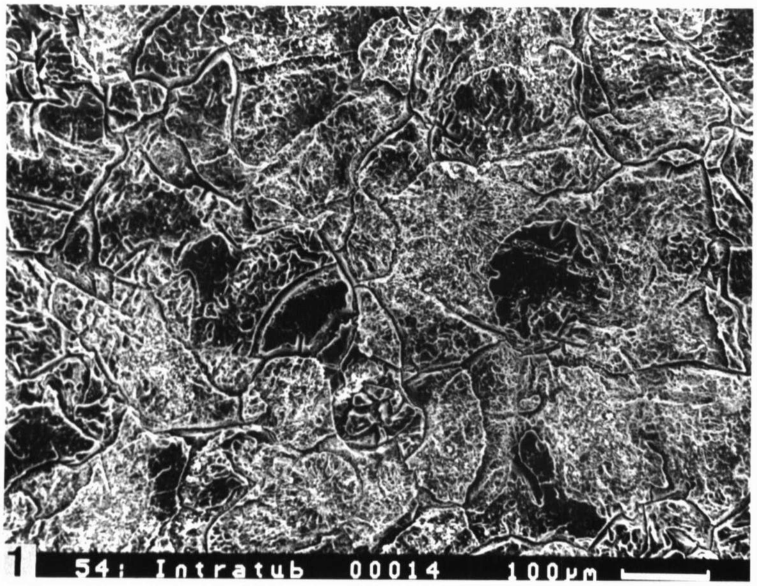
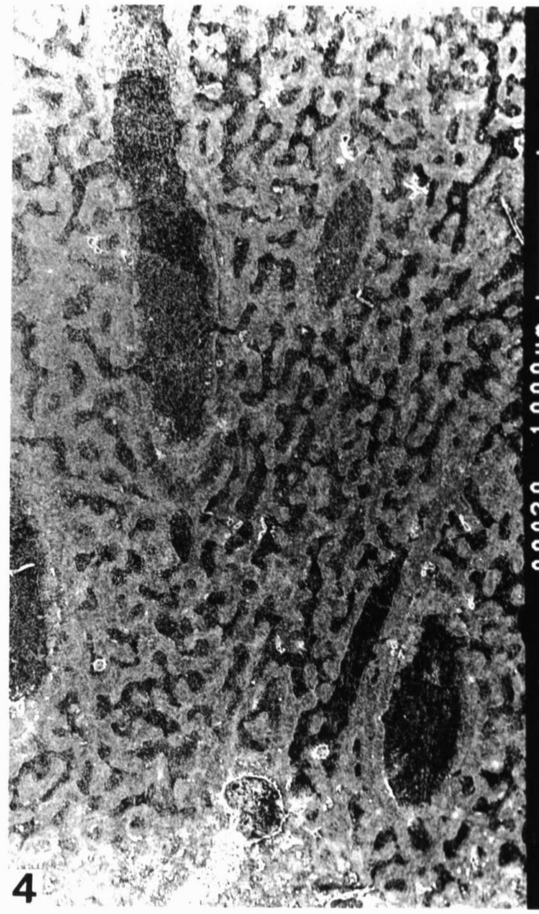
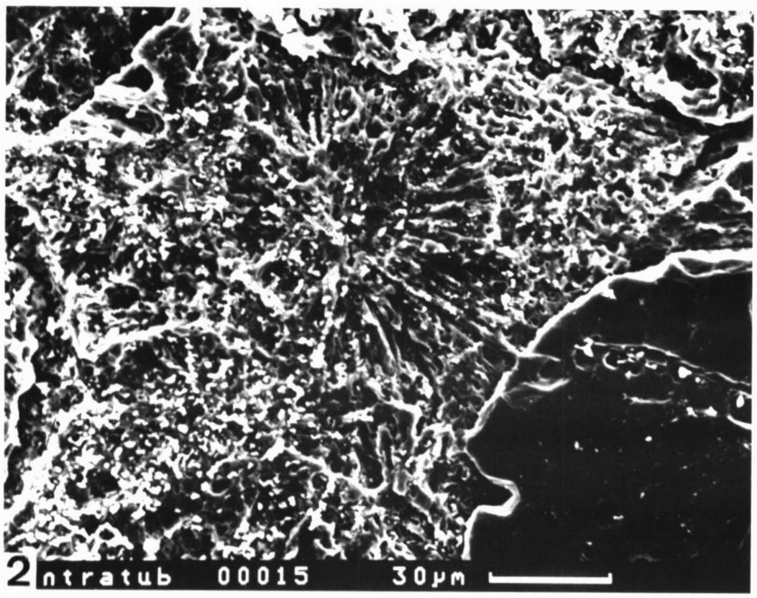

1
Permocor 00031 300μm
2
Permocor 00032 100μm
3
Permocor 00034 30μm
4
Permocor 00039 100μm
5
Permocor 00040 30μm

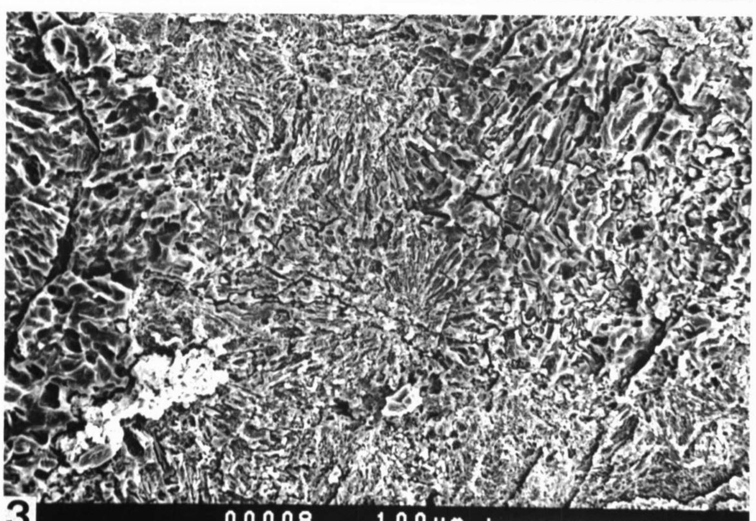
PLATE 64


1
38; P. crysa 00036 30µm
2
38; P. crysa 00034 30µm
3
Precoryn 30043 30µm
4
Precoryn 30041 30µm
5
Precoryn 30042 30µm


54; Intratub 00014 100μm
1


00020 1000μm
4


ntratub 00015 30μm
2


00008 100μm
3

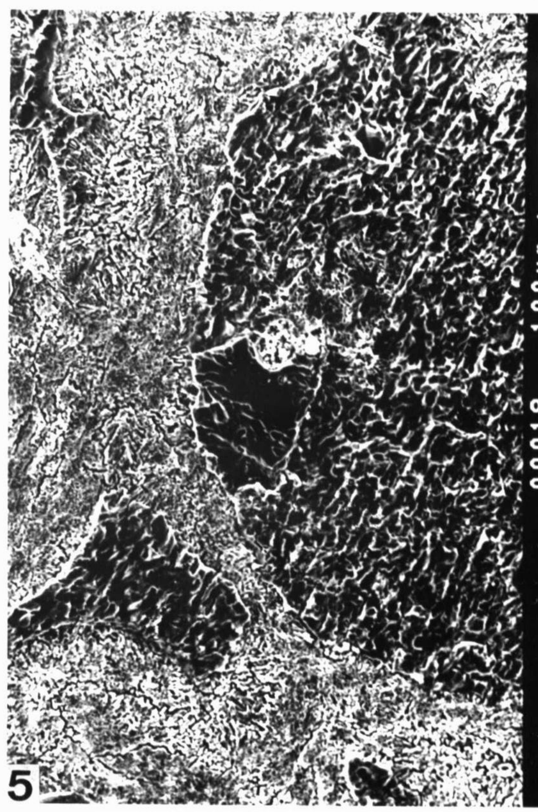
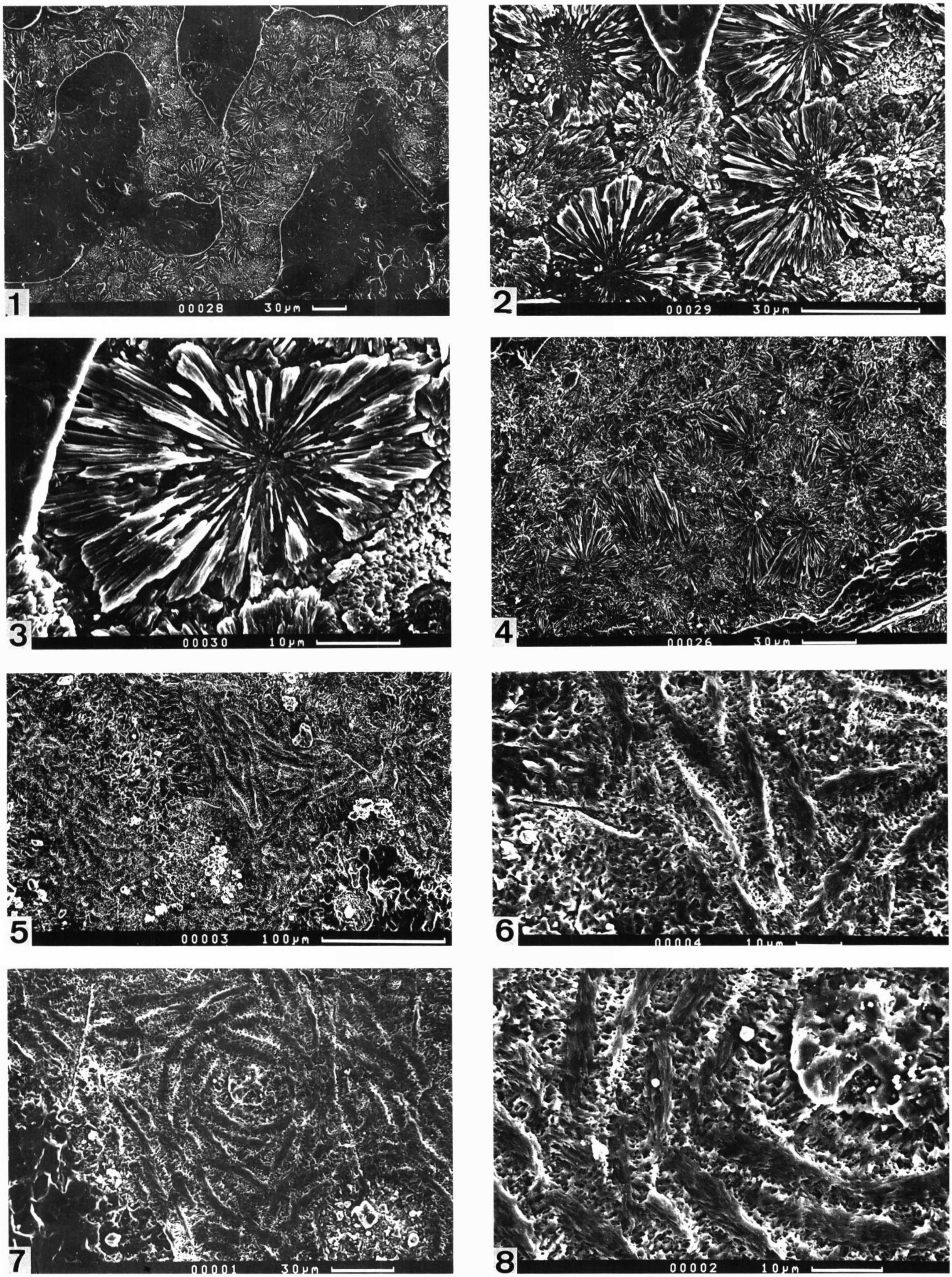

00018 100μm
5

PLATE 66


1
00028 30µm
2
00029 30µm
3
00030 10µm
4
00026 30µm
5
00003 100µm
6
00004 10µm
7
00001 30µm
8
00002 10µm

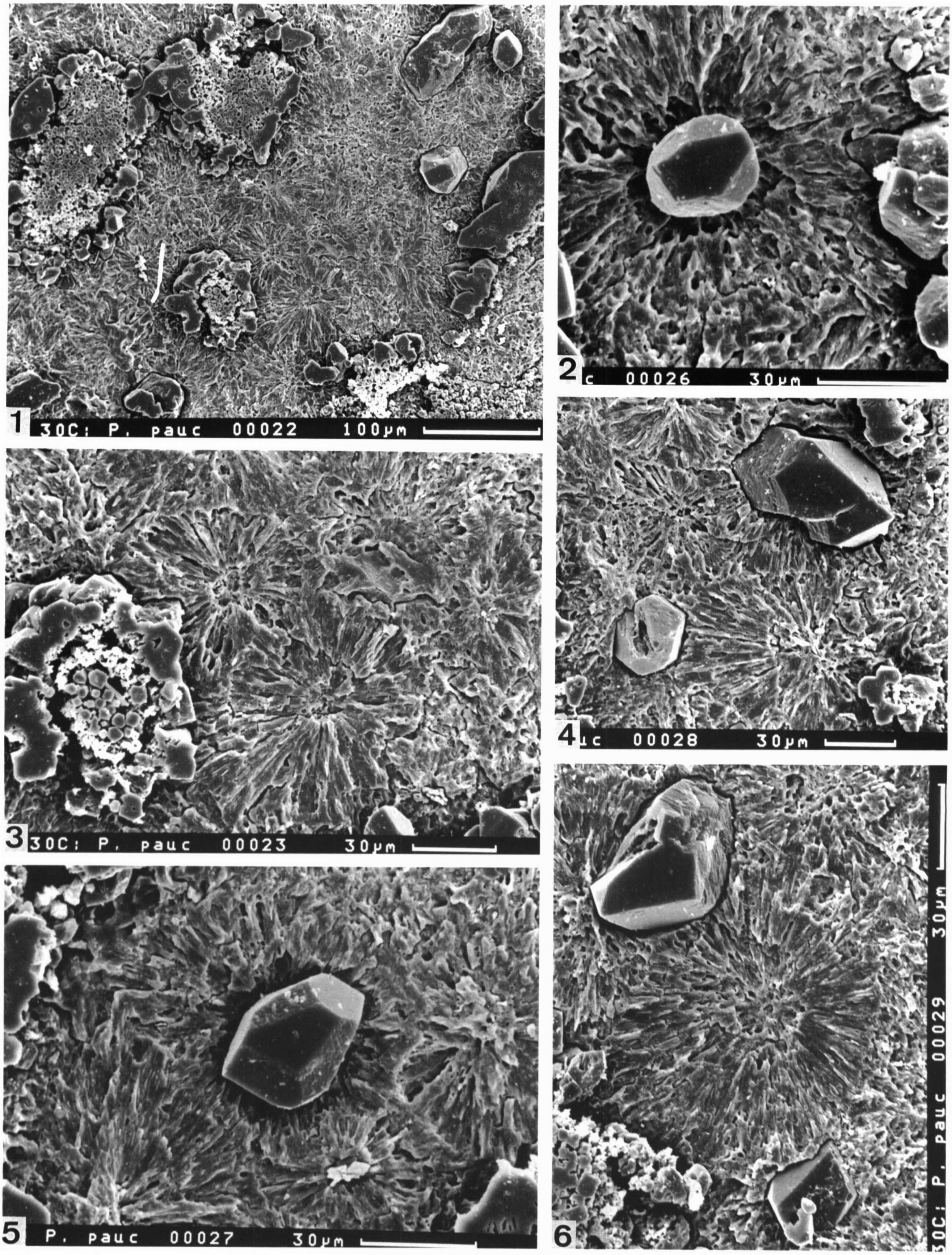
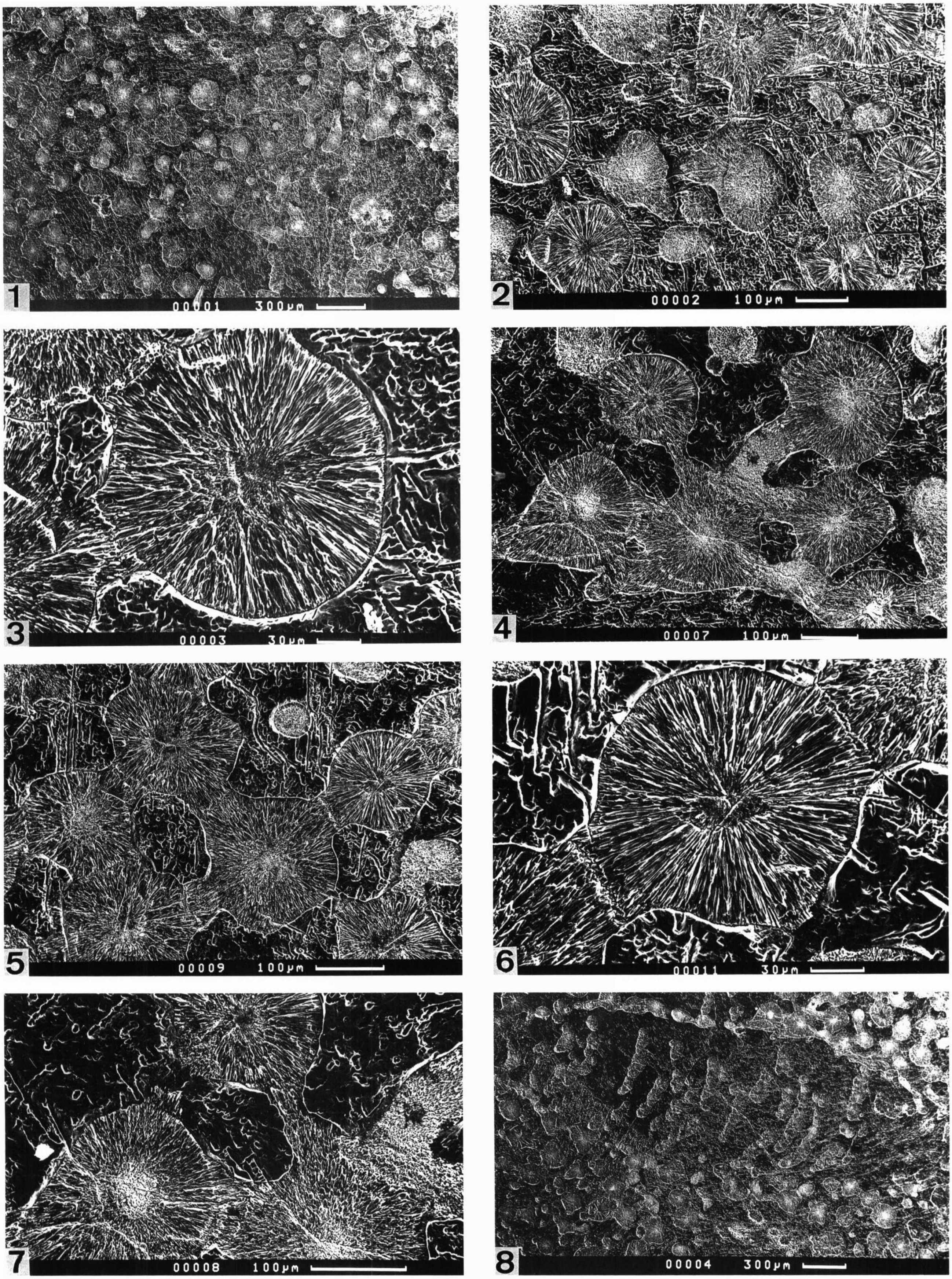
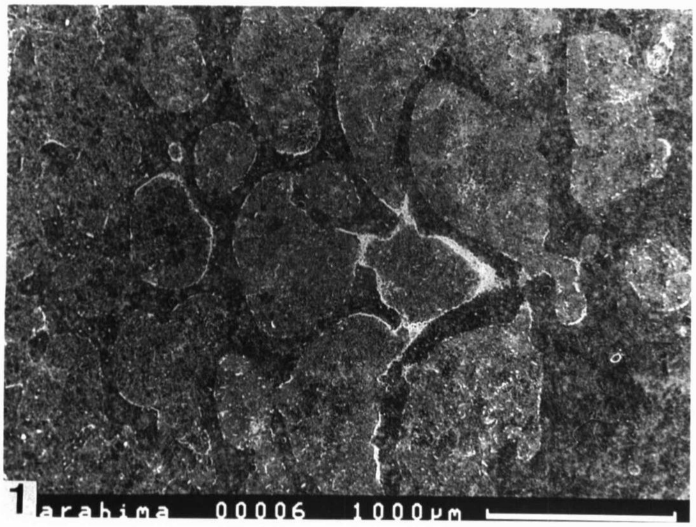
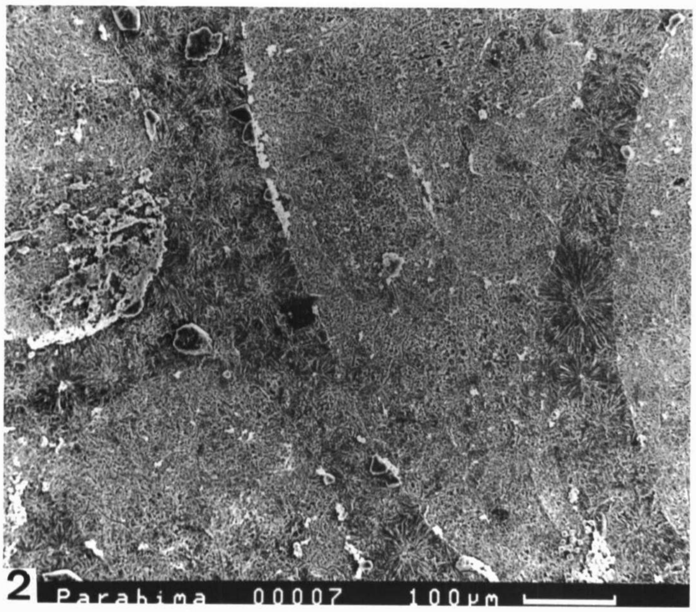
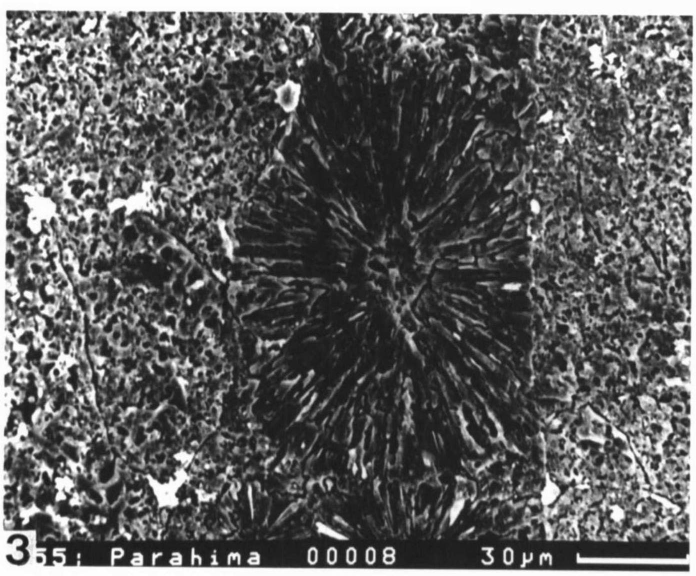

1
30C; P. pauc 00022 100µm
2
c 00026 30µm
3
30C; P. pauc 00023 30µm
4
c 00028 30µm
5
P. pauc 00027 30µm
6
30C; P. pauc 00029 30µm

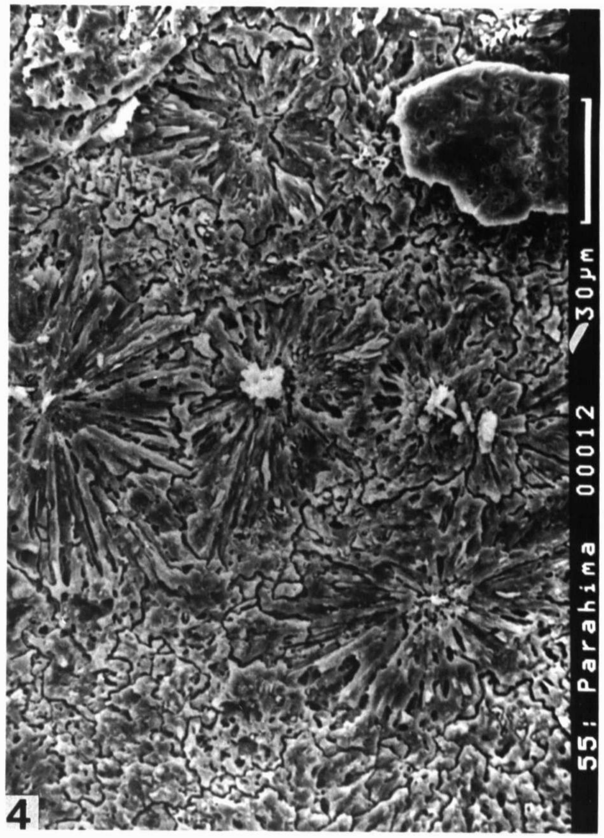
PLATE 68


1
00001 300µm
2
00002 100µm
3
00003 30µm
4
00007 100µm
5
00009 100µm
6
00011 30µm
7
00008 100µm
8
00004 300µm


arahima 00006 1000µm
1


Parahima 00007 100µm
2


55: Parahima 00008 30µm
3


55: Parahima 00012 30µm
4

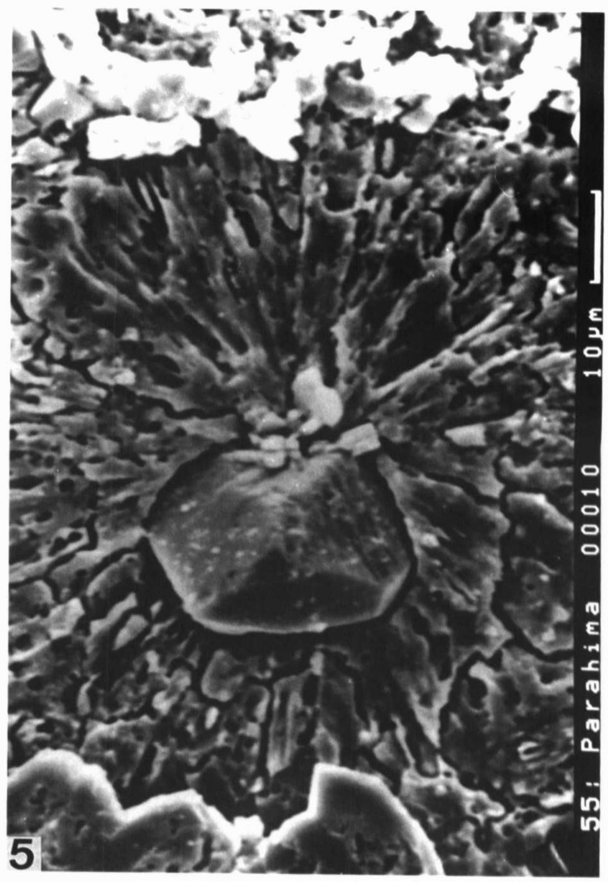
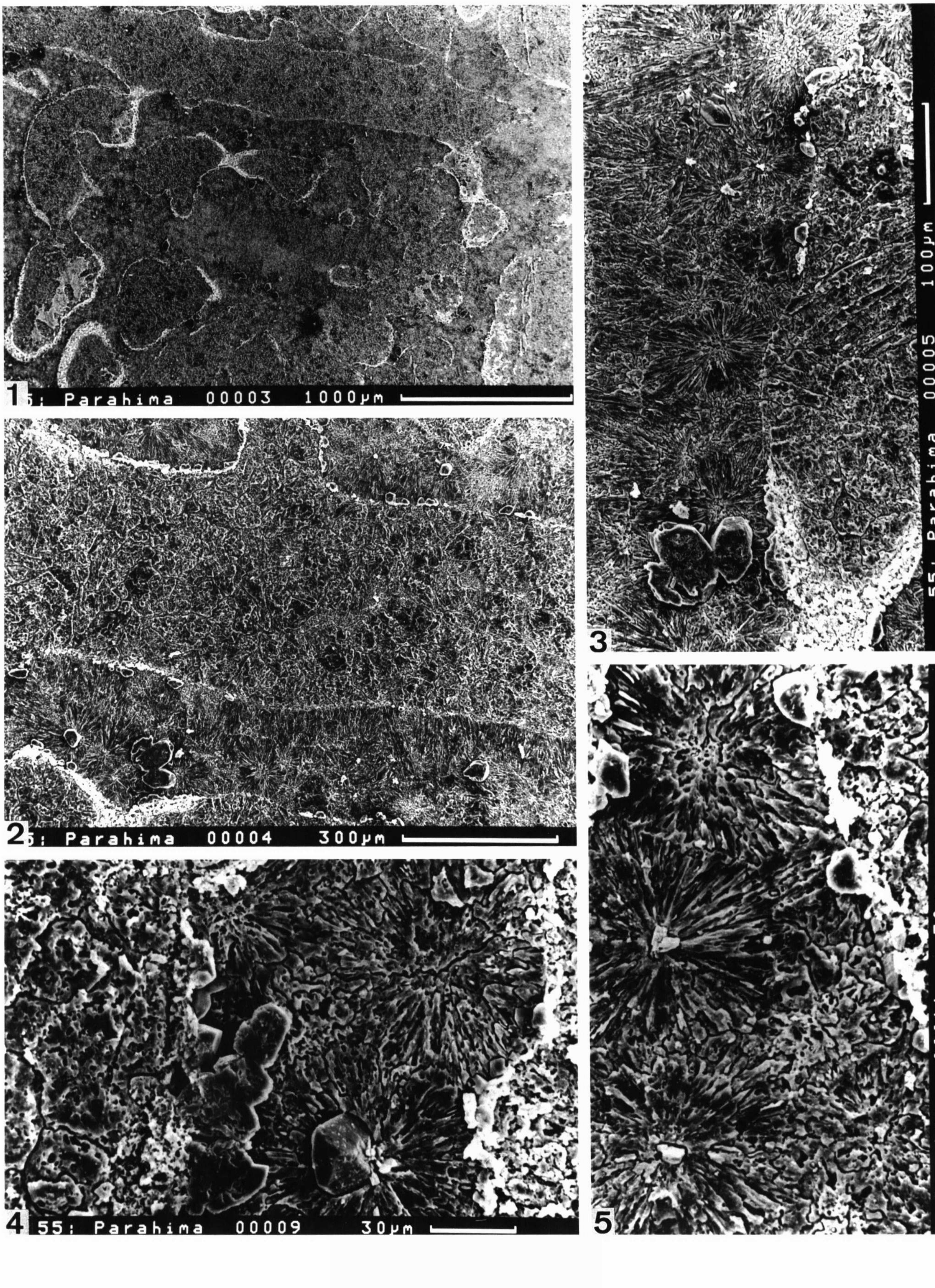
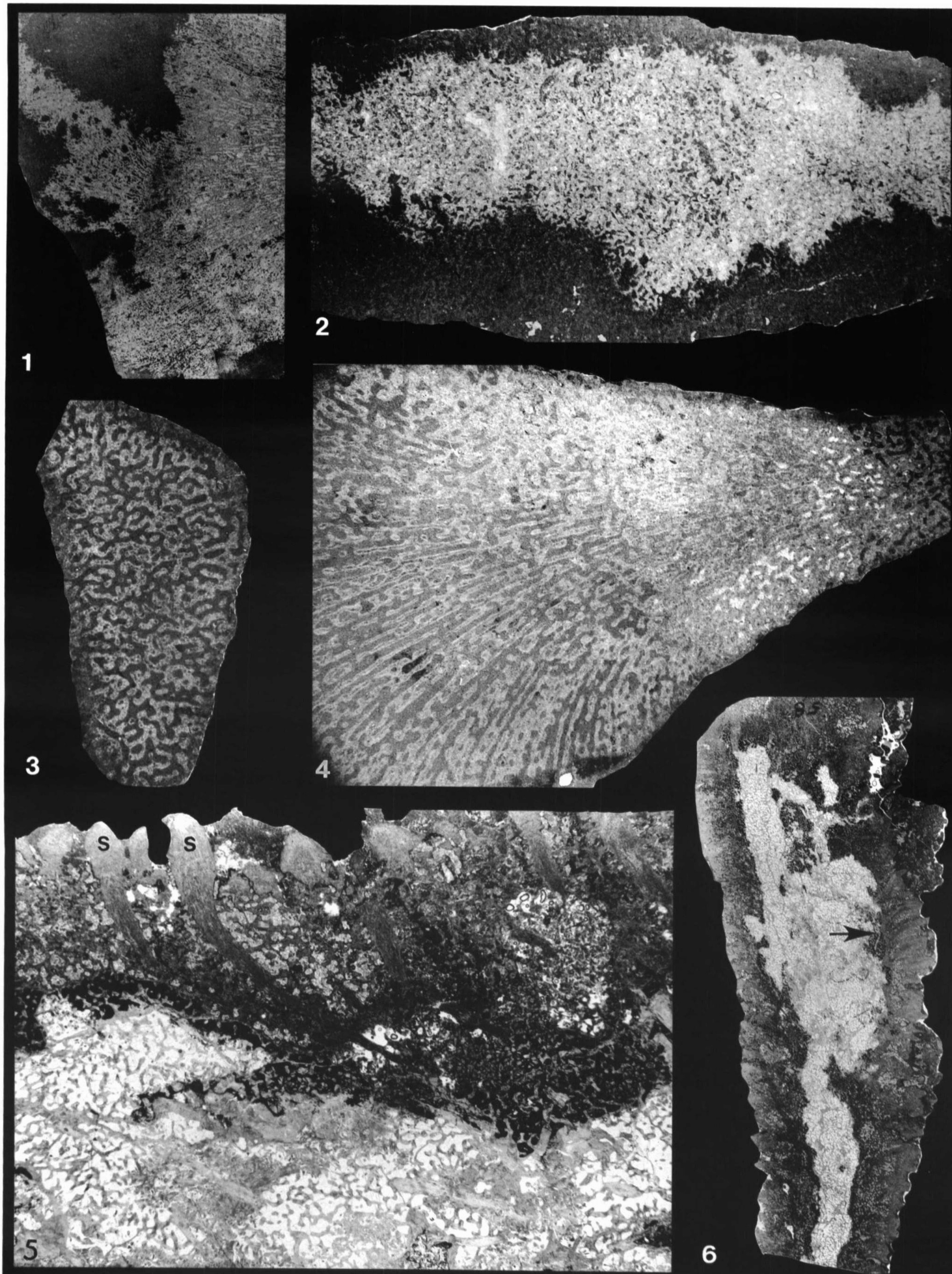
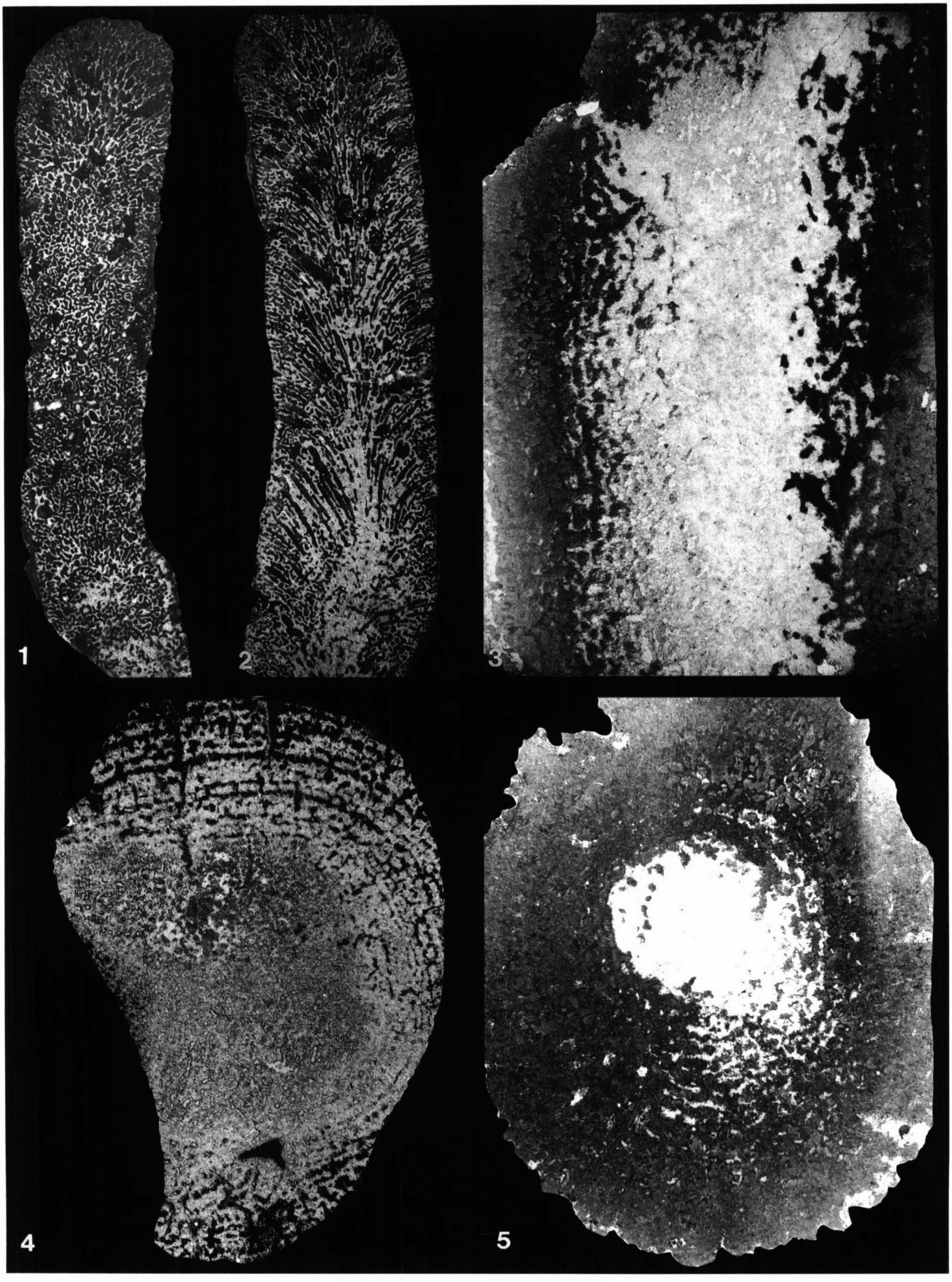
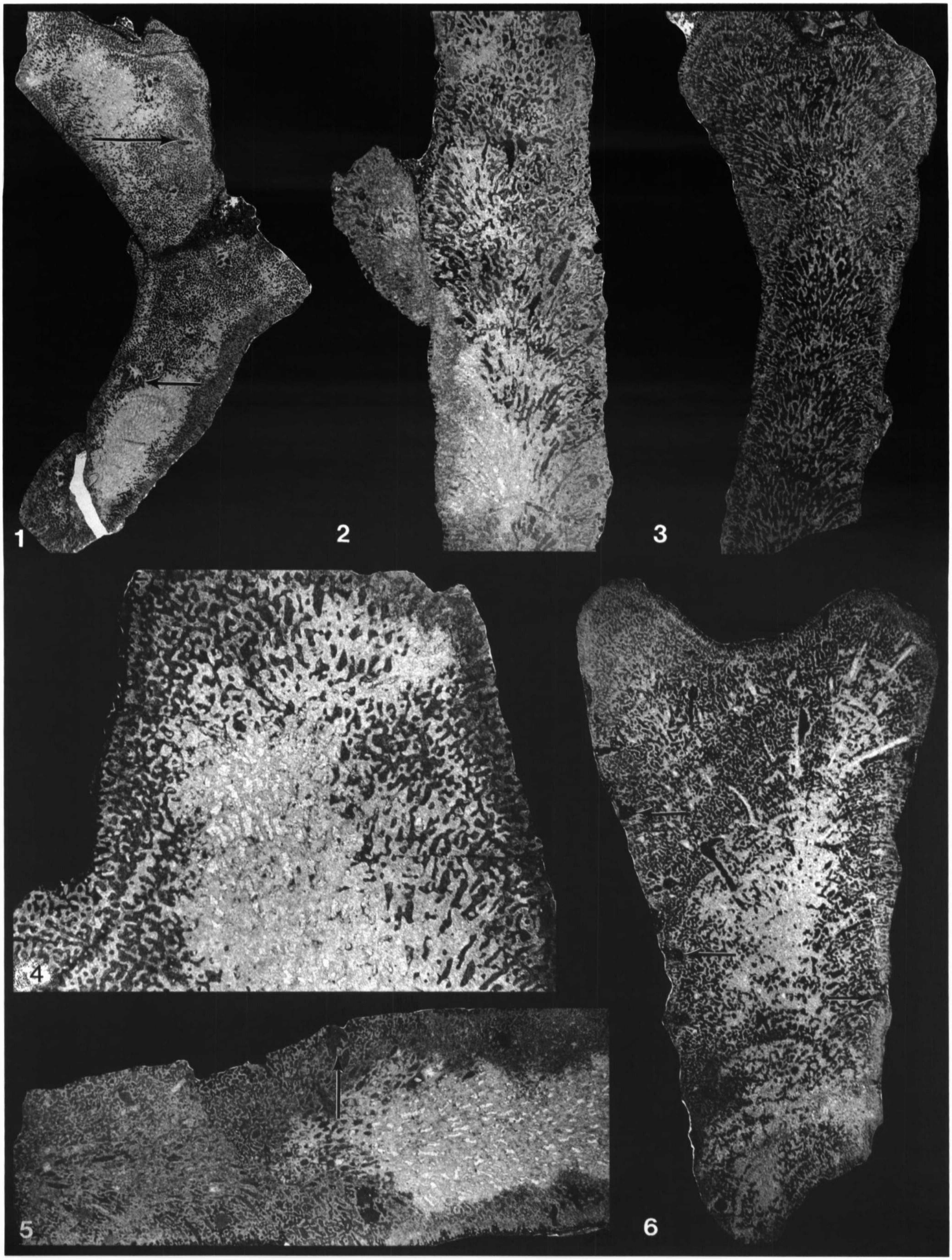

55: Parahima 00010 10µm
5

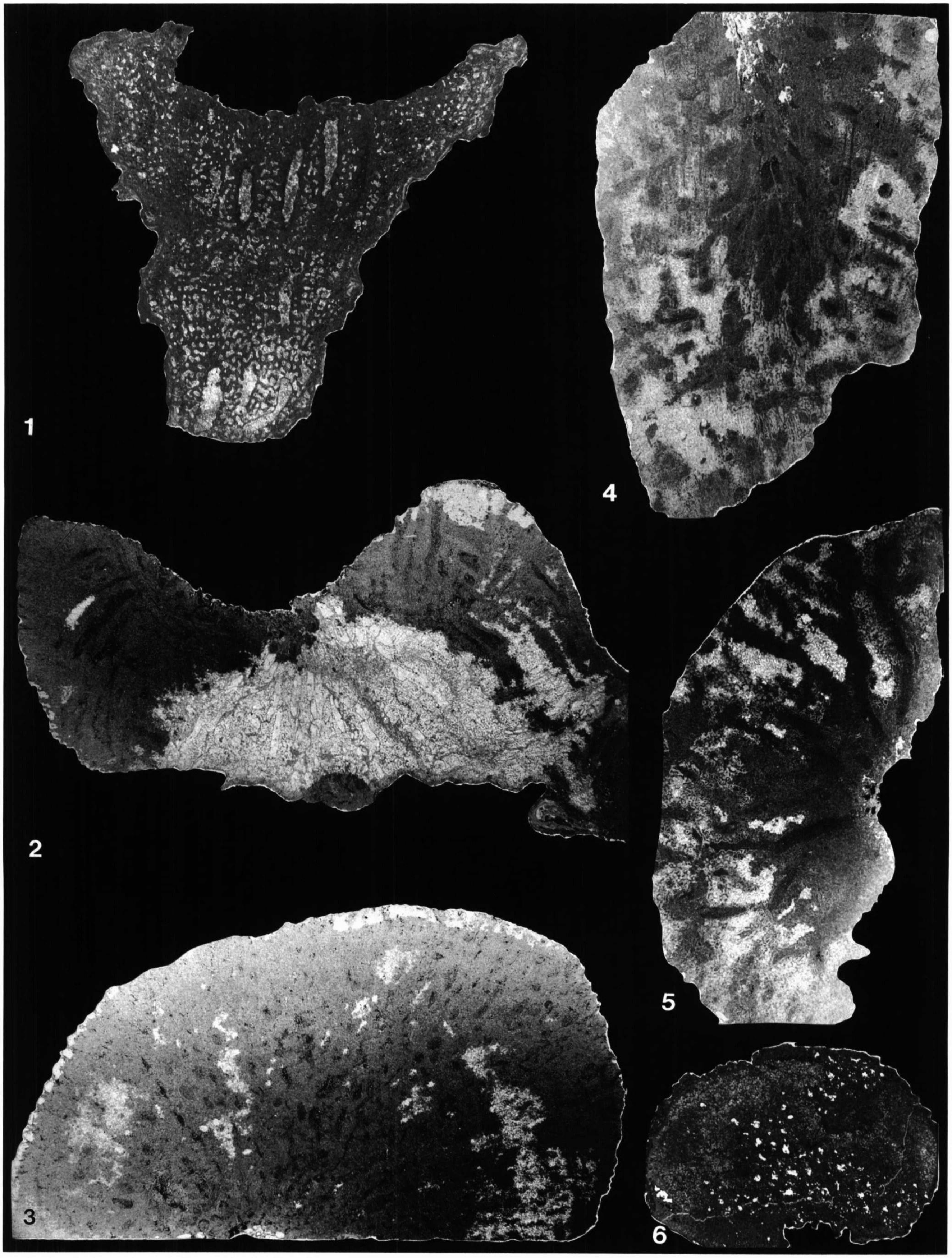
PLATE 70

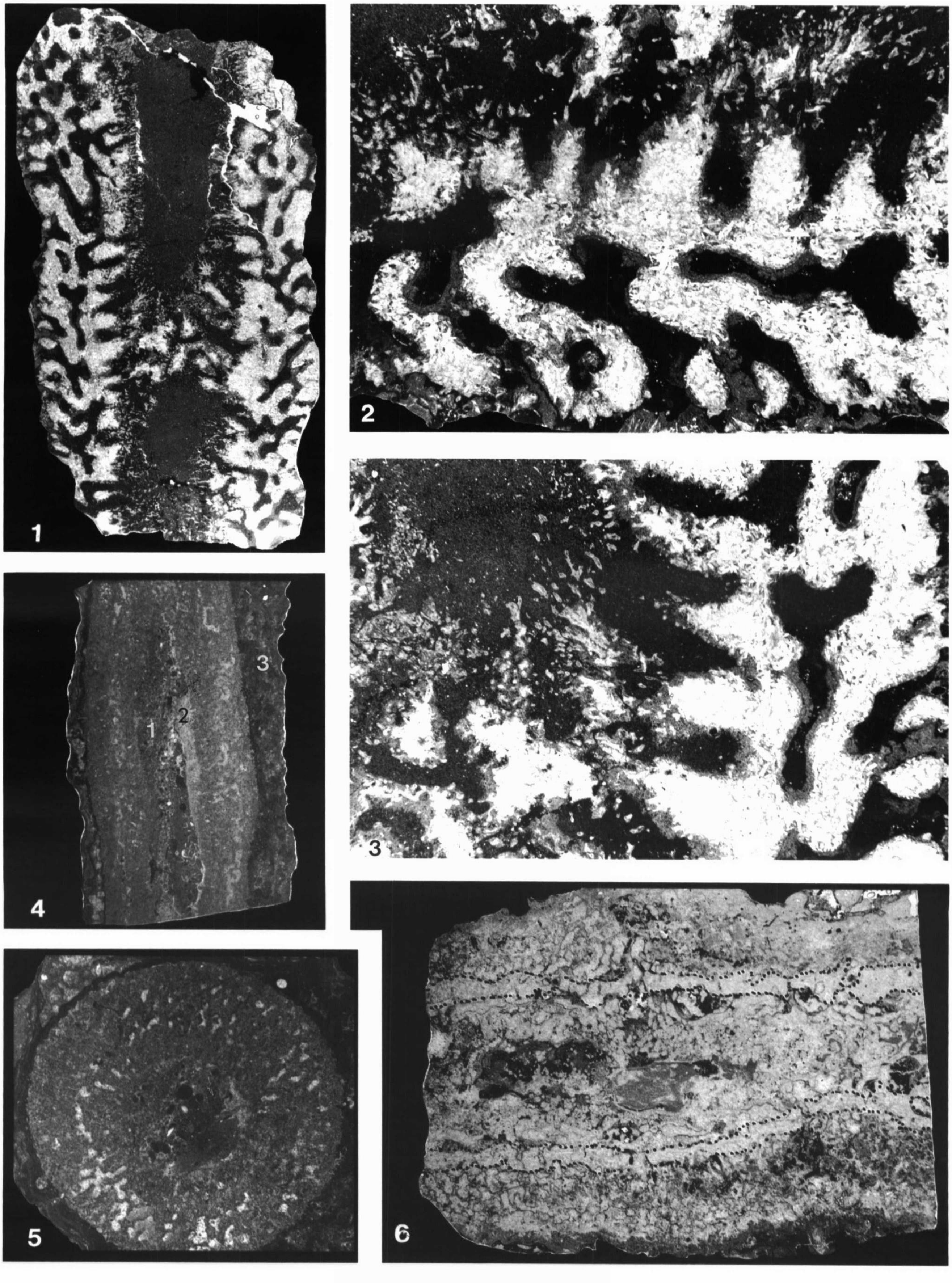

1
5: Parahima 00003 1000µm
2
5: Parahima 00004 300µm
3
55: Parahima 00005 100µm
4
55: Parahima 00009 30µm
5
Parahima 00011 30µm

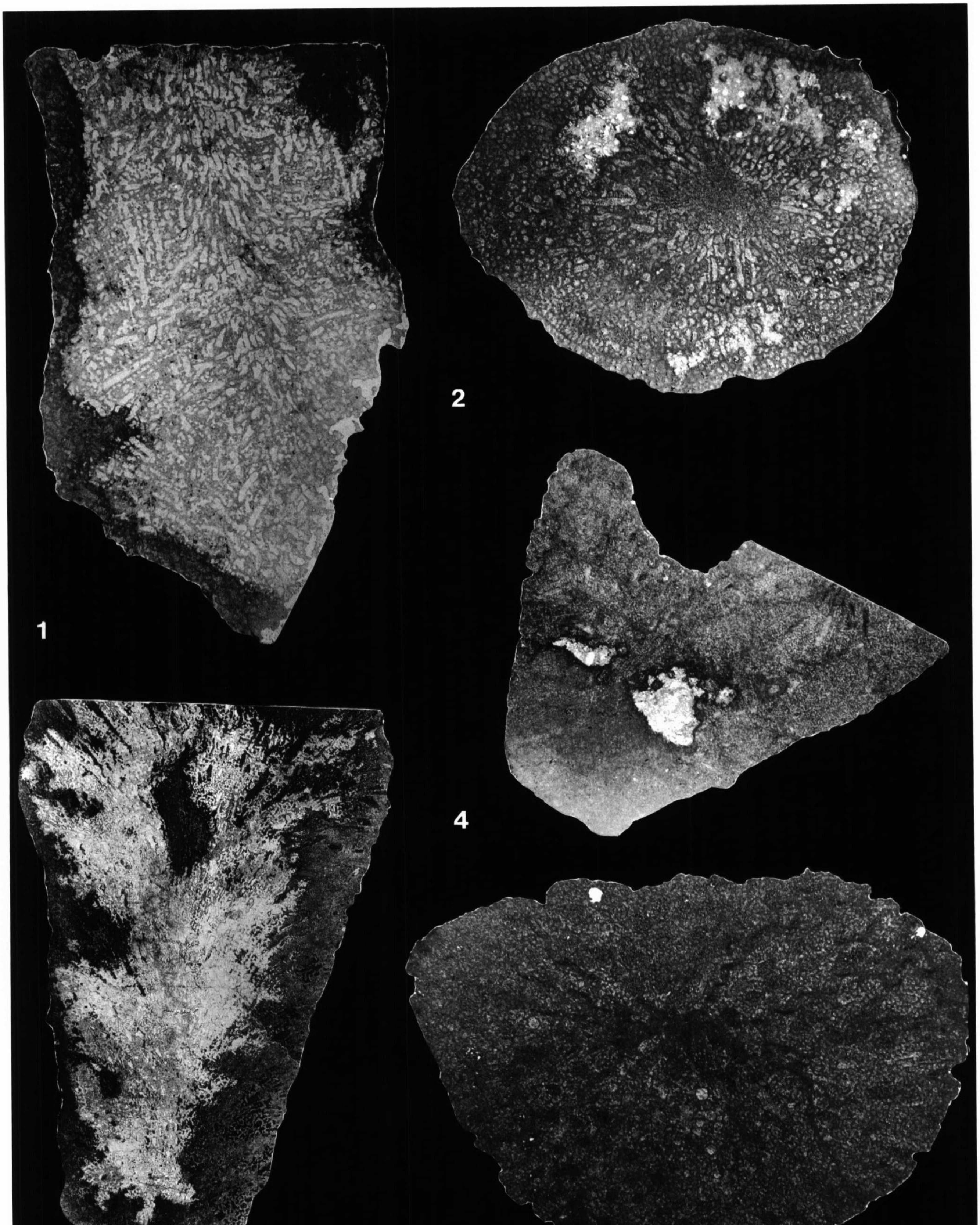

1
2
3
4
S
S
5
6






1
2
3
4
5
6


1
2
3
1
2
3
4
5
6


1
2
3
4
5

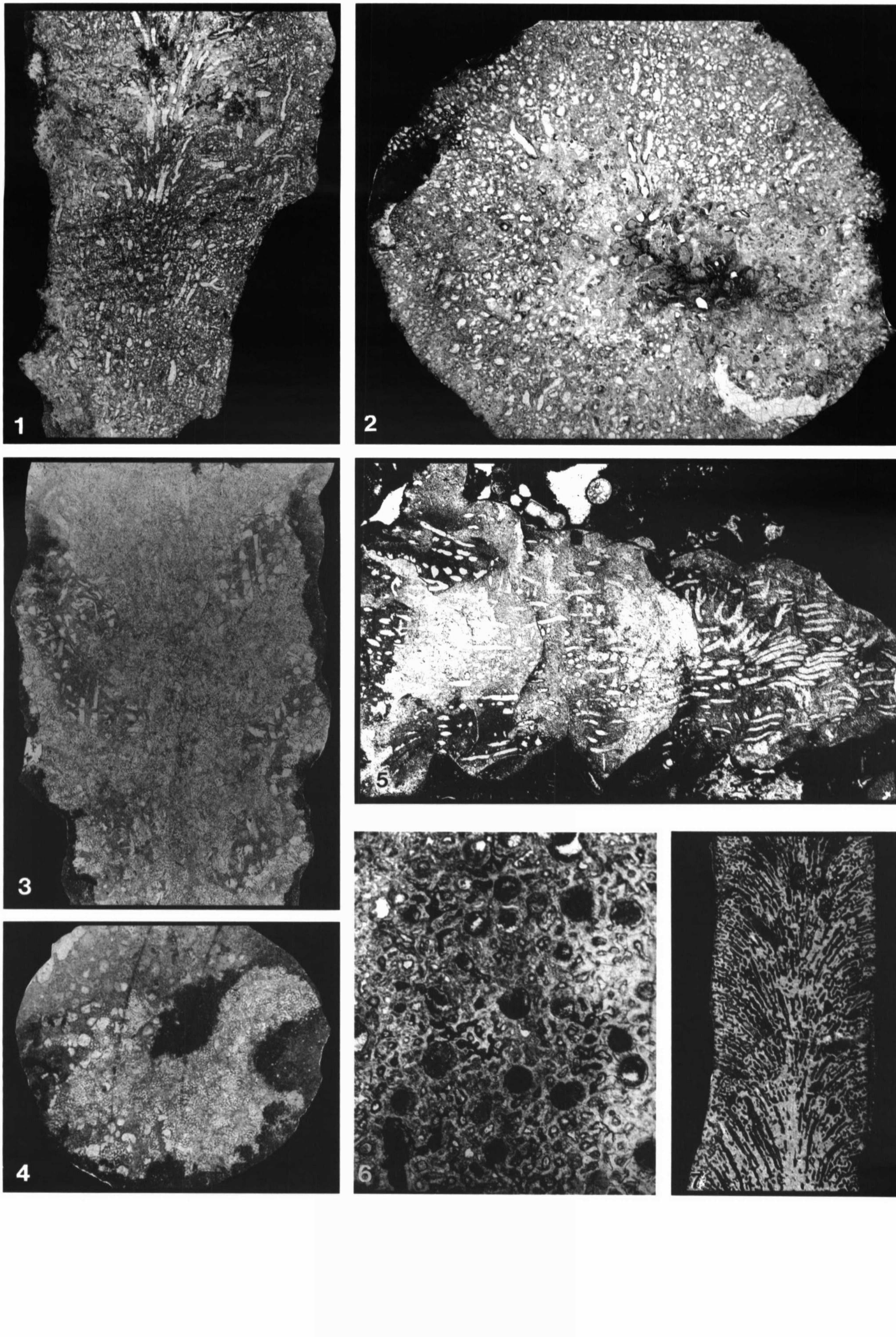
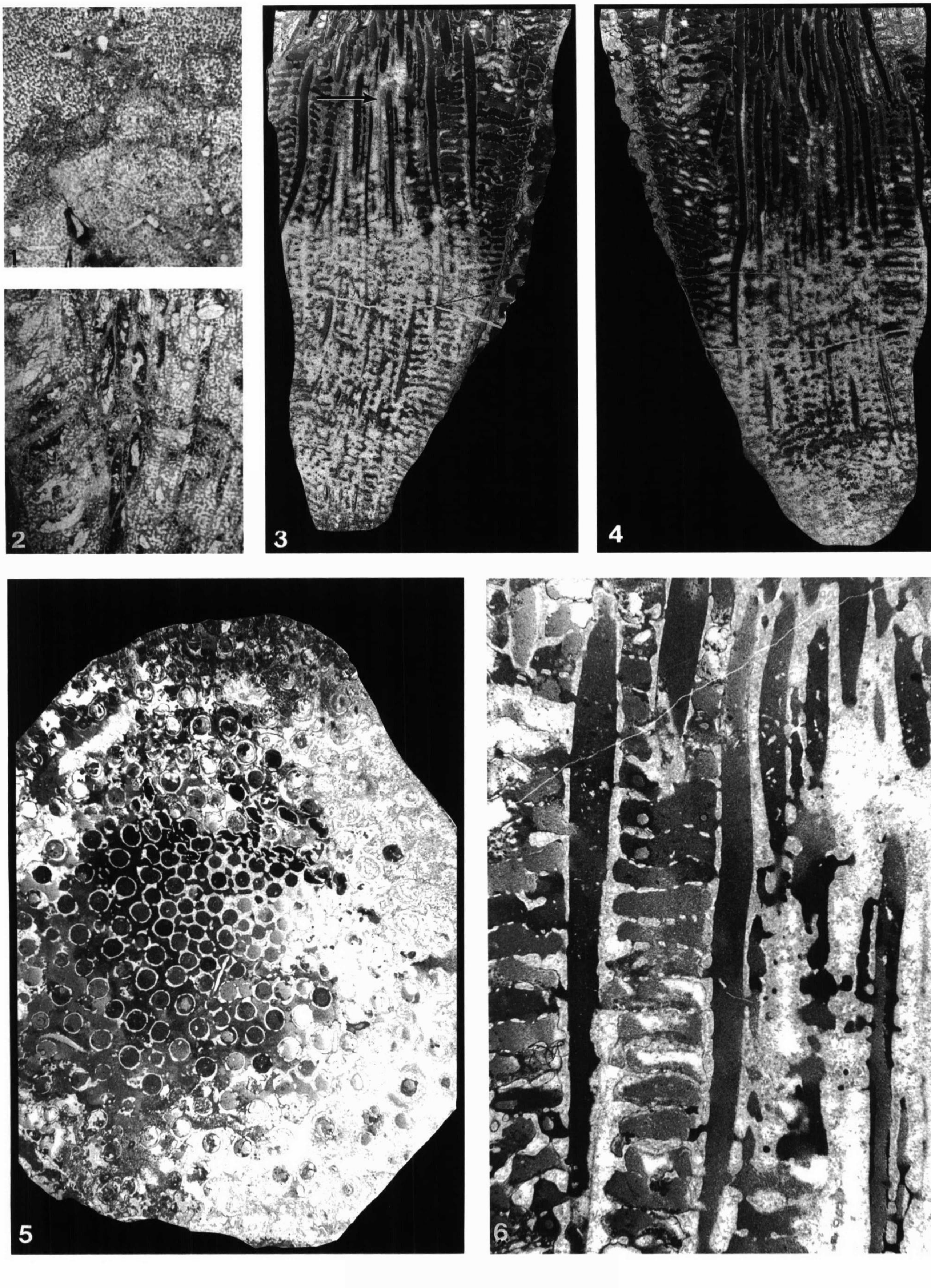
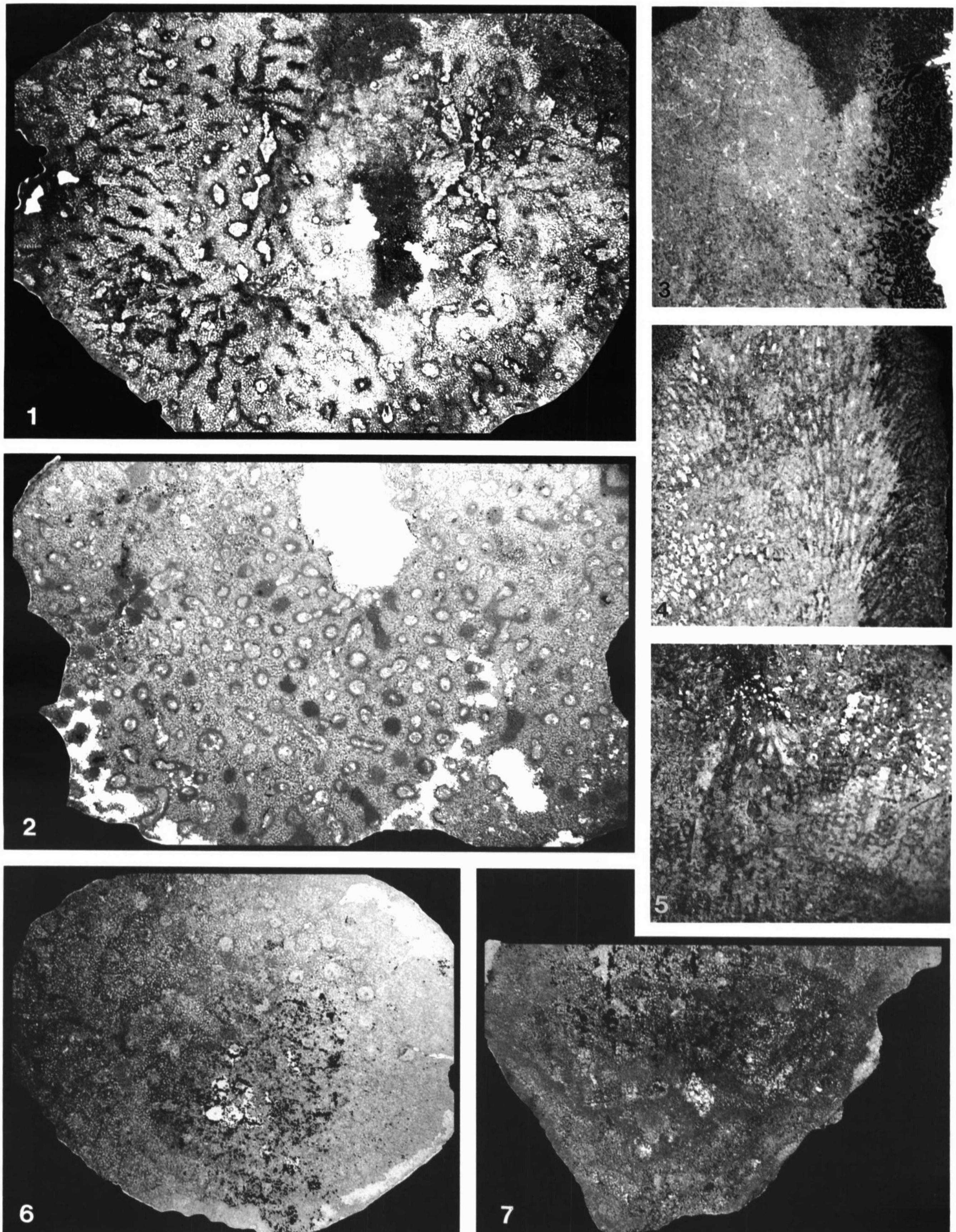

1
2
3
4
5
6
7

PLATE 78




1
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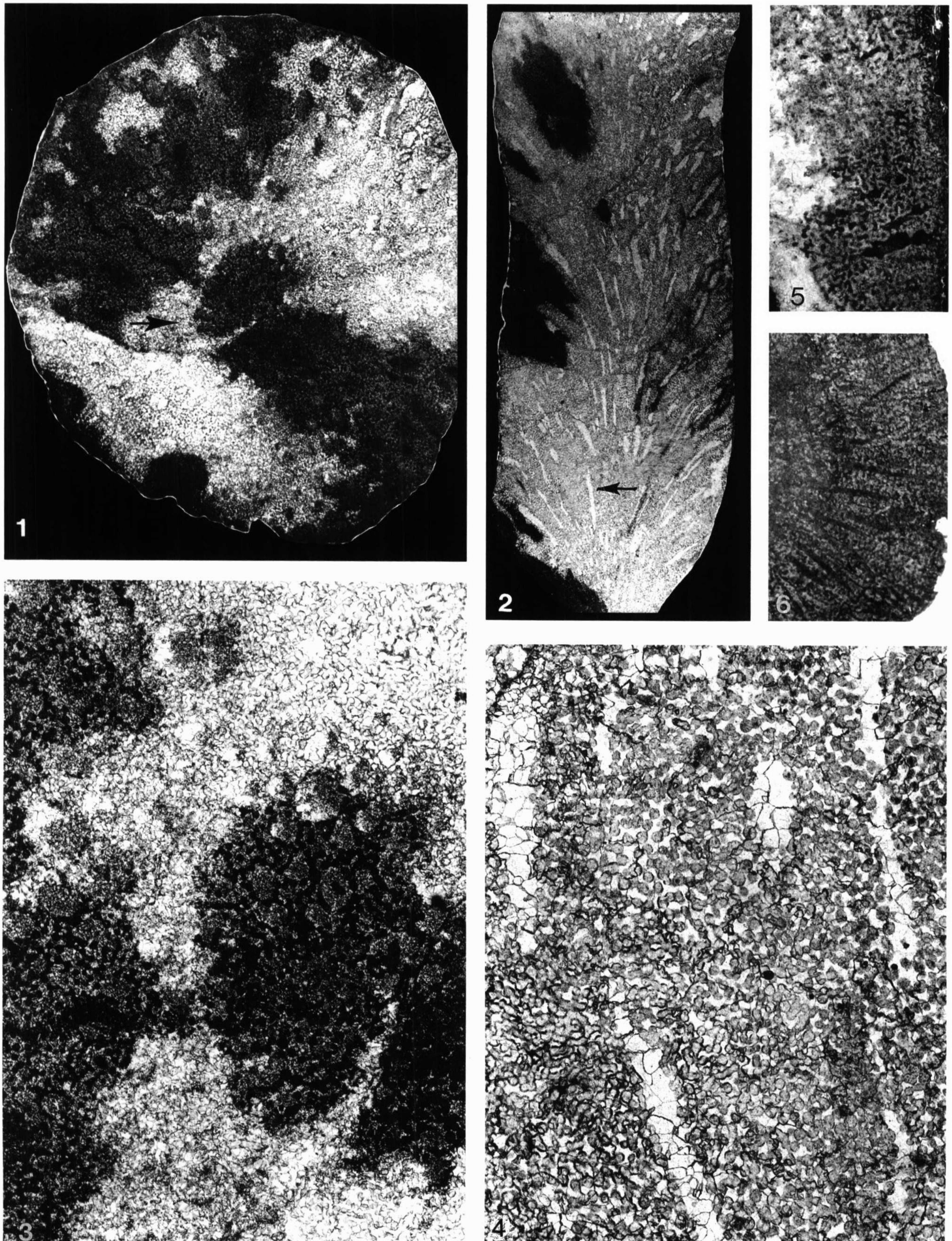
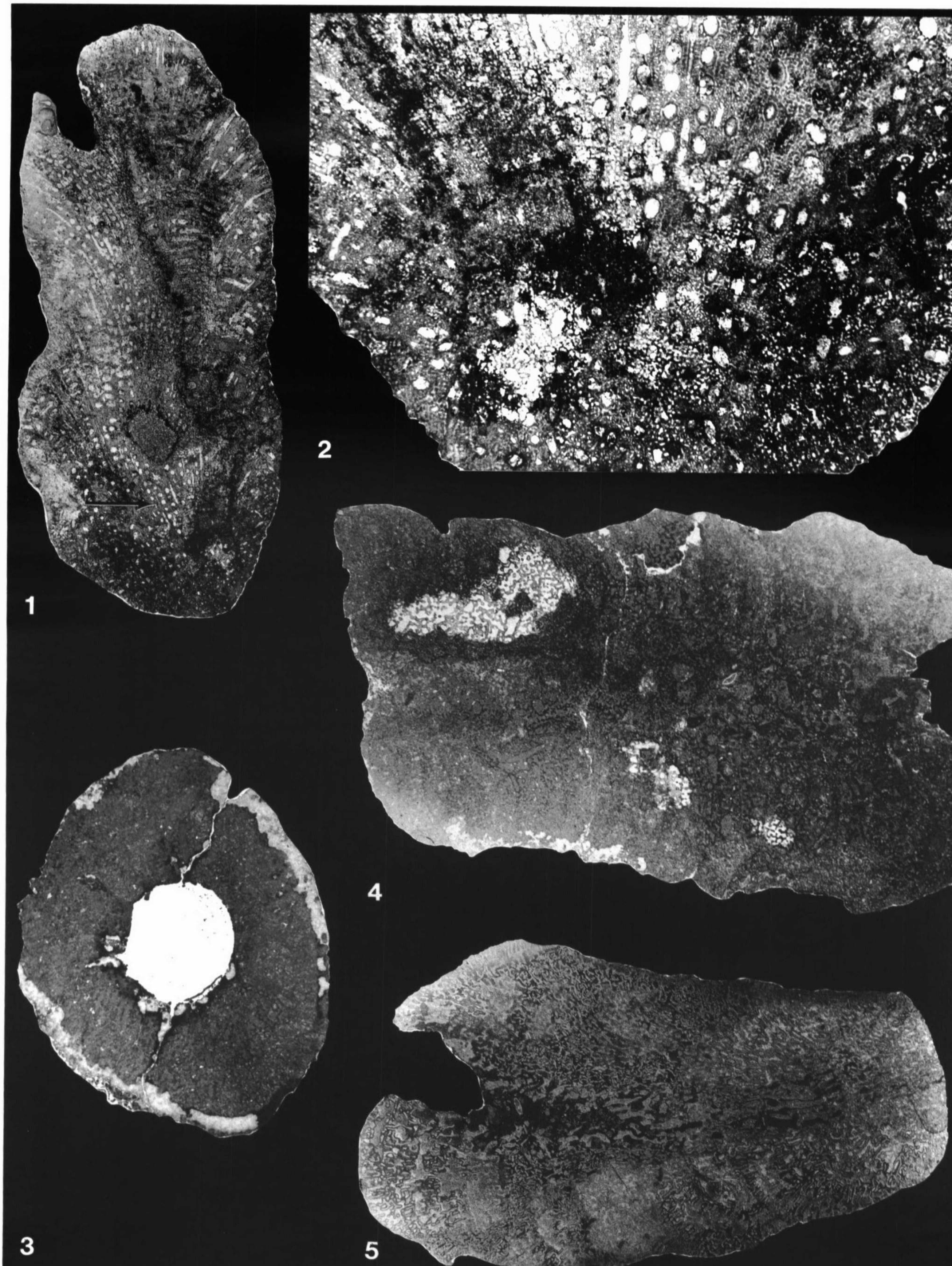
3
4
5
6
7

PLATE 80

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