

13. SILICEOUS SPONGE SPICULES, SILICOFLAGELLATES, AND EBRIDIANS FROM HOLE 918D, CONTINENTAL RISE OF THE GREENLAND MARGIN¹

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ABSTRACT

Sediments recovered from Hole 918D on the continental rise of the Greenland Margin were found to contain siliceous sponge spicules, silicoflagellates, and ebridians. An extreme fossil-barren interval occurred in lower Miocene and upper Miocene sediments of the core, with sponge spicules occurring in the middle Miocene. Though generally rare, the sponge spicules were morphologically diverse, with monaxons being the most abundant. Other morphologies and an undescribed spicule type were found. Representatives of several silicoflagellate genera were found in a narrow horizon of the upper Pliocene. The silicoflagellates were of a variety of ages, showing that this layer has been reworked. This interval also included two large ebridians, *Triskelion gorgon* and *Adonnadonna primadonna*, that have not been previously described from the North Atlantic.

INTRODUCTION

Ocean Drilling Program (ODP) Leg 152 recovered sediment samples from six sites off the Greenland coast in order to study the rift volcanism and history of glaciation of the area. These sites were on a northwest-southeast transect across the East Greenland Margin, approximately 130 km from the Greenland coast near the center of a seaward-dipping reflector sequence (SDRS) (Fig. 1).

A diverse assemblage of siliceous sponge spicules were found in middle Miocene sediments from Site 918D. The spicules were not generally abundant but were well preserved. The assemblage was dominated by monaxons with other spicule morphologies representing a fraction of total spicule abundance. The abundance and diversity of sponge spicules at Hole 918D are tabulated in this study (Table 1).

Sponge spicules from deep ocean sediments have been studied infrequently. The results of this study can be compared to those of McCartney (1987, 1990), Ahlback and McCartney (1992) and Zolnik et al., (1992); see McCartney (1990) for a tabulation of other sponge spicule literature from deep ocean studies. These studies show a generally similar diversity, with monaxons being the predominant spicule group. Palmer (1988) and Ivanik (1983) found abundant tetraxonal and triaxonal spicules and used their relative abundances to make paleobathymetric interpretations, but these spicule types were not abundant in this study.

METHODS

Raw samples were processed by disaggregating the sediment samples in 100-mL beakers after which H₂O₂ and 10% HCl solutions were added. The beakers were then heated for 3–4 hr on a hot plate. The remaining solutions were placed in test tubes and centrifuged and decanted three times. Smear slides were made from the remaining sediments using Canada balsam and 22 mm × 50 mm coverslips.

Investigations were made using an Olympus BH-2 light microscope with a 20× objective. The entire coverslip was examined and absolute counts of specimens were recorded. In the event that no specimens were found on half of the coverslip, the rest was not investigated. In the narrow horizon where silicoflagellates and ebridians were present, extra slides were made and examined to increase specimen counts. The abundance of specimens was recorded in absolute counts, with pieces representing over half of the specimen, or enough to allow identification, counted as one.

SITE SUMMARY

Site 918D (63°5.572'N, 38°38.334'W; water depth 1868.2 m) was drilled on the upper continental rise and has a thick Quaternary section. The site was selected to determine the age and subsidence history of the SDRS, the oceanographic history of the Irminger Basin, and the history of glaciation in southern Greenland. The core from Hole 918D provides the most complete sedimentary record recovered in the North Atlantic.

Sponge spicules were found to be sparse in an 80-m interval of the middle Miocene and rare or absent elsewhere in the core. The sponge spicule-bearing interval is in lithologic Unit II, which is a silt with varying amounts of nanofossils and clay. The sponge spicules were always present in this interval but their numbers never exceeded 31 specimens in a slide.

Silicoflagellates and ebridians were only found in two samples; all but one of the observed specimens came from Sample 152-918D-13R-1, 93–94 cm. This sample is from lithologic Subunit ID, which is a silt with dropstones.

SPONGE SPICULES

Sponges have an internal skeleton of spicules that may be of calcareous or siliceous composition. Various spicule shapes and sizes have been used to classify poriferans taxonomically (Ehrenberg, 1854). However, a single living sponge may contain a variety of spicule types. A descriptive terminology has been used to classify sponge spicules in recent literature (Bukry, 1978; Palmer, 1988; Ahlback and McCartney, 1992), and is used in this study. Various types of sponge spicules are described here including monaxons, which have a skeletal element with a single axis; polyaxons, which have many equal-sized rays radiating from a single central point; and triaxons, which are spicules with three axes.

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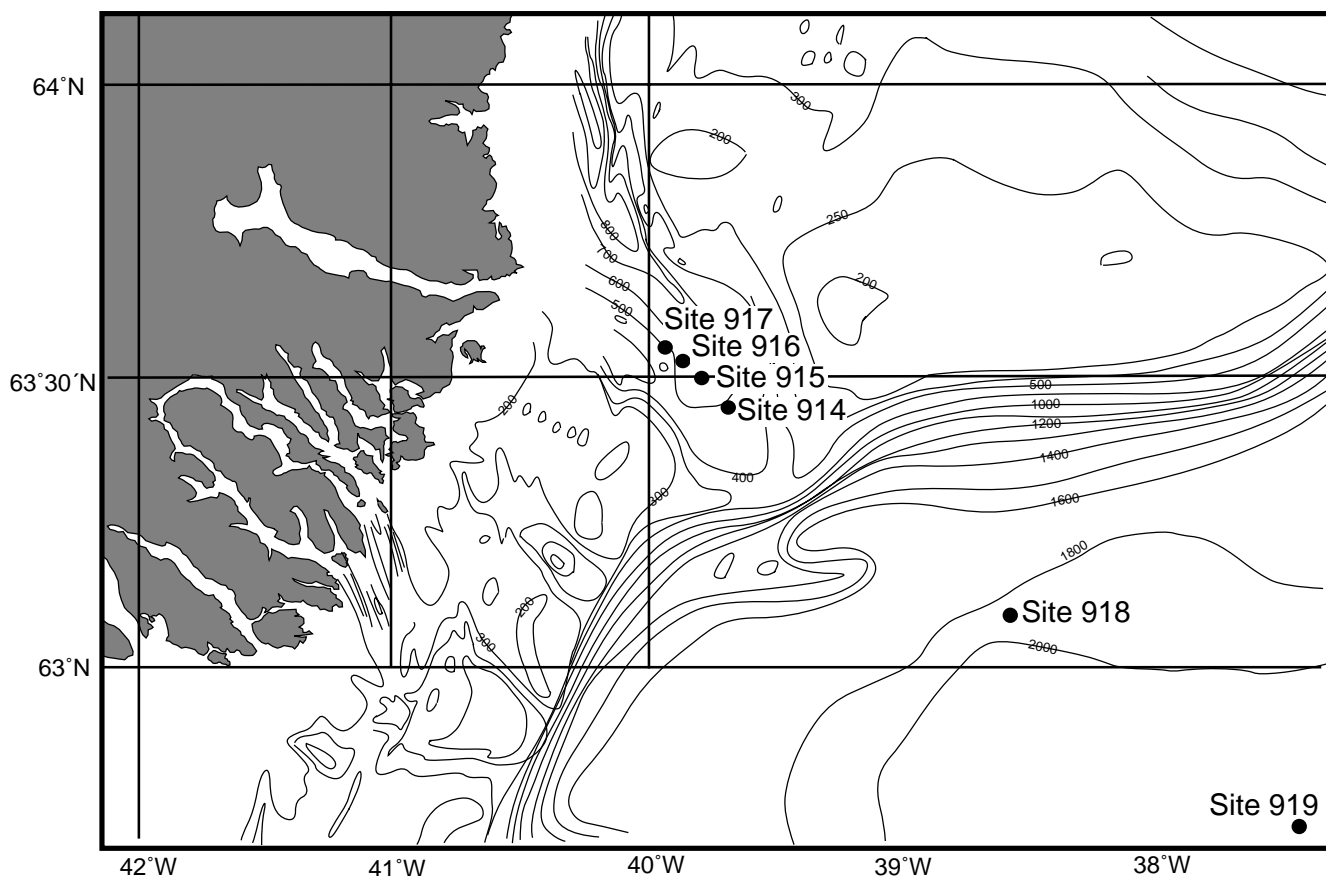


Figure 1. Location map of sites drilled during Leg 152.

Monaxons

Diactinal (monaxons with similar ends)

Oxeas (monaxon with both ends tapering to a point; Pl. 1, Figs. 1, 2, 5–7.): Oxeas were the predominant spicule type found throughout the samples from Hole 918D. Short, thick oxeas are included in this grouping, which differ from the separate tabulation used by McCartney (1987). Many nearly identical, slightly curved oxea (Pl. 1, Figs. 1, 5) were found that were similar to those found by Hartman (1982), where they are called *Haliclona* sp. The oxeas showed a wide variability and several interesting variations were noted; one unusual oxea had a tiny bulb at the tip (Pl. 1, Fig. 7; see Hartman, 1982, fig. 16–13. g, for a similar specimen.)

Acanthoxeas (spinose oxeas; Pl. 1, Figs. 3, 4): These monaxons varied in length from 30 μ m to 60 μ m. The spines were generally distinct and spread over the entire length of the spicule.

Strongyles (monaxons with both ends rounded; for photo, see McCartney 1987, pl. 1, fig. 5): Strongyles were very rare throughout the samples.

Acanthostrongyles (spinose strongyles; Pl. 1, Fig. 3): Sample 152-918D-14R-1, 109–110 cm, contained a single specimen that was an acanthostrongyle. The spines were arranged evenly across the specimens.

Monactinal (monaxons with one round end and one pointed end)

Styles (no change in thickness at rounded end): Many styles were noted (see McCartney, 1987, pl. 1, fig. 2, for characteristic form). An unusual style with a bulbous entral region was found in Sample 152-918D-39R-1, 78–79 cm (Pl. 1, Figs. 6, 7). This is referred to here as a centrotylote style. Hartman (1982) noted a similar feature in an oxea belonging to *Plakina* sp.

Acanthostyles (spinose styles): Similar specimens to those found in this study are illustrated by McCartney (1987; pl. 1, fig. 4).

Tylostyles (one pointed end and one knobbed end; Pl. 1, Fig. 8): Typical specimens found in this study were similar to those illustrated by McCartney (1987, pl. 2, fig. 7; 1990, pl. 2, fig. 6). An unusual example (Pl. 1, Fig. 8) with

a bent bulbous termination was found in Sample 152-918D-41R-3, 120–121 cm.

Acanthotylostyles (spinose tylostyles; Pl. 1, Figs. 9, 10): This type was rare throughout the spicule-bearing interval.

Sinusoidal-spicules (spicules with sinusoid curvature; Pl. 2, Fig. 9): Similar spicules have been illustrated by Bukry (1978, pl. 14, fig. 7), McCartney (1987, pl. 2, fig. 10) and Locker and Martini (1986, pl. 13, fig. 3). The abundance in this study (five specimens) appears to be unusually high compared with the previous work.

Isochelae (curved bar-bearing shovel-like shaped ends of similar size; Pl. 2, Figs. 4–6): Isochelae occurred sparsely throughout the interval. A well-preserved cluster of isochela was found in Sample 152-918D-41R-2, 9–10 cm.

Polyaxons

Spherasters (conical rays emanating from a spherical center; Pl. 2, Fig. 10): Oxyasters (thin, pointed rays; Pl. 2, Fig. 11) were included within this group.

Streptasters (spines radiate from various points along a straight or twisted axis; Pl. 2, Fig. 8): These were very rare throughout the samples.

Triaxons

Triods (three rays of equal size; Pl. 2, Fig. 7): Triods were rare throughout the spicule-bearing interval.

Hexactines (six rays nearly perpendicular to each other): Two specimens of this morphology were found.

Miscellaneous Spicules

Amphidiscs (both ends expanded in umbrella-like fashion): A single amphidisc with an anchorate termination similar to one illustrated by McCartney (1987, pl. 3, fig. 6) was found in Sample 152-918B-39R-3, 93–94 cm.

Table 1. Abundance of siliceous sponge spicules, silicoflagellates, and ebridians from Hole 918D.

Epoch	Core, section, interval (cm)	Depth (mbsf)	Number of slides examined	Sponge Spicules													Silicoflagellates					Ebridians											
				Oxeas	Acanthoxeas	Strongyles	Acanthostrongyles	Styles	Acanthostyles	Spherasters (Oxyasters)	Sigmas	Isochelae	Disorhabds	Amphidiscs	Sinusoidal styles	Tylostyles	Hexactines	Triods	Acanthotyllostyles	Streptasters	Unknown spicule type	<i>Bachmannocena apiculata</i>	<i>Corbisema hastata</i>	<i>Corbisema triacantha</i>	<i>Dictyocha messanensis</i>	<i>Distephanus crux</i>	<i>Naviculopsis constricta</i>	<i>Adonnadonna primadonna</i>	<i>Ammodochium rectangulare</i>	<i>Craniopsis octo</i>	<i>Ebriopsis antiqua antiqua</i>	<i>Triskelion gorgon</i>	Unidentified ebridian
early Pliocene	152-918D-11R-1, 62-63	386.7	0.5																		2	2	1	1	12	4		1	6	2	1	8	3
	13R-1, 93-94	404.8	2.0																														
	14R-1, 109-110	413.9	0.5																														
	18R-1, 61-62	448.8	0.5																														
	22R-3, 65-67	487.5	0.5																														
late Miocene	24R-1, 61-62	503.8	0.5																														
	25R-1, 63-64	513.4	0.5																														
	27R-1, 66-67	532.8	0.5																														
	28R-1, 67-68	542.5	0.5																														
	29R-1, 67-68	552.1	0.5																														
	31R-1, 64-65	571.3	0.5																														
	32R-1, 65-66	581.0	0.5																														
	33R-1, 59-60	590.6	0.5																														
	34R-1, 78-79	600.4	0.5																														
	35R-1, 33-34	609.5	0.5																														
	36R-1, 74-75	619.6	0.5																														
	37R-1, 34-35	628.9	0.5																														
middle Miocene	38R-1, 59-60	638.8	0.5																														
	38R-3, 62-63	641.8	0.5																														
	38R-4, 17-18	642.9	0.5																														
	38R-5, 15-16	644.4	0.5																														
	39R-1, 78-79	648.7	1.0	15		1	1	2	1			1			3																		
	39R-2, 95-96	650.4	1.0	14				1	1	2					2	1										1							
	39R-3, 93-94	651.8	1.0	5									2																				
	39R-4, 18-19	652.6	1.0	7							1	1	3	1																			
	39R-5, 80-81	654.7	1.0	4	1								1								1												
	40R-2, 41-42	659.4	0.5	1									1																				
	40R-3, 33-34	660.8	1.0	11	2	2			1	1																							
	40R-4, 50-51	662.5	1.0	18	4				1		1		1				1																
	40R-5, 63-64	664.1	1.0	11	2		1				1	1	2																				
	41R-1, 91-92	668.1	1.0	3	1						3																						
	41R-2, 9-10	668.8	1.0	13				1		1	4		7	1		2	1																
	41R-3, 120-121	671.4	1.0	10	1	1			1	1	1																						
	41R-4, 109-110	672.8	1.0	10	1	4	1			2	1		1			1	3	1		5													
	41R-5, 70-71	673.9	1.0	8	1					1						1	1																
	42R-1, 71-72	677.5	1.0	3	1					1	1	1	1	1																			
	42R-2, 65-66	678.9	1.0	6	1								1				3																
	42R-3, 54-55	680.3	1.0	16	1			1			5		4				1		2	1	1												
	42R-4, 63-64	681.9	1.0	1			1	1		1		1																					
	42R-5, 96-97	683.8	1.0	20	3	1	1				1		3			2																	
	43R-1, 72-73	687.1	1.0	2	1											1																	
	43R-2, 52-53	688.5	1.0	5	1						4	1							1	1		1											
	44R-1, 61-63	696.7	1.0	8					3	3	1		1			1																	
	44R-3, 64-65	699.7	1.0	2	1		1				1		1																				
	44R-4, 66-67	701.8	1.0	6			2			2			1																				
	47R-2, 66-67	726.8	0.5	1						3	2		1							1													
early Miocene	51R-2, 51-52	765.2	0.5																														
	51R-4, 28-29	768.0	0.5	1																													
	52R-1, 74-75	773.6	0.5																														
	52R-4, 91-92	778.3	0.5																														
	53R-1, 38-39	782.9	0.5																														
	53R-4, 77-78	787.8	0.5																														
	55R-1, 38-39	802.2	0.5																														
	55R-4, 74-75	807.0	0.5																														
57R-1, 87-88	821.9	0.5																															
Oligocene	62R-1, 67-68	870.0	0.5																														

Dischorhabds (Pl. 2, Figs. 1–3): This type was rare, with three specimens found altogether. These specimens are very similar to one illustrated by Locker and Martini (1986, pl. 13, fig. 4) and Bukry (1979, pl. 6, fig. 14).

Unknown spicule type (Pl. 2, Figs. 12, 13): Several specimens of an unknown spicule were found. The spicule has the general morphology of a small curved oxea but with rounded terminations. To both sides of the spicule's central point are several nodes, which appear to be in a tetragonal arrangement; the nodes are short and rounded. Additional smaller nodes may occur on the spicule, and the general texture of the spicule was sometimes rough. The occurrence of five very similar specimens suggests that these are not broken

fragments or the result of dissolution. No illustrations of similar spicule morphologies have been found in the literature.

SILICOFLAGELLATES

Representatives of several silicoflagellate genera were found in Sample 152-918D-13R-1, 92–94 cm. Only a single additional silicoflagellate was found in the rest of the study.

Genus *BACHMANNOCENA* Locker, 1974; emend. Bukry, 1987

Bachmannocena apiculata (Schulz)
(Pl. 3, Figs. 3, 4)

Bachmannocena apiculata (Schulz), Bukry, 1987, p. 403–404

Remarks. This silicoflagellate is common in sediments of the Eocene and Oligocene and suggests that the sediments in Sample 152-918D-13R-1, 92–94 cm have been reworked.

Genus *CORBISEMA* Hanna, 1928

Corbisema hastata hastata (Lemmermann)
(Pl. 3, Figs. 5, 6)

Dictyocha triacantha hastata Lemmermann, 1901, p. 259, pl. 10, figs. 16, 17
Corbisema hastata hastata (Lemmermann), Bukry, 1976, p. 892, pl. 4, figs. 9–16

Remarks. The two specimens of this taxon were distinctly arrowhead shaped and were slightly asymmetrical.

Corbisema triacantha (Lemmermann)
(Pl. 3, Fig. 2)

Corbisema apiculata (Lemmermann), Ling, 1972, p. 153, pl. 24, fig. 1

Remarks. The two specimens found of this taxon were slightly larger than typical *C. triacantha*.

Genus *DICTYOGA* Ehrenberg, 1837

Dictyocha messanensis Haeckel
(Pl. 3, Fig. 10)

Dictyocha messanensis Haeckel, in Peters (1860), p. 799–800

Remarks. This taxon has considerable variability in the shape of its basal ring, the robustness of the skeletal elements, and in the presence or absence of an apical spine. Locker and Martini (1986) and other workers divided this taxon into several subspecies and forms, but these distinctions were difficult to apply consistently, thus, this taxon was not subdivided in this study.

Genus *DISTEPHANUS* Stohr, 1880

Distephanus crux (Ehrenberg)
(Pl. 3, Figs. 7–9)

Distephanus crux crux (Ehrenberg), Bukry, 1976 [Leg 36], p. 895

Remarks. This was the most abundant silicoflagellate found in the study with a total count of 12. Several of these were variants with longer spines than usual for the species. A lone member of this species, shown on Plate 3, Fig. 9, was found in Sample 152-918D-39R-2, 95–96 cm.; this was the only silicoflagellate in this study not found in Sample 152-918D-13R-1, 92–94 cm.

Genus *NAVICULOPSIS* Frenguelli, 1940

Naviculopsis constricta (Schulz)
(Pl. 3, Fig. 1)

Naviculopsis constricta (Schulz), McCartney and Wise, 1987, p. 807, pl. 5, figs. 5–8

EBRIDIAN

Several representatives of ebridians were also found in Sample 152-918D-13R-1, 92–94 cm. No ebridians were found elsewhere in the study.

Genus *ADONNADONNA* Gombos, 1982

Adonnadonna primadonna (Gombos)
(Pl. 4, Fig. 1)

Adonnadonna primadonna Gombos, 1982, p.446

Remarks. This very unusual and large ebridian is similar and is probably closely related to *Triskelion gorgon*. Both have enormous size and exceptional surface ornamentation. For further remarks see those with *Triskelion gorgon*.

Genus *AMMODOCHIUM* Hovasse, 1932

Ammodochium rectangulare (Schulz)
(Pl. 4, Fig. 6)

Ammodochium rectangulare (Schulz), Ling, 1971, p. 694

Genus *CRANIOPSIS* Hovasse ex Frenguelli, 1940

Craniopsis octo Hovasse ex Frenguelli, 1940

Craniopsis octo Hovasse ex Frenguelli, 1940, p. 92, figs. 31 a–c

Genus *EBRIOPSIS* Hovasse, 1932

Ebriopsis antiqua antiqua (Schulz)

Ebriopsis antiqua Schulz, 1928 (in part), p. 273–274, fig. 696
Ebriopsis antiqua antiqua (Schulz), Ling, 1977, p. 215, pl. 17–18

Genus *TRISKELION* Gombos, 1982

Triskelion gorgon Gombos
(Pl. 4, Figs. 2–4)

Triskelion gorgon Gombos, 1982, p. 446–447

Remarks. This problematic fossil has previously been found by Gombos (1982) in the middle Eocene of the southwest Atlantic Ocean and by McCartney and Wise (1990) in Oligocene sediments from the Weddell Sea near Antarctica. The occurrence in reworked sediments off Greenland suggests that this taxon is far more widely distributed, both geologically and geographically, than its sparse literature would indicate.

DISCUSSION

This study documents primarily the occurrence of sponge spicules in Hole 918D. Sample 152-918D-13R-1, 93–94 cm, which lacked sponge spicules, was unusual in that it contained nearly all of the silicoflagellates and ebridians found in the study. The silicoflagellates and ebridians found in this sample were diverse, but include only one taxon, the silicoflagellate *Dictyocha messanensis* that is typically found in lower Pliocene sediments. The other taxa are reworked.

Most of the reworked taxa are of geologically long-ranging species, making the age of the source material difficult to determine precisely. The presence of the ebridian *Triskelion gorgon* in the sample, however, indicates an age of middle Eocene to early Oligocene. All of the silicoflagellates found in this sample, except for the single specimen of *Dictyocha messanensis*, could be of the same age.

The core description (Larsen, Saunders, Clift, et al., 1994) indicates that the sediment of Sample 152-918D-13R-1, 93–94 cm was moderately disturbed. This is part of lithologic Unit ID, which consists of well-lithified quartz silt with clay and dark-gray compact sediment with isolated dropstones scattered throughout. The core description does not mention turbidites in this interval, although turbidites of two types are found in lithologic Unit IB, which occurred at 71.1–236.0 mbsf.

Several other studies of the Greenland transect also found reworking during the Pliocene or Pleistocene. Pliocene sediments at Site 919 included several foraminifers that were reworked (Israelson and

Spezzaferri, this volume), and Wei (this volume) found Cretaceous nannofossils associated with dropstones in Pleistocene sediments, which he suggests were ice-rafted detritus.

The reworked fossils of Sample 152-918D-13R-1, 93–94 cm, might also be deposited as a result of ice-rafting, but it is more difficult to explain by this mechanism the concentration of typically uncommon and giant specimens such as *Triskelion gorgon*. Rafting should widely disperse the reworked specimens, and it would take unusual amounts of ice-rafting to deposit such a large concentration of silicoflagellates and ebridians in this sample. We believe that the concentration of siliceous microfossils in this sample can better be explained by a turbidity current.

CONCLUSIONS

The core from Hole 918D contained siliceous sponge spicules, silicoflagellates, and ebridians. The sponge spicules were found in the middle Miocene sediments, but were generally low in absolute abundance. The lower Miocene was largely barren, as was the upper Miocene and lower Pliocene. However, in the lower Pliocene there did occur an unusual presence of silicoflagellates and ebridians in Sample 152-918D-13R-1, 93–94 cm. The core description indicates the sample was moderately reworked. This study found unusually large microfossils, including *Triskelion gorgon*, which suggests a turbidity current.

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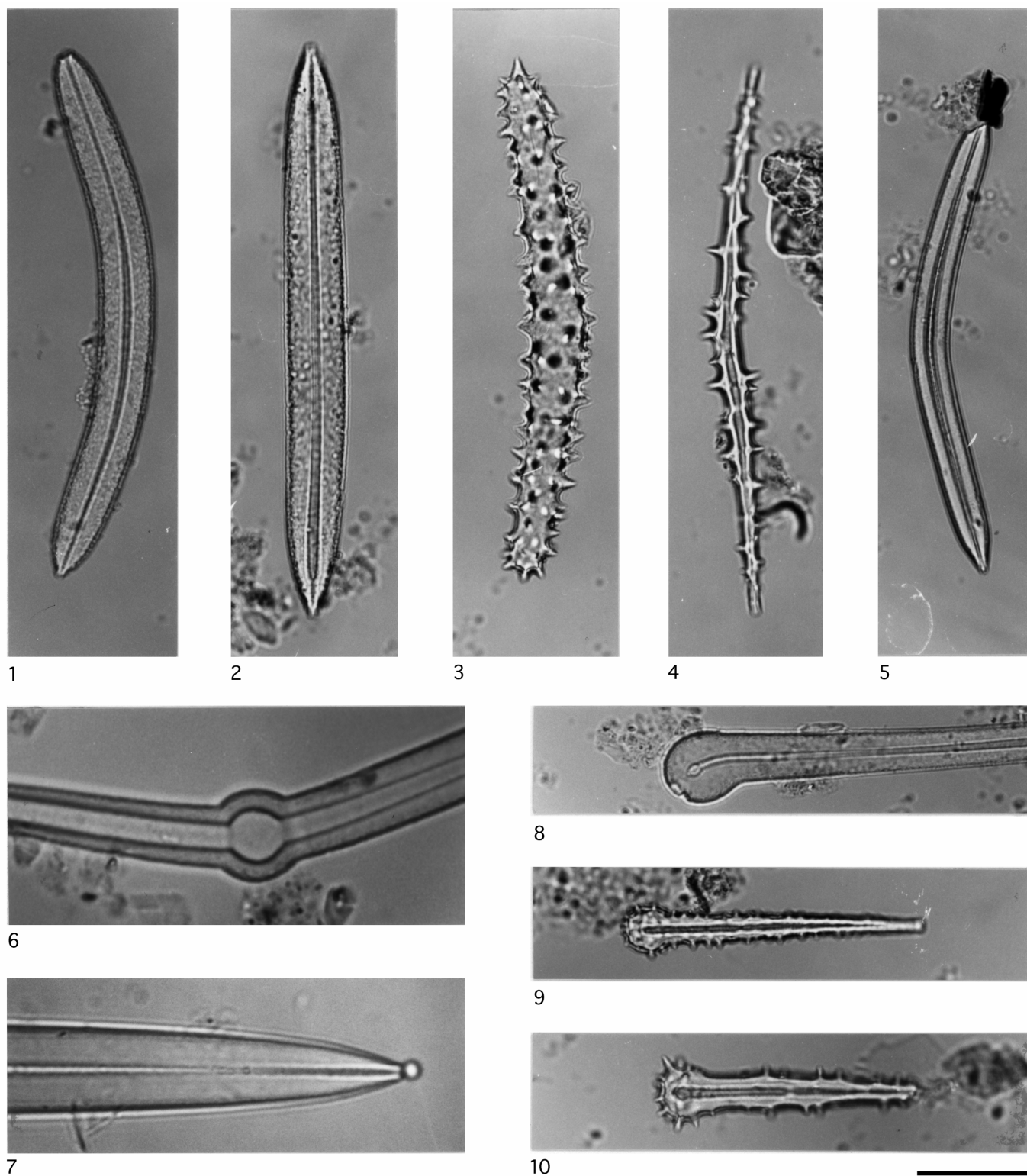


Plate 1. Sponge spicules from Site 918D (570 \times ; scale bar = 35 μ m). **1–2.** Oxea; (1) Sample 152-918D-41R-3, 120–121 cm; (2) Sample 152-918D-44R-4, 66–67 cm. **3.** Acanthostrongyle; Sample 152-918D-44R-4, 66–67 cm. **4.** Acanthoxea; Sample 152-918D-42R-3, 54–55 cm. **5.** Oxea, bent; Sample 152-918D-44R-1, 61–63 cm. **6.** Style with bulbous central region; Sample 152-918D-39R-1, 78–79 cm (1140 \times). **7.** Oxea with bulbous tip; Sample 152-918D-39R-2, 95–96 cm (1140 \times). **8.** Tylostyle with bent bulb; Sample 152-918D-41R-3, 120–121 cm. **9–10.** Acanthotylostyles; (9) Sample 152-918D-47R-2, 66–67 cm; (10) Sample 152-918D-41R-4, 109–110 cm.

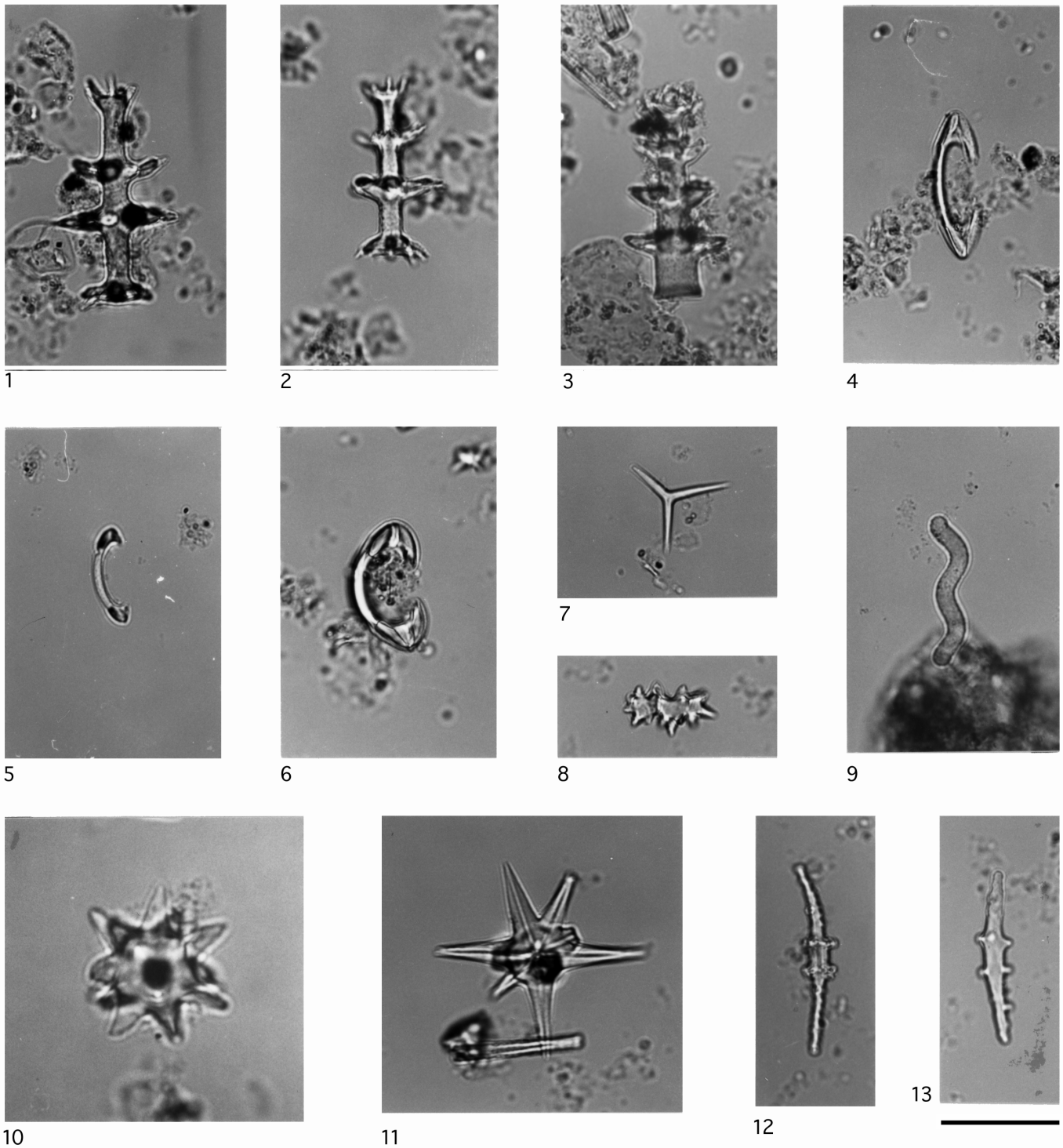


Plate 2. Sponge spicules from Site 918D (570 \times ; scale bar = 35 μ m.) **1–2.** Discorhabds; (1) Sample 152-918D-47R-2, 66–67 cm; (2) Sample 152-918D-47R-2, 66–67 cm. **3.** Discorhabd (?); Sample 152-918D-40R-5, 63–64 cm. **4–6.** Isochela; (4) Sample 152-918D-42R-3, 54–55 cm; (5) Sample 152-918D-47R-2, 66–67 cm; (6) Sample 152-918D-42R-3, 54–55 cm. **7.** Triod; Sample 152-918D-43R-2, 52–53 cm. **8.** Streptaster; Sample 152-918D-42R-3, 54–55 cm. **9.** Sinusoidal-strongyle; Sample 152-918D-41R-4, 109–110 cm. **10.** Spheraster; Sample 152-918D-39R-2, 95–96 cm. **11.** Oxyaster; Sample 152-918D-47R-2, 66–67 cm. **12.** Sample 152-918D-40R-4, 50–51 cm. **13.** Acanthoxea(?); Sample 152-918D-41R-4, 109–110 cm.

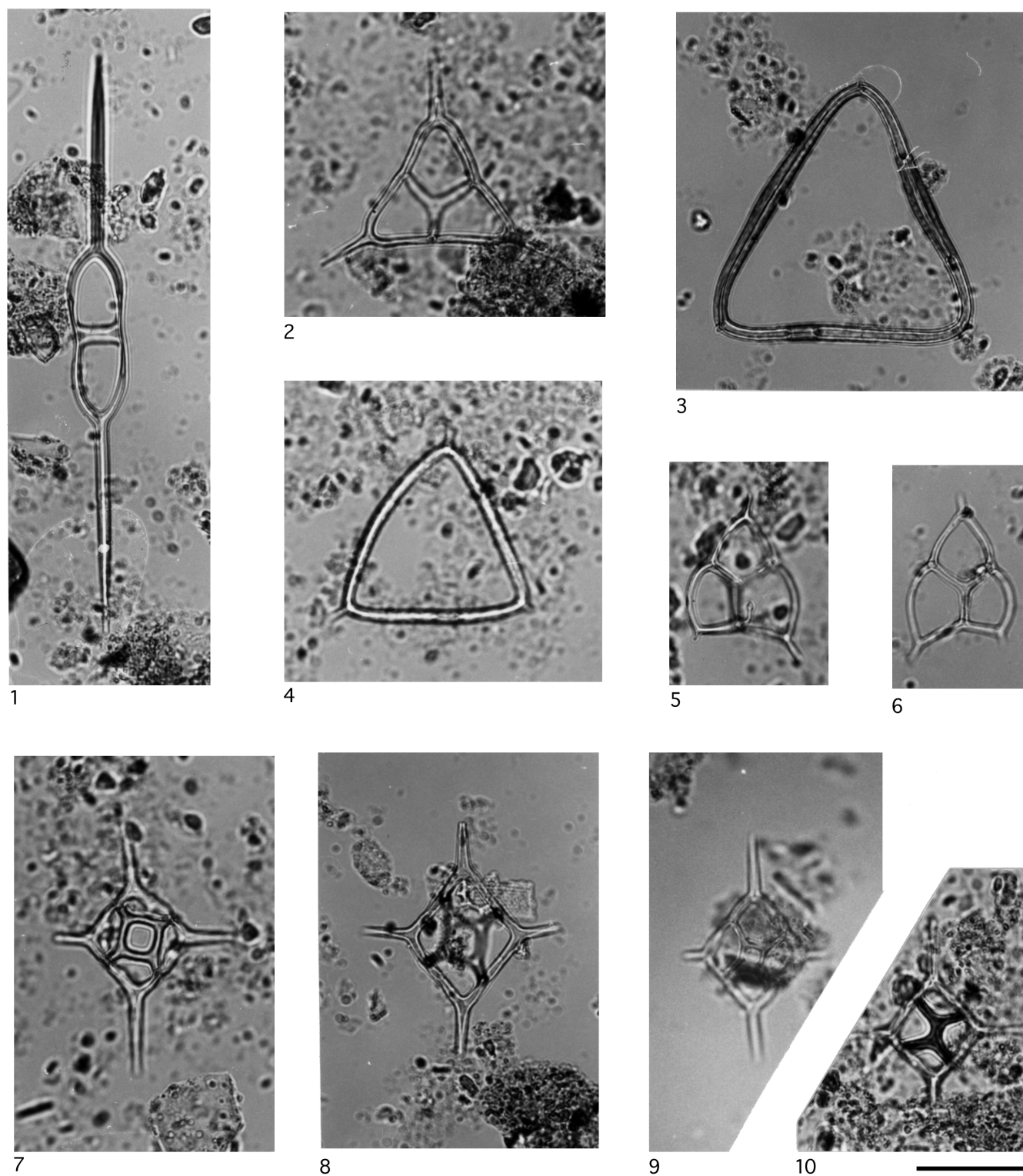
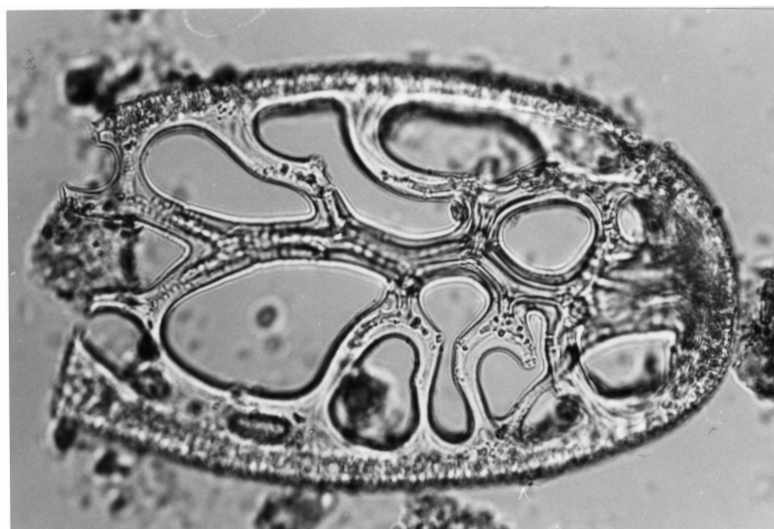


Plate 3. Silicoflagellates (570 \times ; scale bar = 35 μ m). **1.** *Naviculopsis constricta* (Schulz); Sample 152-918D-13R-1, 92–94 cm. **2.** *Corbisema triacantha* (Lemmermann); Sample 152-918D-13R-1, 93–94 cm. **3–4.** *Bachmannocena apiculata* (Schulz); Sample 152-918D-13R-1, 93–94 cm. **5–6.** *Corbisema hastata*; Sample 152-918D-13R-1, 93–94 cm. **7–9.** *Distephanus crux* (Ehrenberg); (7–8) Sample 152-918D-13R-1, 93–94 cm; (9) Sample 152-918D-39R-2, 95–96 cm. **10.** *Dictyocha messanensis* Haeckel; Sample 152-918D-13R-1, 92–94 cm.



1



2



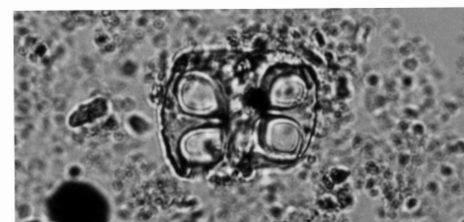
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Plate 4. Ebridians (570 \times ; scale bar = 35 μ m). 1. *Adonnadonna primadonna* Gombos; Sample 152-918D-13R-1, 93–94 cm. 2–4. *Triskelion gorgon* Gombos; Sample 152-918D-13R-1, 93–94 cm. 5. Unknown ebridian, Sample 152-918D-13R-1, 93–94 cm. 6. *Ammodochium rectangulare* (Schulz), lorica; Sample 152-918D-13R-1, 93–94 cm.