Kroon, D., Norris, R.D., and Klaus, A. (Eds.)
Proceedings of the Ocean Drilling Program, Scientific Results Volume 171B

6. Data Report: Organic Walled Dinoflagellate Cyst Biostratigraphy of the Latest Middle to Late Eocene at Hole 1053A (Subtropical Atlantic Ocean)[1]

Caroline A. van Mourik[2] and Henk Brinkhuis[3]

INTRODUCTION

Site 1053 is located at the top of an escarpment cut into the upper part of Blake Nose (29°59.5385′N, 76°31.4135′W). The total core recovery was 189.5 m of upper middle to upper Eocene deposits. An exceptionally thick upper Eocene section was recovered, consisting mainly of siliceous nannofossil ooze (Norris, Kroon, Klaus, et al., 1998). These Eocene sediments are unconsolidated as they were not buried by younger deposits. This chapter discusses the distribution of organic walled dinoflagellate cysts (dinocysts) at Hole 1053A.

Bio(chrono)stratigraphic divisions cited here follow the initial assignment by the Leg 171B Shipboard Scientific Party (Norris, Kroon, Klaus, et al., 1998).

METHODS

The samples from Hole 1053A were prepared using standard palynological procedures. An average of 5 g of sediment per sample was treated with 30% HCl for carbonate removal. After at least 7 hr, the acid was decanted. To remove the silicates, 38% HF was added and the samples were agitated for 2 hr. After an interval of at least 7 hr, the samples were decanted. The HCl and HF steps were repeated and then samples were

[1]van Mourik, C.A., and Brinkhuis, H., 2000. Data report: Organic walled dinoflagellate cyst biostratigraphy of the latest middle to late Eocene at Hole 1053A (subtropical Atlantic Ocean). *In* Kroon, D., Norris, R.D., and Klaus, A. (Eds.), *Proc. ODP, Sci. Results,* 171B, 1–25 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/171B_SR/VOLUME/CHAPTERS/SR171B06.PDF>. [Cited YYYY-MM-DD]
[2]Department of Geology and Geochemistry, Stockholm University, S-106 91 Stockholm, Sweden. Caroline.vanMourik@geo.su.se
[3]Laboratory of Palaeobotany and Palynology, Utrecht University, Budapestlaan 4, NL-3584 CD Utrecht, The Netherlands.

Initial receipt: 18 June 1999
Acceptance: 13 March 2000
Web publication: 8 September 2000
Ms 171BSR-121

given an HCl wash. The residues were sieved over a 15-mm mesh sieve and were treated for 10 to 20 s in an ultrasonic bath.

The samples were stained for 10 s with a 10 g/L Safranine-O solution 1:20 ethanol:distilled water and then washed again. The stained remains on the sieve were transferred to a glass tube and centrifuged for 5 min at 2500 rpm. From the glass tube, the residue was transferred to a vial. The homogenized residue was placed on a slide, using glycerine jelly as mounting medium. For each sample, two slides were made.

Counting Procedures

For the purpose of this study, 19 samples were quantitatively analyzed. More samples will be analyzed in the near future. First, a minimum of 100 palynomorphs were counted in each sample. These palynomorphs were divided into seven broad categories: bisaccate pollen, other pollen and spores, organic foraminifer inner walls (foraminifer linings), prasinophyte algae, acritarchs, indeterminable dinocysts, and determinable dinocysts. Broken but determinable parts were counted as one-half, one-quarter, or one-eighth of a specimen. Thereafter, if possible, up to 200 dinocysts per sample were counted. The remainder was scanned for taxa not included in the counts. Additional taxa are marked by an asterisk (*) in the distribution chart.

The dinocyst taxonomy that follows was cited in Williams et al. (1998). Previously undescribed taxa are briefly treated in the **"Taxonomic List,"** p. 3.

Light microscope photographs were made using a JVC TK-C1380E digital color video camera attached to a Leica DMLP polarized light microscope and connected to a LEICA Q500 Imaging Workstation. The LEICA Qwin image analysis program was used to digitally capture the images. Using this program, it was possible to enhance the brightness and contrast of the images and add a scale bar before the images were saved as JPEG files. In the plate captions the sample, slide, and "England Finder" coordinates are stated.

All material is stored at the Department of Geology and Geochemistry, Stockholm University, Sweden.

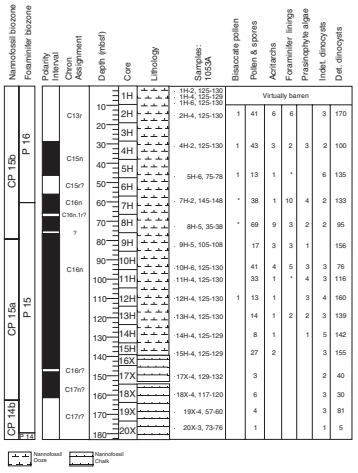
RESULTS

Most of the investigated samples contain well-preserved palynomorph assemblages (Fig. **F1**). However, Core 171B-1053A-1H is virtually barren, whereas the abundance of dinocysts in the nannofossil chalk is much lower than that of samples from the nannofossil ooze.

Despite the HF treatment, diatom remains were found in all samples. In all palynologically productive samples, the aquatic palynomorph fraction outnumbers the terrestrial component. Within all encountered dinocyst assemblages, the *Achomosphaera/Spiniferites* group is dominant (Table **T1**). In the dinocyst distribution diagram (Table **T1**), the taxa are arranged following their first occurrence.

Most occurring taxa are well known from upper Eocene deposits elsewhere. An exception is the finding of *Wetzeliella gochtii,* previously only reported from early Oligocene sediments.

F1. Distribution pattern of palynomorphs at Site 1053A, p. 8.



T1. Quantitative distribution pattern of dinocysts by their first occurrence, p. 9.

TAXONOMIC LIST

The following is an alphabetical list for the dinoflagellate cysts identified in this study.

Achomosphaera/Spiniferites spp. *pars*.

Achomosphaera? sp. A, Plate **P1,** Figures 1 and 2.
Remarks: The overall morphology of this taxon resembles that of species of *Achomosphaera*. A precingular single-plate archeopyle is inferred, type P (3"). It is, however, problematic to identify the processes as definitively gonal in position. Hence, its attribution to *Achomosphaera* is questionable.
Dimensions: Diameter of central body 25–35 µm, length of processes 10–20 µm (N = 9).

Areoligera? sp. A, Plate **P3,** Figures 7, 8, and 9.
Remarks: The overall morphology of this taxon resembles that of species of *Areoligera*. Notably, the apical archeopyle, the dorsoventral flattening, and the presence of dorsal penitabular processes support attribution to the genus *Areoligera*. The wall surface of the central body is finely granular. However, the ventral processes are distally connected—a feature that would indicate attribution to the morphologically related genus *Glaphyrocysta*.
Dimensions: Central body width 55–60 µm, height 45–50 µm, processes 35–40 µm (N = 2).

Areoligera? sp. B, Plate **P3,** Figures 3 and 6.
Remarks: Mainly broken specimens are found. The presence of quasi-penitabular processes on the dorsal surface supports attribution to *Areoligera*. The processes are solid, distally fenestrate, and sometimes distally connected.
Dimensions: Central body width 40–65 µm, height 40–50 µm, processes 25–40 µm (N = 5).

Areosphaeridium diktyoplokum (Klumpp, 1953) emend. Stover & Williams, 1995, Plate **P3,** Figure 12.

Batiacasphaera compta Drugg, 1970, Plate **P3,** Figures 4 and 5.

Cassidium fragile (Harris, 1965) Drugg, 1967, Plate **P8,** Figure 15.

Cerebrocysta bartonensis Bujak in Bujak et al., 1980, Plate **P2,** Figures 6 and 7.

Charlesdowniea clathrata (Eisenack, 1938) Lentin & Vozzhennikova, 1989, Plate **P5,** Figures 11 and 12.

Cordospaeridium gracile (Eisenack, 1954) emend. Davey and Williams, 1966, 14–4, E29, Plate **P2,** Figures 1 and 2.

Cordosphaeridium minimum (Morgenroth, 1966) Benedek, 1972, 2–4 J35, Plate **P2,** Figures 4 and 5.

Corrudinium incompositum (Drugg, 1970) Stover & Evitt, 1978, Plate **P2,** Figure 3.

Cribroperidinium tenuitabulatum (Gerlach, 1961) Helenes, 1984, Plate **P2,** Figures 8 and 9.

Dapsilidinium pastielsii (Davey & Williams, 1966) Bujak et al., 1980, Plate **P1,** Figures 11 and 12.

Dapsilidinium pseudocolligerum (Stover, 1977) Bujak et al., 1980, Plate **P1,** Figure 15.

Dapsilidinium simplex (White, 1842) Bujak et al., 1980, Plate **P1,** Figure 18.

Deflandrea granulata Menéndez, 1965, Plate **P5,** Figure 13.

Deflandrea phosphoritica Eisenack, 1938, Plate **P5,** Figure 16.

Dinopterygium cladoides sensu Morgenroth, 1966, Plate **P5,** Figures 2 and 3.

Diphyes colligerum (Deflandre & Cookson, 1955) emend. Goodman & Witmer, 1985, Plate **P1,** Figures 9 and 10.

Distatodinium ellipticum (Cookson, 1965) Eaton, 1976, Plate **P1,** Figure 8.

Enneadocysta multicornuta (Eaton, 1971) Stover & Williams, 1995, Plate **P3,** Figures 10 and 11.

Eocladopyxis tessellata Liengjarern et al., 1980, Plate **P5,** Figures 9 and 10.

Glaphyrocysta intricata (Eaton, 1971) Stover & Evitt, 1978, Plate **P3,** Figures 1 and 2.

Hemiplacophora semilunifera Cookson & Eisenack, 1965, Plate **P4,** Figures 5 and 6.

Hemiplacophora sp. A, Plate **P4,** Figures 1, 2, 3, and 4.

Remarks: The apical archeopyle (type tA), the incomplete penitabular septa, and the absence of any indication of the cingulum supports attribution to the genus *Hemiplacophora*. The endophragm (closely appressed to periphragm except below processes) is smooth. The periphragm is finely granulate. It differs from *H. semilunifera* by having larger and more irregular processes/septa.

Dimensions: Central body 35–45 µm, septa 10–20 µm (N = 10).

Heteraulacacysta campanula Drugg & Loeblich, 1967, Plate **P5,** Figure 1.

Homotryblium aculeatum Williams, 1978

Homotryblium floripes (Deflandre & Cookson, 1955) emend. Stover, 1975, Plate **P5,** Figures 4, 5, and 6.

Homotryblium plectilum Drugg & Loeblich, 1967

Homotryblium tenuispinosum Davey & Williams, 1966, Plate **P5,** Figures 7 and 8.

Hystrichokolpoma cinctum Klumpp, 1953

Hystrichokolpoma rigaudiae Deflandre & Cookson, 1955, Plate **P3,** Figures 14, 15, and 16.

Hystrichosphaeropsis sp. of Brinkhuis & Biffi, 1993, Plate **P1,** Figures 13 and 14.

Impagidinium brevisulcatum Michoux, 1985

Impagidinium cf. *I. aculeatum* (Wall, 1967) Lentin & Williams, 1981, Plate **P6,** Figures 1, 2, and 3.

Remarks: This species differs from *Impagidinium aculeatum* in having distally furcate processes/septa.

Impagidinium cf. *I. velorum,* Plate **P6,** Figures 11 and 12.

Remarks: This species differs from *Impagidinium velorum* in having incomplete septa.

Dimensions: Central body 30 µm, septa 15 mm (N = 1).

Impagidinium dispertitum (Cookson & Eisenack, 1965) Stover & Evitt, 1978, Plate **P6,** Figures 8 and 9.

Impagidinium maculatum (Cookson & Eisenack, 1961) Stover & Evitt, 1978, Plate **P6,** Figures 5 and 6.

Impagidinium sp. of Brinkhuis & Biffi, 1993, Plate **P6,** Figures 10 and 13.

Impagidinium sp. A, Plate **P6,** Figures 4 and 7.

Remarks: The clear S-type sulcus and the parasutural ridges attribute this species to *Impagidinium.* The sutural ridges and the cell wall are smooth and very thin.

Dimensions: Central body 45–55 mm, ridges 5 mm (N = 2).

Impagidinium velorum Bujak, 1984, Plate **P6,** Figures 14, 15, and 16.

Lentinia serrata Bujak in Bujak et al., 1980

Lingulodinium machaerophorum. (Deflandre & Cookson, 1955) Wall, 1967, Plate **P1,** Figures 16 and 17.

Melitasphaeridium pseudorecurvatum (Morgenroth, 1966) Bujak et al., 1980, Plate **P3,** Figure 13.

Nematosphaeropsis sp. of Goodman, 1979, Plate **P1,** Figures 5, 6, and 7.

Operculodinium spp. Wall, 1967, emend. Matsuoka et al., 1997

Pentadinium laticinctum Gerlach, 1961, emend. Benedek et al., 1982, Plate **P7,** Figures 10, 11, 12, 13, and 14.

Pentadinium lophophorum Benedek, 1972, emend. Benedek et al., 1982, Plate **P7,** Figure 15.

Phthanoperidinium comatum (Morgenroth, 1966) Eisenack & Kjellström, 1971, Plate **P8,** Figures 1, 2, and 3.

Phthanoperidinium? sp. A, Plate **P8,** Figures 4, 5, 6, 7, and 8.

Remarks: This species is attributed to *Phthanoperidinium* in view of its general morphology, clearly having an indicated cingulum and showing peridinioid paratabulation. Most of the observed specimens have a short apical horn. No archeopyle was observed. The surface is smooth.

Dimensions: Central body width 20–25 µm, length 25–30 µm, apical horn 2 µm (N = 4).

Phthanoperidinium sp. B, Plate **P8,** Figures 10, 11, 13, and 14.

Remarks: The short apical horn and the indication of two antapical horns; an intercalary (2a) archeopyle, the clear peridinioid paratabulation, and the clear cingulum are typical features for *Phthanoperidinium*. The surface is finely granular.

Dimensions: Central body width 25 mm, length 35–40 µm, apical horn 4 µm (N = 2).

Phthanoperidinium? sp. C, Plate **P8,** Figures 9 and 12.

Remarks: Only a single specimen was found. It is tentatively attributed to *Phthanoperidinium,* in view of its paratabulation pattern and its small apical horn. The surface is smooth, the sutural ridges are low, and at the plate junctions short spines are present.

Dimensions: Central body width 24 µm, length 30 µm, apical horn 2 µm (N = 1).

Samlandia chlamydophora Eisenack, 1954, Plate **P4,** Figure 13.

Samlandia chlamydophora sensu Stover and Hardenbol, 1994, Plate **P4,** Figures 14 and 15.

Schematophora speciosa Deflandre & Cookson, 1955, emend. Stover, 1975, Plate **P4,** Figures 7, 8, and 9.

Spiniferites sp. A, Plate **P1,** Figures 3 and 4.

Remarks: The precingular archeopyle and the sutural septa with distally bi- and trifurcate gonal processes support the placement of this species in *Spiniferites*. It differs from other *Spiniferites* species by having relatively high sutural crests with their typical denticulated margins.

Dimensions: Central body 22–30 µm, septa 5–8 µm (N = 4).

Systematophora ancyrea Cookson & Eisenack, 1965, Plate **P4,** Figure 10.

Systematophora placacantha (Deflandre & Cookson, 1955) Davey et al., 1966, emend. May, 1980, Plate **P4,** Figures 11 and 12.

Tectatodinium pellitum Wall, 1967, emend. Head 1994, Plate **P2,** Figure 10.

Thalassiphora delicata Williams & Downie, 1966, emend. Eaton, 1976, Plate **P7,** Figures 7 and 8.

Thalassiphora patula (Williams and Downie, 1966) Stover and Evitt 1978, Plate **P2,** Figures 13 and 14.

Thalassiphora pelagica (Eisenack, 1954) Eisenack & Gocht 1960, emend. Benedek & Gocht, 1981, Plate **P7,** Figures 6 and 9.

Turbiosphaera filosa (Wilson, 1967) Archangelsky, 1969, Plate **P2,** Figures 11 and 12.

Wetzeliella gochtii Costa & Downie, 1976, Plate **P5,** Figures 14 and 15.

Incertae sedis

Skolchorate cysts, Plate **P2,** Figures 15, 16, and 17.

Remarks: In the present material, small spiny skolochorate cysts are present. They resemble the acritarch species *Impletosphaeridium kroemmelbeinii*.

Dimensions: Central body width 40–45 µm, height 45–50 µm, processes 10 mm (N = 4).

Forma A, Plate **P7,** Figures 1, 2, 3, 4, 5, and 6.

Remarks: This structure may be characterized by a subspherical shape and the presence of two wall layers. The inner wall is smooth to granulate and subspherical. The outer wall is distinctly coarsely perforate and smooth. No indications of paratabulation or archeopyle have been observed. This form resembles Dinocyst sp. B of Head & Norris (1989).

Dimensions: Overall size 45–50 µm, inner body 25–30 µm, average diameter of the perforations 5 µm (N = 6). Affinity uncertain.

ACKNOWLEDGMENTS

Financial support was provided by the Swedish Natural Research Council, the LPP-Foundation (Utrecht), and the Pieter Langerhuizen Lambertuszoon Fund.

REFERENCES

Brinkhuis, H., and Biffi, U., 1993. Dinoflagellate cyst stratigraphy of the Eocene/Oligocene transition in central Italy. *Mar. Micropaleontol.,* 22:131–183.

Goodman, D.K., 1979. Dinoflagellate "communities" from the Lower Eocene Nanjemoy Formation of Maryland, U.S.A. *Palynology,* 3:169–190.

Head, M.J., and Norris, G., 1989. Palynology and dinocyst stratigraphy of the Eocene and Oligocene in ODP Leg 105, Hole 647A, Labrador Sea. *In* Srivastava, S.P., Arthur, M.A., Clement, B., et al., *Proc. ODP, Sci. Results,* 105: College Station, TX (Ocean Drilling Program), 515–550.

Norris, R.D., Kroon, D., Klaus, A., et al., 1998. *Proc. ODP, Init. Repts.,* 171B: College Station, TX (Ocean Drilling Program).

Williams, G.L., Lentin, J.K., and Fensome, R.A., 1998. The Lentin and Williams Index of fossil dinoflagellates 1998 edition. *Am. Assoc. Stratigr. Palynol., Contrib. Ser.,* 34.

Figure F1. Distribution pattern of palynomorphs at Site 1053A, correlated with the lithology, nannofossil and foraminiferal biozones, and polarity and paleomagnetic subdivisions (Norris, Kroon, Klaus, et al., 1998). * = a palynomorph present in that sample but not included in the total count. Indet. = indeterminable, and Det. = determinable.

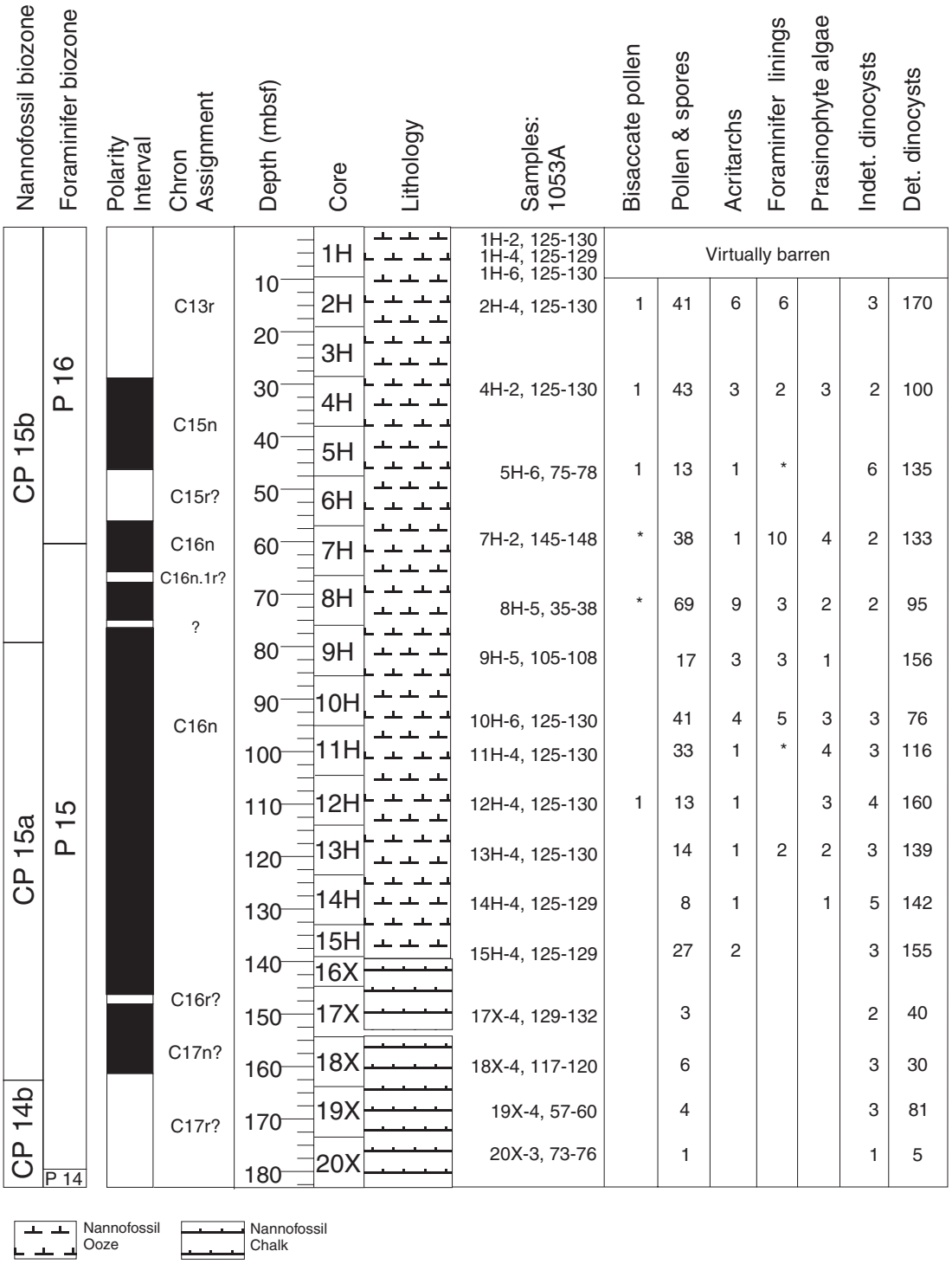


Table T1. Quantitative distribution pattern of dinocysts by their first occurrence, Hole 1035A. (**See table note.** Continued on next page.)

Core:	1H	1H	1H	2H	4H	5H	7H	8H	9H	10H	11H	12H	13H	14H	15H	17X	18X	19X	20X
Section:	2	4	6	4	2	6	2	5	5	6	4	4	4	4	4	4	4	4	3
Interval top (cm):	124	124	125	125	125	75	145	35	105	125	125	125	125	125	125	129	117	57	73
Interval bottom (cm):	130	129	130	130	130	78	148	38	108	130	130	130	130	129	129	132	120	60	76
Depth (mbsf):	2.74	5.74	8.75	15.25	31.25	46.25	59.95	72.85	83.05	94.25	100.75	110.25	119.75	129.25	138.75	150.49	159.97	168.97	177.23
Total determinable dinocysts counted:		3		202	301	224	285	264	275	234	136	275	144	255	164	39	30	81	6
Impagidinium velorum					1														
Hystrichosphaeropsis sp. of Brinkhuis & Biffi, 1993					3														
Eocladopyxis tessellata				2	3														
Homotryblium aculeatum						1	1												
Homotryblium tenuispinosum						10	2												
Impagidinium brevisulcatum					1		2												
Cassidium fragile				1			1												
Wetzeliella gochtii							*	1											
Charlesdowniea clathrata					2		3	1											
Homotryblium plectilum				10			1	1											
Dapsilidinium simplex									1										
Turbiosphaera filosa									1										
Glaphyrocysta intricata							2	1		*									
Cordosphaeridium minimum				6		1	1			1									
Distatodinium ellipticum				1		1				*									
Impagidinium sp. A							1			4									
Areoligera? sp. A						1	1			3									
Hystrichokolpoma cinctum					2	4	2	6	2	7									
Samlandia chlamydophora				1		*	1	1	1	1									
Hemiplacophora sp.				4	11	8	3		*	4									
Cribroperidinium tenuitabulatum					2	2		2			1								
Forma A				5				9	1		1								
Batiacasphaera compta					2	3		2						1					
Phthanoperidinium? sp. A				4							1								
Turbiosphaera magnifica												1							
Corrudinium incompositum							1			1		1							
Deflandrea granulata				1	1	3		*		1	3	2							
Tectatodinium pellitum										1			1						
Dinopterygium cladoides sensu Morgenroth, 1966				1		1							1						
Thalassiphora delicata					2	3		1	*				1						
Lentinia serrata					2								1						
Systematophora placacantha				1	4	5	4	23			1	2	1						
Pentadinium lophophorum				1		1		*			4		1						
Samlandia chlamydophora sensu Stover and Hardenbol, 1994														1					
Cordosphaeridium gracile									1					1					
Skolchorate cyst					4	3		4	1			3		1					
Dapsilidinium pastielsii				2	7	6								1					
Pentadinium laticinctum				2	2	1	1	2	3	1	5	*	2	3					
Phthanoperidinium sp. B				1								1		1					
Spiniferites sp. A									3	1		5		1	1				
Heteraulacacysta campanula							1							1	1				
Schematophora speciosa							3			1					4				
Cerebrocysta bartonensis					1			1			1	1			1				
Deflandrea phosphoritica					4	*		2			2	1			1				
Systematophora ancyrea					2	2	7	3	6	*	4	2	1	3	2				
Aeroligera? sp. B					1		1	3	3			2		5	18				

Table T1 (continued).

Core:	1H	1H	1H	2H	4H	5H	7H	8H	9H	10H	11H	12H	13H	14H	15H	17X	18X	19X	20X
Section:	2	4	6	4	2	6	2	5	5	6	4	4	4	4	4	4	4	4	3
Interval top (cm):	124	124	125	125	125	75	145	35	105	125	125	125	125	125	125	129	117	57	73
Interval bottom (cm):	130	129	130	130	130	78	148	38	108	130	130	130	130	129	129	132	120	60	76
Depth (mbsf):	2.74	5.74	8.75	15.25	31.25	46.25	59.95	72.85	83.05	94.25	100.75	110.25	119.75	129.25	138.75	150.49	159.97	168.97	177.23
Total determinable dinocysts counted:		3		202	301	224	285	264	275	234	136	275	144	255	164	39	30	81	6
Diphyes colligerum				1	2		*							1	1				
Impagidinium sp. of Brinkhuis & Biffi, 1993				2	2	1		2		2		5	5	4	4				
Phthanoperidinium comatum							3	3		3	1					1			
Achomosphaera? sp. A					2				1						3	3			
Dapsilidinium pseudocolligerum				5		2	3	6	2	4	3				4	1			
Enneadocysta multicornuta				6		1	2			3	5	2	3			1			
Impagidinium maculatum																	1		
Hemiplacophora semilunifera								1									1		
Thalassiphora pelagica						*				11	1						1		
Nematosphaeropsis sp. of Goodman, 1966					2	2	2			3				1	1		2		
Hystrichokolpoma rigaudiae				2	4	3	4	2	4	4			1				1		
Lingulodinium machaerophorum				1	12	2	3		3	1	*						1		
Impagidinium cf. I. *velorum*																		1	
Phthanoperidinium? sp. C																		1	
Melitasphaeridium pseudorecurvatum											1		1	1				1	
Impagidinium dispertitum				1			*	5	*	1	1	3	2	*				1	
Operculodinium spp.				4	15	22	27	33	19	17	10	29	17	30	30	3	3	7	
Areosphaeridium diktyoplokum												1					1		1
Homotryblium floripes				32	7	37	5		2	3	3	7	2	6	1		1	1	1
Impagidinium cf. I. *aculeatum*				3	5	2			3	1		*		1	3	1	2		2
Achomosphaera/Spiniferites spp. pars.		3		102	193	96	197	149	218	155	88	207	104	192	89	29	16	69	2

Note: * = species is present in the sample but not included in the total count.

Plate P1. 1, 2. *Achomosphaera*? sp. A sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (S23). Figure 2 is to same scale as Figure 1. **3, 4.** *Spiniferites* sp. sample/slide, Sample 171B-1053A-14H-4, 125–129 cm/I (C43). Figure 4 is to same scale as Figure 3. **5, 6, 7.** *Nematosphaeropsis* sp. of Goodman, 1979 sample/slide, Sample 171B-1053A-18X-4, 117–120 cm/I (Q27). Figures 6 and 7 are to same scale as Figure 5. **8.** *Distatodinium ellipticum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (C49). **9, 10.** *Diphyes colligerum* sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (T28). Figure 10 is to same scale as Figure 9. **11, 12.** *Dapsilidinium pastielsii* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (T23). Figure 12 is to same scale as Figure 11. **13, 14.** *Hystrichosphaeropsis* sp. of Brinkhuis and Biffi, 1993 sample/slide, Sample 171B-1053A-4H-2, 125–130 cm/I (O27). Figure 14 is to same scale as Figure 13. **15.** *Dapsilidinium pseudocolligerum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (O22). **16, 17.** *Lingulodinium machaerophorum* sample/slide, Sample 171B-1053A-9H-5, 105–108 cm/I (L44). Figure 16 is to same scale as Figure 17. **18.** *Dapsilidinium simplex* sample/slide, Sample 171B-1053A-9H-5, 105–108 cm/I (Z24).

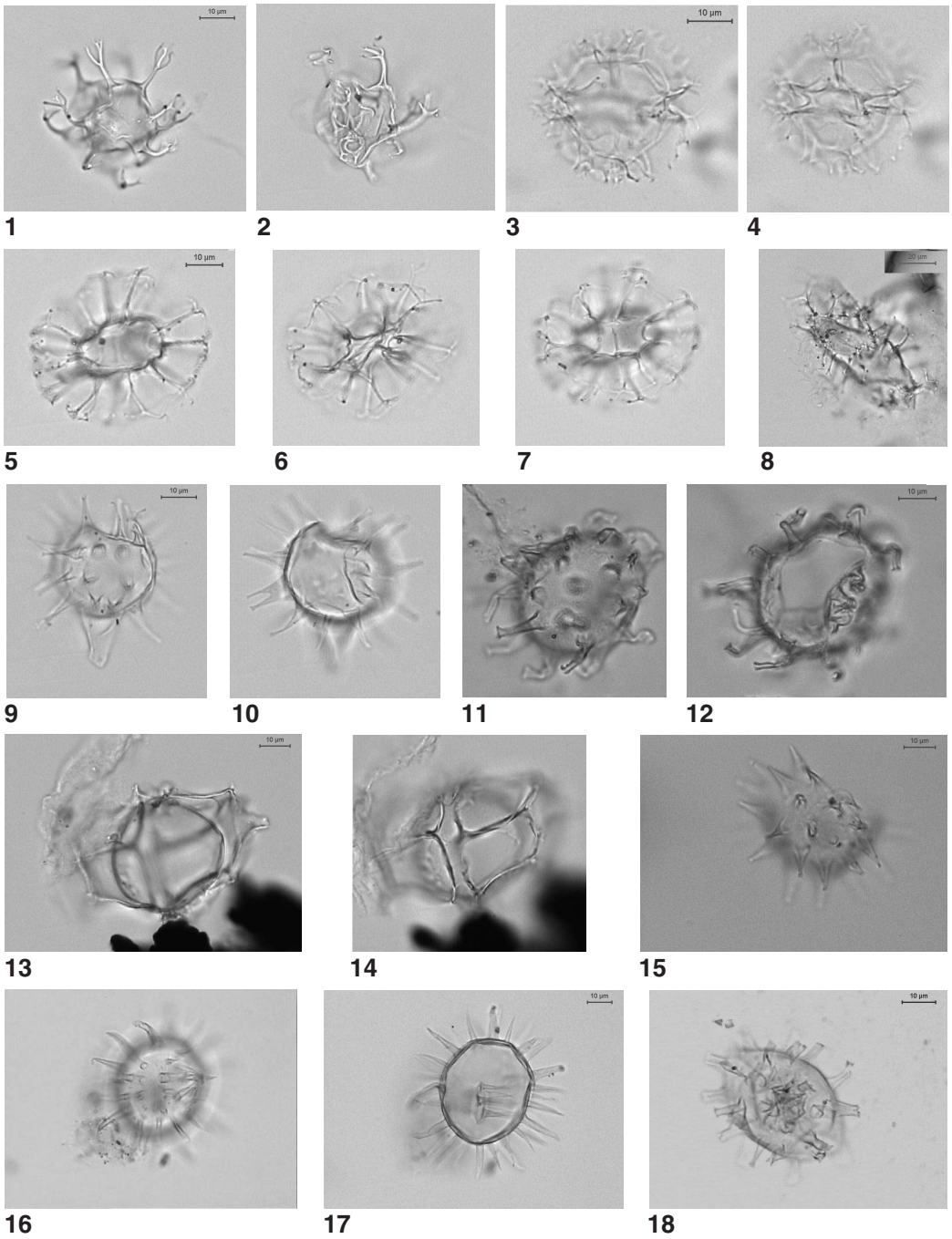


Plate P2. 1, 2. *Cordosphaeridium gracile* sample/slide, Sample 171B-1053A-14H-4, 125–129 cm/I (E29). Figure 2 is to the same scale as Figure 1. **3.** *Corrudinium incompositum* sample/slide, Sample 171B-1053A-10H-6, 125–130 cm/I (E35). **4, 5.** *Cordosphaeridium minimum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (J35). Figure 5 is to the same scale as Figure 4. **6, 7.** *Cerebrocysta bartonensis* sample/slide, Sample 171B-1053A-9H-5, 105–108 cm/I (B35). Figure 7 is to the same scale as Figure 6. **8, 9.** *Cribroperidinium tenuitabulatum* sample/slide, Sample 171B-1053A-11H-4, 125–130 cm/I (F32). Figure 9 is to the same scale as Figure 8. **10.** *Tectatodinium pellitum* sample/slide, Sample 171B-1053A-9H-5, 105–108 cm/I (Y48). **11, 12.** *Turbiosphaera filosa* sample/slide, Sample 171B-1053A-9H-5, 105–108 cm/I (Y29). Figure 12 is to the same scale as Figure 11. **13, 14.** *Thalassiphora patula* sample/slide, Sample 171B-1053A-12H-4, 125–130 cm/I (Y43). Figure 14 is to the same scale as Figure 13. **15, 16, 17.** Skolchorate cyst sample/slide, Sample 171B-1053A-14H-4, 125–129 cm/I (D25). Figures 16 and 17 are to the same scale as Figure 15. **(Plate shown on next page.)**

Plate P2 (continued).

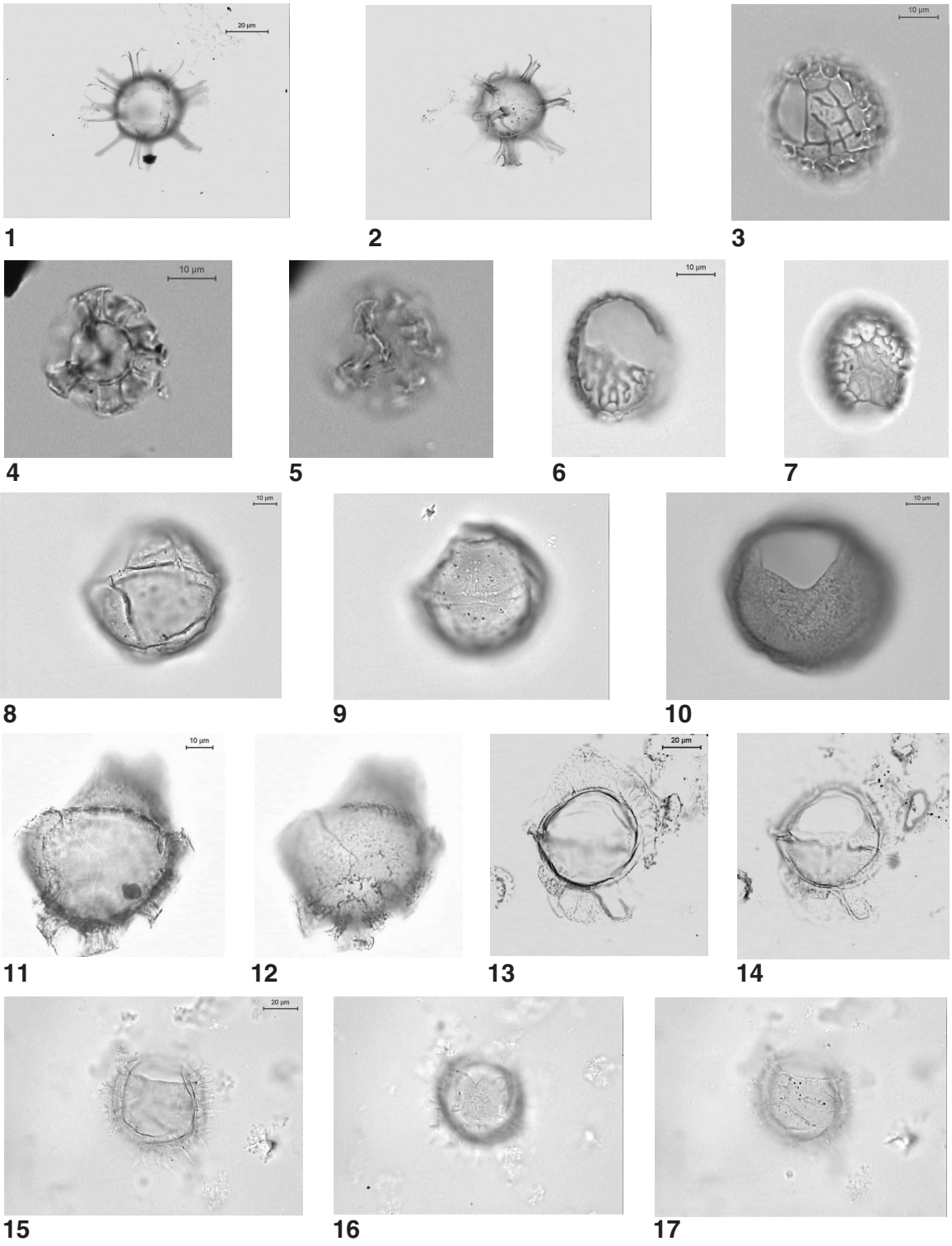


Plate P3. 1, 2. *Glaphyrocysta intricata* sample/slide, Sample 171B-1053A-8H-5, 35–38 cm/I (C36). Figure 2 is to the same scale as Figure 1. **3, 6.** *Areoligera*? sp. B sample/slide, Sample 171B-1053A-15H-4, 125–129 cm/II (M26). Figure 6 is to the same scale as Figure 3. **4, 5.** *Batiacasphaera comptan* sample/slide, Sample 171B-1053A-3H-2, 125–129 cm/I (O44). Figure 5 is to the same scale as Figure 4. **7, 8, 9.** *Areoligera*? sp. A sample/slide, Sample 171B-1053A-5H-6, 75–78 cm/I (Q27). Figures 7, 8, and 9 are to the same scale as Figure 1. **10, 11.** *Enneadocysta multicornuta* sample/slide, Sample 171B-1053A-11H-4, 125–130 cm/I (A35). Figure 10 is to the same scale as Figure 11. **12.** *Areosphaeridium diktyoplokum* (operculum) sample/slide, Sample 171B-1053A-18X-4, 117–120 cm/I (Y46). **13.** *Melitasphaeridium pseudorecurvatum* sample/slide, Sample 171B-1053A-19X-4, 57–60 cm/I (F30). **14, 15, 16.** *Hystrichokolpoma rigaudiae* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I. (14, 15) Y29; (16) W33. Figure 15 is to the same scale as Figure 14. **(Plate shown on next page.)**

Plate P3 (continued).

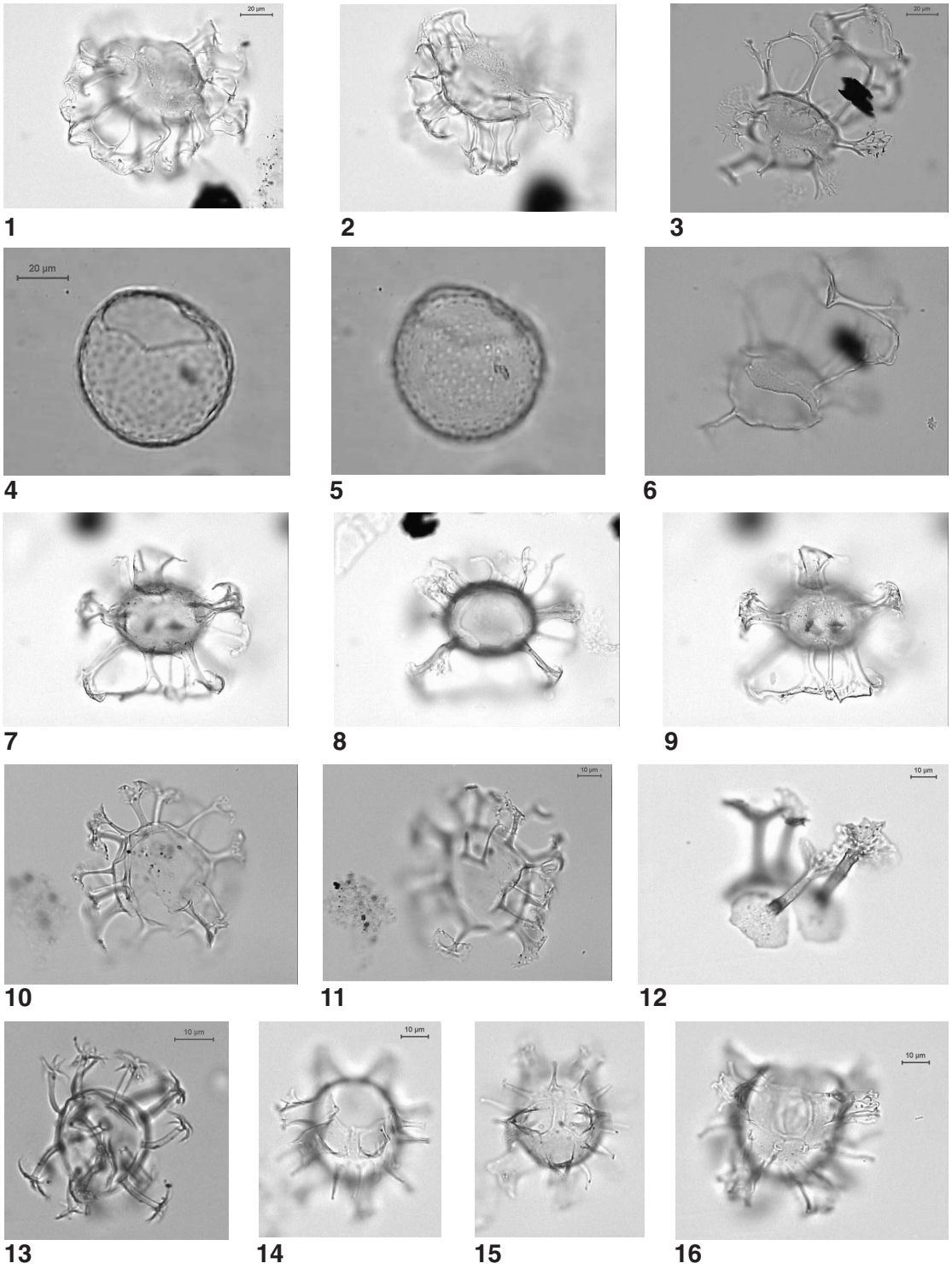
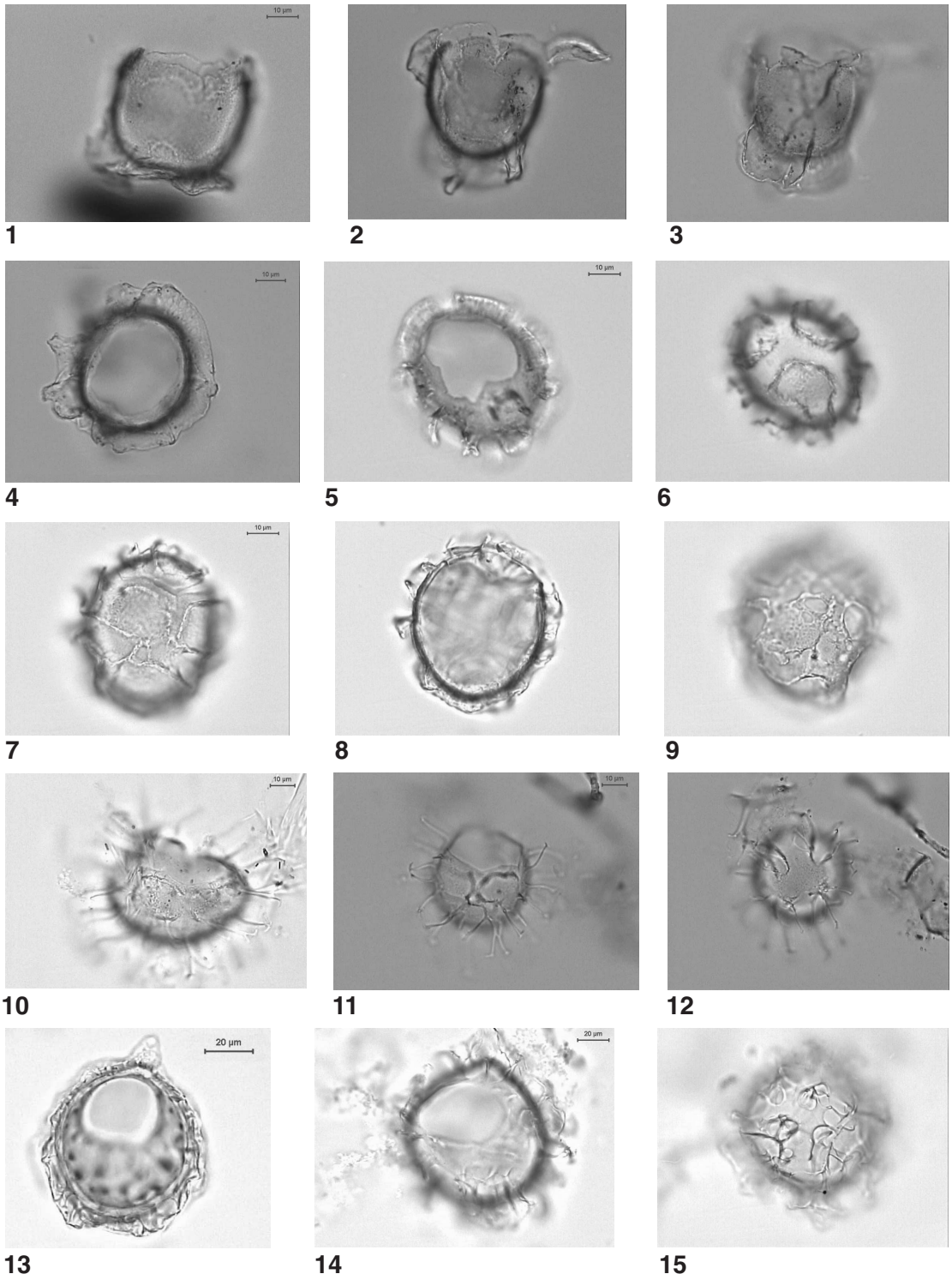


Plate P4. 1, 2, 3, 4. *Hemiplacophora* sp. A sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I. (1) H36; (2, 3) J46; (4) B27. Figures 2 and 3 are to the same scale as Figure 1. **5, 6.** *Hemiplacophora semilunifera* sample/slide, Sample 171B-1053A-18X-4, 117–120 cm/I (T51). Figure 6 is to the same scale as Figure 5. **7, 8, 9.** *Schematophora speciosa* sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (H37). Figures 8 and 9 are to the same scale as Figure 7. **10.** *Systematophora ancyrea* sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (N50). **11, 12.** *Systematophora placacantha* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (G28). Figure 12 is to the same scale as Figure 11. **13.** *Samlandia chlamydophora* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (C45). **14, 15.** *Samlandia chlamydophora* sensu Stover and Hardenbol 1994 sample/slide, Sample 171B-1053A-14H-4, 125–129 cm/I (P26). Figure 15 is to the same scale as Figure 14. **(Plate shown on next page.)**

Plate P4 (continued).



1 2 3

4 5 6

7 8 9

10 11 12

13 14 15

Plate P5. 1. *Heteraulacacysta campanula* sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (R22). **2, 3.** *Dinopterygium cladoides* sensu Morgenroth 1966 sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (R47). Figure 3 is to the same scale as Figure 2. **4, 5, 6.** *Homotryblium floripes* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (N30). Figures 5 and 6 are to the same scale as Figure 4. **7, 8.** *Homotryblium tenuispinosum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (J47). Figure 8 is to the same scale as Figure 7. **9, 10.** *Eocladopyxis tessellata* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (Y34). Figure 10 is to the same scale as Figure 9. **11, 12.** *Charlesdowniea clathrata* sample/slide, Sample 171B-1053A-8H-5, 35–38 cm/I (D45). Figure 12 is to the same scale as Figure 11. **13.** *Deflandrea granulata* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (Z41). **14, 15.** *Wetzeliella gochtii* sample/slide, Sample 171B-1053A-8H-5, 35–38 cm/I (C34). Figure 15 is to the same scale as Figure 14. **16.** *Deflandrea phosphoritica* sample/slide, Sample 171B-1053A-15H-4, 125–130 cm/I (K35). **(Plate shown on next page.)**

Plate P5 (continued).

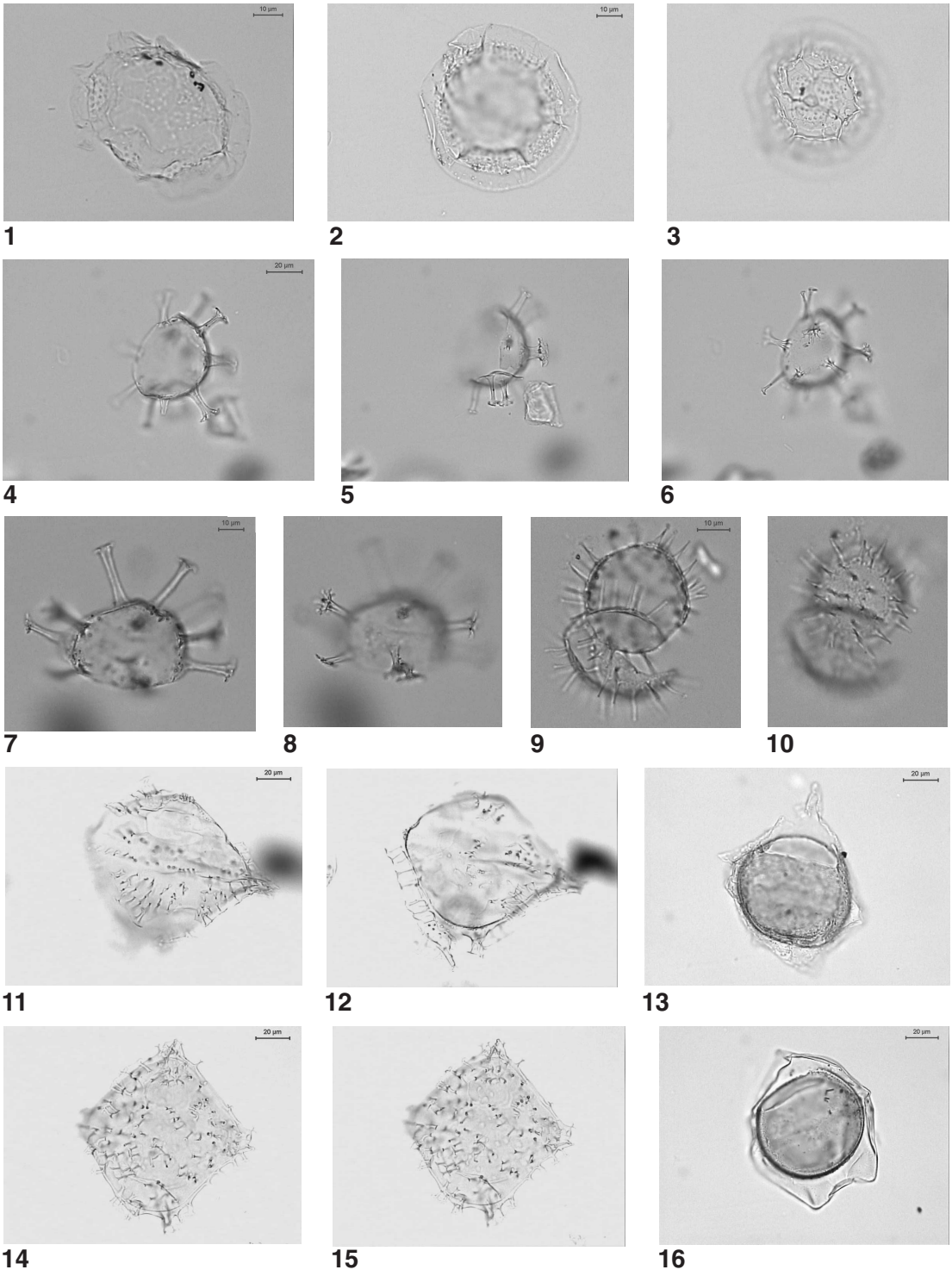


Plate P6. 1, 2, 3. *Impagidinium* cf. *I. aculeatum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (R29). Figures 2 and 3 are to the same scale as Figure 1. **4, 7.** *Impagidinium* sp. A sample/slide, Sample 171B-1053A-10H-6, 125–130 cm/I (E39). Figure 7 is to the same scale as Figure 4. **5, 6.** *Impagidinium maculatum* sample/slide, Sample 171B-1053A-17X-4, 129–132 cm/I (V19). Figure 6 is to the same scale as Figure 5. **8, 9.** *Impagidinium dispertitum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (F40). Figure 9 is to the same scale as Figure 8. **10, 13.** *Impagidinium* sp. of Brinkhuis and Biffi 1993 sample/slide, Sample 171B-1053A-13H-4, 125–130 cm/I (F26). Figure 13 is to the same scale as Figure 10. **11, 12.** *Impagidinium* cf. *I. velorum* sample/slide, Sample 171B-1053A-19X-4, 57–60 cm/I (N52). Figure 12 is to the same scale as Figure 11. **14, 15, 16.** *Impagidinium velorum* sample/slide, Sample 171B-1053A-4H-2, 125–130 cm/I (F37). Figures 15 and 16 are to the same scale as Figure 14. **(Plate shown on next page.)**

Plate P6 (continued).

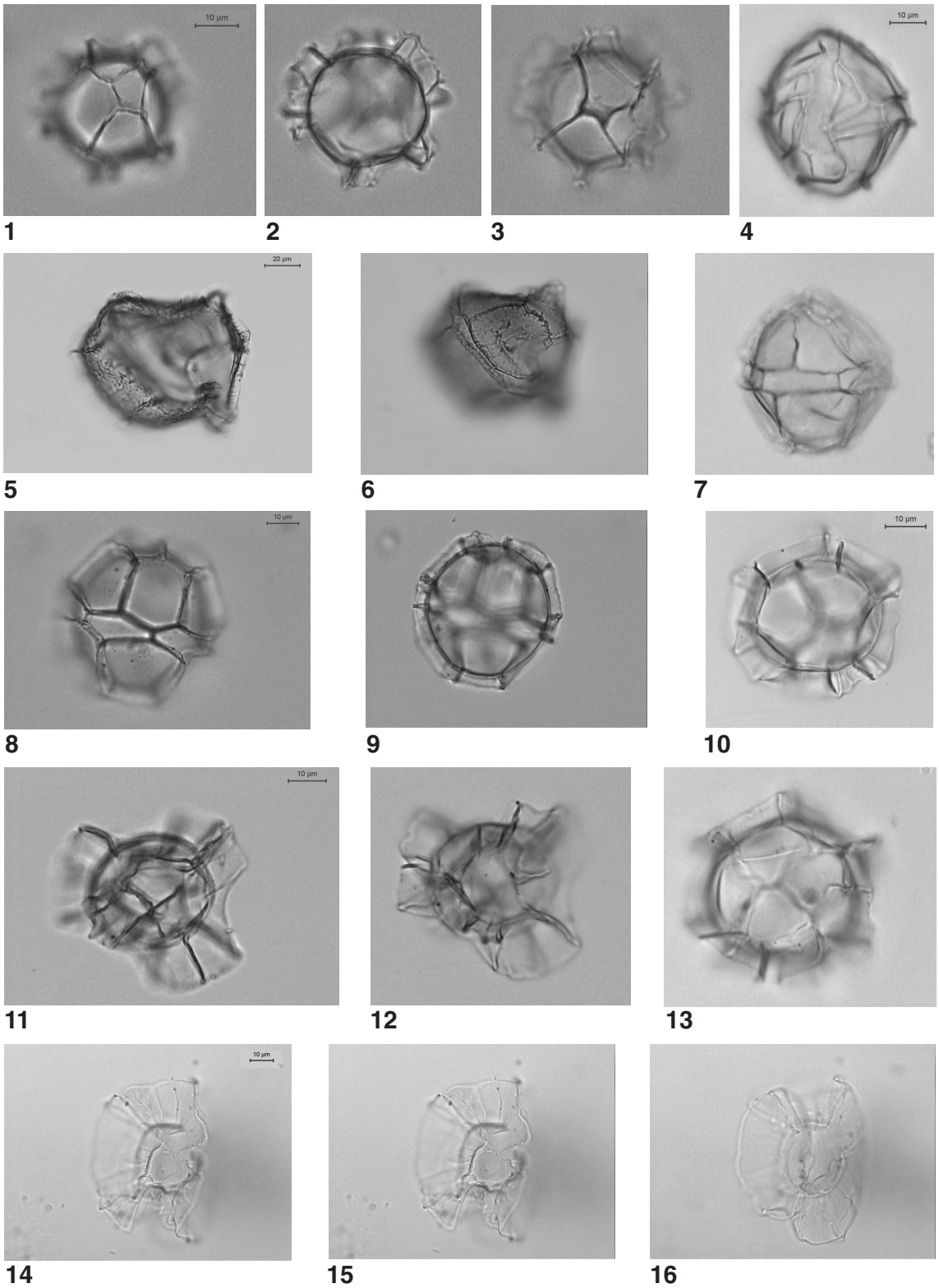


Plate P7. 1, 2, 3, 4, 5. Forma A. sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I. (1–3) L38; (4, 5) S46. Figures 2 and 3 are to the same scale as Figure 1; Figure 5 is to the same scale as Figure 4. **6, 9.** *Thalassiphora pelagica* sample/slide, Sample 171B-1053A-10H-6, 125–130 cm/I (F46). Figure 9 is to the same scale as Figure 6. **7, 8.** *Thalassiphora delicata* sample/slide, Sample 171B-1053A-10H-6, 125–130 cm/II (L26). Figure 8 is to the same scale as Figure 7. **10, 11, 12, 13, 14.** *Pentadinium laticinctum* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I. (10, 11) R33; (13, 14) L38. Sample 171B-1053A-14H-4, 125–129 cm/I. (12) D39. Figure 11 is to the same scale as Figure 10; Figure 12 is to the same scale as Plate P6, Figure 8; Figure 14 is to the same scale as Figure 13. **15.** *Pentadinium lophophorum* sample/slide, Sample 171B-1053A-7H-2, 145–148 cm/I (F44). **(Plate shown on next page.)**

Plate P7 (continued).

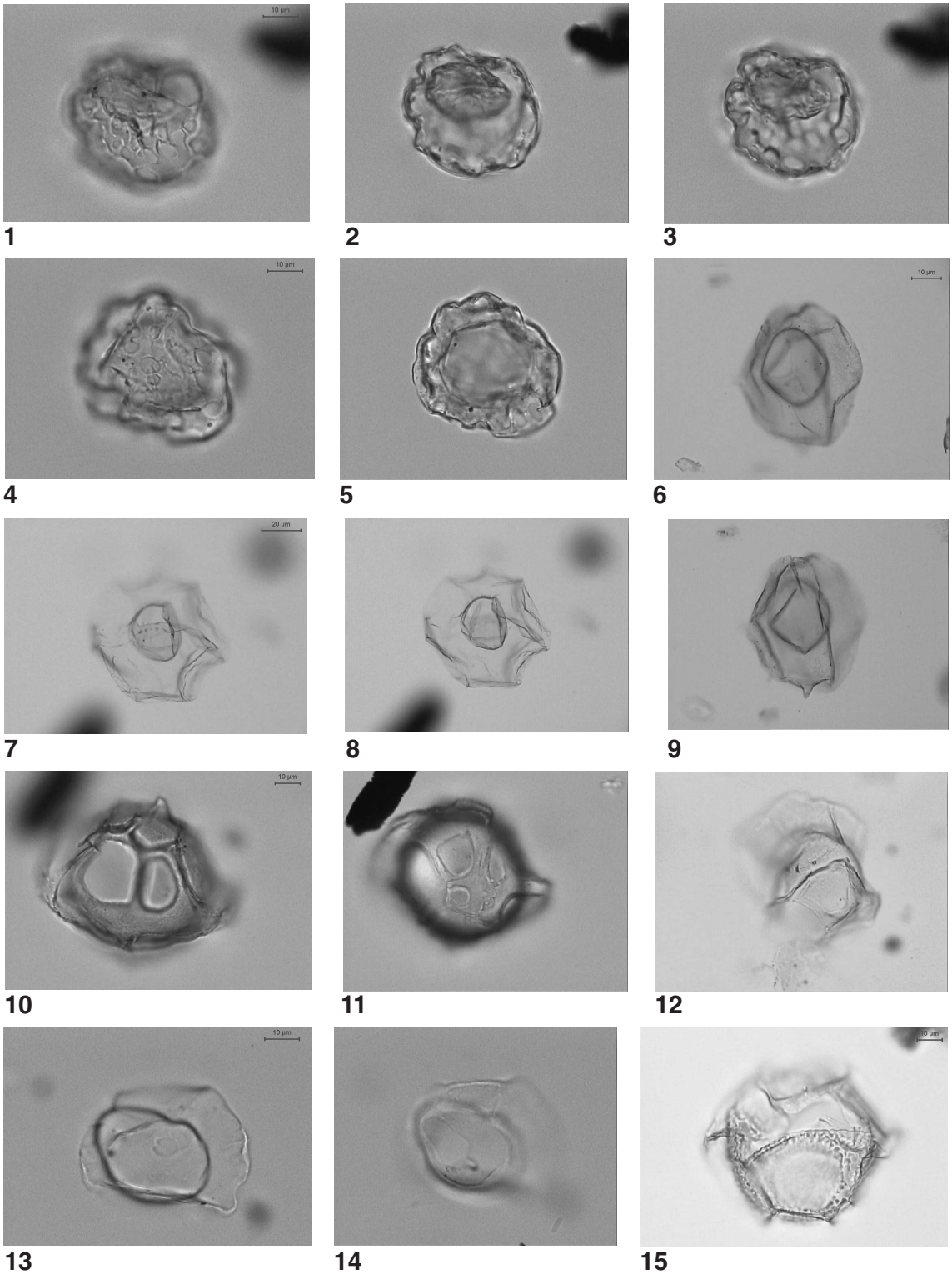


Plate P8. 1, 2, 3. *Phthanoperidinium comatum* sample/slide, Sample 171B-1053A-8H-5, 35–38 cm/I (F47). Figures 2 and 3 are to the same scale as Figure 1. **4, 5, 6, 7, 8.** *Phthanoperidinium*? sp. A. sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I. (4, 5) H34; (6–8) B37. Figure 5 is to the same scale as Figure 4; Figures 7 and 8 are to the same scale as Figure 6. **9, 12.** *Phthanoperidinium* sp. C. sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (P26). **10, 11, 13, 14.** *Phthanoperidinium*? sp. B. sample/slide, Sample 171B-1053A-19X-4, 57–60 cm/I (A20). Figures 11, 13, and 14 are to the same scale as Figure 10. **15.** *Cassidium fragile* sample/slide, Sample 171B-1053A-2H-4, 125–130 cm/I (G17). **(Plate shown on next page.)**

Plate P8 (continued).