
Dinocyst biostratigraphy of Cenomanian–Coniacian formations of the western Gulf Coastal Plain, southern United States

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This palynological investigation of Cenomanian–Coniacian formations of Texas, U.S.A., consists of an examination of 63 outcrop samples from 9 stratigraphic sections exposed in 7 counties in a north-south trend from about Dallas to Del Rio. The Grayson Formation, the Eagle Ford Formation, the lower Austin Chalk, and their southern equivalents were examined for palynological data. Most of the samples are rich in dinocyst assemblages. Seventy-eight dinocyst species of 47 genera, 3 acritarch species of three genera, and 28 spore-pollen species of 20 genera are recognized and their stratigraphic distribution documented. Systematic descriptions and illustrations of all dinocyst and acritarch taxa are given. Spore-pollen taxa have rare occurrences in all the studied sections and are thus only listed and illustrated.

The stratigraphic distribution of dinocyst taxa indicates that *Cyclonephelium eisenackii* and *Ovoidinium verrucosum* terminate at the end of the Cenomanian, and *Litosphaeridium siphoniphorum* at the end of the Turonian. *Dinogymnium acuminatum* and *Chatangella victoriensis* appear in the Coniacian.

Key-words—Palynology, Dinoflagellates, Acritarchs, Cenomanian, Coniacian, Cretaceous, North America

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सारांश

दक्षिणी संयुक्त राज्य में पश्चिमी खाड़ी के तटीय मैदान में सीनोमानियन-कोनियासियन शैल-समूहों का घूर्णीकशाभ पुटी जैवस्तरविन्यास

सतीश कुमार श्रीवास्तव

टेक्सस (अमेरिका) के सीनोमानियन-कोनियासियन कालीन शैल-समूहों के इस परागाणविक अन्वेषण में 63 दृश्यांस नमूनों का अध्ययन किया गया। ये नमूने डल्लस से डेलरियो तक फैले 9 विभिन्न स्तरिक खंडों के हैं। परागाणविक आंकड़े एकत्र करने हेतु ग्रेसन शैल-समूह, ईगल फोर्ड शैल-समूह, अधिर ऑस्टिन चाक तथा इनके दक्षिणी समतुल्यों का भी अध्ययन किया गया। इनमें से अधिकतर नमूने घूर्णीकशाभ पुटीयों से भरपूर हैं। घूर्णीकशाभ पुटीयों की 47 प्रजातियाँ व 78 जातियाँ, ऐक्रीटाकों की 3 प्रजातियाँ व 3 जातियाँ तथा बीजाणु परागकणों की 20 प्रजातियाँ एवं 28 जातियाँ अभिर्नधारित की गई हैं तथा इनके स्तरिकीय वितरण की विवेचना की गई है। सभी घूर्णीकशाभ पुटी एवं ऐक्रीटाक वर्गकों के चित्र एवं वर्णन आदि भी दिये गये हैं। अध्ययन किये गये सभी खंडों में बीजाणु-परागकणों की काफी संख्या मिलती है।

घूर्णीकशाभ पुटी वर्गकों के स्तरिकीय वितरण से प्रदर्शित होता है कि सीनोमानियन की समाप्ति पर साइबलोनोफेलियम आइज़नेकाई एवं ओवोइडीनियम बेरुकोसम तथा टुरोनियन के अन्त तक लिटोस्फेरिडीयम साइफोनीफेरम की उपस्थिति शून्य हो जाती है। कोनियासियन काल में डाइनोफ्लिग्मियम एक्वुमिनाटम एवं शैटेन्जियेल्ला विक्टोरियेन्सिस मिलने प्रारम्भ हो जाते हैं।

MARINE stratigraphic sections outcropping in Texas represent almost all Upper Cretaceous stages. These formations are rich in marine fossils which have been studied extensively. All these formations have been age-dated by comprehensive studies of ammonites (Young, 1963) and foraminifers (Pessagno, 1967, 1969). Longoria (1984) provided a

refined biozonation of the Cretaceous of the Gulf Region based on planktonic microfossils.

Palynomorphs, terrestrial or marine, are much smaller than many other microfossils and their occurrences are much more varied in the sediments. In instances where other microfossils are not present, palynomorphs may occur in abundance and

can be useful in biostratigraphy. The literature on Upper Cretaceous palynomorphs from the U.S. Gulf Coast is very scanty, and that on Turonian-Coniacian palynomorphs in particular is almost non-existent. Thus, a project for the study of Upper Cretaceous palynomorphs of the western U.S. Gulf Coastal Plain was undertaken.

This study consists of palynological biostratigraphic results of the Cenomanian-Coniacian formations exposed in the western U.S. Gulf Coastal Plain. Dinocysts dominate the palynomorph assemblages derived from these formations which have mainly marine sediments. Descriptions and illustrations of all encountered dinocysts and acritarch taxa are given to facilitate identifications. Spore-pollen taxa are listed and illustrated only since terrestrial palynomorphs have rare occurrences in these sediments.

MATERIAL AND METHOD

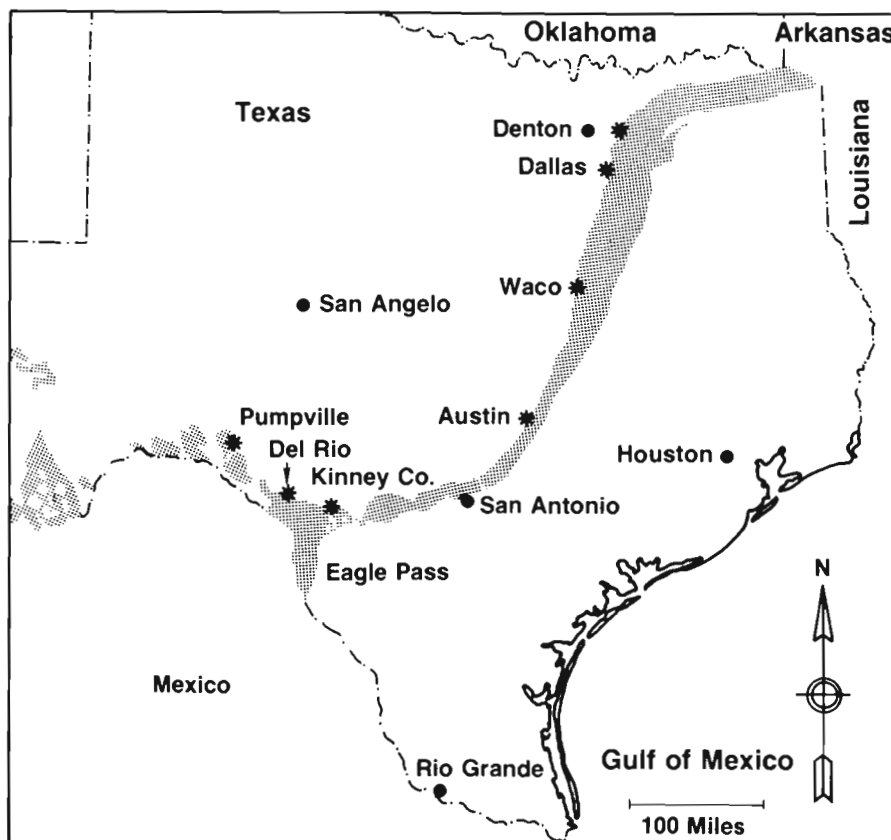
Upper Cretaceous strata outcrop in a north-south trend from about Dallas to Del Rio in Texas, U.S.A. (Text-fig. 1). Sixty-three samples from 9 stratigraphic sections of Cenomanian-Coniacian ages

were collected in 7 Texas counties. The relative stratigraphic positions of the samples collected and studied are shown in Text-figure 2. The details of sample collection localities and stratigraphic position of samples are given below. The sample numbers and their series numbers are given in parentheses at the end of each locality which correspond with sample numbers shown in Text-figure 2.

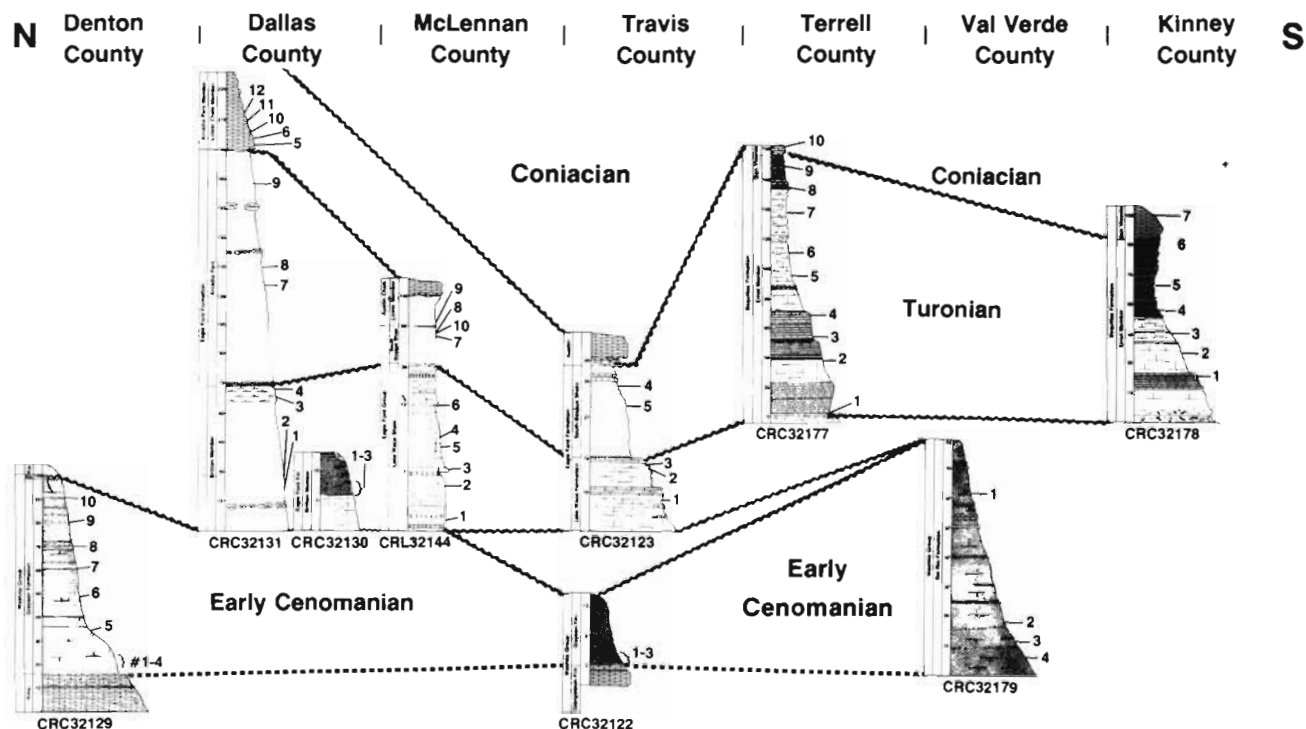
Locality description

Denton County—Grayson Formation exposed in south-facing bluff near the NW end of Grapevine Lake. Complete section from Main Street Limestone at the base to the lowest sandstone of the Woodbine above the Grayson. Exposure is 0.1 miles south of Farm Road 1171, 4 miles N51°E of intersection of Texas Highway 114 and U.S. Highway 377. Roanoke, Texas (CRC 32129-1 to 10).

1-Base of Grayson; 2-5' above base of Grayson; 3-6' above base of Grayson; 4-10' above base of Grayson; 5-15' above base of Grayson; 6-27' above base of Grayson; 7-34' above base of Grayson; 8-54' above base of Grayson; 9-64' above base of Grayson;



Text-figure 1—Map of Texas showing Upper Cretaceous deposits (stippled) and sample collection localities (asterisks), modified after Pessagno, Jr., 1969.



Text-figure 2—Outcrop sections in Texas countries showing samples collected and their relative stratigraphic positions. Distances in between respective outcrop sections is not to any scale; vertical stratigraphic thickness is given in feet.

10-74' above base of Grayson.

Dallas County—Middle Britton Member of the Eagle Ford Formation exposed in road ditch in the NE quadrant of intersection of Valley View Lane and Belt Line Road 3.7 miles N of State Highway 183 in Irving, Texas (CRC 32130-1 to 3).

1-6' above base outcrop, top of chalk; 2-6.5' above base outcrop, transition zone (non-chalk); 3-9' above base outcrop, shale, 3' above transition.

Dallas County—Upper Britton and Arcadia Park members of the Eagle Ford Formation, and lower chalk member of the Austin Chalk, exposed alongside Mansfield Road, 2-3.6 miles west of Cedar Hill (CRC 32131-1 to 12).

1-Britton, 20' above base of section (5' above *Miticocean whitei*); 2-Britton, 23' above base of section; 3-Britton, 68' above base of section; 4-Britton, 71' above base of section; 5-Austin Chalk, 195' above base of at the base of Austin); 6-Austin Chalk, 200' above base of section (5' above base of Austin); 7-Arcadia Park, 128' above base of section (54' above base of Arcadia Park); 8-Arcadia Park, 135' above base of section (61' above base of Arcadia Park); 9-Arcadia Park, 170' above base of section (96' above base of Arcadia Park); 10-Austin Chalk, 207' above base of section (7' above base of Austin); 11-Austin Chalk, 217' above base of section (22' above base of Austin); 12-Austin Chalk, 223' above base of section (28' above base of Austin).

McLennan County—Lake Waco Shale, South

Bosque Shale, and lower-most Austin Chalk exposed in road cuts and clay pits of the Waco Aggregate Company, located along Cloice Branch of the South Bosque River, about 5 miles southwest of Waco and 1/4 mile south of U.S. Highway 84 (CRC 32144-1 to 10).

1-1.5' above base (Lake Waco Shale); 2-5' above base (Lake Waco Shale); 3-7.5' above base (Lake Waco Shale); 4-11' above base (Lake Waco Shale); 5-10' above base (Lake Waco Shale); 6-13' above base (Lake Waco Shale); 7-20' below limestone (70' above base); 8-7' below limestone (83' above base); 9-Just above limestone (91' above base); limestone is 90' above the base; 10-14' below limestone (76' above base).

Travis County—Various exposures of the Grayson Formation in Pease Park in bed of Shoal Creek, along Lamar Blvd., between 12th Street and 24th Street, Austin (CRC 32122-1 to 3).

1-2.5' above base section, 0.5' below base of Grayson (Georgetown Formation); 2-3' above base of section, basal Grayson (Grayson Formation); 3-5' above base of section, 2' above base of Grayson (Grayson Formation).

Travis County—Lake Waco Shale, South Bosque Shale, and lowest part of Austin Chalk exposed along Bouldin Creek, from 0.5-0.8 mile south of Barton Springs Road, in south Austin (CRC 32123-1 to 5).

1-9' above Lake Waco Formation; 2-16.5' above Lake Waco Formation; 3-17.5' above Lake Waco

Formation; 4-34' above base of section (16' above base of Bosque Shale); 5-29' above base of section (11' above base of Bosque Shale).

Terrell County—Buda Limestone and Boquillas Formation (Ernst and San Vicente members) exposed in southwest bluff of Lozier Canyon, 0.5 to 1 mile south (downstream) from the U.S. Highway 90 bridge, 17.5 miles west of Langtry, Texas (CRC 32177-1 to 10).

1-Base of Section (Ernst Member); 2-40' above base of section (Ernst Member); 3-50' above base of section (Ernst Member); 4-69' above base of section; 5-94' above base of section; 6-105' above base of section; 7-137' above base of section; 8-155' above base of section; 9-165' above base of section; 10-180' above base of section.

Kinney County—Upper part of Boquillas Formation exposed in bluffs on Sycamore Creek, 1.5 miles downstream from U.S. Highway 277 bridge, southeast of Del Rio, Texas (CRC 32178-1 to 7).

1-22' above base of section (Ernst Member); 2-35' above base of section (Ernst Member); 3-45' above base of section (Ernst Member); 4-55' above base of section (Ernst Member); 5-70' above base of section (Ernst Member); 6-93' above base (Top Ernst Member); 7-105' above base (10' above base of San Vicente Member).

Val Verde County—Upper part of Del Rio Formation exposed on both sides of U.S. Highway 277, 0.8 to 1.0 mile southeast of Del Rio, Texas (CRC 32179-1 to 4).

1-61' above base of section; 2-16' above base of section; 3-12' above base of section; 4-7' above base of section.

Palynomorphs were concentrated by conventional processing techniques to eliminate carbonates, silicates, and superfluous organic matter from the samples by dissolving them in dilute hydrochloric acid, hydrofluoric acid, and nitric acid successively. The residue samples were washed after each acid treatment. Palynofossils were cleaned by a weak solution (5%) of Calgon detergent and further concentrated by panning the residue and discarding superfluous organic matter. The residue was sieved through 20 µm nylon mesh and several slides were prepared from the > 20 µm and < 20 µm residues.

For this study, 2 to 3 slides of each fraction of a sample were examined to document palynomorphs present in a sample. The slides were scanned with a Leitz Orthoplan microscope with Smith T interference stage and 35 mm camera attachment. Certain large specimens were photomicrographed by aristophot on 10 × 12.5 cm negatives.

Each identified dinocyst and acritarch taxon are described here. Diagnostic generic characteristics

European Stages	Standard North American Stages	Assemblage Zones (Pessagno, 1969)	Subzones (Pessagno, 1969) Biozones (Longoria, 1984)	Taxa Formations
Coniacian		Marginotruncana rensi	(K 21)	Lower Austin Chalk
Turonian	Eaglefordian	Marginotruncana helvetica	Whiteinella archaeocretacea (K-21)	South Bosque Fm. / Arcadia Park Fm.
	Bocian		Marginotruncana sigali (K 20)	
Cenomanian	Lozierian	Rotalipora s.s.	Rotalipora cushmani greenhornensis (K 19) (K 18)	Lake Waco Fm / Lower Eagle Ford Fm. (Britton Mbr.)
	Woodbinian		?	
	Washitian		Rotalipora evoluta (K 17)	Grayson / Del Rio Fms

Text-figure 3—Foraminiferal zonation and correlation of Cenomanian-Coniacian formations of Texas with European and North American stages (after Pessagno, Jr., 1969; Longoria, 1984).

are noted for easy reference to distinguish among similar forms. Spores and pollen occur rarely in the studied samples. Thus, these taxa are only listed at the end of the described taxa. Each taxon is illustrated by at least one example. Distribution ranges of individual dinocysts are plotted by their appearance, their disappearance, and in alphabetical order of their names.

BIOSTRATIGRAPHY

The formations studied here are correlated with European stages and standard North American stages in Text-figure 3 indicating foraminiferal assemblage zones and subzones (Pessagno, 1969) and biozones (Longoria, 1984). It is apparent that Cenomanian-Coniacian outcrops in Texas are punctuated by missing stratigraphic intervals. For example, the Woodbine Formation is missing in the Texas outcrops, although it occurs in the subsurface (Vail *et al.*, 1977, p. 113). Another missing interval is in the Early Turonian which is equivalent to Pessagno's (1969) *Marginotruncana sigali* subzone or Longoria's (1984) K-20 biozone. There is a minor unconformity at the base of the Coniacian also.

The appearance and disappearance levels of individual taxa are considered significant for

determining their ranges in this investigation. It is assumed that they occurred during the time on the missing interval. The taxa recognized and documented are listed below.

Dinoflagellate cysts

1. *Achomosphaera heterostylis* (Heisecke) Stover & Evitt; Pl. 1, figs 1-3.
2. *A. ramulifera* (Deflandre) Evitt; Pl. 1, figs 4-5.
3. *A. sagena* Davey & Williams; Pl. 1, figs 6-8.
4. *Aldorfia deflandrei* (Clarke & Verdier) Stover & Evitt; Pl. 2, figs 1-5.
5. *Alterbia minor* (Alberti) Lentin & Williams; Pl. 2, figs 6-7.
6. *Apteodinium conjunctum* Eisenack & Cookson; Pl. 2, figs 8-9.
7. *A. granulatum* Eisenack; Pl. 3, figs 1-3.
8. *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams; Pl. 3, figs 4-7.
9. *Canningia aspera* C. Singh; Pl. 3, figs 8-9.
10. *C. colliveri* Cookson & Eisenack; Pl. 4, fig. 1.
11. *C. senonica* Clarke & Verdier; Pl. 4, figs 2-5.
12. *Chatangiella spectabilis* (Alberti) Lentin & Williams; Pl. 4, figs 6-7.
13. *C. victoriensis* (Cookson & Manum) Lentin & Williams; Pl. 5, figs 1-2.
14. *Cleistosphaeridium armatum* (Deflandre) Davey; Pl. 5, figs 3-5.
15. *C. diversispinosum* Davey *et al.*; Pl. 5, figs 6-7.
16. *C. ebrenbergii* (Deflandre) Davey *et al.*; Pl. 5, figs 8-9.
17. *C. flexuosum* Davey *et al.*; Pl. 6, figs 1-2.
18. *C. multifurcatum* (Deflandre) Davey *et al.*; Pl. 6, fig. 3.
19. *C. polytes* (Cookson & Eisenack) Davey; Pl. 6, figs 4-6.
20. *Coronifera oceanica* Cookson & Eisenack; Pl. 6, figs 7-10.
21. *Cribroperidinium cooksoniae* Norvick *in* Norvick & Burger; Pl. 6, figs 11-12.
22. *Cyclonephelium compactum* Deflandre & Cookson; Pl. 6, figs 13.
23. *C. distinctum* Deflandre & Cookson; not illustrated.
24. *C. eisenackii* Davey; Pl. 7, figs 1-4.
25. *C. membraniphorum* Cookson & Eisenack; Pl. 7, figs 5-8.
26. *Dapsilidinium laminaspinosum* (Davey & Williams) Lentin & Williams; Pl. 7, figs 9-10.
27. *Dinogymnium acuminatum* Evitt, Clarke & Verdier; Pl. 8, figs 1-6.
28. *Dinopterygium cladoides* Deflandre; Pl. 9, figs 1-8.
29. *Ellipsodinium rugulosum* Clarke & Verdier; Pl. 10, figs 1-2.
30. *Exochosphaeridium cenomaniense* Norvick *in* Norvick & Burger; Pl. 10, figs 3-8.
31. *E. phragmites* Davey *et al.*; Pl. 10, fig. 9.
32. *E. truncatum* (Davey) Stover & Evitt; Pl. 10, figs 10-12.
33. *Florentinia clavigera* (Deflandre) Davey & Verdier; Pl. 11, figs 1-6.
34. *F. cooksoniae* (C. Singh) Duxbury; Pl. 11, figs 7-11.
35. *F. laciniata* Davey & Verdier; Pl. 12, figs 1-6.
36. *F. mantellii* (Davey & Williams) Davey & Verdier; Pl. 12, figs 7-8; Pl. 13, figs 1-3.
37. *F. radiculata* (Davey & Williams) Davey & Verdier; Pl. 13, figs 4-10.
38. *F. resex* Davey & Verdier; Pl. 14, figs 1-6.
39. *Gonyaulacysta cassidata* (Eisenack & Cookson) Sarjeant; Pl. 15, figs 1-6.
40. *Hystriochodinium oligacanthum* Deflandre & Cookson; Pl. 16, figs 1-4.
41. *H. pulchrum* Deflandre; Pl. 16, fig. 5.
42. *Hystriochosphaeridium tubiferum* subsp. *brevispinum* (Davey & Williams) Lentin & Williams; Pl. 16, figs 6-7.
43. *Kallosphaeridium norvickii* (Burger) Lentin & Williams; Pl. 16, figs 8-9.
44. *Kiokansium unituberculatum* (Tasch) Stover & Evitt; Pl. 17, figs 1-3.
45. *Kleithrisphaeridium fasciatum* (Davey & Williams) Davey; Pl. 17, figs 4-5.
46. *K. loffrense* Davey & Verdier; Pl. 17, figs 6-8.
47. *Leberidocysta chlamydata* (Cookson & Eisenack) Stover & Evitt; Pl. 18, figs 1-2.
48. *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams; Pl. 18, figs 3-8.
49. *Nummus monoculatus* Morgan; Pl. 19, figs 1-2.
50. *Odontochitina costata* Alberti emend. Clarke & Verdier; Pl. 19, figs 3-6.
51. *O. operculata* (O. Wetzel) Deflandre *in* Deflandre & Cookson; Pl. 19, fig. 7.
52. *Oligosphaeridium complexum* (White) Davey & Williams; Pl. 20, figs 1-2.
53. *O. pulcherrimum* (Deflandre & Cookson) Davey & Williams; Pl. 20, figs 3-7.
54. *Ovoidinium verrucosum* (Cookson & Hughes) Davey; Pl. 21, figs 1-9.
55. *Palaeohystriochophora infusorioides* Deflandre; Pl. 22, figs 1-6.
56. *Palaeoperidinium cretaceum* Pocock *ex* Davey; Pl. 22, figs 7-8.
57. *Palaeostomocystis fragilis* Cookson & Eisenack; Pl. 22, figs 9-10.
58. *Pareodinia ceratophora* Deflandre; Pl. 23, figs 1-2.
59. *Prolixosphaeridium conulum* Davey; Pl. 23, figs 3-4.

60. *Pterodinium cornutum* Cookson & Eisenack; Pl. 23, figs 5-8; Pl. 24, figs 1-3.
61. *P. perforatum* (Clarke & Verdier) Davey & Verdier; Pl. 24, figs 4-5.
62. *Silicisphaera ferox* (Deflandre) Davey & Verdier; Pl. 24, figs 6-9; Pl. 25, figs 1-5.
63. *Spiniferites cingulatus* (O. Wetzel) Sarjeant; Pl. 25, figs 6-8.
64. *S. compactus* Cookson & Eisenack; Pl. 26, figs 1-2.
65. *S. ramosus* subsp. *gracilis* (Davey & Williams) Lentin & Williams; Pl. 26, fig. 3.
66. *S. ramosus* subsp. *granomembranaceus* (Davey & Williams) Lentin & Williams; Pl. 26, figs 4-7.
67. *S. ramosus* subsp. *multibrevis* (Davey & Williams) Lentin & Williams; Pl. 27, figs 1-5.
68. *S. ramosus* subsp. *ramosus*; Pl. 27, figs 6-10.
69. *Stephodium coronatum* Deflandre; Pl. 28, figs 1-2.
70. *Subtilisphaera cheit* Below; Pl. 28, figs 3-8.
71. *Surculosphaeridium longifurcatum* (Firtion) Davey *et al.*; Pl. 29, figs 1-2.
72. *Tanyosphaeridium regulare* Davey & Williams; Pl. 29, figs 3-4.
73. *Trichodinium castaneum* (Deflandre) Clarke & Verdier; Pl. 29, figs 5-8.
74. *Trigonopyxidialia ginella* (Cookson & Eisenack) Manum & Cookson; Pl. 29, figs 9-10.
75. *Trithyrodinium suspectum* (Manum & Cookson) Davey; Pl. 29, figs 11-12.
76. *Walldodinium lunum* (Cookson & Eisenack) Lentin & Williams; Pl. 29, fig. 13.
77. *Xenascus ceratioides* (Deflandre) Lentin & Williams; Pl. 30, fig. 1.
78. *Xiphophoridium alatum* (Cookson & Eisenack) Sarjeant; Pl. 30, figs 2-3.
88. *Biretisporites potoniae* Delcourt & Sprumont; Pl. 33, figs 6-7.
89. *Camarozonosporites insignis* Norris; Pl. 33, figs 8-10.
90. *Cicatricosisporites annulatus* Archangelsky & Gambero; Pl. 34, figs 1-2.
91. *C. australiensis* (Cookson) R. Potonié; Pl. 34, figs 3-4.
92. *C. ballei* Delcourt & Sprumont; Pl. 34, figs 5-6.
93. *C. ornatus* S. K. Srivastava; Pl. 34, figs 7-8.
94. *C. venustus* Deák; Pl. 34, figs 9-10; Pl. 35, figs 1-2.
95. *Contignisporites fornicatus* Dettmann; Pl. 35, figs 3-6.
96. *Costatofoveosporites foveolatus* Deák; Pl. 35, figs 7-9.
97. *Crybelosporites pannuceus* (Brenner) S. K. Srivastava; Pl. 36, figs 1-6.
98. *Foveosporites labiosus* C. Singh; Pl. 36, figs 7-8.
99. *Gleicheniidites senonicus* Ross; Pl. 36, figs 9-10.
100. *Heliosporites altmarkensis* E. Schulz; Pl. 37, figs 1-3.
101. *Lusatisporis dettmannae* (Drugg) S. K. Srivastava; Pl. 37, figs 4-5.
102. *Retitriletes singhii* S. K. Srivastava; Pl. 37, figs 6-8.
103. *Tauocusporites segmentatus* Stover; Pl. 37, figs 9-10.
104. Spores *incertae sedis*; Pl. 37, figs 11-12.
105. Trilete spore *incertae sedis*; Pl. 38, fig. 1.
106. *Exesipollenites tumulus* Balme; Pl. 38, fig. 2.
107. *Cerebropollenites macroverrucosus* (Thiergart) E. Schulz; Pl. 38, figs 3-4.
108. *Rugubivesiculites reductus* Pierce; Pl. 38, figs 5-6.
109. *Clavatipollenites* sp.; Pl. 38, figs 7-8.

Acritarchs

79. *Micrhystridium stellatum* Deflandre; Pl. 30, figs 4-9.
80. *Pterospermella aristotelesii* (Ioannides *et al.*) S. K. Srivastava; Pl. 31, figs 1-4.
81. *Tubulospina oblongata* Davey; Pl. 31, figs 5-8.

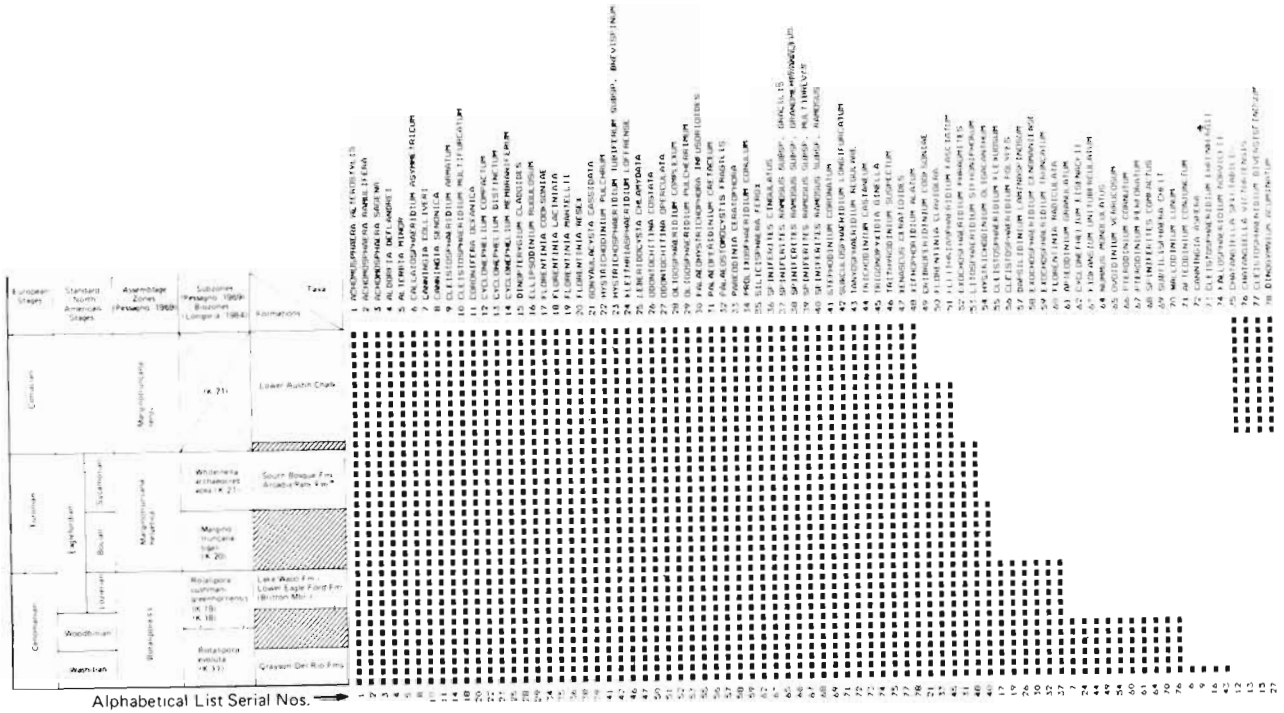
Spores and pollen

82. *Appendicisporites baconicus* (Deák) S. K. Srivastava; Pl. 32, figs 1-2.
83. *A. bifurcatus* C. Singh; Pl. 32, figs 3-5.
84. *A. dentimarginatus* Brenner; Pl. 32, figs 6-7.
85. *A. erdtmanii* Pocock; Pl. 32, figs 8-9.
86. *A. jansonii* Pocock; Pl. 33, figs 1-2.
87. *Baculatisporites comaumensis* (Cookson) R. Potonié; Pl. 33, figs 3-5.

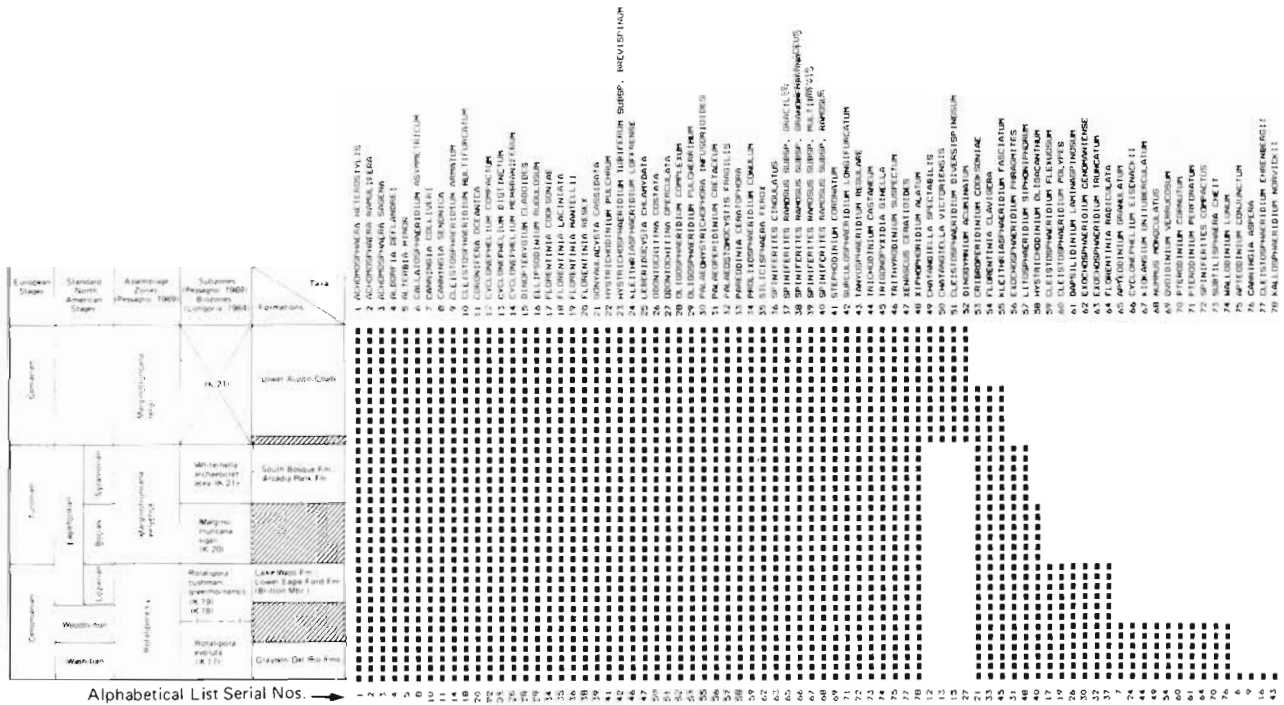
Spore-pollen and acritarchs occur rarely in these samples. Dinocysts are dominant in the assemblages recovered and their distribution is plotted by their first appearance (Text-fig. 4), their last appearance (Text-fig. 5), and alphabetically (Text-fig. 6).

Cyclonephelium eisenackii and *Ovoidinium verrucosum* occur in the Grayson Formation, the Britton Member of the Eagle Ford Formation, and their equivalent strata in southern Texas. Their worldwide reported range is Albian-Cenomanian. Their first appearances in subsurface samples seem to be indicative of the Cenomanian inter-regionally. Both species are conspicuous and easily recognizable.

Litosphaeridium siphoniphorum is also a distinctive dinocyst taxon. It is present in the Grayson Formation, lower Eagle Ford Formation, and Arcadia Formation/South Bosque Formation. Its reported worldwide range is Albian-Turonian. Thus,



Text-figure 4—Dinocyst taxa ranges in the Cenomanian-Coniacian of Texas. Taxa arranged by first appearance.

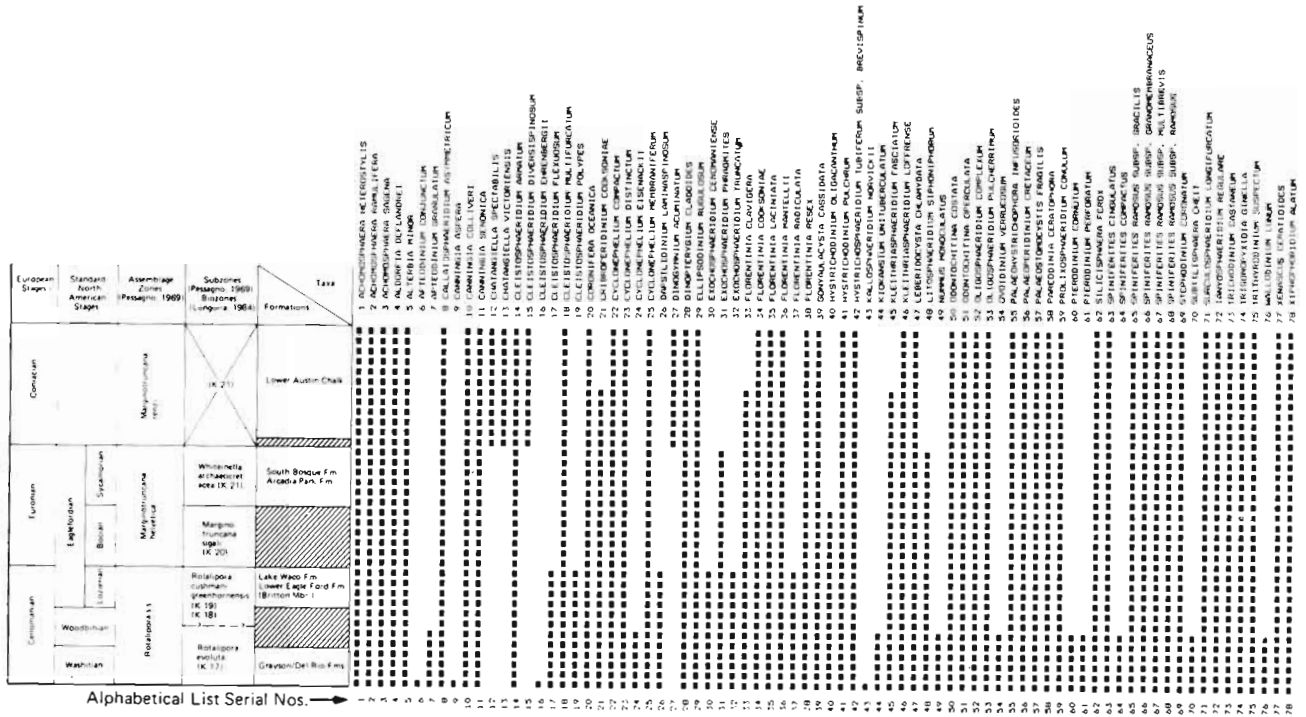


Text-figure 5—Dinocyst taxa ranges in the Cenomanian-Coniacian of Texas. Taxa arranged by last appearance.

the first occurrence of *L. siphoniphorum* in subsurface samples should be indicative of Turonian strata.

Dinogymnium acuminatum and *Chatangiella*

victoriensis appear in the Lower Austin Chalk. Both taxa have been reported worldwide from Coniacian-Maastrichtian strata. Their appearance marks the onset of Coniacian time.



Text-figure 6—Dinocyst taxa ranges in the Cenomanian-Coniacian of Texas. Taxa arranged in an alphabetical order

SYSTEMATIC DESCRIPTIONS

Dinoflagellate cysts

Genus—*Achomosphaera* Evitt 1963

1963 *Achomosphaera* Evitt, p. 163

Type species—*Achomosphaera ramulifera* (Deflandre) Evitt 1962 = *Hystrichosphaeridium ramuliferum* Deflandre 1937 (original designation).

Remarks—*Achomosphaera* has a precingular archeopyle and obscurely discernible gonyaulacacean paratabulation. It includes proximochorate to skolochorate cysts having a spherical body possessing discrete processes with trifurcate and/or bifurcate tips without distal interconnections. The wall between the processes is

smooth to variously ornamented with low relief features (Stover & Evitt, 1978). The holotype of the type-species *A. ramulifera* is illustrated by a sketch drawing (Deflandre, 1937; pl. 14, fig. 5) but the paratype is illustrated by a photomicrograph (Deflandre, 1937; pl. 14, fig. 6). The wall between the processes in the paratype appears to be faintly reticulate.

Hansen (1977) proposed the genus *Hafniasphaera* without distinguishing it from other genera. This genus also has a precingular archeopyle with paraplate sutures discernible in some species and ambiguous in others, although, it seems that Hansen (1977) had no difficulty in detecting paraplate sequences. However, if paraplates are well-defined, *Hafniasphaera* becomes similar to

PLATES 1-38

In figure captions of the following plates, reference data for each specimen is given after the name or figure numbers within parentheses in the following sequence:

CRC sample no./slide no.: microscope stage coordinates horizontal/vertical, film roll no./exposure nos., x objective used; the name of the formation.

PLATE 1

- 1-3. *Achomosphaera heterostylis* (Heisecke) Stover & Evitt (CRC 32129-6/1A : 22.5/104, 84005/21, 22, 23, x 100; Grayson Formation)
- 4, 5. *Achomosphaera ramulifera* (Deflandre) Evitt, in two foci (CRC 32129-3/+107 (single mount) : 37.5/107.5, 850315

- (4 x 5)/3, 4, x 40; Grayson Formation).
 - 6-8. *Achomosphaera sagena* Davey & Williams (CRC 32128-8/5 : 49.5/108.5, 84012/14, x 40; 15, 16, x 100; Grayson Formation)
- Scale bar length = 20 μm except for figs 4-6 = 50 μm

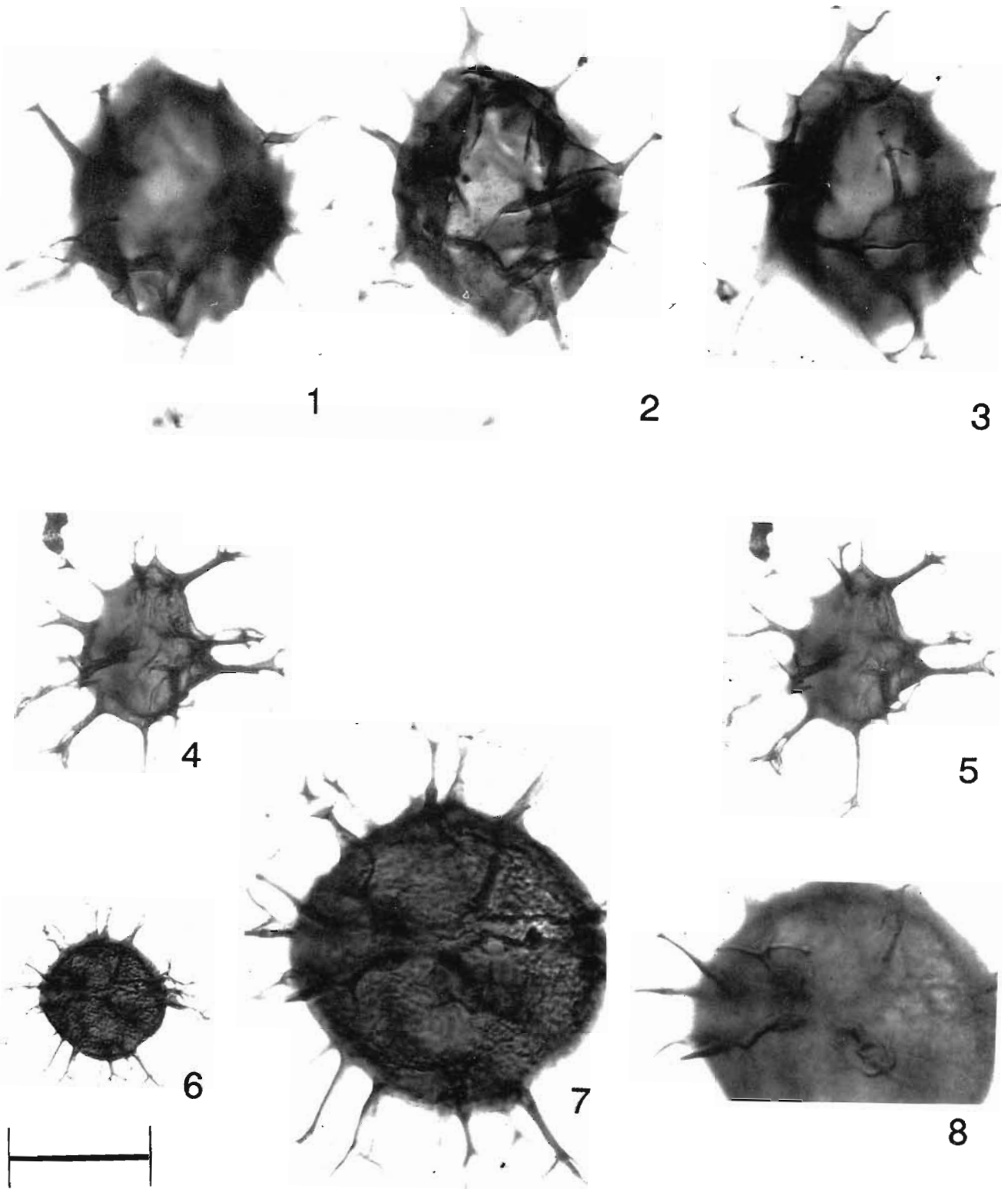


PLATE 1

Spiniferites otherwise it is similar to *Achomosphaera*.

Achomosphaera differs from *Spiniferites* by either lacking parasutural features or having only faint linear markings between the bases of the processes (Stover & Evitt, 1978).

Achomosphaera heterostylis (Heisecke)

Stover & Evitt 1978

Pl. 1, figs 1-3

1970 *Hystrichosphaera heterostylis* Heisecke, p. 238; pl. 5, figs 1-4; pl. 6, figs 4-5.

1973 *Spiniferites heterostylis* (Heisecke) Lentin & Williams, p. 129.

1978 *Achomosphaera heterostylis* (Heisecke) Stover & Evitt, p. 138.

Measurements—Total length and breadth 54 μm , body 35.5 \times 34 μm , process length 14 μm (Heisecke, 1970); range of total length and breadth 55-74 \times 55-65 μm , body 35-44 \times 32-33 μm , processes 10-20 μm long and antapical process 15-20 \times 10-12 μm in 5 specimens of this study.

Remarks—*Achomosphaera heterostylis* is distinct from *A. ramulifera* and *A. sagena* in having a distinctly larger antapical process than its other processes.

Previous record—Danian, Argentina (Heisecke, 1970).

Achomosphaera ramulifera (Deflandre)

Evitt 1963

Pl. 1, figs 4-5

1937 *Hystrichosphaeridium ramuliferum* Deflandre, p. 74; pl. 14, figs 5-6; pl. 17, fig. 10.

1963 *Baltisphaeridium ramuliferum* (Deflandre) Downie & Sarjeant, p. 92.

1963 *Achomosphaera ramulifera* (Deflandre) Evitt, p. 163.

Measurements—Diameter of central body 24-56 μm , process length up to 35-36 μm (Davey & Williams in Davey *et al.*, 1966); central body diameter 36-61 μm , process length 16-36 μm (Davey, 1969); overall size 96-99 \times 65-91 μm , body 47-57 \times

36-42 μm , process length 15-36 μm in 10 specimens of this study.

Remarks—*Achomosphaera ramulifera* has a smooth or slightly wrinkled periphragm. Thus, it is distinct from *A. sagena* in having a reticulate periphragm.

Previous records—Common in Neocomian-Miocene strata.

Achomosphaera sagena Davey & Williams
in Davey *et al.* 1966

Pl. 1, figs 6-8

1966 *Achomosphaera sagena* Davey & Williams in Davey *et al.*, p. 51; pl. 2, figs 1-2.

1967 *Achomosphaera reticulata* Clarke & Verdier, p. 41; pl. 8, figs 2-3; text-fig. 16.

Measurements—Body diameter 35-59 μm , length of processes 17-28 μm (Davey & Williams in Davey *et al.*, 1966; Davey, 1969); 38-53 μm , 15-28 μm (Clarke & Verdier, 1967); 44-30 μm (Foucher & Taugourdeau, 1975); 30-40 μm (Ashraf, 1979); overall diameter 62-99 μm , body 44-57 μm in 10 specimens of this study.

Remarks—*Achomosphaera sagena* is distinct from *A. ramulifera* in having a thick reticulate periphragm.

Previous records—Albian-Danian. Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1973; Foucher & Taugourdeau, 1975); Vraconian-Cenomanian, Switzerland (Davey & Verdier, 1973); Cenomanian, England (Davey & Williams in Davey *et al.*, 1966; Davey, 1969); Cenomanian-Senonian, Isle of Wight, England (Clarke & Verdier, 1967); Early Cenomanian, Mazagan Plateau, offshore NW Africa (Below, 1984); Cenomanian-Campanian, North America (Davey, 1969; Millioud, Williams & Lentin, 1975); Campanian-Maastrichtian, Senegal, West Africa (Jain & Millepied, 1975); Maastrichtian, southern Sweden (Kjellström, 1973); Maastrichtian-Danian, Belgium (Schumacker-Lambry, 1975); Ashraf (1979) reported *Achomosphaera sagena* from the Lower Cretaceous of southern Afghanistan.

PLATE 2

1-5. *Aldorfia deflandrei* (Clarke & Verdier) Stover & Evitt. 1-3, a specimen in three foci (CRC 32130-2/1 : 46.3/103.0, 84015/13-15, \times 100, middle Britton Member of the Eagle Ford Formation); 4-5, another specimen in two foci (CRC 32131-11/10 : 38.4/94.8, 84023/24, 25, \times 100; Austin Chalk Formation)

6, 7. *Alterbia minor* (Alberti) Lentin & Williams (CRC 32129-7/2 :

37.7/106.2, 84002/33, 34, \times 40; Grayson Formation)

8, 9. *Apteodinium conjunctum* Eisenack & Cookson (CRC 32129-6/1 : 45.0/108.0, 84006/7, 8, \times 100; Grayson Formation)

Scale bar length = 20 μm except for figs. 6, 7 = 50 μm .

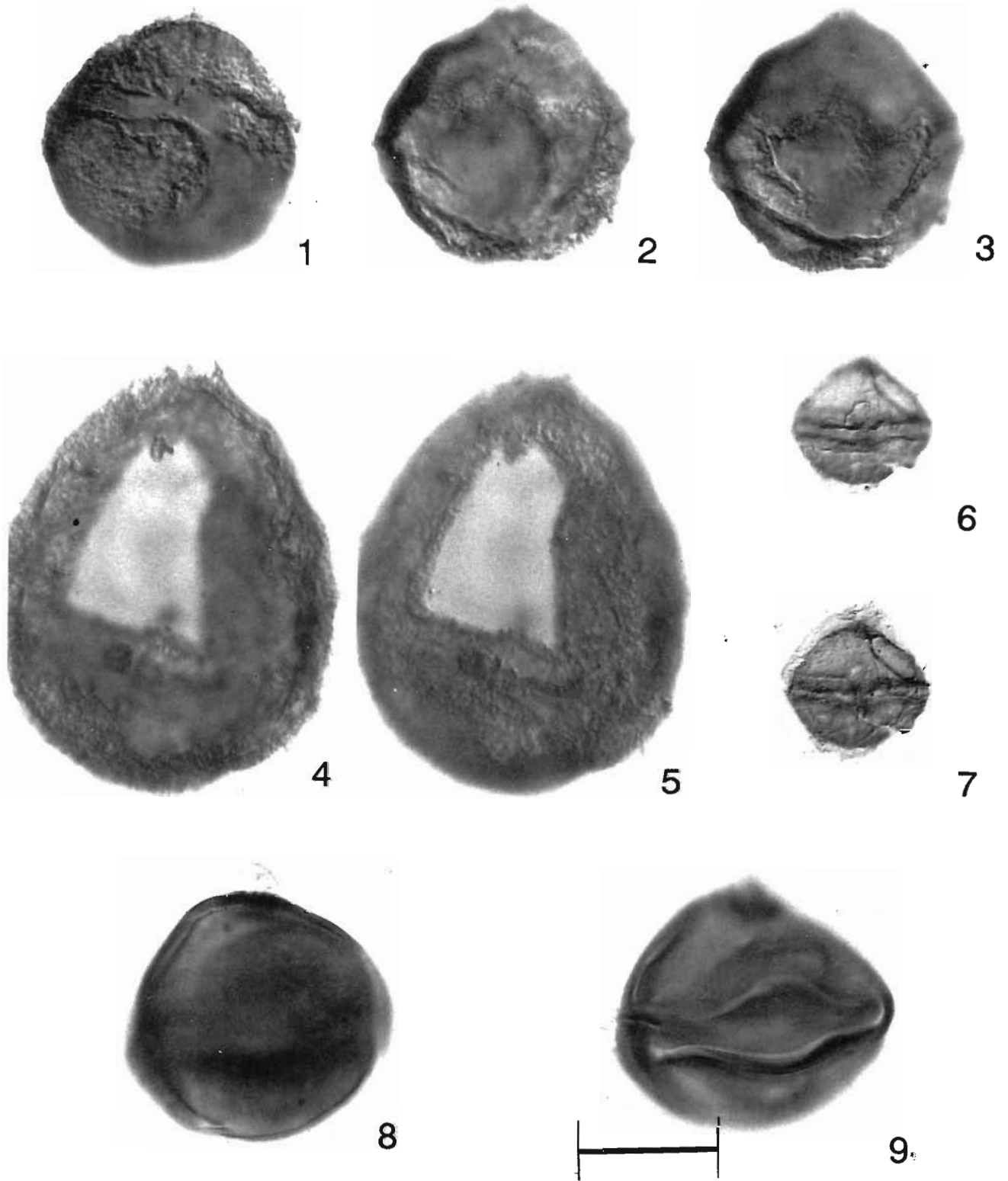


PLATE 2

Genus—*Aldorfia* Stover & Evitt 1978

1978 *Aldorfia* Stover & Evitt, p. 140.

Type species—*Aldorfia aldorfensis* (Gocht) Stover & Evitt 1978 = *Gonyaulacysta aldorfensis* Gocht 1970 (original designation).

Remarks—*Aldorfia* includes subspherical cysts having an apical projection, precingular archeopyle, faint paratabulation and ectocoel with continuous sculpture. It differs from *Apteodinium* in having an ectopocoel filled with various sculptures.

Aldorfia deflandrei (Clarke & Verdier)
Stover & Evitt 1978

Pl. 2, figs 1-5

1967 *Gardodinium deflandrei* Clarke & Verdier, p. 26; pl. 3, figs 10-12; text-fig. 10.

1978 *Aldorfia deflandrei* (Clarke & Verdier) Stover & Evitt, p. 140.

Measurements—Overall dimensions 52.56 × 40.48 μm; length of apical horn 8.10 μm (Clarke & Verdier, 1967); overall 50.57 × 38.44 μm; apical horn length 8.10 μm (Foucher, 1972); overall 35.44; apical horn length 6.8 μm (Foucher, 1974); overall 60.66 × 46.54 μm (Yun, 1981); overall 43.86 × 40.75 μm in specimens of this study.

Previous records—Albian-Campanian. Late Albian-Coniacian, France (Foucher, 1971, 1972, 1974; Faucomnier, 1979); Late Albian-Cenomanian, offshore western Atlantic Ocean (Hochuli & Kelts, 1980); Santonian, England (Clarke & Verdier, 1967); Santonian, Germany (Yun, 1981); Campanian, Scotian Shelf, Canada (Millioud *et al.*, 1975; Williams, 1975); Campanian-Maastrichtian, Senegal, West Africa (Jain & Millepied, 1975).

Genus—*Alterbia* Lentin & Williams 1976

1967 *Alterbia* Vozzhennikova, p. 150.

1976 *Alterbia* Lentin & Williams, p. 47 (nom. subst. pro *Albertia* Vozzhennikova, 1967, non *Albertia* Schimper, 1837).

Type species—*Alterbia recticornis* (Vozzhennikova) Lentin & Williams 1976 = *Albertia recticornis* Vozzhennikova 1967 (original designation).

Remarks—*Alterbia* consists of compressed proximate circumcavate cysts which are ellipsoidal to nearly biconical in shape and have an apical and generally prominent left antapical horn. Its right antapical horn is reduced or absent. The endocyst is elliptical and generally approximates the outline of pericyst except at the bases of the horns. The paratabulation is indicated by archeopyle and sometimes by the paracingulum. The archeopyle is intercalary.

Alterbia is distinct from *Senegalinium* in having its epipericoel connected with the exterior through the archeopyle and in possessing a reduced right antapical horn which may sometimes be absent. *Eucladinium* is mainly epicavate, although it has a reduced right antapical horn similar to that of *Alterbia*.

Alterbia minor (Alberti) Lentin & Williams 1976

Pl. 2, figs 6-7

1959 *Deflandrea minor* Alberti, p. 98; pl. 9, figs 9-11.

1976 *Alterbia minor* (Alberti) Lentin & Williams, p. 49; pl. 5, fig. 70.

Measurements—Overall length and breadth 44.68 × 29.46 μm (Alberti, 1959); 45.65 × 37.43 μm (Cookson & Eisenack, 1960); 47.49 × 35.45 μm (Benson, 1976); overall 60 × 45 μm in specimens of this study.

Previous records—Turonian-Maastrichtian. Turonian-Middle Senonian, Australia (Cookson & Eisenack, 1960); Senonian, Chatham Islands (Wilson, 1976); Santonian-Maastrichtian, North America (McIntyre, 1974, 1975; Wall & Singh, 1975; Benson, 1976; Aurisano & Habib, 1977); Late Senonian, Germany (Alberti, 1959); Maastrichtian, Sweden (Kjellström, 1973).

Genus—*Apteodinium* Eisenack 1958

1958 *Apteodinium* Eisenack, p. 385.

1961 *Emslandia* Gerlach, p. 171.

1971 *Coniferatium* Burgess, p. 80.

1972 *Archeotectatum* Habib, p. 375.

Type species—*Apteodinium granulatum* Eisenack 1958 (original designation).

PLATE 3

- 1-3. *Apteodinium granulatum* Eisenack (CRC 32129-8/5 : 43.2/99.5, 84011/30-32, × 100; Grayson Formation)
4-7. *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams. 4, (CRC 32129-6/1 : 42.0/99.5, 84004/24, × 54, Grayson Formation); 5-7, (CRC 32129-6/1A : 27.4/103.7, 84005/14, 15, × 54; 17, × 100; Grayson For-

mation)

- 8,9. *Canningia aspera* C. Singh (CRC 32129-7/2 : 39.0/96.0, 84002/7, 8, × 40, Grayson Formation)
Scale bar length = 20 μm except for figs. 5 and 6 = 35 μm and figs 4, 8 and 9 = 50 μm.

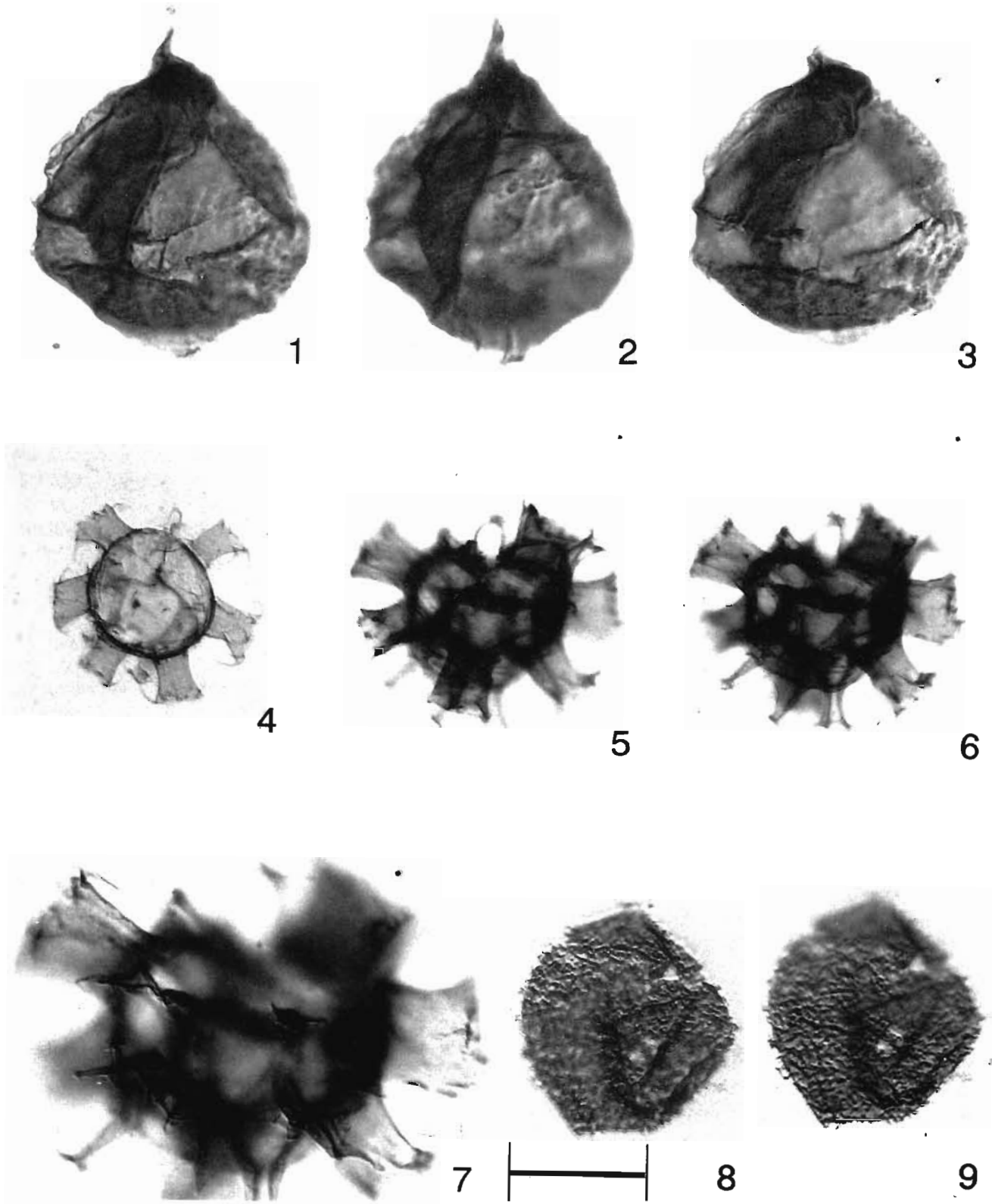


PLATE 3

Remarks—*Apteodinium* consists of proximate subspherical cysts with a precingular archeopyle and a short apical projection. Autophragm may have some nontabular features of low reliefs. Paratabulation is indicated by the archeopyle and the paracingulum, and occasionally by faint equatorial parasutural features.

Apteodinium is distinct from *Millioudodinium* in lacking paratabulation except the archeopyle and paracingulum.

Apteodinium conjunctum Eisenack & Cookson 1960
Pl. 2, figs 8-9

1960 *Apteodinium conjunctum* Eisenack & Cookson, p. 5; pl. 1, figs 7-8.

Measurements—Overall dimensions 60-80 × 59-67 μm (Eisenack & Cookson, 1960); 40-91 × 40-83 μm in specimens of this study.

Previous records—Late Oxfordian-Albian (Eisenack, 1958; Eisenack & Cookson, 1960; Harris, 1976; Burger, 1980; Davies, 1983; Helenes, 1984); Oligocene, Germany (Benedek, 1972).

Apteodinium granulatum Eisenack 1958

Pl. 3, figs 1-3

1958 *Apteodinium granulatum* Eisenack, p. 386; pl. 23, figs 8-14, text-fig. 1.

Measurements—Overall length × breadth 50-80 × 50-67 μm, apical horn length 4-12 μm (Eisenack, 1958); 64-89 × 47-60 μm (Alberti, 1961); 42-53 × 31-44 μm, horn length 5-8 μm (Davey, 1969); 78-90 × 70-80 μm, horn length 8-13 μm (Gitmez, 1970); 78-90 × 70-80 μm, horn length 10 μm (Baltes, 1963); 50-80 μm, horn length 4-12 μm (Foucher & Taugourdeau, 1975); 37-60 × 37-53 μm, horn length 4-10 μm in specimens of this study.

Previous records—Kimmeridgian-Cenomanian. Kimmeridgian-Cenomanian, western Europe (Eisenack, 1958; Gocht, 1959; Alberti, 1961; Davey, 1969, 1974; Davey & Verdier, 1971; Gitmez, 1970; Foucher & Taugourdeau, 1975); Albian, Romania (Baltes, 1963); Barremian-Cenomanian, western Atlantic Ocean (Habib, 1970, 1972); Late Jurassic/Berriasian-Aptian, Australia (Burger, 1982).

Lower Eocene records of *A. granulatum* from Belgium (de Coninck, 1975) appear to be doubtful.

Genus—*Callaiosphaeridium* Davey & Williams in Davey et al. emend. Below 1981

1966 *Callaiosphaeridium* Davey & Williams in Davey et al., p. 103.

1967 *Hexasphaera* Clarke & Verdier, p. 42.

1980 *Callaiosphaeridium* Davey & Williams emend. Duxbury, p. 113.

1981a *Callaiosphaeridium* Davey & Williams emend. Below, p. 27.

Type species—*Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams in Davey et al. 1966 = *Hystrichosphaeridium asymmetricum* Deflandre & Courteville 1939 (original designation).

Remarks—*Callaiosphaeridium* includes acavate skolochorate cysts having subspherical body, gonyaulacacean paratabulation and an epicystal archeopyle. It differs from *Spiniferites* in having an epicystal archeopyle; and from *Actinotheca* in having paracingular intratabular processes.

Callaiosphaeridium asymmetricum (Deflandre & Courteville) Davey & Williams in Davey et al. 1966

Pl. 3, figs 4-7

1939 *Hystrichosphaeridium asymmetricum* Deflandre & Courteville, p. 100; pl. 4, figs 1-2.

1966 *Callaiosphaeridium asymmetricum* (Deflandre & Courteville) Davey & Williams in Davey et al., p. 104; pl. 8, figs 9-10; pl. 9, fig. 2.

1967 *Hexasphaera asymmetrica* (Deflandre & Courteville) Clarke & Verdier, p. 43; pl. 7, figs 1-3; text-fig. 17.

Measurements—Shell size 34-58 μm, paracingular process length 10-32 μm (Davey & Williams in Davey et al., 1966); 37-58 μm, 10-32 μm (Davey, 1969); 35-40 μm, 24-30 μm (Foucher, 1974); overall 72-83 × 69-81 μm (Duxbury, 1977); shell size 32-42 μm, paracingular process length 10-19 μm (Below, 1981a); overall 58-90 μm, shell size 31-55 μm, paracingular process length 6-18 μm (Srivastava, 1984); overall 70-109 × 65-83 μm, shell 43-78 × 37-55 μm, process length 18-23 μm in specimens of this study.

Previous records—Hauterivian-Maastrichtian (see Below, 1981a, p. 28, for localities and ages under his list of synonymy); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Upper Aptian, northern Germany (Below, 1982b); Early Albian, India (Jain, 1977); Aptian-Cenomanian, Australia (Morgan, 1980).

Genus—*Canningia* Cookson & Eisenack 1960a

1960a *Canningia* Cookson & Eisenack, p. 251.

1961 *Circulodinium* Alberti, p. 28.

Type species—*Canningia reticulata* Cookson & Eisenack 1960a (original designation).

Remarks—*Canningia* consists of proximate lenticular cysts with an apical archeopyle, and

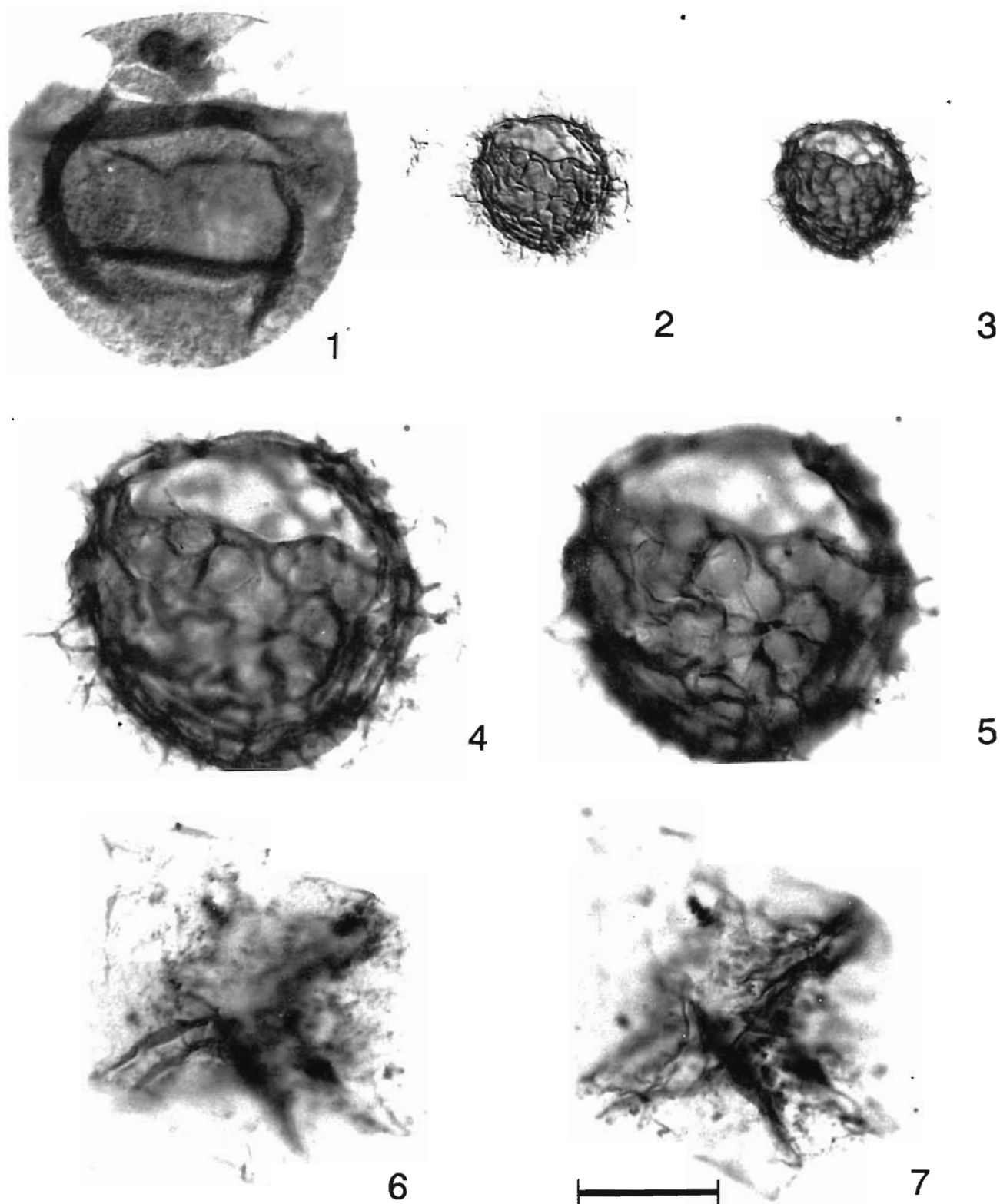


PLATE 4

1. *Canningia colliveri* Cookson & Eisenack (CRC 32129-6/1 : 30.4/96.5, 84004/15, $\times 100$; Grayson Formation)
- 2-5. *Canningia senonica* Clarke & Verdier (CRC 32129-6/1 : 30.8/112.5, 84005/16, 17, $\times 40$; 19, 20, $\times 100$; Grayson Formation)
- 6, 7. *Chatangiella spectabilis* (Alberti) Lentin & Williams (CRC 32131-12/1 : 32.7/110.5, 84024/1, 2, $\times 100$; Austin Chalk Formation)
- Scale bar length = 20 μm except for figs. 2 and 3 = 50 μm .

having an apical prominence, and two antapical lobes. It differs from *Cyclonephelium* in having uniformly distributed surface ornamentation and from *Canningiopsis* in lacking tabulation.

Canningia aspera C. Singh 1971

Pl. 3, figs 8-9

1971 *Canningia aspera* C. Singh, p. 322; pl. 50, fig. 1.

Measurements—Length \times breadth 96-105 \times 94-103 μm (Singh, 1971); 83-110 \times 58-105 μm (Brideaux, 1977); 65-75 \times 62-68 μm in specimens of this study.

Remarks—*Canningia aspera* appears to have larger ornamental elements than those on *C. colliveri*.

Previous records—Hauterivian-Albian, Canada (Singh, 1971; Brideaux, 1977).

Canningia colliveri Cookson & Eisenack
1960a

Pl. 4, fig 1

1960a *Canningia colliveri* Cookson & Eisenack, p. 251; pl. 38, figs 3-5.

Measurements—Length and breadth, 106-107 \times 90-100 μm (Cookson & Eisenack, 1960a); 102-127 \times 68-114 μm (Singh, 1964, 1971); 40-78 \times 35-74 μm (Srivastava, 1984); 44-52 \times 44-50 μm in specimens of this study.

Remarks—*Canningia colliveri* differs from *C. aspera* in lacking definite five-sided cysts; from *C. circularis* in having fewer spinules; from *C. minor* in having more and larger ornamental elements; and from *C. reticulata* in having a spinulose wall-surface.

Previous records—Barremian-Santonian. Barremian-Albian, Canada (Pocock, 1976; Singh, 1964, 1971); Barremian, France (Srivastava, 1984); Aptian, Australia and New Guinea (Cookson & Eisenack, 1960a), Canada (Williams, 1975); Cenomanian-Santonian, France (Clarke & Verdier, 1967).

Canningia senonica Clarke & Verdier 1967

Pl. 4, figs 2-5

1967 *Canningia senonica* Clarke & Verdier, p. 20; pl. 1, figs 12-14; text-fig. 7.

Measurements—Overall length and breadth 60-85 \times 50-70 μm , maximum process length 6-12 μm (Clarke & Verdier, 1967); 36-67 \times 40-63 μm , process length 2-8 μm (Harland, 1973); overall length \times breadth 60-68 \times 50-62 μm , body 45-50 \times 37-45 μm , process length 7-13 μm in 5 specimens of this study.

Remarks—*Canningia senonica* is distinct from *C. reticulata* in having a larger reticulum supporting 3-5 μm long, thin and membranous processes on muri. *Cassiculosphaerida reticulata* lacks processes on its reticulum, but otherwise appears similar to *Canningia senonica*.

Previous records—Senonian. Senonian, Isle of Wight, England (Clarke & Verdier, 1967); Upper Campanian, southern Alberta, Canada (Harland, 1973); Santonian-Campanian, France (Foucher, 1976).

**Genus—*Chatangiella* Vozzhennikova emend.
Lentin & Williams, 1976**

1967 *Chatangiella* Vozzhennikova, p. 128.

1967 *Australiella* Vozzhennikova, p. 129.

1967 *Cooksoniella* Vozzhennikova, p. 182.

1976 *Chatangiella* Vozzhennikova emend. Lentin & Williams, p. 51.

Type species—*Chatangiella niiga* Vozzhennikova 1967 (original designation).

Remarks—*Chatangiella* consists of proximate, commonly bicavate, rarely circumcavate, compressed cysts which are longitudinally elongate with subrectangular outline, a short broad-based apical horn and poorly developed antapical horns. It has an intercalary archeopyle and peridiniacean paratabulation.

Chatangiella is distinct from *Isabelidinium* in having a more rectangular outline and a broad-based apical horn.

→
PLATE 5

- 1, 2. *Chatangiella victoriensis* (Cookson & Manum) Lentin & Williams (CRC 32131-10/1 : 47.8/113.2, 84021/28, 29, \times 100; Austin Chalk Formation)
3-5. *Cleistosphaeridium armatum* (Deflandre) Davey (CRC 32129-6/12 : 17.3/95.0, 84007/21, 22, \times 40; 23, \times 100; Grayson Formation)
6, 7. *Cleistosphaeridium diversispinosum* Davey et al. (CRC

- 32131-10/1 : 47.8/113.2, 84021/36, 37, \times 40; Austin Chalk Formation)
8, 9. *Cleistosphaeridium ebrenbergii* (Deflandre) Davey et al. (CRC 32129-6/1A : 50.5/106.0, 84005/27, 28, \times 54; Grayson Formation)
Scale bar length = 20 μm except for figs 3-7 = 50 μm and figs 8-9 = 35 μm .

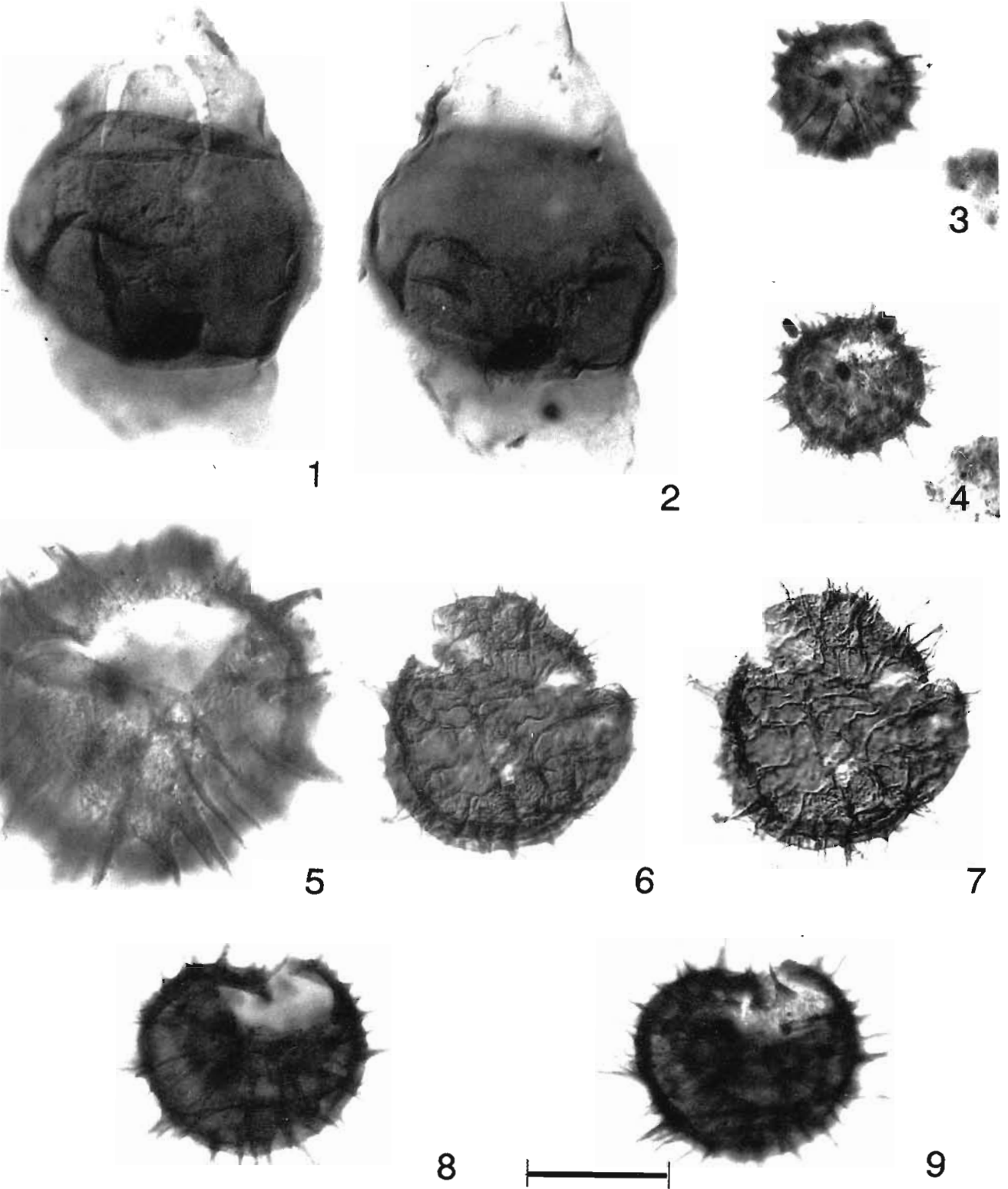


PLATE 5

Chatangiella spectabilis (Alberti) Lentin & Williams 1976

Pl. 4, figs 6-7

1959 *Deflandrea spectabilis* Alberti, p. 99; pl. 9, figs 7-8.

1976 *Chatangiella spectabilis* (Alberti) Lentin & Williams, p. 55; pl. 6, fig. 83.

Measurements—Length and breadth 86-110 × 52-68 μm (Alberti, 1959); 58-87 × 32-50 μm (Harland, 1973); 67 × 56 μm in specimens of this study.

Previous records—Senonian. Senonian, Germany (Alberti, 1959); Santonian-Campanian, western Canada (Harland, 1973; McIntyre, 1974, 1975; Wall & Singh, 1975).

Chatangiella victoriensis (Cookson & Manum) Lentin & Williams 1976

Pl. 5, figs 1-2

1964 *Deflandrea victoriensis* Cookson & Manum, p. 522; pl. 76, figs 3-8.

1976 *Chatangiella victoriensis* (Cookson & Manum) Lentin & Williams, p. 55; pl. 6, fig. 78.

Measurements—Overall length and breadth 76-116 × 49-73 μm (Cookson & Manum, 1964); 75-99 × 43-53 μm (Foucher, 1972); 89-93 × 48-60 μm (Yun, 1981); 75 × 41 μm in specimens of this study.

Previous records—Coniacian-Maastrichtian. Coniacian, France (Foucher, 1972); Santonian, Germany (Yun, 1981); Santonian, Isle of Wight (Clarke & Verdier, 1967); Campanian-Maastrichtian, North America (Wall & Singh, 1974; Aurisano & Habib, 1977); Senonian, Australia (Cookson & Manum, 1964; Cookson & Eisenack, 1982); ?Paleocene, Belgium (Schumacker-Lambry, 1978).

Genus—*Cleistosphaeridium* Davey et al. in Davey et al. 1966

1966 *Cleistosphaeridium* Davey et al. in Davey et al., p. 166.

Type species—*Cleistosphaeridium diversispinosum* Davey et al. in Davey et al. 1966 (original designation).

Remarks—The genus *Cleistosphaeridium* differs from *Operculodinium* in having an apical archeopyle; from *Polysphaeridium* in having distally closed processes.

Cleistosphaeridium armatum (Deflandre) Davey 1969

Pl. 5, figs 3-5

1937 *Hystrichosphaeridium armatum* Deflandre, p. 76; pl. 16, figs 6-7.

1963 *Baltisphaeridium armatum* (Deflandre) Downie & Sarjeant, p. 91 (basonymo non cit.).

1969 *Cleistosphaeridium armatum* (Deflandre) Davey, p. 153; pl. 8, figs 1-2, 12.

Measurements—Shell diameter 19-42 μm, process length 5-16 μm (Davey, 1969); shell dimensions ca 25 × 18-20 μm, process length 10-15 μm (Foucher, 1972); 25-30 × 32-36 μm, 7-14 μm (Yun, 1981); overall diameter 44-83 μm, body diameter 30-55 μm, process length 8-18 μm in specimens of this study.

Remarks—*Cleistosphaeridium armatum* has several long processes with striations at their base and distally apices of some processes are divided into several small spines.

Previous records—Cenomanian-Senonian. Cenomanian-Senonian, France (Deflandre, 1937; Davey, 1969; Foucher, 1972, 1974); Cenomanian-Campanian, England (Davey, 1969; Clarke & Verdier, 1967); Santonian, Germany (Yun, 1981); Cenomanian, U.S.A. (Davey, 1969).

Cleistosphaeridium diversispinosum Davey et al. in Davey et al. 1966

Pl. 5, figs 6-7

1966 *Cleistosphaeridium diversispinosum* Davey et al. in Davey et al., p. 167; pl. 10, fig. 7.

PLATE 6

- 1, 2. *Cleistosphaeridium flexuosum* Davey et al. (CRC 32129-3/1 : 30.5/96.5, 84004/16, 17, ×40; Grayson Formation)
 3. *Cleistosphaeridium multifurcatum* (Deflandre) Davey et al. (CRC 32129-10/9 : 40.0/99.5, 84014/1, ×40; Grayson Formation)
 - 4-6. *Cleistosphaeridium polytes* (Cookson & Eisenack) Davey (CRC 32129-10/8 : 39.9/108.0, 84014/31-33, ×100; Grayson Formation)
 - 7-10. *Coronifera oceanica* Cookson & Eisenack. 7-8, (CRC 32130-2/1 : 42.4/113.5, 84015/36, 37, ×100; middle Britton Member of the Eagle Ford Formation); 9-10, (CRC 32131-10/2 : 24.6/96.6, 84022/16, 15, ×40; Austin Chalk Formation)
 - 11, 12. *Cribroperidinium cooksoniae* Norvick in Norvick & Burger (CRC 32131-7/6A : 26.0/93.4, 84019/32, 33, ×40; Arcadia Park Member of the Eagle Ford Formation)
 13. *Cyclonephelium compactum* Deflandre & Cookson (CRC 32129-7/1 : 46.0/98.0, 84010/25, ×100; Grayson Formation)
- Scale bar length = 20 μm except for figs. 1-3 and 9-12 = 50 μm.

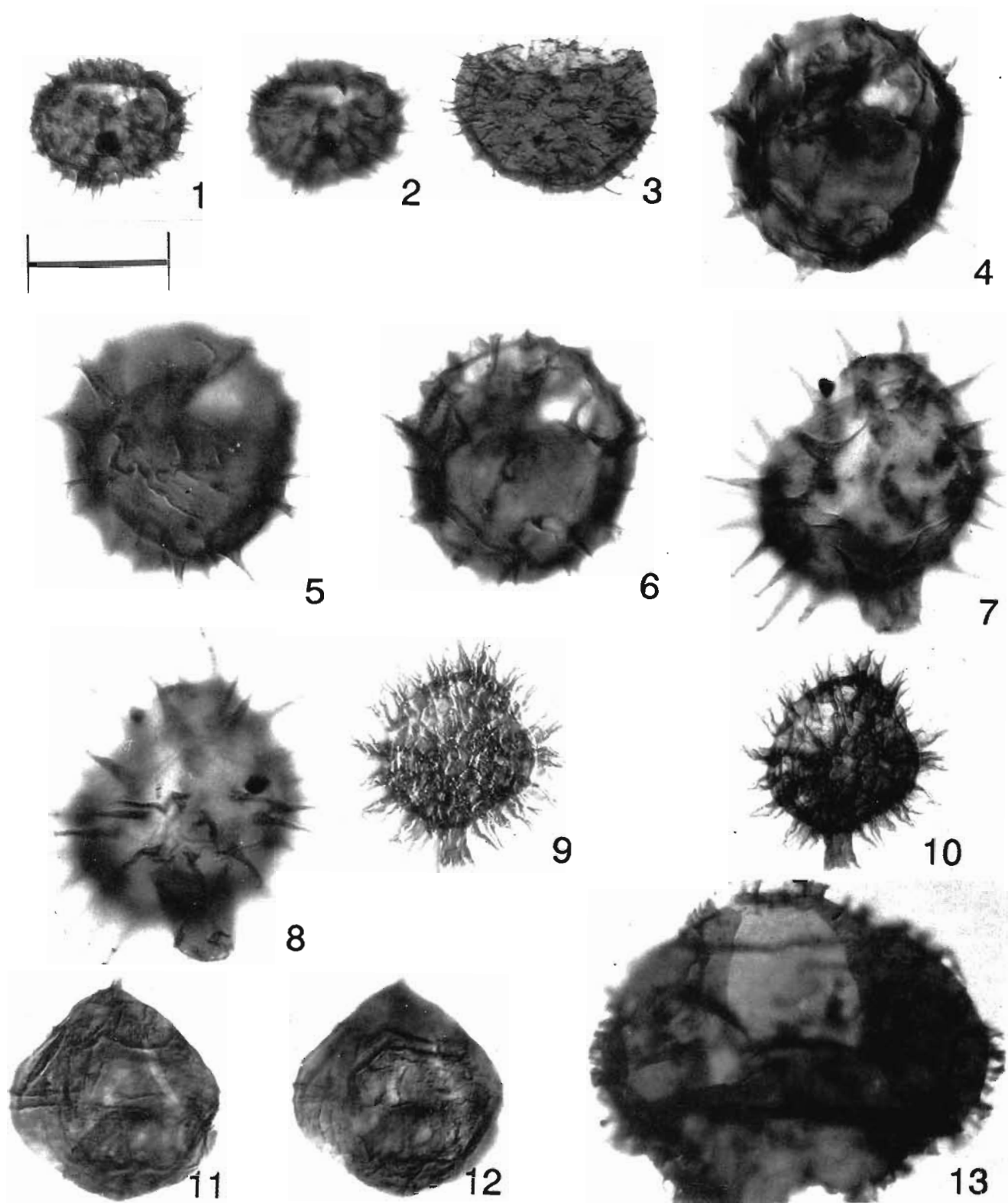


PLATE 6

Measurements—Body diameter 38-43 μm , length of processes 7-23 μm (Davey *et al.* in Davey *et al.*, 1966); body length \times breadth 35-57 \times 43-67 μm , process length 5-19 μm (Harland, 1973); overall diameter 104-117 μm , process length 18-31 μm in six specimens of this study.

Remarks—*Cleistosphaeridium diversispinosum* has long processes with bifurcate, orthogonal or patulate apices. The specimens of this study are larger than reported elsewhere.

Cleistosphaeridium ehrenbergii (Deflandre)

Davey *et al.* in Davey *et al.* 1969

Pl. 5, figs 8-9

1938 *Hystrichosphaeridium cf. hirsutum* Deflandre; pl. 10, fig. 9.

1947 *Hystrichosphaeridium ehrenbergii* Deflandre, fig. 1, no. 5 (err. orth. pro *ehrenbergii*).

1961 *Baltisphaeridium ehrenbergii* (Deflandre) Sarjeant, p. 103 (err. orth. pro *ehrenbergii*).

1966 *Cleistosphaeridium ehrenbergii* (Deflandre) Davey *et al.* in Davey *et al.*, p. 170 (basionym non cit.; err. orth. pro *ehrenbergii*).

1969 *Cleistosphaeridium ehrenbergii* (Deflandre) Davey *et al.* in Davey *et al.*, p. 16 (err. orth. pro *ehrenbergii*).

Measurements—Shell dimensions 30-65 \times 30-50 μm , process lengths 15-30 μm (Gitmez, 1970); shell diameter 34-50 μm , process length 6-21 μm (Ioannides *et al.*, 1976); overall diameter 55-85 μm , body diameter 40-55 μm , process length 12-20 μm in four specimens of this study.

Remarks—*Cleistosphaeridium ehrenbergii* appears to have several long processes with acuminate apices.

Previous records—Middle Jurassic-Early Cretaceous. Middle Jurassic-Late Jurassic, Europe (Deflandre, 1938, 1947; Sarjeant, 1968; Gitmez, 1970; Ioannides *et al.*, 1976); Kimmeridgian, Greenland (Fensome, 1979); Lower Cretaceous, Afghanistan (Ashraf, 1979).

Cleistosphaeridium flexuosum Davey *et al.* in

Davey *et al.* 1966

Pl. 6, figs 1-2

1966 *Cleistosphaeridium flexuosum* Davey, Downie, Sarjeant & Williams in Davey *et al.*, p. 169; pl. 2, fig. 5.

Measurements—Shell diameter 20-45 μm , length of processes up to 20 μm (Davey *et al.*, 1966); overall dimensions 28-50 \times 31-50 μm , shell dimensions 25-50 \times 23-42 μm , length of processes up to 20 μm (Srivastava, 1984); overall diameter 86-88 μm , body diameter 50-57 μm , process length 18-20 μm in specimens of this study.

Remarks—The flexuous, acuminate processes of *Cleistosphaeridium flexuosum* distinguish it from other *Cleistosphaeridium* spp.

Previous records—Early Cretaceous-Cenomanian. Cenomanian, Europe (Davey *et al.*, 1966; Davey, 1969); Lower Cretaceous, Israel (Brenner, 1974).

Cleistosphaeridium multifurcatum (Deflandre)

Davey *et al.* 1969

Pl. 6, fig. 3

1937 *Hystrichosphaeridium multifurcatum* Deflandre, p. 76; pl. 16, figs 1-3.

1960 *Baltisphaeridium multifurcatum* (Deflandre) Klement, p. 59.

1966 *Cleistosphaeridium multifurcatum* (Deflandre) Davey, Downie, Sarjeant & Williams in Davey *et al.*, p. 170 (basionym non cit.).

1969 *Cleistosphaeridium multifurcatum* (Deflandre) Davey, Downie, Sarjeant & Williams in Davey *et al.*, p. 16.

Measurements—Overall diameter 60-90 μm , shell diameter 45-65 μm (Deflandre, 1937); shell diameter 39-68 μm , length of processes 8-13 μm (Davey, 1969); overall diameter 60-75 μm , shell diameter 29-50 μm , length of processes 8-20 μm (Srivastava, 1984); overall diameter 68-86 μm , body diameter 52-75 μm , process length 5-10 μm in specimens of this study.

Remarks—*Cleistosphaeridium heteracanthum* and *C. multifurcatum* are very similar. Davey *et al.* (1966) noted the difficulty in distinguishing these two species. Both species include cysts with numerous processes with variable apices.

PLATE 7

1-4. *Cyclonephelium eisenackii* Davey (CRC 32129-6/12 : 25.7/103.0, 84008/21, 22, \times 40; 24, 23, \times 100, Grayson Formation)

5-8. *Cyclonephelium membraniporum* Cookson & Eisenack (CRC 32130-2/1 : 34.5/103.0, 84015/18, 19, \times 40; 20, 21, \times 100; middle Britton Member of the Eagle Ford For-

mation)

9, 10. *Dapsilidium laminaspinosum* (Davey & Williams) Lentin & Williams (CRC 32129-6/5 : 39.7/102.5, 85001/31, 32, \times 40; Grayson Formation)

Scale bar length = 20 μm except for figs 1, 2, 5, 6 = 50 μm and for figs 9, 10 = 40 μm .

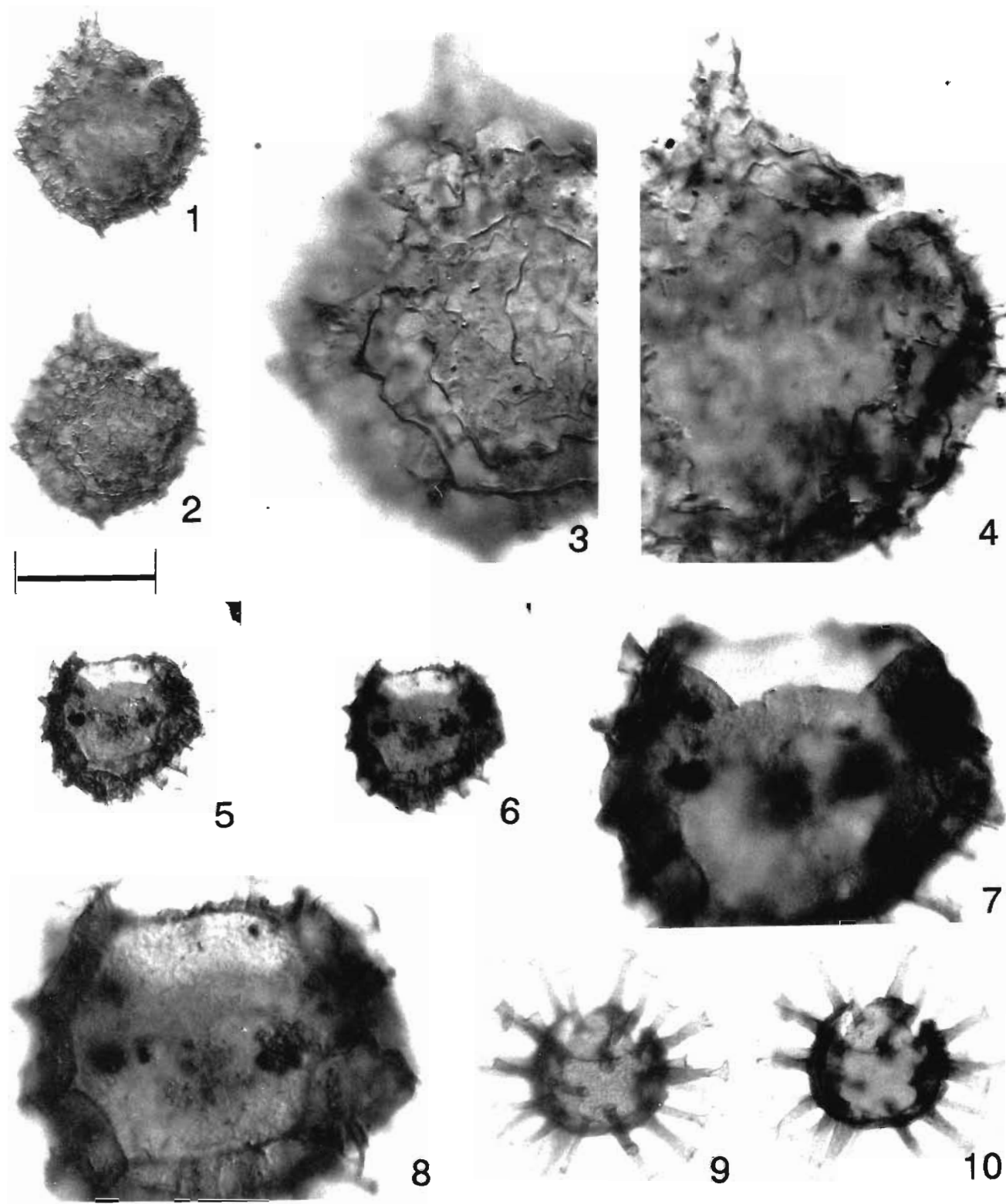


PLATE 7

Previous records—Barremian-Danian. Barremian-Senonian, Europe (Srivastava, 1984; Davey, 1969; Deflandre, 1937; Foucher, 1972; Górka, 1963); Danian, U.S.A. (Drugg, 1967).

Cleistosphaeridium polytes (Cookson & Eisenack)
Davey 1969

Pl. 6, figs 4-6

1962 *Hystrichosphaeridium recurvatum* subsp. *polytes* Cookson & Eisenack, p. 491; pl. 4, figs 11-13.

1969 *Cleistosphaeridium polytes* (Cookson & Eisenack) Davey, p. 154; pl. 6, figs 7-8.

Measurements—Overall diameter 52.99 μm , body diameter 33.57 μm , process length 15.25 μm (Cookson & Eisenack, 1962); body diameter 31.47 μm , process length 9.18 μm (Davey, 1969); overall diameter 60.72 μm , body 34.47 μm , process length 12.19 μm (Singh, 1971); body 31.52 \times 28.44 μm , process length 13.19 μm (Duxbury, 1977); overall 44 \times 40 μm , body 33 \times 27 μm , process length 8.15 μm in one specimen of this study.

Remarks—*Cleistosphaeridium polytes* has numerous long processes with branched apices.

Previous records—Hauterivian-Turonian. Hauterivian, Spitsbergen (Bjaerke, 1978); Barremian-Cenomanian, England (Davey, 1969, 1974; Duxbury, 1977); Cenomanian, France (Davey, 1969); Albian-Cenomanian, North America (Davey, 1969; Singh, 1971; Williams, 1975; May & Stein, 1979); Albian-Cenomanian, Australia (Norvick & Burger, 1976; Burger, 1980); Early Albian, south India (Jain, 1977); Turonian, South Atlantic Ocean, off southwestern Africa (Davey, 1978); Lower Cretaceous, northern Afghanistan (Ashraf, 1979).

**Genus—*Coronifera* Cookson & Eisenack
emend. Davey 1974**

1958 *Coronifera* Cookson & Eisenack, p. 45.

1969 *Coronifera* Cookson & Eisenack emend. Davey, p. 161.

1974 *Coronifera* Cookson & Eisenack emend. Davey, p. 47.

Type species—*Coronifera oceanica* Cookson & Eisenack 1958 (original designation).

Remarks—*Coronifera* is distinct from *Diphyes* Cookson emend. Davey & Williams in having a precingular archeopyle rather than an apical one.

Coronifera oceanica Cookson & Eisenack 1958

Pl. 6, figs 7-10

1958 *Coronifera oceanica* Cookson & Eisenack, p. 45; pl. 12, fig. 6.

Measurements—Range of overall dimensions 60.95 \times 44.94 μm , shell dimensions 33.58 \times 29.65 μm , length of apical horn 6.24 μm , width of apical horn 6.18 μm , dimensions of processes 5.22 \times 1.3 μm (Srivastava, 1984); overall 60.70 \times 50.65 μm , shell dimensions 37.50 \times 33.50 μm , antapical horn length \times width 13.20 \times 10.15 μm , process length \times breadth 13.20 \times 1.3 μm in 20 specimens of this study.

Remarks—Size variations are considerable in the shell, antapical horn, and processes of *Coronifera oceanica*. *C. albertii* Milloud is distinct from *C. oceanica* in having fewer processes. *C. monstrosa* (Tasch) Stover & Evitt has not been distinguished from *C. oceanica* and may be conspecific.

Previous records—Hauterivian-Paleocene (see Srivastava, 1984).

Genus—*Cribroperidinium* Neale & Sarjeant 1962

1962 *Cribroperidinium* Neale & Sarjeant, p. 443.

Type species—*Cribroperidinium sepimentum* Neale & Sarjeant 1962 (original designation).

Remarks—*Cribroperidinium* is distinct from *Gonyaulacysta* and *Millioudodinium* in having accessory ridges in between parasutural ones.

Cribroperidinium cooksoniae Norvick in Norvick & Burger 1976

Pl. 6, figs 11-12

1976 *Cribroperidinium cooksonae* Norvick in Norvick & Burger, p. 36; pl. 1; text-fig. 13 (err. orth. pro *cooksoniae*).

Measurements—Overall length 58.95 μm (Norvick & Burger, 1976); 80.96 μm (Srivastava, 1984); 60.73 μm in specimens of this study.

Previous records—Valanginian-Cenomanian. Valanginian, northwestern Germany (Below, 1981b); Barremian, France (Srivastava, 1984); Cenomanian, Australia (Norvick & Burger, 1976); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

**Genus—*Cyclonephelium* Deflandre & Cookson
emend. Stover & Evitt 1978**

1955 *Cyclonephelium* Deflandre & Cookson, p. 285.

1958b *Tenua* Eisenack, p. 410.

1961 *Circulodinium* Alberti, p. 28.

1978 *Cyclonephelium* Deflandre & Cookson emend. Stover & Evitt, p. 35.

Type species—*Cyclonephelium compactum* Deflandre & Cookson 1955 (original designation).

Remarks—The genera *Cyclonephelium* and *Tenua* have been emended several times since their

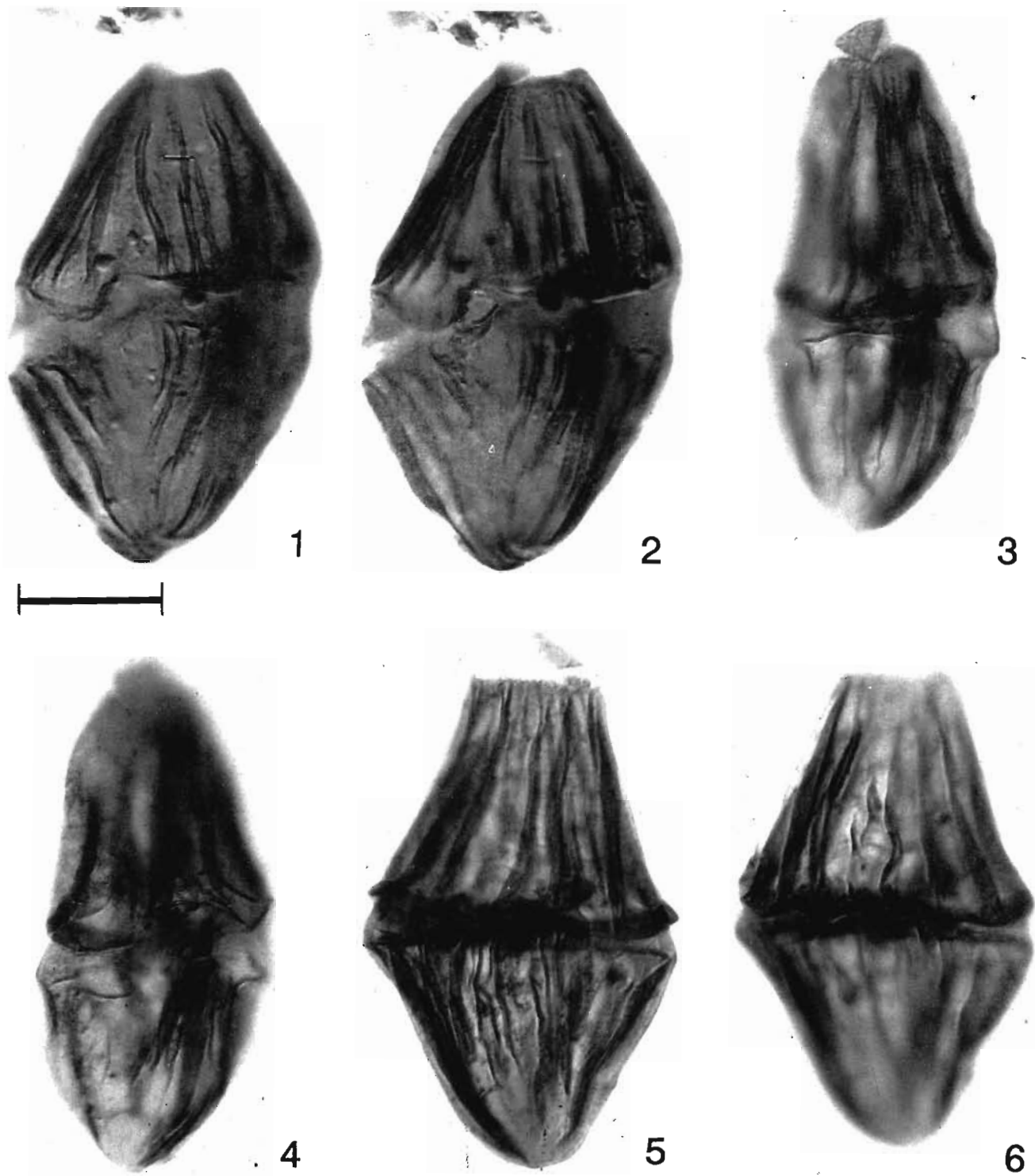


PLATE 8

1-6. *Dinogymnium acuminatum* Evitt, Clarke & Verdier. 1-2, (CRC 32131-10/2 : 27.0/99.0, 84022/26, 27, $\times 100$; Austin Chalk Formation); 3-4, (CRC 32131-12/1 : 23.2/106.4, 84023/34, 35, $\times 100$; Austin Chalk Formation); 5-6, (CRC

32131-12/6 : 20.0/105.0, 84024/20, 21, $\times 100$; Austin Chalk Formation)
Scale bar length = 20 μm .

institution (Cookson & Eisenack, 1962; Williams & Downie in Davey *et al.*, 1966; Sarjeant, 1968; Pocock, 1972; Ioannides *et al.*, 1977; Sarjeant & Stover, 1978; Stover & Evitt, 1978). Sarjeant and Stover (1978) and Davey (1978) transferred the type species *Tenua bystrix* to the genus *Cyclonephelium*, and so *Tenua* Eisenack became a junior synonym of *Cyclonephelium*. Davey (1978) proposed the conservation of the genus *Tenua* substituting the type species with *T. rioulti* Sarjeant. Lentin and Williams (1981) rejected the retention of *Tenua* by Davey (1978) which was neither justified nor according to the International Code of Botanical Nomenclature (see Voss *et al.*, 1983; Article 15). Srivastava's (1984, p. 61) acceptance of *Tenua* Davey non Eisenack is not a valid treatment.

Circulodinium Alberti has spinules all over the cyst-surface except on mid-ventral and mid-dorsal areas, hence it is a junior synonym of *Cyclonephelium* and not of *Canningia*.

Cyclonephelium is distinct from *Canningia* in lacking or having reduced ornamentation on mid-ventral and mid-dorsal areas.

Cyclonephelium compactum Deflandre & Cookson
1955

Pl. 6, fig. 13

1955 *Cyclonephelium compactum* Deflandre & Cookson, p. 285; pl. 2, figs 11-13; text-figs 44-46.

Measurements—Overall diameter 72-87 μm , body 61-72 μm , process length 5-10 μm (Deflandre & Cookson, 1955); overall dimensions 84-126 \times 81-98 μm , process length 7-28 μm (Brideaux, 1971); overall dimensions 60-72 \times 45-60 μm , process length 12-18 μm (Yun, 1981); overall dimensions 52-88 \times 60-83 μm , processes 3-7 μm long in specimens of this study.

Remarks—*Cyclonephelium compactum* has short processes which are generally joined together and arranged in a reticulate pattern.

Previous records—Aptian-Senonian. Aptian-Senonian, Australia (Deflandre & Cookson, 1955; Cookson & Eisenack, 1958, 1962, 1982; Norvick & Burger, 1976; Morgan, 1980); Albian, Canada and Alaska (Brideaux, 1971; Brideaux & McIntyre, 1975; Doerenkamp *et al.*, 1976; May & Stein, 1979); Aptian-earliest Albian, Southern England (Duxbury, 1983); Albian, France (Fauconnier, 1975); Turonian DSDP leg 40, offcoast southwestern Africa (Davey, 1978); Santonian, Germany (Yun, 1981).

Cyclonephelium distinctum Deflandre & Cookson
1955
(not illustrated)

1955 *Cyclonephelium distinctum* Deflandre & Cookson, p. 285; Pl. 2, fig. 14; text-figs 47-48.

1961 *Circulodinium deflandrei* Alberti, p. 29; pl. 4, figs 7-13.

Measurements—Cyst diameter 64-97 μm (Deflandre & Cookson, 1955); length and breadth 128 \times 124 μm (Cookson & Eisenack, 1971); 60-84 \times 50-78 μm (Singh, 1971); 37-84 \times 39-87 μm (Harland, 1973); 67 \times 60 μm (Foucher & Taugourdeau, 1975); 55-110 \times 46-106 μm (Ioannides, Stavrinos & Downie, 1977); 65-105 \times 57-99 μm (Duxbury, 1977); 66-98 \times 53-88 μm (Srivastava, 1984).

Remarks—*Cyclonephelium distinctum* is distinct from *C. areolatum* Cookson & Eisenack in lacking a vermiculate or areolate outer cyst-wall; from *C. compactum* Deflandre & Cookson and *C. crassimarginatum* Cookson & Eisenack in having discrete processes. *C. densibarbatum* Cookson & Eisenack has denser distribution of its processes than those of *C. distinctum*. *C. eisenackii* Davey has a reticulate cyst-surface with low crests, which sometimes appear as processes in the broken reticulum.

Previous records—Kimmeridgian-Danian. Kimmeridgian-Campanian, England (Ioannides, Stavrinos & Downie, 1977; Duxbury, 1977, 1983; Davey, 1969, 1974; Clarke & Verdier, 1967); Berriasian-Cenomanian, France (Millioud, 1969; Davey & Verdier, 1971; Foucher & Taugourdeau, 1975; de Renéville & Raynaud, 1981; Srivastava, 1984); Valanginian, northwestern Germany (Below, 1981b); Valanginian-Hauterivian, Spitsbergen (Bjaerke, 1978); Albian, Rumania (Baltes, 1967); Aptian-Albian, Israel (Brenner, 1974) and India (Jain & Taugourdeau-Lantz, 1973; Jain, 1977); Aptian-Maastrichtian, Canada (Brideaux & McIntyre, 1975; Singh, 1971; Davey, 1969; Harland, 1973; McIntyre, 1974; Doerenkamp, Jardiné & Moreau, 1976); Upper Campanian-Danian, USA (Benson, 1976; Drugg, 1967; Harland, 1977); Campanian-Maastrichtian, Senegal (Jain & Millepied, 1975); Albian-Maastrichtian, Australia (Cookson & Eisenack, 1971; Playford, Haig & Dettmann, 1975; Norvick & Burger, 1976; Deflandre & Cookson, 1955).

C. distinctum is most commonly found in Hauterivian-Cenomanian strata.

Cyclonephelium eisenackii Davey 1969

Pl. 7, figs 1-4

1969 *Cyclonephelium eisenackii* Davey, p. 170; pl. 8, figs 3-4; pl. 9, fig. 4; text-figs 17A-B (err. orth. pro *eisenackii*).

1974 *Aptea eisenackii* (Davey) Davey & Verdier, p. 643 (err. orth. pro *eisenackii*).

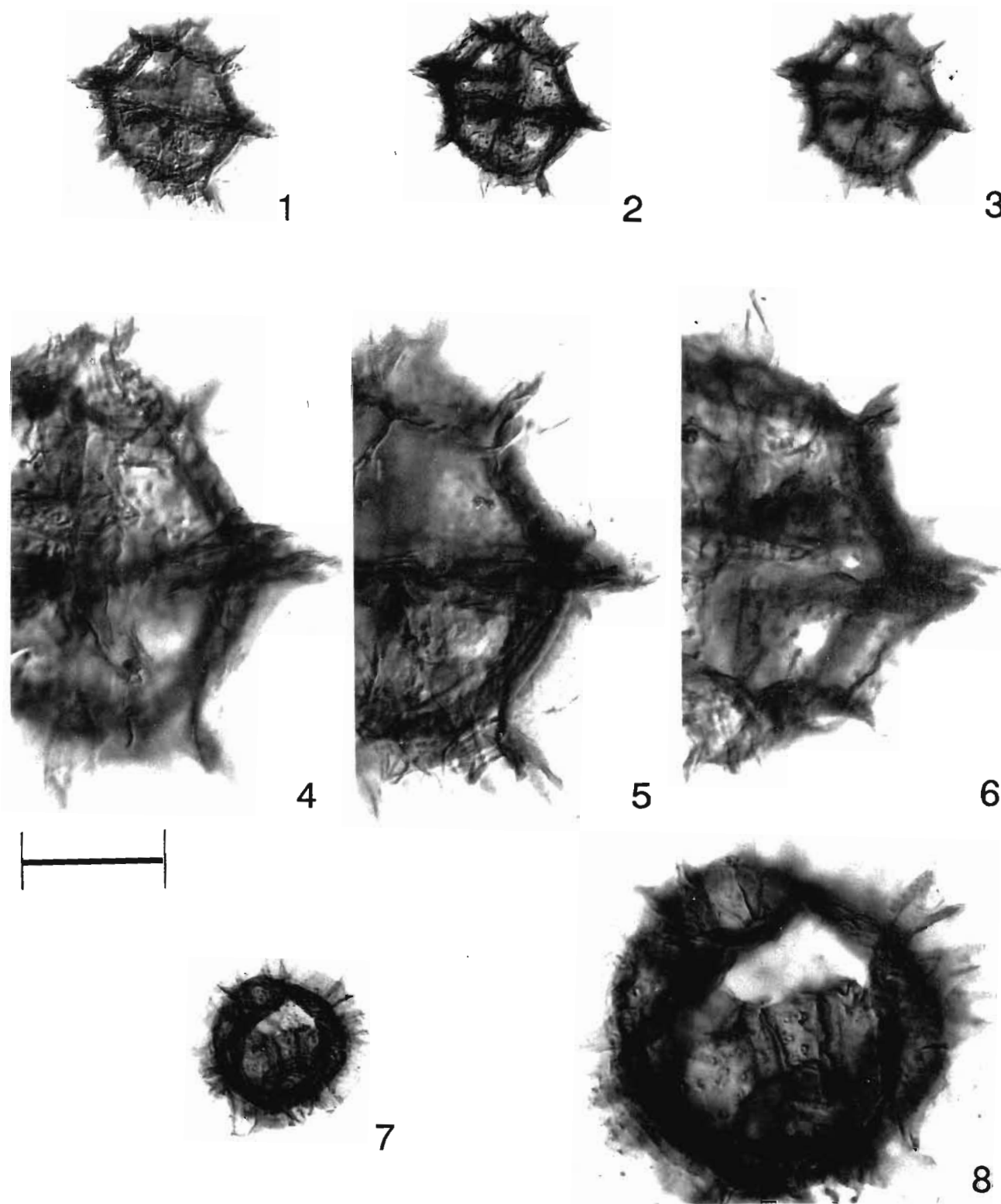


PLATE 9

1-8. *Dinopterygium cladoides* Deflandre. 1-6, (CRC 32129-7/1 : 50.8/108.0, 84001/18, 19, 20, $\times 40$; 21, 22, 23, $\times 100$; Grayson Formation); 7-8, apical view of a specimen (CRC 32129-

6/12 : 18.2/97.8; 84007/24, $\times 40$; 25, $\times 100$; Grayson Formation)
Scale bar length = 20 μm except for figs 1-3 and 7 = 50 μm .

1978 *Cyclonephelium eisenackii* Davey, Sarjeant & Stover, p. 52.

Measurements—Shell dimensions 70.92 × 66.84 μm, crest height 2.7 μm (Davey, 1969); 73.103 × 53.83 μm (Brideaux, 1971); 60.88 × 50.75 μm, crest height 3.5 μm in seven specimens of this study.

Previous records—Albian-Cenomanian. Albian-Cenomanian, western and Arctic Canada (Davey, 1969, Brideaux, 1971; Doerenkamp *et al.*, 1976); Albian, Alaska (May & Stein, 1979); Albian, France (Davey & Verdier, 1971); Albian-Early Cenomanian, Atlantic Ocean, off western Africa (Williams, 1978).

Cyclonephelium membraniphorum Cookson & Eisenack 1962

Pl. 7, figs 5-8

1962 *Cyclonephelium membraniphorum* Cookson & Eisenack, p. 495; pl. 6, figs 8-14.

Measurements—Overall dimensions 73.128 μm, width of ornamentation 6.22 μm (Cookson & Eisenack, 1962); overall 37.79 × 41.82 μm, sculpture width 6.26 μm (Davey, 1969); 65 × 65 μm with 10 μm high sculpture in specimens of this study.

Remarks—*Cyclonephelium membraniphorum* has long processes joined by crests forming large reticulate sculpture in marginal areas.

Previous records—Late Albian-Early Senonian. Late Albian-Cenomanian, Australia (Cookson & Eisenack, 1958, 1962, 1968, 1971; Norvick & Burger, 1976; Morgan, 1980); Cenomanian-Lower Senonian, southern England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1969); Late Albian-Turonian, France (Davey, 1969; Davey & Verdier, 1971; Foucher, 1974; Fauconnier, 1979).

Genus—*Dapsilidinium* Bujak *et al.* 1980

1980 *Dapsilidinium* Bujak, Downie, Eaton & Williams, p. 27.

Type Species—*Dapsilidinium pastielsii* (Davey & Williams) Bujak *et al.* 1980 = *Polysphaeridium pastielsi* Davey & Williams, in Davey *et al.* 1966 (original designation).

Remarks—*Dapsilidinium* has an apical archeopyle, and hollow, distally open, tubiform or tapering processes. Thus it is distinct from *Polysphaeridium* Davey & Williams which has an epicystal archeopyle.

Dapsilidinium laminaspinosum (Davey & Williams in Davey *et al.*) Lentin & Williams 1981.

Pl. 7, figs 9-10

1966 *Polysphaeridium laminaspinosum* Davey & Williams in Davey *et al.*, p. 94; pl. 8, fig. 8.

1981 *Dapsilidinium laminaspinosum* (Davey & Williams in Davey *et al.*) Lentin & Williams, p. 69.

Size measurements—Diameter of the central body and length of the processes: 23.28 μm and 11.17 μm (Davey & Williams in Davey *et al.*, 1966); 20.29 μm and 9.17 μm (Davey, 1969a); 30 μm and 8.10 μm (Brideaux & McIntyre, 1975); 30.37 × 25.34 and 15.22 μm (Duxbury, 1977); 25.40 μm and 12.20 μm (Srivastava, 1984); overall diameter 40.73 μm, body diameter 25.36 μm, process length 12.21 μm, process width 2.5 μm in seven specimens of this study.

Remarks—Long, tubular, ribbon-shaped processes distinguish *Dapsilidinium laminaspinosum* from other species of this genus. *D. multispinosum* has a scabrate cyst wall and more processes than in *D. laminaspinosum*.

Previous records—Hauterivian-Cenomanian. Hauterivian-Cenomanian, Europe (Davey & Williams in Davey *et al.*, 1966; Davey, 1969a, 1974; Davey & Verdier, 1971; Duxbury, 1977, 1980; Srivastava, 1984); Middle Albian, district of MacKenzie, Northwest Territories, Canada (Brideaux & McIntyre, 1975).

Genus—*Dinogymnium* Evitt, Clarke & Verdier 1967

1967 *Dinogymnium* Evitt, Clarke & Verdier, p. 4.

Type species—*Dinogymnium acuminatum* Evitt, Clarke & Verdier 1967 (original designation).

Remarks—*Dinogymnium* includes biconical to ellipsoidal cysts with varying number of longitudinal

PLATE 10

1, 2. *Ellipsodinium rugulosum* Clarke & Verdier (CRC 32130-2/1 : 34.7/98.0, 84015/9, 10, × 100; middle Britton Member of the Eagle Ford Formation)

3-8. *Exochosphaeridium cenomaniense* Norvick in Norvick & Burger 3-6, (CRC 32130-2/1 42.4/109.0, 84015/26, 27, × 40; 28, 29, × 100; middle Britton Member of the Eagle Ford Formation); 7-8, (32129-6/4 : 34.2/107.0, 85001/15, 16, × 40; Grayson Formation)

9. *Exochosphaeridium pbragmites* Davey *et al.* (CRC 132129-6/1 : 42.8/99.0, 84004/25, × 40; Grayson Formation)

10-12. *Exochosphaeridium truncatum* (Davey) Stover & Evitt (CRC 32129-10/9 : 48.0/104.5, 84014/17, × 40; 18, 19, × 100; Grayson Formation)

Scale bar length = 20 μm except for figs 7, 8 = 40 μm, and figs 3, 4, 9 and 10 = 50 μm.

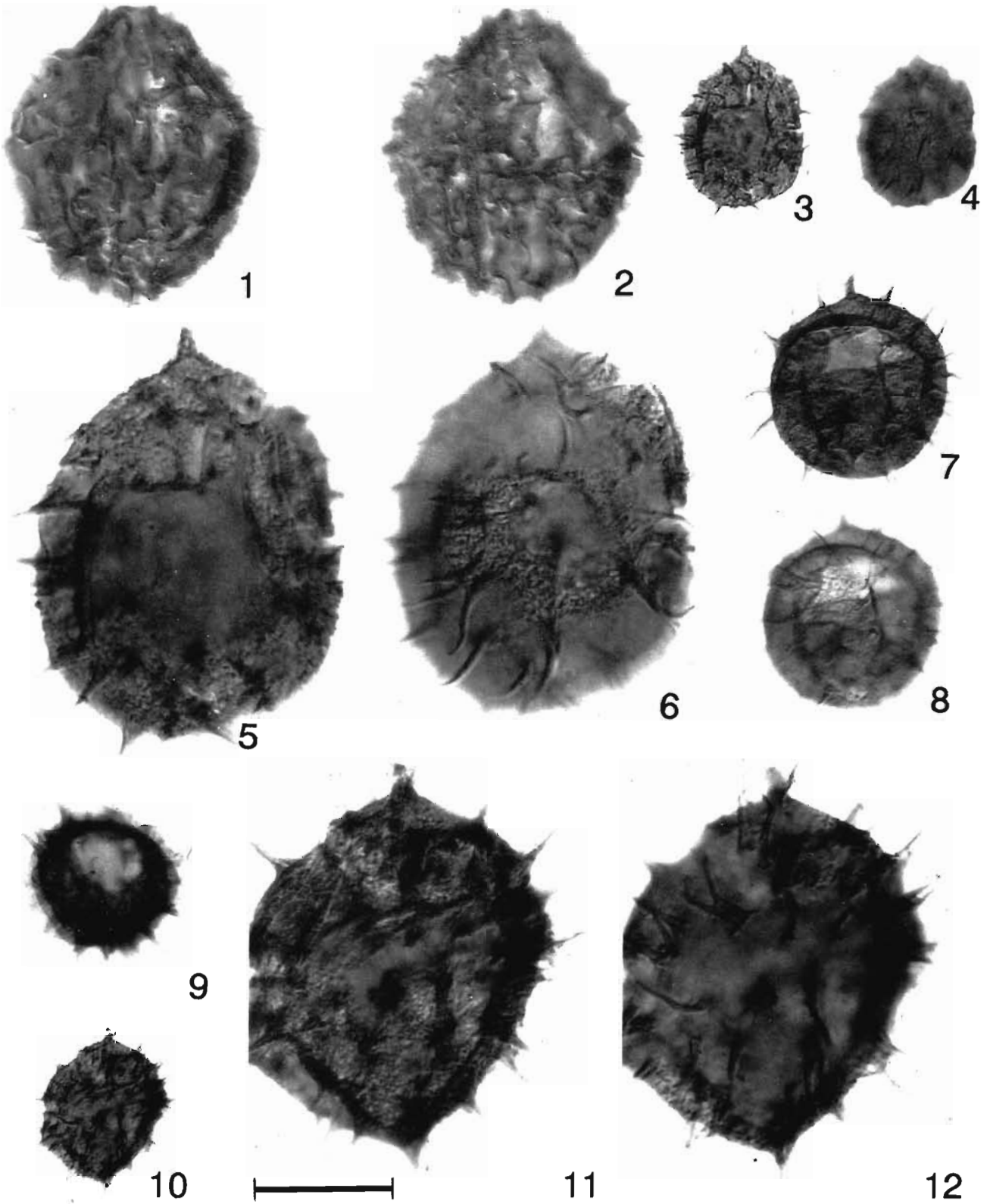


PLATE 10

ribs, equational to subequational paracingulum, and a small apical archeopyle.

Dinogymnium acuminatum Evitt, Clarke & Verdier 1967

Pl. 8, figs 1-6

1967 *Dinogymnium acuminatum* Evitt, Clarke & Verdier, p. 8; pl. 1, figs 1-24; pl. 2, figs 1-22; pl. 3, figs 1-8, 10, 12, 20; text-figs 11-23.

1967 *Gymnodinium* sp. 1, Evitt; pl. 1, figs. A, B, F, G, S-U; text-fig. 1A, J-K.

Measurements—Length and width 48-127 × 27-86 μm (Evitt, Clarke & Verdier, 1967); 60-88 × 37-57 μm in 12 specimens of this study.

Previous records—Coniacian-Maastrichtian. Santonian-Maastrichtian, North America (Evitt, 1967; 1973; Evitt *et al.*, 1967; Drugg, 1967; Wall & Singh, 1975; May, 1980; Martinez-Hernandez *et al.*, 1980; Helenes, 1984); Senonian, Brazil (Hemgreen, 1975); Senonian, Africa (Jain & Millepied, 1975; Boltenhagen, 1977; Doubinger, 1979; Rauscher & Doubinger, 1982); Senonian, India (Jain, Sah & Singh, 1975; Sah & Singh, 1977; Jain, 1978); Late Maastrichtian, Turkey (Erkmen & Sadek, 1981); Upper Coniacian-Senonian, southwestern Atlantic Ocean (Ioannides & Colin, 1977).

Specimens reported from the Early Paleocene, Belgium (Schumacker-Lambry, 1978) may be reworked examples from older strata.

Genus—*Dinopterygium* Deflandre emend. Stover & Evitt 1978

1935 *Dinopterygium* Deflandre, p. 231.

1960 *Oodnadattia* Eisenack & Cookson, p. 6.

1960b *Toolongia* Cookson & Eisenack, p. 14.

Type species—*Dinopterygium cladoides* Deflandre 1935 (original designation, monotypic).

Remarks—*Dinopterygium* has proximochorate, subspherical to polygonal cysts with circular outline in apical-antapical views. It has a gonyaulacacean paratabulation indicated by parasutural septa and intratabular structures between autophragm and ectophragm. It has a combination epicystal archeopyle.

Dinopterygium differs from *Heteraulacacysta* in having clustered intratabular structures, and from *Tubidermodinium* in having raised ectophragm in parasutural areas.

Dinopterygium cladoides Deflandre 1935

Pl. 9, figs 1-8

1935 *Dinopterygium cladoides* Deflandre, p. 231; pl. 8, fig. 6.

1960 *Oodnadattia tuberculata* Eisenack & Cookson, p. 6; pl. 2, figs 10-14.

1960b *Toolongia medusoides* Cookson & Eisenack, p. 14; pl. 3, figs 11-12.

Measurements—Overall dimensions 78 × 65 μm, shell 50 × 40 μm (Deflandre, 1936); overall 73-78 μm, shell 47-53 μm (Morgenroth, 1966); overall 55-60 μm, shell 40-45 μm (de Coninck, 1969); overall 82-94 × 77-94 μm (Foucher, 1974); overall 50-90 μm, shell 40-60 μm (de Coninck, 1975); overall 102-126 × 96-124 μm (Yun, 1981); overall 81-94 × 75-86 μm, body 52-55 × 47-52 μm in specimens of this study.

Previous records—Albian-Oligocene. Albian-Oligocene, Europe (Deflandre, 1935, 1936b; Reissinger, 1950; Valensi, 1956; Morgenroth, 1966; Clarke & Verdier, 1967; de Coninck, 1969, 1975; Davey & Verdier, 1971; Benedek, 1972; Foucher, 1972, 1974; Yun, 1981); Albian-Senonian, Australia (Deflandre & Cookson, 1955; Cookson & Eisenack, 1960b; Eisenack & Cookson, 1960); Cenomanian, Grand Banks, eastern Canada (Millioud *et al.*, 1975); Late Senonian, south Atlantic Ocean (Harris, 1976).

Genus—*Ellipsodinium* Clarke & Verdier 1967

1967 *Ellipsodinium* Clarke & Verdier, p. 68.

Type species—*Ellipsodinium rugulosum* Clarke & Verdier 1967 (original designation).

Remarks—*Ellipsodinium* consists of subspherical to ellipsoidal proximochorate cysts with low rugulae and a precingular archeopyle. It differs from *Apteodinium* in having longitudinal to oblique ridges or rugulae on the autophragm; and from *Trichodinium* in lacking apical protrusion.

PLATE 11

1-6. *Florentinia clavigera* (Deflandre) Davey & Verdier. 1-2, (CRC 32129-8/5 : 31.2/108.8, 84012/17, 18, × 40, Grayson Formation); 3-6, (CRC 32129-10/1 : 39.0/114.0, 84013/23, 24, × 40; 25, 26, × 100; Grayson Formation).

7-11 *Florentinia cooksoniae* (C. Singh) Duxbury. 7-9, (CRC

32129-10/1 : 28.0/99.0, 84013/4, 5, × 100; 3, × 40; Grayson Formation); 10-11, (CRC 32129-3/1 : 38.0/95.0, 85001/1, 2, × 40; Grayson Formation)

Scale bar length = 20 μm except for figs 1-4 and 9 = 50 μm and figs 10-11 = 40 μm.

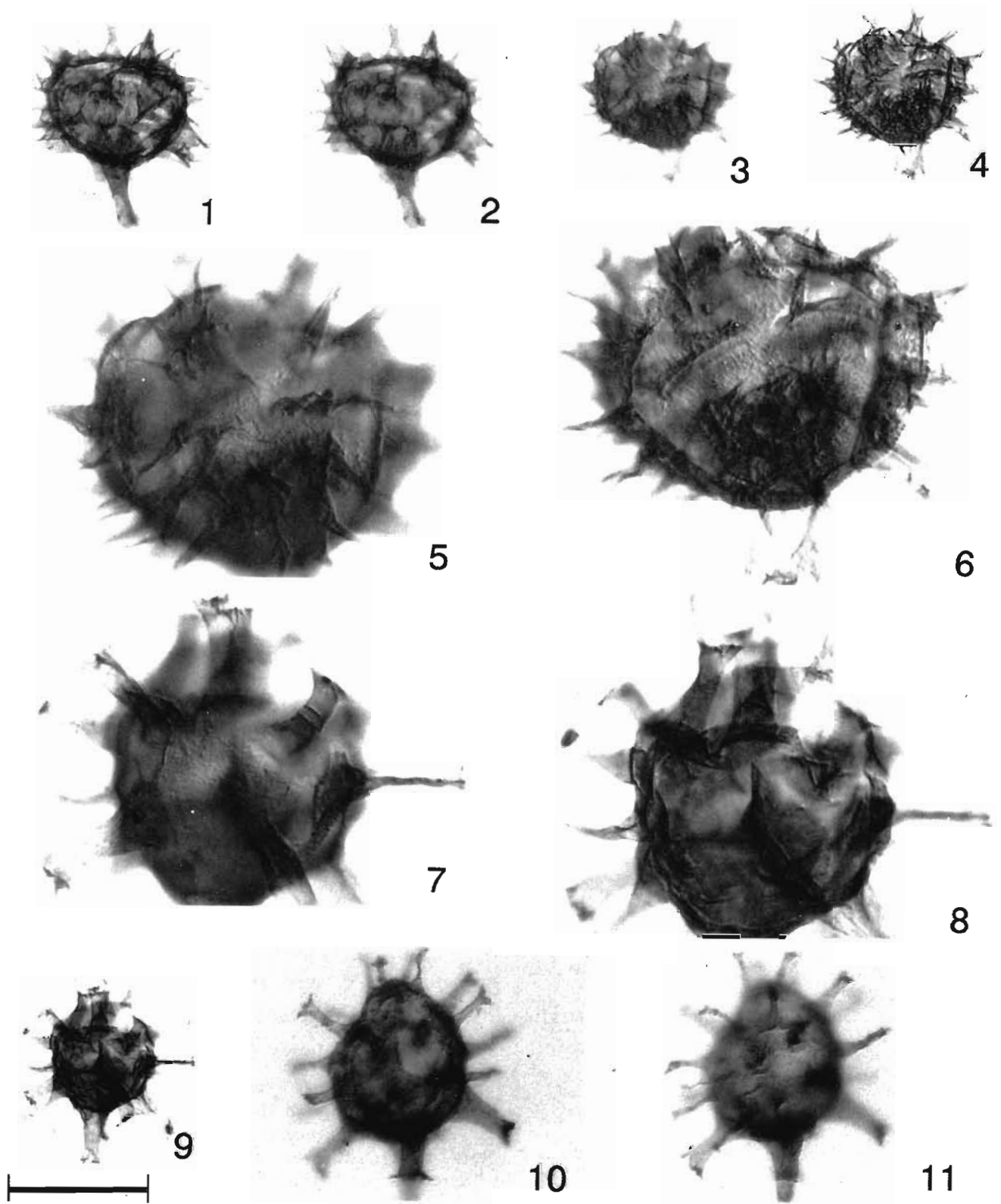


PLATE 11

Ellipsodinium rugulosum Clarke & Verdier 1967

Pl. 10, figs 1-2

1967 *Ellipsodinium rugulosum* Clarke & Verdier, p. 69; pl. 14, figs 4-6; text-fig. 29.

Measurements—Length \times breadth 35.45 \times 33.40 μm , rugulae height 1.3 μm (Clarke & Verdier, 1967); 30.46 \times 25.40 μm , rugulae height 1.5-3.5 μm (Davey, 1969); 45.48 \times 36.42 μm (Yun, 1981); 47 \times 40 μm in specimens of this study.

Previous records—Albian-Santonian. Albian-Santonian, France (Davey, 1969; Davey & Verdier, 1971; Foucher, 1971; 1972; Fouconnier, 1975, 1979; Robaszynski *et al.*, 1982); Cenomanian-Santonian, England (Clarke & Verdier, 1967; Davey, 1969); Santonian, Germany (Yun, 1981) and Northwest Territories, Canada (McIntyre, 1974).

Genus—*Exochosphaeridium* Davey *et al.* in Davey *et al.* 1966

1966 *Exochosphaeridium* Davey, Downie, Sarjeant & Williams in Davey *et al.*, p. 165.

Type species—*Exochosphaeridium phragmites* Davey, Downie, Sarjeant & Williams in Davey *et al.* 1966 (original designation).

Remarks—*Exochosphaeridium* is distinct from *Amphorosphaeridium* in having solid, less branched processes; and from *Operculodinium*, in having fibrous processes.

Exochosphaeridium cenomaniense Norvick in Norvick & Burger 1976

Pl. 10, figs 3-8

1976 *Exochosphaeridium cenomaniense* Norvick in Norvick & Burger, p. 52; pl. 4, figs 4, 8.

Measurements—Overall diameter 51.97 μm , process length up to 18 μm (Norvick & Burger, 1976); overall dimensions 62.74 \times 60.74 μm , body dimensions 52.57 \times 42.50 μm , process length 7.13 μm in specimens of this study.

Previous records—Cenomanian, Australia (Norvick & Burger, 1976).

Exochosphaeridium phragmites Davey *et al.* in Davey *et al.* 1966

Pl. 10, figs 9

1966 *Exochosphaeridium phragmites* Davey *et al.* in Davey *et al.*, p. 165; pl. 2, figs 8-10.

Size measurements—Body dimensions 36.56 \times 33.49 μm , length of processes up to 22 μm (Davey *et al.*, 1966); 32.57 \times 41.67 μm , process length 10.40

μm (Davey, 1969); body diameter 36.42 μm (Cookson & Eisenack, 1970); 48.58 μm , process length 16.22 μm (Corradini, 1973); body dimension 33.95 \times 33.75 μm and process length 10.23 μm (Srivastava, 1984); overall diameter 99 μm , body 40.52 μm , process length 31 μm in specimens of this study.

Previous records—Valanginian-Turonian. Valanginian-Turonian, Europe (Davey *et al.*, 1966; Davey, 1969, 1979b, 1982; Davey & Verdier, 1971; Corradini, 1973; Below, 1982b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Hauterivian-Albian, Morocco (Below, 1982a); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwest Africa (Below, 1984); Early Albian, India (Jain, 1977); Cenomanian, Canada (Singh, 1983).

Doubtful records—Senonian, Northern Apennines, Italy (Corradini, 1973).

Exochosphaeridium truncatum (Davey) Stover & Evitt 1978

Pl. 10, figs 10-12

1969 *Exochosphaeridium striolatum* var. *truncatum* Davey, p. 164; pl. 7, figs 1-3.

1973 *Exochosphaeridium striolatum* subsp. *truncatum* (Davey) Lentin & Williams, p. 56.

1978 *Exochosphaeridium truncatum* (Davey) Stover & Evitt, p. 154.

Measurements—Central body diameter 34.81 μm , process length 6.27 μm (Davey, 1969); overall dimensions 70 \times 65 μm , body 50 \times 40 μm , processes 14.16 μm long in specimens of this study.

Previous records—Neocomian-Cenomanian, Neocomian-Aptian, South Atlantic Ocean (Harris, 1976); Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1973; Fauconnier, 1975, 1979); Albian-Turonian, England (Davey, 1969); Cenomanian, Spain (Hengreen, 1980); Cenomanian, U.S.A. (Davey, 1969).

Genus—*Florentinia* Davey & Verdier 1973

1973 *Florentinia* Davey & Verdier, p. 185.

Type species—*Florentinia laciniata* Davey & Verdier 1973 (original designation).

Remarks—*Florentinia* consists of skolochoate cysts which have a subspherical body with precingular archeopyle and a gonyaulacacean paratabulation indicated by intratabular processes of two sizes. The narrower processes occupy paracingular and parasulcal areas whereas a large distinctive process occurs in antapical areas.

Florentinia is distinguished from *Silicisphaera*

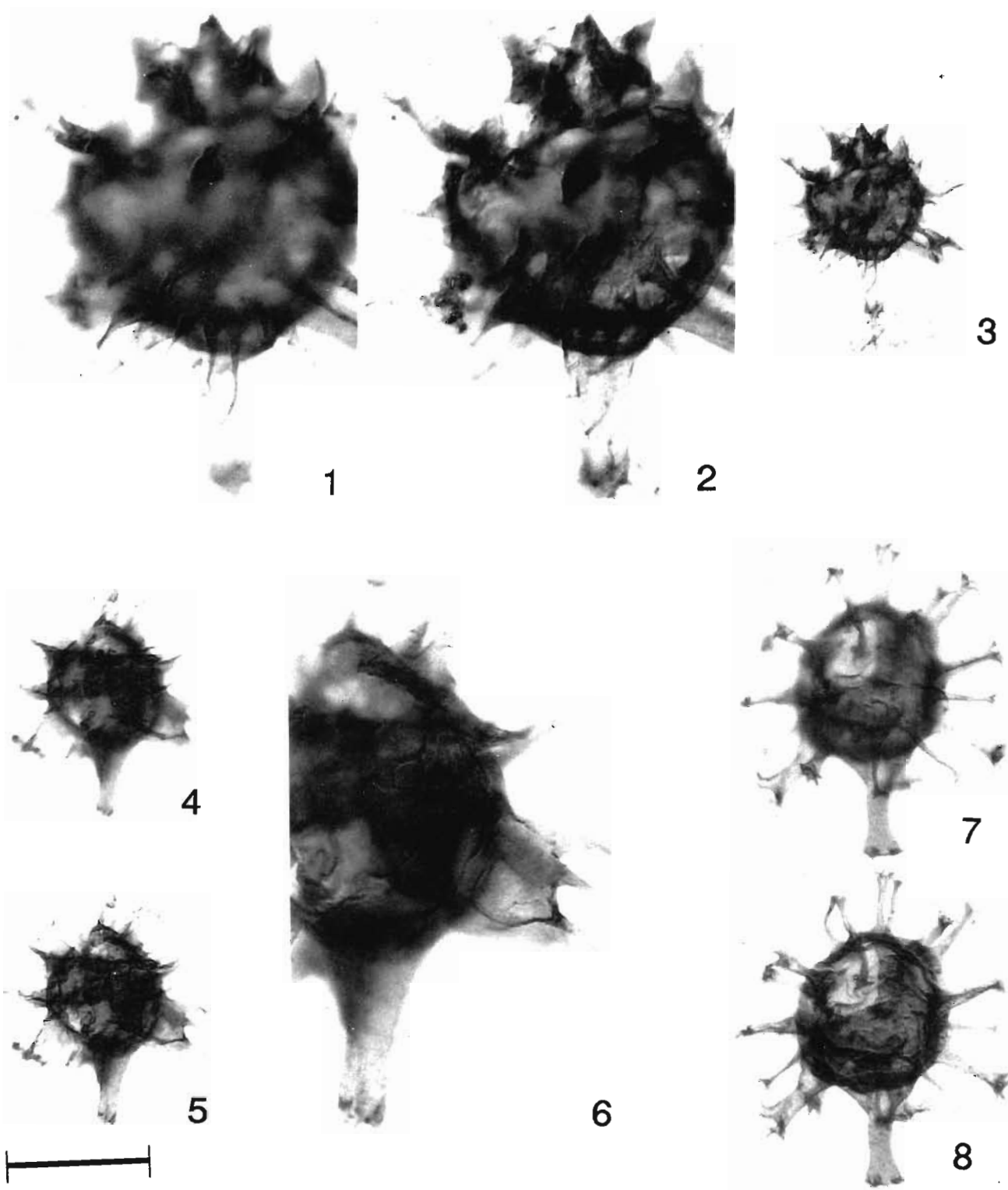


PLATE 12

1-6. *Florentinia laciniata* Davey & Verdier. 1-3, (CRC 32129-6/12 : 34.0/111.0, 84010/2, 3, $\times 100$ and 1, $\times 40$; Grayson Formation); 4-6, (CRC 32129-10/9 : 37.0/102.5, 84014/8, 9, $\times 40$ and 11, $\times 100$; Grayson Formation).

7, 8. *Florentinia mantellii* (Davey & Williams) Davey & Verdier

(CRC 32129-6/5 : 45.5/94.5, 85001/19, 20, $\times 40$; Grayson Formation).

Scale bar length = 20 μm except for figs 3-5 = 50 μm and figs 7-8 = 40 μm .

in having a distinctively large antapical process. However, considering the difficulty of making distinctions in certain gradational forms, Duxbury (1980) treated the genera *Florentinia*, *Silicisphaera* and *Achilleodinium* as synonyms. Lentini and Williams (1981) accepted *Silicisphaera* as a junior synonym of *Florentinia* but excluded *Achilleodinium* on the basis of its distinctive wall structure. Stover and Evitt (1978) considered *Florentinia*, *Silicisphaera*, and *Achilleodinium* as separate entities acknowledging that distinguishing between *Florentinia* and *Silicisphaera* may not always be possible in gradational forms.

The end species of *Florentinia* and *Silicisphaera* are quite distinct. Here the two genera are considered separately maintaining that the antapical process in *Florentinia* is characteristically different whereas *Silicisphaera* does not have any distinctive antapical process.

Florentinia clavigera (Deflandre) Davey & Verdier 1973

Pl. 11, figs 1-6

- 1937 *Hystrichosphaeridium clavigerum* Deflandre, p. 71; pl. 14, figs 1-2.
 1963 *Baltisphaeridium clavigerum* (Deflandre) Downie & Sarjeant, p. 91.
 1966 *Hystrichokolpoma clavigera* (Deflandre) Williams & Downie in Davey *et al.*, p. 181 (Nom. comb. non cit.).
 1973 *Florentinia clavigera* (Deflandre) Davey & Verdier, p. 192.

Measurements—Central body diameter 35-60 μm , process length 9-25 μm (Davey & Verdier, 1976); overall dimensions 88-104 \times 65-86 μm , body dimensions 39-75 \times 39-68 μm , process length 15-29 μm , antapical process dimensions 14-29 \times 8-23 μm in ten specimens of this study.

Previous records—Turonian. Upper Cretaceous, France (Deflandre, 1937); Turonian, France (Davey & Verdier, 1976; Robaszynski *et al.*, 1982).

Florentinia cooksoniae (C. Singh)

Duxbury 1980

Pl. 11, figs 7-11

- 1971 *Hystrichosphaeridium cooksoni* C. Singh, p. 329; pl. 51, figs 7-8; pl. 52, figs 1-4 (err. orth. pro *Cooksoniae*)
 1971 *Hystrichosphaeridium cylindratum* auct. non Morgenroth; Brideaux, p. 91; pl. 26, figs 69-70; pl. 27, fig. 74.
 1980 *Florentinia cooksoniae* (C. Singh) Duxbury, p. 120; pl. 7, figs 6, 9; text-fig. 7.

Measurements—Overall dimensions including processes 60-105 μm , central body length and breadth 36-67 \times 36-50 μm , length and breadth of processes 7-28 \times 3-20 μm (Singh, 1971); body dimensions 30-50 μm , process length 10-20 μm (Ashraf, 1979); maximum body diameter 38-66 μm , process length 16-37 μm (Yun, 1981); overall dimensions 70-112 \times 62-99 μm , body 40-60 \times 38-62 μm , process length 15-44 μm , antapical process length \times widest measurement 22-44 \times 5-26 μm in 8 specimens of this study.

Previous records—Neocomian-Santonian. Neocomian-Aptian, South Atlantic Ocean (Harris, 1976); Barremian-Cenomanian, western Canada (Singh, 1971, 1983; Brideaux, 1971, 1977); Barremian-Aptian, England (Duxbury, 1980, 1983); Lower Cretaceous, Afghanistan (Ashraf, 1979); Santonian, Germany (Yun, 1981).

Florentinia laciniata Davey & Verdier, 1973

Pl. 12, figs 1-6

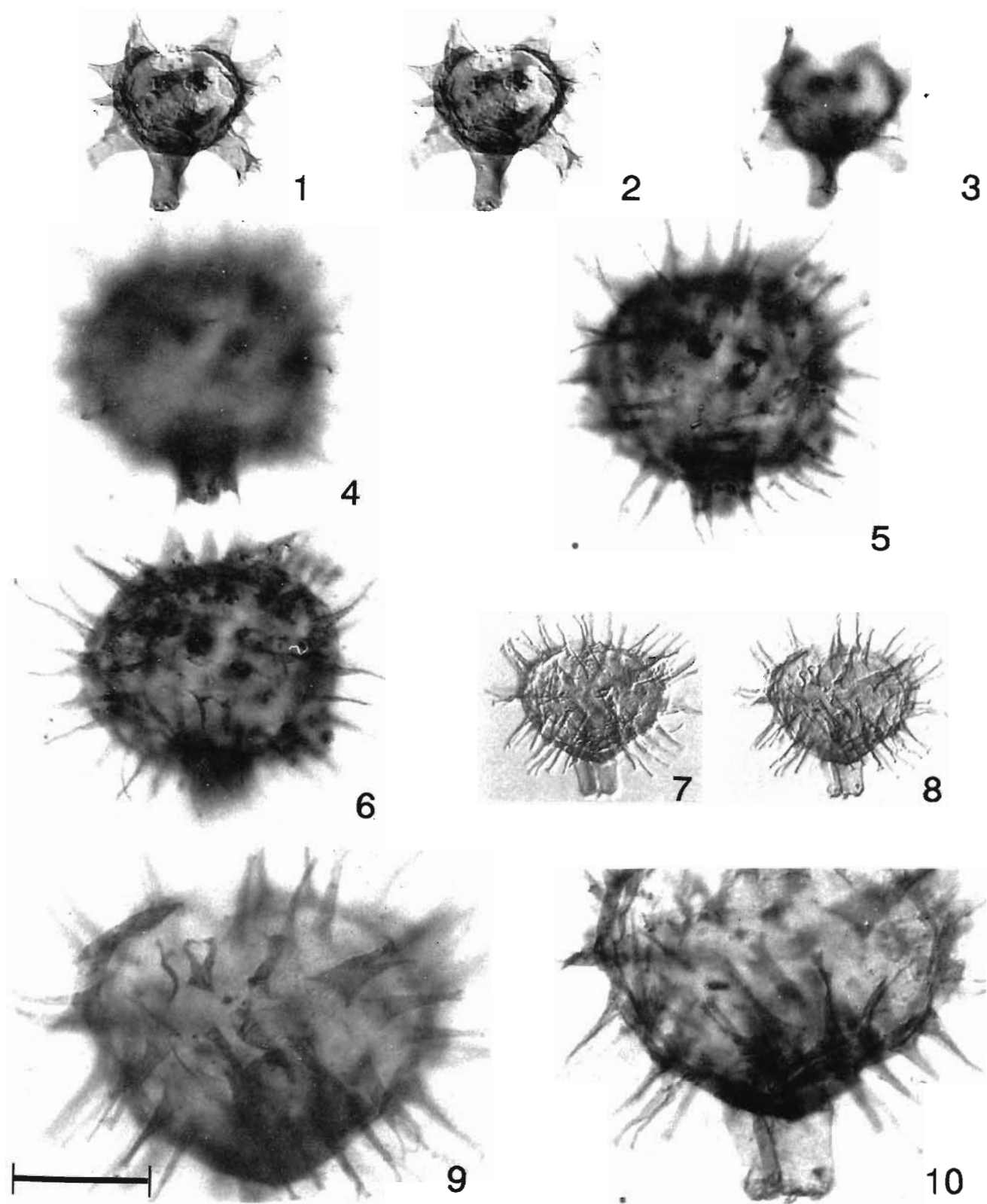
- 1973 *Florentinia laciniata* Davey & Verdier, p. 186; pl. 2, figs 1, 3-4, 6-7, 9.

Measurements—Central body diameter 36-55 μm , process length 26-49 μm (Davey & Verdier, 1973); central body diameter 35-42 μm , process length and breadth ca 24 \times 15-18 μm (Yun, 1981); overall dimensions 75-91 \times 75-91 μm , body dimensions 42-55 \times 42-55 μm , process length 20-26 μm ; antapical process length and breadth 29-34 \times 10-18 μm in five specimens of this study.

PLATE 13

- 1-3. *Florentinia mantellii* (Davey & Williams) Davey & Verdier (CRC 32129-7/2: 31.5/103.6, 84002/30, 31, 32, \times 40; Grayson Formation)
 4-10. *Florentinia radiculata* (Davey & Williams) Davey & Verdier, 4-6, (CRC 32129-6/1A: 38.0/106.0, 84005/24, 25,

26, \times 100; Grayson Formation); 7-10, (CRC 32129-6/1: 48.4/110.0, 84006/12, 13, \times 40; 14, 15, \times 100; Grayson Formation)
 Scale bar length = 20 μm except for figs 1-3 and 7-8 = 50 μm .



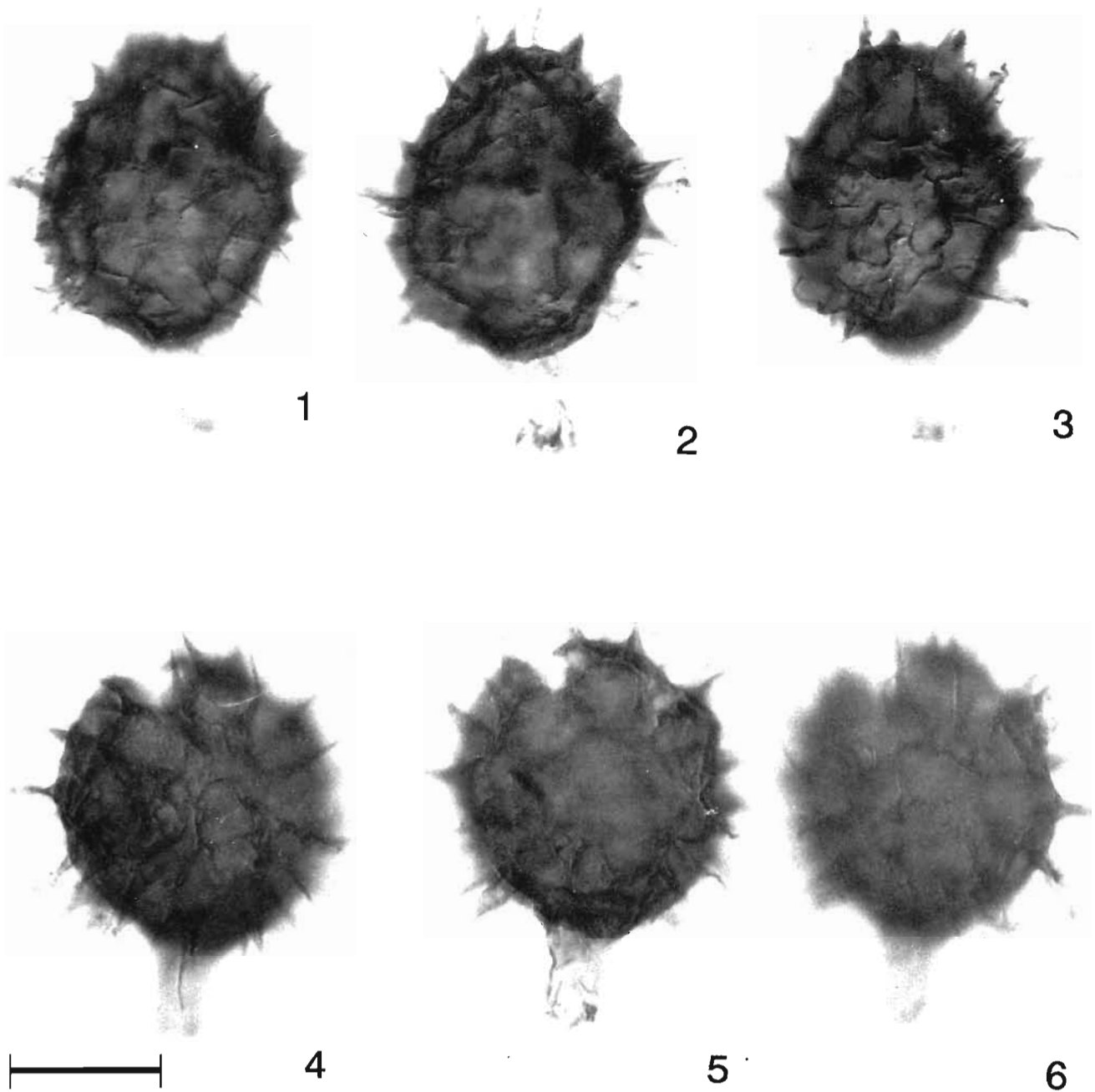


PLATE 14

1-6. *Florentinia resex* Davey & Verdier 1-3, (CRC 32129-10/9
35.0/106.4, 84014/20, 21, 22, $\times 100$; Grayson Formation);
4-6, (CRC 32129-10/8 : 19.5/106.4, 84014/28, 29, 30, $\times 100$;

Grayson Formation)
Scale bar length = 20 μm .

Previous records—Aptian-Santonian. Aptian-Santonian, Germany (Eisenack, 1958; Alberti, 1961, Yun, 1981); Albian-Cenomanian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1969); Albian-Turonian, France (Davey & Verdier,

1973, 1976; Fauconnier, 1975, 1979); Albian, western Canada (Singh, 1971), Albian-Cenomanian, Australia (Cookson & Eisenack, 1962, 1968; Norvick & Burger, 1976; Morgan, 1980).

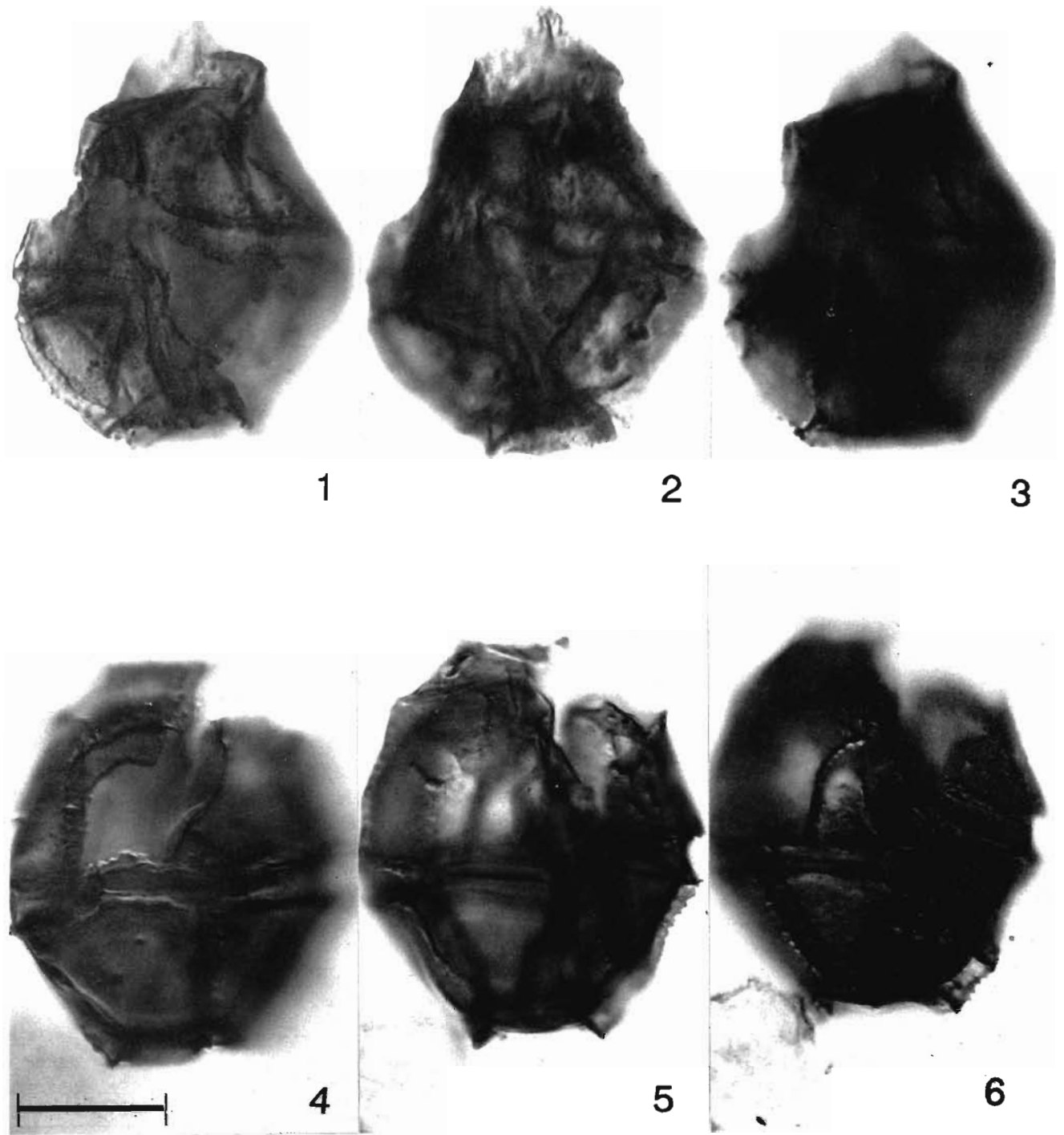


PLATE 15

1-6. *Gonyaulacysta cassidata* (Eisenack & Cookson) Sarjeant. 1-3, (CRC 32129-3/1 : 38.5/97.5, 84003/8, 9, 10, $\times 100$; Grayson Formation); 4-6, (CRC 32129-6/12 : 22.8/110.0, 84009/30, 31, 32, $\times 100$; Grayson Formation). Scale bar length = 20 μm .

Florentinia mantellii (Davey & Williams)
Davey & Verdier 1973

Pl. 12, figs 7-8; Pl. 13, figs 1-3

1966 *Hystrichosphaeridium mantelli* Davey & Williams in Davey *et al.*, p. 66; pl. 6, fig. 6 (err. orth. pro *mantellii*)

1973 *Florentinia mantelli* (Davey & Williams in Davey *et al.*) Davey & Verdier, p. 187; pl. 1, figs 1, 4, 7; pl. 4, figs 1, 3 (err. orth. pro *mantellii*).

Measurements—Central body diameter 36-45 μm , length of processes 13-26 μm (Davey & Williams in Davey *et al.*, 1966); central body diameter 35-47 μm , length of processes 15-19 μm (Yun, 1981); overall dimensions 78.91 \times 78.99 μm , body 30.47 \times 30.47 μm , process length 21.31 μm , antapical process 26.36 \times 16.21 μm in five specimens of this study.

Previous records—Barremian-Santonian. Barremian-Turonian, England (Davey & Williams in Davey *et al.*, 1966; Davey, 1969, 1974); Late Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1973); Santonian, Germany (Yun, 1981); Late Albian-Cenomanian, Morocco (Below, 1982); Early Albian, Indian (Jain, 1977); Albian-Cenomanian, Australia (Cookson & Eisenack, 1962, 1968; Norvick & Burger, 1976); Albian, Alberta, Canada (Brideaux, 1971; Singh, 1971).

Florentinia radiculata (Davey & Williams in Davey *et al.*) Davey & Verdier 1973

Pl. 13, figs 4-10

1966 *Hystrichosphaeridium radiculatum* Davey & Williams in Davey *et al.*, p. 65; pl. 7, fig. 8; pl. 9, fig. 6.

1973 *Florentinia radiculata* (Davey & Williams in Davey *et al.*) Davey & Verdier, p. 191; pl. 4, fig. 7.

Measurements—Diameter of the central body 31-37 μm , length of processes 11-17 μm (Davey &

Williams in Davey *et al.*, 1966; Davey & Verdier, 1976); overall diameter 55-83 μm , body diameter 38-45 μm , process length 11-16 μm , antapical process length and breadth 15.21 \times 10.20 μm in five specimens of this study.

Previous records—Hauterivian-Cenomanian. Hauterivian-Albian, Morocco (Below, 1982); Aptian-Albian, offshore northwestern Africa (Williams, 1978); Albian, Bay of Biscay (Davey, 1979); Albian-Cenomanian, France (Davey & Verdier, 1971, 1973; Foucher & Taugourdeau, 1975; Fauconnier, 1979; Foucher, 1979); Cenomanian, England (Davey & Williams in Davey *et al.*, 1966; Davey, 1969); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Florentinia resex Davey & Verdier 1976

Pl. 14, figs 1-6

1976 *Florentinia resex* Davey & Verdier, p. 319; pl. 4, figs 1-3; text-fig. 2.

Measurements—Central body diameter 38-51 μm , length of processes 7-23 μm (Davey & Verdier, 1976); overall dimensions 43-53 μm , body 36 \times 32-36 μm ; length and width of processes 6-11 \times 3-5 μm (Singh, 1983); overall dimensions 53-78 \times 50-78 μm , body dimensions 32-57 \times 30-52 μm , process length 13-16 μm , antapical process dimensions 16-18 \times 8-12 μm in 10 specimens of this study.

Previous records—Aptian-Maastrichtian. Aptian-Cenomanian, Morocco (Below, 1982a); Late Albian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Turonian, France (Davey & Verdier, 1976); Turonian-Maastrichtian, offshore southwestern Africa (Davey, 1978); Cenomanian, Alberta, Canada (Singh, 1983).

Genus—*Gonyaulacysta* Deflandre emend. Stover & Evitt 1978

1964 *Gonyaulacysta* Deflandre, p. 5030.

1978 *Gonyaulacysta* Deflandre emend. Stover & Evitt, p. 157.

Type species—*Gonyaulacysta jurassica*

PLATE 16

- 1-4. *Hystrichodinium oligacanthum* Deflandre & Cookson (CRC 32131-7/1 : 25.2/107.5, 84016/13, 14, \times 40; 15, 16, \times 100; Arcadia Park Member of the Eagle Ford Formation).
5. *Hystrichodinium pulchrum* Deflandre (CRC 32130-2/1 : 18.5/106.0; 84015/22, \times 40; middle Britton Member of the Eagle Ford Formation).
6,7. *Hystrichosphaeridium tubiferum* subsp. *brevispinum* (Davey & Williams) Lentini & Williams (CRC 32131-7/1A : 38.0/

108.0, 84017/34, 35, \times 40; Arcadia Park Member of the Eagle Ford Formation).

8,9. *Kallosphaeridium norvickii* (Burger) Lentini & Williams (CRC 32129-7/2 : 43.5/97.5, 84002/13, 14, \times 100; Grayson Formation).

Scale bar length = 20 μm except for figs 1-2 and 5-7 = 50 μm .

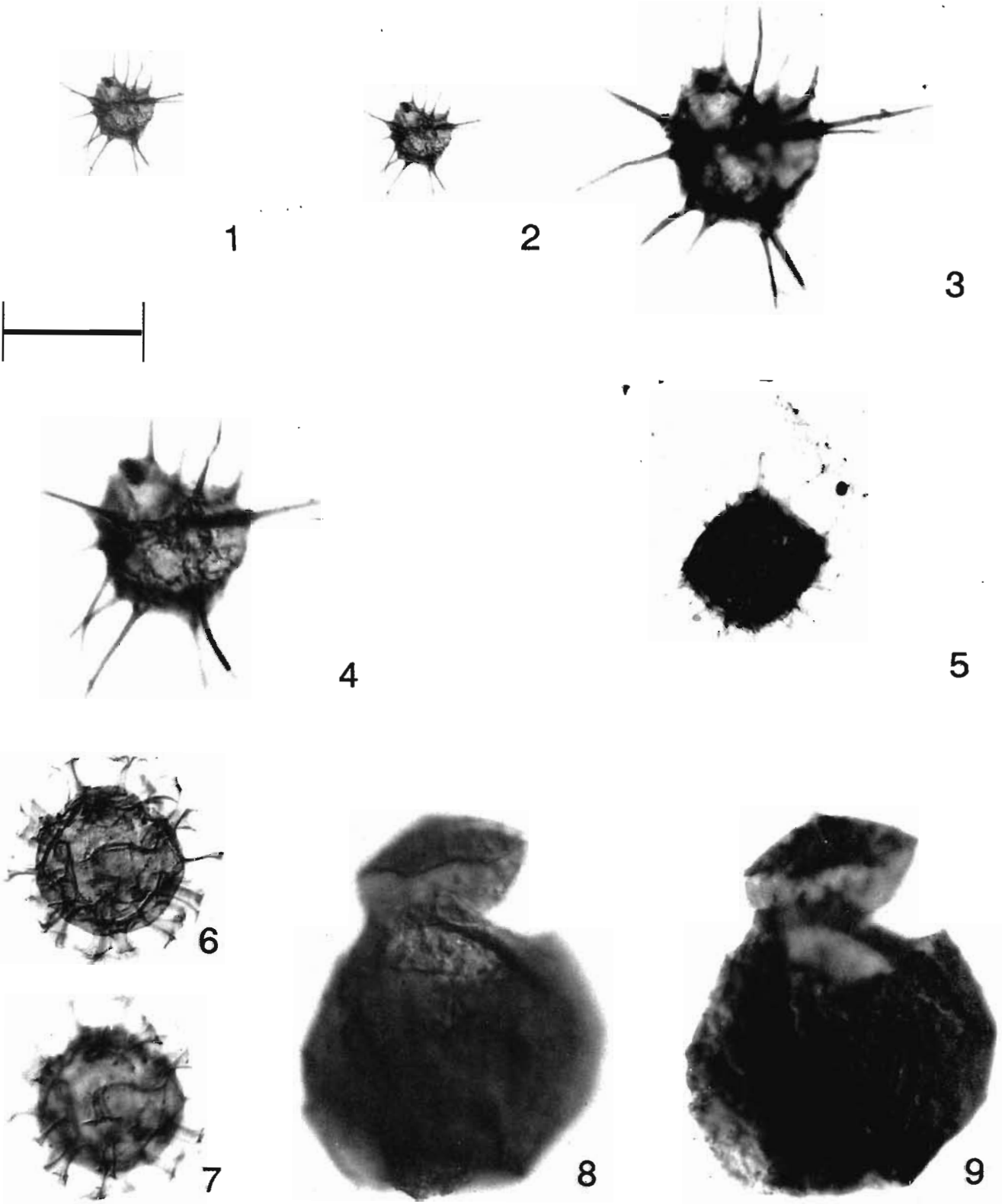


PLATE 16

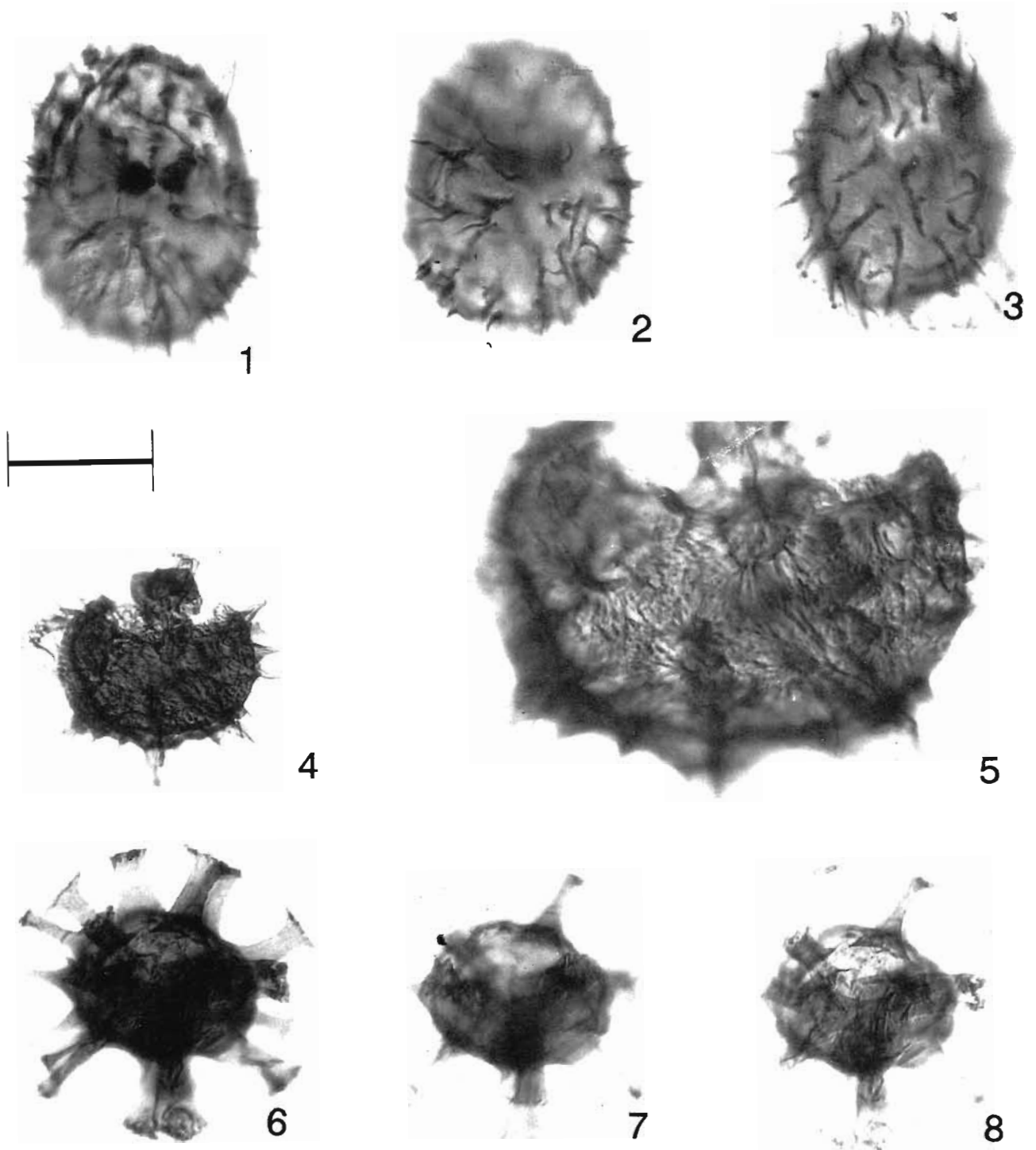


PLATE 17

1-3. *Kiokansium unituberculatum* (Tasch) Stover & Evitt. 1-2. (CRC 32129-7/1 : 38.0/111.0, 84011/12, 13, $\times 100$; Grayson Formation); 3, (CRC 32129-7/1 : 20.2/100.5, 84010/28, $\times 100$; Grayson Formation).
 4, 5. *Kleitbriasphaeridium fasciatum* (Davey & Williams) Davey (CRC 32131-10/2 : 43.0/103.2, 84022 33, $\times 40$; 34, $\times 100$;

Austin Chalk).
 6-8. *Kleitbriasphaeridium loffreense* Davey & Verdier (CRC 32131 7/12 : 32.0/98.4, 84024 26, 27, 28, $\times 40$; Arcadia Park Member of the Eagle Ford Formation).
 Scale bar length = 20 μm except for figs 4 and 6-8 = 50 μm .

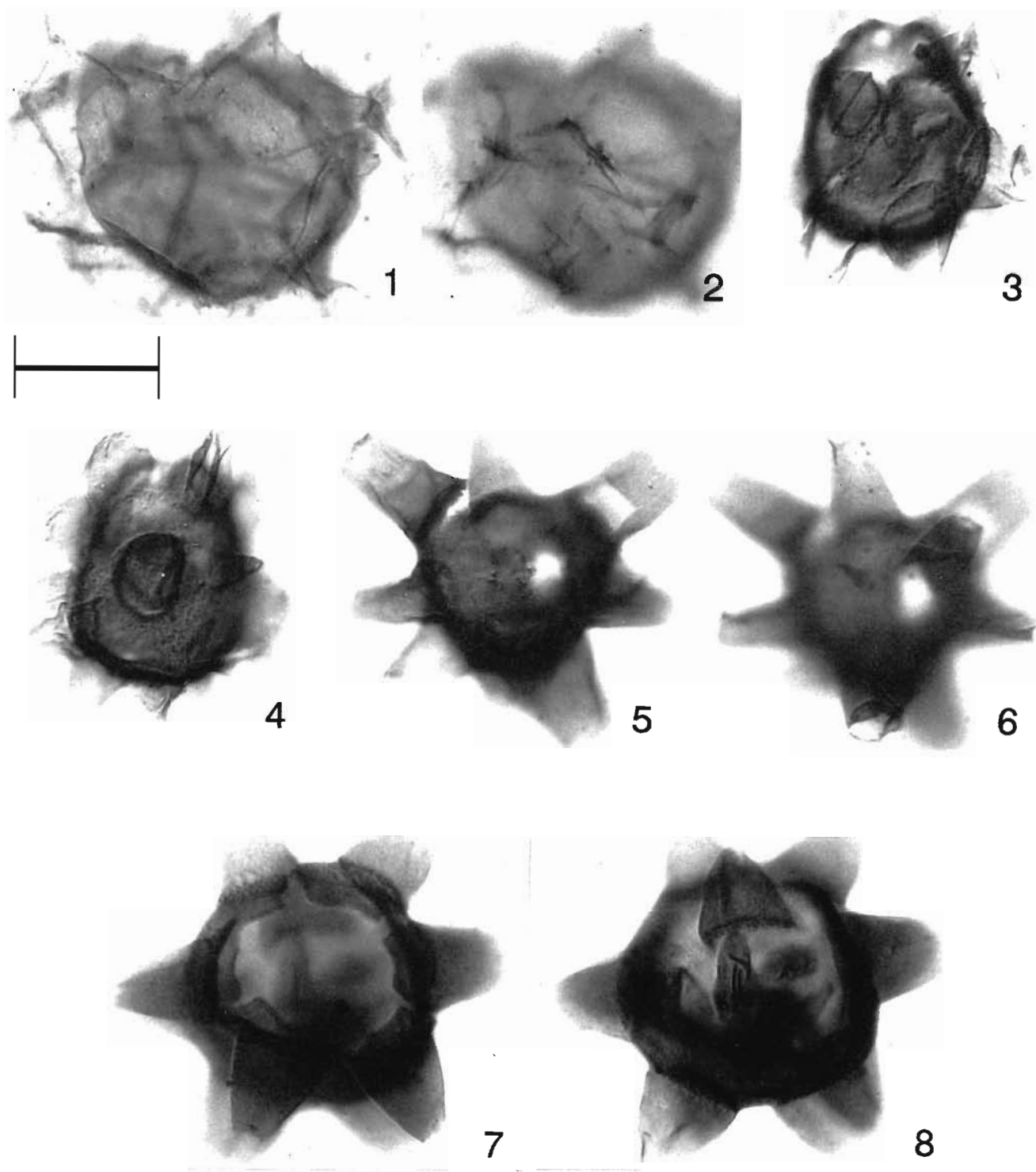


PLATE 18

1, 2. *Leberidocysta cblamydata* (Cookson & Eisenack) Stover & Eviitt (CRC 32129-10/1 : 24.5/111.2, 84013/20, 22, $\times 100$; Grayson Formation).
 3-8. *Litospaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams. 3-4, (CRC 32129-7/1 : 29.4/103.0, 84001/

8, 9, $\times 100$; Grayson Formation); 5-6, (CRC-32129-7/1 : 42.5/98.2, 84010/18, 20, $\times 100$; Grayson Formation); 7-8, (CRC 32129-8/5 : 27.0/95.0, 84011/18, 19, $\times 100$; Grayson Formation).
 Scale bar length = 20 μm .

(Deflandre) Norris & Sarjeant 1965 = *G. jurassica* (Deflandre) Deflandre 1964 (invalid) = *Gonyaulax jurassica* Deflandre 1938 (original designation).

Remarks—*Gonyaulacysta* is distinct from *Rhynchodiniopsis* in being cavate and lacking well-developed spinules at parasutural intersections.

Gonyaulacysta cassidata (Eisenack & Cookson)
Sarjeant 1966

Pl. 15, figs 1-6

1960 *Gonyaulax helicoidea* subsp. *cassidata*
Eisenack & Cookson, p. 3, pl. 1, figs 5-6.

1962 *Gonyaulax cassidata* Eisenack & Cookson—
Cookson & Eisenack, p. 486; pl. 2, figs 1-2
(err. cit. pro n. rank).

1966 *Gonyaulax cassidata* (Eisenack & Cookson)
Sarjeant in Davey *et al.*, p. 125; pl. 14, figs 3-4;
text-fig. 31.

Measurements—Overall dimensions 71.95 × 47.57 μm (Eisenack & Cookson, 1960); 60.78 × 46.53 μm (Sarjeant in Davey *et al.*, 1966); 59.78 × 40.60 μm (Davey, 1969a); 65.70 × 49.57 μm (Duxbury, 1977); 54.62 × 40.50 μm in specimens of this study.

Previous records—Hauterivian-Santonian. Aptian-Turonian range (Millioud *et al.*, 1975); Hauterivian-Cenomanian, England (Cookson & Hughes, 1964; Sarjeant in Davey *et al.*, 1966; Clarke & Verdier, 1967; Davey, 1969a; Duxbury, 1977, 1980, 1983); Barremian, USSR (Vozzhennikova, 1967); Aptian, Leg 11, Site 105, offshore Atlantic Ocean (Habib, 1972); Aptian-Cenomanian, Australia (Eisenack & Cookson, 1960; Cookson & Eisenack, 1962, 1968, 1982; Norvick & Burger, 1976; Morgan, 1980); Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1971; Foucher & Taugourdeau, 1975); Albian, Romania (Baltes 1967a, 1967b); Albian, Alberta, Canada (Singh, 1971); Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Cenomanian, Morocco (Below, 1981a); Santonian, Germany (Yun, 1981).

Genus—*Hystrichodinium* Deflandre emend. Clarke & Verdier 1967

1935 *Hystrichodinium* Deflandre, p. 229.

1961 *Heliodinium* Alberti, p. 33.

1967 *Hystrichodinium* Deflandre emend. Clarke & Verdier, p. 37.

Type species—*Hystrichodinium pulchrum* Deflandre 1935 (monotypic).

Remarks—*Hystrichodinium* differs from *Xiphoboridium* in having a precingular archeopyle; from *Hystrichogonyaulax* in lacking paraplates; and from *Exochosphaeridium* and *Operculodinium* in having a paracingulum.

Hystrichodinium oligacanthum Deflandre & Cookson 1955

Pl. 16, figs 1-4

1955 *Hystrichodinium oligacanthum* Deflandre & Cookson, p. 255; pl. 1, fig. 1; text-figs 2-3.

Measurements—Overall length 106-117 μm, body length × breadth 43-47 × 40-42 μm, process length 35-44 μm (Deflandre & Cookson, 1955); overall 65 × 60 μm, body 23 × 23 μm, process length 31 μm in one specimen of this study.

Previous records—Valanginian-Albian. Valanginian-Albian, Australia (Deflandre & Cookson, 1955; Burger, 1982).

Hystrichodinium pulchrum Deflandre 1935

Pl. 16, fig. 5

1935 *Hystrichodinium pulchrum* Deflandre, p. 229; pl. 5, fig. 1; text-figs 9-11.

Measurements—Overall dimensions 110-125 μm, body 45-55 μm, process length 42-48 μm (Deflandre, 1935); overall 60-120 × 55-110 μm (Alberti, 1961); body 57-62 × 50-52 μm, process length 25-40 μm (Górka, 1963); body 50 μm, process length 30 μm (Michael, 1964); body 38-42 μm, process length 33 μm (Serpagli, 1964); body 40-55 × 35-50 μm, process length 20-40 μm (Foucher, 1972); overall 102-155 × 80-101 μm, body 55 × 35 μm (Sarjeant in Davey *et al.*, 1966); body 40-66 × 35-55 μm, process length 20-34 μm (Duxbury, 1977); overall 50-93 × 31-89 μm, body 35-52 × 31-45 μm, process length 25-31 μm (Srivastava, 1984); overall dimensions 99 × 91 μm, body 55 × 55 μm, process length up to 26 μm in specimens of this study.

PLATE 19

- 1, 2. *Nummus monoculatus* Morgan (CRC 32129-6/12 : 26.5/102.1, 84007/11, 12, × 100; Grayson Formation).
3-6. *Odontochitina costata* Alberti emend. Clarke & Verdier. 3-4, (CRC 32101-1/S2 : 33.0/108.0, 850315/9, × 25; 10, × 40; Britton Member of the Eagle Ford Formation); 5-6, (CRC 32101-1/S1 : 41.0/106.2, 850315/7 × 25; 8, × 40; Britton

Member of the Eagle Ford Formation).

- 7 *Odontochitina operculata* (O. Wetzel) Deflandre in Deflandre & Cookson (CRC 32129-6/12 : 23.5/112.0, 84007/13, × 40; Grayson Formation).
Scale bar length = 20 μm except for figs 3 and 5 = 80 μm and for figs 4, 6 and 7 = 50 μm.

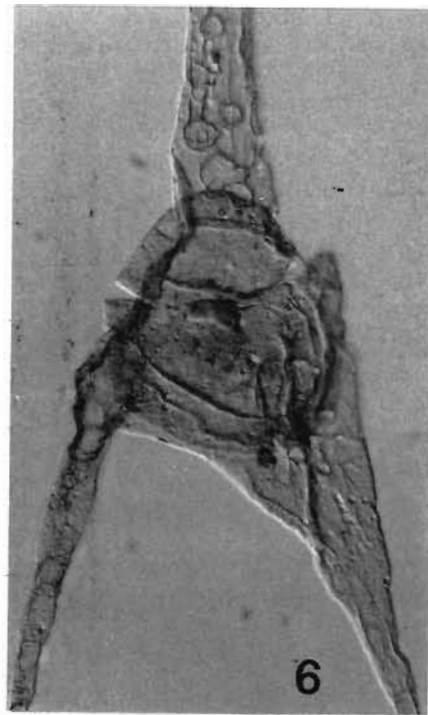
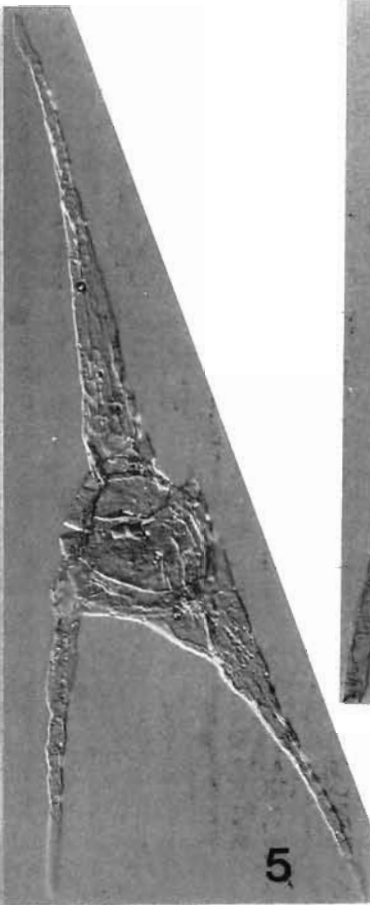
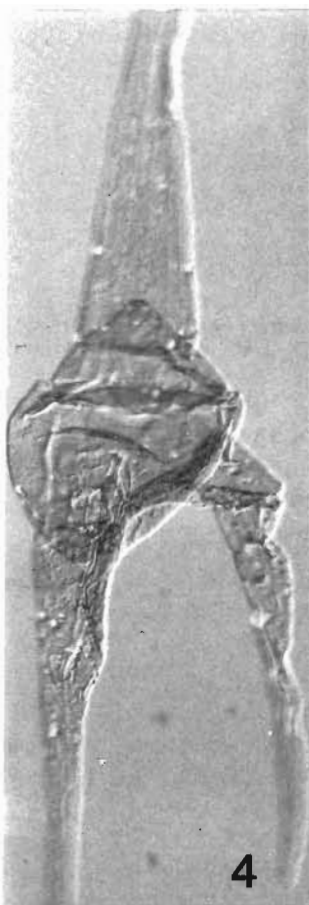
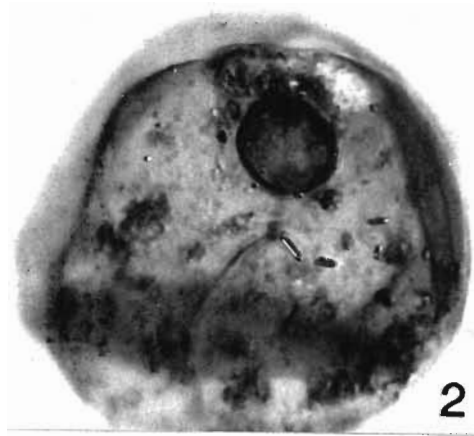
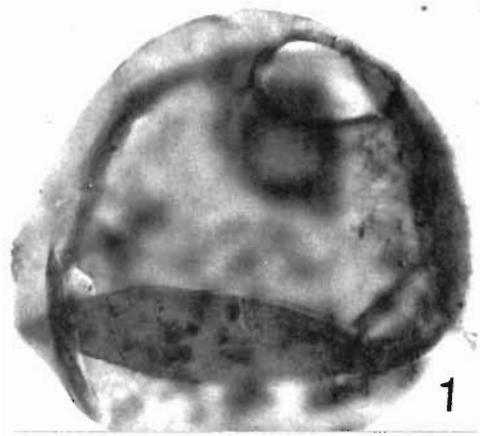


PLATE 19

Previous records—Portlandian-Maastrichtian. Portlandian-Hauterivian, offshore Denmark (Davey, 1982); Berriasian-Early Albian, England (Davey, 1974; Duxbury, 1977, 1983); Valanginian, northwestern Germany (Below, 1981b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Upper Barremian and Upper Aptian, northern Germany (Below, 1982b); Upper Cretaceous, Isle of Wight, England (Clarke & Verdier, 1967); Hauterivian-Maastrichtian, Europe (Alberti, 1961; Górka, 1963; Michael, 1964; Serpagli, 1964; Foucher, 1972; Davey & Verdier, 1971; Corradini, 1973; Kjellström, 1973); Early Albian, India (Jain, 1977); and Aptian-Albian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Genus—*Hystrichosphaeridium* Deflandre restr. Eisenack 1958

1937 *Hystrichosphaeridium* Deflandre, p. 68.

1958 *Hystrichosphaeridium* Deflandre restr. Eisenack, p. 399.

Type species—*Hystrichosphaeridium tubiferum* (Ehrenberg) Deflandre 1937 = *Xanthidium tubiferum* Ehrenberg 1838 (original designation).

Remarks—*Hystrichosphaeridium* differs from *Oligosphaeridium* in having processes in paracingular area; and from *Areosphaeridium*, *Cleistosphaeridium*, and *Surculosphaeridium* in having tubular processes.

Hystrichosphaeridium tubiferum subsp. *brevispinum* (Davey & Williams) Lentin & Williams 1973

Pl. 16, figs 6-7

1966 *Hystrichosphaeridium tubiferum* var. *brevispinum* Davey & Williams in Davey *et al.*, p. 58; pl. 10, fig. 10.

1973 *Hystrichosphaeridium tubiferum* subsp. *brevispinum* (Davey & Williams) Lentin & Williams, p. 80.

Measurements—Diameter of central body 31-53 μm , length of processes 6-11 μm , width of processes up to 13 μm (Davey & Williams in Davey *et al.*, 1966); diameter of central body 25-35 μm , length of processes 5-6 μm , width of processes up to 5-6 μm

(Srivastava, 1984); overall diameter 78 μm , body 55 μm , process length 18 μm in one specimen of this study.

Previous records—Barremian-Eocene. Barremian, France (Srivastava, 1984); ?Lower Cretaceous, Spitsbergen (Bjaerke, Edwards & Thusu, 1976; Bjaerke & Thusu, 1976); Turonian, France (Foucher, 1974); Campanian, western Canada (Harland, 1973); Paleocene, France (Gruas-Cavagnetto, 1972); southern Sweden (de Coninck, 1975); Eocene, England (Davey & Williams in Davey *et al.*, 1966).

Genus—*Kallosphaeridium* de Coninck 1969

1969 *Kallosphaeridium* de Coninck, p. 44.

Type species—*Kallosphaeridium brevibarbatum* de Coninck, 1969 (original designation).

Remarks—*Kallosphaeridium* has an apical archeopyle. It differs from *Batiacasphaera* in having an attached operculum.

Kallosphaeridium norvickii (Burger) Lentin & Williams 1981

Pl. 16, figs 8-9

1980 *Membranosphaera norvickii* Burger, p. 73; pl. 26, figs 7-8.

1981 *Kallosphaeridium norvickii* (Burger) Lentin & Williams, p. 161.

Measurements—Length \times breadth 54.67 \times 53.84 μm (Burger, 1980); 38.96 \times 43.98 μm (Srivastava, 1984); 55 \times 43 μm in specimens of this study.

Previous records—Barremian-Albian. Barremian, France (Srivastava, 1984); Albian, Australia (Burger, 1980).

Genus—*Kiokansium* Stover & Evitt 1978

1978 *Kiokansium* Stover & Evitt, p. 167.

Type species—*Kiokansium unituberculatum* (Tasch in Tasch *et al.*) Stover & Evitt 1978 = *Hystrichosphaeridium unituberculatum* Tasch in Tasch, McClure & Oftedahl, 1964 (original designation).

Remarks—The genus *Kiokansium* includes skolochorate cysts having an ellipsoidal body,

PLATE 20

1, 2. *Oligosphaeridium complexum* (White) Davey & Williams (CRC 32129-6/1A 44.0/101.5, 84005/9, \times 54; 10, \times 100; Grayson Formation).
3-7. *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams. 3-4. (CRC 32129-6/1 40.2/112.0, 84007/

6, 7, \times 54; Grayson Formation); 5-7. (CRC 32129-6/12 : 30.5/109.5, 84009/24, \times 40; 6, 7, \times 100; Grayson Formation). Scale bar length = 20 μm except for figs 1, 3 and 4 = 35 μm and fig. 5 = 50 μm .

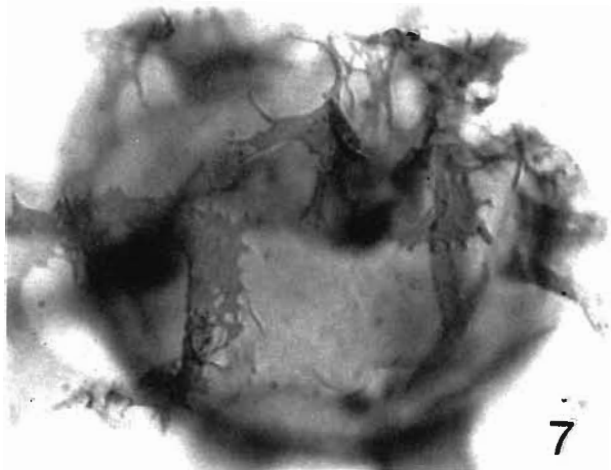
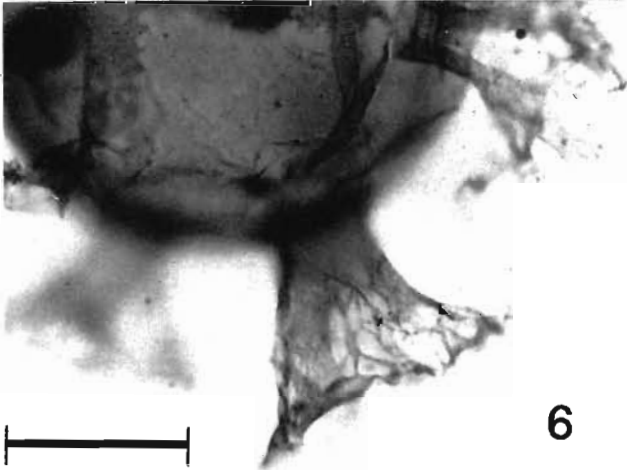
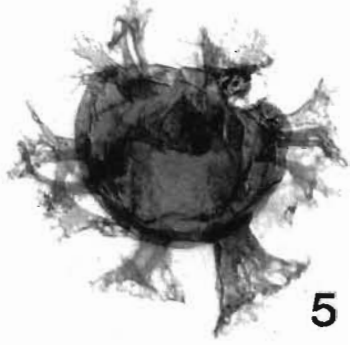
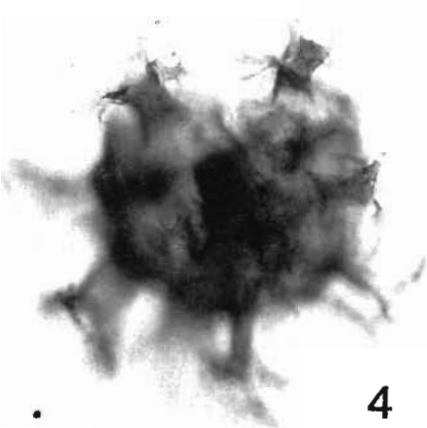
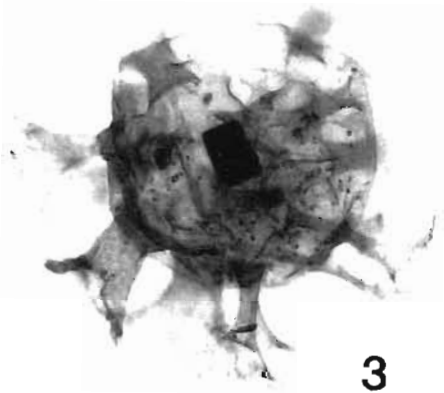
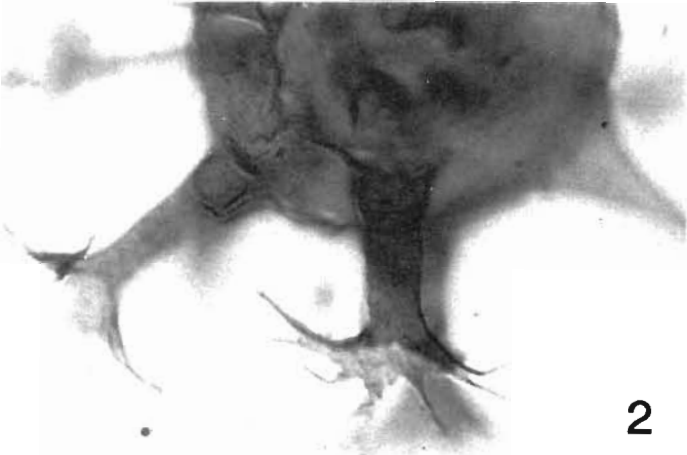
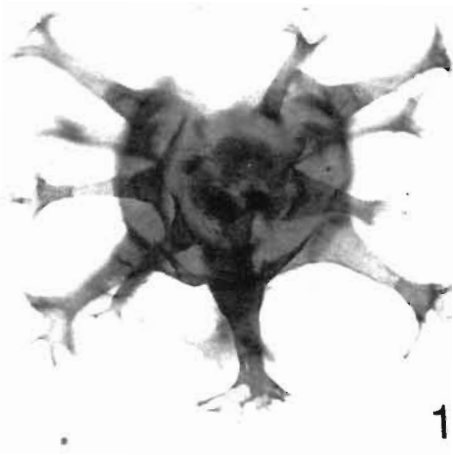


PLATE 20

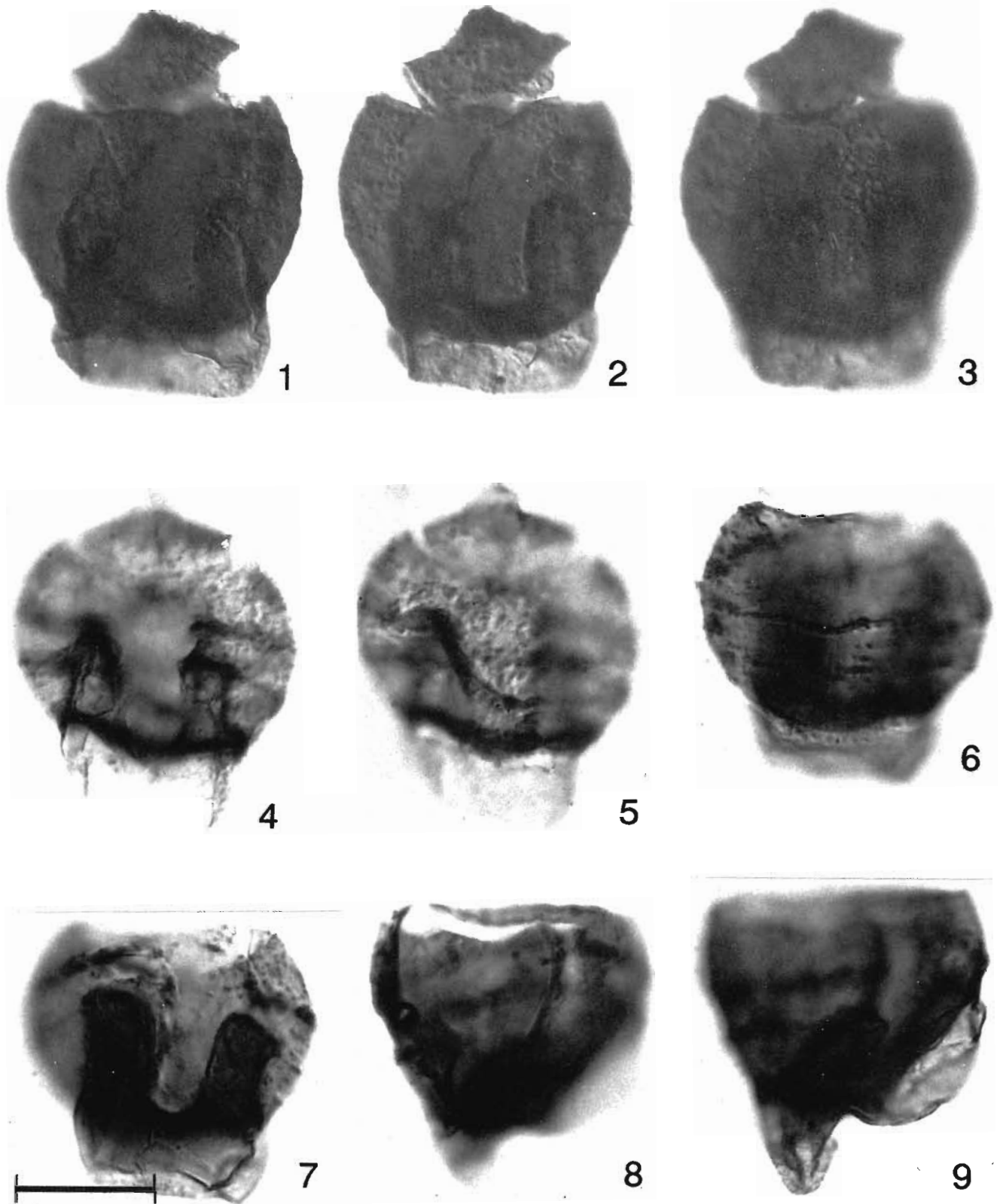


PLATE 21

1-9. *Ovoidinium verrucosum* (Cookson & Hughes) Davey. 1-3, (CRC 32129-4/1 : 19.9/106.0, 84004/6. 7, 8, $\times 100$; Grayson Formation); 4-5, (CRC 32129-6/1 : 49.0/102.0, 84004/32, 33, $\times 100$; Grayson Formation); 6-7, (CRC 32129-6/1A : 16.6/

109.0, 84005/32, 33, $\times 100$; Grayson Formation); 8-9, (CRC 32129-6/1A : 42.5/109.0, 84005/35, 36, $\times 100$; Grayson Formation).
Scale bar length = 20 μm .

precingular archeopyle and numerous nontabular solid processes with acuminate or simply branched tips. It differs from *Exochosphaeridium* and *Operculodinium* in having Type 2P archeopyle. It is distinct from *Exochosphaeridium* in having smooth processes and lacking distinctive apical horn.

Kiokansium unituberculatum (Tasch in Tasch *et al.*) Stover & Evitt 1978

Pl. 17, figs 1-3

Synonyms—See Stover and Evitt (1978, p. 267) also.

- 1964 *Hystrichosphaeridium unituberculatum* Tasch in Tasch *et al.*, p. 194; pl. 3, fig. 8.
 1964 *Hystrichosphaeridium fabium* Tasch in Tasch *et al.*, p. 195; pl. 2, fig. 5.
 1964 *Hystrichosphaeridium follium* Tasch in Tasch *et al.*, p. 195; pl. 1, fig. 8.
 1964 *Hystrichosphaeridium marsupium* Tasch in Tasch *et al.*, p. 193; pl. 3, fig. 16.
 1964 *Hystrichosphaeridium perovatum* Tasch in Tasch *et al.*, p. 194; pl. 3, fig. 13.
 1964 *Hystrichosphaeridium tribrachiosum* Tasch in Tasch *et al.*, p. 195; pl. 1, fig. 3.
 1969 (?) *Polysphaeridium fabium* (Tasch) Davey & Williams in Davey *et al.*, p. 6.
 1969 (?) *Polysphaeridium follium* (Tasch) Davey & Williams in Davey *et al.*, p. 6.
 1969 (?) *Polysphaeridium marsupium* (Tasch) Davey & Williams in Davey *et al.*, p. 6.
 1969 (?) *Polysphaeridium perovatum* (Tasch) Davey & Williams in Davey *et al.*, p. 6.
 1969 (?) *Polysphaeridium tribrachiosum* (Tasch) Davey & Williams in Davey *et al.*, p. 7.

Measurements—Body length and width 51-76 × 38-57, process length 10-20 μm (Stover & Evitt, 1978); overall length and breadth 48-54 × 33-40 μm, body 35-42 × 29-32 μm, process length up to 10 μm in specimens of this study.

Previous records—Albian. Albian, Kansas, USA (Tasch *et al.*, 1964).

Genus—*Kleithriasphaeridium* Davey 1974

1974 *Kleithriasphaeridium* Davey, p. 55.

Type species—*Kleithriasphaeridium corrugatum* Davey 1974 (original designation).

Remarks—The genus *Kleithriasphaeridium* includes skolochorate, acavate cysts with subspherical body bearing 20-27 hollow, intratabular nonfibrous processes and a precingular archeopyle. It has a gonyaulacacean paratabulation.

Kleithriasphaeridium is distinct from *Cardosphaeridium* in having nonfibrous processes which may be connected proximally by low septa; and it is distinct from *Hystrichosphaeridium* in having a precingular archeopyle.

Kleithriasphaeridium fasciatum (Davey & Williams) Davey 1974

Pl. 17, figs 4-5

- 1966 (?) *Cardosphaeridium fasciatum* Davey & Williams in Davey *et al.*, p. 90; pl. 7, figs 5-6.
 1974 *Kleithriasphaeridium fasciatum* (Davey & Williams) Davey, p. 58.

Measurements—Body diameter 35-47 μm, process length 12-25 μm (Davey & Williams in Davey *et al.*, 1966); body size 36-50 × 40-52 μm, process length 14-25 μm (Duxbury, 1977); body diameter 57-99 μm, process length 16-26 μm in specimens of this study.

Previous records—Barremian. Barremian, England (Davey & Williams in Davey *et al.*, 1966; Duxbury, 1977, 1980), and France (de Renéville & Raynaud, 1981).

Kleithriasphaeridium loffrense Davey & Verdier 1976

Pl. 17, figs 6-8

- 1976 *Kleithriasphaeridium loffrensis* Davey & Verdier, p. 310; pl. 1, figs 1-6 (err. orth. pro *loffrense*).

PLATE 22

- 1-6. *Palaeohystrichophora infusorioides* Deflandre. 1-2, (CRC 32131-10/2 46.4/107.0, 84023/1, 2, × 100; Austin Chalk); 3-4, (CRC 32131-10/2 : 14.0/109.4, 84023/6, 7, × 100; Austin Chalk); 5-6, (CRC 32131-10/2 21.8/111.0, 84023/8, 9, × 100; Austin Chalk).
 7, 8. *Palaeoperidinium cretaceum* Pocock ex Davey (CRC 32129-6/12 : 47.5/94.0, 84007/16, × 40; 17, × 100; Grayson Formation).
 9, 10. *Palaeostomocystis fragilis* Cookson & Eisenack (CRC 32131-7/12 : 25.6/107.2, 84024/29, 30, × 40; Arcadia Park member of the Eagle Ford Formation).
 Scale bar length = 20 μm except for figs 7, 9 and 10 = 50 μm.

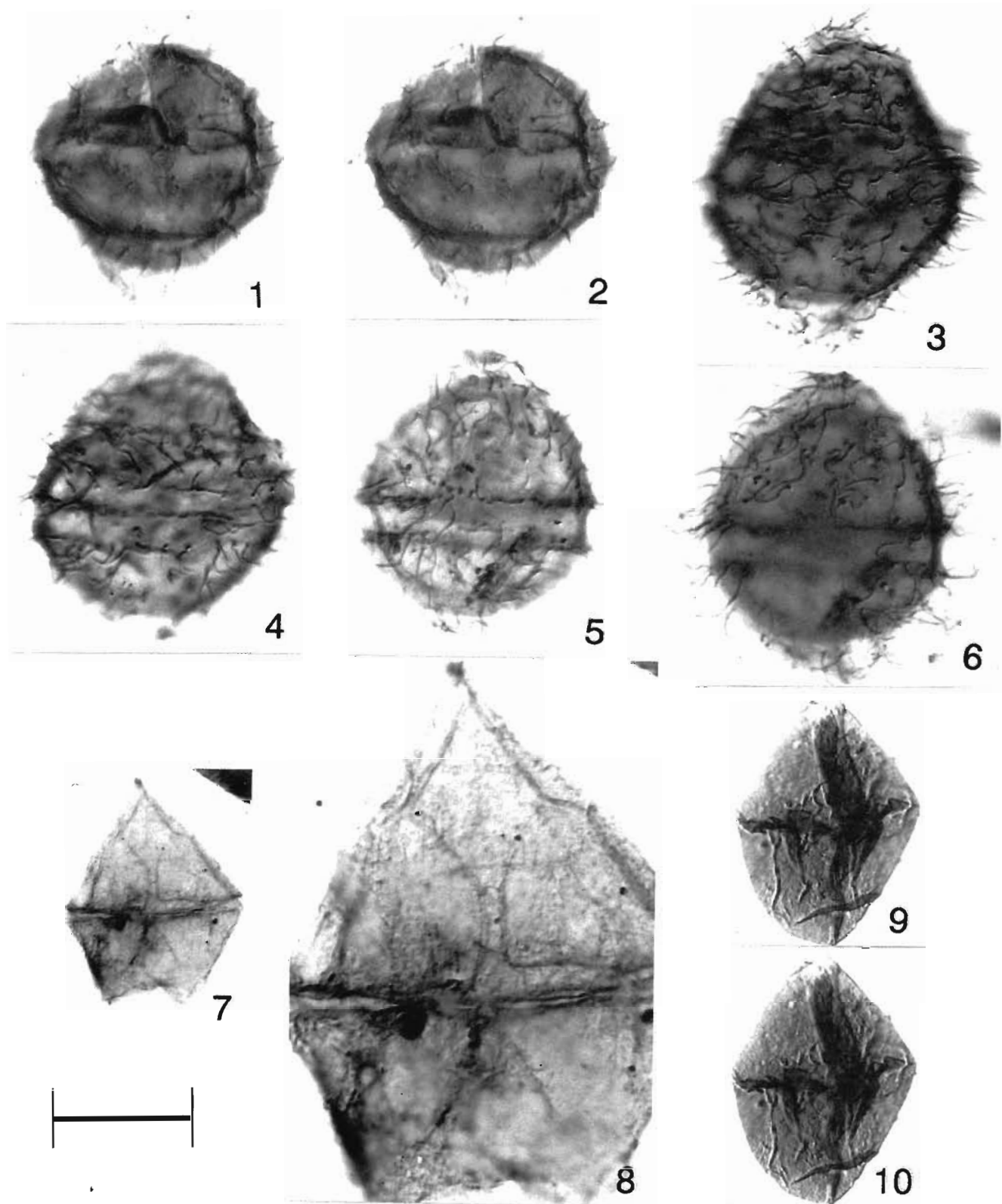


PLATE 22

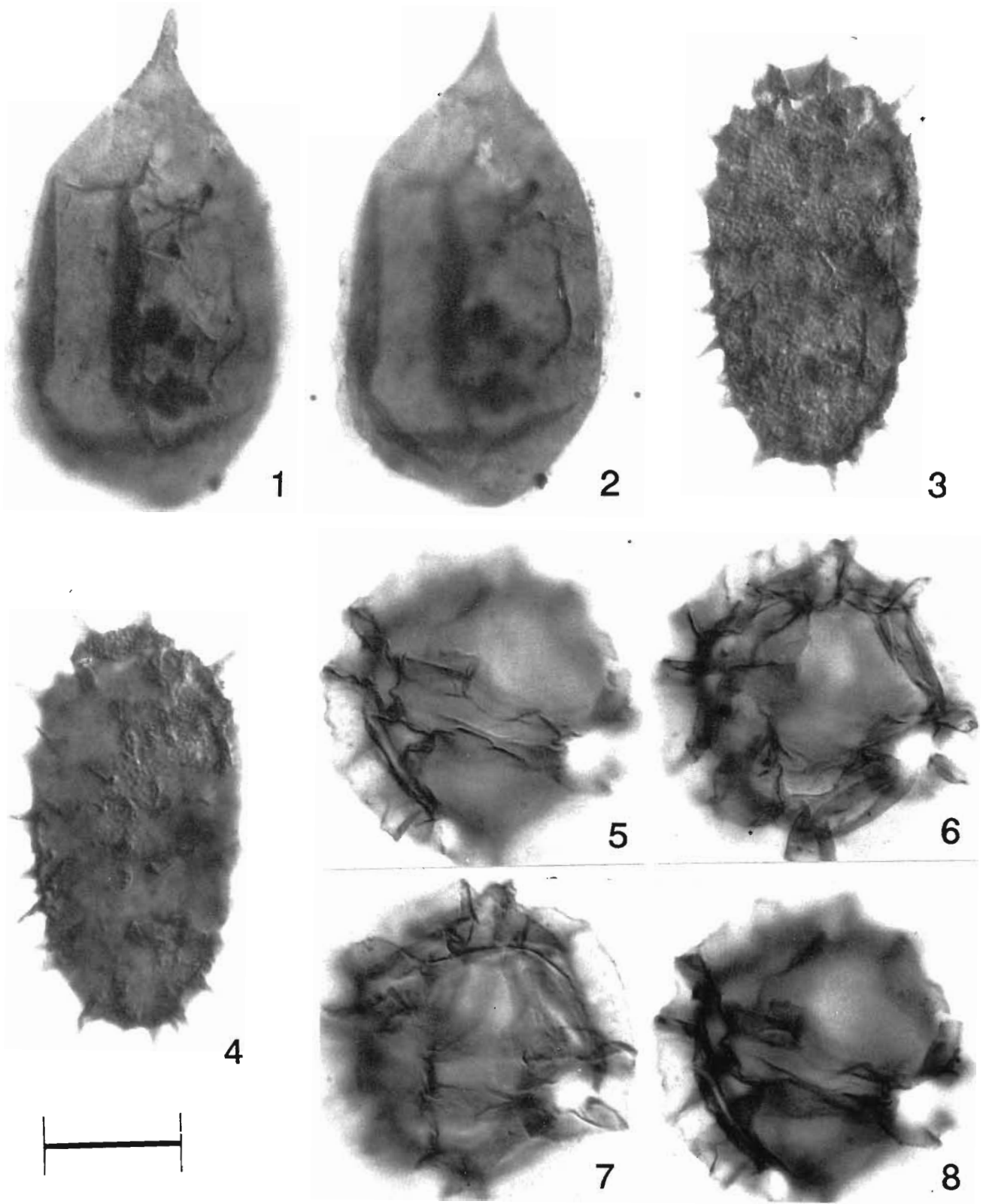


PLATE 23

1, 2. *Pareodinia ceratophora* Deflandre (CRC 32130-2 1 · 42.5
95.5, 84015 4, 5, × 100; middle Britton Member of the Eagle
Ford Formation).
3, 4. *Prolixosphaeridium conulum* Davey (CRC 32130-2 1 · 34.0
105.5, 84015 24, 25, × 100; middle Britton Member of the

Eagle Ford Formation).
5-8. *Pterodinium cornutum* Cookson & Eisenack (CRC 32129-
7 1 : 28.0 111.0, 84001 33-36, × 100; Grayson Formation).
Scale bar length = 20 μm.

Measurements—Central body diameter 45-52 μm , length of processes 30-38 μm (Davey & Verdier, 1976); overall diameter 107-120 μm , body 62-65 μm , process length 31-34 in specimens of this study.

Previous records—Albian-Senonian. Early Albian, Isle of Wight, England (Duxbury, 1983); Senonian, Nord, France (Davey & Verdier, 1976).

Genus—*Leberidocysta* Stover & Evitt 1978

1978 *Leberidocysta* Stover & Evitt, p. 59.

Type species—*Leberidocysta chlamydata* (Cookson & Eisenack) Stover & Evitt 1978 = *Hexagonifera chlamydata* Cookson & Eisenack 1962 (original designation).

Remarks—The genus *Leberidocysta* includes cavate cysts having an ellipsoidal relatively thick-walled endocyst and thin-walled smooth or finely ornamented pericyst. The endocyst sculpture has low relief whereas pericyst wall is thin and folded giving a crumpled appearance. It has an apical archeopyle.

Leberidocysta chlamydata (Cookson & Eisenack)
Stover & Evitt 1978

Pl. 18, figs 1-2

1962 *Hexagonifera chlamydata* Cookson & Eisenack, p. 496; pl. 7, figs 1-3.

1978 *Leberidocysta chlamydata* (Cookson & Eisenack) Stover & Evitt, p. 60.

Measurements—Overall dimensions 68-75 \times 42-54 μm , endocyst dimensions 56-68 \times 42-54 μm (Cookson & Eisenack, 1962); overall diameter 40-99 μm , endocyst dimensions 38-62 \times 30-58 μm (Davey, 1970); overall dimensions 43-63 \times 39-57 μm , endocyst dimensions 30-45 \times 28-36 μm (Singh, 1971); overall diameter 55 μm , endocyst 38 μm in specimens of this study.

Previous records—Albian-Maastrichtian. Early Albian, south India (Jain, 1977); Albian-Cenomanian, Australia (Cookson & Eisenack, 1962, 1968, 1982; Norvick & Burger, 1976; Morgan, 1980); Albian-Maastrichtian, Europe (Cookson & Hughes, 1964; Baltes, 1967b; Clarke & Verdier, 1967; Davey, 1970;

Davey & Verdier, 1971; Foucher, 1974; Fauconnier, 1975, 1979; Wilson, 1971; Kjellström, 1973); Albian-Early Cenomanian, leg 11, Site 105, offshore Atlantic Ocean (Habib, 1972); Upper Albian-Campanian, western Canada (Davey, 1970; Singh, 1971; McIntyre, 1974).

Genus—*Litosphaeridium* Davey & Williams in Davey et al. 1966

1966 *Litosphaeridium* Davey & Williams in Davey et al., p. 79.

Type species—*Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams in Davey et al. 1966 = *Hystriichosphaeridium siphoniphorum* Cookson & Eisenack 1958 (original designation).

Remarks—*Litosphaeridium* is a skolorate cyst with an apical archeopyle and distally open hollow subcylindrical to dome-shaped intratabular processes distributed one per paraplate. Paracingular processes are absent. *Litosphaeridium* differs from *Oligosphaeridium* in lacking distally expanded processes, and from *Conosphaeridium* in having an apical archeopyle.

Davey and Verdier (1973) emended the genus *Litosphaeridium* to include species with paracingular processes or more than one process per plate. Stover and Evitt (1978) rejected the emendation considering it a significant departure from the original generic diagnosis.

Litosphaeridium siphoniphorum (Cookson & Eisenack) Davey & Williams in Davey et al. 1966

Pl. 18, figs 3-8

1958 *Hystriichosphaeridium siphoniphorum* Cookson & Eisenack, p. 44; pl. 11, figs 8-10.

1963 *Hystriichokolpoma* sp. A, Baltes, p. 587; pl. 6, figs 1-5.

1963 *Hystriichokolpoma* sp. B, Baltes, p. 587; pl. 6, figs 6-8.

1968 *Litosphaeridium siphoniphorum* (Cookson & Eisenack); Cookson & Eisenack, p. 119; fig. 5-0 (err. typogr. pro. *Litosphaeridium*).

PLATE 24

- 1-3. *Pterodinium cornutum* Cookson & Eisenack. 1, (CRC 32129-6/1A : 43.8/95.7, 84006/32, \times 40; Grayson Formation); 2-3, (CRC 32129-6/12 : 25.6/105.0, 84009/12, 13, \times 100; Grayson Formation).
4, 5. *Pterodinium perforatum* (Clarke & Verdier) Davey & Verdier (CRC 32129-6/12 : 29.0/97.5, 84007/27, 28, \times 100;

- Grayson Formation).
6-9. *Silicisphaera ferox* (Deflandre) Davey & Verdier (CRC 32129-10/9 : 36.0/102, 84014/4, 5, \times 40; 6, 7, \times 100; Grayson Formation).

Scale bar length = 20 μm except for figs 1, 6 and 7 = 50 μm .

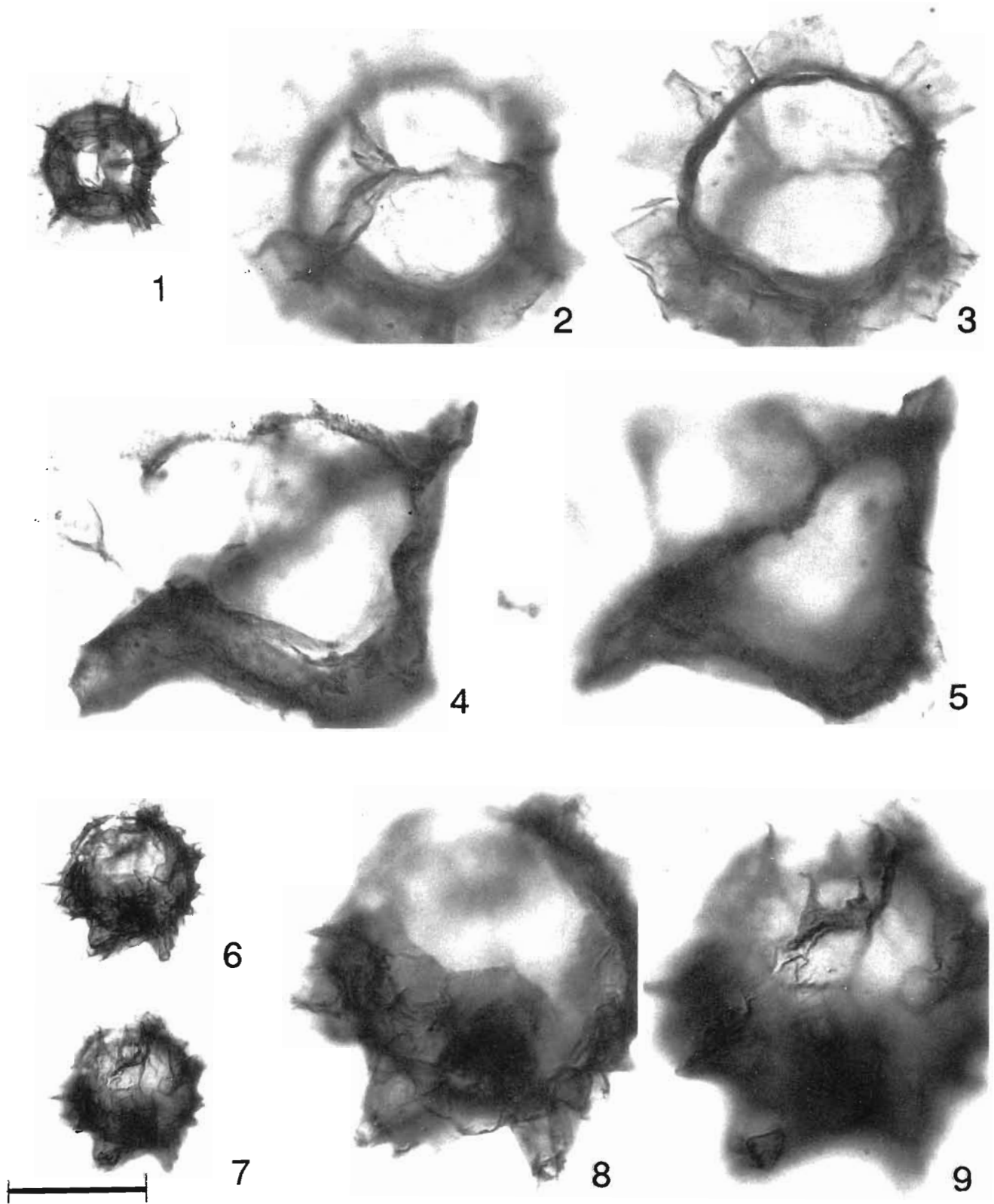


PLATE 24

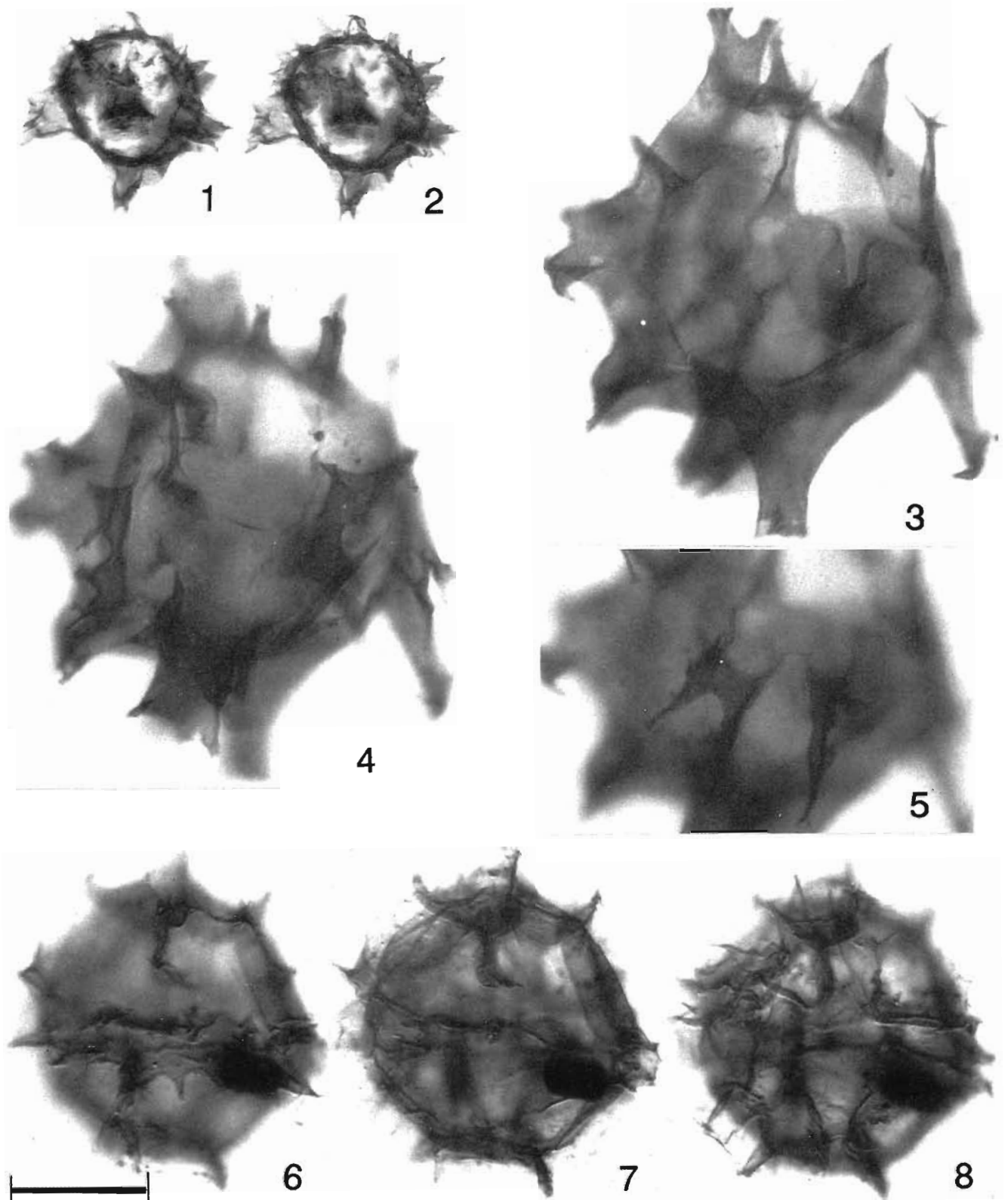


PLATE 25

1-5. *Silicisphaera ferox* (Deflandre) Davey & Verdier. 1-2, (CRC 32129-7/2 : 47.0/102.0: 84002/25, 26, $\times 40$; Grayson Formation); 3-5, (CRC 32129-6/5 : 39.0/102.5, 85001/28-30, $\times 100$; Grayson Formation).
6-8. *Spiniferites cingulatus* (O. Wetzel) Sarjeant (CRC 32129-

10/9 : 55.5/106.9, 84014/24, 23, 25, $\times 100$; Grayson Formation).
Scale bar length = 20 μm except for figs 1-2 = 50 μm , and for figs 3-5 = 15 μm .

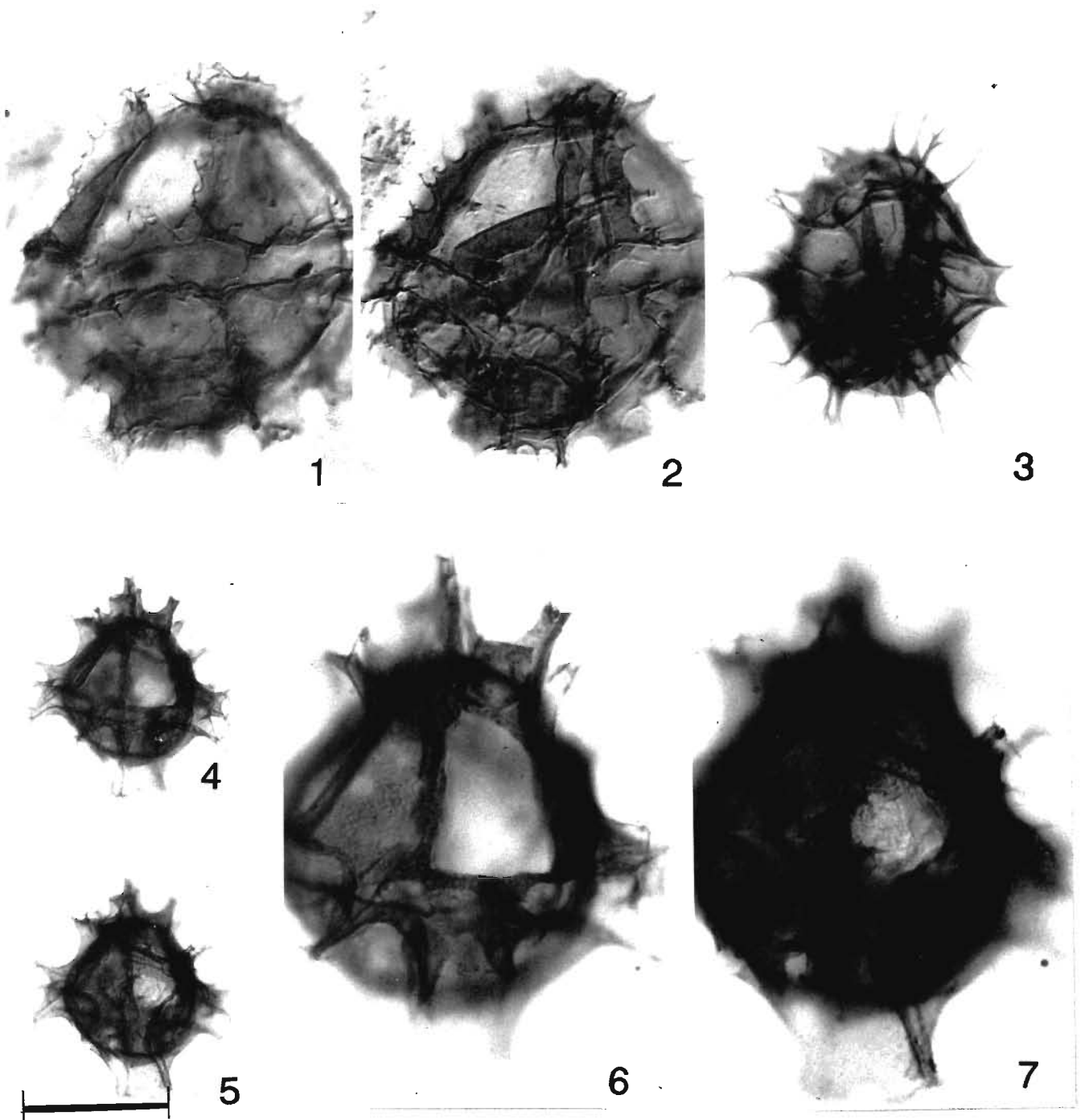


PLATE 26

1, 2. *Spiniferites compactus* Cookson & Eisenack (CRC 32129-6/12 : 49.5/98.5, 84008/3, 2, $\times 100$; Grayson Formation).
 3. *Spiniferites ramosus* subsp. *gracilis* (Davey & Williams) Lentin & Williams (CRC 32129-8/3 : 30.5/101.0, 850603/1, $\times 40$; Grayson Formation).

4-7. *Spiniferites ramosus* subsp. *granomembranceus* (Davey & Williams) Lentin & Williams (CRC 32129-7/1 : 33.4/98.0, 84010/14, 15, $\times 40$; 16, 17, $\times 100$; Grayson Formation).
 Scale bar length = 20 μm except for fig. 3 = 30 μm and figs 4-5 = 50 μm .

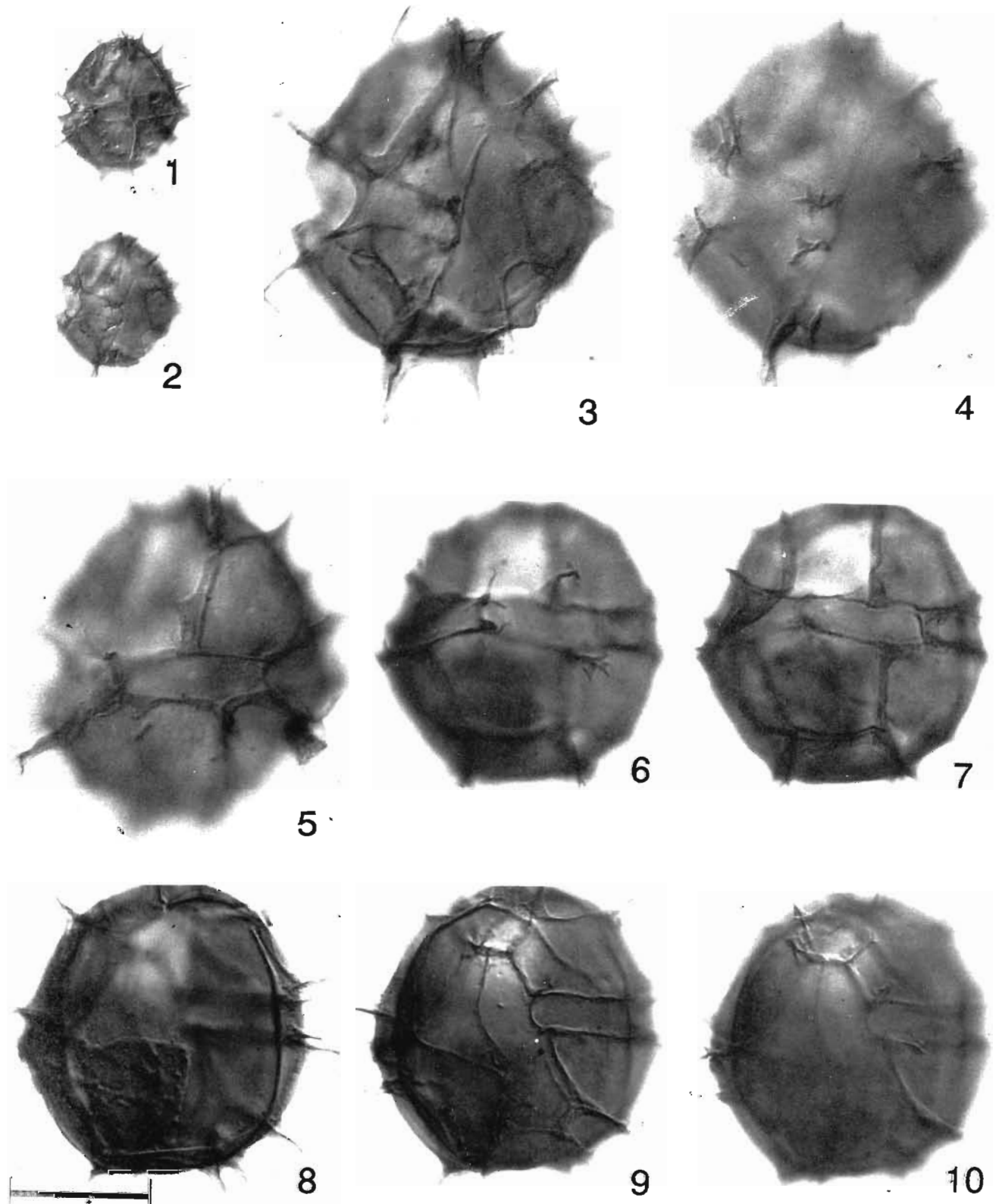


PLATE 27

1-5. *Spiniferites ramosus* subsp. *multibrevis* (Davey & Williams) Lentin & Williams (CRC 32129-7/1 : 37.5/111.0, 84001/27, 28, $\times 40$; 30-32, $\times 100$; Grayson Formation).
 6-10 *Spiniferites ramosus* (Ehrenberg) Mantell subsp. *ramosus*

(CRC 32129-8/5 : 29.3/100.8, 84011/33-37, $\times 100$; Grayson Formation).
 Scale bar length = 20 μm except for figs. 1 and 2 = 50 μm .

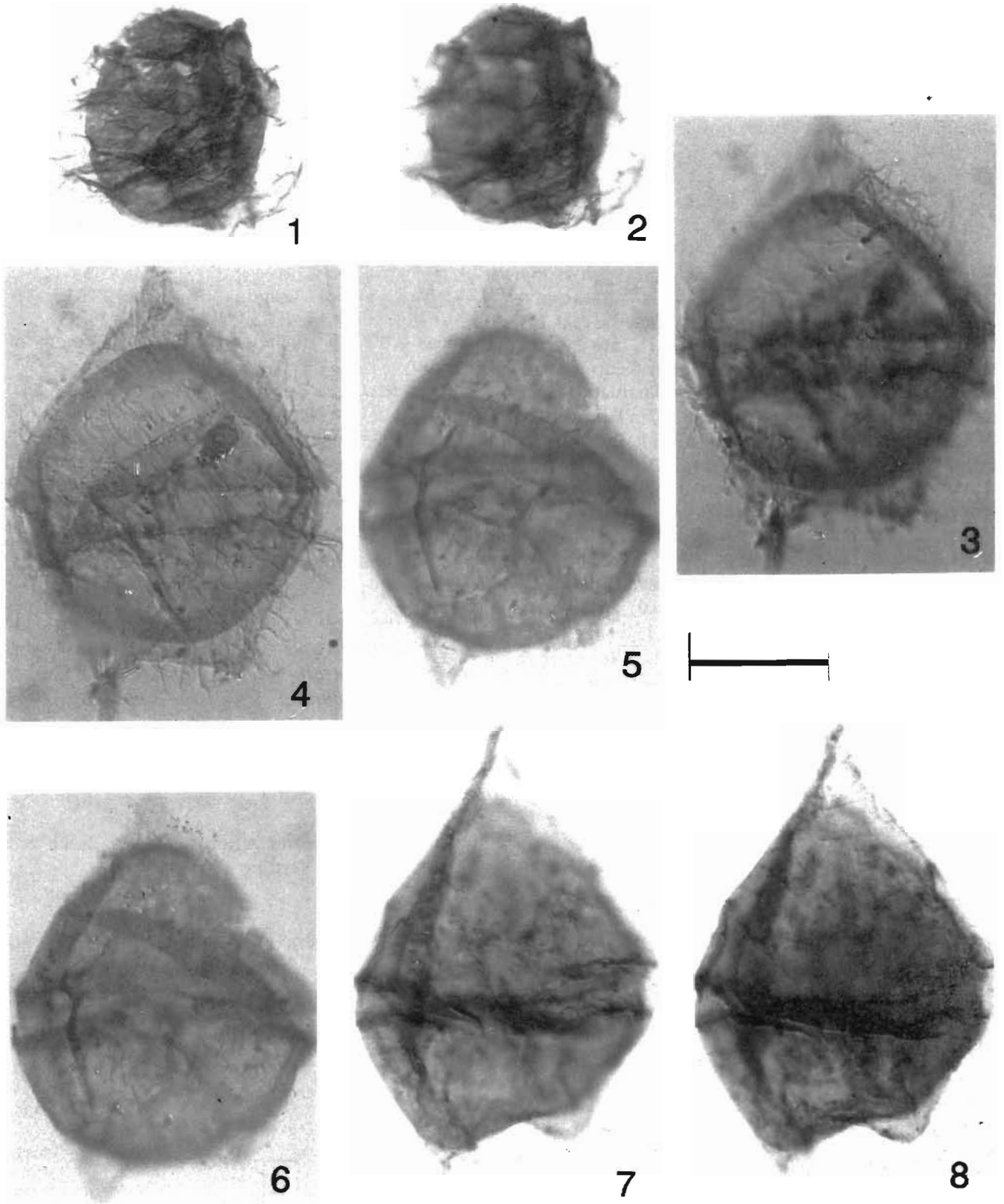


PLATE 28

1, 2. *Stephodinium coronatum* Deflandre (CRC 32129-6'5 : 32.8
99.5, 85001-23, 24, ×40; Grayson Formation).
3-8. *Subtilisphaera cheit* Below 3-4, (CRC 32129-6'1A : 33.0
95.5, 84006-24, 25, ×100; Grayson Formation); 5-6, (CRC

32129-9 1 : 44.0-110.5; 84012-31, 32, ×100; Grayson For-
mation); 7-8, (CRC 32129-10'9 : 46.0-111.0, 84014-26, 27,
×100; Grayson Formation)
Scale bar length = 20 μm except for figs 1 and 2 = 40 μm.

Measurements—Overall diameter, central body diameter, length of processes = 59.76 μm , 33.43 μm , 14.24 μm (Cookson & Eisenack, 1958); —, 25.50 μm , 2.15 μm (Baltes, 1963); —, 21.47 μm , 4.25 μm (Davey & Williams in Davey *et al.*, 1966); 47.76 μm , 28.40 μm , — (Cookson & Eisenack, 1968); —, 30.46 μm , 12.26 μm (Foucher & Taugourdeau, 1975); overall dimensions 45.60 \times 44.52 μm , body 30.35 \times 25.33 μm , process length and breadth 12.15 \times 10.13 μm in specimens of this study.

Previous records—Albian-Turonian. Albian-Turonian range (Millioud, Williams & Lentin, 1975); Albian-Cenomanian, Western Australia (Cookson & Eisenack, 1958); Cenomanian, Bathurst Island, Australia (Norvick & Burger, 1976); Late Albian, Australia (Morgan, 1980); Albian-Cenomanian, Rumania (Baltes, 1963); Albian-Cenomanian, France and Switzerland (Davey & Verdier, 1973; Fauconnier, 1975; Foucher & Taugourdeau, 1975); Late Albian-Early Cenomanian, Paris Basin, northern France (Fauconnier, 1979); Cenomanian, Paris Basin (Foucher, 1979); Cenomanian, Britain, northern France, Canada, USA (Davey & Williams in Davey *et al.*, 1966; Clarke & Verdier, 1967; Davey, 1969); Vraconian, Morocco (Below, 1982); Late Albian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Early Cenomanian, DSDP Sites 367 and 370, Atlantic Ocean, offshore northwestern Africa (Williams, 1978); Cenomanian-Coniacian, offshore eastern Canada (Williams, 1975).

Genus—*Nummus* Morgan 1975

1975 *Nummus* Morgan, p. 163.

Type species—*Nummus monoculatus* Morgan 1975 (original designation).

Remarks—Genus *Nummus* includes single-walled lenticular shells with a subcircular to rounded angular pylome in an "intercalary"

position. Morgan (1975) considered this genus restricted to the Aptian of Australia, although he recorded *N. monoculatus* from Late Neocomian-Aptian strata. He considered its rare Late Aptian or Early Albian occurrences as reworked specimens from older strata.

Nummus monoculatus Morgan 1975

Pl. 19, figs 1-2

1975 *Nummus monoculatus* Morgan, p. 163; pl. 3, figs 1a-d, 4a-c.

Measurements—Length and breadth 35.55 \times 31.43 μm (Morgan, 1975); diameter 23.38 μm (Srivastava, 1984); diameter 50 μm in specimens of this study.

Previous records—Late Neocomian-Cenomanian. Late Neocomian-Cenomanian, Australia (Morgan, 1975, 1980); Barremian, France (Srivastava, 1984).

Genus—*Odontochitina* Deflandre emend. Davey 1970

1935 *Odontochitina* Deflandre, p. 234.

1970 *Odontochitina* Deflandre emend.: Davey, p. 354.

Type species—*Odontochitina operculata* (O. Wetzel) Deflandre & Cookson 1955 (basonym: *Ceratium (Euceratium) operculatum* O. Wetzel 1933) = *Odontochitina silicorum* Deflandre 1935 (monotypic).

Remarks—*Odontochitina* includes ceratoid cavate cysts having single long apical, antapical, and postcingular horns with an apical archeopyle.

Odontochitina costata Alberti emend. Clarke & Verdier 1967

Pl. 19, figs 3-6

1961 *Odontochitina costata* Alberti, p. 31; pl. 6, figs 10-13

PLATE 29

- 1, 2. *Surculosphaeridium longifurcatum* (Firtion) Davey *et al.* (CRC 32129-6/5 : 33.5/99.5, 85001/25, 26, \times 40; Grayson Formation).
- 3, 4. *Tanyosphaeridium regulare* Davey & Williams (CRC 32129-6/12 : 29.5/113.7, 84010/6, 7, \times 100; Grayson Formation).
- 5-8. *Trichodinium castaneum* (Deflandre) Clarke & Verdier 5-6. (CRC 32131-10/2 : 25.0/94.6, 84022/2, 1, \times 40; Austin Chalk); 7-8. (CRC 32131-10/3 : 43.0/102.4, 84023/17, 18, \times 40; Austin Chalk).
- 9, 10. *Trigonopyxida ginella* (Cookson & Eisenack) Manum &

Cookson (CRC 32129-7/1 : 46.6/109.0, 84001/24, 25, \times 100; Grayson Formation).

- 11, 12. *Trithyrodinium suspectum* (Manum & Cookson) Davey. 11. (CRC 32131-10/3 : 47.0/100.0, 84023/16, \times 40; Austin Chalk); 12. (CRC 32131-10/3 : 30.4/108.5, 840023/20, \times 40; Austin Chalk).

13. *Walldonium lunum* (Cookson & Eisenack) Lentin & Williams (CRC 32129-8/5 : 50.0/98.0, 84011-29, \times 40; Grayson Formation).

Scale bar length = 20 μm except for figs 1, 2, 5-8, and 11-12 = 40 μm and for fig. 13 = 50 μm .

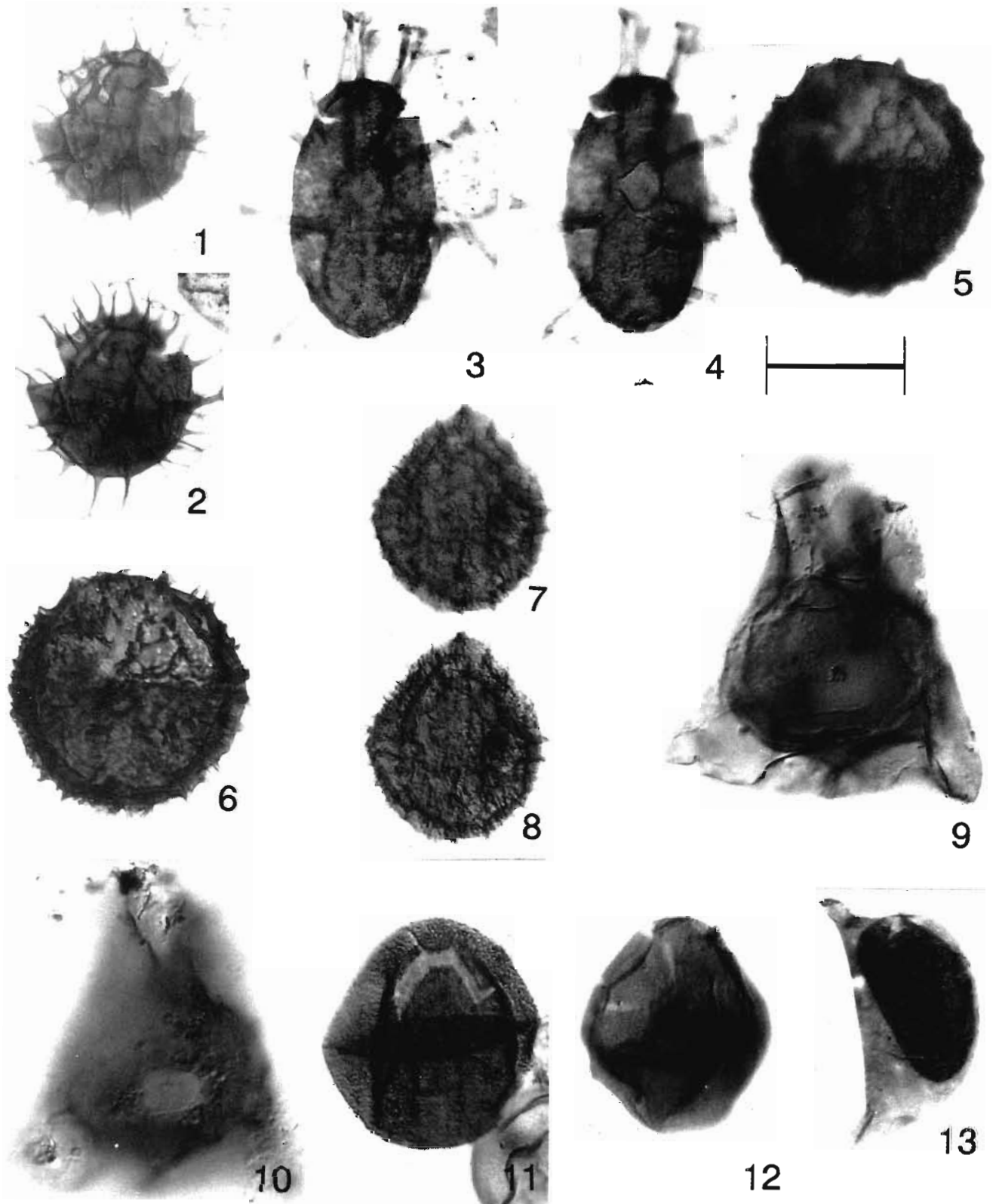


PLATE 29

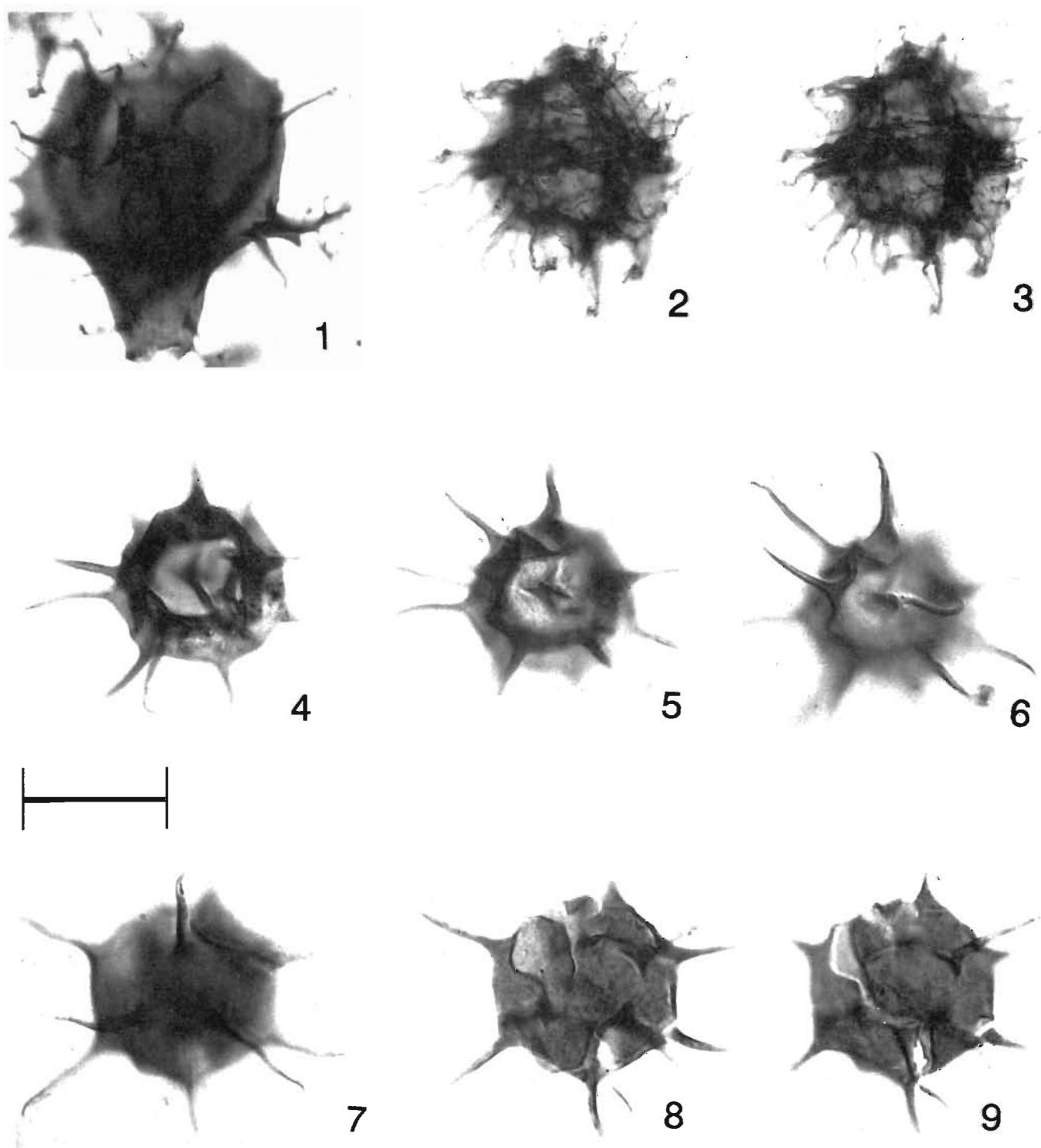


PLATE 30

1. *Xenascus ceratioides* (Deflandre) Lentin & Williams (CRC 32129-7 1 : 19.0'105.0, 84010 33, $\times 100$; Grayson Formation).
- 2, 3. *Xiphophoridium alatum* (Cookson & Eisenack) Sarjeant (CRC 32129-3 1 : 49.2 97.5, 85001 3, 4, $\times 40$, Grayson Formation).
- 4-9. *Micrhystridium stellatum* Deflandre. 4-6. (CRC 32129-6'12 : 50.0'99.0, 84008 7-9, $\times 100$; Grayson Formation); 7-9. (CRC 32129-6 12 : 42.6'100.5, 84008 16-18, $\times 100$; Grayson Formation).
- Scale bar length = 20 μm except for figs 2 and 3 = 40 μm .

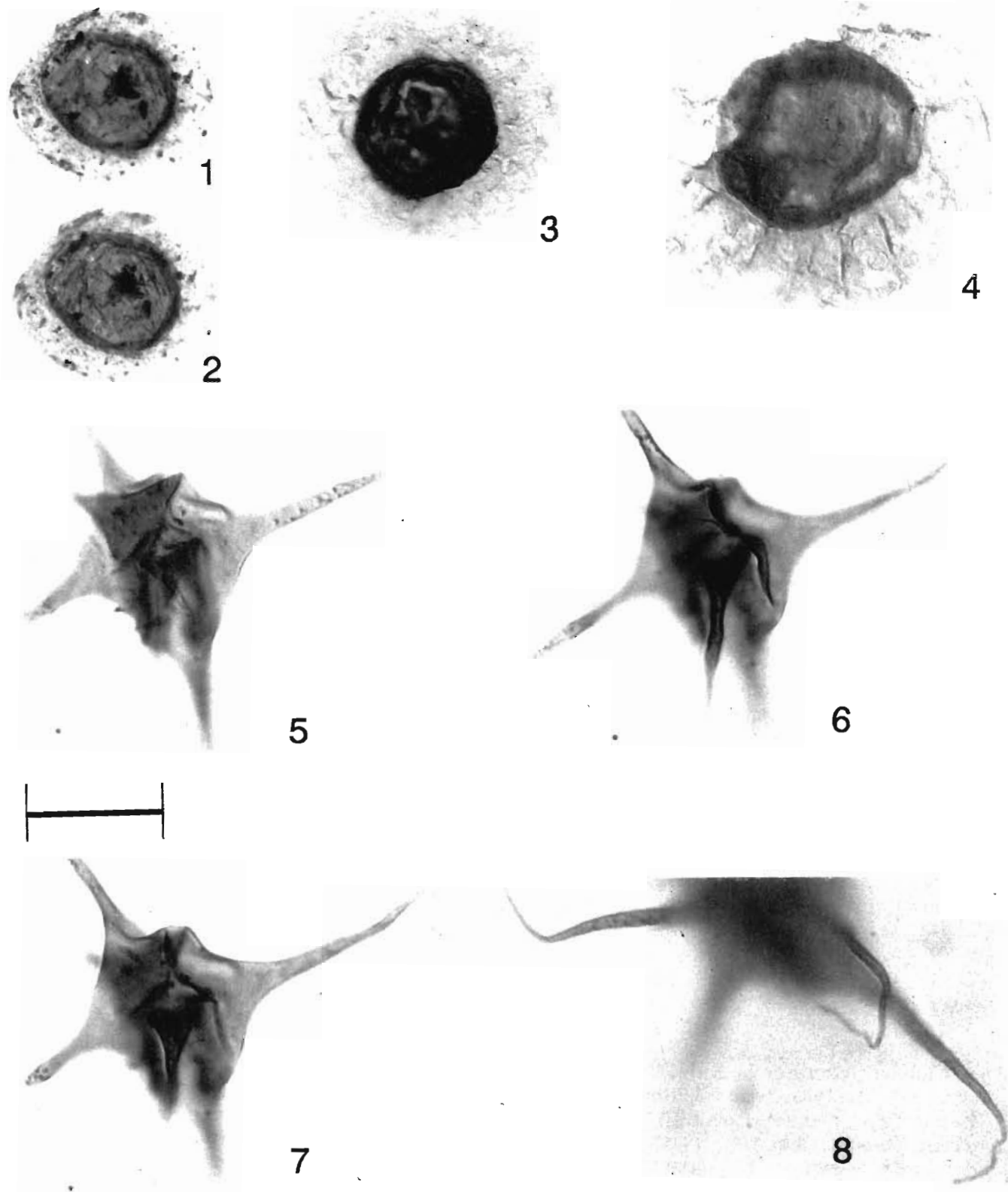


PLATE 31

1-4. *Pterospermella aristotelesii* (Ioannides *et al.*) S. K. Srivastava. 1-2, (CRC 32131-7/12 : 43.0 107.0, 84024/31, 32, × 40; Arcadia Park Member of the Eagle Ford Formation); 3, (CRC 32129-6/12 : 22.0/107.0; 84009/17, × 40; Grayson Formation); 4, (CRC 32129-6/5 : 38.0/99.5, 85001/27, × 40;

Grayson Formation). 5-8. *Tubulospina oblongata* Davey (CRC 32130-2 1 : 40.0/112.5, 84015/31, 32, 30, 34, × 100; middle Britton Member of the Eagle Ford Formation). Scale bar length = 20 μm except for figs 1-4 = 50 μm

Measurements—The overall length of *Odontochitina costata* is highly variable, 305-620 μm (Alberti, 1961; May, 1980).

Previous records—Aptian-Early Paleocene. Aptian-Albian, Senegal, Africa (Jain & Millepied, 1975); Turonian-Senonian, South Atlantic Ocean (Harris, 1976; Davey, 1978); Aptian-Cenomanian, Australia (Cookson & Eisenack, 1962; Morgan, 1980); Late Albian-Early Paleocene, Europe (Alberti, 1961; Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1970; Foucher, 1972; Davey & Verdier, 1973; Schumacker-Lambry, 1978); Albian-Campanian, North America (Davey, 1970; McIntyre, 1974; Millioud *et al.*, 1975; May, 1980).

Odontochitina operculata (O. Wetzel) Deflandre
in Deflandre & Cookson 1955

Pl. 19, fig. 7

- 1933a *Ceratium (Euceratium) operculatum* O. Wetzel, p. 170.
1933b *Ceratium (Euceratium) operculatum* O. Wetzel; pl. 2, fig. 21.
1935 *Odontochitina silicorum* Deflandre, p. 234; pl. 9, figs 8-10 (err. orth. pro *silicora*).
1955 *Odontochitina operculata* (O. Wetzel) Deflandre in Deflandre & Cookson, p. 291; pl. 3, figs 5-6.

Measurements—Body 48-40 μm , length of appendages 72-116 μm (Deflandre & Cookson, 1955), the size of *Odontochitina operculata* varies considerably.

Previous records—Hauterivian-Paleocene. Hauterivian-Paleocene, Europe (O. Wetzel, 1933a, 1933b; Deflandre, 1935, 1937; Firtion, 1952; Valensi, 1956; Alberti, 1961; Górká, 1963; Serpagli, 1965; Sarjeant in Davey *et al.*, 1966; Clarke & Verdier, 1967; Baltes, 1967a, 1967b; Millioud, 1969; Davey, 1970, 1974; Davey & Verdier, 1971; Wilson, 1971; Foucher, 1972; Corradini, 1973; Kjellström, 1973; Foucher & Taugourdeau, 1975; Schumacker-Lambry, 1975, 1978; Duxbury, 1980, 1983; Hemgreen, 1980; Yun, 1981; de Renéville & Raynaud, 1981); Upper Cretaceous, USSR (Vozzhennikova, 1967); Lower Cretaceous, Afghanistan (Ashraf, 1979); Early Albian, south India (Jain, 1977); Hauterivian, Spitsbergen (Bjaerke, 1978); Upper Hauterivian-Albian, western North Atlantic Ocean (Habib, 1972, 1975, 1978; Hochuli & Kelts, 1980); Albian-Alaska (May & Stein, 1979); Barremian-Maastrichtian, Canada (Pocock, 1962, 1980; Singh, 1964, 1971; Vagvolgyi & Hills, 1969; Davey, 1970; Brideaux, 1971; Harland, 1973; McIntyre, 1974; Williams, 1975; Wilson, 1978); Cenomanian-Maastrichtian, U.S.A. (Davey, 1970;

Harland, 1977); Albian, Mexico (Helenes, 1984); Cenomanian-Senonian, Brazil (Herngreen, 1975); Neocomian-Late Cretaceous, South Atlantic Ocean (Harris, 1976; Ioannides & Colin, 1977); Aptian-Albian, Senegal, West Africa (Jain & Millepied, 1975); Barremian-Albian, Morocco, Africa (Below, 1981a); Aptian-Cenomanian, Australia (Deflandre & Cookson, 1955; Verdier, 1970; Playford, Haig & Dettmann, 1975; Norvick & Burger, 1976; Burger, 1980; Morgan, 1980).

Genus—*Oligosphaeridium* Davey & Williams in Davey *et al.* 1966

1966 *Oligosphaeridium* Davey & Williams in Davey *et al.*, p. 70.

Type species—*Oligosphaeridium complex* (White) Davey & Williams in Davey *et al.* 1966 = *Xanthidium tubiferum complex* White 1842 (original designation).

Remarks—*Oligosphaeridium* is distinct from *Hystrichosphaeridium* and *Perissetiasphaeridium* in lacking paracingular processes.

Oligosphaeridium complexum (White) Davey & Williams in Davey *et al.* 1966

Pl. 20, figs 1-2

- 1842 *Xanthidium tubiferum complex* White, p. 39; pl. 4, div. 3, fig. 11 (err. orth. pro *complexum*).
1848 *Xanthidium complexum* (White) Bronn, p. 1375.
1940 *Hystrichosphaeridium elegantulum* Lejeune-Carpentier, p. B222; text-figs 11-12.
1946 *Hystrichosphaeridium complex* (White) Deflandre, p. 111 (err. orth. pro *complexum*).
1966 *Oligosphaeridium complex* (White) Davey & Williams in Davey *et al.*, p. 71; pl. 7, figs 1-2; pl. 10, fig. 3; text-fig. 14 (err. orth. pro *complexum*).

Measurements—Diameter of the central body 34-55 μm , length of processes 22-43 μm (Davey & Williams in Davey *et al.*, 1966); overall dimensions 93-130 μm , central body 40-65 μm , process length about 25-35 μm , (Srivastava, 1984); overall diameter 90-104 μm , body 45-52 μm , process length 25-34 μm in specimens of this study.

Previous records—Cretaceous-Danian (see in the list of synonymy noted in Below, 1982a). Valanginian, northwestern Germany (Below, 1981b); Hauterivian, offshore Denmark (Davey, 1982); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Upper Barremian-

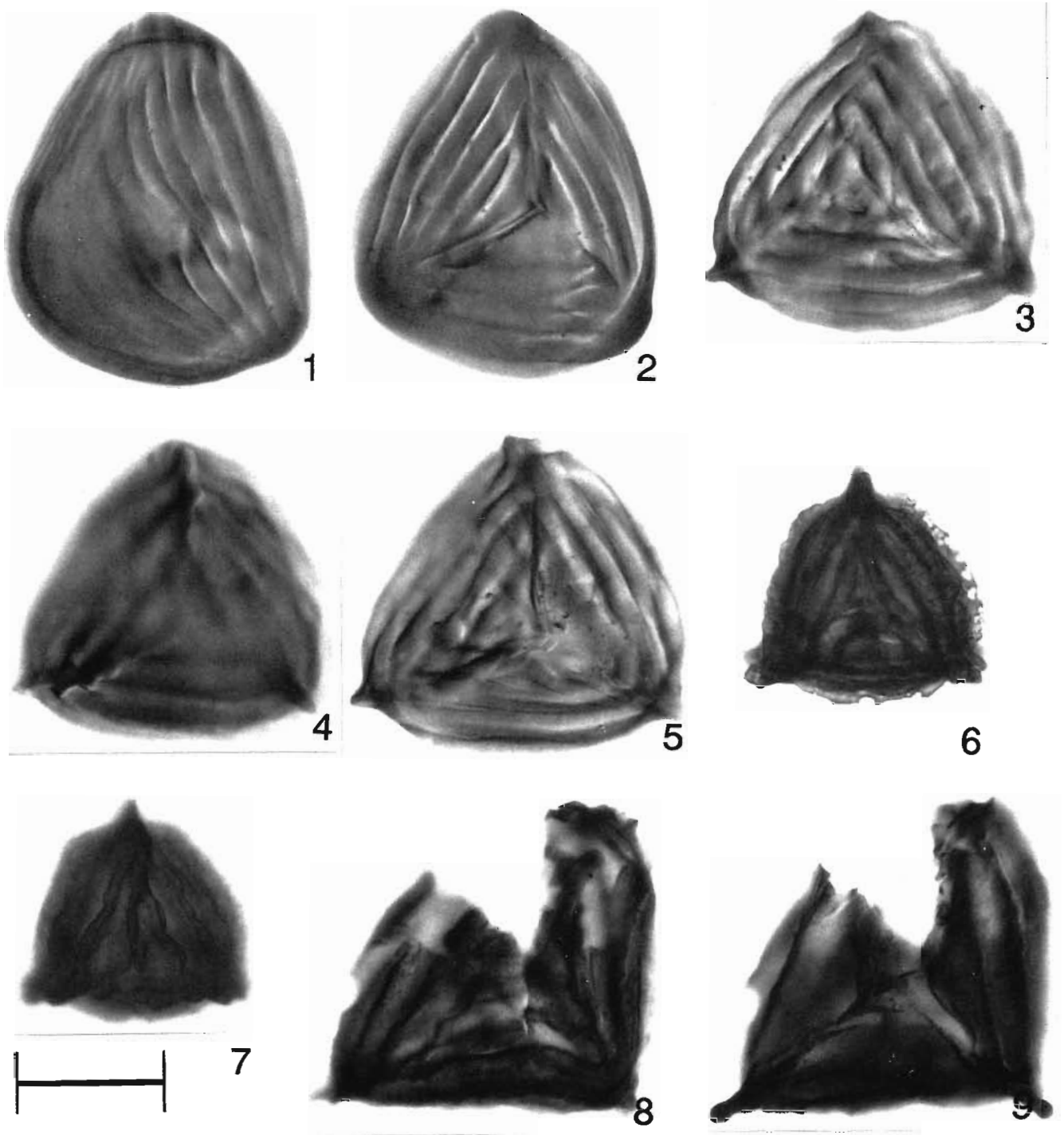


PLATE 32

- 1, 2. *Appendicisporites baconicus* (Deák) S. K. Srivastava (CRC 32131-7/2A : 52.0/101.0, 84018/18, 19, ×100; Arcadia Park Member of the Eagle Ford Formation).
 3-5. *Appendicisporites bifurcatus* C. Singh (CRC 32131-7/2A : 37.4/95.0, 84018/4-6, ×100; Arcadia Park Member of the Eagle Ford Formation).
 6, 7. *Appendicisporites dentimarginatus* Brenner (CRC 32129-6/4 : 27.0/112.0, 85001/17, 18, ×40; Grayson Formation).
 8, 9. *Appendicisporites erdtmanii* Pocock (CRC 32129-6/1 40.0/87.0; 84004/13, 14, ×100; Grayson Formation).
 Scale bar length = 20 μm except for figs 6 and 7 = 40 μm.

Aptian, northern Germany (Below, 1982b); Aptian-Early Albian, Isle of Wight, England (Duxbury, 1983); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Oligosphaeridium pulcherrimum (Deflandre & Cookson) Davey & Williams in Davey *et al.* 1966
Pl. 20, figs 3-7

1955 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson, p. 270; pl. 1, fig. 8; text-figs 21, 22.

1966 *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams in Davey *et al.*, p. 75; pl. 10, fig. 9; pl. 11, fig. 5.

Measurements—Overall diameter 118 μm , body $47 \times 61 \mu\text{m}$, process length 26-38 μm (Deflandre & Cookson, 1955); body diameter 30-48 μm , process length 17-40 μm (Davey & Williams in Davey *et al.*, 1966); overall diameter 90-100 μm , body 52-60 μm , process length 25-31 μm in specimens of this study.

Previous records—Widely distributed in Kimmeridgian-Eocene strata.

Genus—*Ovoidinium* Davey emend. Lentin & Williams 1976

1970 *Ovoidinium* Davey, p. 351.

1972 *Evittia* Pocock (*non* Brito, 1967), p. 93.

1973 *Pocockia* Lentin & Williams, p. 114.

1976 *Ovoidinium* Davey emend. Lentin & Williams, p. 103.

Type species—*Ovoidinium verrucosum* (Cookson & Hughes) Davey 1970 = *Ascodinium verrucosum* Cookson & Hughes 1964 (original designation).

Remarks—*Ovoidinium* consists of proximate, bicavate, compressed peridinioid cysts with a short apical horn, commonly reduced antapical horns, and a combination apical intercalary archeopyle. *Ovoidinium* differs from *Ascodinium* in being bicavate and not circumcavate.

Ovoidinium verrucosum (Cookson & Hughes)
Davey 1970

Pl. 21, figs 1-9

1964 *Ascodinium verrucosum* Cookson & Hughes, p. 41; pl. 5, figs 4-7.

1970 *Ovoidinium, verrucosum* (Cookson & Hughes) Davey, p. 351; pl. 4, figs 1-2; text-fig. 1A.

Measurements—Overall length 60-61 μm (Davey, 1970); length and breadth $55-80 \times 40-59 \mu\text{m}$ (Cookson & Hughes, 1964); overall length and breadth $50-60 \times 38-50 \mu\text{m}$ in specimens of this study.

Previous records—Late Albian-Cenomanian. Europe and North America (Cookson & Hughes, 1964; Baltes, 1967; Davey, 1970; Burgess, 1971; Davey & Verdier, 1973; Fauconnier, 1975); Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

**Genus—*Palaeohystrichophora* Deflandre emend.
Deflandre & Cookson 1955**

1934 *Palaeohystrichophora* Deflandre, p. 967 (nom. nud.).

1935 *Palaeohystrichophora* Deflandre, p. 230.

1955 *Palaeohystrichophora* Deflandre emend. Deflandre & Cookson, p. 257.

Type species—*Palaeohystrichophora infusorioides* Deflandre 1935 (original designation; monotypic).

Remarks—*Palaeohystrichophora* is a bicavate cyst consisting of biconical to compressed peridinioid pericyst, ellipsoidal to subspherical endocyst, apical and antapical pericoels, clearly delineated paracingulum, and short to long hair-like processes on the periphragm without an archeopyle.

Palaeohystrichophora can be distinguished from *Subtilisphaera* in possessing hair-like processes and in being more elongate.

PLATE 33

1, 2. *Appendicisporites jansonii* Pocock (CRC 32131-7/1A : 45.5/96.0, 84017/8, 9, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

3-5. *Baculatisporites comaumensis* (Cookson) R. Potonié (CRC 32131-7/3A : 41.0/95.6, 84018/36, 35, 34, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

6, 7. *Biretisporites potoniae* Delcourt & Sprumont (CRC 32131-7/1A; 30.0/93.0, 84016/24, 25, $\times 100$; Arcadia Park Member

of the Eagle Ford Formation).

8-10. *Camarozonosporites insignis* Norris. 8-9, (CRC 32131-7/1A : 27.4/93.0, 84016/26, 27, $\times 100$; Arcadia Park Member of the Eagle Ford Formation); 10, (CRC 32131-7/1A : 37.5/97.0, 84017/5, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

Scale bar length = 20 μm .

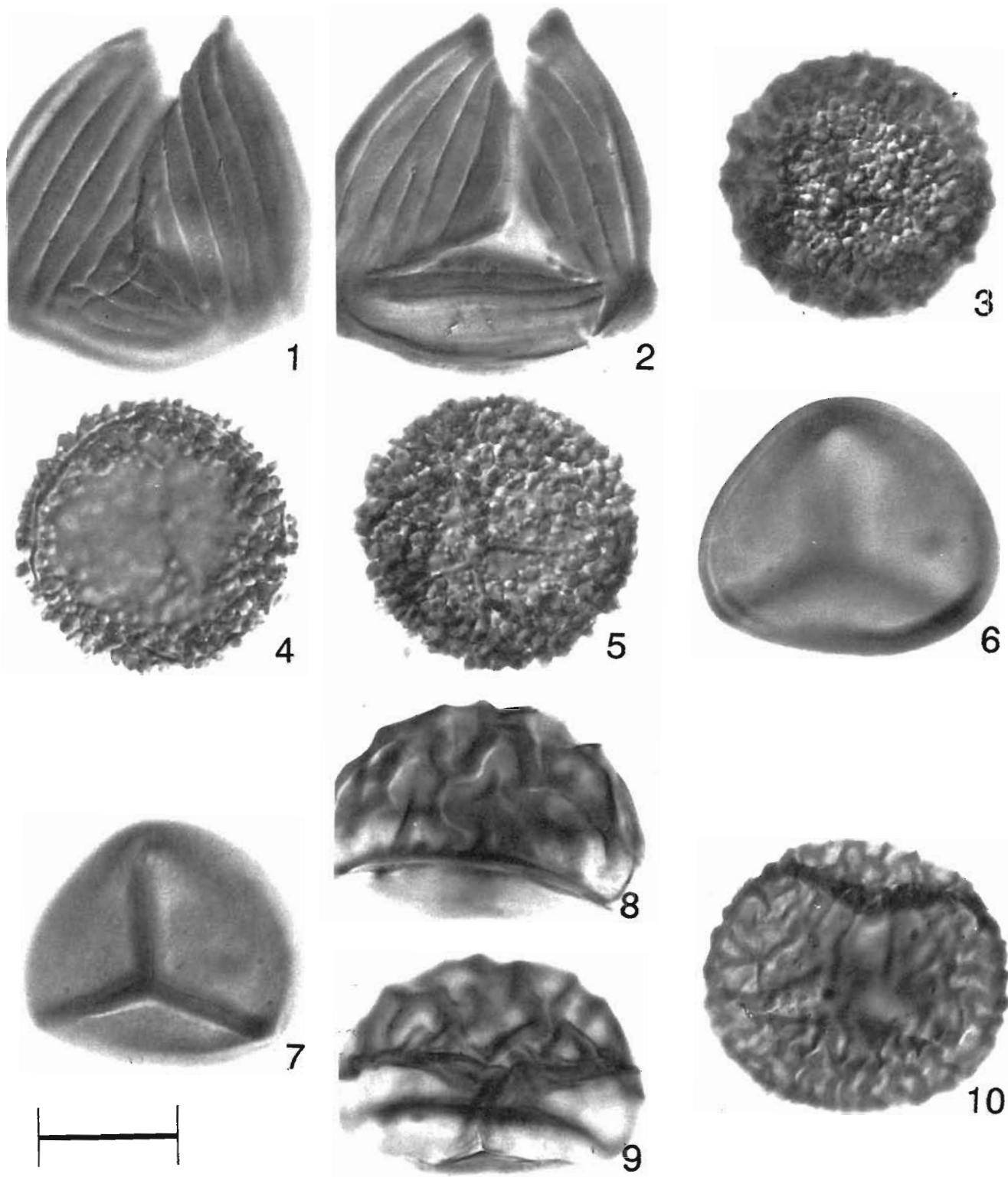


PLATE 33

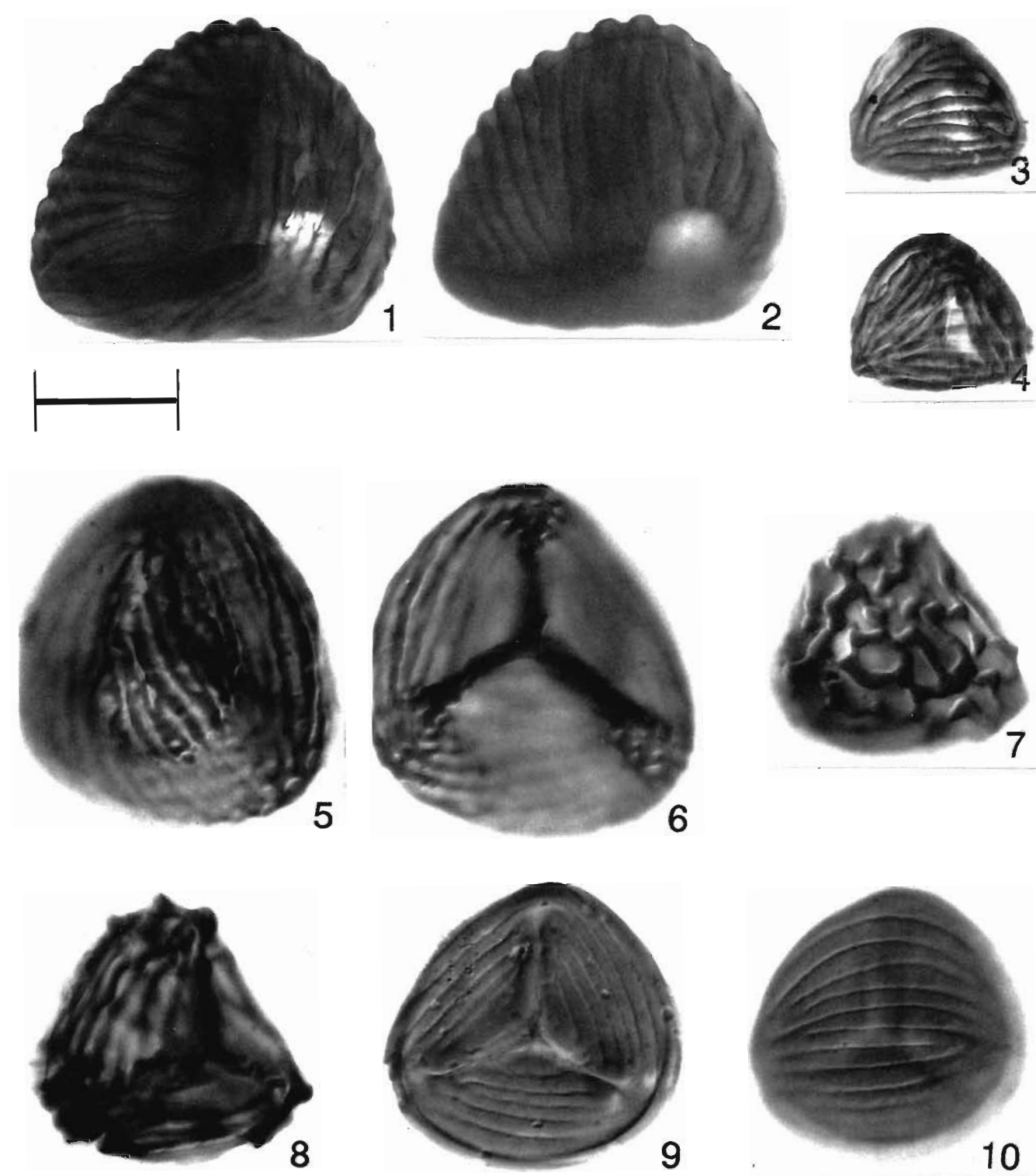


PLATE 34

- 1, 2. *Cicatricosporites annulatus* Archangelsky & Gamberro (CRC 32129-3/1 : 21.8/105.0, 84003/22, 23, $\times 100$; Grayson Formation).
 3, 4. *Cicatricosporites australiensis* (Cookson) R. Potonie (CRC 32131-7/1A : 38.0/110.5, 84017/36, 37, $\times 40$; Arcadia Park Member of the Eagle Ford Formation).
 5, 6. *Cicatricosporites hallei* Delcourt & Sprumont (CRC 32131-7/1A : 38.0/108.0, 84017/24, 26, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
 7, 8. *Cicatricosporites ornatus* S. K. Srivastava (CRC 32131-7/1A : 41.7/107.3, 84017/27, 28, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
 9, 10. *Cicatricosporites venustus* Deák (CRC 32171-7/1A : 27.3/101.0, 84017/22, 23, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
 Scale bar length = 20 μm except for figs 3 and 4 = 50 μm .

Palaeohystrichophora infusorioides Deflandre 1935
Pl. 22, figs 1-6

1934 *Palaeohystrichophora infusorioides*
Deflandre, p. 967; fig. 8 (nom. nud.).

1935 *Palaeohystrichophora infusorioides*
Deflandre, p. 230; Pl. 8, fig. 4.

Measurements—Overall dimensions 47.71 × 33.37 μm (Vozzhennikova, 1967); overall 33.63 × 27.47 μm, inner body 27.42 × 27.47 μm, length of spines 4.10 μm (Davey, 1970); overall range 60.78 × 41.52 μm, spines 4.7 μm long (Davey & Verdier, 1973); overall dimensions 34.55 × 19.26 μm; inner body 25.32 × 19.26 μm, spine length 5.10 μm (Foucher, 1974); overall dimensions 31.62 × 25.41 μm (Alberti, 1961); 48.62 × 36.46 μm (Boltenhagen, 1977); 37.95 × 24.46 μm (Harker, 1979); 27.33 × 39.48 μm, spine length 6.12 μm (Yun, 1981); overall dimensions 116.120 × 53.58 μm (May, 1980); overall dimensions 51.86 × 35.50 μm, inner body 35.55 × 35.50 μm, process length 3.12 μm (Singh, 1983); overall 45.70 × 42.52 μm, body 33.52 × 35.40 μm, process length 6.12 μm in 10 specimens of this study.

Previous records—Albian-Maastrichtian. Cenomanian-Santonian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1970); ?Albian-Senonian, France (Deflandre, 1934, 1935, 1936, 1940; Deflandre & Courteville, 1939; Valensi, 1956; Foucher, 1972, 1974; Foucher & Taugourdeau, 1975); Middle Albian-Senonian, Germany (Alberti, 1961; Yun, 1981); Cenomanian/Turonian, Romania (Baltes, 1966); Upper Cretaceous, Belgium (Schumacker-Lambry, 1975); Cenomanian-Maastrichtian, North America (Leopold & Pakiser, 1964; Manum & Cookson, 1964; Davey, 1970; Zaitzeff & Cross, 1971; Stone, 1973; Millioud *et al.*, 1975; Harker, 1979; May, 1980; Singh, 1983); Late Albian-Cenomanian, western North Atlantic Ocean (Habib, 1970, 1972; Hochuli & Kelts, 1980); Albian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Cenomanian-Turonian, western Africa (Boltenhagen, 1977); Albian-Campanian, Australia (Cookson & Eisenack, 1958, 1960, 1969, 1970, 1974; Norvick & Burger, 1976); Upper Cretaceous, USSR (Vozzhennikova, 1967).

Doubtful records—Paleocene, Belgium (Schumacker-Lambry, 1978).

Genus—*Palaeoperidinium* Deflandre ex Sarjeant emend. Lentin & Williams 1976

1934 *Palaeoperidinium* Deflandre, p. 968.

1963 *Pentagonum* Vozzhennikova, p. 183.

1967 *Palaeoperidinium* Deflandre ex Sarjeant, p. 246.

1970 *Astrocysta* Davey, p. 359.

1976 *Palaeoperidinium* Deflandre ex Sarjeant emend. Lentin & Williams, p. 106. *

Type species—*Palaeoperidinium pyrophorum* (Ehrenberg) Sarjeant 1967 = *Peridinium pyrophorum* Ehrenberg 1838 (subsequent designation by Sarjeant, 1967).

Remarks—*Palaeoperidinium* consists of proximate, compressed peridinioid cysts having a well-developed apical and two antapical horns, and a combination archeopyle.

Palaeoperidinium is distinct from *Saeptodinium* in having prominent apical and antapical horns, and a less rounded outline; from *Laciniadinium* and *Luxadinium* in having a thick apical paraplate involved in the archeopyle formation.

Palaeoperidinium cretaceum Pocock ex Davey
1970

Pl. 22, figs 7-8

1962 *Palaeoperidinium cretaceum* Pocock, p. 80; pl. 14, figs 219-221 (invalid name pro ICBN Art. 43, Para 1).

1970 *Astrocysta cretacea* (Pocock) Davey, p. 359; pl. 2, fig. 4.

1970 *Palaeoperidinium cretaceum* Pocock ex Davey, p. 359.

Measurements—Length and breadth 81.95 × 50.69 μm (Pocock, 1962); 80.95 × 50.70 μm (Singh, 1964); 81.118 × 50.82 μm (Davey, 1970); 68.92 × 48.72 μm (Singh, 1971); 60.92 × 57.68 μm (Below, 1981); 78.93 × 65.78 μm in specimens of this study.

Previous records—Barremian-Coniacian. Barremian-Albian, western Canada (Pocock, 1962; Singh, 1964, 1971; Davey, 1970) and Alaska (May & Stein, 1979); Barremian-Albian, England (Duxbury, 1980, 1983); Barremian-Albian, southwestern Morocco (Below, 1981); Late Aptian, South Atlantic Ocean, off southwestern Africa (Davey, 1978); early Late Cretaceous, Arctic Canada (Manum & Cookson, 1964).

Genus—*Palaeostomocystis* Deflandre emend.

Deflandre 1966

1937 *Palaeostomocystis* Deflandre, p. 52.

1966 *Palaeostomocystis* Deflandre emend. Deflandre, p. 6.

Type species—*Palaeostomocystis reticulata* Deflandre 1937 = *P. reticulata* 1935 (nom. nud.), 1936b (nom. nud.) (original designation).

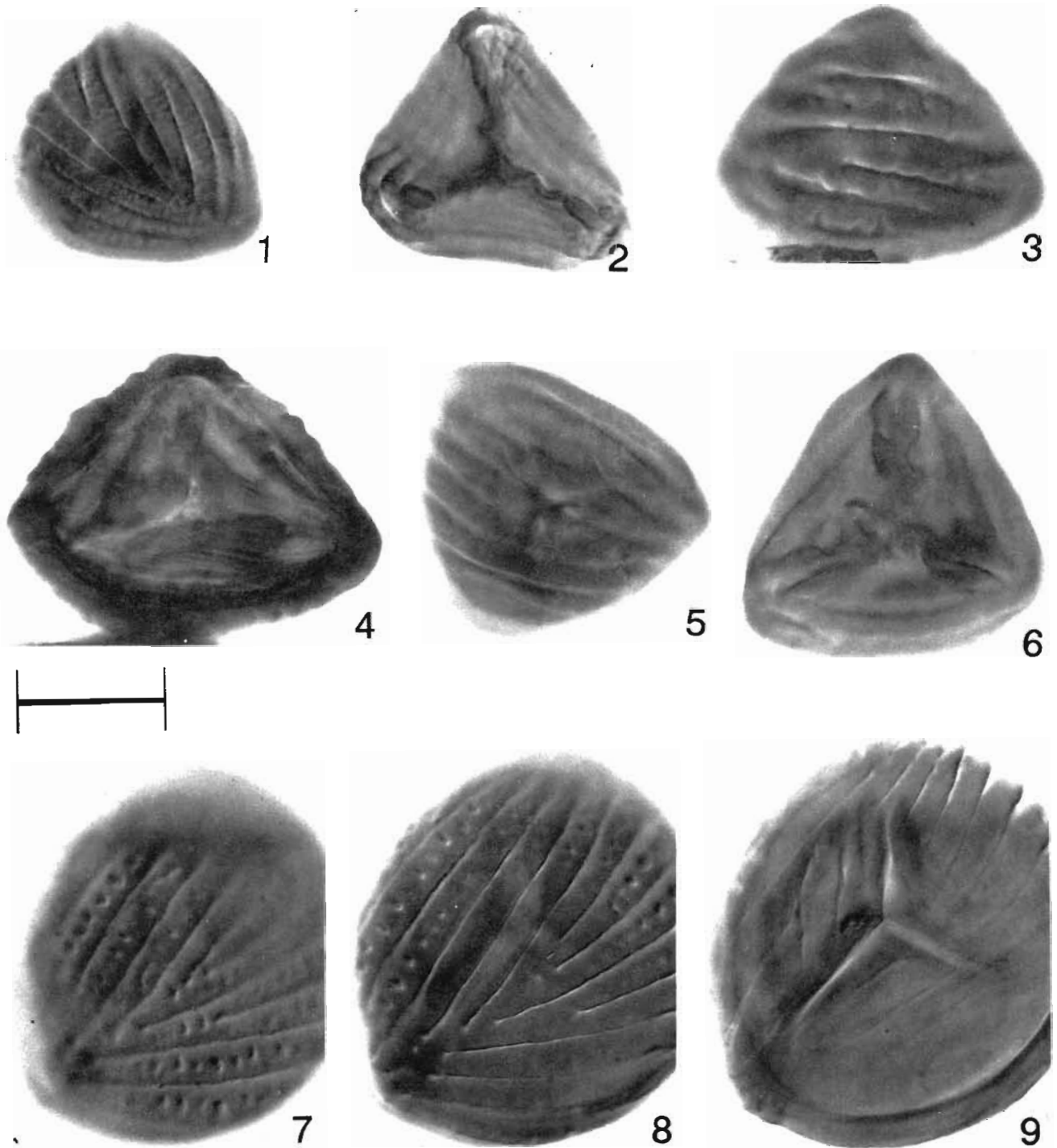


PLATE 35

1, 2. *Cicatricosporites venustus* Deák (CRC 32131-7/1A : 33.0/110.0, 84017/33, 32, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

3-6. *Contignisporites fornicatus* Dettmann. 3-4, (CRC 32131-7/1A : 42.0/95.5, 84017/7, 6, $\times 100$; Arcadia Park Member of the Eagle Ford Formation); 5-6 (CRC 32131-7/2A : 45.2/101.0,

84018/17, 16, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

7-9. *Costatofoveosporites foveolatus* Deák (CRC 32131-7/3A : 34.8/104.0, 84019/10, 9, 8, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

Scale bar length = 20 μm .

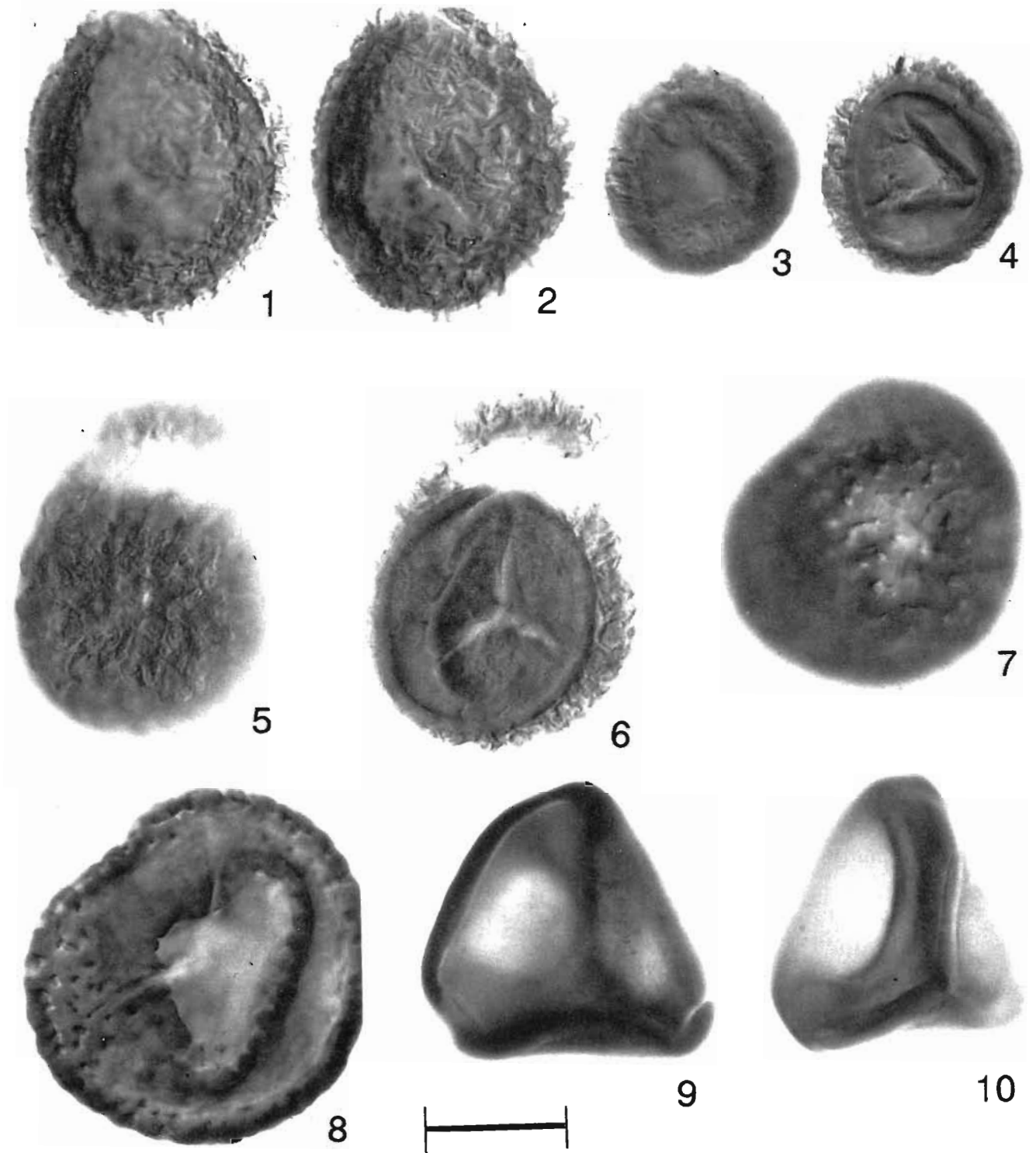


PLATE 36

1-6. *Crybelosporites pannuceus* (Brenner) S. K. Srivastava. 1-2, (CRC 32131-7/1A : 26.8/93.0, 84016/28, 29, $\times 100$; Arcadia Park Member of the Eagle Ford Formation); 3-4, (CRC 32131-7/1A : 34.6/96.2, 84017/4, 3, $\times 100$; Arcadia Park Member of the Eagle Ford Formation); 5-6, (CRC 32131-7/2A : 27.0/95.5, 84018/8, 7, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).

7, 8. *Foveosporites labiosus* C. Singh (CRC 32131-7/2A : 38.4/101.0, 84018/15, 14, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
 9, 10. *Gleichenioidites senonicus* Ross (CRC 32131-7/2A : 47.5/106.0, 84018/25, 23, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
 Scale bar length = 20 μm .

Remarks—*Palaeostomocystis* consists of ellipsoidal cysts having an apical archeopyle for reticulate sculpture with narrow muri and small lumina. It differs from *Fromea* in having reticulate sculpture.

Palaeostomocystis fragilis Cookson & Eisenack
1962

Pl. 22, figs 9-10

1962 *Palaeostomocystis fragilis* Cookson & Eisenack, p. 496; pl. 7, figs 10-11.

Measurements—Dimensions 82-157 × 70-105 μm (Cookson & Eisenack, 1962); 60-140 × 25-77 μm (Brideaux, 1971); 72-145 × 55-110 μm (Singh, 1971); 52-130 × 42-110 μm (Burger, 1980); 60-99 × 45-75 μm in specimens of this study.

Previous records—Aptian-Maastrichtian. Aptian-Cenomanian, Australia (Cookson & Eisenack, 1962; Norvick & Burger, 1976; Burger, 1980; Morgan, 1980); Albian-Maastrichtian, Canada and Canadian Arctic (Manum & Cookson, 1964; Brideaux, 1971; Singh, 1971; McIntyre, 1974; Doerenkamp *et al.*, 1976); Albian, Alaska (May & Stein, 1979); Cenomanian, western North Atlantic Ocean bottom (Habib, 1969, 1970).

**Genus—*Pareodinia* Deflandre emend. Stover & Evitt
1978**

1947 *Pareodinia* Deflandre, p. 4.

1966 *Paranetrellytron* Sarjeant in Davey *et al.*, p. 201.

1967 *Imbatodinium* Vozzhennikova, p. 52.

1975 *Glomodinium* Dodekova, p. 26.

1978 *Pareodinia* Deflandre emend. Stover & Evitt, p. 116.

Type species—*Pareodinia ceratophora* Deflandre 1947 (original designation).

Remarks—*Pareodinia* includes proximate to proximochorate, ellipsoidal cysts with an apical horn and an intercalary archeopyle. It is distinct from *Kalyptea* in lacking an antapical horn and having a different intercalary archeopyle.

Pareodinia ceratophora Deflandre 1947

Pl. 23, figs 1-2

1947 *Pareodinia ceratophora* Deflandre, p. 4, figs 1-3.

Measurements—Length and breadth 65-78 × 35-38 μm (Deflandre, 1947); 57-106 × 32-60 μm (Singh, 1971); 70-105 × 38-44 μm (Yun, 1981); 68-86 × 40-60 μm in specimens of this study.

Previous records—Bajocian-Santonian (see Yun, 1981).

**Genus—*Prolixosphaeridium* Davey *et al.* in Davey *et al.*
1966**

1966 *Prolixosphaeridium* Davey, Downie, Sarjeant & Williams in Davey *et al.*, p. 171.

Type species—*Prolixosphaeridium parvispinum* (Deflandre) Davey, Downie, Sarjeant & Williams in Davey *et al.* 1966 = *Prolixosphaeridium deirense* Davey, Downie, Sarjeant & Williams in Davey *et al.* 1966 (original designation).

Remarks—*Prolixosphaeridium* has an elongate, oval to ellipsoidal body with several spinulose processes and granulose, spinulose, or smooth surfaces. The processes are closed proximally, and their distal ends have pointed, flared or slightly furcate apices which are usually closed.

It has an apical archeopyle and one or two antapical processes. It is distinct from *Tanyosphaeridium* in having short, tapering and proximally closed processes.

Prolixosphaeridium conulum Davey 1969

Pl. 23, figs 3-4

1969 *Prolixosphaeridium conulum* Davey, p. 160; pl. 8, figs 5-6.

Measurements—Shell dimensions 38-50 × 20-29 μm, process length 11-18 μm (Davey, 1969); 36 × 54 μm, process length ca 12 μm (Yun, 1981); overall 75 × 42 μm, body 58-31 μm, process length 10 μm in specimens of this study.

PLATE 37

1-3. *Heliosporites altmarkensis* E. Schulz (CRC 32131-7/2A : 58.8/111.5, 84018/30, 29, 28, × 100; Arcadia Park Member of the Eagle Ford Formation).

4, 5. *Lusatisporis dettmannae* (Drugg) S. K. Srivastava (CRC 32131-7/2A : 27.2/100.0, 84018/13, 12, × 100; Arcadia Park Member of the Eagle Ford Formation).

6-8. *Retitriteles singhii* S. K. Srivastava (CRC 32129-6/1 : 50.0, 105.5, 84006/3, 2, 1, × 100; Grayson Formation).

9, 10. *Taurocusporites segmentatus* Stover (CRC 32131-7/30.0/101.5, 84017/21, 20, × 100; Arcadia Park Member of the Eagle Ford Formation).

11, 12. *Sporae incertae sedis* (CRC 32131-7/4A : 42.0/102.0, 84019/12, 11, × 54; Arcadia Park Member of the Eagle Ford Formation).

Scale bar length = 20 μm except for figs 11 and 12 = 35 μm.

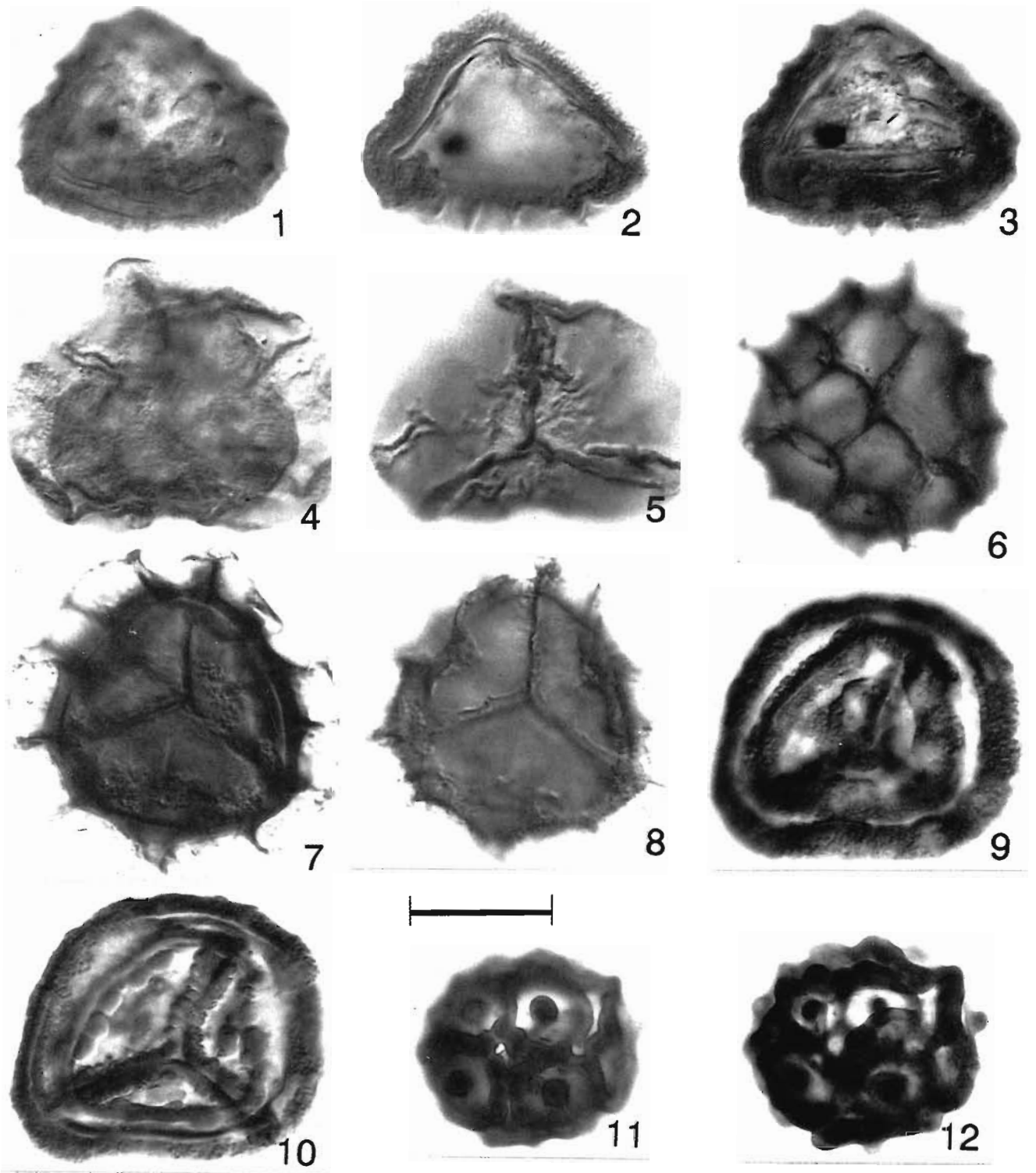


PLATE 37

Previous records—Aptian-Santonian. Aptian-Cenomanian, Mazagan Plateau, offshore northwest Africa (Below, 1984); Albian, Morocco (Below, 1982a); Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1973); Cenomanian, Australia (Norvick & Burger, 1976); Santonian, Germany (Yun, 1981).

Genus—*Pterodinium* Eisenack 1958

1958 *Pterodinium* Eisenack, p. 395.

Type species—*Pterodinium aliferum* Eisenack 1958 (original designation).

Remarks—*Pterodinium* consists of proximochorate cysts having a subspherical body with high parasutural septa, and a precingular archeopyle.

Pterodinium cornutum Cookson & Eisenack 1962

Pl. 23, figs 5-8; Pl. 24, figs 1-3

1962 *Pterodinium cornutum* Cookson & Eisenack, p. 490; pl. 3, figs 1-4.

Measurements—Overall length and breadth $48.86 \times 70.76 \mu\text{m}$ (Cookson & Eisenack, 1962); $84.86 \times 74.76 \mu\text{m}$ (Singh, 1971); $54.57 \times 44.54 \mu\text{m}$ (Below, 1981a); $52 \times 35.48 \mu\text{m}$ in specimens of this study.

Previous records—Barremian-Cenomanian. Barremian, Morocco (Below, 1981a); Aptian-Albian, Senegal, Africa (Jain & Millepied, 1975); Aptian-Albian, Australia (Cookson & Eisenack, 1962; Haig & Barnbaum, 1978); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Albian-Cenomanian, western North Atlantic Ocean (Habib, 1970); Albian, Alberta, Canada (Singh, 1971); Albian, Alaska (May & Stein, 1979).

Pterodinium perforatum (Clarke & Verdier)
Davey & Verdier 1971

Pl. 24, figs 4-5

1967 *Dinopterygium perforatum* Clarke & Verdier, p. 36; pl. 6, figs 1-3; text-fig. 15.

1971 *Pterodinium perforatum* (Clarke & Verdier) Davey & Verdier, p. 30; pl. 6, figs 1-3.

1981a *Magbrebinia perforata* (Clarke & Verdier) Below, p. 23; pl. 1, figs 1-2; pl. 12, figs 9-10; pl. 15, fig. 21; text-fig. 14.

Measurements—Overall length and breadth $60.90 \times 60.84 \mu\text{m}$ (Clarke & Verdier, 1967); $62.96 \times 60.99 \mu\text{m}$ (Below, 1981a); $60 \times 71 \mu\text{m}$ in a specimen of this study.

Previous records—Latest Albian-Cenomanian. Vraconian-Cenomanian, Morocco, Africa (Below, 1981a); latest Albian-Cenomanian, France (Davey &

Verdier, 1971, 1973; Fauconnier, 1979); Cenomanian, England (Clarke & Verdier, 1967).

Genus—*Silicisphaera* Davey & Verdier 1976

1976 *Silicisphaera* Davey & Verdier, p. 320.

Type species—*Silicisphaera ferox* (Deflandre) Davey & Verdier 1976 = *Hystrichosphaeridium ferox* Deflandre 1937 (original designation).

Remarks—*Silicisphaera* consists of proximochorate to skolochorate cysts in which body is subspherical with gonyaulacacean paratabulation indicated by hollow penitabular processes of almost uniform length but of variable types and width. It lacks a distinctive antapical process but has a precingular archeopyle. *Silicisphaera* differs from *Florentinia* in lacking a large antapical process.

Duxbury (1980) considered *Silicisphaera* a junior synonym of *Florentinia* as the separation of the two genera becomes difficult due to the presence of intergradational forms with and without a distinctive antapical process. Although much difficulty was recognized when the genus was proposed (Davey & Verdier, 1976), Stover and Evitt (1978) maintained the two genera separately as the problem of distinguishing them is restricted to a few intergradational species. Lentin and Williams (1981), however, accepted *Silicisphaera* as a junior synonym of *Florentinia*. As the end species of the two genera are quite distinct in having or lacking a distinctive antapical process, the two genera are considered here separately valid.

Silicisphaera ferox (Deflandre) Davey & Verdier
1976

Pl. 24, figs 6-9; Pl. 25, figs 1-5

1937 *Hystrichosphaeridium ferox* Deflandre, p. 16; pl. 14, fig. 3.

1963 *Baltisphaeridium ferox* (Deflandre) Downie & Sarjeant, p. 91.

1969 *Hystrichokolpoma ferox* (Deflandre) Davey, p. 159; pl. 9, figs 5-7.

1976 *Silicisphaera ferox* (Deflandre) Davey & Verdier, p. 322; pl. 3, figs 1-2; text-fig. 4.

1980 *Florentinia ferox* (Deflandre) Duxbury, p. 121.

Measurements—Central body $40.49 \times 40.49 \mu\text{m}$, process length $10.16 \mu\text{m}$ (May, 1980); maximum diameter of central body $42.50 \mu\text{m}$, process length and width $17.25 \times 13.16 \mu\text{m}$ (Yun, 1981); overall diameter $55.86 \mu\text{m}$, body $35.52 \mu\text{m}$, process length and breadth $11.26 \times 12.16 \mu\text{m}$ in specimens of this study.

Previous records—Late Albian-Danian. Late Albian-Maastrichtian, North America (Singh, 1971;

Williams & Brideaux, 1975; May, 1980); Turonian-Senonian, France (Deflandre, 1937; Deflandre & Courteville, 1939; Foucher, 1972, 1974; Davey & Verdier, 1976); Danian, Germany (Wetzel, 1952); Late Santonian or Early Campanian, Australia (Cookson & Eisenack, 1968).

Genus—*Spiniferites* Mantell ex Loeblich, Jr. & Loeblich, III emend. Sarjeant 1970

- 1850 *Spiniferites* Mantell, p. 191.
 1932 *Hystrichosphaera* O. Wetzel, p. 136 (nom. nud.)
 1933 *Hystrichosphaera* O. Wetzel, p. 79 (invalid, two type species indicated).
 1937 *Hystrichosphaera* O. Wetzel ex Deflandre, p. 61.
 1953 *Hystrichokibotium* Klumpp, p. 387.
 1966 *Spiniferites* Mantell ex Loeblich, Jr. & Loeblich, III, p. 56.
 1970 *Spiniferites* Mantell emend. Sarjeant, p. 75.

Type species—*Spiniferites ramosus* (Ehrenberg) Mantell 1854 = *Xanthidium ramosus* Ehrenberg 1837 (subsequent designation by Loeblich, Jr. & Loeblich, III, 1966).

Spiniferites cingulatus (O. Wetzel) Sarjeant 1970

Pl. 25, figs 6-8

- 1933b *Cymatiosphaera cingulata* O. Wetzel, p. 74; pl. 4, fig. 10.
 1954 *Hystrichosphaera cingulata* (O. Wetzel) Deflandre, p. 258.
 1970 *Spiniferites cingulatus* (O. Wetzel) Sarjeant, p. 76.

Measurements—Overall 45-55 × 40-50 μm (Srivastava, 1984); body dimensions 48-72 × 70-78 μm, process length 9-12 μm, crest 3-7 μm high (Yun, 1981); overall 53-91 × 53-83 μm, body 45-73 × 40-78 μm, process length ca 10-16 μm, crest height ca 3-8 μm in specimens of this study.

Previous records—Barremian-Miocene (see Davey & Verdier, 1971; Duxbury, 1980). Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Early Albian, India (Jain, 1977).

Spiniferites compactus Cookson & Eisenack 1974

Pl. 26, figs 1-2

- 1974 *Spiniferites compactus* Cookson & Eisenack, p. 59; pl. 21, fig. 11.

Measurements—Overall dimensions 58 × 52 μm, central body 38 × 28 μm (Cookson & Eisenack, 1974); overall 50-78 × 50-68 μm, processes ca 7 μm long in specimens of this study.

Previous records—Aptian-Albian, Australia (Cookson & Eisenack, 1974).

Spiniferites ramosus subsp. *gracilis* (Davey & Williams) Lentin & Williams 1973 *

Pl. 26, fig. 3

- 1966 *Hystrichosphaera ramosa* var. *gracilis* Davey & Williams in Davey *et al.*, p. 34; pl. 1, fig. 5; pl. 5, fig. 6.
 1973 *Spiniferites ramosus* var. *gracilis* (Davey & Williams) Corradini, p. 165; pl. 26, fig. 3.
 1973 *Spiniferites ramosus* subsp. *gracilis* (Davey & Williams) Lentin & Williams, p. 130.

Measurements—Central body diameter 28-62 μm, process length up to 29 μm (Davey & Williams in Davey *et al.*, 1966); central body dimensions 30-40 × 40-50 μm, process length 18-28 μm (Corradini, 1973).

Previous records—Cenomanian-Miocene.

Spiniferites ramosus subsp. *granomembranaceus* (Davey & Williams) Lentin & Williams 1973

Pl. 26, figs 4-7

- 1966 *Hystrichosphaera ramosa* var. *granomembranacea* Davey & Williams in Davey *et al.*, p. 37; pl. 4, fig. 4.
 1973 *Spiniferites ramosus granomembranaceus* (Davey & Williams) Lentin & Williams, p. 130.
 1973 *Spiniferites ramosus* var. *granomembranaceus* (Davey & Williams) Corradini, p. 166; pl. 26, fig. 4.

Measurements—Body diameter 41.5-56 μm, process length up to 27 μm (Davey & Williams in Davey *et al.*, 1966); body 42-54 μm, process length 20-28 μm (Corradini, 1973); body 48 μm, process length 14 μm (Wilson, 1978); overall length and breadth 75-99 × 70-91 μm, body 50-57 × 45-52 μm, process length 15-26 μm in specimens of this study.

Previous records—Campanian-Lower Eocene. Senonian-Eocene, Europe (Corradini, 1973; de Coninck, 1975; Bujak *et al.*, 1980); Maastrichtian, Arctic Canada (Wilson, 1978).

Spiniferites ramosus subsp. *multibrevis* (Davey & Williams in Davey *et al.*) Lentin & Williams 1973

Pl. 27, figs 1-5

- 1966 *Hystrichosphaera ramosa* var. *multibrevis* Davey & Williams in Davey *et al.*, p. 35; pl. 1, fig. 4; pl. 4, fig. 6; text-fig. 9.
 1973 *Spiniferites ramosus* subsp. *multibrevis* (Davey & Williams in Davey *et al.*) Lentin & Williams, p. 130.

Measurements—body diameter 31-61 μm , process length 12-19 μm (Davey & Williams in Davey *et al.*, 1966); body dimensions 27-68 \times 25-65 μm , processes up to 10 μm long (Srivastava, 1984); overall dimensions 47-68 \times 45-55 μm , process length up to 10 μm in specimens of this study.

Previous records—Hauterivian-Eocene.

Spiniferites ramosus (Ehrenberg) Mantell 1854,
subsp. *ramosus*

Pl. 27, figs 6-10

- 1838 *Xanthidium ramosum* Ehrenberg, pl. 1, figs 1-2, 5.
1854 *Spiniferites ramosus* (Ehrenberg) Mantell, p. 239.
1966 *Hystriosphraera ramosa* var. *ramosa* Davey & Williams in Davey *et al.*, p. 33; pl. 1, figs 1, 6; pl. 3, fig. 1; text-fig. 8.
1971 *Spiniferites ramosus* var. *ramosus* (Davey & Williams in Davey *et al.*) Davey & Verdier, p. 33; pl. 4, figs 1, 3; pl. 7, fig. 5.
1973 *Spiniferites ramosus* subsp. *ramosus* (Davey & Williams in Davey *et al.*) Lentin & Williams, p. 130.

Measurements—Body diameter 30-56 μm , process length 5-27 μm (Davey & Williams in Davey *et al.*, 1966); overall dimensions 56-84 \times 55-77 μm , main body 39-55 \times 33-50 μm (Duxbury, 1977); overall 50-67 \times 46-55 μm , body 30-50 \times 30-50 μm (Srivastava, 1984); overall 52-60 \times 55-57 μm , body 40 \times 35-47 μm , process length 6-14 μm in specimens of this study.

Previous records—Valanginian-Recent (see Duxbury, 1977). Valanginian-Hauterivian, offshore Denmark (Davey, 1982); Valanginian, northwestern Germany (Below, 1981b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Albian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Genus—*Stephodium* Deflandre emend. Davey 1970

- 1936a *Stephodium* Deflandre, p. 58.
1970 *Stephodium* Deflandre emend. Davey, p. 347.

Type species—*Stephodium coronatum* Deflandre 1936 (original designation; monotypic).

Remarks—*Stephodium* consists of camocavate cysts having a precingular archeopyle and a subspherical to ellipsoidal endocyst with periphragm appressed or close to endophragm in ventral, apical and antapical areas and separated elsewhere. It differs from *Hystriostrogylon* and *Thalassiphora* in having its wall layer appressed ventrally instead of distally.

Stephodium coronatum Deflandre 1936a

Pl. 28, figs 1-2

- 1936a *Stephodium coronatum* Deflandre, p. 59; fig. 104.
1962 *Stephodium australicum* Cookson & Eisenack, p. 491; pl. 2, figs 5-10.
1964 *Stephodium europaicum* Cookson & Hughes, p. 50; pl. 8, figs 9-17.

Measurements—Maximum diameter of outer membrane 65-82 μm , minimum diameter of outer membrane 52-69 μm , diameter of central body 36-54 μm (Davey, 1970); maximum overall dimensions 81-73 μm , body dimensions 62 \times 49 μm , membrane flange up to 16 μm in specimens of this study.

Previous records—Late Aptian-Senonian. Late Aptian-Cenomanian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1970; Duxbury, 1983); Albian-Senonian, France (Deflandre 1936a, 1936b; Mercier, 1938; Davey & Verdier, 1971, 1973; Foucher, 1974; Foucher & Taugourdeau, 1975); Albian, Romania (Baltes, 1967b); Upper Cretaceous, Canada (Manum & Cookson, 1964; Millioud *et al.*, 1975; Singh, 1983).

Genus—*Subtilisphaera* Jain & Millepied 1973

- 1973 *Subtilisphaera* Jain & Millepied, p. 26.

Type species—*Subtilisphaera senegalensis* Jain & Millepied 1973 (original designation).

Remarks—*Subtilisphaera* includes proximate cavate cysts which may be compressed in a subspherical to round peridinioid shape. It lacks any discernible archeopyle but may have an apical horn and has two antapical horns or protrusions. Its paratabulation is generally indicated by paracingulum only.

Subtilisphaera is very similar to *Saepodinium* and *Geiselodinium* which have combination and intercalary archeopyle. The nature of the archeopyle in *Subtilisphaera* is not certain, hence considered separately (see Stover & Evitt, 1978, p. 239).

Subtilisphaera cheit Below 1981

Pl. 28, figs 3-8

- 1981a *Subtilisphaera cheit* Below, p. 126; pl. 9, figs 23-24; text-fig. 85.

Measurements—Pericyst length and breadth 48-78 \times 28-48 μm , endocyst length and breadth 36-50 \times 24-48 μm ; appendage length 2.5-6 μm (Below, 1981a); pericyst 60-70 \times 40-52 μm , endocyst diameter 36-42 μm , spinule length ca 6 μm in specimens of this study.

Previous records—Aptian-Albian, Morocco (Below, 1981a); Late Aptian-Early Cenomanian,

Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Genus—*Surculosphaeridium* Davey et al. in Davey et al. 1966

1966 *Surculosphaeridium* Davey, Downie, Sarjeant & Williams in Davey et al., p. 160.

Type species—*Surculosphaeridium cribratiferum* (Sarjeant) Davey, Downie, Sarjeant & Williams in Davey et al. 1966 = *Hystrichosphaeridium cribratiferum* Sarjeant 1960 (original designation).

Remarks—*Surculosphaeridium* consists of skolochorate cysts having a spherical body with an apical archeopyle. It has several discrete solid and distally branched intratabular processes indicating a gonyaulacacean paratabulation (Stover & Evitt, 1978, p. 83). It is distinct from *Hystrichosphaeridium* in having solid processes; and from *Areosphaeridium* in lacking distally fenestrate processes.

Surculosphaeridium longifurcatum (Firtion)
Davey et al. in Davey et al. 1966

Pl. 29, figs 1-2

1952 *Hystrichosphaeridium longifurcatum* Firtion, p. 157; pl. 9, fig. 1; text-fig. I, H, K, L, M.

1963 *Baltisphaeridium longifurcatum* (Firtion) Downie & Sarjeant, p. 91 (basonymo non cit.)

1966 *Surculosphaeridium longifurcatum* (Firtion) Davey, Downie, Sarjeant & Williams in Davey et al., p. 163; pl. 8, figs 7, 11; text-figs 43, 44.

Measurements—Shell 30-50 μm , length of processes 14-29 μm (Davey et al., 1966); overall 62-93 \times 50-65 μm , shell 30-45 \times 24-36 μm , and length of processes 5-20 μm (Srivastava, 1984); overall 65 μm , body 44 μm , process length 13 μm in specimens of this study.

Previous records—Barremian-Coniacian. Lower Barremian, southeastern France (Srivastava, 1984); Upper Barremian-Upper Aptian, northern Germany (Below, 1982b); Albian-Coniacian (Davey et al., 1966; Fauconnier, 1975; Davey, 1969; Davey & Verdier, 1971; Foucher, 1972, 1976; Foucher & Taugordeau, 1975; Williams, 1975; Millioud, Williams & Lentin, 1975; Jain, 1977; Duxbury, 1983).

Genus—*Tanyosphaeridium* Davey & Williams in Davey et al. 1966

1966 *Tanyosphaeridium* Davey & Williams in Davey et al., p. 98.

Type species—*Tanyosphaeridium variecalamum* Davey & Williams in Davey et al., 1966 (original designation).

Remarks—The genus *Tanyosphaeridium* encompasses elongate ellipsoidal cysts with an apical archeopyle and distally open tubular processes that are not interconnected distally. *Tanyosphaeridium* is distinct from *Prolixosphaeridium* in having longer, distally open processes.

Tanyosphaeridium regulare Davey & Williams in Davey et al. 1966
Pl. 29, figs 3-4

1966 *Tanyosphaeridium regulare* Davey & Williams in Davey et al., p. 99; pl. 3, fig. 4 (non fig. 3, as cited).

Measurements—Central body length and breadth 30-44 \times 21-24 μm , process length 12-19 μm (Davey & Williams in Davey et al., 1966); body 34-38 \times 22-23 μm , process length 14-15 μm in specimens of this study.

Remarks—*Tanyosphaeridium regulare* differs from *T. variecalamum* in having more processes.

Previous records—Hauterivian-Eocene. Hauterivian-Cenomanian, Morocco (Below, 1982a); Maastrichtian, southern Sweden (Kjellström, 1973); Eocene, England (Davey & Williams in Davey et al., 1966; Bujak et al., 1980).

Genus—*Trichodinium* Eisenack & Cookson emend. Clarke & Verdier 1967

1960 *Trichodinium* Eisenack & Cookson, p. 5.

1967 *Trichodinium* Eisenack & Cookson emend. Clarke & Verdier, p. 18.

Type species—*Trichodinium pellitum* Eisenack & Cookson 1960 (original designation).

Remarks—*Trichodinium* consists of proximochorate cysts having a subspherical to ellipsoidal body with a short apical protrusion, precingular archeopyle and short densely distributed processes on the autophragm. It differs from *Xenicodinium* in having indications of paracingulum, more densely covered autophragm, and an apical protrusion; from *Apteodinium* in having densely ornamented autophragm; from *Cometodinium* in having an apical protrusion; from *Exochosphaeridium* in having an indication of a paracingulum and shorter autophragm sculpture.

Trichodinium castaneum (Deflandre) Clarke & Verdier 1967

Pl. 29, figs 5-8

1935 *Palaeoperidinium castanea* Deflandre, p. 229; pl. 6, fig. 8 (err. orth. pro. *Castaneum*).

1967 *Trichodinium castanea* (Deflandre) Clarke & Verdier, p. 19; pl. 1, figs 1-2 (err. orth. pro. *castaneum*).

Measurements—Body diameter 35-64 μm , process length 1.5 μm (Davey, 1969); body dimensions 45.50 \times 39.49 μm , process length 1.4 μm (Foucher, 1974); body 70.83 \times 62.66 μm (McIntyre & Brideaux, 1980); body 42.65 \times 36.60 μm , process length 1.4-3.6 μm (Below, 1981a); body diameter 46.63 μm , process length 3.5 μm in 5 specimens of this study.

Previous records—Valanginian-Maastrichtian. Valanginian-Santonian, Canada (McIntyre, 1974; Millioud *et al.*, 1975; Williams, 1975; McIntyre & Brideaux, 1980); Barremian-Lower Turonian, England (Clarke & Verdier, 1967; Davey, 1969, 1974; Duxbury, 1980); Albian-Senonian, France (Deflandre, 1935; Mercier, 1938; Davey, 1969; Davey & Verdier, 1971; Foucher, 1972, 1974; Foucher & Robaszynski, 1977); Hauterivian-Cenomanian, southwestern Morocco (Below, 1981a); Early Albian, India (Jain, 1977); Middle and Upper Cretaceous, Australia (Morgan, 1980; Cookson & Eisenack, 1982); Cenomanian, Australia (Norvick & Burger, 1976); Turonian-Maastrichtian, South Atlantic Ocean, offshore southwestern Africa (Harris, 1976; Davey, 1978); offshore northeastern South America (Ioannides & Colin, 1977); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

Upper Jurassic records of *Trichodinium* (Vozzhennikova, 1967; Fensome, 1979; Ashraf, 1979) are doubtful and not included above.

Genus—*Trigonopyxidia* Cookson & Eisenack 1961

- 1960b *Trigonopyxis* Cookson & Eisenack *non* Penard, p. 11.
 1961 *Trigonopyxidia* Cookson & Eisenack, p. 75 (basionym *non* cit.).
 1964 *Trigonopyxidia* Cookson & Eisenack in Manum & Cookson, p. 26.

Type species—*Trigonopyxidia ginella* (Cookson & Eisenack) Manum & Cookson 1964 = *Trigonopyxis ginella* Cookson & Eisenack 1960b (original designation).

Remarks—Cookson and Eisenack (1960b) instituted the genus *Trigonopyxis* for triangular, proximate, circumcavate and compressed cysts with a round endocyst. The outer shell wall has an archeopyle at the apex (Stover & Evitt, 1978). Since the name *Trigonopyxis* was preoccupied in zoological nomenclature, Cookson and Eisenack (1961) proposed *Trigonopyxidia* to replace *Trigonopyxis* Cookson & Eisenack 1960, *non* Penard. However, the type species, transferred by Manum and Cookson (1964) met all formal requirements and predates its citation in Downie and Sarjeant (1964).

Trigonopyxidia is distinct from *Palaeotetradinium* in having a concavely triangular outline.

Trigonopyxidia ginella (Cookson & Eisenack) Manum & Cookson 1964

Pl. 29, figs 9-11

- 1960b *Trigonopyxis ginella* Cookson & Eisenack, p. 11; pl. 3, figs 18-20.
 1964 *Trigonopyxidia ginella* Cookson & Eisenack—Manum & Cookson, p. 26; pl. 6, fig. 6 [err. cit. pro (Cookson & Eisenack) Manum & Cookson]; (publication date February 1964).
 1964 *Trigonopyxidia ginella* Cookson & Eisenack—Cookson & Hughes, p. 57; pl. 11, fig. 6 (basionym *non* cit.).
 1964 *Trigonopyxidia ginella* (Cookson & Eisenack, 1960a)—Downie & Sarjeant, p. 149 (basionym *non* cit.; publication date December 1964; effective publication date 1965).
 1966 *Trigonopyxidia ginella* (Cookson & Eisenack) Downie & Sarjeant 1964 [1965]—Loeblich, Jr. & Loeblich III, p. 59.
 1978 *Trigonopyxidia ginella* (Cookson & Eisenack) Downie & Sarjeant 1965—Stover & Evitt, p. 96.

Measurements—Shell 50.66 μm , inner body 30.43 μm (Cookson & Eisenack, 1960b); shell 48 \times 47 μm , inner body 25 μm in a specimen of this study.

Previous records—Albian-Maastrichtian (see Millioud *et al.*, 1975).

Genus—*Trithyrodinium* Drugg emend. Lentin & Williams 1976

- 1967 *Trithyrodinium* Drugg, p. 20.
 1976 *Trithyrodinium* Drugg emend. Lentin & Williams, p. 98.

Type species—*Trithyrodinium evittii* Drugg 1967 (original designation).

Remarks—*Trithyrodinium* consists of proximate, cavate and subspherical to ellipsoidal cysts with one short apical horn and two poorly developed antapical horns of nearly equal size. Periphragm is usually fragile and sometimes only the endocyst is found preserved. Endoarcheopyle is intercalary by removal of three plates.

Trithyrodinium is distinct from *Deflandrea* in having an archeopyle formed by the removal of three intercalary plates rather than one.

Trithyrodinium suspectum (Manum & Cookson) Davey 1969

Pl. 29, figs 11-12

- 1964 *Hexagonifera suspecta* Manum & Cookson, p. 9; pl. 1, figs 9-13.

1969b *Trithyrodinium suspectum* (Manum & Cookson) Davey, p. 12.

Size measurements—Overall length 91-97 μm , shell diameter 65-78 μm (Manum & Cookson, 1964); endocyst length and breadth 55-65 \times 49-60 μm in seven specimens of this study.

Previous records—Cenomanian-Campanian. Lower Upper Cretaceous, Graham Island, Arctic Canada (Manum & Cookson, 1964); and Santonian-Lower Campanian, Horton River Range, district of Mackenzie, N.W.T., Canada (McIntyre, 1974).

Genus—*Wallogdinium* Loeblich, Jr. & Loeblich, III 1968

non 1874 *Diplotesta* Brongniart, p. 247.

1960a *Diplotesta* Cookson & Eisenack, p. 256.

1968 *Wallogdinium* Loeblich, Jr. & Loeblich, III, p. 212.

Type species—*Wallogdinium glaessneri* (Cookson & Eisenack) Loeblich, Jr. & Loeblich, III 1968 = *Diplotesta glaessneri* Cookson & Eisenack 1960a.

Remarks—Loeblich, Jr. and Loeblich, III (1968) substituted the generic name *Wallogdinium* for *Diplotesta* Cookson & Eisenack, a homonym of the fossil plant-seed genus *Diplotesta* Brongniart. The genus *Wallogdinium* includes ellipsoidal, elongate, cavate cysts with an apical archeopyle and a considerably smaller endocyst in comparison to the pericyst. *Wallogdinium* is distinct from *Svalbardella* in having an apical archeopyle and in lacking paratabulation indications.

Wallogdinium lunum (Cookson & Eisenack)
Lentin & Williams 1973

Pl. 29, fig. 13

For synonymy see Srivastava (1984, p. 62).

Measurements—Length and breadth 70 \times 30 μm (Cookson & Eisenack, 1960b); 105-125 \times 34-45 μm (Alberti, 1961); 80-134 \times 29-44 μm (Cookson & Hughes, 1964); 77-135 \times 29-48 μm (Duxbury, 1977; size ranges of *W. krutzschii* and *W. lunum* are included here together); 52-117 \times 32-50 μm (Srivastava, 1984); overall 101 \times 47 μm , inner body 65 \times 36 μm in specimens of this study.

Remarks—Davey (1974), Davey and Verdier (1974) and Brideaux (1977) considered *Wallogdinium lunum*, *W. krutzschii* and *W. anglicum* as synonyms.

Previous records—*Wallogdinium lunum* has been reported throughout in the Cretaceous but Hauterivian-Cenomanian may be its reliable range. Berriasian-Cenomanian, England (Duxbury, 1977, 1983; Cookson & Hughes, 1964; Davey, 1970, 1974);

Hauterivian-Aptian, Germany (Alberti, 1961; Below, 1982b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Aptian-Cenomanian, France and Switzerland (Davey & Verdier, 1973, 1974; Fauconnier, 1975); Valanginian, North Atlantic sub-bottom (Habib, 1972); Hauterivian-Barremian (Brideaux, 1977) and Santonian-Campanian, Canada (McIntyre, 1974); Upper Cretaceous, Western Siberia, U.S.S.R. (Vozzhennikova, 1967); Hauterivian-Aptian, Morocco (Below, 1981a); Late Aptian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); latest Neocomian-Cenomanian, Australia (Kemp, 1976; Cookson & Eisenack, 1960b; Norvick & Burger, 1976; Morgan, 1980).

Genus—*Xenascus* Cookson & Eisenack 1969

1969 *Xenascus* Cookson & Eisenack, p. 7.

Type species—*Xenascus australense* Cookson & Eisenack 1969 (original designation).

Remarks—*Xenascus* consists of ceratioid proximate to proximochorate, cornucavate cysts with a subspherical to ellipsoidal endocyst. Its periphragm has one apical, one antapical, and rarely one lateral horn or two lateral unequal horns with wide bases. The periphragm has a variable number of irregularly distributed processes or small protrusions varying in shape and size. *Xenascus* has an apical archeopyle.

Xenascus is similar to *Phoberocysta* but can be distinguished in having wider based horns and very different lateral horns.

Xenascus ceratioides (Deflandre) Lentin & Williams 1973

Pl. 30, fig. 1

1937 *Hystrichosphaeridium ceratioides* Deflandre, p. 66; pl. 12, figs 7-8.

1966 *Pseudoceratium ceratioides* (Deflandre) Deflandre, p. 6.

1973 *Xenascus ceratioides* (Deflandre) Lentin & Williams, p. 144.

Measurements—Overall dimensions of the central body 64-70 \times 72-80 μm , length of apical horn 80-120 μm , antapical horn 84-120 μm , lateral horns 60-86 μm , process length and breadth 33-36 \times ca 12 μm ; archeopyle diameter 48-60 μm (Yun, 1981); overall 50-78 \times 52-70 μm in specimens of this study.

Previous records—Albian-Maastrichtian (see Yun, 1981). Late Albian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984).

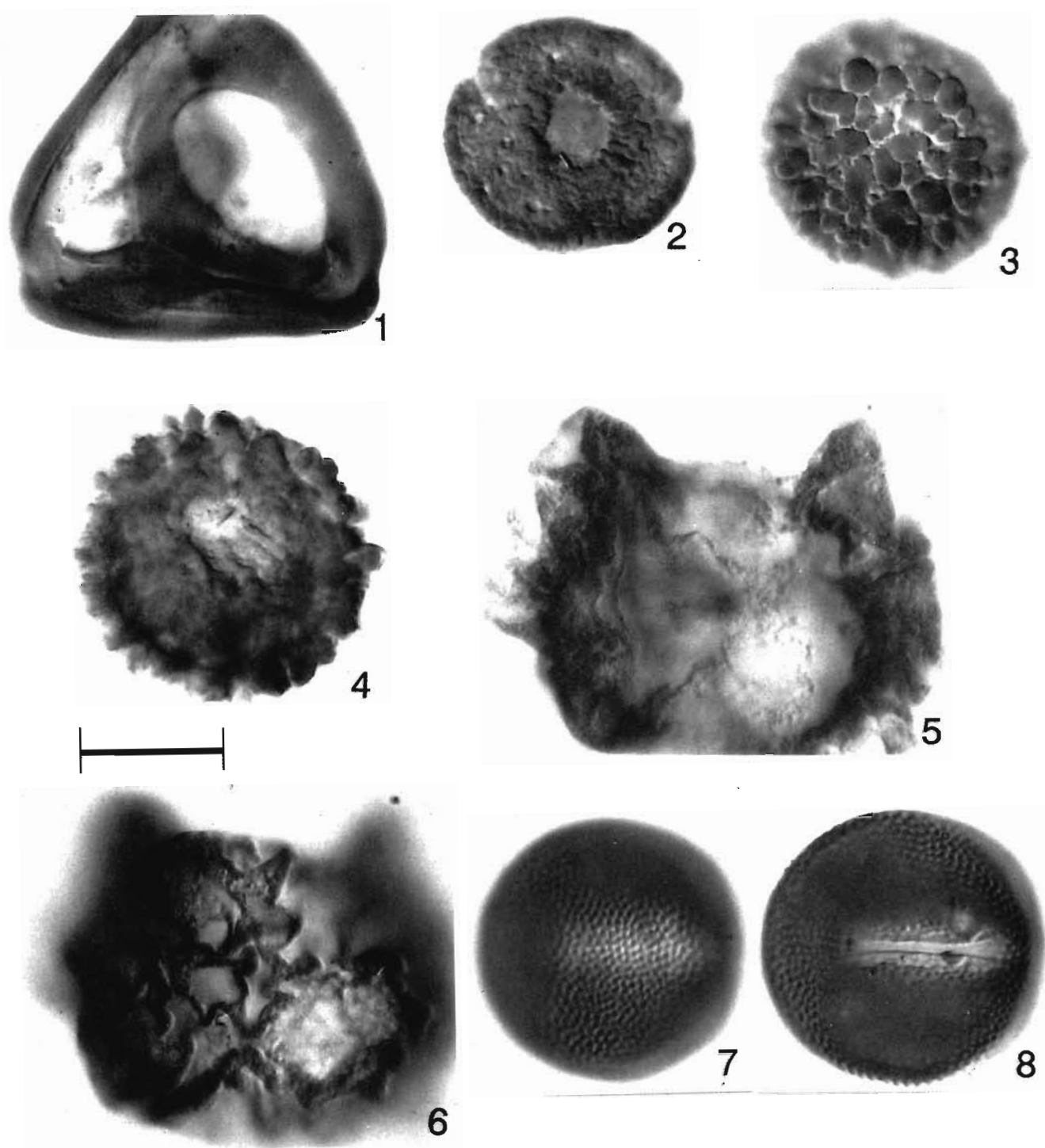


PLATE 38

1. Trilete spore—*incertae sedis* (CRC 32131-7/1A : 52.0/98.5, 84017/13, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
2. *Exesipollenites tumulus* Balme (CRC 32131-7/2A : 34.6/105.5, 84018/21, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
- 3, 4. *Cerebropollenites macroverrucosus* (Thiergart) E. Schulz (CRC 32131-7/2A : 29.8/110.0, 84018/27, 26, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
- 5, 6. *Rugubivesiculites reductus* Pierce (CRC 32131-7/2A : 26.3/98.8, 84018/9, 10, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
- 7, 8. *Clavatipollenites* sp. (CRC 32131-7/1A : 42.4/107.0, 84017/31, 30, $\times 100$; Arcadia Park Member of the Eagle Ford Formation).
- Scale bar length = 20 μm .

Genus—*Xiphophoridium* Sarjeant in Davey et al. 1966

1966 *Xiphophoridium* Sarjeant in Davey et al., p. 146.

1967 *Pyramidium* Clarke & Verdier, p. 39.

Type species—*Xiphophoridium alatum* (Cookson & Eisenack) Sarjeant in Davey et al. 1966 = *Hystrichodinium alatum* Cookson & Eisenack 1962 (original designation).

Remarks—*Xiphophoridium* consists of subspherical to subpolyhedral gonyaulacacean proximochorate cysts with an apical archeopyle in which paratabulation is indicated by high parasutural septa with widely to closely spaced crestal spines. *Xiphophoridium* is distinct from *Hystrichodinium* and *Dinopterygium* in having an apical archeopyle.

Xiphophoridium alatum (Cookson & Eisenack)
Sarjeant in Davey et al. 1966

Pl. 30, figs 2-3

1962 *Hystrichodinium alatum* Cookson & Eisenack, p. 487; pl. 2, figs 1-4.

1966 *Xiphoridium alatum* (Cookson & Eisenack) Sarjeant in Davey et al., p. 147; pl. 16, fig. 11. (err. typogr. pro *Xiphophoridium*).

1967 *Pyramidium alatum* (Cookson & Eisenack) Clarke & Verdier, p. 40; pl. 6, figs 5-6.

Measurements—Ranges of overall length and breadth 100-125 × 92-100 μm, shell length and breadth 32-70 × 40-65 μm, length of processes 16-45 μm (Cookson & Eisenack, 1962; Sarjeant in Davey et al., 1966; Davey, 1970; Foucher, 1972); overall diameter 68-83 μm, body 50-62 μm, process length 13-31 μm in specimens of this study.

Previous records—Upper Albian-Coniacian. Upper Albian-Coniacian (Cookson & Eisenack, 1962; Sarjeant in Davey et al., 1966; Clarke & Verdier, 1967; Davey, 1970; Foucher, 1972; Davey & Verdier, 1971, 1973; Norvick & Burger, 1976; Williams, 1978; Yun, 1981). *Xiphophoridium alatum* reported from the Barremian of the Speeton Clay, England (Davey, 1974) and from the Aptian-Barremian of DSDP Leg 11 (Habib, 1972) are doubtful.

Acritarchs**Genus—*Micrbystridium* Deflandre 1937**

1937 *Micrbystridium* Deflandre, p. 79.

Type species—*Micrbystridium inconspicuum* (Deflandre) Deflandre 1937 = *Hystrichosphaera inconspicua* Deflandre 1935 (original designation).

Micrbystridium stellatum Deflandre 1945

Pl. 30, figs 4-9

1942 *Micrbystridium stellatum* Deflandre, p. 476; figs 7-8 (nom. nud.)

1945 *Micrbystridium stellatum* Deflandre. Deflandre, p. 27; pl. 3, figs 16-19.

Measurements—Overall diameter 25-28 μm with spines about 11-16 μm long (Deflandre, 1945); shell diameter 21-24 μm, spines 11-12 μm long (Singh, 1971); Shell 27-40 μm, spines 11-20 μm long (Srivastava, 1984); shell 20-25 μm, spines 15-17 μm long in specimens of this study.

Genus—*Pterospermella* Eisenack 1972

1972 *Pterospermella* Eisenack, p. 597.

Type species—*Pterospermella aureolata* (Cookson & Eisenack) Eisenack 1972 = *Pterospermopsis aureolata* Cookson & Eisenack 1958 (original designation).

Pterospermella aristotelesii (Ioannides et al.) S.
K. Srivastava 1984

Pl. 31, figs 1-4

1977 *Pterospermopsis aristotelesii* Ioannides, Stavrinou & Downie, p. 466; pl. 5, figs 22-25.

1984 *Pterospermella aristotelesii* (Ioannides et al.) S. K. Srivastava, p. 67; pl. 36, figs 9-10.

Measurements—Overall diameter 50-100 μm, central body diameter 28-65 μm (Ioannides et al., 1977); overall 46-102 × 40-89 μm, central body 28-53 μm (Srivastava, 1984); overall 81-104 μm, body 47-57 μm in specimens of this study.

Previous records—Kimmeridgian, England (Ioannides et al., 1977); Barremian, France (Srivastava, 1984).

Genus—*Tubulospina* Davey 1970

1970 *Tubulospina* Davey, p. 375.

Type species—*Tubulospina oblongata* Davey 1970 (original designation).

Remarks—*Tubulospina* includes acritarchs with triangular to polygonal tests having tapering processes at each apex, and 1-6 subsidiary processes arranged symmetrically on the body. The processes are long, tapering, hollow, and closed both proximally and distally.

Tubulospina oblongata Davey 1970

Pl. 31, figs 5-8

1970 *Tubulospina oblongata* Davey, p. 376; p. 8, figs 7-9; text-fig. 4.

Measurements—Body diameter 13-32 μm , process length ca 30 μm (Davey, 1970); body about 22 μm with process up to 50 μm long in specimens of this study.

Previous records—Cenomanian, England and France (Davey, 1970).

Spores and Pollen

For a complete list of spores and pollen please see page 160.

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