Dinocyst biostratigraphy of Santonian-Maastrichtian formations of the Western Gulf Coastal Plain, southern United States

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This palynological investigation of Santonian-Maastrichtian formations of Texas, U.S.A., consists of an examination of 82 outcrop samples from 19 stratigraphic sections exposed in 9 counties in a north-south trend from about Dallas to Kinney. The Austin Chalk Formation, the Taylor Group, and the lower Navarro Group are examined for palynological data. Most of the samples are rich in dinocyst assemblages. In a total assemblage of 163 palynomorph species in 95 genera, 111 dinocyst species of 60 genera, 6 acritarch species of 5 genera, and 46 spore-pollen species of 33 genera are recognized and their stratigraphic distribution documented. Systematic descriptions and illustrations of all dinocyst and acritarch taxa are given. Spore-pollen taxa occur sporadically in the studied sections and thus are only listed, illustrated, and their occurrences noted in the text.

The stratigraphic distribution of dinocyst species indicating the Santonian age can be recognized by the presence of *Chatangiella granulifera, C. robusta, C. spectabilis, Phelodinium gadiatum* and *Spinidinium lanternum*. The characteristic species of Campanian assemblage are: *Cannosphaeropsis hyperacantha, C. utinensis, Ceratiopsis subquadra, Chatangiella armata, C. williamsii, Diconodinium martianum, Dinogymnium denticulatum, D. euclaense, D. nelsonense, Impagidinium cristatum, I. microarmum, Rottnestia borussica, Triblastula utinensis* and *Xenascus gochtii*.

The appearance of the following dinocyst species, viz., *Andalusiella acicornuta, Areoligera senonensis, Ceratiopsis navarriana, Glaphyrocysta retiintexta, Lejeunecysta decorinassa, L. hyalina, Lutosphaeridium fenestreconum, Palaeocystodinium australinum, Phelodinium tricuspe* and *Thalassiphora bononiensis* in the Maastrichtian is significant.

Pollen occurrences indicate that the land area, west of the Senonian epeiric sea, was terrigenous source in the Santonian and the Late Maastrichtian whereas the land on the east of the epeiric sea was the source in the Campanian.

Key-words—Palynology, Dinocysts, Santonian-Maastrichtian, Western Gulf (U.S.A.).

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सारॉंश

दक्षिणी संयुक्त राज्य में दक्षिणी गल्फ़ तटीय मैदान के सैन्तोनियन-मॉस्ट्रिक्शियन शैल-समूहों का घूर्णीकशाभपुटी जैवस्तरविन्यास

सतीश कुमार श्रीवास्तव

संयुक्त राज्य अमेरिका में टेक्सास के सैन्तोनियन-मॉस्ट्रिक्शियन शैल-समूहों के परागाणविक अन्वेषण में डेल्लस से किन्ने तक उत्तर से दक्षिण की ओर नौ देश-भागों में विगोपित 19 स्तरिकीय खण्डों से प्राप्त 82 दृश्यांश नमूनों का अध्ययन किया गया है। ऑस्टिन चाक शैल-समूह, टेलर समूह तथा अधरि नवर्रो समूह के परागाणविक आँकड़ों का अध्ययन किया गया है। अधिकतर नमूने घूर्णीकशाभपुटी समुच्चयों से भरपूर हैं। कुल मिलाकर 95 प्रजातियों एवं 163 जातियों वाली इस समुच्चय में 60 प्रजातियों की 111 घूर्णीकशाभपुटी जातियाँ, ऐक्रीटार्को की 5 प्रजाति एवं 6 जातियाँ तथा बीजाणु-परागकणों की 33 प्रजाति एवं 46 जातियाँ अभिनिर्धारित की गई है। घूर्णीकशाभपुटीयों एवं ऐक्रीटार्को के वर्गीकृत वर्णन एवं चित्र आदि भी दिये गये है। अध्ययन किये गये खंडों में बीजाणु-परागकण अपेक्षाकृत अल्प मात्रा में विद्यमान हैं और इसीलिए इनकी तालिका, छायाचित्र आदि दिये गये हैं। ***शैटेन्जियॅल्ला ग्रेनुलिफ़ेरा, शै० रोबस्टा, शै० स्पेक्टेबाइलिस, फीलोडीनियम गाडीटेटम*** एवं ***स्पाइनीडीनियम लैंटर्नम्*** की उपस्थिति के कारण सैन्तोनियन आयु सुनिश्चित की गई है। ***कैन्नोस्फ़ेयरॉप्सिस हाइपरकेन्था, कै० यूटीनेन्सिस, सिरॅटिऑप्सिस सबक्वाड्रा, शैटेन्जियॅल्ला आर्मेटा, शै० विलियमसाई, डाइकोनोडीनियम् मार्शियानम्, डाइनोजिम्नियम् डेन्टिकुलाटम्, डा० यूक्लायेन्से, डी० नेल्सोनेन्से इम्पेजिडीनियम् क्रिस्टाटम्, इ० माइक्रोआर्मम, रॉटनेस्टिआ बौरुसिका, ट्राइब्लास्टुला यूटीनेन्सिस*** एवं ***जीनास्कस गोक्टाई*** नामक जातियाँ कैम्पेनियन आयु की द्योतक हैं।

ऍन्डालुसियॅल्ला एसिकॉर्नूटा, एरिओलिजेरा सीनोनेन्सिस, सिरेटिऑप्सिस नवर्रियाना, ग्लेफ़ाइरोसिस्टा रेटिन्टेक्सटा, लिजूनीसिस्टा डेकोरिनासा, लि० हिएलाइना, लिटोस्फ़ेयरीडियम् फ़ेनेस्ट्रेकॉनम्, पेलियोसिस्टोडीनियम् ऑस्ट्रेलाइनम्, फीलोडीनियम ट्राइकस्पे एवं ***थैलेसिफ़ोरा बोनोनियेन्सिस*** नामक घूर्णीकशाभपुटी जातियों का प्रादुर्भाव मॉस्ट्रिक्शियन आयु इंगित करता है।

परागकणों की उपस्थिति से इंगित होता है कि सीनोनियन कालीन समुद्र का पश्चिम भू-भाग सीनोनियन एवं अनंतिम मॉस्ट्रिक्शियन कल्प में स्थलजात स्रोत था जबकि इस समुद्र के पूर्व की भूमि सीनोनियन काल में स्थलजात स्रोत थी।

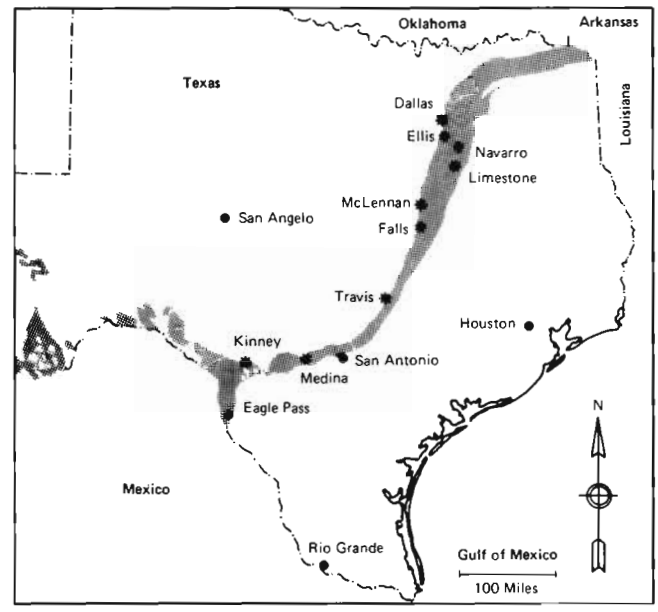
FREQUENT transgression-regression cycles of the Late Cretaceous North American epeiric sea deposited marine sequences in the western interior and the Gulf areas. Subsidence and tectonism in the area formed characteristic basins and developed structures for hydrocarbon traps and reservoirs. Practically all stages of North American Gulfian Series have produced oil and gas (Murray, 1961; Stehli *et al.*, 1972; Pratt, 1977) and thus are important economically. Almost all Gulfian stages are exposed in Texas, providing an ideal opportunity for biostratigraphic studies of the Upper Cretaceous and an objective potential for regional correlation of surface or subsurface continental and offshore strata.

Foraminiferal biostratigraphy of the Gulfian Series (Cushman, 1946; Pessagno, Jr., 1967, 1969; Longoria, 1984) provides a controlled zonation and determines unconformities and hiatuses. Planktonic marine dinoflagellates and other terrestrial or marine palynomorphs have abundant and varied occurrences in the sediments, providing a potential of fine zonation and regional correlations. No comprehensive study of Gulf Coastal Upper Cretaceous palynomorphs has been published. Thus, a project for the study of Upper Cretaceous palynomorphs of the Western Gulf Coastal Plain was initiated. The palynological study of the Cenomanian-Coniacian formations exposed in the Western Gulf Coastal Plain has been completed (Srivastava, 1991). This investigation consists of the results of palynological biostratigraphy of the Santonian-Maastrichtian formations exposed in the Western Gulf Coastal Plain.

Dinocysts dominate the palynomorph assemblages recovered from these formations which have mainly marine sediments. Systematic descriptions and illustrations of all encountered dinocysts and acritarch taxa are given to facilitate identifications. Spore-pollen taxa are only listed and illustrated 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 (Text-figure 1). Ninety-seven samples from 19 stratigraphic sections of Santonian-Maastrichtian age were collected in nine Texas counties. The relative stratigraphic positions of the samples studied are shown in Text-figure 2. The localities and other details of samples collected are given below. The locality numbers given below are



Text-figure 1—Map of Texas showing Upper Cretaceous deposits and sample collection localities.

the same as described in the field trip guidebook (Powell, 1970).

Locality D4, Dallas County—Lower and middle members of the Austin Chalk exposed on the east bank of Ten Mile Creek, 100-200 yards upstream from the bridge of Pleasant Run Road, 1 mile north and 1 mile east of DeSoto, Texas.

CRC 32131-1, lower chalk member, 18 ft above the base of the section; -2, lower chalk member, 27 ft above the base of the section; -3, lower chalk member, 30 ft above the base of the section.

Locality D5, Dallas County—Middle member of the Austin Chalk exposed on the north bank of Ten Mile Creek along Belt Line Road, 1/2 mile east of the Interstate Highway 35E.

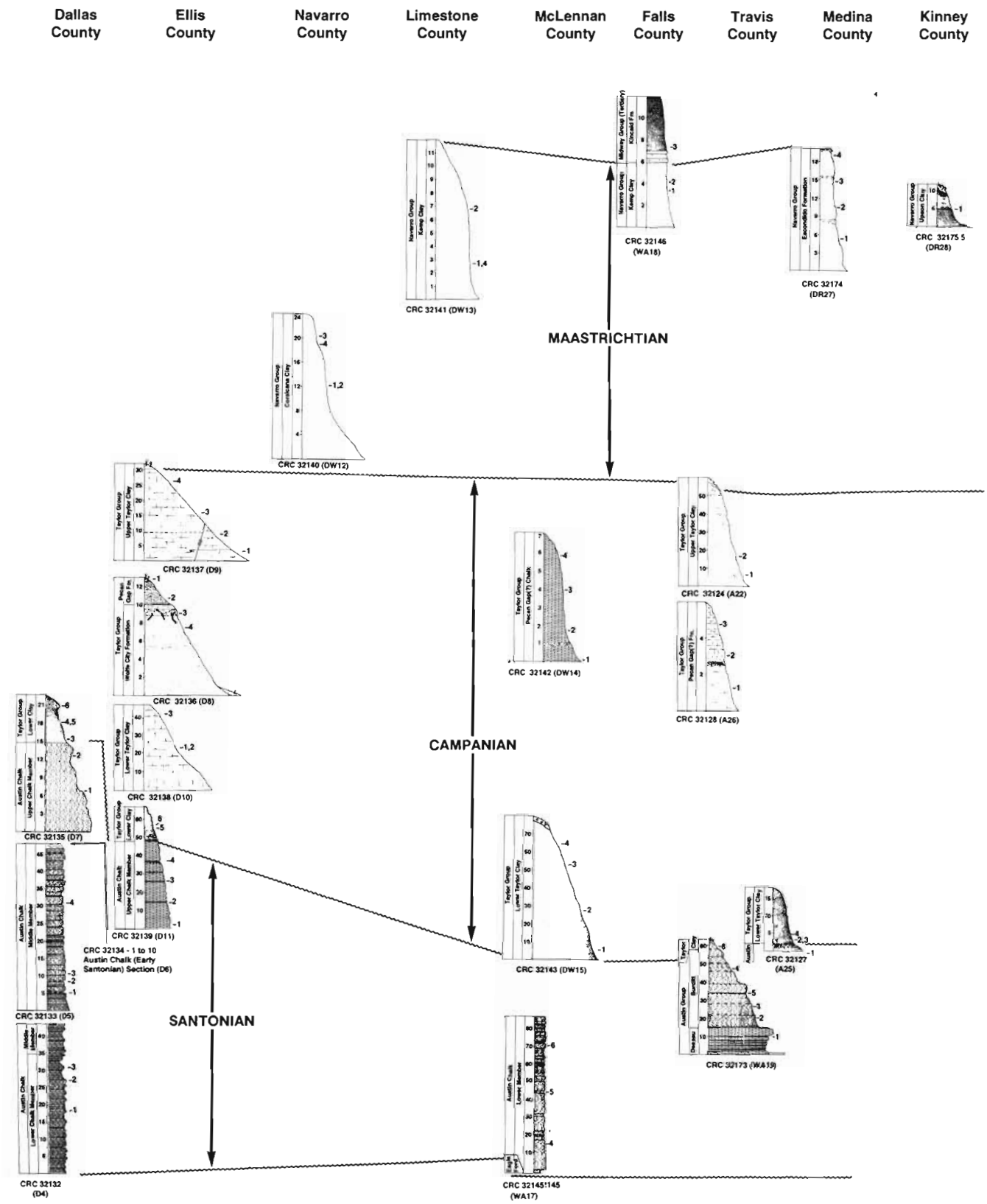
CRC 32133-1, middle chalk member, 5 ft above the base of the section; -2, middle chalk member, 9-1/2 ft above the base of the section; -3, middle chalk member, 11 ft above the base of the section; -4, middle chalk member, 31 ft above the base of the section.

Locality D6, Dallas County—Middle member of the Austin Chalk exposed in an abandoned quarry, 0.15 mile due north of R.J. Langdon home, 0.35 mile north of the intersection of J.J. Lemmons Road & Langdon Drive, just north of Hutchins, Texas.

CRC 32134-1, base of the exposed section; -2, 5 ft above the base; -3, 14 ft above the base; -4, 20 ft above the base; -5, 25 ft above the base; -6, 35 ft above the base; -7, 40 ft above the base; -8, 48 ft above the base; -9, 55 ft above the base; -10, 60 ft above the base.

Locality WA17, McLennan County—Lower chalk of the Austin Chalk exposed in various quarries of the

*Note: Locality D-6 as mapped out in the field trip guidebook has been destroyed by a freeway. D-6 has been taken as a substitute. See map on page A-35 of the Guidebook (Powell, 1970). Middle Austin is about 75 ft above the top of D-4 locality.



Text-figure 2—Outcrop sections in Texas counties showing samples collected and their relative stratigraphic positions. Locality designations are given in parentheses under sample series numbers. Locality designations are the same as given in the Field Trip Guidebook (Powell, 1970).

Atco Cement Company, located about 1 mile northeast of Locality WA16.

CRC 32145-1, base of the section (Eagle Ford) (Samples 1-3 limestone pit); -2, 6 ft below the Austin and 19 ft above the base of the section (Eagle Ford); -3, basal Austin, 25 ft above the base of the section (Austin Chalk, lower member); -4, 15 ft above the base of the section (Austin Chalk, lower member); -5, 44 ft above the base of the section (Austin Chalk, lower member); -6, 70 ft above the base of the section (Austin Chalk, lower member) (Samples 4-6 2nd pit).

Locality D11, Ellis County—Upper chalk member of the Austin Chalk and the lower Taylor Clay exposed just downstream from the spillway of Lake Waxahachie, about 4 miles southeast of Waxahachie, Texas, on Farm Road 877

CRC 32139-1, base of the section (the Austin Chalk, upper member); -2,15 ft above base of the section (the Austin Chalk, upper member); -3, 26 ft above the base of the section (the Austin Chalk, upper member); -4, 36 ft above the base of the section (the Austin Chalk, upper member); -5, in the Taylor Group (slump block); -6, 4 ft above the base of the Taylor

Locality WA19, Travis County—The upper Austin Chalk and the lowermost Taylor Clay exposed along the west side of Little Walnut Creek, 200-300 yards upstream from the U.S. Highway 290 bridge, east edge of Austin, Texas.

CRC 32173-1, 10 ft above the base (the Dessau); -2, 20 ft above the base of the section (6 ft above the Dessau in the Burditt); -3, 26 ft above the base of the section (12 ft above the Dessau in the Burditt); -4, 46 ft above the base of the section (31 ft above the Dessau in the Burditt); -5, 32 ft above the base of the section (18 ft above the Dessau in the Burditt); -6, 59 ft above the base of the section (1 ft above the base of the Taylor).

Locality A25, Travis County—Uppermost Austin and the lower Taylor Clay exposed in sharp bend of Little Walnut Creek, downstream from the bridge on Old Manor Road, in east-central Austin, just west of the U.S. 183 By-Pass.

CRC 32127-1, just below the section in Austin (2 ft below the top); -2, base of the Taylor; -3, base of the Taylor (farther downstream, less weathered); -4, 3 ft from the base of the lower Taylor Clay

Locality D7, Dallas County—Upper member of the Austin Chalk and the lower Taylor Clay exposed in the bed of Cottonwood Creek, western edge of Wilmer, Texas. Exposure is about 200 yards east of the old U.S. Highway 75 bridge over Cottonwood Creek.

CRC 32135-1, 8 ft below the Taylor (the Austin); -2, 3 ft below the Taylor (the Austin); -3, base of the Taylor; -4, 3 ft above the base of the Taylor; -5, 3 ft or at the most 4 ft above the base of the Taylor (-5 is a darker band at the same level as 4); -6, 6 ft above the base of the Taylor.

Locality D8, Ellis County—Parts of the Wolfe City and the Pecan Gap formations exposed in road ditch along east side of Andrews Road, approximately 800 feet south of its intersection with Slate Rock Road, 1.7 miles east of Bristol, Texas.

CRC 32136-1, 3 ft above the base of the Pecan Gap; -2, base of the Pecan Gap-just above the phosphatic zone; -3, 9 ft above the base of the section (1 ft below the Pecan Gap); -4, 7 ft above the base of the section (3 ft below the Pecan Gap).

Locality D9, Ellis County—Part of the Upper Taylor Clay exposed in the east-flowing gullies just east of Andrews Road, about 2 miles south of Locality D-8.

CRC 32137-1, 2 ft above the base of the section; -2, 9 ft above the base of the section; -3, 16 ft above the base of the section, -4, 26 ft above the base of the section.

Locality D10, Ellis County—Part of the lower Taylor Clay exposed in an active quarry of the Barron Brick Pit, located in the northern part of Palmer, Texas.

CRC 32138-1, 22 ft above the base of the section; -2, 22 ft above the base of the section; -3, 40 ft above the base of the section (top of the Campanian according to Pessagno, 1969).

Locality DW14, McLennan County—The Pecan Gap Chalk exposed in the bed of Big Creek 0.5 mile downstream from the bridge over the same creek, just west of Mart, Texas.

CRC 32142-1, 1 ft just above the phosphatic zone; -2, 2 ft above the base; -3, 4 ft above the base; -4, 5 ft above the base.

Locality DW15, McLennan County—The lower Taylor Clay exposed along 80 feet high northwest-facing bank of Tradinghouse Creek, 1.6 airline miles east of its confluence with Tehuacana Creek, and 1.2 airline miles NNW of Harrison, Texas, which is east of Waco along the State Highway 6.

CRC 32143-1, 2 ft above the base; -2, 27 ft above the base; -3, 51 ft above the base; -4, 64 ft above the base.

Locality A26, Travis County—The Pecan Gap (?) chalky shale exposed in the road cuts along the Old Manor Road, 1 mile west of its junction with U.S. Highway 290, east of Austin.

CRC 32128-1, 1 ft above the base; -2, 3 ft above the base; -3, 4-1/2 ft above the base; Late Campanian or Early Maastrichtian (probably Early Maastrichtian).

Locality DR28, Kinney County—The Upson Clay exposed on south side of the Farm Road 1572 in the curve of the road near Lindsey Creek crossing and about 1.5 miles east of Spofford, Texas.

CRC 32175-1, 5 ft above the base.

Locality DW12, Navarro County—The Corsicana Clay of the Navarro Group exposed in an active quarry of Corsicana Brick Company, 1 mile south of Corsicana, Texas, along Farm Road 709.

CRC 32140-1, 12 ft above the base of the section; -2, 12 ft above the base of the section; -3, 20 ft above the base of the section (ferruginous); -4, 19 ft above the base of the section.

Locality DW13, Limestone County—The Kemp Clay of the Navarro Group exposed in drainage ditch at the intersection of Farm Roads 27 and 73, 2.5 miles east of Coolidge, Texas.

CRC 32141-1, 3 ft above the base; -2, 7 ft above the base; -3, 10-1/2 ft above the base; -4, 3 ft above the base (deeper in the hole than sample no. 1).

Locality DR27, Medina County—The Escondido Formation exposed along the west Bank of Seco Creek on the Rowe Ranch, 3 miles north of D'Hanis, and west of Farm Road 1796.

CRC 32174-1, 5 ft above the base; -2, 10-1/2 ft above the base; -3, 15 ft above the base; -4, 19 ft above the base.

Locality WA18, Falls County—The uppermost Kemp Clay and the lowest Kincaid Formation exposed above water level along the west bank of the Brazos River, 50-600 yards downstream from Farm Road 413 bridge, located about 8 miles southwest of Reagan, Texas.

CRC 32146-1, 2.5 ft below the contact (the Kemp Clay, east bank); -2, 4-1/2 ft above the base of the section (the Kemp Clay) and 1-1/2 ft below the contact; -3, 7 ft above the base of the section (the Kincaid Formation—Danian).

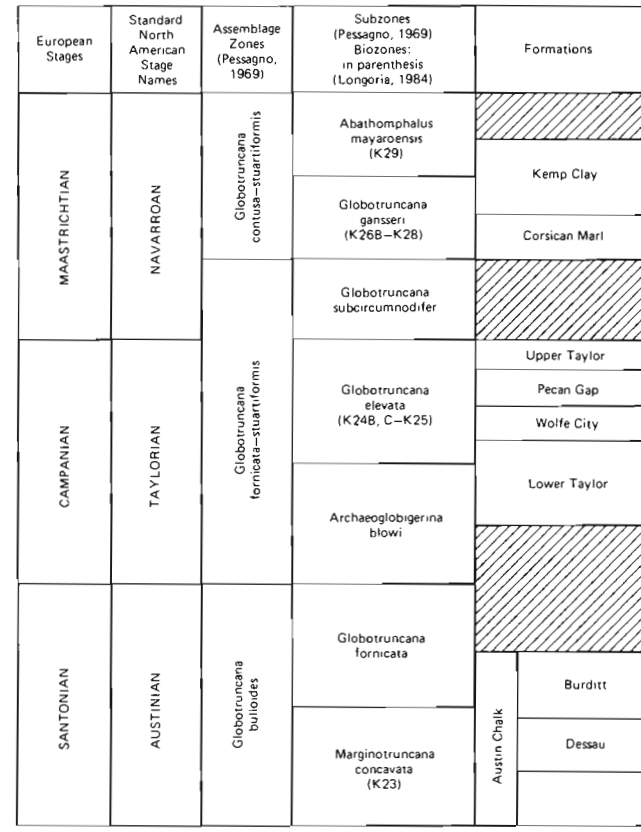
Palynomorphs were concentrated by conventional processing techniques to eliminate carbonates, silicates, and superfluous organic matter from the samples by dissolving them in dilute hydrochloric acid, hydrofluoric acid, and nitric acid successively. The residue samples were washed after each acid treatment. Palynomorphs 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, at least 2 to 3 slides of each fraction of a sample were examined to document palynomorphs present in a sample. In certain cases, several slides were prepared and examined. 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 4 × 5 inch negatives.

Systematic descriptions of each identified dinocyst taxon are given in this report. Diagnostic generic characteristics are noted for easy reference to distinguish among similar forms. Each identified taxon including acritarchs, spores, and pollen is illustrated by at least one example. Distribution ranges of individual dinocyst taxa are plotted by their appearance, their disappearance, and in alphabetical order of their names. Spore-pollen occurrences are noted under individual taxon listed following dinocyst and acritarch descriptions.

PALYNOLOGIC BIOSTRATIGRAPHY AND PALEOECOLOGY

The formations studied 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). Santonian-Maastrichtian outcrops in Texas have several missing stratigraphic intervals of various time-spans. Locally, the Coniacian is not represented in Waco-Dallas Counties (Pessagno, 1969). Similar hiatuses occur at Santonian-Campanian and Maastrichtian-Danian boundaries. Another hiatus has been identified in the upper part of Pessagno's (1969) *Rugotruncana (Globotruncana) subcircumnodifer* subzone (Text-figure 3).



Text-figure 3—Foraminiferal zonation and correlation of Santonian-Maastrichtian formations of Texas with European and North American stages.

The lithological boundary between the Austin Chalk and the Taylor Clay formations has recently been considered as time transgressive and without hiatus at certain localities (Marks & Stam, 1983). However, Coniacian-Santonian fauna found in the lower Taylor Clay may be reworked older fauna, particularly as suspected in the Taylor Clay exposed at the Tradinghouse Creek in McLennan County (Marks & Stam, 1983). Frequent transgressions and regressions of the North American inland sea created several hiatuses of various time-spans and introduced short-interval reworking of the older fauna or flora on younger deposits and have created confusion in determining correct ages (Evitt, 1973).

The appearance and disappearance levels of individual taxon are considered significant for determining their ranges in this report. Taxa occurring above and below hiatuses are assumed to occur during the time of the missing interval. Taxa recognized and documented in this report are listed below.

LIST OF PALYNOMORPH TAXA DOCUMENTED IN THIS STUDY

Dinoflagellate Cysts

Achomosphaera heterostylis (Heisecke) Stover & Evitt 1978
Adnatosphaeridium multispinosum Williams & Downie in Davey *et al.* 1966
Aiora fenestrata (Deflandre & Cookson) Cookson & Eisenack 1960
Aldorfia deflandrei (Clarke & Verdier) Stover & Evitt 1978
Andalusiella acicornuta S.K. Srivastava, n. sp.
Areoligera coronata (O. Wetzel) Lejeune-Carpentier 1938
A. senonensis Lejeune-Carpentier 1938
Batiacasphaera scrobiculata (Deflandre & Cookson) Burger 1980
Calligodinium amiculum Drugg 1970
Canningia colliveri Cookson & Eisenack 1960a
C. reticulata Cookson & Eisenack 1960a
C. senonica Clarke & Verdier 1967
Cannosphaeropsis hyperacantha Cookson & Eisenack 1960b
C. utinensis O. Wetzel 1933b
Cassiculosphaeridia reticulata Davey 1969a
Ceratiopsis navarriana S. K. Srivastava, n. sp.
C. striata (Drugg) Lentin & Williams 1977
C. subquadra Corradini 1973
Chatangiella armata (Cookson & Eisenack) Lentin & Williams 1976
C. granulifera (Manum) Lentin & Williams 1975
C. robusta (Benson) Stover & Evitt 1978
C. spectabilis (Alberti) Lentin & Williams 1976
C. victoriensis (Cookson & Manum) Lentin & Williams 1976
C. williamsii Yun 1981
Cleistosphaeridium aciculare Davey 1969a
C. giganteum (Caro) Stover & Evitt 1978
C. mediterraneum Corradini 1973
Cordosphaeridium fibrospinosum Davey & Williams in Davey *et al.* 1966
Coronifera oceanica Cookson & Eisenack 1958
Craspedodinium indistinctum Cookson & Eisenack 1974
Cribroperidinium edwardsii (Cookson & Eisenack) Davey 1969a
Cyclonephelium castelcasiense Corradini 1973
C. distinctum Deflandre & Cookson 1955
Diconodinium martianum S. K. Srivastava, n. sp.
Dinogymnium acuminatum Evitt, Clarke & Verdier 1967
D. albertii Clarke & Verdier 1967
D. cerviculum Cookson & Eisenack 1970
D. curvatum (Vozzhennikova) Lentin & Williams 1973
D. denticulatum (Alberti) Evitt, Clarke & Verdier 1967
D. digitum (Deflandre) Evitt, Clarke & Verdier 1967
D. elongatum May 1977
D. euclaense Cookson & Eisenack 1970
D. heterocostatum (Deflandre) Evitt, Clarke & Verdier 1967
D. kasachstanicum (Vozzhennikova) Lentin & Williams 1973
D. lanceolatum May 1977
D. microgranulosum Clarke & Verdier 1967
D. nelsonense (Cookson) Evitt, Clarke & Verdier 1967
D. rigaudiae Boltenhagen 1977
D. sibiricum (Vozzhennikova) Lentin & Williams 1973
D. sphaerocephalum (Vozzhennikova) Lentin & Williams 1973
Exochosphaeridium bifidum (Clarke & Verdier) Davey 1969b
E. muelleri Yun 1981
E. phragmites Davey *et al.* in Davey *et al.* 1966
Florentinia clavigera (Deflandre) Davey & Verdier 1973
F. cooksoniae (C. Singh) Duxbury 1980
F. laciniata Davey & Verdier 1973
F. mantellii (Davey & Williams) Davey & Verdier 1973
F. resex Davey & Verdier 1976
F. stellata (Maier) Below 1982a
Fromea amphora Cookson & Eisenack 1958
F. apiculata (Cookson & Eisenack) Stover & Evitt 1978
Glaphyrocysta retiintexta (Cookson) Stover & Evitt 1978
Hystrichodinium pulchrum Deflandre 1935
Impagidinium cristatum (May) Lentin & Williams 1981
Isabelidinium microarmum (McIntyre) Lentin & Williams 1977b
Kleithriasphaeridium loffrense Davey & Verdier 1976
Lanternosphaeridium lanosum Morgenroth 1966
Lejeunecysta decorinassa S. K. Srivastava, n. sp.
L. hyalina (Gerlach) Artzner & Dörhöfer 1978
Litosphaeridium fenestreconum (May) Lucas-Clark 1984
Litosphaeridium sp. *sensu* Stein 1983
Manumiella lata (Cookson & Eisenack) Bujak & Davies 1983
Membranilarnacia ovalis Cookson & Eisenack 1974
Odontochitina costata Alberti emend. Clarke & Verdier 1967
O. operculata (O. Wetzel) Deflandre in Deflandre & Cookson 1955 (not illustrated)
Oligosphaeridium complexum (White) Davey & Williams in Davey *et al.* 1966
Oligosphaeridium pulcherrimum (Deflandre & Cookson) Davey & Williams in Davey *et al.* 1966
Operculodinium major Jain & Dutta in Dutta & Jain 1980
Palaeocystodinium australinum (Cookson) Lentin & Williams 1976
Palaeohystrichophora infusorioides Deflandre 1935
Palaeoperidinium cretaceum Pocock ex Davey 1970
Phelodinium gaditanum (Riegel) Riegel & Sarjeant 1982
P. magnificum (Stanley) Stover & Evitt 1978
P. pentagonale (Corradini) Stover & Evitt 1978
P. tricuspe (O. Wetzel) Stover & Evitt 1978
Renidinium vitilare (Cookson) Stover & Evitt 1978
Rottnestia borussica (Eisenack) Cookson & Eisenack 1961
Senoniasphaera protrusa Clarke & Verdier 1967
Silicisphaera ferox (Deflandre) Davey & Verdier 1976
Spinidinium densispinatum Stanley 1965
S. echinoideum (Cookson & Eisenack) Lentin & Williams 1976
S. lanternum Cookson & Eisenack 1970
S. compactus Cookson & Eisenack 1974
S. ramosus subsp. *gracilis* (Davey & Williams) Lentin & Williams 1973
S. ramosus subsp. *granomembranaceus* (Davey & Williams) Lentin & Williams 1973
S. ramosus subsp. *multibrevis* (Davey & Williams) Lentin & Williams 1973
S. ramosus (Ehrenberg) Mantell 1854, subsp. *ramosus*
S. supparus (Drugg) Sarjeant 1970

Spongodinium delitiense (Ehrenberg) Deflandre 1936
Subtilisphaera cheit Below 1981
Surculosphaeridium longifurcatum (Firtion) Davey *et al* in Davey *et al* 1966
Tanyosphaeridium regulare Davey & Williams in Davey *et al* 1966
Thalassiphora hononiensis Corradini 1973
Triblastula utinensis O Wetzel 1933
Trichodinium castaneum (Deflandre) Clarke & Verdier 1967
Trigonopyxidia ginella (Cookson & Eisenack) Manum & Cookson 1964
Truhyrodinium druggii Stone 1973
T evittii Drugg 1977
Wallodinium lunum (Cookson & Eisenack) Lentin & Williams 1973
Xenascus ceratioides (Deflandre) Lentin & Williams 1973
X gochtii (Corradini) Stover & Evitt 1978

Acritarchs

Baltisphaeridium crameri C. Singh 1971
B infulatum Wall 1965
Horologinella extrema Cookson & Eisenack 1962
Micrhystridium exilium Wall 1965
Palambages morulosa O Wetzel 1961
Pterospermella aristotelesii (Ioannides *et al*) S. K. Srivastava 1984

Spores

Aequitriradites spinulosus (Cookson & Dettmann) Cookson & Dettmann 1961
Appendicisporites bilateralis C Singh 1964
A. potomacensis Brenner 1963
Appendicisporites sp.
Camarozonosporites concinnus S. K. Srivastava 1972a
Cicatricosisporites sp
C hallei Delcourt & Sprumont 1955
Echinatisporis levidensis (Balme) S. K Srivastava 1972a
Gabonisporis bacaricumulus S. K. Srivastava 1972a
Ghoshispora scollardiana S. K Srivastava 1966
Hamulatisporis rugulatus (Couper) S K Srivastava 1972a
Kuylisporites scutatus Newman 1965
Pilosisporites trichopapillosus (Thiergart) Delcourt & Sprumont 1955
Retitriletes saxatilis S K Srivastava 1972a
Trilete spore
Uvaesporites sp.

Gymnosperm Pollen

Classopollis classoides Pflug 1953
Eucommiidites sp.
Rugubivesiculites reductus Pierce 1961

Angiosperm Pollen

Albertipollenites sp.
Aquilapollenites amplus Stanley 1961a
A delicatus var *collaris* Tschudy & Leopold 1971
Bolchovitinaepollenites miniverrucatus Kedves & Diniz 1981
Complexiopollis exigua Christopher 1979
Extratriporopollenites fossulotrudens Pflug 1953
Extremipollis versatilis R Tschudy 1975
Margocolporites cribellatus S K. Srivastava 1972b
Margocolporites sp. 1
Margocolporites sp 2
Minorpollis minimus Krutzsch 1959
Plicapollis incisa Christopher 1979
P retusus R Tschudy 1975
P rusticus R. Tschudy 1975
Polyporina cribraria S K. Srivastava 1969
Proteacidites retusus Anderson 1960
P thalmannii Anderson 1960
Rhoipites cryptoporus S. K Srivastava 1972b
Santalacites minor Christopher 1979
Striatopollis sp
Tricolpites hians Stanley 1965
T micromunus (Groot & Penny) C Singh 1971
T mutabilis Leffingwell 1971
Tricolpopollenites compactus Norton in Norton & Hall 1969
Tricolporopollenites affluens (Stanley) Stone 1973
Wodehouseia spinata Stanley 1961b
Pollen tetrad *incertae sedis*

All formations studied here have marine sediments with abundant dinoflagellate cysts. Spore-pollen occurrences are sporadic, but their distribution indicates terrigenous sources. North American Senonian epeiric sea (Text-figure 4) extended from north to south, separating land areas completely on its eastern and western borders (Williams & Stelck, 1975). The terrestrial flora on either side of the Senonian epeiric sea of North America had discrete flora different from each other. The western flora belonged to the Normapolles phytogeoprovince and the eastern flora to the *Aquilapollenites* phytogeoprovince (Tschudy, 1971; Srivastava, 1978). The regression of the epeiric sea in the Late Maastrichtian opened land areas connecting

Text-figure 4—Map of North America showing land and sea distribution in the Middle Campanian (after Williams & Stelck, 1975)

eastern and western land areas of central North America. The flora of the two phytogeoprovinces intermingled and the provincialism disintegrated (Srivastava, 1981) at the end of the Cretaceous.

A single specimen of *Aquilapollenites amplus* was found in the middle Austin Chalk Formation exposed in Dallas County, indicating western land as the source of terrigenous material in the Early Santonian. The Campanian Taylor Clay Formation studied here yielded spores-pollen of Normapolles province. The emergence of Ozarks land in North American mid-Campanian seaways (Text-figure 4) may have become a main terrigenous source redepositing older microfossils such as those of the Coniacian-Santonian in the Taylor Clay (Marks & Stam, 1983). Late Maastrichtian pollen indicate that the source of deposition was again from the westward land of the *Aquilapollenites* province. The presence of *Wodehouseia spinata* in the Kemp Clay indicates that sedimentation represents a Lancian age.

The dinocysts dominating the assemblages are useful for biostratigraphy and zonation. Their distribution is plotted by their first appearance (Text-figure 5), their last appearance (Text-figure 6), and alphabetically (Text-figure 7). The specimens of *Cassiculosphaeridia reticulata, Craspedodinium indistinctum, Spiniferites compactus, Subtilisphaera cheit* and *Wallodinium lunum* appear to be reworked examples from the older strata as their ranges do not extend in the Senonian.

Chatangiella granulifera, C. robusta, C. spectabilis. Dinogymnium kasachstanicum, Phelodinium gaditanum and *Spinidinium lanternum* indicate a Santonian age. *Chatangiella granulifera, C. victoriensis, Exochosphaeridium bifidum* and *Palaeohystrichophora infusorioides* are common in Santonian assemblages studied here and those of northeastern Texas (Heine *in* Thompson *et al.*, 1991).

Cannosphaeropsis hyperacantha, C. utinensis, Ceratiopsis subquadra, Chatangiella armata, C williamsii, Diconodinium martianum, Dinogymnium denticulatum, D. sphaerocephalum, Impagidinium cristatum, I. microarmum, Membranilarnacia ovalis, Rottnestia borussica, Triblastula utinensis and *Xenascus gochtii* indicate a Campanian age in this study.

The dinoflagellate flora intermixed worldwide during the Campanian and Early Maastrichtian due to interconnected highstand seas. North American inland sea (Text-figure 4) extended longitudinally joining the Arctic Ocean in the north and the Gulf of Mexico in the south. Its eastward arm flooded the land south of the Hudson Bay joining the Atlantic Ocean. The palynomorph assemblage of this study has 30 dinoflagellate species common with the assemblages recorded from northeast Texas (Zaitzeff & Cross, 1971; Heine *in* Thompson *et al.*, 1991) and New Jersey, U.S.A. (May, 1980). *Dinogymnium elongatum* and *D. lanceolatum* are reported from Campanian-Early Maastrichtian sediments of New Jersey (May, 1980) and in this study. Their restricted occurrence in the two far removed localities of the United States is rather difficult to explain except that probably they have not been recognized in other contemporaneous deposits of the Senonian inland sea.

Canningia senonica, Cannosphaeropsis utinensis, Chatangiella spectabilis. Cleistosphaeridium aciculare, Dinogymnium sphaerocephalum, Phelodinium magnificum, Phelodinium tricuspe and *Spinidinium echinoideum* are common among Campanian-Early Maastrichtian assemblages from northern and southern areas of North American inland sea (Harland, 1973, 1977; McIntyre, 1974; Harker *et al.*, 1990; this study).

Aldorfia deflandrei, Cordosphaeridium fibrospinosum, Coronifera oceanica, Cyclonephelium distinctum, Dinogymnium acuminatum, D. albertii, D. denticulatum, D. digitum, D. euclaense, D. heterocostatum, Florentinia resex, F. stellata, Fromea amphora, Glaphyrocysta retiintexta, Hystrichodinium pulchrum, Odontochitina costata, O. operculata, Oligosphaeridium complexum, O. pulcherrimum, Palaeocystodinium australinum, Palaeohystrichophora infusorioides, Palaeoperidinium cretaceum, Senoniasphaera protrusa, Spinidinium echinoideum, various *Spiniferites* spp., *Spongodinium delitiense, Surculosphaeridium longifurcatum, Tanyosphaeridium regulare, Triblastula utinensis* and *Xenascus ceratioides* occur commonly in Campanian-Early Maastrichtian sediments of North American and Euro-African regions (Millioud *et al.*, 1975; Jain & Millepied, 1975; Boltenhagen, 1977; Davey, 1978; Rauscher & Doubinger, 1982).

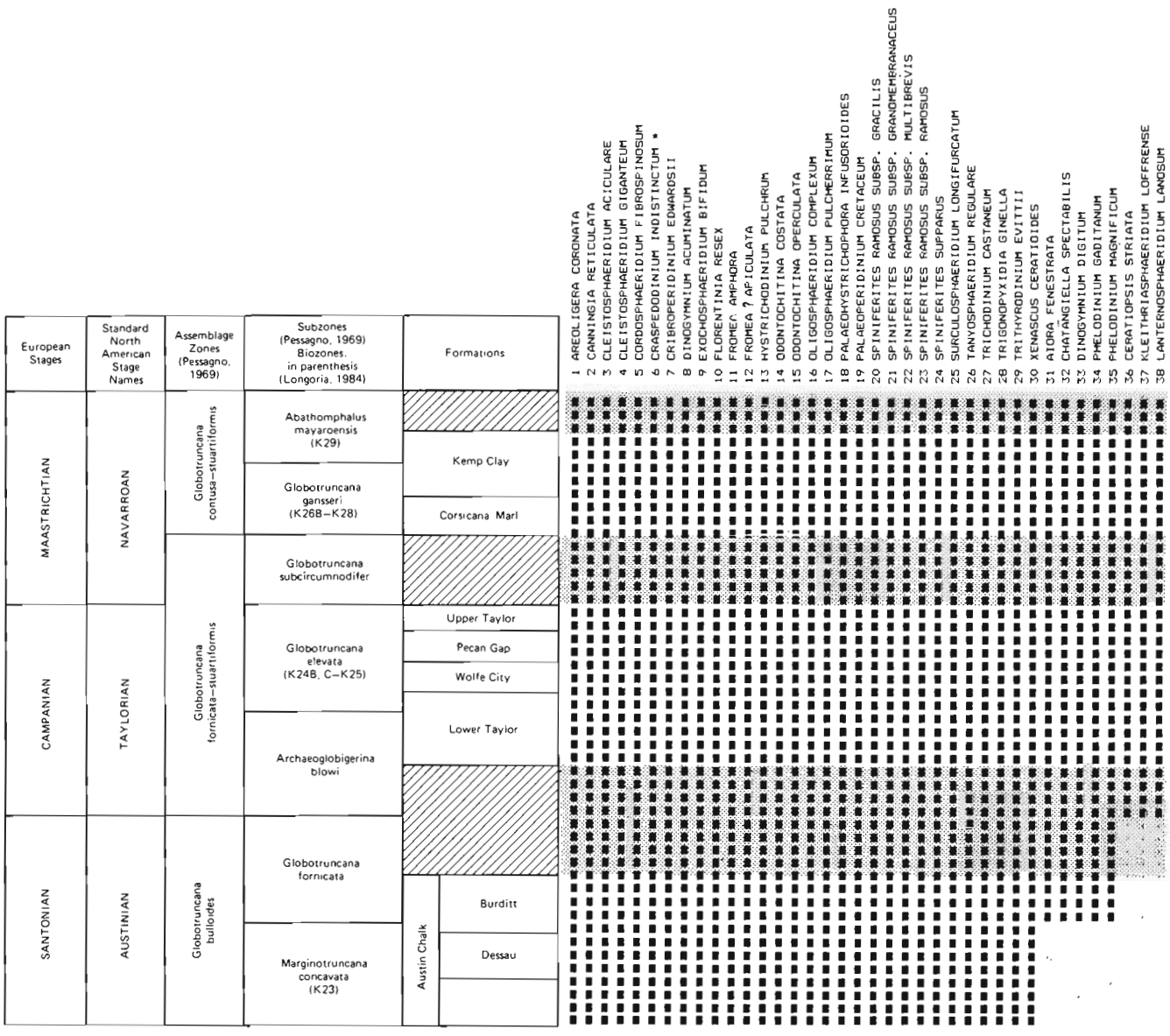
Areoligera coronata, A senonensis, Canningia reticulata, C. senonica, Cannosphaeropsis utinensis, Chatangiella granulifera, C. spectabilis, C. victoriensis, Cleistosphaeridium aciculare, Dinogymnium albertii, D. curvatum, D. digitum, Exochosphaeridium phragmites, Hystrichodinium pulchrum, Impagidinium cristatum, Isabelidinium microarmum, Odontochitina operculata, Oligosphaeridium complexum, O. pulcherrimum, Spinidinium lanternum, Spiniferites ramosus, Trichodinium castaneum and *Xenascus ceratioides* of the studied assemblages here also occur in the Senonian assemblages from the southern Indian Ocean at about latitude 60° South (Mao & Mohr, 1992).

Chatangiella victoriensis, Dinogymnium euclaense, D. nelsonense, Exochosphaeridium phragmites, Isabelidinium microarmum, Manumiella lata, Odontochitina costata, O. operculata, Oligosphaeridium complexum, O. pulcherrimum, Palaeohystrichophora infusorioides, Phelodinium magnificum, Senoniasphaera protrusa, Spinidinium echinoideum, S. lanternum, Spiniferites ramosus, Trichodinium castaneum and

Serial Numbers	Serial Nos. from First Appearance Range Chart (Fig. 6)	Serial Nos. from Last Occurrence Range Chart (Fig. 7)	
1	55	31	ACHOMOSPHAERA HETEROSTYLIS
2	87	45	ADNATOSPHAERIDIUM MULTISPINOSUM
3	31	59	AIORA FENESTRATA
4	56	32	ALDORFIA DEFLANDREI
5	43	101	ANDALUSIELLA ACICORNUTA
6	1	1	AREOLIGERA CORONATA
7	44	102	AREOLIGERA SENONENSIS
8	96	83	BATIACASPHAERA SCROBICULATA
9	57	33	CALIGODINIUM AMICULUM
10	108	55	CANNINGIA COLLIVERI
11	2	2	CANNINGIA RETICULATA
12	58	34	CANNINGIA SENONICA
13	97	84	CANNOSPHAEROPSIS HYPERCANTHA
14	70	74	CANNOSPHAEROPSIS UTINENSIS
15	102	52	CASSICULOSPHAERIDIA RETICULATA *
16	45	103	CERATIOPSIS NAVARRIANA
17	36	70	CERATIOPSIS STRIATA
18	71	75	CERATIOPSIS SUBQUADRA
19	72	76	CHATTANGIELLA ARMATA
20	109	56	CHATTANGIELLA GRANULIFERA
21	110	57	CHATTANGIELLA ROBUSTA
22	32	60	CHATTANGIELLA SPECTABILIS
23	111	58	CHATTANGIELLA VICTORIENSIS
24	73	77	CHATTANGIELLA WILLIAMSII
25	3	3	CLEISTOSPHAERIDIUM ACICULARE
26	4	4	CLEISTOSPHAERIDIUM GIGANTEUM
27	88	46	CLEISTOSPHAERIDIUM MEDITERRANEUM
28	5	5	CORDOSPHAERIDIUM FIBROSPINOSUM
29	89	47	CORONIFERA OCEANICA
30	6	6	CRASPEDODINIUM INDISTINCTUM *
31	7	7	CRIBROPERIDINIUM EDWARDSII
32	40	89	CYCLONEPHELIUM CASTELCASIENSE
33	90	48	CYCLONEPHELIUM DISTINCTUM
34	79	93	DICONODINIUM MARTIANUM
35	8	8	DINOGYMNIUM ACUMINATUM
36	59	35	DINOGYMNIUM ALBERTII
37	60	36	DINOGYMNIUM CERVICULUM
38	61	37	DINOGYMNIUM CURVATUM
39	80	94	DINOGYMNIUM DENTICULATUM
40	33	61	DINOGYMNIUM DIGITUM
41	41	90	DINOGYMNIUM ELONGATUM
42	98	85	DINOGYMNIUM EUCLAENSE
43	69	64	DINOGYMNIUM HETEROCOSTATUM
44	105	67	DINOGYMNIUM KASACHSTANICUM
45	42	91	DINOGYMNIUM LANCEOLATUM
46	94	65	DINOGYMNIUM MICROGRANULOSUM
47	74	78	DINOGYMNIUM NELSONENSE
48	81	95	DINOGYMNIUM RIGAUDIAE
49	62	38	DINOGYMNIUM SIBIRICUM
50	82	96	DINOGYMNIUM SPHAEROCEPHALUM
51	9	9	EXOCHOSPHAERIDIUM BIFIDUM
52	83	97	EXOCHOSPHAERIDIUM MUELLERI
53	103	53	EXOCHOSPHAERIDIUM PHRAGONITES
54	75	79	FLORENTINIA CLAVIGERA
55	95	66	FLORENTINIA COOKSONIAE
56	91	49	FLORENTINIA LACINIATA
57	63	39	FLORENTINIA MANTELLII
58	10	10	FLORENTINIA RESEX
59	92	50	FLORENTINIA STELLATA
60	11	11	FROMEA AMPHORA
61	12	12	FROMEA APICULATA
62	46	104	GLAPHYROCYSTA RETIINTEXTA
63	13	13	HYSTRICHODINIUM PULCHRUM
64	84	98	IMPAGIDINIUM CRISTATUM
65	99	86	ISABELIDINIUM MICROARMUM
66	37	71	KLEITHRIASPHAERIDIUM LOFFRENSE
67	38	72	LANTERNOSPHAERIDIUM LANOSUM
68	47	105	LEJEUNECYSTA DECORINASSA
69	48	106	LEJEUNECYSTA HYALINA
70	49	107	LITOSPHAERIDIUM FENESTRECONUM
71	54	92	LITOSPHAERIDIUM SP. SENSU STEIN, 1983
72	100	87	MANUMIELLA LATA
73	101	88	MEMBRANILARNACIA OVALIS
74	14	14	ODONTOCHITINA COSTATA
75	15	15	ODONTOCHITINA OPERCULATA
76	16	16	OLIGOSPHAERIDIUM COMPLEXUM
77	17	17	OLIGOSPHAERIDIUM PULCHERRIMUM
78	93	51	OPERCULODINIUM MAJOR
79	50	108	PALAEOCYSTODINIUM AUSTRALINUM
80	18	18	PALAEOHYSTRICHOPHORA INFUSORIOIDES
81	19	19	PALAEOPERIDINIUM CRETACEUM
82	34	62	PHELODINIUM GADITANUM
83	35	63	PHELODINIUM MAGNIFICUM
84	39	73	PHELODINIUM PENTAGONALE
85	51	109	PHELODINIUM TRICUSPE
86	64	40	RENIDINIUM VITILARE
87	85	99	ROTTNESTIA BORUSSICA
88	65	41	SENONIASPHAERA PROTRUSA
89	104	54	SILICISPHAERA FEROX
90	106	68	SPINIDINIUM DENSISPINATUM
91	66	42	SPINIDINIUM ECHINOIDEUM
92	107	69	SPINIDINIUM LANTERNUM
93	76	80	SPINIFERITES COMPACTUS *
94	20	20	SPINIFERITES RAMOSUS SUBSP. GRACILIS
95	21	21	SPINIFERITES RAMOSUS SUBSP. GRANOMEMBRANACEUS
96	22	22	SPINIFERITES RAMOSUS SUBSP. MULTIBREVIS
97	23	23	SPINIFERITES RAMOSUS SUBSP. RAMOSUS
98	24	24	SPINIFERITES SUPPARUS
99	67	43	SPONGODINIUM DELITIENSE
100	77	81	SUBTILISPHAERA CHEIT
101	25	25	SURCULOSPHAERIDIUM LONGIFURCATUM
102	26	26	TANYOSPHAERIDIUM REGULARE
103	52	110	THALASSIPHORA BONONIENSIS
104	78	82	TRIBLASTULA UTINENSIS
105	27	27	TRICHODINIUM CASTANEUM
106	28	28	TRIGONOPYXIDIA GINELLA
107	68	44	TRITHYRODINIUM DRUGGII
108	29	29	TRITHYRODINIUM EVITTII
109	53	111	WALLODINIUM LUNUM *
110	30	30	XENASCUS CERATIOIDES
111	86	100	XENASCUS GOCHTII

Text-figure 5—Alphabetical listing of dinocyst taxa documented in Santonian-Maastrichtian sediments of Texas showing corresponding serial numbers from the "First-Appearance" and "Last Occurrence" range charts for cross reference. Taxa marked with an asterisk (*) are considered here as reworked from older beds.

Xenascus ceratioides are common in the Campanian assemblages studied here and those of the James Ross Island area, Antarctic Peninsula (Keating, 1992; Summer, 1992; Dolding, 1992; Wood & Askin, 1992; Smith, 1992).

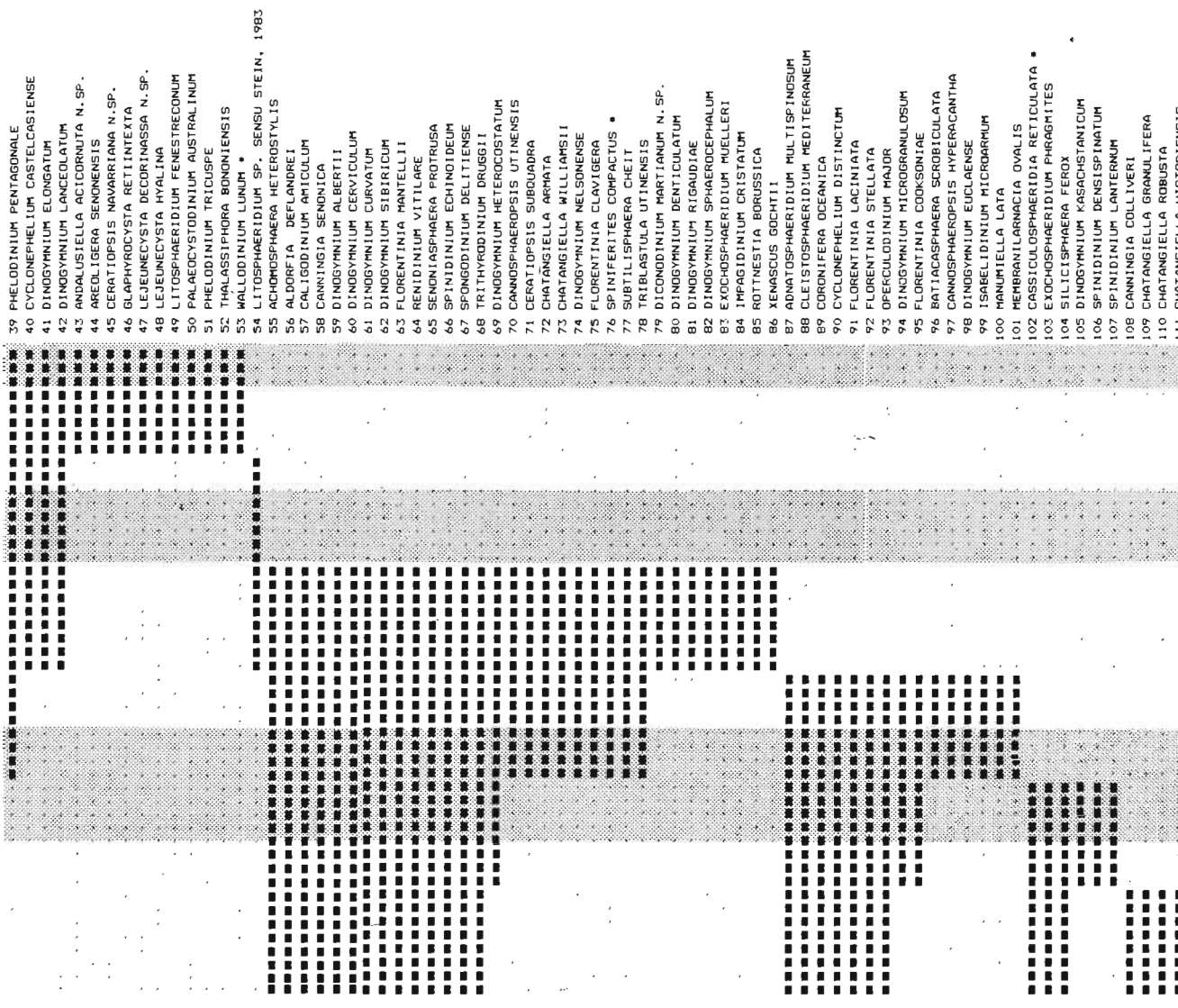


Text-figure 6—Dinocyst taxa ranges in Santonian-Maastrichtian of Texas (taxa arranged by the first appearances). Taxa marked with an

The following taxa appear in the Maastrichtian sediments of the studied formations of Texas: *Andalusiella acicornuta*, *Areoligera senonensis*, *Ceratiopsis navarriana*, *Glaphyrocysta retiintexta*, *Lejeunecysta decorinassa*, *L. hyalina*, *Litosphaeridium fenestreconum*, *Palaeocystodinium australinum*, *Phelodinium tricuspe* and *Thalassiphora bononensis*.

Cordosphaeridium fibrospinosum, *Dinogymnium acuminatum*, *Odontochitina costata*, *O. operculata*, *Palaeohystrichophora infusorioides*, *Phelodinium tricuspe*, *Spiniferites ramosus*, *Trigonopyxidia ginella* and *Xenascus ceratioides* are common in Maastrichtian assemblages studied here and those from northeast Texas (Heine *in* Thompson *et al.*, 1991). Early Maastrichtian sediments of northeast Texas studied by Heine (*in* Thompson *et al.*, 1991) are not represented in the sections studied here.

Areoligera senonensis, *Hystrichodinium pulchrum*, *Odontochitina operculata*, *Palaeocystodinium australinum* and *Trigonopyxidia ginella* are common in the Maastrichtian assemblages studied here and those of Europe (Wilson, 1971). Only three species of Maastrichtian assemblages studied here, viz., *Areoligera coronata*, *A. senonensis* and *Cordosphaeridium fibrospinosum* occur in the Late Maastrichtian assemblage of Salzburg, Austria (Kuhn & Kirsch, 1992). Common taxa with Maastrichtian assemblages studied here, those from southern Sweden (Kjellström, 1973) are: *Areoligera senonensis*, *Cordospbaeridium fibrospinosum*, *Hystrichodinium pulchrum*, *Odontochitina operculata*,



asterisk (*) are considered here as reworked from older beds.

Oligosphaeridium complexum, Spiniferites ramosus and *Tanyosphaeridium regulare;* and those from Denmark (Hansen, 1977) are: *Areoligera senonensis, Spiniferites ramosus* subsp. *gracilis, S. ramosus* subsp. *granomembranaceus* and *S. supparus.*

Brinkhuis and Zachariasse (1988) studied dinocyst assemblages across the Cretaceous-Tertiary boundary at El Haria, northwest Tunisia and documented the following taxa in the Maastrichtian sediments which also occur in Texan Maastrichtian assemblages studied here : *Areoligera senonensis, Ceratiopsis striata, Cordosphaeridium fibrospinosum, Cyclonephelium castelcasiense, Dinogymnium acuminatum, Lejeunecysta hyalina, Palaeocystodinium australinum* and *Phelodinium magnificum.* It is interesting to note that *Dinogymnium* spp. have not been reported in Late Maastrichtian assemblages of northern high latitudes.

In conclusion, the Santonian-Maastrichtian dinoflagellate assemblages have a significant potential for correlation and age determination of marine sediments inter-regionally at long distances.

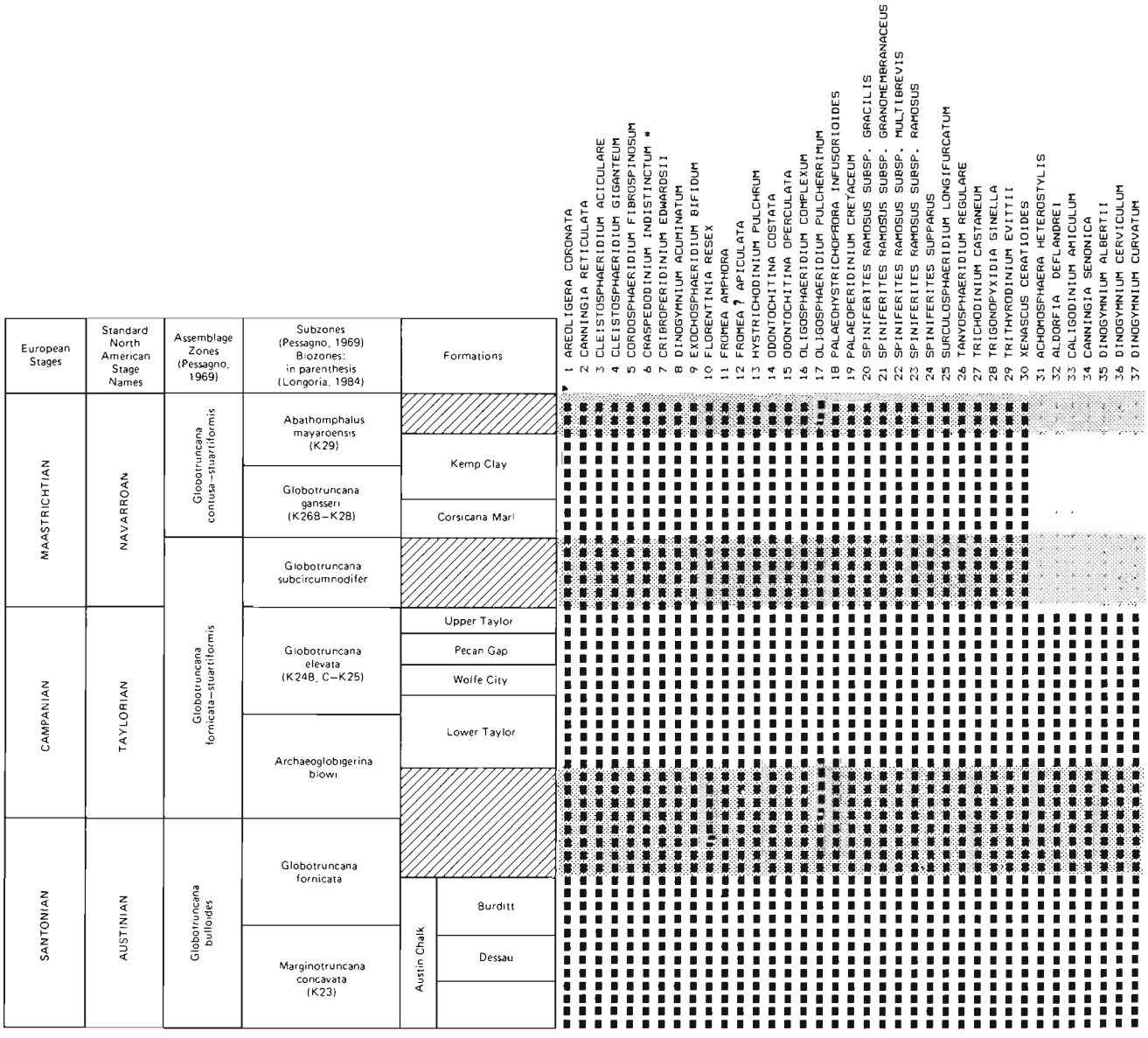
All the specimen slides are in the Palynology Laboratory, Chevron Oil Field Research Company, LaHabra, California, U.S.A.

SYSTEMATIC DESCRIPTION

Dinoflagellate cysts

Genus—*Achomosphaera* Evitt 1963

1963 *Achomosphaera* Evitt, p. 163.



Text-figure 7—Dinocyst taxa ranges in Santonian-Maastrichtian of Texas (taxa arranged by the last appearances). Taxa marked with an

Type species—*Achomosphaera ramulifera* (Deflandre) Evitt 1963 = *Hystrichosphaeridium ramuliferum* Deflandre 1937 (original designation)

Remarks—*Achomosphaera* includes proximochorate to skolochorate cysts having a spherical body possessing discrete processes with trifurcate and/or bifurcate tips without distal interconnections. The outer wall surface between the processes is smooth to variously ornamented with low relief features. It has a precingular archeopyle and an obscurely discernible gonyaulacacean paratabulation. *Hafniasphaera* may be congeneric to *Achomosphaera*. *Achomosphaera* differs from *Spiniferites* in lacking definite parasutural features between the bases of the processes.

Achomosphaera heterostylis (Heisecke) Stover & Evitt 1978

Pl. 1, figs 1, 2

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.

Size measurements—Total length × breadth 61 × 54 μm, body 35.5 × 34 μm, process length 14 μm (Heisecke, 1970); range of total length × breadth 55-74 × 55-65 μm, body 35-44 × 32-33 μm, processes 10-20

Asterisk (*) are considered here as reworked from older beds.

μm long, and antapical process 15-20 × 10-12 μm (Srivastava, 1991).

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

Previous records—Danian, Argentina (Heisecke, 1970); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Genus—*Adnatosphaeridium* Williams & Downie in Davey *et al.* 1966

1966 *Adnatosphaeridium* Williams & Downie in Davey *et al.*, p. 215.

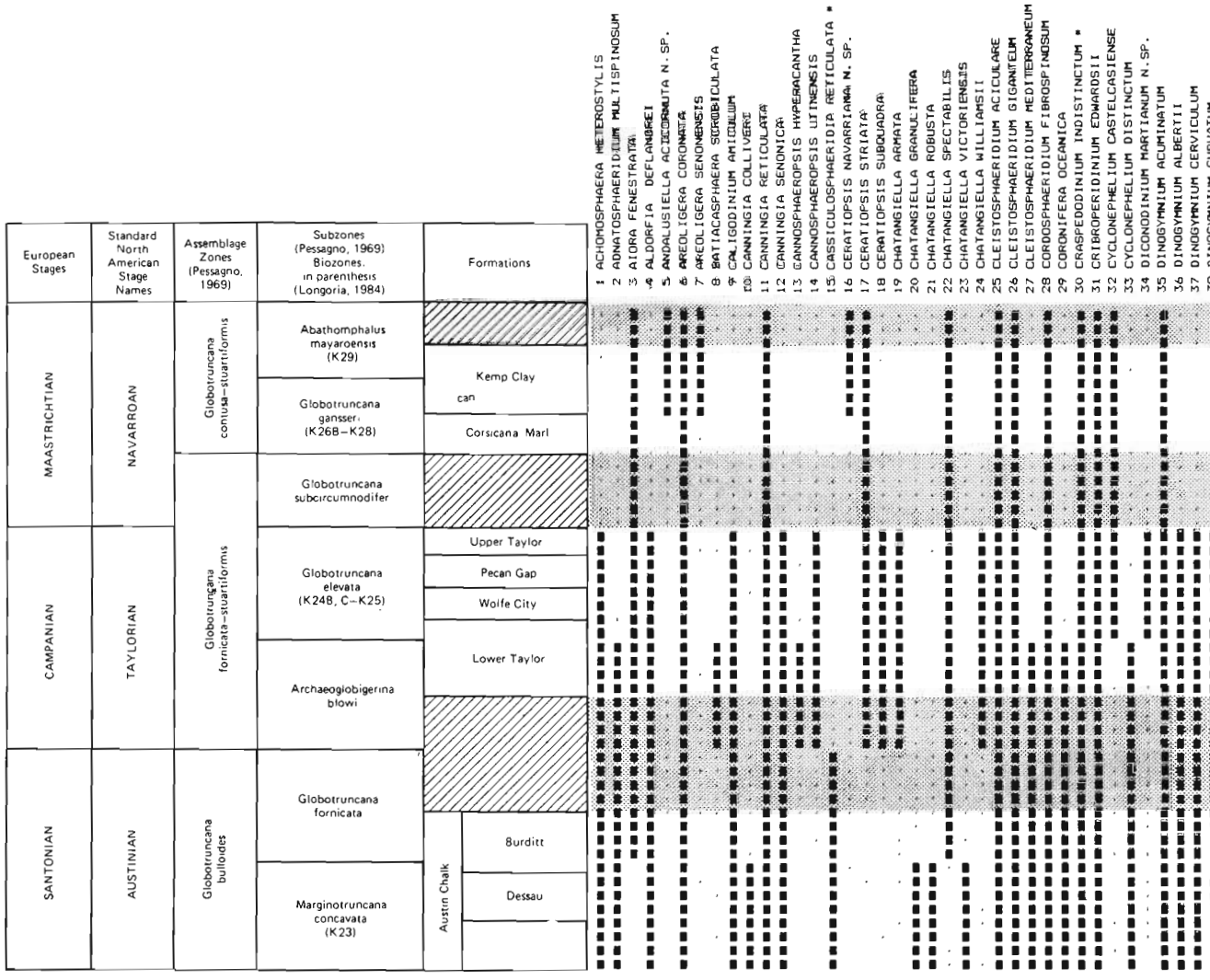
Type species—*Adnatosphaeridium vittatum* Williams & Downie in Davey *et al.* 1966 (original designation).

Remarks—*Adnatosphaeridium* consists of skolochorate cysts having subspherical body with an apical archeopyle and solid or hollow, tubular to funnel-form, intratabular processes connected distally by ribbon-like to fenestrate trabeculae. *Adnatosphaeridium* differs from *Glaphyrocysta* in having a spherical body and lacking the process-free areas.

Adnatosphaeridium multispinosum Williams & Downie in Davey *et al.* 1966

Pl. 1, figs 3-5

1966 *Adnatosphaeridium multispinosum* Williams & Downie in Devey *et al.*, p. 216, pl. 24, fig. 5; text-fig. 57.



Text-figure 8—Dinocyst taxa ranges in Santonian-Maastrichtian of Texas (taxa arranged in alphabetical order). Taxa marked with an

Size measurements—Diameter of central body 44-71 µm, process length up to 23 µm (Williams & Downie in Davey *et al.*, 1966); overall diameter 75-101 µm, body 49-75 µm, process length 16-21 µm in four specimens of this study.

Previous records—Paleocene-Eocene, Europe and Turkey (Williams & Downie in Davey *et al.*, 1966; Caro, 1973; de Coninck, 1975a; Jan du Chene *et al.*, 1975; Eaton, 1976; Bujak *et al.*, 1980; Erkmen & Sadek, 1981; Herngreen, 1984).

Genus—*Aiora* Cookson & Eisenack 1960b

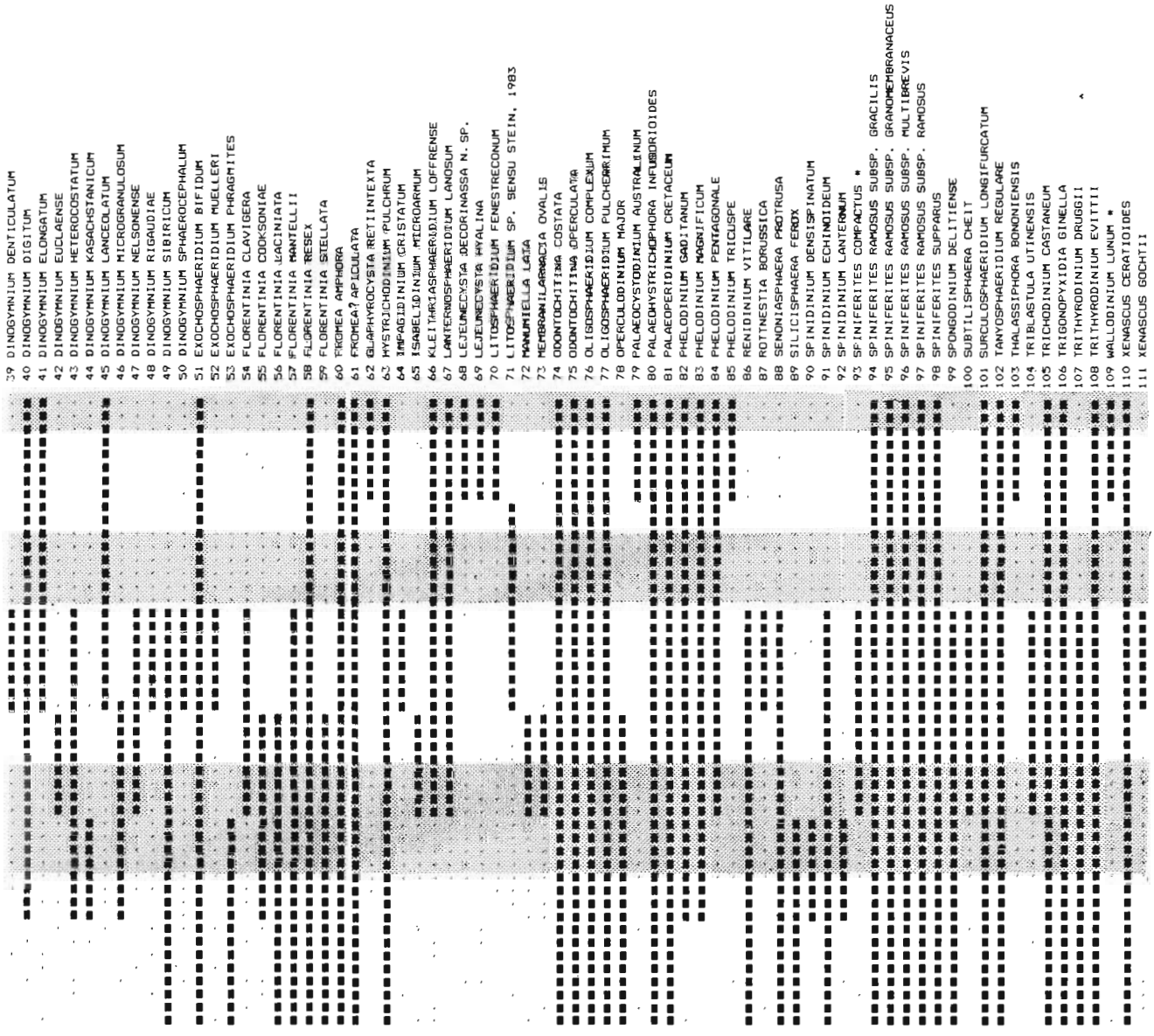
1960b *Aiora* Cookson & Eisenack, p. 9.
non-1978 *Aiora* Cookson & Eisenack ex Davey, p. 892.

Type species—*Aiora fenestrata* (Deflandre & Cookson) Cookson & Eisenack 1960b = *Cannosphaeropsis fenestrata* Deflandre & Cookson 1955 (original designation).

Remarks—As represented by the type species, the genus *Aiora* has an ellipsoidal body with a thin smooth membrane and several processes that are united distally by thin, flattened and perforated trabeculae. Its archeopyle position and paratabulation is uncertain (Stover & Evitt, 1978).

Aiora fenestrata (Deflandre & Cookson) Cookson & Eisenack 1960

Pl. 1, figs 6, 7



Asterisk (*) are considered here as reworked from older beds.

1955 *Cannosphaeropsis fenestrata* Deflandre & Cookson, p. 283, pl. 3, fig. 2.

1960 *Aiora fenestrata* (Deflandre & Cookson) Cookson & Eisenack, p. 9 (non pl. 2, figs 17, 18).

Size measurements—Shell 64 × 64 µm, overall diameter ca 128 µm (Deflandre & Cookson, 1955); overall 70 × 57 µm in one specimen of this study.

Previous records—Senonian-Eocene. Senonian, Australia (Deflandre & Cookson, 1955); Santonian-Early Maastrichtian, off southwestern Africa (Davey, 1978); Lower Tertiary, McMurdo Sound, Antarctica (Wilson, 1967); Middle Eocene, DSDP Leg 29, off southeastern Australia and western New Zealand (Haskell & Wilson, 1975); Eocene, Argentina (Archangelsky, 1969).

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 filled with continuous sculpture. It differs from *Apteodinium* in having an ectocoel filled with various sculptures.

Aldorfia deflandrei (Clarke & Verdier) Stover & Evitt 1978

Pl. 1, figs 8, 9; Pl. 2, figs 1-7

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

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

Size 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 44 × 35-44; apical horn length 6-8 μm (Foucher, 1974); overall 60-66 × 46-54 μm (Yun, 1981), overall 43-86 × 40-75 μm (Srivastava, 1991); 60-68 × 49-62 μm in four specimens of this study.

Previous records—Albian-Campanian. Late Albian-Coniacian, France (Foucher, 1972, 1974; Fauconnier, 1979); Late Albian-Cenomanian, offshore western Atlantic Ocean (Hochuli & Kelts, 1980); Santonian, England (Clarke & Verdier, 1967) and Germany (Yun, 1981); Campanian, Scotian Shelf, Canada (Millioud *et al.*, 1975; Williams, 1975); Campanian-Maastrichtian, Senegal, W. Africa (Jain & Millepied, 1975); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Genus—*Andalusiella* Riegel emend. Riegel & Sarjeant 1982

1974 *Andalusiella* Riegel, p. 357.

1982 *Andalusiella* Riegel emend. Riegel & Sarjeant, p. 284.

Type species—*Andalusiella mauthei* Riegel 1974 (original designation).

Remarks—*Andalusiella* has proximate, cornucavate to acrocavate, rhomboidal to spindle-shaped cysts with an intercalary archeopyle, an apical and two unequal antapical horns. The term "acrocavate" was proposed by Riegel and Sarjeant (1982) to describe a condition on which periphragm and endophragm extends up to or form half-length of the horn but only periphragm forms the apices of the horns. It differs from *Phelodinium* in having rhomboidal to spindle-shaped outline and closely spaced antapical horns. It is distinct from *Palaeocystodinium* in lacking discrete endocyst.

Andalusiella acicornuta S.K. Srivastava, n. sp.

Pl. 3, figs 1-6

Description—Cyst compressed ellipsoidal with a prominent apical horn and two unequal short antapical horns; antapical horns close together near longitudinal axis having a common base and appearing as bifurcated single horn, left antapical horn very short and poorly developed, bases of all other horns closed by thickened plugs, endophragm extending to the tips of the horns; walls proximate, acrocavate, periphragm thinner than endophragm; parasutural features absent, periphragm wrinkled; paracingulum shallow, bordered by faint low folds; paratabulation indicated by archeopyle and a faint paracingulum, no other paratabulation present; archeopyle intercalary, operculum free.

Holotype—Pl. 3, figs, 1, 2; photomicrograph reference no. 85036/13, 14; objective × 40; microscope location-horizontal 37.0/vertical 102.0; size-total length × breadth 182 × 57 μm, body length 113 μm, apical horn length 51 μm, antapical horns length 39 μm and 8 μm; sample no. CRC 32146-1/Slide 6; locality WA18, the Navarro Group, the uppermost Kemp Clay, Falls County, Texas; Late Maastrichtian.

Paratype—Pl. 3, figs 3-4; photomicrography reference no. 85035/24, 25; objective × 40; microscope location-horizontal 40.0/vertical 106.7; size-total length × breadth 143 × 44 μm, body length 91 μm, apical horn length 27 μm, antapical horns length 27 μm and 8 μm; sample no. CRC 32146-1/Slide 1; locality WA18, the Navarro Group, the uppermost Kemp Clay, Falls County, Texas; Late Maastrichtian.

Paratype—Pl. 3, figs 5, 6; photomicrograph reference no. 85036/18, 19; objective × 40; microscope location—horizontal 45.4/vertical 109.0; size—total length × breadth 161 × 47 μm, body length 89 μm, apical horn length 35 μm, antapical horns length 37 μm and 8 μm; sample no. CRC 32146-1/Slide 7; locality WA18, the Navarro Group, the uppermost Kemp Clay, Falls County, Texas; Late Maastrichtian.

Remarks—*Andalusiella acicornuta* is distinct from

PLATE 1 →

In figure captions of the following Plates, reference data for each specimen is given after the name of figure numbers in the following sequence : × objective used in photomicrography; sample number, locality designation, name of the formation, county; and age. Photomicrographs taken with 40 × objective are illustrated at magnification × 700 and those with 100 × objective at magnification × 1200.

1-2. *Achomosphaera heterostylis* (Heisecke) Stover & Evitt 1978; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

3-5. *Adnatosphaeridium multispinosum* Williams & Downie in Davey *et al.* 1966; × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

6-7. *Aiora fenestrata* (Deflandre & Cookson) Cookson & Eisenack 1960; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

8-9. *Aldorfia deflandrei* (Clarke & Verdier) Stover & Evitt, 1978; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

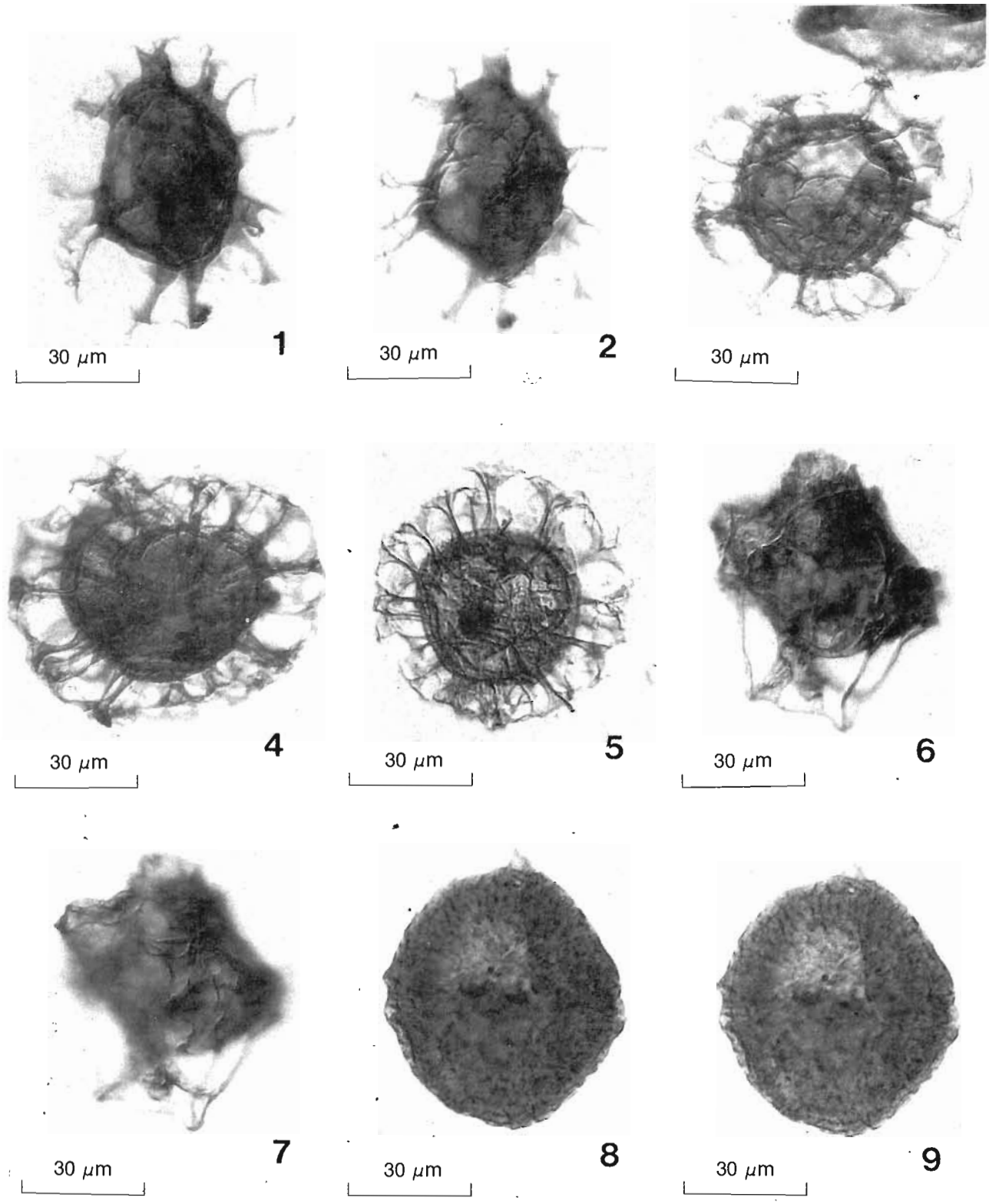


PLATE 1

A. mauthei and *A. polymorpha* in having thinner spindle-shaped body, longer horns, and lacking granular wall surface. It differs from *A. rhombohedra* (Benson) Stover & Evitt in horny endophragm extended up to the tips of the horns. Specimens described as *Svalbardella australina* from Gabon, West Africa (Malloy, 1972), south east Turkey (Erkmen & Sadek, 1981) and Maastrichtian-Paleocene of Argentina (Gamerro &

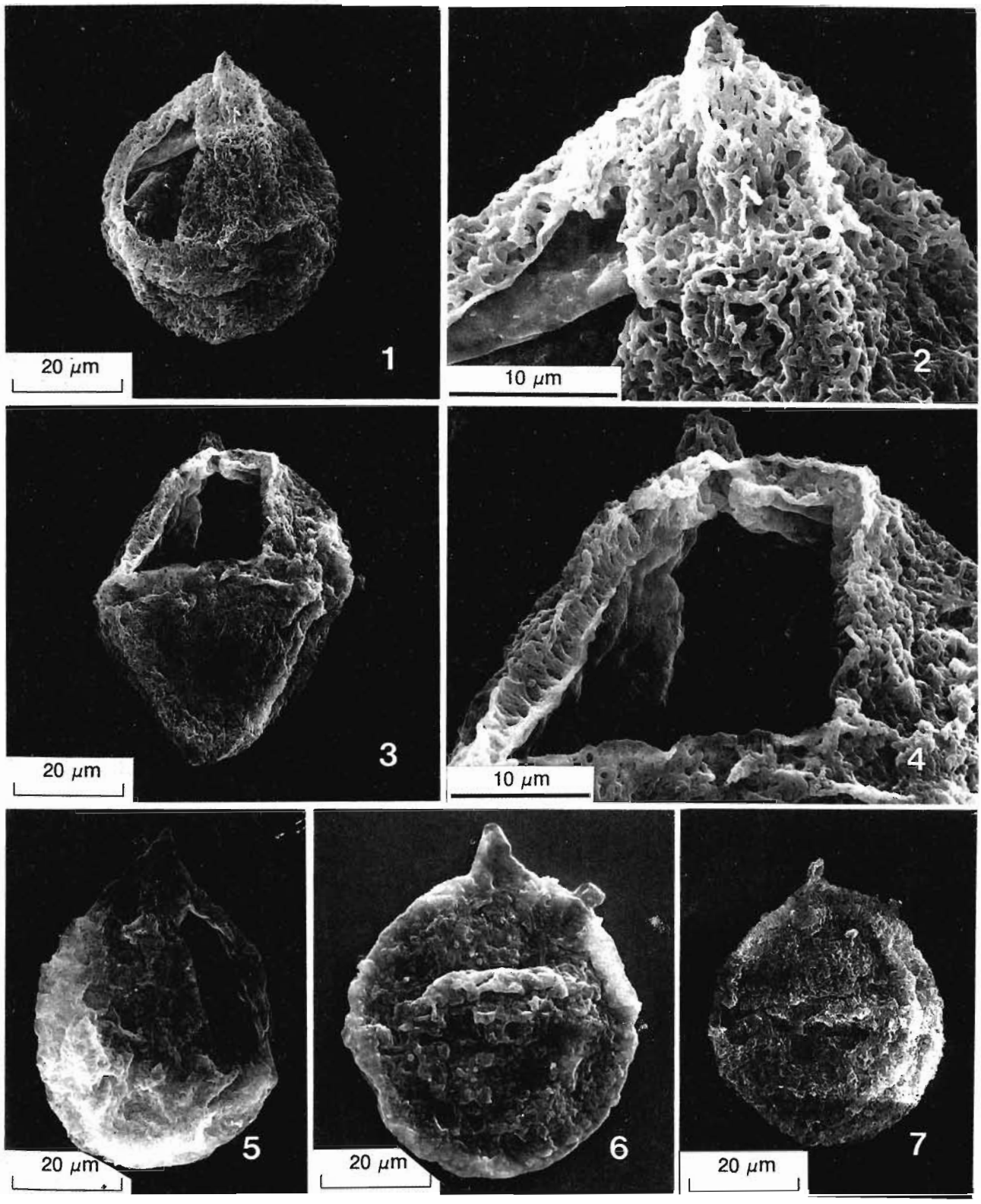


PLATE 2

1-7. *Aldorfia deflandrei* (Clarke & Verdier) Stover & Evitt 1978; CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

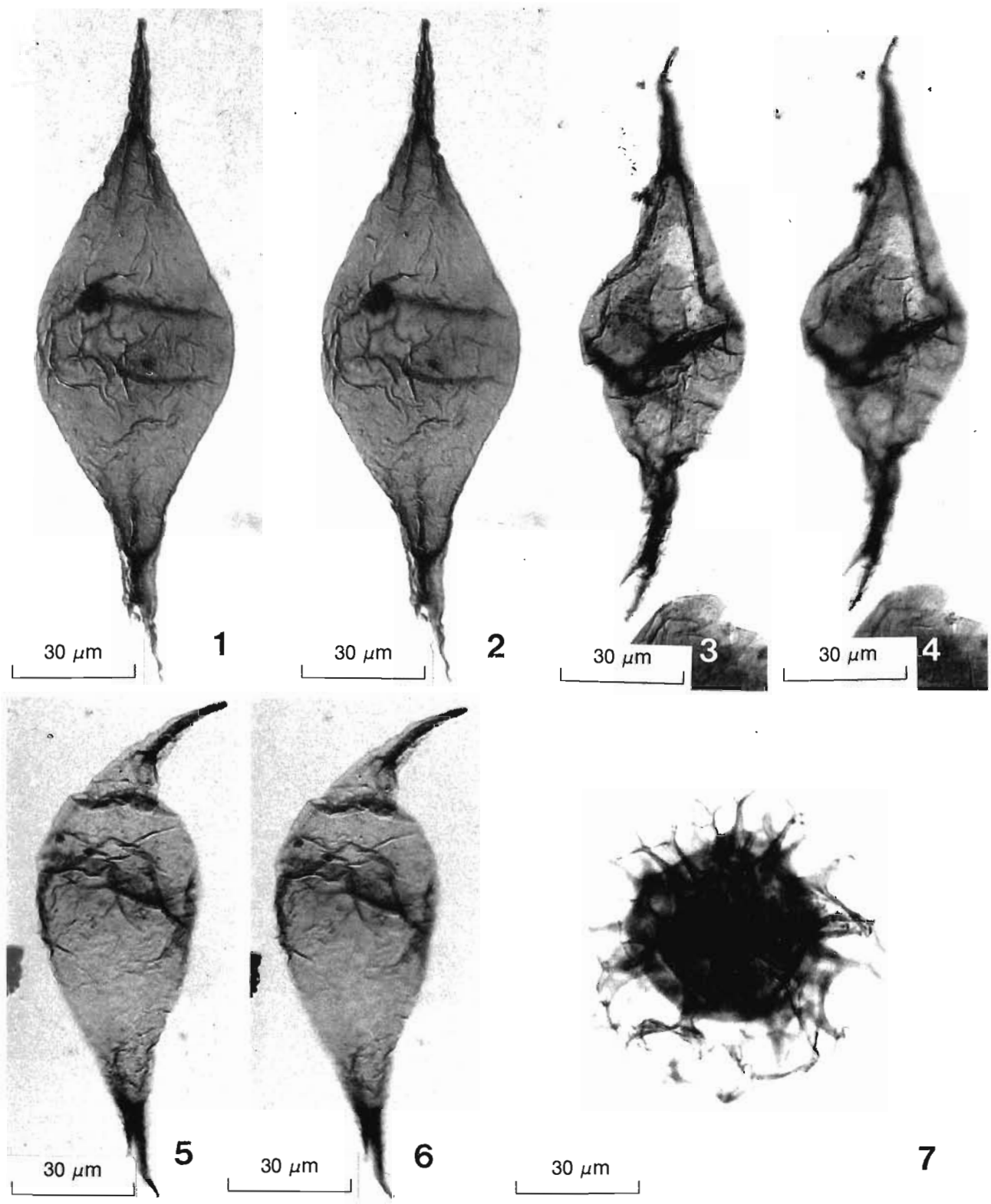


PLATE 3

1-6. *Andalusiella acicornuta* S.K. Srivastava, n. sp.; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian; figs 1, 2—holotype.

7 *Areoligera coronata* (O. Wetzel) Lejeune-Carpentier 1938; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

Archangelsky, 1981) are very similar to *Andalusiella acicornuta* described here.

Name derivation—Latin *acus* = needle, *cornutus* = bearing horns; *acicornuta* = bearing needle-like horns.

Genus—*Areoligera* Lejeune-Carpentier emend. Williams & Downie in Davey *et al.* 1966

1938 *Areoligera* Lejeune-Carpentier, p. 164.
1966 *Areoligera* Lejeune-Carpentier emend. Williams & Downie in Davey *et al.*, p. 227.

Type species—*Areoligera senonensis* Lejeune-Carpentier 1938 (original designation).

Remarks—Areoligera consists of skolochorate gonyaulacacean cysts having lenticular body with an apical archeopyle and complexly branched, arcuate penitabular and rectilinear processes in groups. Mid-ventral and mid-dorsal surfaces of the body are consistently free of processes or processes reduced by size and number. Its parasulcal notch is offset.

Areoligera differs from *Glaphyrocysta* in lacking complex networks of trabeculae, although some of the adjacent groups of processes may be joined occasionally by trabeculae; and from *Systematophora* in being lenticular and either lacking or having reduced processes on mid-ventral and mid-dorsal surfaces.

Areoligera coronata (O. Wetzel) Lejeune-Carpentier 1938

Pl. 3, fig. 7; Pl. 4, figs 1-6

1933 *Hystrichosphaera penicillata coronata* O. Wetzel, p. 87, pl. 4, fig. 17
1938 *Areoligera coronata* (O. Wetzel) Lejeune-Carpentier, p. 168, text-fig. 6.

Size measurement—Body length × breadth 53-66 × 57-76 µm, process length 10-38 µm (Williams & Downie in Davey *et al.*, 1966); 47-75 × 44-67 µm, process length 11-60 µm (Morgenroth, 1968); 50-68 × 50-74 µm, process length 10-35 µm (Corradini, 1973); overall length × breadth 78-104 × 60-104 µm, body 42-75 × 42-65 µm, process length 18-39 µm in nine specimens of this study.

Previous records—Senonian-Eocene Senonian-Eocene, Europe (O. Wetzel, 1933b; Lejeune-Carpentier, 1938; Williams & Downie in Davey *et al.*, 1966; Morgenroth, 1968; Caro, 1973; Corradini, 1973; Jan du Chene *et al.*, 1975; de Coninck, 1975a; Eaton, 1976; Schumacker-Lambry & Chateauneuf, 1976; Foucher & Robaszynski, 1977); Paleocene, Morocco (Doubinger, 1979).

Areoligera senonensis Lejeune-Carpentier 1938

Pl. 4, figs 7, 8

1938 *Areoligera senonensis* Lejeune-Carpentier, p. B164, text-figs 1-3.

Size measurement—Body dimensions 44-57 × 22-30 µm, process length 14-25 µm (Lejeune-Carpentier, 1938); overall dimensions 138 × 30 µm, body 23 × 78 µm, process length 41 µm in one specimen of this study.

Previous records—Senonian-Miocene. Senonian-Oligocene, Europe (Lejeune-Carpentier, 1938; Gocht, 1969; Wilson, 1971; Kjellström, 1973; Eaton, 1976; Schumacker-Lambry & Chateauneuf, 1976; Schumacker-Lambry, 1978; Foucher & Robaszynski, 1977); Late Maastrichtian, Turkey (Erkmen & Sadek, 1981); Campanian-Middle Eocene, North America (Zaitzeff & Cross, 1971; Millioud *et al.*, 1975; Williams & Bujak, 1977); Late Maastrichtian, south India (Jain, 1978); Miocene, Japan (Matsuoka, 1974).

Genus—*Batiacasphaera* Drugg 1970

1970 *Batiacasphaera* Drugg, p. 813.

Type species—*Batiacasphaera compta* Drugg 1970 (original designation).

Remarks—Batiacasphaera is distinct from *Chytroeisphaeridia* in having an apical archeopyle, and from *Cassiculosphaeridia* in lacking membranous reticulate crests.

Batiacasphaera scrobiculata (Deflandre & Cookson) Burger 1980

Pl. 5, fig. 1

Synonymy—see Srivastava (1984, p. 21).

Size measurements—Overall diameter 35-55 µm (Burger, 1980); 36-50 µm (Srivastava, 1984); 55-57 µm in specimens of this study.

Previous records—Cretaceous-Early Tertiary.

PLATE 4 →

1-6. *Areoligera coronata* (O. Wetzel) Lejeune-Carpentier 1938; 1, 3, × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; 2, × 40, CRC 32140-2, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; 4,5, CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian; 6, CRC 32140-4, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

7-8. *Areoligera senonensis* Lejeune-Carpentier, 1938; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

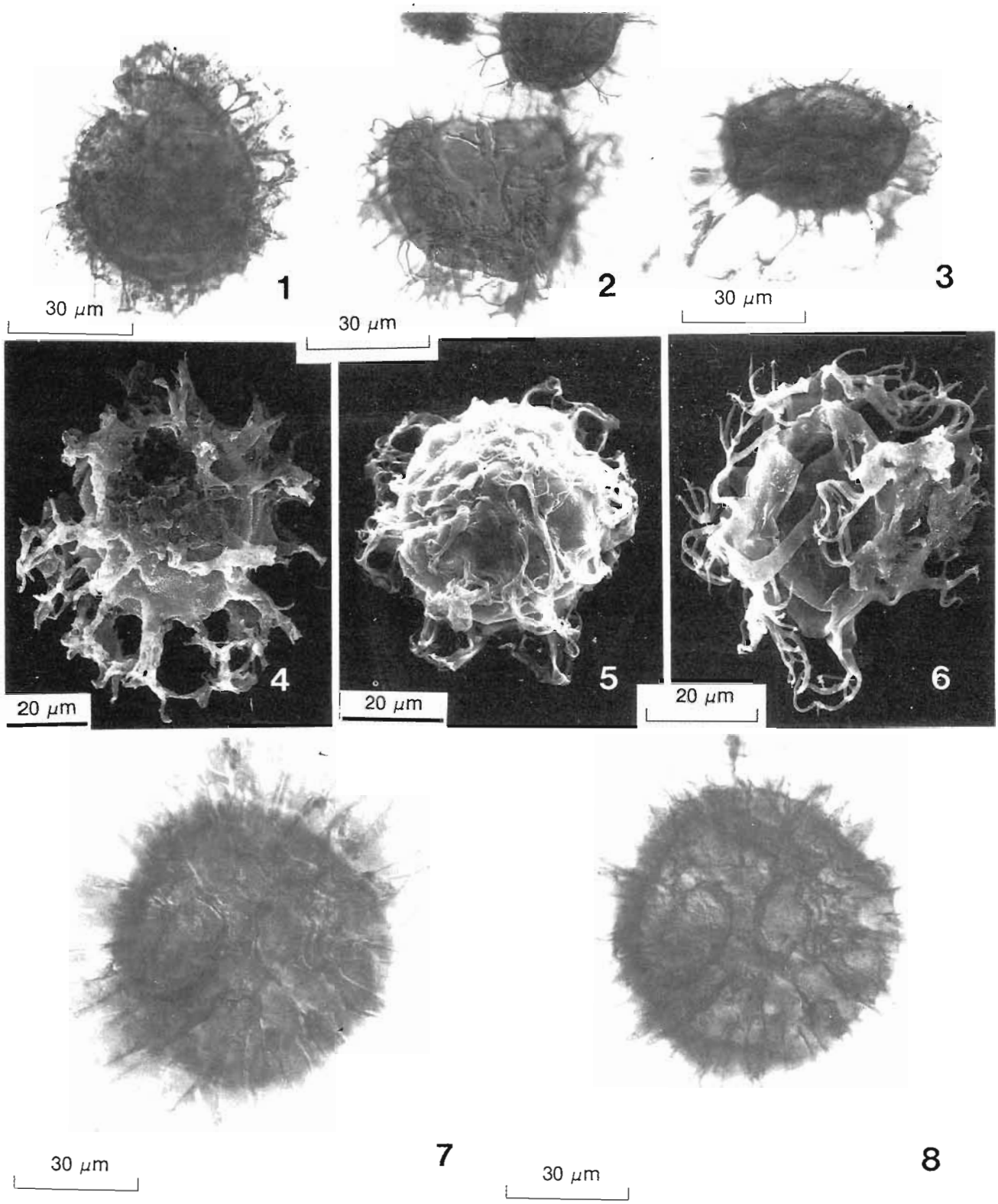


PLATE 4

Genus—*Caligodinium* Drugg 1970

1970 *Caligodinium Drugg*, p. 814.

Type species—*Caligodinium amiculum* Drugg 1970 (original designation).

Remarks—*Caligodinium* includes proximate cysts

with an apical archeopyle and having subspherical to ellipsoidal body with flocculent material and without any elevated features. Operculum of *Caligodinium* has three paraplates. *Caligodinium* is distinct from *Leberidocysta* in having an apical archeopyle with an operculum composed of three paraplates.

Caligodinium amiculum Drugg 1970

Pl. 5, figs 2, 3

1970 *Caligodinium amiculum* Drugg, p. 815, figs 8A-B, 9A-E.

Size measurements—Body length × breadth 56-90 × 46-71 µm (Drugg, 1970); overall dimensions 64-101 × 48-83 µm, body 42-57 × 33-60 µm in ten specimens of this study.

Previous records—Paleocene. Paleocene, U.S.A. (Drugg, 1970; Edwards *et al.*, 1984); Selandian (Middle Paleocene), Denmark (Thomsen & Heilmann-Clausen 1985).

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

Canningia colliveri Cookson & Eisenack 1960a

Pl. 5, fig. 4

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

Size measurements—Length × breadth, 106-107 × 90-100 µm (Cookson & Eisenack, 1960a); 102-127 × 68-114 µm (Singh, 1964, 1971); 40-78 × 35-74 µm (Srivastava, 1984); 44-52 × 44-50 µm (Srivastava, 1991); 45 × 44 µm in one specimen of this study.

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); Cenomanian-Coniacian, Texas, U.S.A (Srivastava, 1991).

Canningia reticulata Cookson & Eisenack 1960a

Pl. 5, figs 5-6

1960a *Canningia reticulata* Cookson & Eisenack, p. 251, pl. 38, figs 1, 2.

Size measurements— Dimensions 94-108 × 74-98 µm (Cookson & Eisenack, 1960a); 70-90 × 69-84 µm (Below, 1981a); 50-100 × 45-88 µm (Srivastava, 1984); overall 78-109 × 62-96 µm, process length 5-13 µm in nine specimens of this study.

Previous records—Late Jurassic-Santonian. Tithonian-Aptian, Australia (Cookson & Eisenack, 1960a; Burger, 1982); Late Jurassic, Tethys Himalaya, India (Jain *et al.*, 1984); Neocomian-Albian, Libya (Thusu & van der Eem, 1985); Barremian-Albian, Morocco (Below, 1981a); Barremian, France (Srivastava, 1984); Cenomanian, Isle of Wight, England (Clarke & Verdier, 1967); Santonian Grand Banks, Canada (Millioud *et al.*, 1975).

Canningia senonica Clarke & Verdier 1967

Pl. 5, figs 7-9

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

Size measurements—Overall length × breadth 60-85 × 50-70 µm, maximum process length 6-12 µm (Clarke & Verdier, 1967); 36-67 × 40-63 µm, process length 2-8 µm (Harland, 1973); overall length × breadth 60-68 × 50-62 µm, body 45-50 × 37-45 µm, process length 7-13 µm (Srivastava, 1991); overall 40-94 × 49-83 µm, process length 5 µm in three specimens of this study.

PLATE 5 →

1. *Batiacasphaera scrobiculata* (Deflandre & Cookson) Burger 1980; × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian.
2-3. *Caligodinium amiculum* Drugg 1970; 2. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 3. × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.
4. *Canningia colliveri* Cookson & Eisenack 1960a; × 40, CRC 32134-6, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.
5-6. *Canningia reticulata* Cookson & Eisenack 1960a; 5. × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian; 6. × 40, CRC 32134-1, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.
7-9. *Canningia senonica* Clarke & Verdier 1967; × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

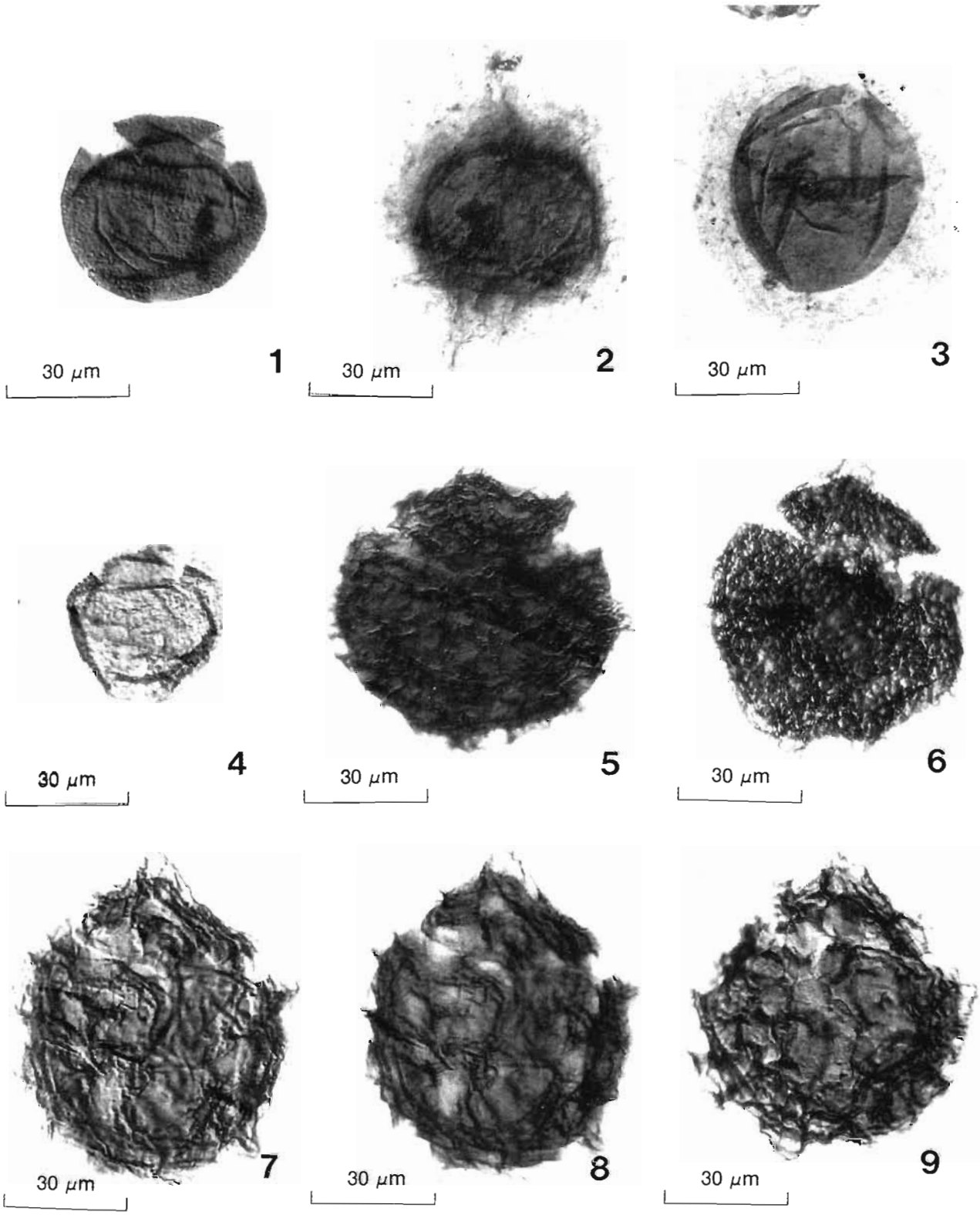


PLATE 5

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

reticulum, otherwise appears similar to *Canningia senonica*.

Previous records—Cenomanian-Campanian. Senonian, Isle of Wight, England (Clarke & Verdier, 1967); Upper Campanian, southern Alberta, Canada (Harland, 1973); Santonian-Campanian, France (Foucher, 1976); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Genus—*Cannosphaeropsis* O. Wetzel emend. Williams & Downie in Davey *et al.* 1966

1933b *Cannosphaeropsis* O. Wetzel, p. 52.

1966 *Cannosphaeropsis* O. Wetzel emend. Williams & Downie in Davey *et al.*, p. 222.

Type species—*Cannosphaeropsis utinensis* O. Wetzel 1933b (monotypic).

Remarks—*Cannosphaeropsis* consists of chorate cysts having subspherical body with varying number of processes supporting a network, gonal triradiate accessory trabeculae branches, intergonally two short branches, a gonyaulacacean paratabulation, and a precingular archeopyle type *P cannosphaeropsis* differs from *Nematosphaeropsis* in having intergonally single parasutural trabeculae.

Cannosphaeropsis hyperacantha Cookson & Eisenack 1960b

Pl. 6, figs 1, 2

1960b *Cannosphaeropsis hyperacantha* Cookson & Eisenack, p. 9, pl. 2, figs 14, 15.

Size measurements—Overall diameter 62-100 µm (Cookson & Eisenack, 1960b); overall dimensions 65 × 52 µm, process length 13 µm in one specimen of this study.

Previous records—Senonian (probably Campanian), Australia (Cookson & Eisenack, 1960b).

Cannosphaeropsis utinensis O. Wetzel 1933b

Pl. 6, figs 3-6

1933b *Cannosphaeropsis utinensis* O. Wetzel, p. 52, pl. 3, figs 9-17; text-fig. 12.

Size measurements—Overall diameter 61 µm, body 25-30 µm (Alberti, 1961); length × breadth-overall 75-145 × 70-108 µm, body 34-68 × 30-55 µm (Corradini, 1973). Overall diameter 90-98 µm, body length × breadth 48-50 × 43-45 µm (May, 1980); length × breadth: overall 70-117 × 70-104 µm, body 42-65 × 29-60 µm, process length from the body 13-31 µm in seven specimens of this study.

Previous records—Senonian. Senonian, Europe (O. Wetzel, 1932, 1933b, 1961; Deflandre, 1935, 1937, 1947; Alberti, 1961; Wilson, 1971; Corradini, 1973; Kjellström, 1973; Foucher & Robaszynski, 1977; Foucher, 1983); Campanian-Maastrichtian, Scotian Shelf, Canada (Millioud *et al.*, 1975; Williams, 1975); near Campanian-Maastrichtian boundary, New Jersey, U.S.A. (May, 1980); rare occurrence in a sample from the upper Taylor Marl (Campanian) of Texas, U.S.A. (Harker *et al.*, 1990).

Genus—*Cassiculosphaeridia* Davey 1969a

1969a *Cassiculosphaeridia* Davey, p. 141.

Type species—*Cassiculosphaeridia reticulata* Davey 1969a (original designation).

Remarks—*Cassiculosphaeridia* is distinct from *Dictyopyxidia* and *Ellipsodinium* in lacking indications of paracingulum or any other paratabulation.

Cassiculosphaeridia reticulata Davey 1969a

Pl. 6, figs 7, 8

1969a *Cassiculosphaeridia reticulata* Davey, p. 142, pl. 3, fig. 7; pl. 4, fig. 3.

Size measurements—Shell diameter 33-55 µm and crest height 3-11 µm (Davey, 1969a); 33-55 µm and 3-11 µm (Foucher, 1974); shell length × breadth 40-45 × 37-40 µm and crest height about 2 µm (Srivastava, 1984); overall diameter 52-65 µm, body 44-52 µm, muri height 5-8 µm in specimens of this study.

Previous records—Valanginian-Turonian, Valanginian-Hauterivian, offshore Denmark (Davey, 1982b); Valanginian and Upper Barremian-Upper Aptian, northern Germany (Below, 1981b, 1982b); Barremian-Turonian, Europe (Davey, 1969, 1974, 1979a; Davey & Verdier, 1971, 1974; Foucher, 1974); Barremian stratotype, France (de Reneville & Raynaud, 1981; Srivastava, 1984); Cenomanian, Australia (Norvick & Burger, 1976); Late Aptian-Turonian, DSDP Leg 40 off southwestern Africa (Davey, 1978); middle-late Aptian, Mazagan Plateau,

PLATE 6 →

1-2. *Cannosphaeropsis hyperacantha* Cookson & Eisenack 1960; × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

3-6. *Cannosphaeropsis utinensis* O. Wetzel 1933b; 3, 4, × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; 5,6. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

7-8. *Cassiculosphaeridia reticulata* Davey, 1969a; × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

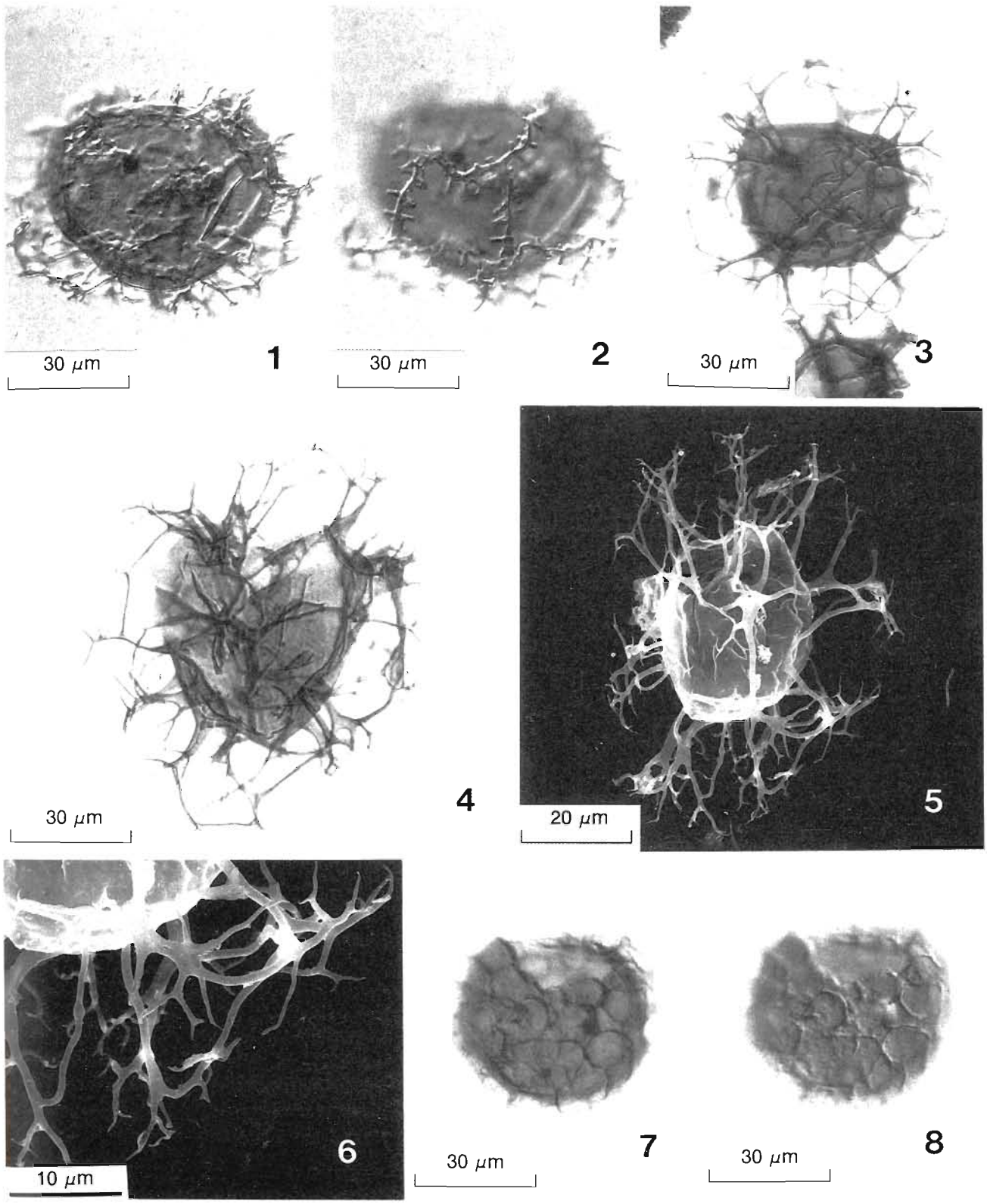


PLATE 6

off northwest Africa (Below, 1984); Early Albian, India (Jain, 1977); a single specimen in a sample from the Lea Park Formation (Campanian) of Saskatchewan, Canada (Harker *et al.*, 1990).

Genus—*Ceratiopsis* Vozzhennikova emend. Bujak *et al.* 1980

1963 *Ceratiopsis* Vozzhennikova, p. 181.
1980 *Ceratiopsis* Vozzhennikova emend. Bujak *et al.*, p. 27.

Type species—*Ceratiopsis leptoderma* Vozzhennikova 1963 (original designation).

Remarks—Lentin and Williams (1976) and Stover and Evitt (1978) considered *Ceratiopsis* as a junior synonym of *Deflandrea* Eisenack 1938. Lentin and Williams (1977a) accepted *Ceratiopsis* as a distinctly separate genus from *Deflandrea* in having the hexa 2a archeopyle. Bujak *et al.* (1980) emended *Ceratiopsis* accordingly.

Ceratiopsis navarriana S.K. Srivastava, n. sp.

Pl. 7, figs 1-3

Description—Cysts compressed peridinioid, pentagonal to roundly pentagonal with a single long apical and two equal divergent tapering antapical horns, sides straight to slightly convex; cornucavate, rarely slightly bicavate, endocyst pentagonal to roundly pentagonal filling the main body; periphragm smooth with a few wrinkles aligned longitudinally, sometimes anastomosing in certain areas; endophragm smooth; paratabulation indicated by an archeopyle and a low irregular paracingulum; archeopyle intercalary, 2a type, operculum free; paracingulum low transverse parallel ridges, ridges sometimes granular.

Size measurements—Total length × breadth range 104-169 × 49-99 µm in eight specimens.

Holotype—Pl. 7, fig. 2; photomicrograph reference no. 85029/11; objective × 40; microscope location-horizontal 19.0/ vertical 113.0; size-total length × breadth 122 × 73 µm, endocyst 70 × 70 µm; sample no. CRC 32140-1/slide 1; locality DW12, the Navarro Group, the Corsicana Clay, Navarro County, Texas; Maastrichtian.

Paratype—Pl. 7, figs 1, 3; photomicrograph reference no. 85030/34; objective × 40; microscope location-horizontal 18.0/ vertical 102.0; size-total length × breadth 133 × 81 µm, sample no. CRC 32140-1/Slide 7; locality DW12, the Navarro Group, the Corsicana Clay, Navarro County, Texas; Maastrichtian.

Paratype—Pl. 7, fig. 3; photomicrograph reference no. 85030/6; objective × 40; microscope location-horizontal 20.5/vertical 113.0; size—total length × breadth 169 × 99 µm; sample no. CRC 32140-1/Slide 4; locality DW12, the Navarro Group, the Corsicana Clay, Navarro County, Texas; Maastrichtian.

Remarks—*C. navarriana* is distinct from *C. albertii* (Corradini), *C. striata* (Drugg), and *C. subquadra* (Corradini) in being cornucavate; from *C. cordifera* (May) and *C. leptoderma* Vozzhennikova in having pentagonal endocyst; from *C. crassistriata* (Jain *et al.*) and *C. granulostriata* (Jain & Millepied) in having smooth endocyst and from *C. pannucea* (Stanley) in lacking well-developed paracingulum.

Name derivation—After Navarro Group from Navarro County, Texas.

Ceratiopsis striata (Drugg) Lentin & Williams 1977

Pl. 7, figs 4, 5

1967 *Deflandrea striata* Drugg, p. 18, pl. 2, figs 13, 14.
1977a *Ceratiopsis striata* (Drugg) Lentin & Williams, p. 21.

Size measurements—Length × breadth 138-168 × 79-97 µm (Drugg, 1967); 130-143 × 70 µm in three specimens of this study.

Previous records—Campanian-Paleocene, Campanian-Maastrichtian, Gabon, West Africa (Boltenhagen, 1977); Campanian-Danian, U.S.A. (Drugg, 1967; May, 1980; Helenes, 1984); Maastrichtian-Thanetian, Morocco (Doubinger, 1979); Danian, Scotian Shelf, Canada (Millioud *et al.*, 1975); Early Paleocene, France (du Chéne *et al.*, 1975); Paleocene, Denmark (Heilmann-Clausen, 1985).

Ceratiopsis subquadra Corradini 1973

Pl. 7, fig. 6

1973 *Deflandrea subquadra* Corradini, p. 175, pl. 28, fig. 1.
1977a *Ceratiopsis subquadra* (Corradini) Lentin & Williams, p. 22.

Size measurements—Length × breadth, pericyst 115-143 × 72-75 µm, endocyst 55-60 × 60-65 µm (Corradini, 1973); pericyst 108-161 × 86 µm, endocyst 40-65 × 52-80 µm in eight specimens of this study.

Previous records—Senonian, Italy (Corradini, 1973).

PLATE 7 →

1-3. *Ceratiopsis navarriana* S.K. Srivastava, n. sp.: × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; holotype-fig. 2, paratypes-figs 1 and 3.
4-5. *Ceratiopsis striata* (Drugg) Lentin & Williams 1977; ×40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.
6. *Ceratiopsis subquadra* Corradini 1973; × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

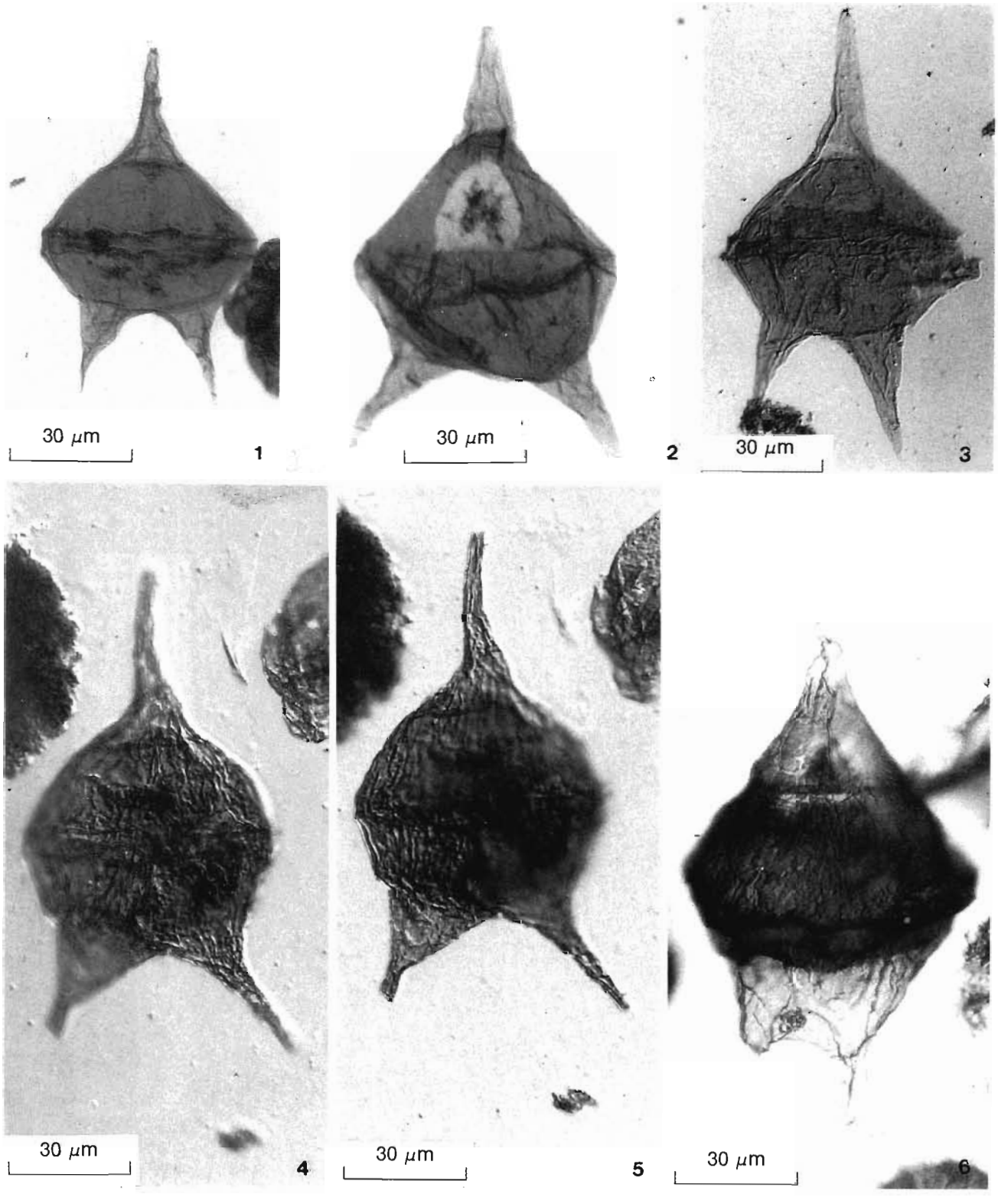


PLATE 7

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 longitudinally elongate cysts with subrectangular outline, a short broad-based apical horn, poorly developed antapical horns, an intercalary archeopyle, and peridiniacean paratabulation. *Chatangiella* is distinct from *Isabelidinium* in having a more rectangular outline and a broad-based apical horn.

Chatangiella armata (Cookson & Eisenack) Lentin & Williams 1976

Pl. 8, figs 1-6

1970 *Deflandrea armata* Cookson & Eisenack, p. 142, pl. 13, fig. 9.
1976 *Chatangiella armata* (Cookson & Eisenack) Lentin & Williams, p. 53.

Size measurements—Length × breadth 67-80 × 48-57 µm (Cookson & Eisenack, 1970); 52 × 40 µm in one specimen of this study.

Previous records—Senonian, Western Australia (Cookson & Eisenack, 1970).

Chatangiella granulifera (Manum) Lentin & Williams 1975

Pl 8, figs 7-9

1963 *Deflandrea granulifera* Manum, p. 61, pl. 3, figs 5-9.
1975 *Chatangiella granulifera* (Manum) Lentin & Williams, p. 54.

Size measurements—Length × breadth-pericyst 95-124 × 60-84 µm (Manum, 1963); pericyst 81-104 × 49-62 µm, endocyst 46-49 × 49-55 µm in three specimens of this study.

Previous records—Senonian. Senonian, Graham Island, Arctic Canada (Manum, 1963); Campanian, Saskatchewan and Manitoba, Canada (Harker *et al.*, 1990).

Chatangiella robusta (Benson) Stover & Evitt 1978

Pl. 9, fig. 1

1976 *Trithyrodinium robustum* Benson, p. 198, pl. 11, figs 9-12; pl. 12, fig. 1.
1978 ?*Chatangiella robusta* (Benson) Stover & Evitt, p. 99.

Size measurements—Overall length × breadth 101-153 × 53-82 µm, endocyst 44-79 × 46-75 µm (Benson, 1976); overall 124-151 × 60-69 µm (May, 1980); overall 99 × 55 µm, endocyst 55 × 52 µm in one specimen of this study.

Previous records—Campanian-Maastrichtian, Maryland and New Jersey, U.S.A. (Benson, 1976; May, 1980; Whitney, 1984); Maastrichtian, Morocco (Rauscher & Doubinger, 1982).

Chatangiella spectabilis (Alberti) Lentin & Williams 1976

Pl. 9, figs 2-6

1959 *Deflandrea spectabilis* Alberti, p. 99, pl. 9, figs 7, 8.
1976 *Chatangiella spectabilis* (Alberti) Lentin & Williams, p. 55, pl. 6, fig. 83.

Size measurements—Length × breadth 86-110 × 52-68 µm (Alberti, 1959); 58-87 × 32-50 µm (Harland, 1973); 67 × 56 µm (Srivastava, 1991); pericyst 63-130 × 41-85 µm, endocyst 36-68 × 39-65 µm in six specimens of this study.

Previous records—Senonian, Germany (Alberti 1959); Santonian-Campanian, western Canada (Harland, 1973; McIntyre, 1974, 1975; Wall & Singh, 1975); Campanian, western interior of North America (Harker *et al.*, 1990).

Chatangiella victoriensis (Cookson & Manum) Lentin & Williams 1976

Pl. 10, figs 1-6

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

PLATE 8 →

1-6. *Chattangiella armata* (Cookson & Eisenack) Lentin & Williams 1976; 1-3 × 100, CRC 32137-2, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian; 4-6, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

7-9. *Chatangiella granulifera* (Manum) Lentin & Williams 1975; 7 × 40, CRC 32134-1, D6, the Austin Chalk, middle Chalk member Dallas County; Santonian; 8,9, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

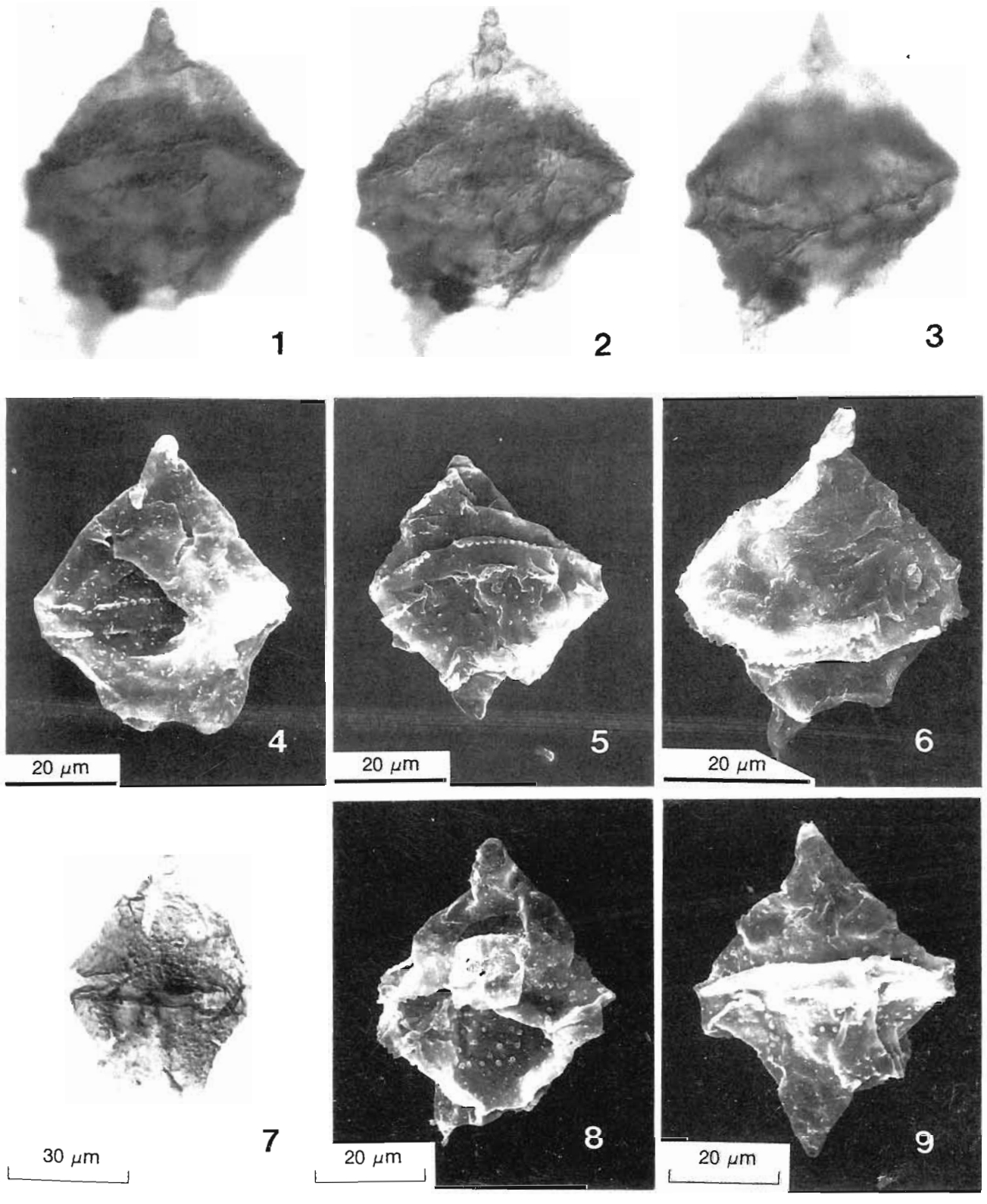


PLATE 8

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

Size measurements—Overall length × breadth 76-116 × 49-73 μm (Cookson & Manum, 1964); 75-99 ×

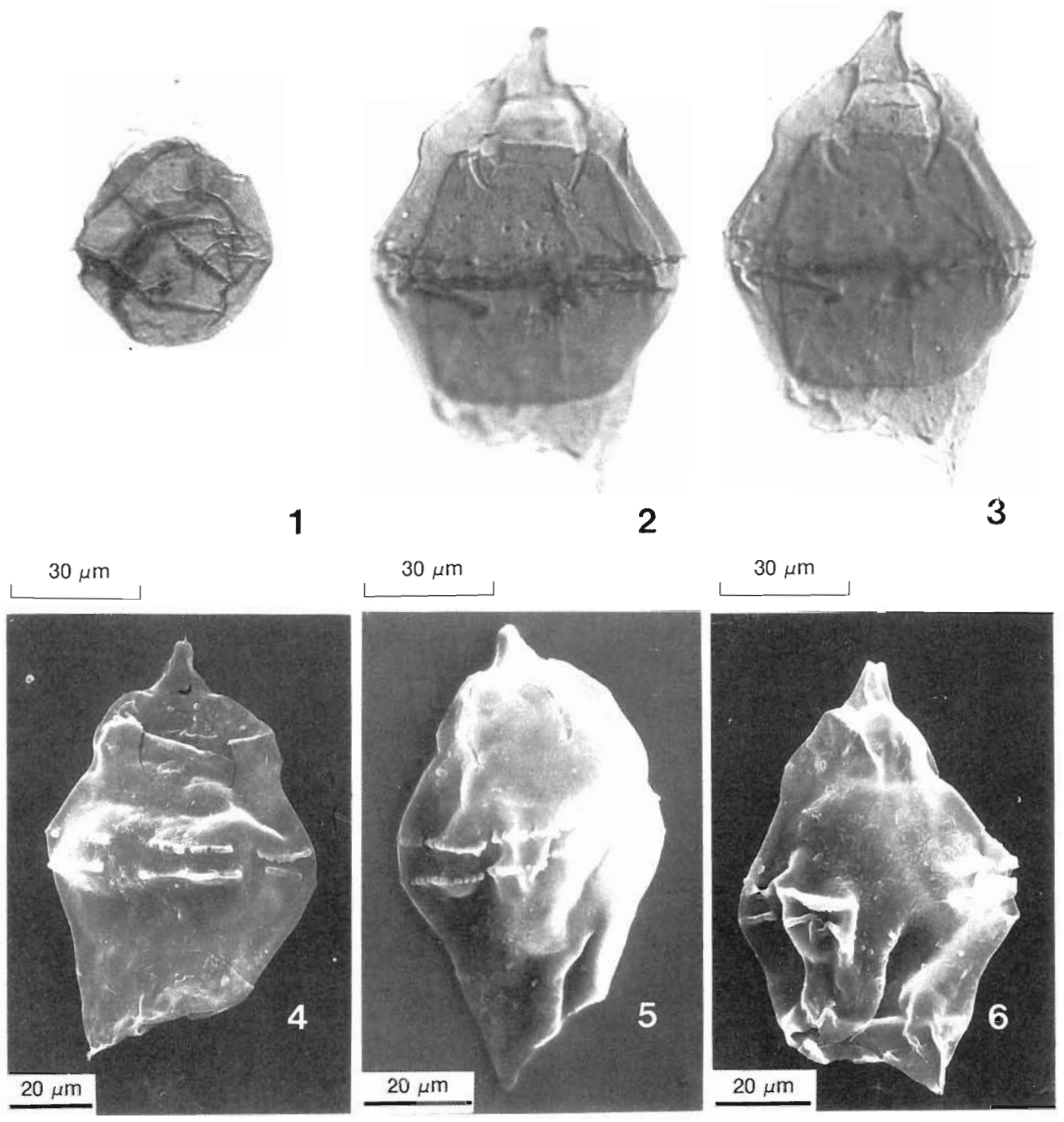


PLATE 9

1 *Chatangiella robusta* (Benson) Stover & Evitt 1978: × 40, CRC 32134-4, D6, the Austin Chalk, middle Chalk member Dallas County; Santonian.

2-6. *Chatangiella spectabilis* (Alberti) Lentin & Williams 1976: 2, 3, × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian; 4-6, CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

43-53 μm (Foucher, 1972); 89-93 × 48-60 μm (Yun, 1981); 75 × 41 μm (Srivastava, 1991); pericyst length × breadth 96-104 × 49-62 μm, endocyst 46-52 × 49-62 μm in three specimens of this study.

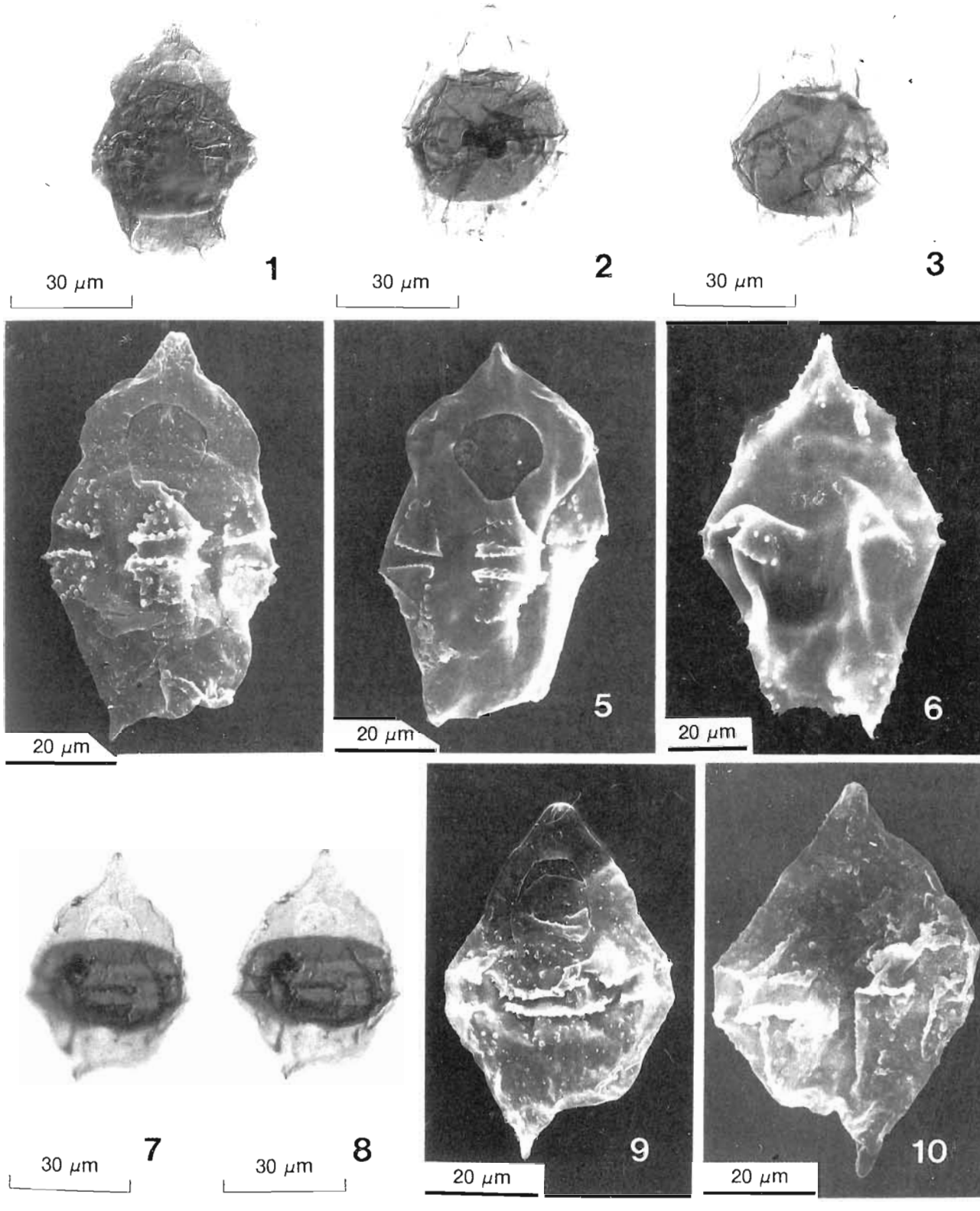


PLATE 10

Previous records—Coniacian-Maastrichtian. Coniacian, France (Foucher, 1972); Santonian, Germany (Yun, 1981); Santonian, Isle of Wight (Clarke & Verdier, 1967); Coniacian-Maastrichtian, North America (Wall &

Singh, 1975; Aurisano & Habib 1977; Srivastava, 1991); Campanian, western interior of North America (Harker *et al.*, 1990); Senonian, Australia (Cookson & Manum 1964; Cookson & Eisenack, 1982); ?Paleocene, Belgium (Schumacker-Lambry, 1978).

Chatangiella williamsii Yun 1981

Pl. 10, figs 7-10

1981 *Chatangiella williamsii* Yun, p. 66, pl. 13, figs 8, 12, 14.

Size measurements—Length × breadth-pericyst 66-78 × 50-54 µm, endocyst 48-51 × 27-30 µm (Yun, 1981); pericyst 64-101 × 40-57 µm, endocyst 23-52 × 35-57 µm in six specimens of this study.

Previous records—Santonian, England (Clarke & Verdier, 1967), Germany (Yun, 1981).

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—*Cleistosphaeridium* differs from *Operculodinium* and *Bacchidinium* in having an apical archeopyle, from *Polysphaeridium* in having distally closed processes, and from *Surculosphaeridium* in lacking branched processes.

Cleistosphaeridium aciculare Davey 1969a

Pl. 11, figs 1-3

1969a *Cleistosphaeridium aciculare* Davey, p. 158, pl. 6, figs 6, 11, 12.

Size measurements—Body diameter 32-54 µm, process length 8-21 µm (Davey, 1969a); body 30-35 µm, process length up to 20 µm, (Brideaux, 1977); body 31-57 µm, process length 13-21 µm (Srivastava, 1984); body 49 µm, process length 21-23 µm in specimens of this study.

Previous records—Barremian-Campanian, Canada (Davey, 1969a; Brideaux & McIntyre, 1975; Brideaux, 1977; McIntyre, 1974); Barremian, France (Srivastava, 1984); Middle Aptian-Early Albian, Australia (Burger, 1980); Campanian, western interior of North America (Harker *et al.*, 1990).

Cleistosphaeridium giganteum (Caro) Stover & Evitt 1978

Pl. 11, figs 4-6

1973 *Polysphaeridium giganteum* Caro, p. 360, pl. 2, fig. 12.

1978 *Cleistosphaeridium giganteum* (Caro) Stover & Evitt, p. 31.

Size measurements—Body diameter 79-110 µm, process length 35-37 µm (Caro, 1973); body 62-68 µm, process length 21-29 µm in three specimens of this study.

Previous records—Upper Paleocene, Spain (Caro, 1973).

Cleistosphaeridium mediterraneum Corradini 1973

Pl. 11, figs 7-9

1973 *Cleistosphaeridium mediterraneum* Corradini p. 137, pl. 19, figs 5a, 5b; text-fig. 4.

Size measurements—Body dimension 40-50 × 48-52 µm, process length 12-24 µm (Corradini, 1973); body diameter 62-65 µm, process length 18-23 µm in specimens of this study.

Previous records—Senonian, Italy (Corradini, 1973).

← **PLATE 10**

1-6. *Chatangiella victoriensis* (Cookson & Manum) Lentin & Williams 1976; 1- × 40, CRC 32134-1, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian; 2, 3. × 40, CRC 32134-2, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian; 4-6. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

7-10. *Chatangiella williamsii* Yun 1981; 7, 8 × 40; CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian. 9, 10. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

PLATE 11 →

1-3. *Cleistosphaeridium aciculare* Davey 1969a; 1. × 40, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian; 2, 3. CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

4-6. *Cleistosphaeridium giganteum* (Caro) Stover & Evitt 1978; 4. × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian; 5, 6. × 40, CRC 32173, the Austin Group, Burditt Formation, Travis County; Santonian.

7-9. *Cleistosphaeridium mediterraneum* Corradini 1973; 7 × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian. 8, 9. CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

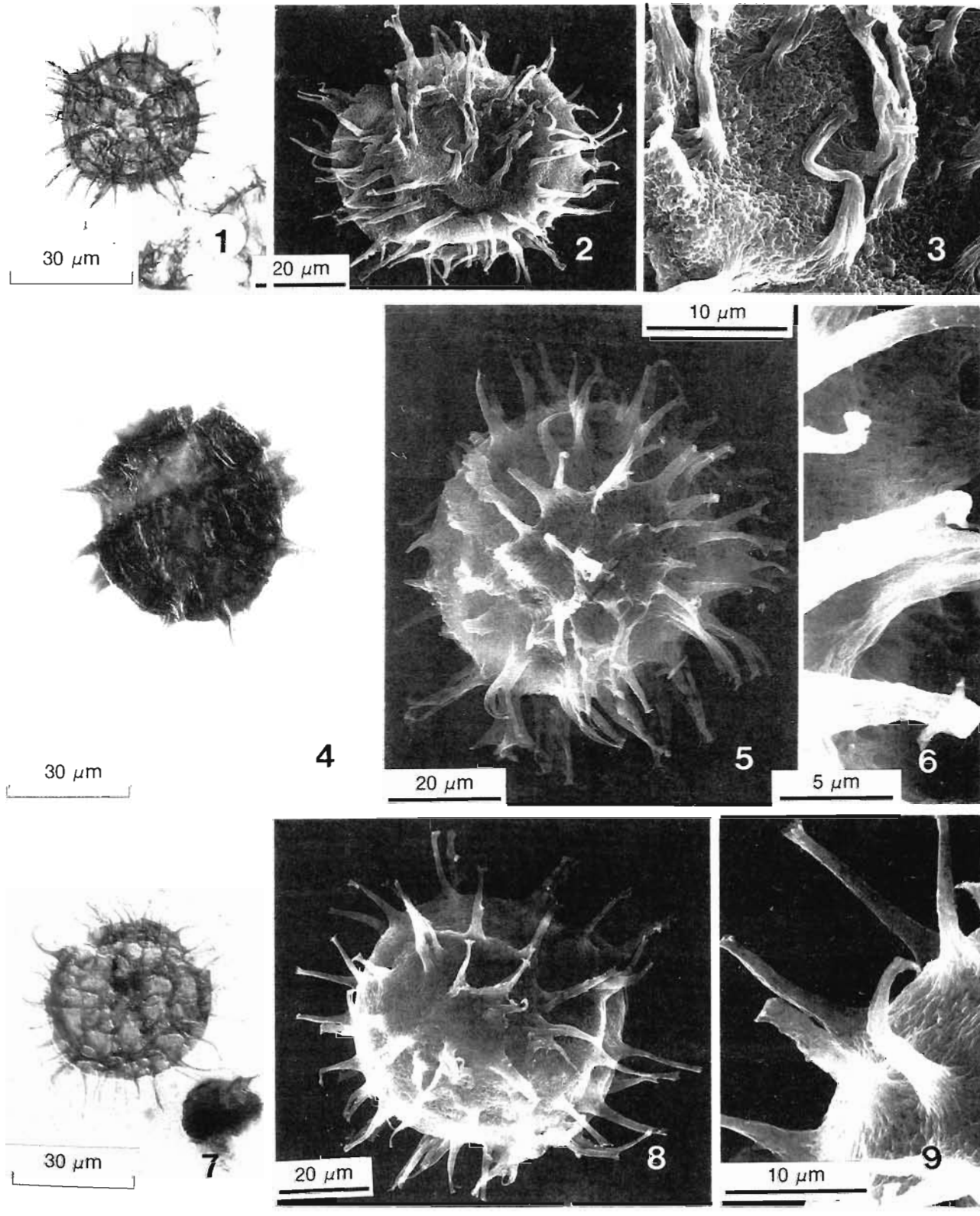


PLATE 11

Genus—*Cordosphaeridium* Eisenack emend. Davey 1969

1963 *Cordosphaeridium* Eisenack, p. 261.
1969b *Cordosphaeridium* Eisenack emend. Davey, p. 35.

Type species—*Cordosphaeridium inodes* (Klumpp) Eisenack 1963 = *Hystrichosphaeridium inodes* Klumpp 1953 (original designation).

Remarks—Cordosphaeridium consists of skolochorate cysts having subspherical body with fibrous, solid or hollow, mostly intratabular processes indicating a gonyaulacacean paratabulation and a precingular archeopyle.

Cordosphaeridium is distinct from *Kleithriasphaeridium* in having fibrous processes; from *Amphorosphaeridium* and *Kenleyia* in having mostly intratabular processes; from *Fibrocysta* in having subspherical body and a larger number of paracingular processes; and from *Turbiosphaera* in being subspherical and having longer processes.

Cordosphaeridium fibrospinosum Davey & Williams in Davey *et al.*, 1966

Pl. 12, figs 1-3

1966 *Cordosphaeridium fibrospinosum* Davey & Williams in Davey *et al.*, p. 86, pl. 5, fig. 5.

Size measurements—Body dimensions 59-72 µm, process length up to 39 µm, width up to 26 µm (Davey & Williams in Davey *et al.*, 1966); 49-63 µm, process length 14-20 µm (Davey, 1969b); 52-72 µm, process length 15-38 µm (Corradini, 1973); 58-80 µm, process length up to 30 µm, width up to 36 µm (Benson, 1976); 40-70 µm, process 15 × 26 µm (Eaton, 1976); 61-90 × 54-83 µm, process length 17-32 µm (May, 1980); 65-77 × 62-75 µm process length 10-30 × 20-35 µm (Saxena & Rao, 1984); 65-88 × 57-65 µm, process length 25-26 × 21-25 µm in three specimens of this study.

Previous records—Albian-Cenomanian, Australia (Cookson & Eisenack, 1982); Upper Cretaceous, South Africa (Davey, 1969b); Senonian-Oligocene, Europe (Davey & Williams in Davey *et al.*, 1966; Gocht, 1969; Benedek, 1972; Caro, 1973; Corradini, 1973; Kjellström, 1973; Eaton, 1976; Bujak *et al.*, 1980; Antonescu & Alexandrescu, 1982); Campanian-Paleocene, U.S.A. (Zaitzeff & Cross, 1971; Stone, 1973; Benson, 1976; May, 1980); Late Maastrichtian, south India (Jain, 1978); Oligocene-Lower Miocene, eastern India (Saxena & Rao, 1984).

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

1958 *Coronifera* Cookson & Eisenack, p. 45.
1969a *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* in having a precingular archeopyle.

Coronifera oceanica Cookson & Eisenack 1958

Pl. 12, figs 4-5

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

Size measurements—Range of overall dimensions 60-95 × 44-94 µm, shell dimensions 33-58 × 29-65 µm, length of apical horn 6-24 µm, width of apical horn 6-18 µm, dimensions of processes 5-22 × 1-3 µm (Srivastava, 1984); overall 60-70 × 50-65 µm, shell dimensions 37-50 × 33-50 µm, antapical horn length × width 13-20 × 10-15 µm, process length × breadth 13-20 × 1-3 µm (Srivastava, 1991); overall 68-91 × 68-81 µm, body 55-57 × 49-57 µm; process length 16-18 µm; antapical process 18 × 8 µm in two specimens of this study.

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

Genus—*Craspedodinium* Cookson & Eisenack 1974

1974 *Craspedodinium* Cookson & Eisenack, p. 75.

Type species—*Craspedodinium indistinctum* Cookson & Eisenack 1974 (original designation).

Remarks—Craspedodinium has an apical archeopyle and consists of cavate, subspherical to ovoidal cysts having an endocyst enveloped by a loose pericyst. *Craspedodinium* differs from *Leberidocysta* in having thicker periphragm.

PLATE 12 →

1-3. *Cordosphaeridium fibrospinosum* Davey & Williams in Davey *et al.* 1966; 1, 2. × 40, CRC 32134-1, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian, 3. × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

4-5. *Coronifera oceanica* Cookson & Eisenack 1958; × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian.

6-7. *Craspedodinium indistinctum* Cookson & Eisenack 1974; 6. × 40, CRC 32140-1, DW 12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian, 7. × 40, CRC 32127-2, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian.

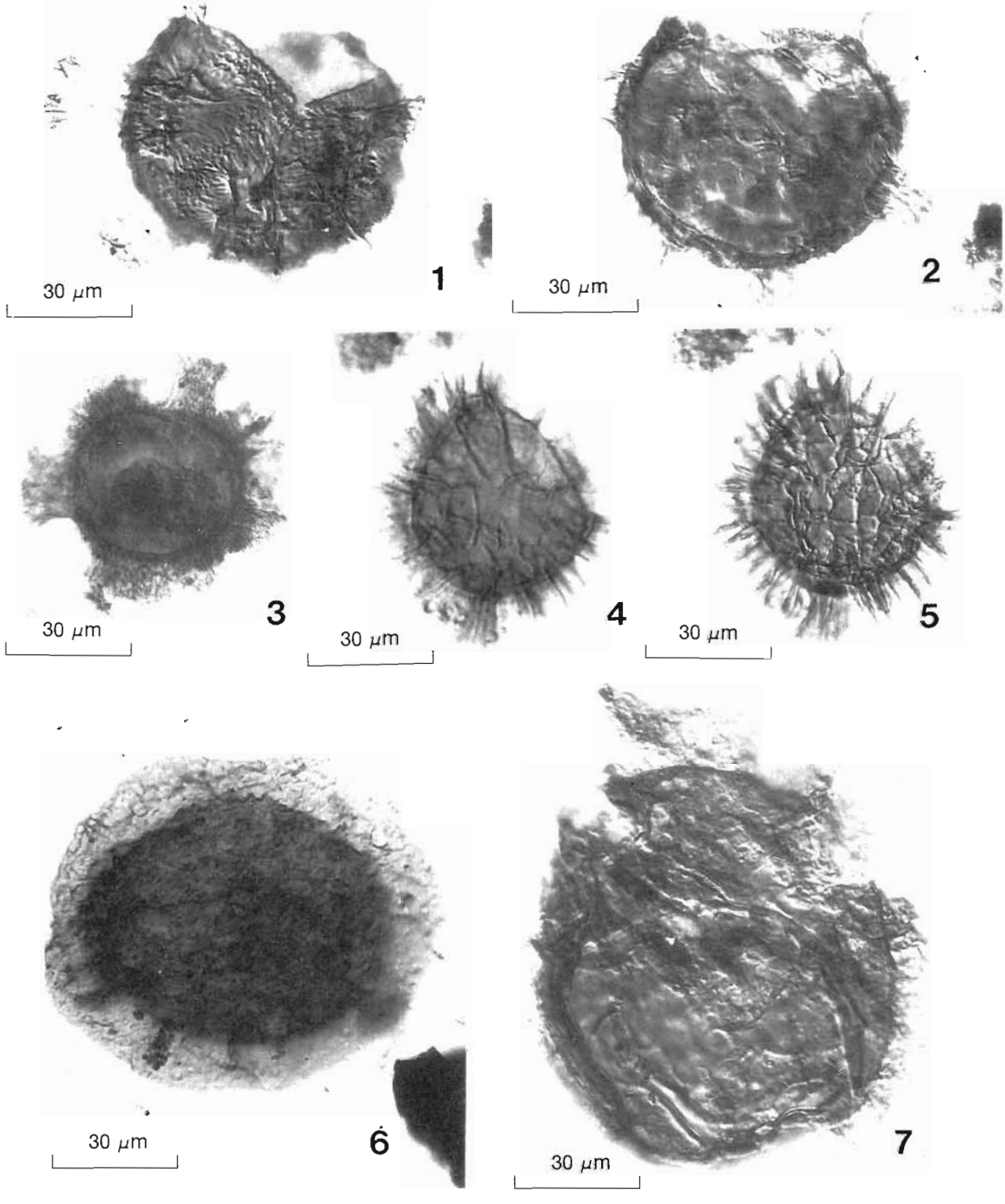


PLATE 12

Craspedodinium indistinctum Cookson & Eisenack 1974

Pl. 12, figs 6-7

1974 *Craspedodinium indistinctum* Cookson & Eisenack, p. 76, pl. 25, figs 6-8.

Size measurements—Length × breadth 86-104 × 66-96 µm (Cookson & Eisenack, 1976); 94-130 × 78-117 µm, endocyst 62- ±05 µm in seven specimens of this study.

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

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 ridges.

Cribroperidinium edwardsii (Cookson & Eisenack) Davey 1969

Pl. 13, figs 1-2

1958 *Gonyaulax edwardsi* Cookson & Eisenack, p. 32, pl. 3, figs 5-6; text-fig. 7 (err orth. pro *edwardsii*) [effective publication date, March 1958].

1958 *Gonyaulax orthoceras* Eisenack, p. 388, pl. 21, figs 3-11; pl. 24, fig. 1, text-figs 2-3 [effective publication date, August 1958].

1966 *Gonyaulacysta orthoceras* (Eisenack) Sarjeant in Davey *et al.*, p. 121, pl. 14, figs 5-6; text-fig. 29.

1966 *Gonyaulacysta edwardsi* (Cookson & Eisenack) Sarjeant in Davey *et al.*, p. 130 (basionymo non cit.; err. orth. pro *edwardsii*).

1969a *Cribroperidinium edwardsi* (Cookson & Eisenack) Sarjeant in Davey *et al.*, p. 128 (err. orth. pro *edwardsii*).

1969a *Cribroperidinium orthoceras* (Eisenack) Davey, p. 128, figs 13A-B.

Size measurements—Overall dimensions 143 × 125 µm (Cookson & Eisenack, 1958); 70-105 µm (Eisenack, 1958); 80-115 µm (Sarjeant in Davey *et al.*, 1966); 90-130 × 66-100 µm (Below, 1981a); 60-114 × 50-88 µm (Srivastava, 1984); 83-117 × 60-86 µm in nine specimens of this study.

Remarks—Davey and Verdier (1971), Stover and Evitt (1978) and Lentin and Williams (1981) considered *Cribroperidinium edwardsii* and *C. orthoceras* conspecific. Sarjeant (1985a) restudied and re-illustrated the holotype and paratypes of *C. orthoceras*, but did not consider it conspecific of *C. edwardsii* until the later species is also restudied in detail.

Previous records—Tithonian-Campanian (see Davey & Verdier, 1971, p. 17; and the synonymy listed in Below, 1981a). Valanginian, Upper Barremian and Upper Aptian, Germany (Below, 1981b, 1982b); Valanginian-Hauterivian, Spitsbergen (Bjaerke, 1978); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Hauterivian, offshore Denmark (Davey, 1982b); Aptian-Early Albian, Isle of Wight, England (Duxbury, 1983); and Early Albian, India (Jain, 1977).

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

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

1958 *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—See Srivastava (1991) for discussion on the synonymy of *Cyclonephelium*. *Cyclonephelium* is distinct from *Canningia* in lacking a uniform sculpture in mid-dorsal and mid-ventral areas. It differs from *Glaphyrocysta* in lacking long processes connected distally

Cyclonephelium castelcasiense Corradini 1973

Pl. 13, figs 3-5

1973 *Cyclonephelium castelcasiense* Corradini, p. 161, pl. 24, figs 2, 5a, 5b; pl. 35, figs 1, 2.

Size measurements—Body length × breadth 54-62 × 56-70 µm, process length 8-20 µm (Corradini, 1973); overall dimensions 83-101 × 78-91 µm, body 57-65 ×

PLATE 13 →

1-2. *Cribroperidinium edwardsii* (Cookson & Eisenack) Davey 1969a; 1. × 40, CRC 32140-4, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian; 2. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

3-5. *Cyclonephelium castelcasiense* Corradini 1973; 3, 4. × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian; 5. × 40, CRC 32146-2, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

6-8. *Cyclonephelium distinctum* Deflandre & Cookson 1955; 6, 7 × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian; 8. × 40, CRC 32134-5, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

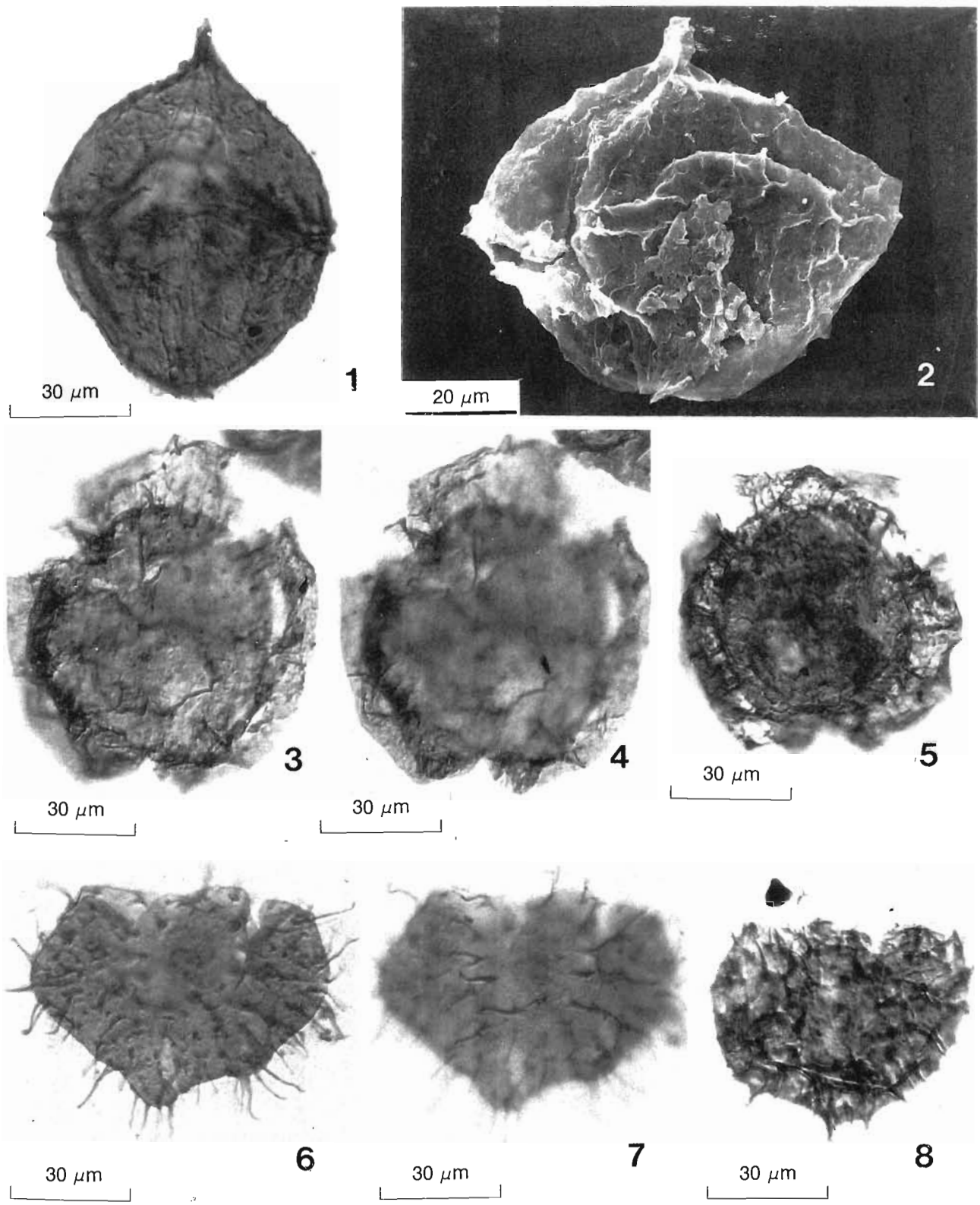


PLATE 13

55-60 μm; process length 13-23 μm in five specimens of this study.

Previous records—Late Maastrichtian, Italy (Corradini, 1973).

Cyclonephelium distinctum Deflandre & Cookson 1955

Pl. 13, figs 6-8

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.

Size measurements—Cyst diameter 64-97 µm (Deflandre & Cookson, 1955); length × breadth 128 × 124 µm (Cookson & Eisenack, 1971); 60-84 × 50-78 µm (Singh, 1971); 37-84 × 39-87 µm (Harland, 1973); 67 × 60 µm (Foucher & Taugourdeau, 1975); 55-110 × 46-106 µm) Ioannides, Stavrinos & Downie, 1977); 65-105 × 57-99 µm (Duxbury, 1977); 66-98 × 53-88 µm (Srivastava, 1984); 73-86 × 49-60 µm in the specimens of this study.

Previous records—Kimmeridgian-Danian. Kimmeridgian-Campanian, Europe (Ioannides, Stavrinos & Downie, 1977; Duxbury, 1977, 1983; Davey, 1969a, 1974; Clarke & Verdier, 1967; Millioud, 1969; Davey & Verdier, 1971; Foucher & Taugourdeau, 1975; de Renéville & Raynaud, 1981; Srivastava, 1984; Below, 1981b; Bjaerke, 1978; Baltes, 1967a); Aptian-Albian, Israel (Brenner, 1974) and India (Jain & Taugourdeau-Lantz, 1973; Jain, 1977); Aptian-Danian, North America (Brideaux & McIntyre 1975; Singh, 1971; Davey, 1969a, Harland, 1973; McIntyre, 1974; Doerenkamp, Jardiné & Moreau, 1976; Benson, 1976; Drugg, 1967; Harland, 1977; Harker *et al.*, 1990; Srivastava, 1991); Campanian-Maastrichtian, Senegal (Jain & Millepied, 1975); Albian-Maastrichtian, Australia (Verdier, 1970; Cookson & Eisenack, 1971; Playford, Haig & Dettmann, 1975; Norvick & Burger, 1976; Deflandre & Cookson, 1955).

Genus—*Diconodinium* Eisenack & Cookson emend. Morgan 1977

1960 *Diconodinium* Eisenack & Cookson, p. 3.
1977 *Diconodinium* Eisenack & Cookson emend. Morgan, p. 124.

Type species—*Diconodinium multispinum* (Deflandre & Cookson) Eisenack & Cookson 1960 = *Palaeohystrichophora multispina* Deflandre & Cookson 1955 (original designation).

Remarks—*Diconodinium* consists of proximate to proximochorate, generally acavate, biconical cysts with single apical and antapical horns, smooth or variously ornamented autophragm and an intercalary archeopyle. It has peridinianean paratabulation, if indicated, usually by paracingulum only, otherwise autophragm or ornamentation is non-tabular or occasionally intratabular.

Diconodinium is distinguished from *Kalyptea* in having an archeopyle with attached operculum and an indication of a paracingulum.

Diconodinium martianum S.K. Srivastava, n. sp.

Pl. 14, figs 1-10

Description—Body shape fusiform to rhomboidal with single apical and antapical horns of almost equal size and shape; autophragm thin, surface smooth, non-tabular except that paracingulum indicated; paracingulum slightly raised, smooth ridges about 6-8 µm apart, paracingulum groove smooth, parasulcus also smooth; archeopyle generally not indicated, intercalary when present.

Size measurements—Total length × breadth range 84-110 × 26-44 µm in nine specimens of this study.

Holotype— Pl. 14, figs 1, 2; photomicrograph reference no. 85032/24, 25; objective × 40; microscope location-horizontal 40.0/vertical 103.0; size-total length × breadth 94 × 52 µm; sample no. CRC 32142-3/Slide 1; locality DW 14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Texas; Late Maastrichtian.

Paratype—Pl. 14, fig. 3; SEM photomicrograph reference no. P9110/N25255; × 800; sample no. CRC 32142-4; locality DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Texas; Late Maastrichtian.

Remarks—*Diconodinium martianum* is distinct from *D. psilatum*, *D. glabrum*, and *D. rhombiforme* in having longer apical and antapical horns.

Name derivation —After Mart, Texas.

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* has biconical to ellipsoidal shape with varying numbers of longitudinal ribs, usually discernible equatorial to subequatorial paracingulum, and a small apical archeopyle.

The original generic diagnosis defined *Dinogymnium* as "Tests of variable size and shape, commonly exhibiting a strong superficial similarity of motile cells of the modern genus *Gymnodinium* Stein; without indications of tabulation and without an inner body" (Evitt, Clarke & Verdier, 1967). The characteristics of cingulum, apical archeopyle and wall canals were emphasized in the original diagnosis. However, Stover and Evitt (1978) modified the generic description of the shape of the test as biconical to ellipsoidal. Lentin and Vozzhennikova (1990) restricted the genus *Dinogymnium* to those species that have distinct biconical to roundly biconical shape with a cingulum index between 40 and 60, and thus proposed genera *Alisogymnium*, *Amphigymnium* and *Yolkinigymnium* for species that deviated from their restricted diagnosis of *Dinogymnium*. Due to the uncertainty of the usefulness of the above restriction

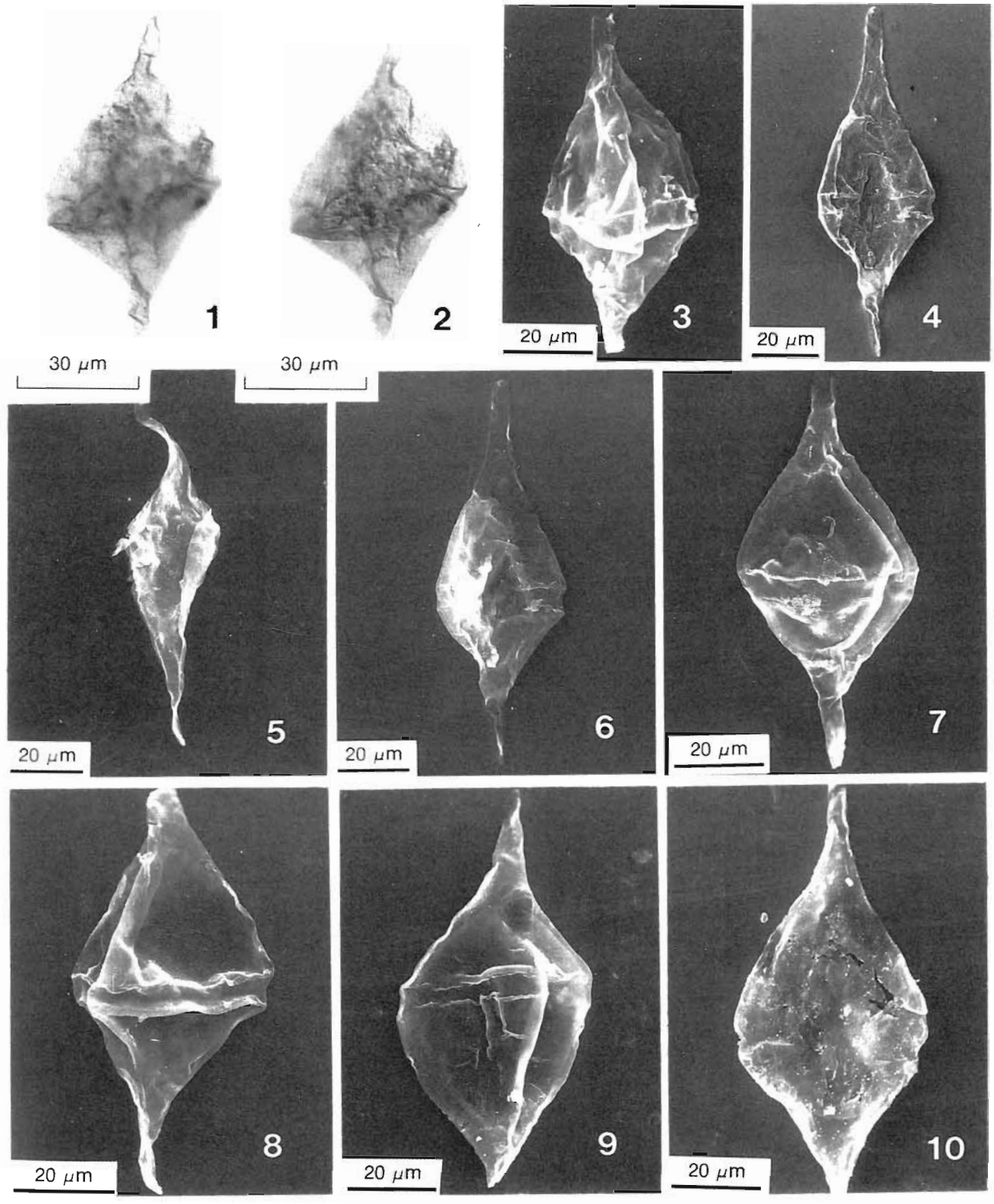


PLATE 14

1-10. *Diconodinium martianum* S.K. Srivastava, n. sp.; 1, 2. holotype, × 40, CRC 32142-3, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 3-10. paratypes, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

and the creation of new genera, the original concept of the genus *Dinogymnium* is followed here.

Dinogymnium acuminatum Evitt, Clarke & Verdier 1967

Pl. 15, figs 1-8; Pl. 16, figs 1-9

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, fig. A,B,F,G, S-U, text-fig. IA, J-K.

Size measurements—Length × width 48-127 × 27-86 µm (Evitt, Clarke & Verdier, 1967); 60-88 × 37-57 µm in 12 Coniacian specimens (Srivastava, 1991); 35-72 × 21-52 µm in 15 specimens of this study.

Remarks—SEM photomicrographs of *Dinogymnium acuminatum* show that canal openings on the exterior surface are distributed on the crest of ridges and at granule tops in between ridges (Pl. 16, figs 2, 3, 5, 6). Extreme apical and antapical areas do not have granules. Blind ended canals (Evitt *et al.*, 1967) should be under closed granules.

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 (Herngreen, 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); Late Coniacian-Senonian, southwestern Atlantic Ocean (Ioannides & Colin, 1977). Specimens reported from the Early Paleocene, Belgium (Schumacker-Lambry, 1978) may be the reworked examples from older strata.

Dinogymnium albertii Clarke & Verdier 1967

Pl. 17, figs 1-8

1967 *Dinogymnium albertii* Clarke & Verdier, p. 33, pl. 17, figs 3,4; text-fig. 13.

Size measurements—Length × breadth 60-70 × 40-50 µm (Clarke & Verdier, 1967); 52 × 30 µm (Yun, 1981); 46-75 × 31-49 µm in nine specimens of this study.

Previous records—Senonian, Santonian, Belgium (Schumacker-Lambry, 1978), Germany (Yun, 1981); Santonian, Isle of Wight, England (Clarke & Verdier, 1967); Campanian, Wyoming and Texas, U.S.A. (Harker *et al.*, 1990); Maastrichtian, Assam, India (Jain, Sah & Singh, 1975).

Dinogymnium cerviculum Cookson & Eisenack 1970

Pl. 17, figs 9-10

1970 *Dinogymnium cerviculum* Cookson & Eisenack, p. 138, pl. 10, fig. 6.

Size measurements—Length × breadth 33-40 × 27 µm (Cookson & Eisenack, 1970); 55-56 × 30-32 µm in two specimens of this study.

Previous records—Senonian, Australia (Cookson & Eisenack, 1970); Maastrichtian, Baja California, Mexico (Helenes, 1984).

Dinogymnium curvatum (Vozzhennikova) Lentin & Williams 1973

Pl. 18, figs 1-10

1967 *Gymnodinium curvatum* Vozzhennikova, p. 43, pl. 1, figs 10-12; pl. 4, figs 2, 3.

1973 *Dinogymnium curvatum* (Vozzhennikova) Lentin & Williams, p. 48.

Size measurements—Length × breadth 70-91.3 × 25-37.5 µm (Vozzhennikova, 1967); 71-143 × 27-57 µm in three specimens of this study.

Previous records—Senonian, Western Siberia, U.S.S.R. (Vozzhennikova, 1967).

Dinogymnium denticulatum (Alberti) Evitt, Clarke & Verdier 1967

Pl. 19, figs 1-3

1961 *Gymnodinium denticulatum* Alberti, p. 5, pl. 3, figs 2, 3.

1967 *Dinogymnium denticulatum* (Alberti) Evitt, Clarke & Verdier, p. 18.

Size measurements—Length × breadth 55 × 45 µm (Alberti, 1961); 55-68 × 28-45 µm in three specimens of this study.

Previous records—Senonian, Germany (Alberti, 1961); Santonian, Isle of Wight, England (Clarke & Verdier, 1967); Campanian, Saskatchewan, Canada (Harker *et al.*, 1990); Campanian-Maastrichtian, Senegal, West Africa (Jain & Millepied, 1975); Maastrichtian, Mahadek Formation, Assam, India (Jain, Sah & Singh, 1975). Lower Landenian (Upper Paleocene) records from Belgium (Schumacker-Lambry, 1978) are doubtful.

Dinogymnium digitum (Deflandre) Evitt, Clarke & Verdier 1967

Pl. 19, figs 4-9

1935 *Gymnodinium digitus* Deflandre, p. 225, figs 7, 8 (holotype non cit.; err. orth. pro *digitum*).

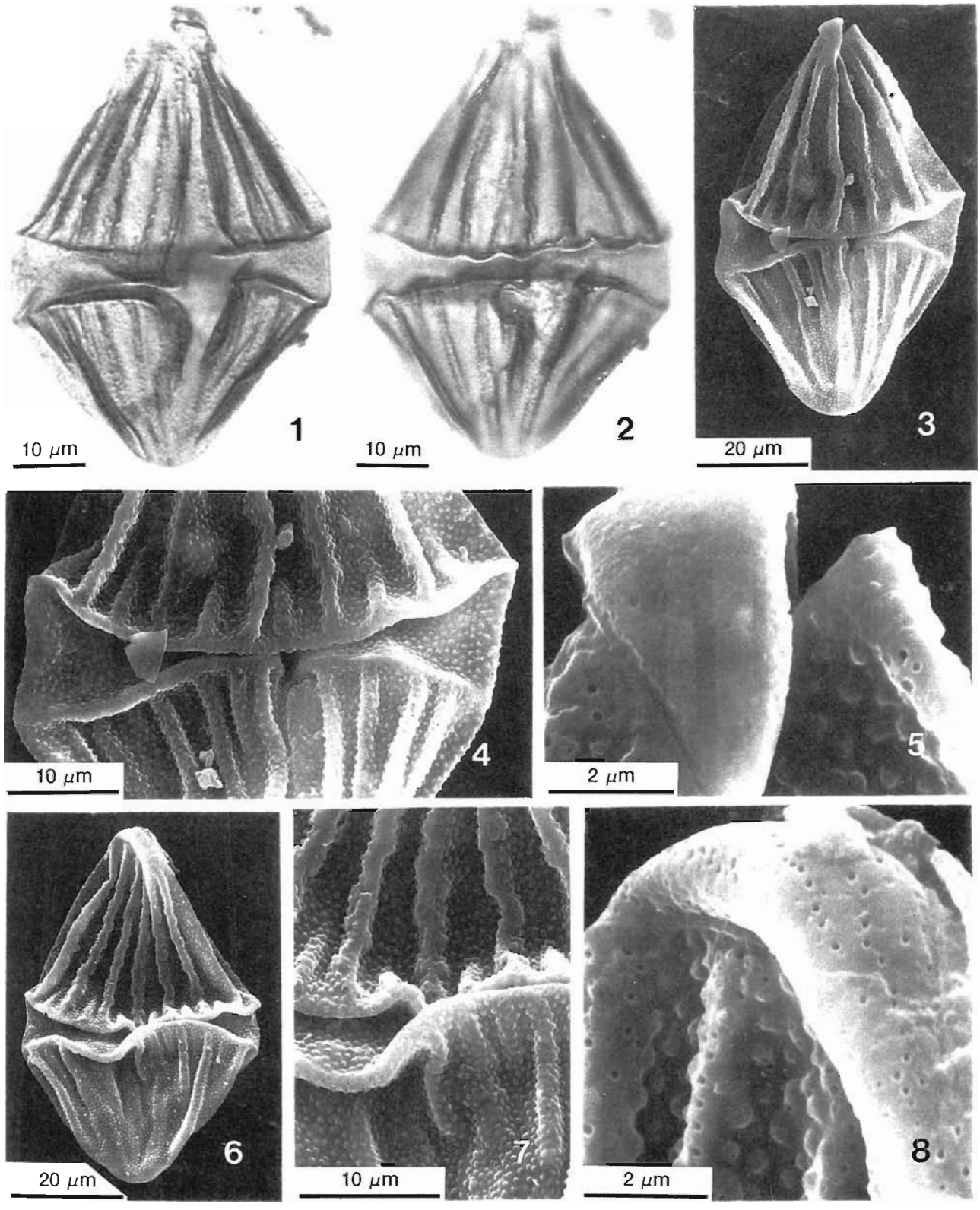


PLATE 15

1-8 *Dinogymnium acuminatum* Evitt, Clarke & Verdier 1967, 1, 2 × 100, CRC32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian. 3-8 CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County Campanian

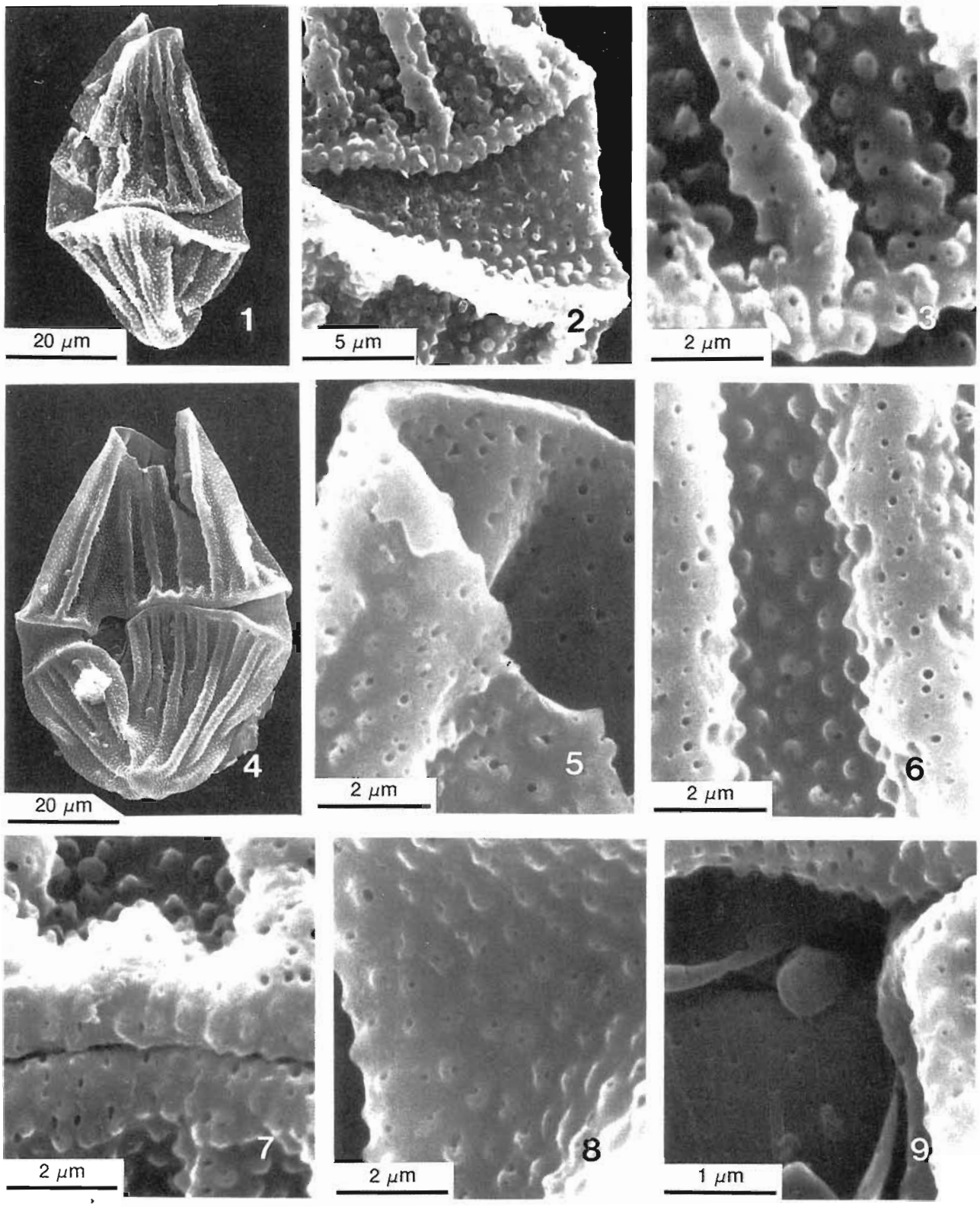


PLATE 16

1-9. *Dinogymnium acuminatum* Evitt, Clarke & Verdier 1967. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian.

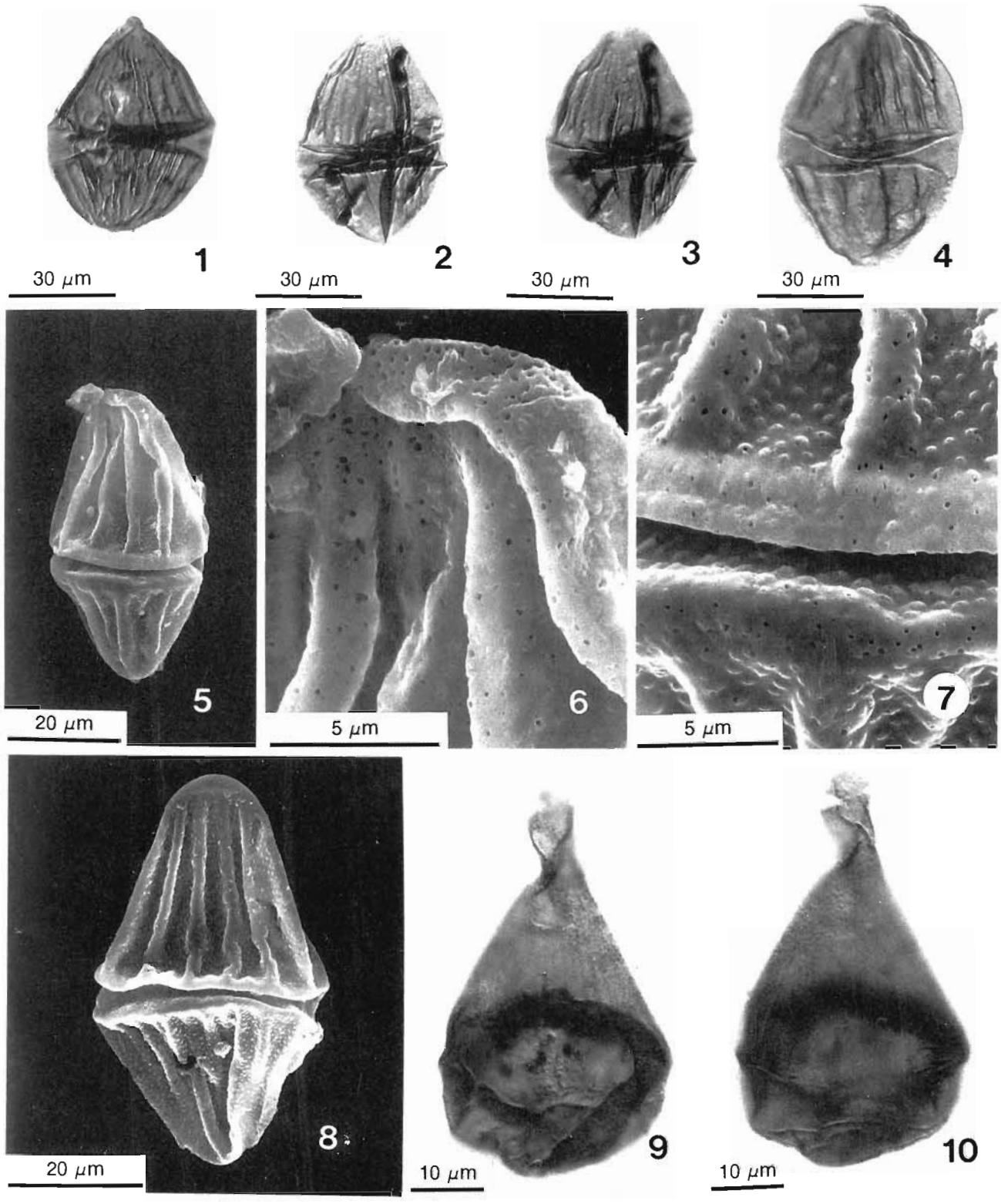


PLATE 17

1-8 *Dinogymnium alberti* Clarke & Verdier 1967. 1-3 × 40, CRC 32134-4, D6, the Austin Chalk, middle Chalk member Dallas County, Santonian. 4. × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian. 5-8 CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian.

9-10. *Dinogymnium cerviculum* Cookson & Eisenack 1970; × 100, CRC 32134-6, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian

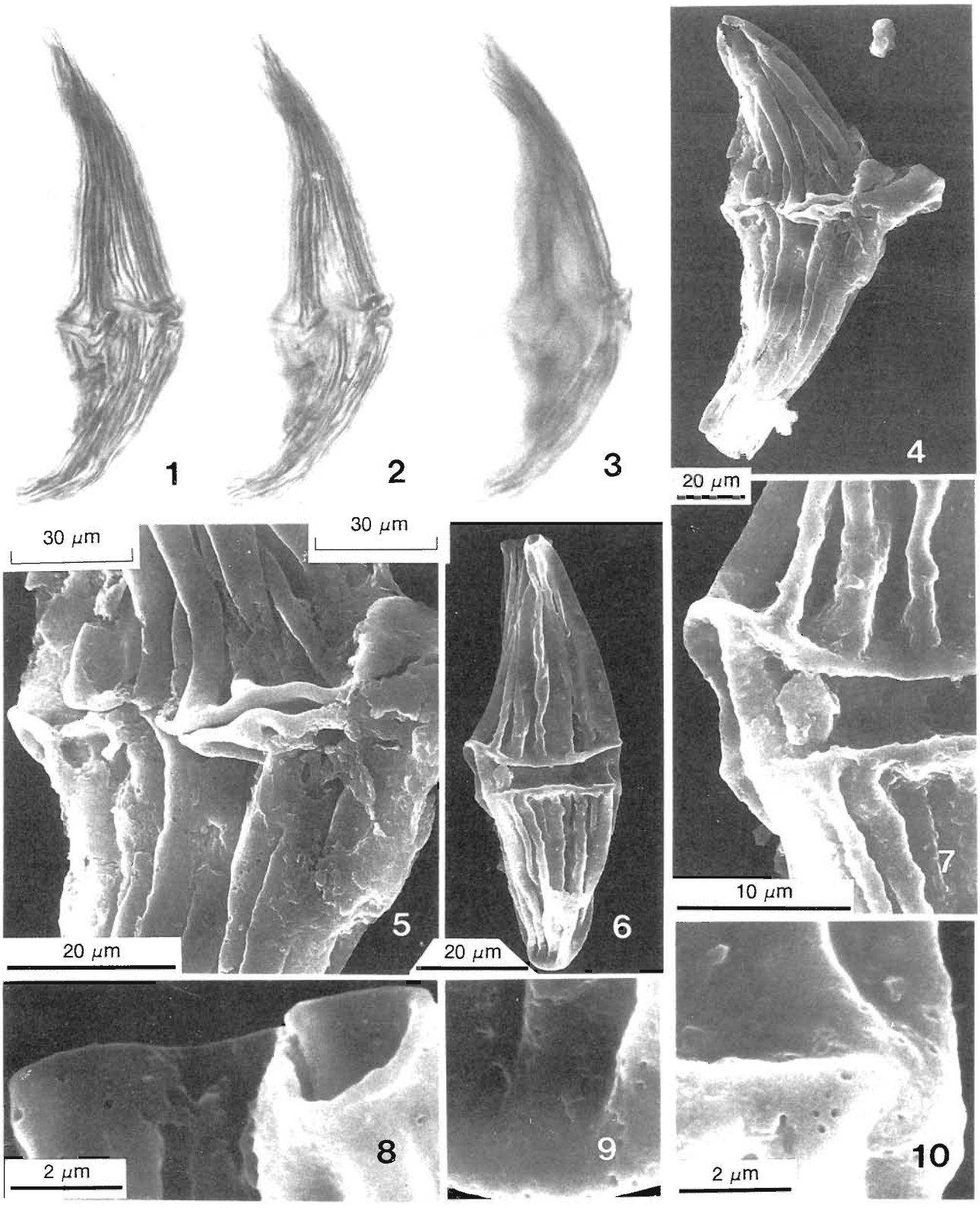


PLATE 18

1-10 *Dinogymnium curvatum* (Vozzhennikova) Lentin & Williams 1973. 1-3 × 40. CRC 32142-1. DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian. 4-10. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian.

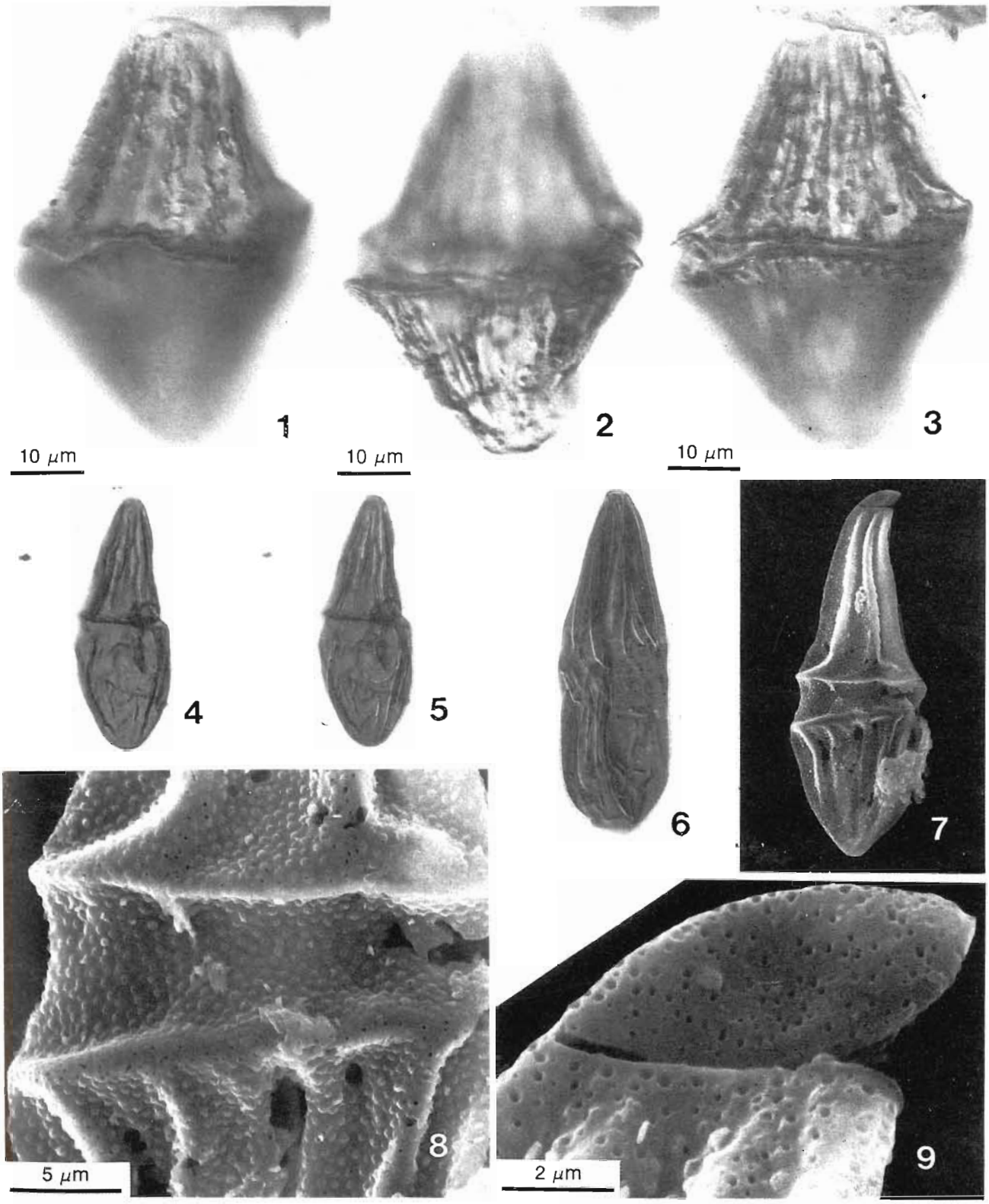


PLATE 19

1-3 *Dinogymnium denticulatum* (Alberti) Evitt, Clarke & Verdier 1967; × 40, CRC 32134-6, D6, the Austin Chalk, middle Chalk member Dallas County, Santonian

4-9 *Dinogymnium digitum* (Deflandre) Evitt, Clarke & Verdier 1967, 4,5 × 40, CRC 32139-3, D11, the Austin Chalk, upper Chalk member, Ellis County, Late Santonian, 6, × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian, 7, 8, 9, × 40, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County, Santonian

1936b *Gymnodinium digitus* Deflandre, p. 166, pl. 2, figs 4,5 (err. orth. pro *digitum*).

1967 *Dinogymnium digitus* (Deflandre) Evitt, Clarke & Verdier, p. 18 (err. orth. pro *digitum*).

Size measurements—Length 68-70 µm (Deflandre, 1936b); length × breadth 74-77 × 25-28 µm (May, 1977, 1980); 70-96 × 26-31 µm in two specimens of this study.

Previous records—Senonian, France (Deflandre, 1936b); Campanian, Grand Banks, Canada (Millioud *et al.*, 1975); Campanian, western interior on North America (Harker *et al.*, 1990); New Jersey, U.S.A. (May, 1980); Maastrichtian, Texas, U.S.A. (Zaitzeff & Cross, 1970).

Dinogymnium elongatum May 1977

Pl. 20, figs 1-9

1977 *Dinogymnium elongatum* May, p. 112, pl. 2, figs 11, 12.

Size measurements—Length × breadth 186-300 × 11-28 µm (May, 1977); 107-252 × 21-42 µm in six specimens of this study.

Remarks—*Dinogymnium elongatum* has a shorter epicyst than its hypocyst. It is extremely difficult to discern the archeopyle or any other morphological characteristics of *D. elongatum* under optical microscope. A faint paracingulum can be detected sometimes. *D. elongatum* is very long and ribbon-shaped. Its specimens crumple easily and complete specimens are rare. However, the SEM photomicrographs show that *D. elongatum* has a slit-like archeopyle and a groove-like paracingulum (Pl. 20, figs 6, 8, 9). Its apical and antapical ends cannot be readily differentiated, but apical end tends to be broadly rounded. SEM photomicrographs show the ridges and canals in *D. elongatum* similar to those characteristic of the genus.

Previous records—Campanian, New Jersey, U.S.A. (May, 1977, 1980).

Dinogymnium euclaense Cookson & Eisenack 1970

Pl. 21, figs 1-13

1970 *Dinogymnium euclaensis* Cookson & Eisenack, p. 139, pl. 10, figs 9-12 (err. orth. pro *euclaense*).

Size measurements—Length × breadth 32-40 × 19-30 µm (Cookson & Eisenack, 1970); 42 × 33 µm (May, 1977); 30 × 23 µm (Martinez-Hernandez *et al.*,1980); 23-31 × 15-28 µm in 11 specimens of this study.

Previous records—Senonian, Western Australia (Cookson & Eisenack, 1970); Brazil (Herngreen, 1975); Mexico (Martinez-Hernandez *et al.*, 1980; Helenes, 1984); Canada (McIntyre, 1974; Millioud *et al.*, 1975; Williams, 1975; Doerenkamp *et al.*, 1976); Campanian, western interior of North America (Harker *et al.*, 1990); Maastrichtian, New Jersey (May, 1977, 1980); Morocco (Doubinger, 1979; Rauscher & Doubinger, 1982).

Dinogymnium heterocostatum (Deflandre) Evitt, Clarke & Verdier 1967

Pl. 21, figs 14-15

1935 *Gymnodinium heterocostatum* Deflandre, p. 225, text-fig. 6 (holotype non cit.).

1936a *Gymnodinium heterocostatum* Deflandre, p. 56, text-fig. 93 (nom. nud.).

1936b*Gymnodinium heterocostatum* Deflandre, p. 165, pl. 2, fig. 6.

1967 *Dinogymnium heterocostatum* (Deflandre) Evitt, Clarke & Verdier, p. 19, pl. 3, figs 9, 11, 13.

Size measurements—Length 60-65 µm (Deflandre, 1936 b); length × breadth 78 × 42 µm in one specimen of this study.

Previous records—Senonian, France (Deflandre, 1935, 1936b, 1943); Belgium (Lejeune-Carpentier, 1951); Santonian, Isle of Wight, England (Clarke & Verdier, 1967); Scotian Shelf, Canada (Millioud *et al.*, 1975).

Dinogymnium kasachstanicum (Vozzhennikova) Lentin & Williams1973

Pl. 21, figs 16-18

1967 *Gymnodinium kasachstanicum* Vozzhennikova, p. 45, pl. 2, figs 4a, 5b; pl. 3, fig. 9a, 9b.

1973 *Dinogymnium kasachstanicum* (Vozzhennikova) Lentin & Williams, p. 49.

Size measurements—Length × breadth 59.4 × 35.1 µm (Vozzhennikova, 1967); 56 × 34 µm in one specimen of this study.

Previous records—Campanian-Maastrichtian, Kazhakhstan, U.S.S.R. (Vozzhennikova, 1967).

Dinogymnium lanceolatum May 1977

Pl. 22, figs 1-9; Pl. 23, figs 1-8

1977 *Dinogymnium lanceolatum* May, p. 115, pl. 2, figs 9, 10.

Size measurements—Length × breadth 140-165 × 13-20 µm (May, 1977); 148-263 × 23-39 µm in five specimens of this study.

Remarks—*Dinogymnium lanceolatum* is very similar to *D. elongatum*. The archeopyle of *D. lanceolatum* is not visible by the optical microscope, hence proper orientation of its specimens has not been possible. SEM photomicrographs show that both species have an indication of archeopyle and cingulum (Pl. 23, figs 2, 3, 6, 7). At higher magnifications, wall canals and faint

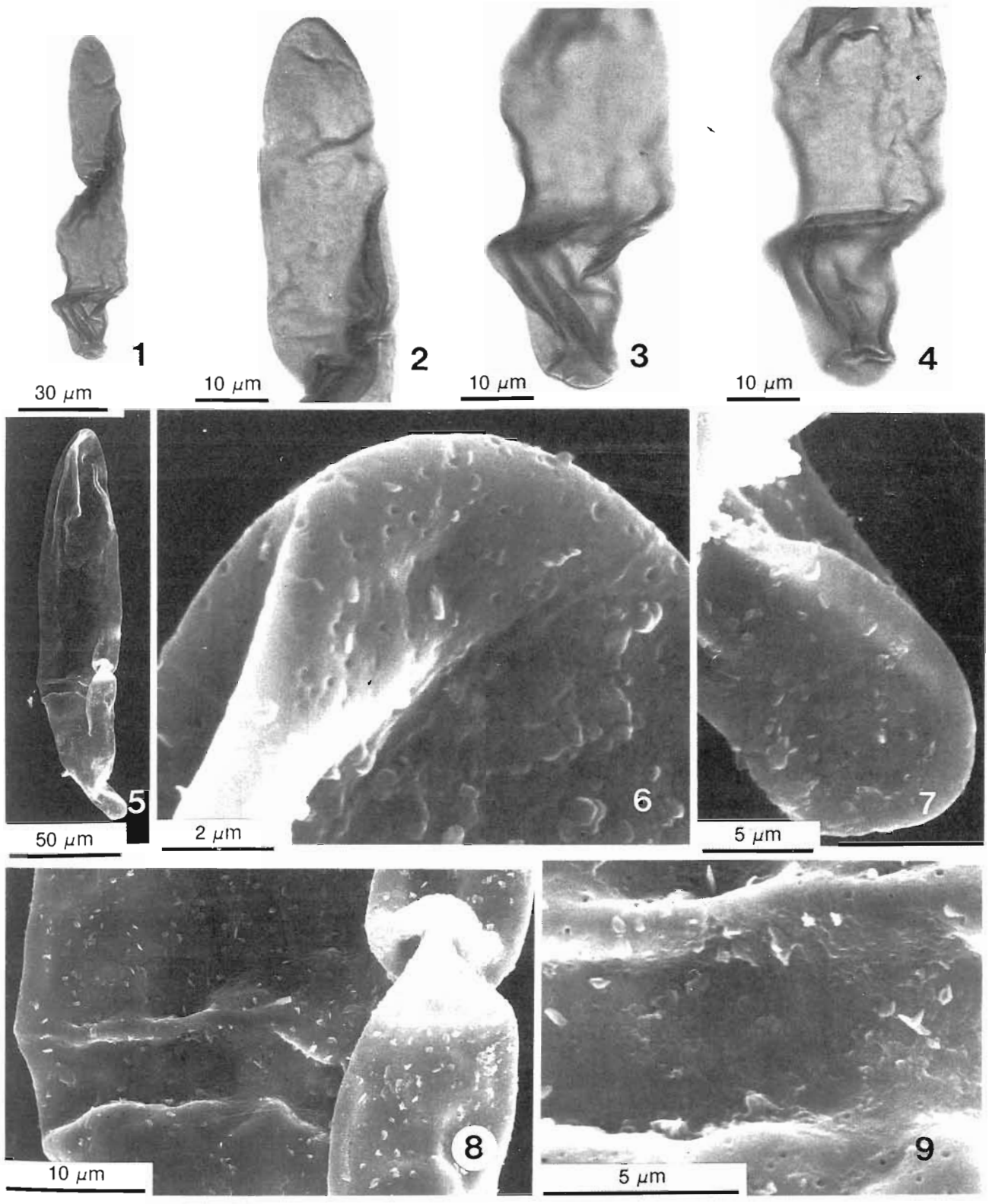


PLATE 20

1-9. *Dinogymnium elongatum* May 1977; 1-4 × 40, 5-9 SEM photomicrographs. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian

ridges may also be seen (Pl. 23, figs 1-8). May (1977) considered that the epicyst is lanceolate and shorter than hypocyst. SEM photomicrographs of specimens studied here show that the archeopyle is on the rounded end of the longer part of the cyst. Thus, *D. elongatum* has shorter epicyst than its hypocyst. Therefore, the two species can be distinguished from each other.

Previous records—Campanian-Maastrichtian, New Jersey, U.S.A. (May, 1977, 1980).

Dinogymnium microgranulosum Clarke & Verdier 1967

Pl. 24, figs 1-4

1967 *Dinogymnium microgranulosum* Clarke & Verdier, p. 34, pl. 5, figs 7-10; text-fig. 10.

Size measurements—Length × breadth 51-85 × 29-54 µm (Clarke & Verdier, 1967); 65-78 × 42-62 µm in three specimens of this study.

Previous records—Senonian, Santonian, Isle of Wight, England (Clarke & Verdier, 1967); Lower Maastrichtian, Denmark (Wilson, 1971).

Dinogymnium nelsonense (Cookson) Evitt, Clarke & Verdier 1967

Pl. 24, figs 5-8

1956 *Gymnodinium nelsonense* Cookson, p. 183, pl. 1, figs 10, 11 (non figs 8, 9).

1967 *Dinogymnium nelsonense* (Cookson) Evitt, Clarke & Verdier, p. 21, pl. 3, figs 21, 22.

Size measurements—Length × breadth 70 × 38 µm (Cookson, 1956); 45-101 × 22-62 µm in five specimens of this study.

Previous records—Senonian, Upper Cretaceous, Victoria, Australia (Cookson, 1956); Senonian, Brazil (Regali *et al.*, 1974; Herngreen, 1975); Maastrichtian, Navarro Group, Texas, U.S.A. (Zaitzeff & Cross, 1971).

Dinogymnium rigaudiae Boltenhagen 1977

Pl. 24, figs 9-13

1977 *Dinogymnium rigaudiae* Boltenhagen, p. 73, pl. 11, figs 1-4 (err. orth. pro *rigaudiae*).

Size measurements—Length × breadth 47-57 × 13-15 µm (Boltenhagen, 1977); 38-55 × 13-15 µm in two specimens of this study.

Previous records—Campanian-Maastrichtian, Gabon, West Africa (Boltenhagen, 1977).

Dinogymnium sibiricum (Vozzhennikova) Lentin & Williams 1973

Pl. 25, figs 1-8

1967 *Gymnodinium sibiricum* Vozzhennikova, p. 47, pl. 2, figs 2, 3a, 3b; pl. 3, figs 2, 3.

1973 *Dinogymnium sibiricum* (Vozzhennikova) Lentin & Williams, p. 50.

Size measurements—Length × breadth 65.6-67.6 × 37.5-37.8 µm (Vozzhennikova, 1967); 43-81 × 32-55 µm in seven specimens of this study.

Remarks—*Dinogymnium sibiricum* has a flange-like paracingulum. Thus, certain specimens are wider than their length. Its epicyst and hypocyst are conical and rounded at their apices. Ridges are heavy. The illustrations of Siberian specimens (Vozzhennikova, 1967) are oriented with their apical end downwards.

Previous records—Senonian, Western Siberia, U.S.S.R. (Vozzhennikova, 1967).

Dinogymnium sphaerocephalum (Vozzhennikova) Lentin & Williams 1973

Pl. 26, figs 1-6

1967 *Gymnodinium sphaerocephalum* Vozzhennikova, p. 48, pl. 2, fig. 7; pl. 3, fig. 1.

1973 *Dinogymnium sphaerocephalum* (Vozzhennikova) Lentin & Williams, p. 50.

Size measurements—Length × breadth 56-81 × 30-32.4 µm (Vozzhennikova, 1967); 60 × 25 µm in one specimen of this study.

Previous records— Senonian, Western Siberia, U.S.S.R. (Vozzhennikova, 1967); Campanian, western interior of Canada (Harker *et al.*, 1990).

PLATE 21 →

1-13. *Dinogymnium euclaense* Cookson & Eisenack 1970; 1-7 and 12-13, × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian; 8, 9, × 100, CRC 32138-1, D10, the Taylor Group, lower Clay, Ellis County; Campanian; 10, 11 × 100, CRC 32139-3, D11 the Austin Chalk, upper Chalk member, Ellis County; Late Santonian.

14-15. *Dinogymnium heterocostatum* (Deflandre) Evitt, Clarke & Verdier 1967; × 40, CRC 32143-3, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

16-18. *Dinogymnium kasachstanicum* (Vozzhennikova) Lentin & Williams 1973; 16, 17, × 100, 18, SEM photomicrograph; CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

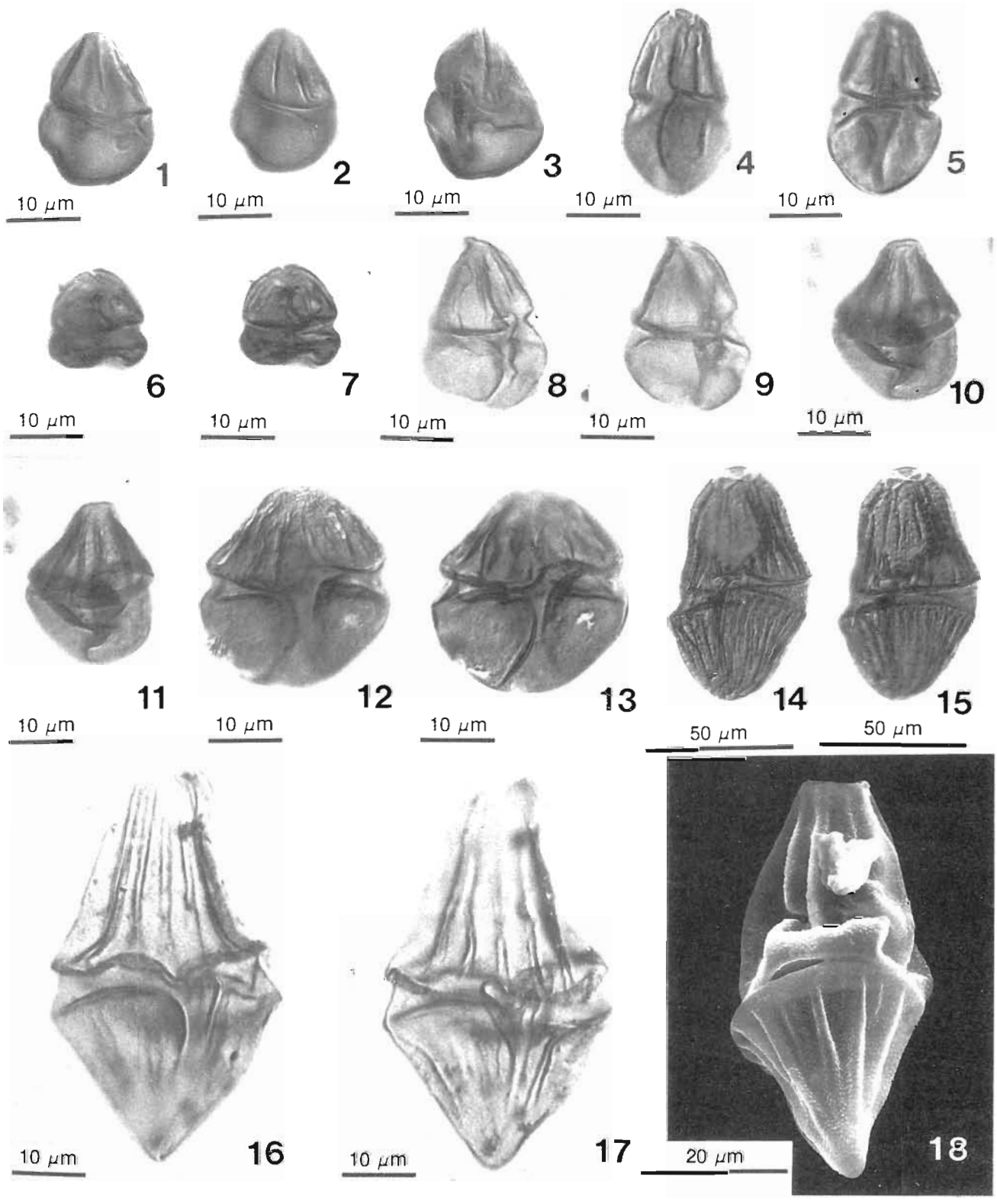

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PLATE 21

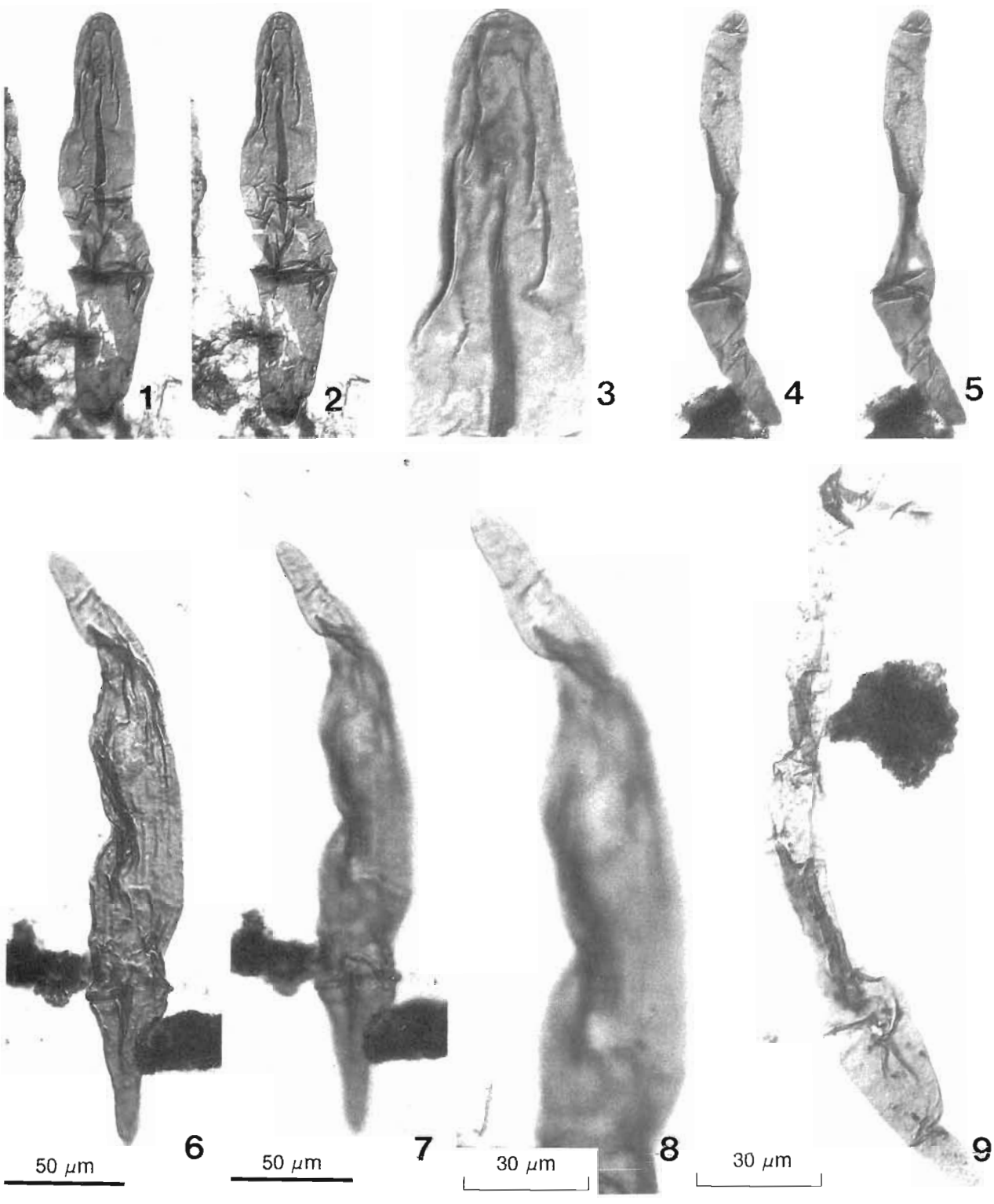

PLATE 22

1-9 *Dinogymnium lanceolatum* May 1977; 1-5, × 40, CRC 32142-2, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County Campanian, 6-9 × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County, Late Maastrichtian

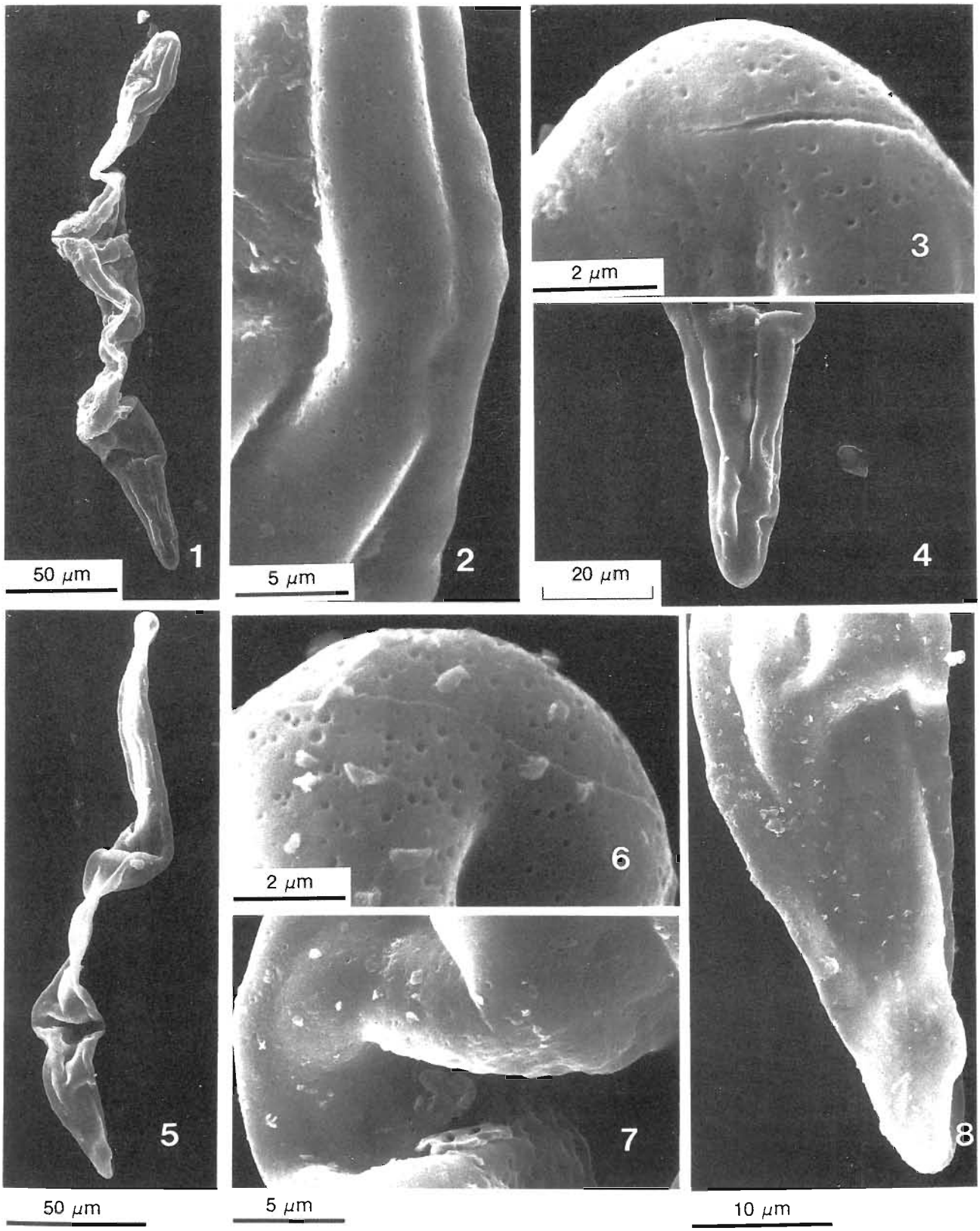

PLATE 23

1-8 *Dinogymnium lanceolatum* May 1977, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian

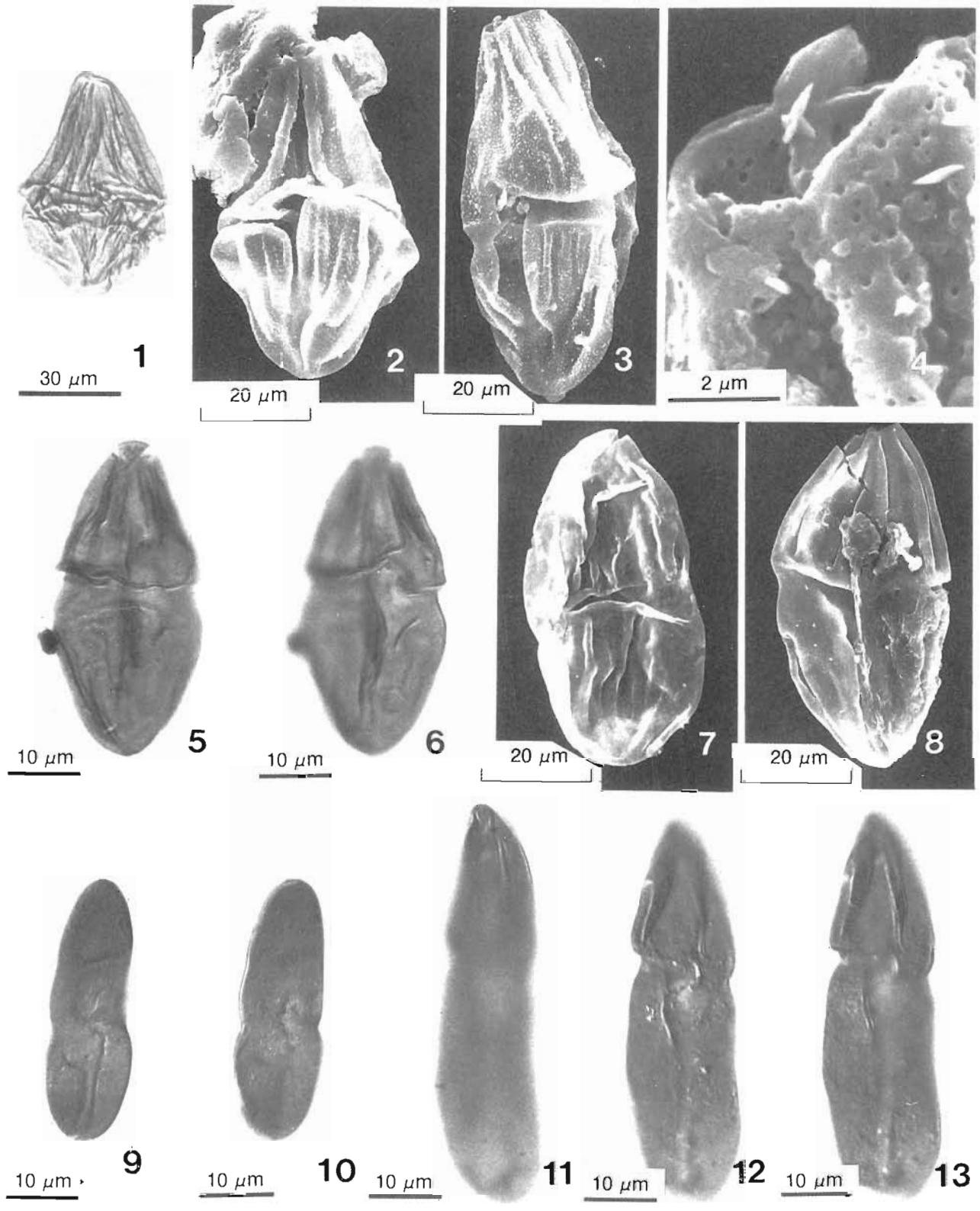

PLATE 24

1-4 *Dinogymnium microgranulosum* Clarke & Verdier 1967. 1 × 40, CRC 32135-4, D7, the Taylor Group, upper Taylor Clay, Dallas County, Campanian. 2, 3, 4 CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian.

5-8 *Dinogymnium nelsonense* (Cookson) Evitt, Clarke & Verdier 1967; 5, 6 × 100, CRC 32138-3, D10, the Taylor Group, lower Taylor Clay, Ellis County, Campanian. 7, 8 CRC 32142-4, DW 14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian.

9-13. *Dinogymnium rigaudiae* Boltenhagen 1977 × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County, Campanian.

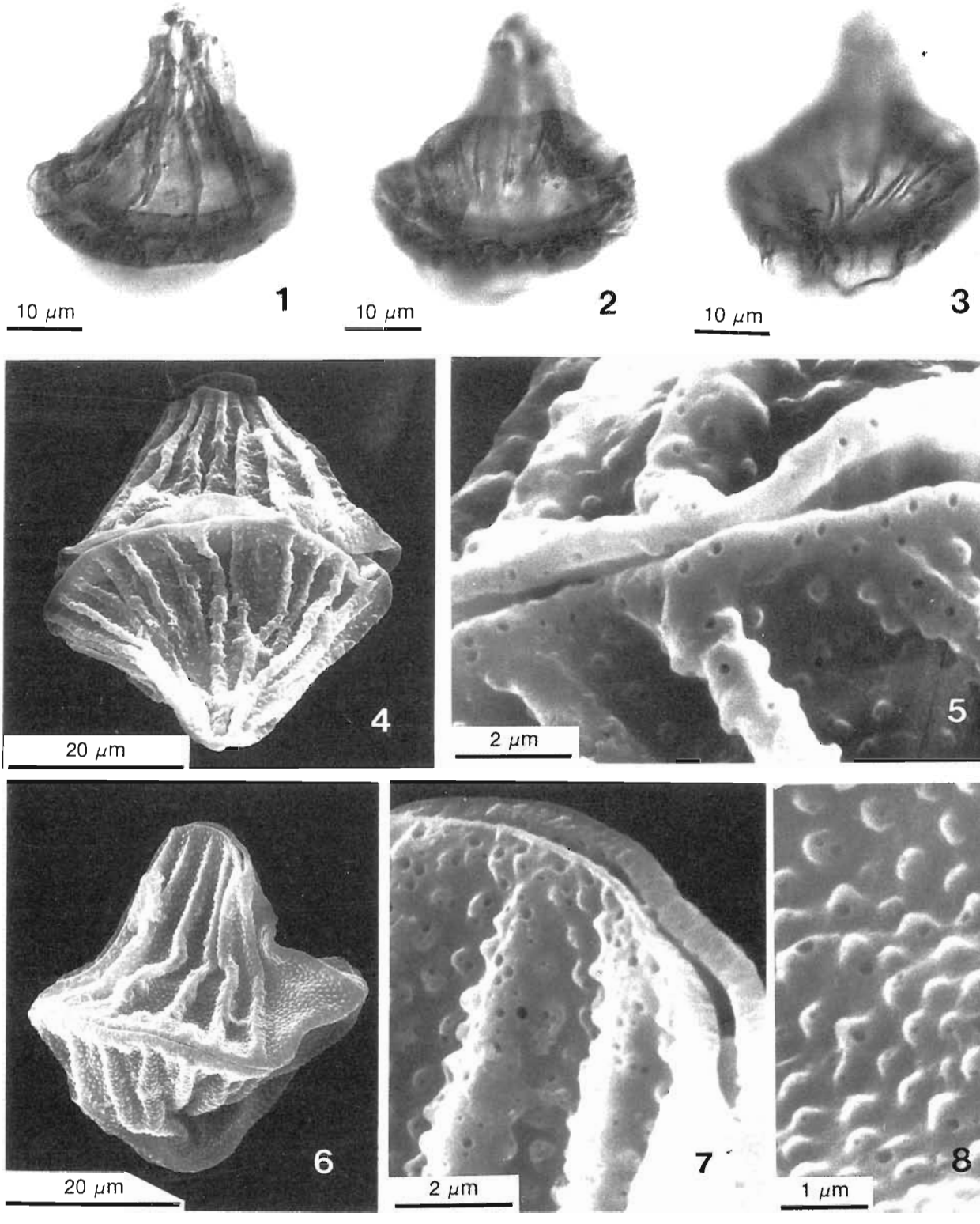

PLATE 25

1-8 *Dinogymnium sibiricum* (Vozzhennikova) Lentin & Williams 1973. 1, 2, 3 × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian. 4, 5 CRC 32145-5, WA17, the Austin Chalk, lower Chalk member McLennan County Santonian. 6, 7, 8. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian

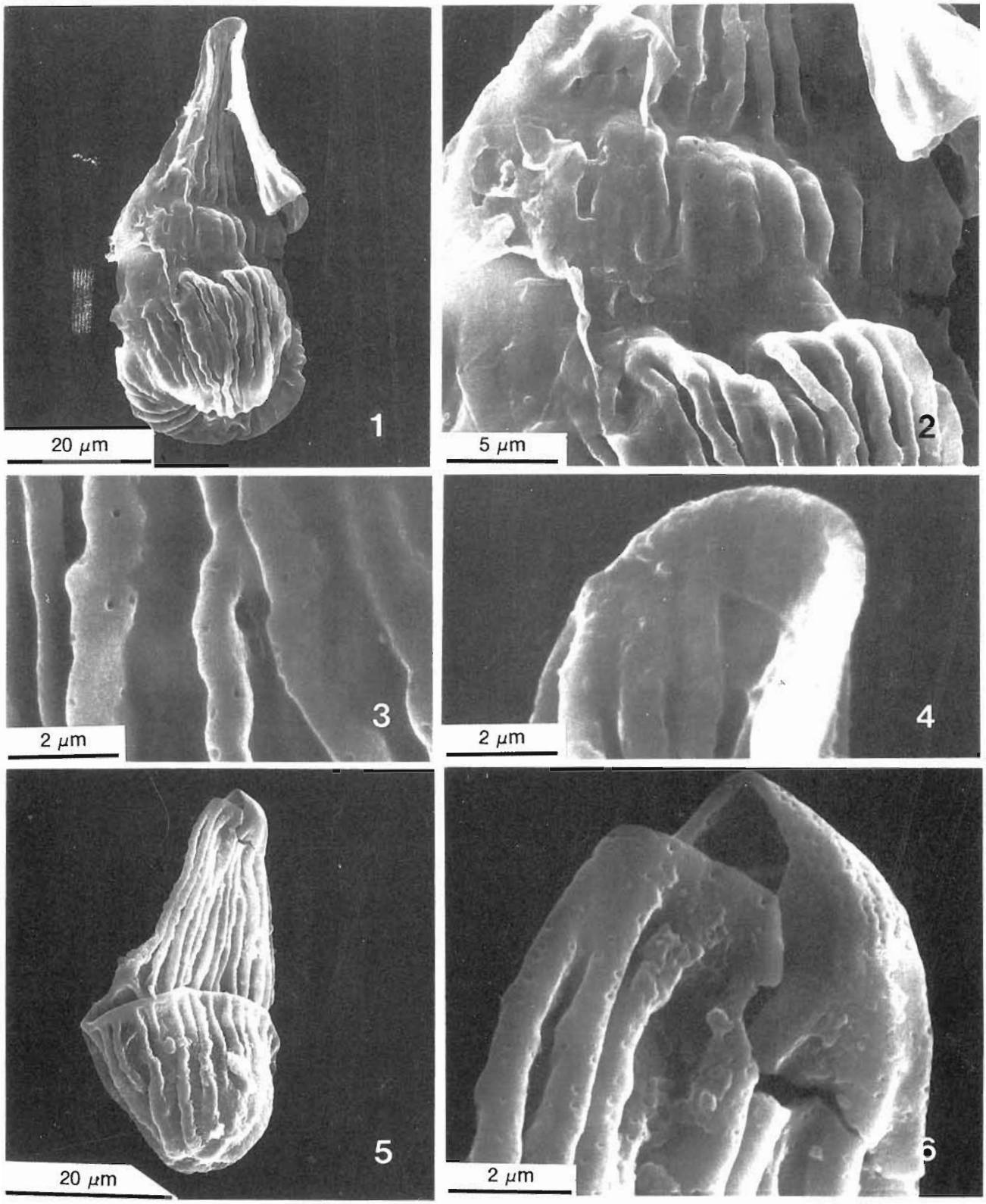

PLATE 26

1-6 *Dinogymnium sphaerocephalum* (Vozzhennikova) Lentin & Williams 1973, 1-4 CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County, Campanian 5,6 CRC 32145-5, WA17 the Austin Chalk, lower Chalk member McLennan County; Santonian

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 bifidum (Clarke & Verdier) Davey 1969

Pl. 27, figs 1-6

1967 *Baltisphaeridium bifidum* Clarke & Verdier, p. 72, pl. 17, figs 5, 6; text-fig. 30.

1969b *Exochosphaeridium bifidum* (Clarke & Verdier) Davey, p. 26, pl. 1, figs 1-5; text-fig. 1, no. 1

Size measurements—Body diameter 44-72 µm, process length 13-34 µm (Clarke & Verdier, 1967); 36-69 µm, process length 11-24 µm (Davey, 1969b); 44-72 µm, process length 13-34 µm (Foucher, 1972); 40-70 µm, process length 14-30 µm (Corradini, 1973); 50-61 µm, process length 16-20 µm (Benson, 1976); body length × breadth 67-84 × 54-73 µm, process length up to 35 µm (Damassa, 1979); body length 50-77 × 43-77 µm, process length 8-31 µm (May, 1980); body diameter 54-72 µm, process length 15-24 µm (Yun, 1981); body 60-68 × 55-67 µm, process length 13-18 µm in three specimens of this study

Previous records—Aptian-Danian. Aptian-Albian, Mazagan Plateau, off northwest Africa (Below, 1984) Upper Cretaceous, South Africa (Davey, 1969b); Campanian, Ghana, Africa (Davey, 1975); Senonian, DSDP Leg 39, Sites 358, 356, 355, southwestern Atlantic Ocean (Ioannides & Colin, 1977); Albian-Senonian, Europe (Clarke & Verdier, 1967; Foucher, 1972; Corradini, 1973; Fauconnier, 1979; Yun, 1981); Late Maastrichtian, Turkey (Erkman & Sadek, 1981); Albian-Danian, North America (Millioud *et al.*, 1975; Benson, 1976; Damassa, 1979; May & Stein, 1979; May, 1980); Upper Cretaceous, Australia (Cookson & Eisenack, 1974).

Exochosphaeridium muelleri Yun 1981

Pl. 27, fig. 7

1981 *Exochosphaeridium muelleri* Yun, p. 25, pl. 4, figs 12, 14, 15; pl. 5, figs 9, 11.

Size measurements—Body dimensions 45-60 × 48-66 µm, process length 10-18 µm (Yun, 1981); body 47 × 42 µm, process length 15 µm in one specimen of this study.

Previous records—Hauterivian-Santonian. Hauterivian-Albian, Morocco (Below, 1982a); Santonian, Germany (Yun, 1981).

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

Pl. 27, figs 8-9

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

Size measurements—Recorded range of dimension: 33-95 × 33-75 µm, length of processes 10-40 µm (see Srivastava, 1991); body 49-83 × 47-65 µm, process length 10-21 µm in four specimens of this study.

Previous records—Valanginian-Santonian. 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); Senonian, Northern Apennines, Italy (Corradini, 1973); Hauterivian-Albian, Morocco (Below, 1982a); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwest Africa (Below, 1984); Early Albian, India (Jain, 1977); Cenomanian, Canada (Singh, 1983); Cenomanian-Turonian, Texas, U.S.A. (Srivastava, 1991); Campanian, western interior of North America (Harker *et al.*, 1990).

Genus—*Florentinia* Davey & Verdier 1973

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

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

Remarks—*Florentinia* consists of skolochorate cysts having a subspherical body with precingular archeopyle and a gonyaulacacean paratabulation indicated by intratabular processes of two sizes, narrower processes in paracingular and parasulcal areas and a large distinctive process in antapical area. *Florentinia* is distinguished from *Silicisphaera* in having a distinctively large antapical process, and from *Achilleodinium* in having a different wall structure.

Florentinia clavigera (Deflandre) Davey & Verdier 1973

Pl. 28, figs 1-2

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.

Size measurements—Central body diameter 35-60 µm, process length 9-25 µm (Davey & Verdier, 1976); overall dimensions 88-104 × 65-86 µm, body 39-75 × 39-68 µm, process length 15-29 µm, antapical process 14-29 × 8-23 µm (Srivastava, 1991); overall 55-94 × 52-78 µm, body 29-62 × 29-52 µm, process length 10-21 µm, antapical process 13-26 × 5-13 µm in six specimens of this study.

Previous records—Cenomanian-Santonian, Upper Cretaceous, France (Deflandre, 1937); Turonian-Santonian, France (Davey & Verdier, 1976; Robaszynski *et al.*, 1982; Foucher, 1983); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Florentinia cooksoniae (C. Singh) Duxbury 1980

Pl. 28, fig. 3

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.

Size measurements—Overall dimensions including processes 60-105 µm, central body length × breadth 36-67 × 36-50 µm, length × breadth of processes 7-28 × 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 × 62-99 µm, body 40-60 × 38-62 µm, process length 15-44 µm, antapical process length × widest measurement 22-44 × 5-26 µm (Srivastava, 1991); overall 57-83 × 57-75 µm, body 26-44 × 26-42 µm, process length 13-21 µm, antapical process length × widest measurement 21-26 × 8-13 µm in three 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); Turonian, France (Robaszynski *et al.*, 1982); Santonian, Germany (Yun, 1981); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Florentinia laciniata Davey & Verdier 1973

Pl. 28, figs 4-5

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

Size measurements—Central body diameter 36-55 µm, process length 26-49 µm (Davey & Verdier, 1973); central body diameter 35-42 µm, process length × breadth ca 24 × 15-18 µm (Yun, 1981); overall dimensions 75-91 × 75-91 µm, body dimensions 42-55 × 42-55 µm, process length 20-26 µm; antapical process length × breadth 29-34 × 10-18 µm (Srivastava, 1991); overall 70 × 70-83 µm, body 39-42 × 39-55 µm, process length16-29 µm; antapical process length × breadth 21-26 × 8-10 µm in three specimens of this study

Previous records—Aptian-Santonian, Germany (Eisenack, 1958; Alberti, 1961; Yun, 1981); Albian-Cenomanian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1969a); 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); Lower Aptian, Argentina (Pöthe de Baldis & Ramos, 1983); Cenomanian, Libya (Batten & Uwins, 1985); Early Cenomanian, Mazagan Plateau, northwest Africa (Below, 1984); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Florentinia mantellii (Davey & Williams) Davey & Verdier 1973

Pl. 28, fig. 6

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

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

Size measurements—Central body diameter 36-45 µm, process length 13-26 µm (Davey & Williams in

PLATE 27 →

1-6. *Exochosphaeridium bifidum* (Clarke & Verdier) Davey 1969b; 1, 2, 3. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 4, 5. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 6. CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

7 *Exochosphaeridium muelleri* Yun 1981; × 40, CRC 32135-1, D7, the Austin Chalk Upper Chalk member, Dallas County; Santonian.

8-9. *Exochosphaeridium phragmites* Davey *et al.* in Davey *et al.*, 1966; × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

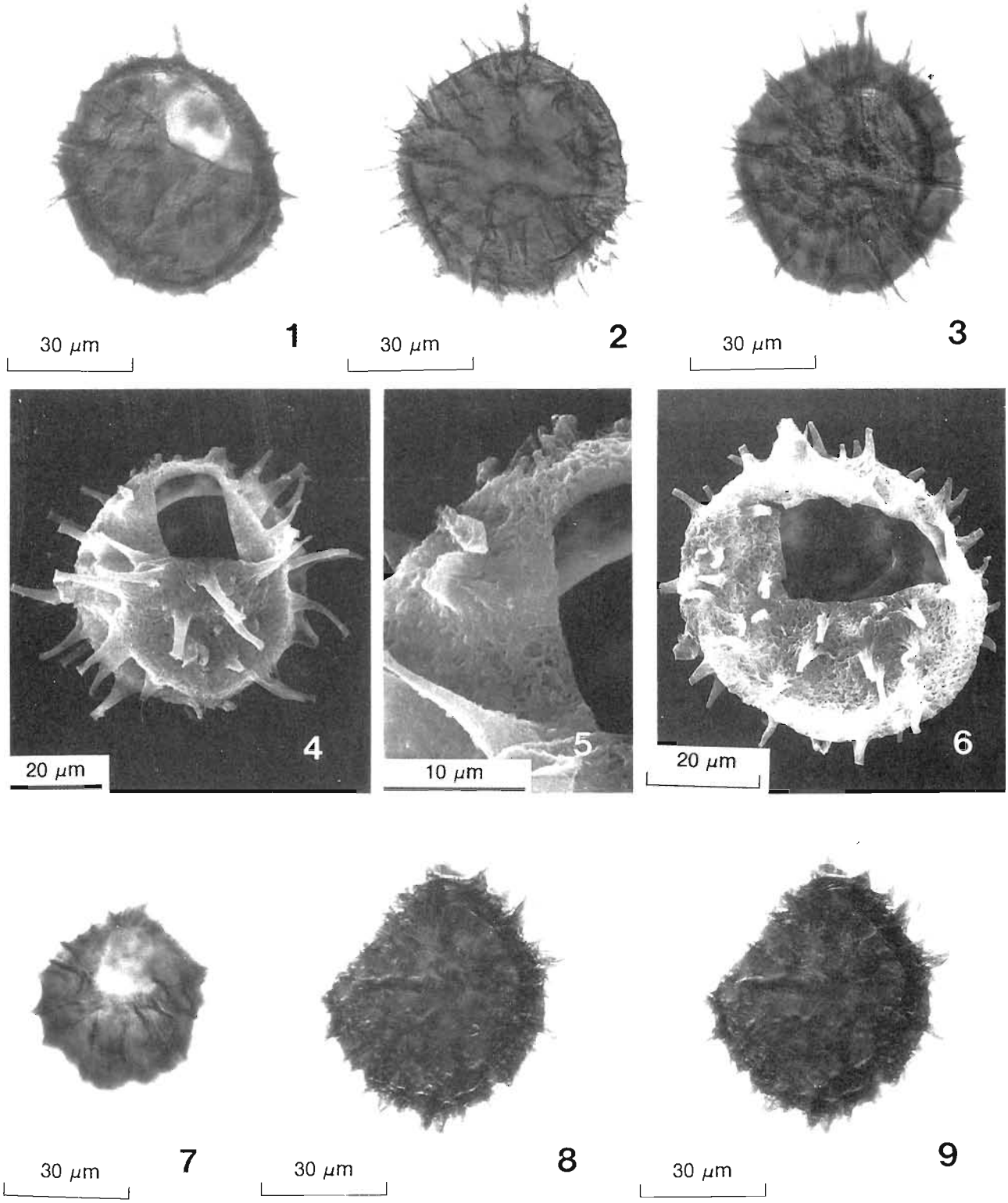

PLATE 27

Davey *et al.*, 1966); body diameter 35-47 μm, process length 15-19 μm (Yun, 1981). Overall dimensions 78-91 × 78-99 μm, body 30-47 × 30-47 μm, process length 21-31 μm, antapical process 26-36 × 16-21 μm (Srivastava,

1991); overall 83-91 × 83-94 µm, body 55-60 × 55-62 µm, process length 21-26 µm, antapical process 26-34 × 16-21 µm in two specimens of this study.

Previous records—Barremian-Santonian. Barremian-Turonian, England (Davey & Williams in Davey *et al.*, 1966; Davey, 1969, 1974; Duxbury, 1983); Late Albian-Cenomanian, France (Davey, 1969; Davey & Verdier, 1973); Late Aptian-Early Albian, Germany (Davey, 1982); Santonian, Germany (Yun, 1981); Albian-Cenomanian, Portugal (Berthou *et al.*, 1980); Aptian-Cenomanian, Morocco (Below, 1982a); Early Aptian-Early Cenomanian, Mazagan Plateau, off northwest Africa (Below, 1984); Albian-Cenomanian, Libya (Batten & Uwins, 1985); Early Albian, India (Jain, 1977); Albian-Cenomanian, Australia (Cookson & Eisenack, 1962, 1968; Norvick & Burger, 1976); Albian, Alberta, Canada (Brideaux, 1971; Singh, 1971); Albian, Baja California, Mexico (Helenes, 1984); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Florentinia resex Davey & Verdier 1976

Pl. 28, fig. 7

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

Size measurements— Central body diameter 38-51 µm, length of processes 7-23 µm (Davey & Verdier, 1976); overall dimensions 43-53 µm, body 36 × 32-36 µm; length and width of processes 6-11 × 3-5 µm (Singh, 1983); overall dimensions 53-78 × 50-78 µm, body dimensions 32-57 × 30-52 µm, process length 13-16 µm, antapical process dimensions 16-18 × 8-12 µm (Srivastava, 1991); overall 70-91 µm, body 42-47 µm, process length 18-21 µm, antapical process 21-31 × 16-18 µm in three 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); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Florentinia stellata (Maier) Below 1982a

Pl. 28, figs 8-9

1959 *Hystrichosphaeridium stellatum* Maier, p. 320, pl. 33, figs 3, 4

1982a *Florentinia stellata* (Maier) Below, p. 10, pl. 3, fig. 3.

Size measurements—Body diameter 62 µm broad, process length 34 µm, slender process length 38 µm (Maier, 1959); body length × breadth 42-56 × 34-54 µm, processes 10-33 × 3-13 µm (Brideaux, 1971); overall dimensions 70-96 µm, body 36-48 µm, process length 20-27 µm (Singh, 1971); body 30-50 µm, broad process 22-24 × 10-20 µm, thin process 18-20 × 5-7 µm (Ashraf, 1979); overall 52-88 × 62-88 µm, body 26-47 × 36-47 µm, processes 16-26 µm long, antapical process length × breadth 16-26 × 6-8 µm in four specimens of this study

Previous records—Lower Cretaceous, Afghanistan (Ashraf, 1979); Aptian-Albian, Morocco (Below, 1982a); Albian- Early Cenomanian, Mazagan Plateau, northwest Africa (Below, 1984); Albian-Turonian, France (Davey & Verdier, 1971; Foucher, 1974); Albian-Campanian, England (Cookson & Hughes, 1964; Clarke & Verdier, 1967); Albian-Cenomanian, Australia (Cookson & Eisenack, 1962, 1968); Albian-Campanian, Canada (Brideaux, 1971; Singh, 1971; McIntyre, 1974; Millioud *et al.*, 1975; Felix & Burbridge, 1976); Danian, California (Drugg, 1967); Middle Oligocene-Middle Miocene, Germany (Maier, 1959).

Genus—*Fromea* Cookson & Eisenack 1958

1958 *Fromea* Cookson & Eisenack, p. 55.

Type species—*Formea amphora* Cookson & Eisenack 1958 (original designation).

Remarks—*Formea* consists of ellipsoidal cysts with smooth and faint ornamentation, an apical archeopyle and possible indications for a paracingulum. *Fromea* is distinct from *Palaeostomocystis* in lacking reticulate ornamentation.

PLATE 28 →

1-2. *Florentinia clavigera* (Deflandre) Davey & Verdier 1973; 1 × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 2. CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

3. *Florentinia cooksoniae* (C. Singh) Duxbury 1980; × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian.

4-5. *Florentinia laciniata* Davey & Verdier 1973; 4. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 5. × CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

6. *Florentinia mantelli* (Davey & Williams) Davey & Verdier1973; × 40, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

7 *Florentinia resex* Davey & Verdier 1976; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

8-9. *Florentinia stellata* (Maier) Below 1982a; × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

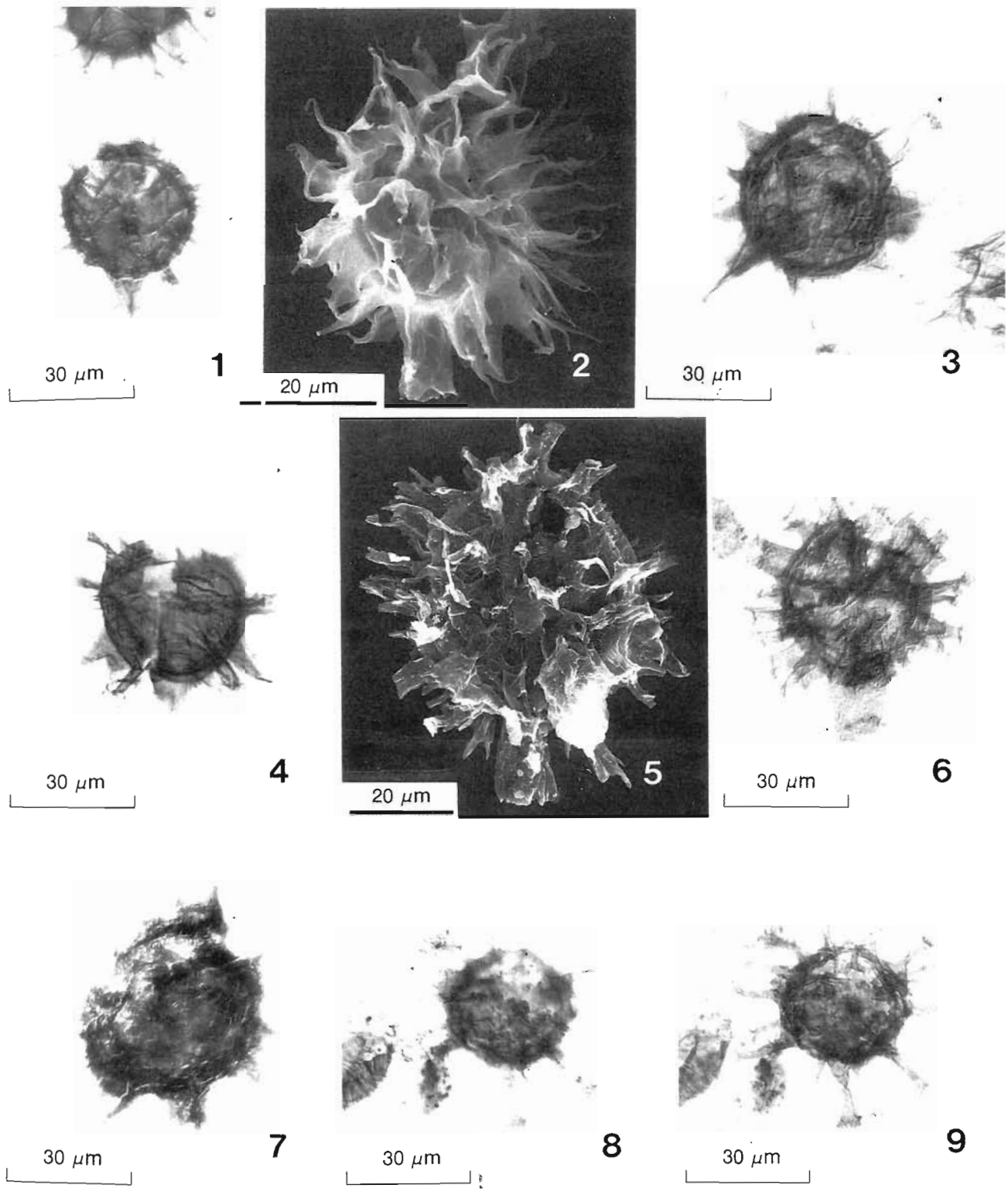

PLATE 28

Fromea amphora Cookson & Eisenack 1958

Pl. 29, figs 1-2

1958 *Fromea amphora* Cookson & Eisenack, p. 56, pl. 5, figs 10, 11.

Size measurements—Length × breadth 62-95 × 47-81 μm (Cookson & Eisenack, 1958); 56-85 × 47-71 μm (Davey, 1969a); 56-108 × 38-74 μm (Brideaux, 1971); 67-125 × 50-170 μm (Singh, 1971); 70-83 × 60-83 μm in three specimens of this study

Previous records—Valanginian-Maastrichtian Valanginian-Cenomanian, England (Cookson & Hughes, 1964; Sarjeant in Davey *et al.*, 1966; Davey, 1969a, 1974; Duxbury, 1977, 1980, 1983); Barremian-Santonian, Europe (Alberti, 1961; Baltes, 1967b; Davey, 1969a; Davey & Verdier, 1971; Yun, 1981); Valanginian-Maastrichtian, North America (Habib, 1970; Brideaux, 1971, Singh, 1971; Brideaux & McIntyre, 1975; McIntyre, 1974; McIntyre & Brideaux, 1980; Doerenkamp *et al.*,1975; Benson, 1976; Pocock, 1980; Harker *et al.*, 1990); Albian, DSDP Sites 417 and 418, western North America (Hochuli & Kelts, 1980); Hauterivian-Albian, Morocco (Below, 1981a); Middle Aptian-early Late Aptian, Mazagan Plateau, off northwestern Africa (Below, 1984); Early Albian, south India (Jain, 1977); Aptian-Senonian, Australia (Cookson & Eisenack, 1958, 1982; Kemp, 1976).

Fromea apiculata (Cookson & Eisenack) Stover & Evitt 1978

Pl. 29, fig. 3

1960b *Palaeostomocystis apiculata* Cookson & Eisenack, p. 12, pl. 3, fig. 15.

1978 *Fromea? apiculata* (Cookson & Eisenack) Stover & Evitt, p. 48.

Size measurements—Length × breadth 38-62 × 19-35 µm (Cookson & Eisenack, 1960b); 68-109 × 36-47 µm in the specimens of this study.

Previous records—Senonian, Australia (Cookson & Eisenack, 1960b, 1970).

Genus—*Glaphyrocysta* Stover & Evitt 1978

1978 *Glaphyrocysta* Stover & Evitt, p. 49.

Type species—*Glaphyrocysta retiintexta* (Cookson) Stover & Evitt 1978 = *Cyclonephelium retiintextum* Cookson 1965a (original designation).

Remarks—Stover and Evitt (1978) proposed the genus *Glaphyrocysta* for skolochorate cysts having a lenticular body with several annulate to arcuate penitabular process complexes which may be mostly joined distally by a simple to intricate trabeculae system. The mid-ventral and mid-dorsal areas of the body are either with reduced processes or without processes. *Glaphyrocysta* has an apical archeopyle and an offset parasulcal notch. *Glaphyrocysta* differs from *Cyclonephelium* in having larger and fewer projections which are connected distally by a trabecular ectophragm, and from *Adnatosphaeridium* in having a lenticular body and more complex processes.

Glaphyrocysta retiintexta (Cookson) Stover & Evitt 1978

Pl. 29, figs 4-6

1965a *Cyclonephelium retiintextum* Cookson, p. 88, pl. 11, fig. 4

1978 *Glaphyrocysta retiintexta* (Cookson) Stover & Evitt, p. 50.

Size measurements—Overall dimensions 177 × 117 µm, body 94 × 78 µm, process length 20-30 µm (Cookson, 1965a); body 55-93 × 50-79 µm, process 12-28 µm long (Archangelsky, 1969); overall 91-114 × 65-104 µm, body 60-65 × 52-60 µm, process length 18-31 µm in seven specimens of this study

Previous records—Senonian-Eocene, Senonian-Paleocene, Australia (Cookson, 1965a, 1965b); Paleocene, Belgium (Schumacker-Lambry, 1978; Paleocene, Morocco (Doubinger, 1979); Eocene, Argentina (Archangelsky, 1969); middle-Late Eocene, DSDP Sites 367 and 370, off west Africa (Williams, 1978).

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 *Xiphophoridium* in having a precingular archeopyle, from *Hystrichogonyaulax* in lacking paraplates and from *Exochosphaeridium* and *Operculodinium* in having a paracingulum.

PLATE 29 →

1-2. *Fromea amphora* Cookson & Eisenack 1958; 1, × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 2 CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

3. *Fromea apiculata* (Cookson & Eisenack) Stover & Evitt 1978; × 40, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

4-6. *Glaphyrocysta retiintexta* (Cookson) Stover & Evitt 1978; 4, 5, × 40, CRC 32146-1 WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian; 6, × 40, CRC 32146-2, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

7 *Hystrichodinium pulchrum* Deflandre 1935; × 40, CRC 32134-7, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

8-9. *Impagidinium cristatum* (May) Lentin & Williams 1981; × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

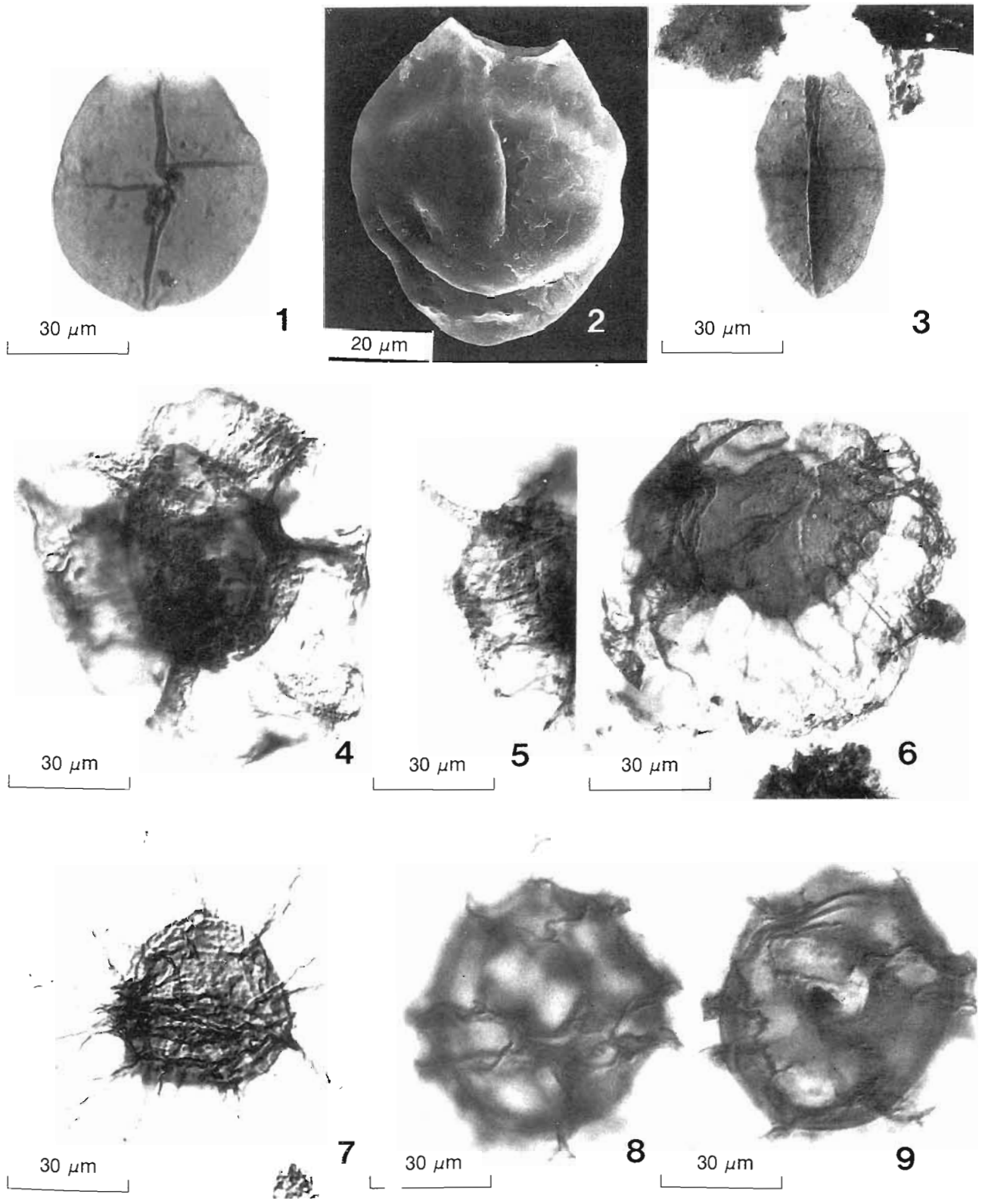

PLATE 29

Hystrichodinium pulchrum Deflandre 1935

Pl. 29, fig. 7

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

Size measurements—Overall previously recorded range of dimensions 50-155 × 31-110 µm, body 35-66 × 31-55 µm, process length 20-48 µm (see Srivastava, 1991); overall 78-104 × 73-104 µm, body 44-65 × 44-65 µm, process length 23-33 µm in four specimens of this study.

Previous records—Portlandian-Maastrichtian (see Srivastava, 1991). Campanian, Manitoba, Canada, and Wyoming and Texas, U.S.A. (Harker *et al.*, 1990).

Genus—*Impagidinium* Stover & Evitt 1978

1978 *Impagidinium* Stover & Evitt, p. 165.

Type species—*Impagidinium dispertitum* (Cookson & Eisenack) Stover & Evitt 1978 = *Leptodinium dispertitum* Cookson & Eisenack 1965b (original designation).

Remarks—Impagidinium consists of proximochorate, acavate, subspherical to ellipsoidal cysts without an apical projection or horn. It has a precingular archeopyle and its gonyaulacacean paratabulation is indicated by parasutural septa only. *Impagidinium* differs from *Leptodinium* in lacking apical projection or horn and being subspherical to ellipsoidal.

Impagidinium cristatum (May) Lentin & Williams 1981

Pl. 29, figs 8-9

1980 *Leptodinium cristatum* May, p. 57, pl. 5, figs 16-20.

1981 *Impagidinium cristatum* (May) Lentin & Williams, p. 153.

Size measurements—Length × breadth 37-50 × 31-49 µm, crest height 3-7 µm (May, 1980); 49-50 × 40-43 µm, crest height 5 µm in two specimens of this study.

Previous records—Campanian-Maastrichtian, New Jersey, U.S.A (May, 1980).

Genus—*Isabelidinium* Lentin & Williams 1977b

1976 *Isabelia* Lentin & Williams, p. 56 (non *Isabelia* Barbosa-Rodrigues, 1877, p. 75).

1977b *Isabelidinium* Lentin & Willliams, p. 167.

Type species—*Isabelidinium korojonense* (Cookson & Eisenack) Lentin & Williams 1977b = *Deflandrea korojonensis* Cookson & Eisenack 1958 (original designation).

Remarks—Isabelidinium consists of proximate, bicavate or circumcavate, compressed cysts having generally longitudinally elongate outlines with a single apical horn and two poorly developed antapical horns. Endocyst outline is circular or elliptical and occurs in the central part of the pericyst. Paratabulation indication by an intercalary archeopyle and/or by a paracingulum. *Isabelidinium* differs from *Nelsoniella* and *Eucladinium* in having an endocyst located in the central portion of the pericyst, and from *Eurydinium* and *Xenikoon* in having a circular to subcircular endocyst with the length equal to or less than the width.

Isabelidinium microarmum (McIntyre) Lentin & Williams 1977b

Pl. 30, figs 1-3

1975 *Deflandrea microarma* McIntyre, p. 65, pl. 1, figs 5-8.

1977b *Isabelidinium microarmum* (McIntyre) Lentin & Williams, p. 168.

Size measurements—Length × breadth: pericyst 99-122 × 41-64 µm, endocyst 39-54 × 41-64 µm (McIntyre, 1975); pericyst 80-86 × 49-52 µm, endocyst 36-47 × 42-52 µm in six specimens of this study.

Previous records—Campanian-Maastrichtian, Northwest Territories (McIntyre, 1975); district of Mackenzie, Canada (Ioannides & McIntyre, 1980).

Genus—*Kleithriasphaeridium* Davey 1974

1974 *Kleithriasphaeridium* Davey, p. 55.

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

PLATE 30 →

1-3. *Isabelidinium microarmum* (McIntyre) Lentin & Williams 1977b; 1, 2. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 3. × 40, CRC 32135-3, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian.

4. *Kleithriasphaeridium loffrense* Davey & Verdier 1976; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian.

5. *Lanternosphaeridium lanosum* Morgenroth 1966b; × 40, CRC 32135-1, D7 the Austin Chalk, upper Chalk member Dallas County; Santonian.

6-7 *Lejeunecysta decorinassa* S.K. Srivastava, n. sp.; 6 (paratype) × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; 7(holotype) × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

8-10. *Lejeunecysta hyalina* (Gerlach) Artzner & Dörhöfer 1978; 8, 9. × 40, CRC 32146-2, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian; 10. × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian.

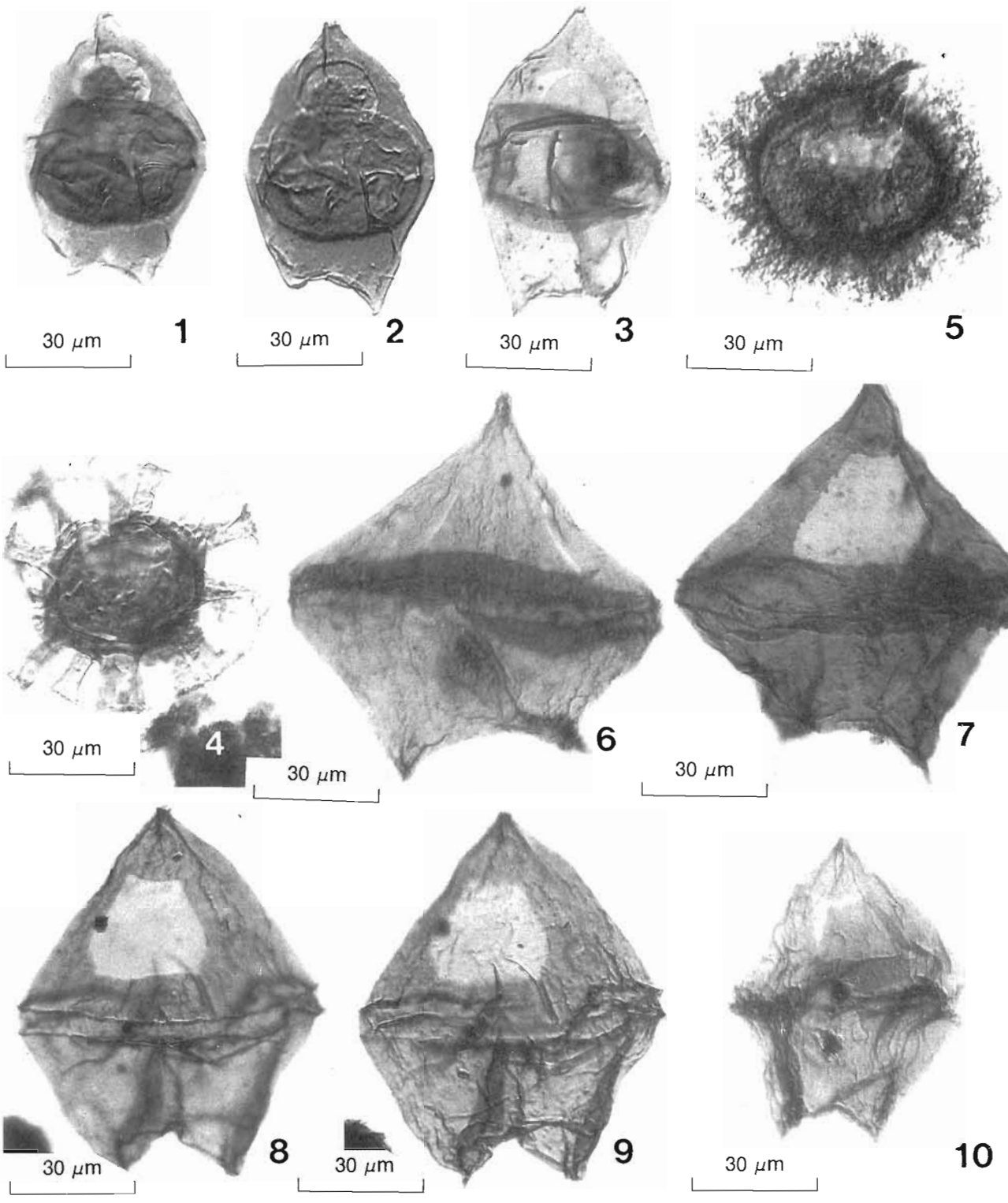

PLATE 30

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 loffrense Davey & Verdier 1976

Pl. 30, fig. 4

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

Size 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 µm (Srivastava, 1991); overall 73-81 µm, body 36-44 µm, process length 21-23 µm in specimens of this study.

Previous records—Albian-Senonian. Early Albian, Isle of Wight, England (Duxbury, 1983); Senonian, Nord, France (Davey & Verdier, 1976); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Genus—*Lanternosphaeridium* Morgenroth emend. Stover & Evitt 1978

1966 *Lanternosphaeridium* Morgenroth, p. 37.

1978 *Lanternosphaeridium* Morgenroth emend. Stover & Evitt, p. 168.

Type species—*Lanternosphaeridium lanosum* Morgenroth 1966 (original designation).

Remarks—*Lanternosphaeridium* includes ellipsoidal cysts having fibrous body surrounded by radially disposed, densely fibrous to loosely filamentous sheath with smooth to moderately serrate or spinulose outer margin. Its paratabulation is indicated by precingular archeopyle. *Lanternosphaeridium* is distinct from *Turbiosphaera* in having a fibrous sheath surrounding the autophragm.

Lanternosphaeridium lanosum Morgenroth 1966

Pl. 30, fig. 4

1966 *Lanternosphaeridium lanosum* Morgenroth, p. 38, pl. 10, figs 10, 11.

Size measurements—Overall length × breadth 87-123 × 50-98 µm, body 61-70 × 45-53 µm (Morgenroth, 1966); body 65-85 × 53-71 µm, process height 18-34 µm (Benson, 1976); body 60-68 × 44-50 µm, membrane height up to 22 µm (Eaton, 1976); overall 83-104 × 78-91 µm, body 52-70 × 52-60 µm, process height 16-21 µm in five specimens of this study.

Previous records—Maastrichtian-Paleocene, Maryland, U.S.A. (Benson, 1976); Eocene, Europe (Morgenroth, 1966; Gruas-Cavagnetto, 1975; Eaton, 1976; de Coninck, 1977); early-Middle Eocene, Alabama, U.S.A. (Drugg & Stover, 1975).

Genus—*Lejeunecysta* Artzner & Dörhöfer 1978

1961 *Lejeunia* Gerlach, p. 169.

1972 *Lejeunia* Gerlach emend. Kjellström, p. 467

1976 *Lejeunia* Gerlach emend. Lentin & Williams, p. 68.

1978 *Lejeunecysta* Artzner & Dörhöfer, p. 1381 (nom. nov., pro *Lejeunia* Gerlach, 1961; *non* Libert, 1820).

1980 *Lejeunia* Gerlach emend. Bujak in Bujak *et al.*, p. 68.

Type species—*Lejeunecysta hyalina* (Gerlach) Artzner & Dörhöfer 1978 = *Lejeunia hyalina* Gerlach 1961 (original designation).

Remarks—*Lejeunecysta* includes proximate, pentagonal, compressed peridinoid cysts with an intercalary archeopyle and a short apical and two antapical horns. Autophragm is smooth, wrinkled or chagrinate (Bujak *et al.*, 1980). Paratabulation indicated by archeopyle and/or paracingulum. *Lejeunecysta* is distinct from *Phelodinium* in having only autophragm and shorter horns; and from *Morkallacysta* in lacking well-developed horns.

Lejeunecysta decorinassa S.K. Srivastava, n. sp.

Pl. 30, figs 6-7

Description—Cysts pentagonal with a single apical and two antapical horns; apical horn short but distinct with rounded apex; antapical horns two, unequal with acuminate apices; wall layers not distinct, probably autophragm only, parasutural features absent,

PLATE 31 →

1. *Litosphaeridium fenestreconum* (May) Lucas-Clark 1984; × 40, CRC 32140-4, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.
2-3. *Litosphaeridium* sp. *sensu* Stein 1983; × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.
4. *Manumiella lata* (Cookson & Eisenack) Bujak & Davies 1983; × 40, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.
5. *Membranilarnacia ovalis* Cookson & Eisenack 1974; × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.
6-10. *Odontochitina costata* Alberti emend. Clarke & Verdier 1967; CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

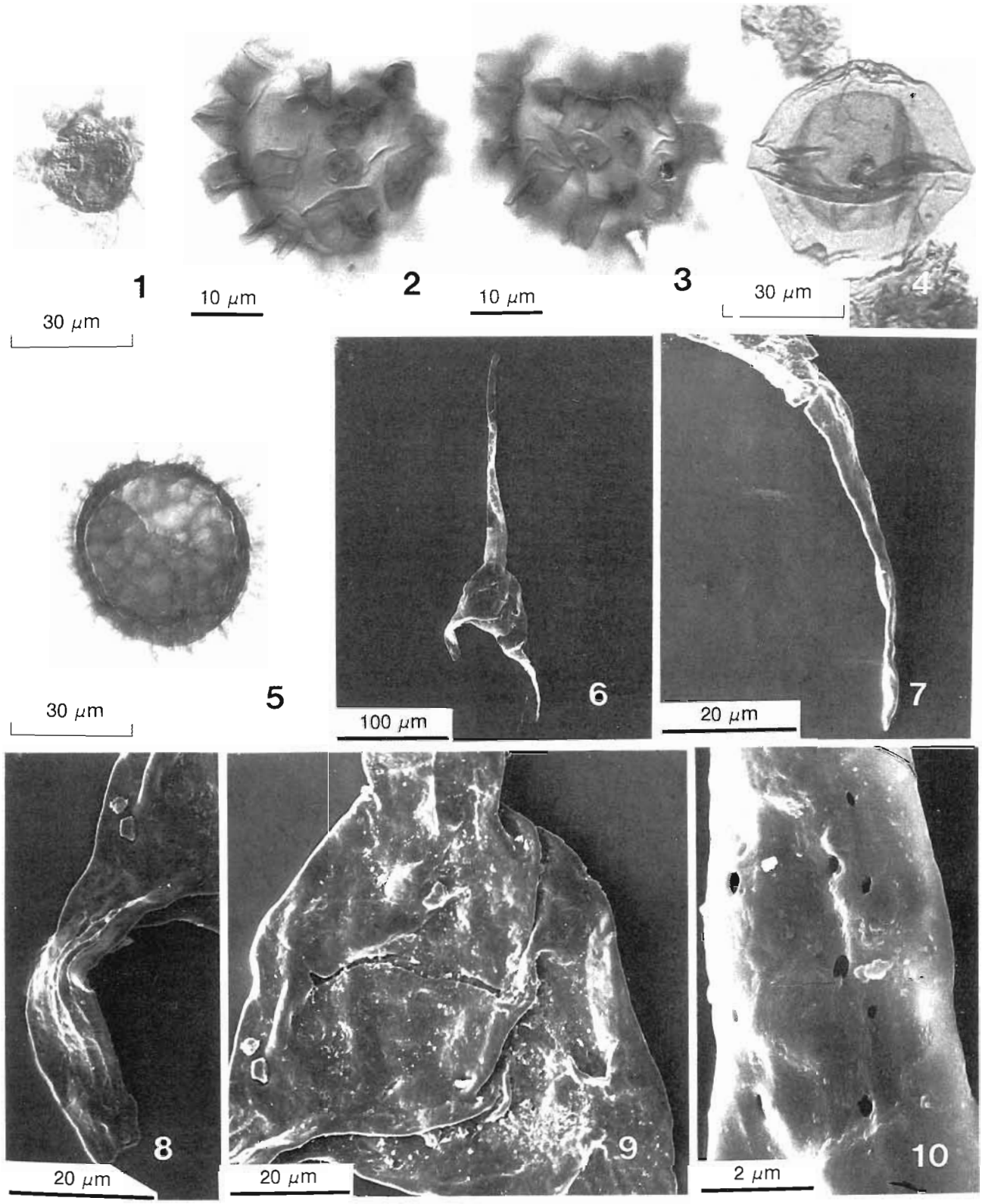

PLATE 31

autophragm with wrinkled surface, wrinkles running from apical end to antapical end longitudinally anastomosing irregularly, wrinkles or rugulae granulose; paratabulation indicated by a paracingulum and an

archeopyle only; archeopyle intercalary, type 1 (2a), hexagonal, sometimes operculum attached, antapical margin near paracingulum margin; paracingulum indicated in the widest part as broad folds; parasulcus indicated by a longitudinal concavity in the hypocyst.

Size measurements—Total length × breadth range 109-117 × 99-104 µm.

Holotype—Pl. 30, fig. 7; photomicrograph reference no. 85030/4; objective X 40; microscope location-horizontal 34.0/vertical 112.0; size-total length × breadth 117 × 99 µm; sample no. CRC 32140-1/Slide 2; locality DW12, the Navarro Group, the Corsicana Clay, Navarro County, Texas, Maastrichtian.

Paratype—Pl. 30, fig. 6; photomicrograph reference no. 85029/14; objective X 40; microscope location-horizontal 52.0/vertical 101.0; size-total length × breadth 109 × 104 µm; sample no. CRC 32140-1/Slide 4; locality DW12, the Navarro Group, the Corsicana Clay, Navarro County, Texas, Maastrichtian.

Remarks—Lejeunecysta decorinassa is distinct from *L. fallax* and *L. communis* in being larger having distinct in apical and antapical horns, and an autophragm with granulose wrinkles; and from *Phelodinium magnificum* in having autophragm only.

Name derivation—L. decoris = ornamented; *nassa* = wicker basket with narrow neck, or fish-trap; *decor* + *i* + *nassa* = ornamented fish-trap.

Lejeunecysta hyalina (Gerlach) Artzner & Dörhöfer 1978

Pl. 30, figs 8-10

1961 *Lejeunia hyalina* Gerlach, p. 169, pl. 26, figs 10, 11.

1978 *Lejeunecysta hyalina* (Gerlach) Artzner & Dörhöfer, p. 1381.

Size measurements—Length × breadth 61-93 × 61-93 µm (Gerlach, 1961); 86-104 × 65-86 µm in two specimens of this study.

Previous records—Paleocene-Miocene, Thanetian, Morocco (Doubinger, 1979); Eocene-Miocene, Europe (Gerlach, 1961; de Coninck, 1969; Gocht, 1969; Benedek, 1972; Eaton, 1976; Bujak *et al.*, 1980; Sarjeant, 1984); Late Eocene-Middle Miocene, Argentina (Gamerro & Archangelsky, 1981).

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 = *Hystrichosphaeridium siphoniphorum* Cookson & Eisenack 1958 (original designation).

Remarks—Litosphaeridium includes skolochorate 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 fenestreconum (May) Lucas-Clark 1984

Pl. 31, fig. 1

1980 *Hystrichokolpoma fenestrecona* May, p. 54, pl. 3, figs 6-11

1984 *Litosphaeridium fenestreconum* (May) Lucas-Clark, p. 190, pl. 2, figs 5, 6, 9, 10, 13, 14.

Size measurements—Body dimensions 29-34 × 29-34 µm, larger process 14-20 × 7-12 µm (base), slender processes 15-20 × 2-4 µm (May, 1980); overall diameter 52 µm, body 26 µm, process length 16 µm in one specimen of this study

Previous records— Maastrichtian, New Jersey, U.S.A. (May, 1980).

Litosphaeridium sp. *sensu* Stein, 1983

Pl. 21, figs 2-3

1983 *Litosphaeridium* sp. Stein, p. 125, pl. 18, figs 3, 4, 7, 8.

1984 *Litosphaeridium* sp. of Stein-Lucas-Clark, p. 191, pl. 2, figs 7, 8, 11, 12.

Size measurements—Body dimensions 39-54 × 33-42 µm, process length 9-18 µm (Stein, 1983); overall 40 × 36 µm, body 26 × 26 µm, process 10 × 6 µm in one specimen of this study.

Previous records— Maastrichtian, southern California, U.S.A. (Stein, 1983).

Genus—*Manumiella* Bujak & Davies 1983

1983 *Manumiella* Bujak & Davies, p. 160.

Type species—*Manumiella seelandica* (Lange) Bujak & Davies 1983 = *Broomea seelandica* Lange 1969 (original designation).

Remarks—Manumiella has peridinoid circumcavate cysts with intercalary archeopyle and having a subrhombic and subcircular outline. It differs from

Isabelidinium in being circumcavate; from *Eucladinium* and *Nelsoniella* in having a centrally located endocyst; from *Eurydinium* in having a circular endocyst; and from *Amphidiadema* in lacking strongly developed shoulders.

Manumiella lata (Cookson & Eisenack) Bujak & Davies 1983

Pl. 31, fig. 4

1968 *Deflandrea lata* Cookson & Eisenack, p. 110, fig. 1A-C.
1976 *Isabelia lata* (Cookson & Eisenack) Lentin & Williams, p. 58.
1977b *Isabelidinium latum* (Cookson & Eisenack) Lentin & Williams, p. 168.
1983 *Manumiella lata* (Cookson & Eisenack) Bujak & Davies, p. 161, pl. 7, fig. 13.

Size measurements—Length × breadth pericyst 78-105 × 76-97 µm, endocyst 48-50 × 48-75 µm (Cookson & Eisenack, 1968); pericyst 78 × 62 µm, endocyst 39 × 42 µm in one specimen of this study.

Previous records—?Santonian-Early Campanian, Australia (Cookson & Eisenack, 1968).

Genus—*Membranilarnacia* Eisenack 1963b

1963b *Membranilarnacia* Eisenack, p. 99.

Type species—*Membranilarnacia leptoderma* (Cookson & Eisenack) Eisenack 1963 = *Membranilarnax leptoderma* Cookson & Eisenack 1958 (original designation).

Remarks—*Membranilarnacia* has an apical archeopyle and includes cavate cysts having subspherical endocyst surrounded by thinner pericyst. Endophragm and epiphragm connected by rods, pillars or processes which may be divided distally. *Membranilarnacia* is distinct from *Eatonicysta* in having shorter processes unrelated to paraplates.

Membranilarnacia ovalis Cookson & Eisenack 1974

Pl. 31, fig. 5

1974 *Membranilarnacia ovalis* Cookson & Eisenack, p. 72, pl. 29, fig. 21.

Size measurements—Overall 68 × 54 µm, body 58 × 44 µm, processes 3-5 µm long (Cookson & Eisenack, 1974); overall diameter 65 µm, body 52 µm, processes 8 µm long in one specimen of this study.

Previous records—Senonian, Australia (Cookson & Eisenack, 1974).

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 (basionym: *Ceratium (Euceratium) operculatum* O. Wetzel 1933) = *Odontochitina silicorum* Deflandre 1935 (monotypic).

Remarks—*Odontochitina* consists of ceratioid cavate cysts having single long apical, antapical and postcingular horns with an apical archeopyle.

Odontochitina costata Alberti emend. Clarke & Verdier 1967

Pl. 31, figs 6-10

1961 *Odontochitina costata* Alberti, p. 31, pl. 6, figs 10-13.
1962a *Odontochitina striatoperforata* Cookson & Eisenack, p. 490, pl. 3, figs 14-19.
1967 *Odontochitina costata* Alberti emend. Clarke & Verdier, p. 58, pl. 13, figs 4-6.

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

Previous records—Aptian-Early Paleocene. Harker *et al.* (1990) reported its rare occurrence in Campanian samples from Saskatchewan and Manitoba in Canada and the Campanian Austin Chalk and the Taylor Marl of Texas in U.S.A. (see also Srivastava, 1991)

Odontochitina operculata (O. Wetzel) Deflandre in Deflandre & Cookson 1955 (not illustrated)

1933a *Ceratium (Euceratium) operculatum* O. Wetzel, p. 107.
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.

Size 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 (see Srivastava, 1991, pl. 19, fig. 7). Harker *et al.* (1990) reported a rare occurrence of *O. operculata* in Campanian sediments of Alberta, Saskatchewan, and Manitoba in Canada, and Wyoming, U.S.A. They recorded its rare to common occurrence in the Taylor Marl (Campanian) of Texas, U.S.A.

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 *Perisseiasphaeridium* in lacking paracingular processes.

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

Pl 32, figs 1-3

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*).

Size 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 (Srivastava, 1991); overall 65-99 µm, body 31-39 µm, process length 21-31 µm in five specimens of this study.

Previous records—Cretaceous-Danian. Valanginian, northwestern Germany (Below, 1981b); Hauterivian, offshore Denmark (Davey, 1982b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984); Upper Barremian-Aptian, northern Germany (Below, 1982b); Aptian-Early Albian, Isle of Wight, England (Duxbury, 1983); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Campanian, western interior of Canada, and Wyoming and Texas, U.S.A. (Harker *et al.*, 1990); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991); (see also the list of synonymy noted in Below, 1982a).

Oligosphaeridium pulcherrimum (Deflandre & Cookson) Davey & Williams in Davey *et al.*, 1966

Pl. 32, figs 4-9

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.

Size measurements—Overall diameter 118 µm, body 47 × 61 µm, 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 (Srivastava, 1991); overall 109-117 µm, body 39-42 µm, process length 29-42 µm in the specimens of this study.

Previous records—Widely distributed in Kimmeridgian-Eocene strata. Campanian, western interior of Canada (Harker *et al.*, 1990).

Genus—*Operculodinium* Wall 1967

1967 *Operculodinium* Wall, p. 110.

Type species—*Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967 = *Hystrichosphaeridium centrocarpum* Deflandre & Cookson 1955 (original designation).

Remarks—*Operculodinium* has a precingular archeopyle and consists of proximochorate to skolochorate cysts having spherical to ellipsoidal body with numerous nontabular varied processes of similar shape and size, but typically capitate, hollow and distally closed or solid. *Operculodinium* differs from *Exochosphaeridium* and *Amphorosphaeridium* in having nonfibrous processes and in lacking prominent apical and/or antapical processes; from *Lingulodinium* in having a different precingular archeopyle; from *Cleistosphaeridium* and *Surculosphaeridium* in having a precingular archeopyle.

Operculodinium major Jain & Dutta in Dutta & Jain 1980

Pl. 33, figs 1-2

PLATE 32 →

1-3. *Oligosphaeridium complexum* (White) Davey & Williams in Davey *et al.* 1966; 1. × 40, CRC 32139-2, D11, the Austin Chalk, upper Chalk member, Ellis County; Late Santonian; 2, 3. CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

4-9. *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams in Davey *et al.* 1966; 4. × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian; 5, 6, 7 CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian; 8, 9. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

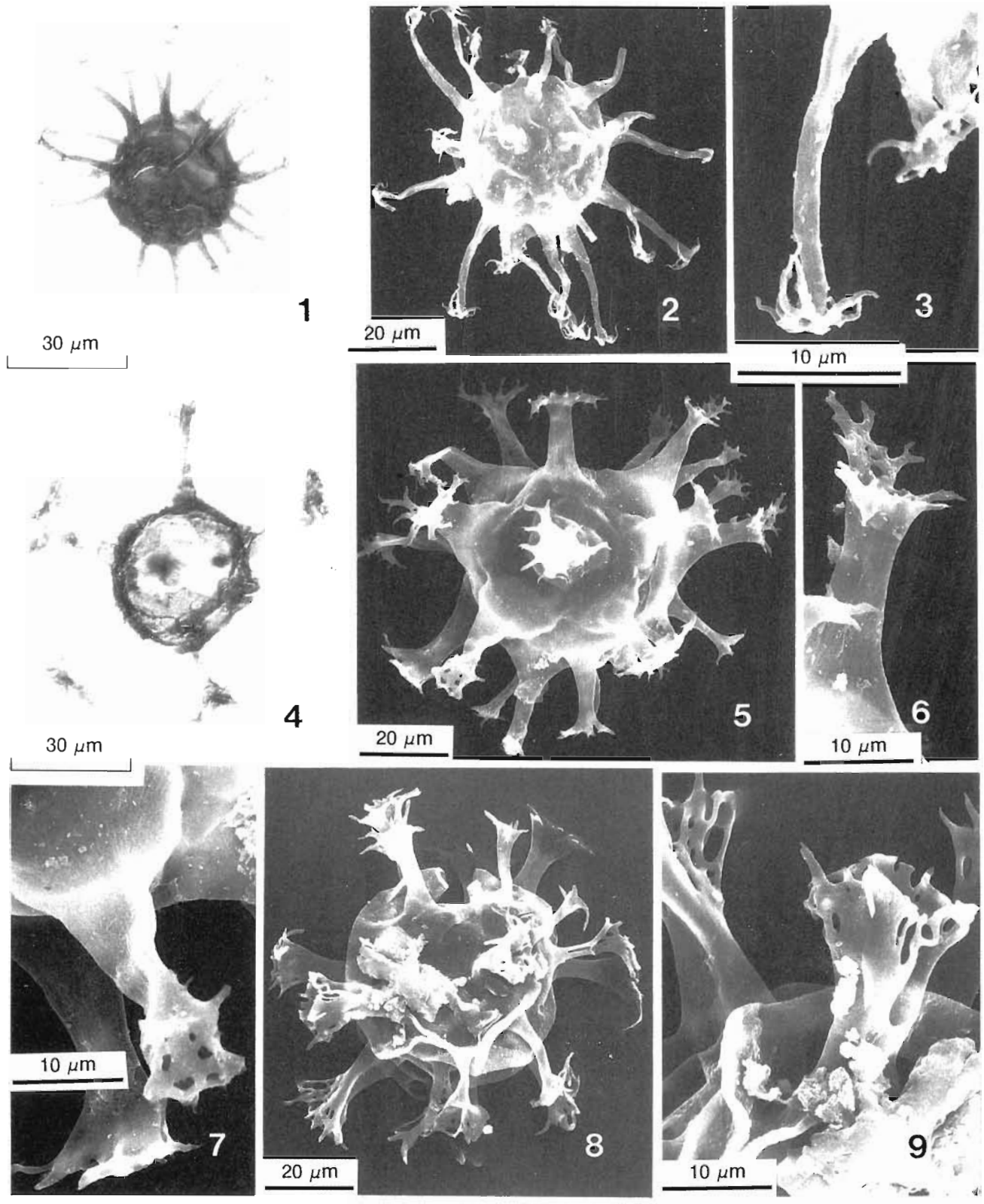

PLATE 32

1980 *Operculodinium major* Jain & Dutta in Dutta & Jain, p. 68, pl. 3, figs 19-22.

Size measurements—Overall dimensions 62-84 × 62-84 μm, process length 23-29 μm (Dutta & Jain, 1980);

overall diameter 70-83 µm, body 52-60 µm, process length 15-21 µm in three specimens of this study

Previous records—Late Paleocene, eastern India (Dutta & Jain, 1980).

Genus—*Palaeocystodinium* Alberti 1961

1961 *Palaeocystodinium* Alberti, p. 20.

Type species—*Palaeocystodinium golzowense* Alberti 1961 (original designation).

Remarks—Palaeocystodinium has proximate, cornucavate or circumcavate, ellipsoidally elongate cysts with a slender tapering, apical and an antapical horn, and an intercalary archeopyle. It is distinct from *Svalbardella* in having thin tapering apical and antapical horns and lacking paratabulation other than the archeopyle.

Palaeocystodinium australinum (Cookson) Lentin & Williams 1976

Pl. 33, figs 3-4

1965 *Svalbardella australina* Cookson, p. 140, pl 25, figs 1-4.

1976 *Palaeocystodinium australinum* (Cookson) Lentin & Williams, p. 89, pl. 12, fig. 177.

Size measurements—Length × width 239-302 × 40-61 µm (Cookson, 1965); 158-215 × 38-63 µm (Benson, 1976); 152-270 × 43-66 µm (May, 1980); 208-268 × 49-65 µm, endocyst 101-120 × 47-65 µm, length of apical horn 39-60 µm, length of antapical horn 52-65 µm in five complete specimens of this study.

Remarks—P australinum differs from *P golzowense* in having a rudimentary bifurcation of the antapical horn near its distal end; from *P. granulatum* in lacking granules on surface; and from *P benjaminii* in lacking spinules at the distal ends of the horns.

Previous records—Late Campanian-Maastrichtian, New Jersey, U.S.A. (May, 1980); Maastrichtian-Paleocene, Maryland (Benson, 1976); Maastrichtian, Morocco (Rauscher & Doubinger, 1982); Maastrichtian-Paleocene, Denmark (Wilson, 1971; Heilmann-Clausen, 1985); Late Maastrichtian-Paleocene, New Zealand (Wilson, 1984); Paleocene, southwestern Victoria, Australia (Cookson, 1965).

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 (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 being more elongate and having conical antapical end without any indication of two unequal horns.

Palaeohystrichophora infusorioides Deflandre 1935

Pl. 33, figs 5-6; Pl 34, figs 1-3

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

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

Size 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 (Srivastava, 1991); overall 50-60 × 45-50 µm, without processes 45-55 × 34-45 µm, endocyst 27-35 × 32-36 µm, process length 9-10 µm in three specimens of this study.

Previous records—Albian-Maastrichtian Cenomanian-Santonian, England (Cookson & Hughes,

PLATE 33 →

1-2. *Operculodinium major* Jain & Dutta in Dutta & Jain 1980; × 40, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

3-4. *Palaeocystodinium australinum* (Cookson) Lentin & Williams 1976; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian.

5-6. *Palaeohystrichophora infusorioides* Deflandre 1935; × 40, CRC 32135-4A, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian.

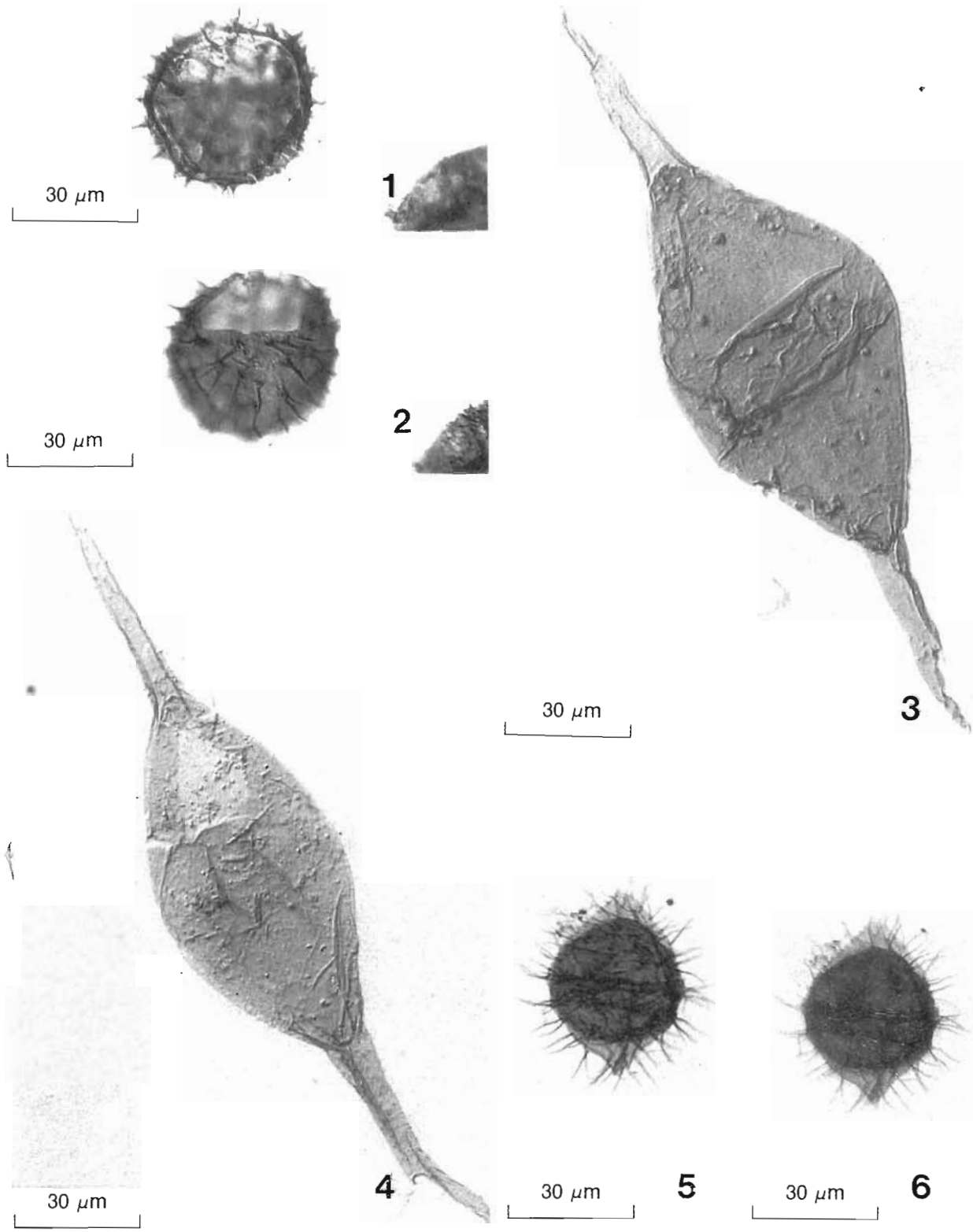

PLATE 33

1964; Clarke & Verdier, 1967; Davey, 1970); ?Albian-Senonian, France (Deflandre, 1934, 1935, 1936b, 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; Harker *et al.*, 1990); 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, 1960b, 1969, 1970, 1974, Norvick & Burger, 1976); Upper Cretaceous, U.S.S.R. (Vozzhennikova, 1967); Cenomanian-Coniacian, Texas (Srivastava, 1991).

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

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

1934 *Palaeoperidinium* Deflandre, p. 968.
1963 *Pentagonum* Vozzhennikova, p. 183.
1967 *Palaeoperidinium* Deflandre emend. Sarjeant, p. 246.
1970 *Astrocysta* Davey, p. 359.
1976 *Palaeoperidinium* Deflandre emend. Lentin & Williams, p. 106.

Type species—*Palaeoperidinium pyrophorum* (Ehrenberg) Deflandre 1935 = *Peridinium pyrophorum* Ehrenberg 1838 (subsequent designation by Sarjeant, 1967).

Remarks—*Palaeoperidinium* includes proximate, compressed peridinioid cysts with a well-developed apical and two antapical horns, a combination of archeopyle and a peridiniacean paratabulation, if present. *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. 34, figs 4-5

1962 *Palaeoperidinium cretaceum* Pocock, p. 80, pl. 14, figs 219-221
1970 *Astrocysta cretacea* (Pocock) Davey, p. 359, pl. 2, fig. 4.
1971 *Lejeunia? cretacea* (Pocock) Brideaux, p. 86, pl. 24, figs 46, 47
1973 *Astrocysta manumcooksoni* Corradini, p. 176, p. 28, figs 4, 6 (err orth. pro *manumcooksoniae*).

Size measurements—Length × breadth 81-95 × 50-69 µm (Pocock, 1962); 80-118 × 57-82 µm (Davey 1970); 68-95 × 48-72 µm (Singh, 1964, 1971); 63-119 × 41-88 µm (Brideaux, 1971); 60-92 × 57-68 µm (Below, 1981a); 78-93 × 65-78 µm (Srivastava, 1991); 81-104 × 65-86 µm in six specimens of this study.

Previous records—Barremian-Paleocene, Barremian-Albian, western Canada (Pocock, 1962; Singh, 1964, 1971, Davey, 1970; Brideaux, 1971; Bujak & Davies, 1983) and Alaska (May, 1979; May & Stein, 1979); Campanian, western interior of Canada and U.S.A. (Harker *et al.*, 1990); Barremian-Albian, England (Duxbury, 1980, 1983); Barremian-Albian, southwestern Morocco (Below, 1981a); Late Aptian, South Atlantic Ocean, off southwestern Africa (Davey, 1978); Aptian-Early Cenomanian, Mazagan Plateau, offshore northwest Africa (Below, 1984); Albian-Cenomanian, Portugal (Berthou *et al.*, 1980); Senonian-Paleocene, Italy (Corradini, 1973); Early Late Cretaceous, Arctic Canada (Manum & Cookson, 1964).

Genus—*Phelodinium* Stover & Evitt 1978

1978 *Phelodinium* Stover & Evitt, p. 117

Type species—*Phelodinium pentagonale* (Corradini) Stover & Evitt 1978 = *Deflandrea pentagonalis* Corradini 1973 (original designation).

Remarks—*Phelodinium* has proximate, cornucavate, compressed peridinioid cysts with an intercalary archeopyle and a short to long apical and two antapical horns. *Phelodinium* differs from *Lejeunia* in being cornucavate and having straight to concave sides.

Phelodinium gaditanum (Riegel) Riegel & Sarjeant 1982

Pl. 34, figs 6-9

1974 *Deflandrea gaditana* Riegel, p. 356, pl. 2, figs 8, 9; pl 3, figs 1, 2.

PLATE 34 →

1-3. *Palaeohystrichophora infusorioides* Deflandre 1935; 1, 2. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay Travis County, Campanian; 3. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.
4-5. *Palaeoperidinium cretaceum* Pocock ex Davey 1970, 4. × 40, CRC 32143-2, DW15 the Taylor Group, lower Taylor Clay McLennan County; Campanian; 5. × 40, CRC 32143-1 DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.
6-9. *Phelodinium gaditanum* (Riegel) Riegel & Sarjeant 1982; 6, 7 × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian; 8, 9. × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

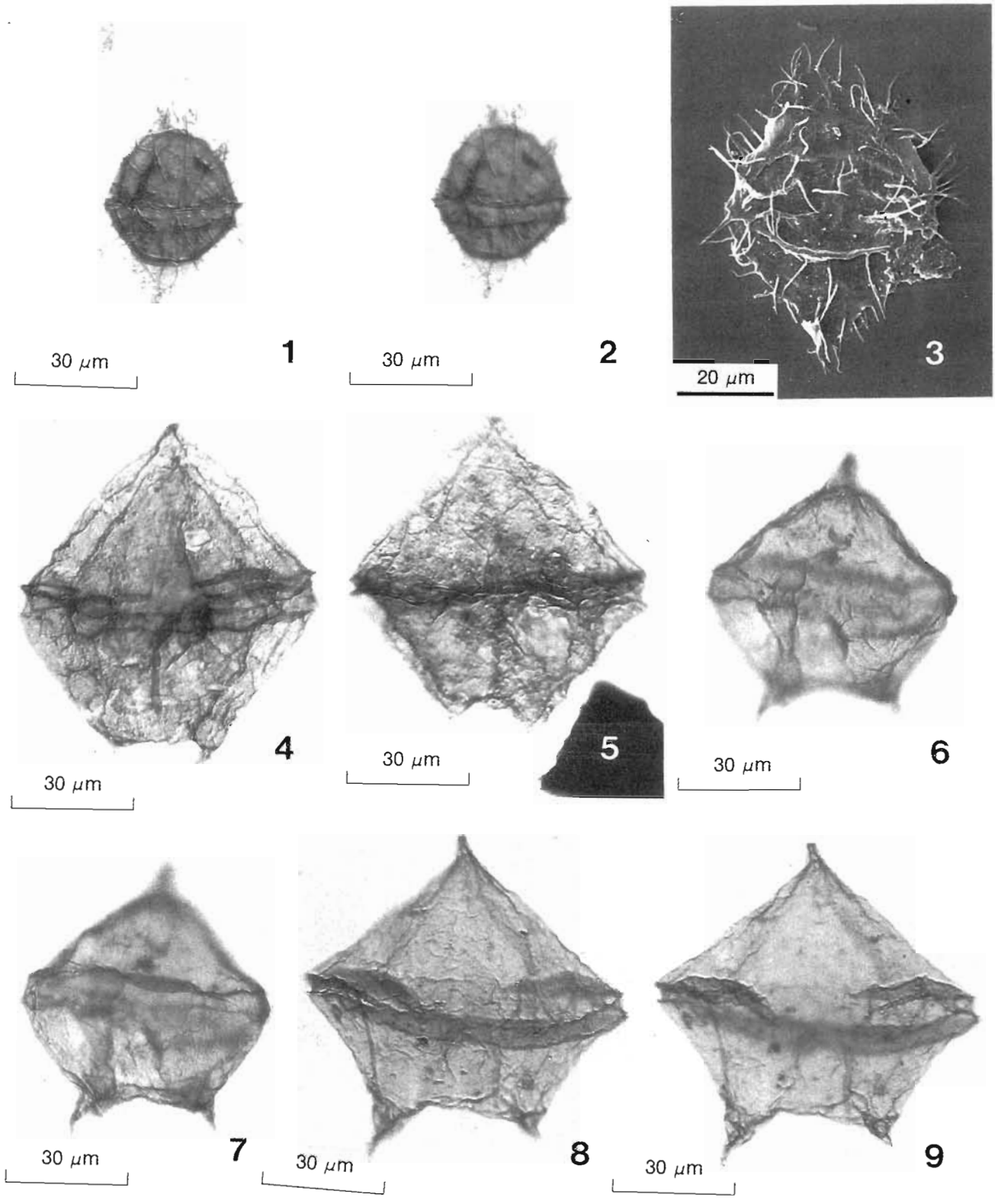

PLATE 34

1977 *Senegalinium gaditanum* (Riegel) Harland, p. 189.

1977a *Senegalinium gaditanum* (Riegel) Lentin & Williams, p. 144.

1982 *Phelodinium gaditanum* (Riegel) Riegel & Sarjeant, p. 297, fig. 7C-D.

Size measurements—Overall length × breadth 49-84 × 55-76 µm (Riegel, 1974; Riegel & Sarjeant, 1982); 81-96 × 52-94 µm in six specimens of this study.

Previous records—Senonian, Spain (Riegel, 1974; Riegel & Sarjeant, 1982).

Phelodinium magnificum (Stanley) Stover & Evitt 1978

Pl. 35, figs 1-3

1965 *Deflandrea magnifica* Stanley, p. 218, pl. 20, figs 1-6.
1976 *Lejeunia magnifica* (Stanley) Lentin & Williams, p. 71.
1977 *Senegalinium magnificum* (Stanley) Harland, p. 188, pl. 25, fig. 2.
1978 *Phelodinium magnificum* (Stanley) Stover & Evitt, p. 118.

Size measurements—Overall length × breadth 120-135 × 100-115 µm (Stanley, 1965); 78-104 × 60-78 µm in five specimens of this study.

Previous records—Campanian-Paleocene. Paleocene, South Dakota (Stanley, 1965); Maastrichtian, Montana, U.S.A. (Harland, 1977); Campanian Bearpaw Formation of Saskatchewan, Canada (Harker *et al.*, 1990).

Phelodinium pentagonale (Corradini) Stover & Evitt 1978

Pl. 35, figs 4-5

1973 *Deflandrea pentagonalis* Corradini, p. 175, pl. 28, fig. 3.
1976 *Lejeunia pentagonalis* (Corradini) Lentin & Williams, p. 71.
1978 *Phelodinium pentagonale* (Corradini) Stover & Evitt, p. 118.

Size measurements—Overall length × breadth 110-120 × 60-68 µm (Corradini, 1973); 65-107 × 44-78 µm in three specimens of this study.

Previous records—Senonian, Italy (Corradini, 1973).

Phelodinium tricuspe (O. Wetzel) Stover & Evitt 1978

Pl. 35, figs 6-7

1933a *Peridinium tricuspis* O. Wetzel, p. 166 (err. orth. pro *tricuspe*).
1933b *Peridinium tricuspis* O. Wetzel, pl. 2, fig. 14 (err. orth. pro *tricuspe*).
1970 *Astrocysta tricuspis* (O. Wetzel) Davey, p. 360.
1973 *Lejeunia tricuspis* (O. Wetzel) Harland, p. 673, pl. 84, fig. 4.
1976 *Lejeunia tricuspia* (O. Wetzel) Lentin & Williams, p. 71 (err. orth. pro *tricuspis*).
1977 *Senegalinium tricuspis* (O. Wetzel) Harland, p. 188, pl. 25, figs 3, 5 (err. orth. pro *tricuspe*).
1978 *Phelodinium tricuspis* (O. Wetzel) Stover & Evitt, p. 118 (err. orth. pro *tricuspe*).

Size measurements—Overall length × breadth 100-116 × 50-76 µm (Wetzel, 1933a); 88-140 × 52-117 µm in seven specimens of this study.

Previous records—Campanian-Maastrichtian, Baltic Senonian (Wetzel, 1933a, 1933b); Late Campanian, Alberta, Canada (Harland, 1973); Late Campanian-Maastrichtian, Montana, U.S.A. (Harland, 1977).

Genus—*Renidinium* Morgenroth 1968

1968 *Renidinium* Morgenroth, p. 551.

Type species—*Renidinium membraniferum* Morgenroth 1968 (original designation).

Remarks—*Renidinium* is similar to *Cyclonephelium* in being dorso-ventrally compressed, in having an apical archeopyle, and lacking or having reduced sculpture in dorsal and ventral areas. It differs from *Cyclonephelium* in having gonyaulacacean paratabulation expressed partly by penitabular ridges or folds which may form large reticulate sculpture. *Renidinium* differs from *Palynodinium* in lacking gonal and intergonal processes.

Renidinium vitilare (Cookson) Stover & Evitt 1978

Pl. 35, figs 8-9

1965 *Cyclonephelium vitilare* Cookson, p. 138, pl. 24, figs 1-7.

PLATE 35 →

1-3. *Phelodinium magnificum* (Stanley) Stover & Evitt 1978; 1, 2. × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; 3. × 40, CRC 32139-3, D11, the Austin Chalk, upper Chalk member, Ellis County; Late Santonian.

4-5. *Phelodinium pentagonale* (Corradini) Stover & Evitt 1978; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

6-7 *Phelodinium tricuspe* (O. Wetzel) Stover & Evitt 1978; × 40, CRC 32140-4, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

8-9. *Renidinium vitilare* (Cookson) Stover & Evitt 1978; 8. × 40, 9. × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

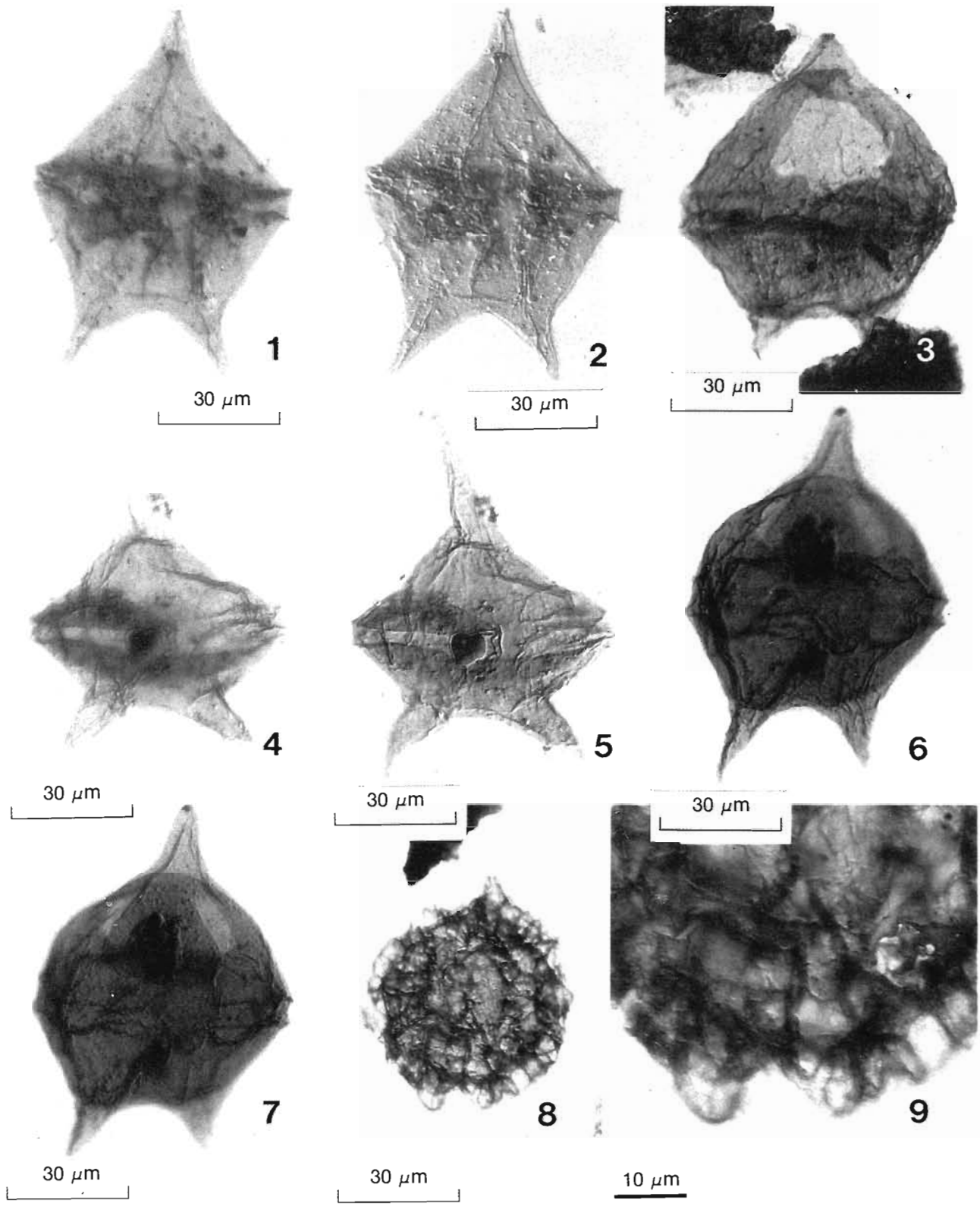

PLATE 35

1978 *Renidinium vitilare* (Cookson) Stover & Evitt, p. 79.

Size measurements—Overall dimensions 98-112 × 78-102 μm (Cookson, 1965); 88-91 × 78 μm, endocyst

73 × 65 µm, reticulum height 13 µm in two specimens of this study.

Previous records—Paleocene, Australia (Cookson, 1965); Middle Eocene, France (Jan du Chene *et al.*, 1975).

Genus—*Rottnestia* Cookson & Eisenack 1961b

1961b *Rottnestia* Cookson & Eisenack, p. 40.

Type species—*Rottnestia borussica* (Eisenack) Cookson & Eisenack 1961b = *Hystrichosphaera (Hystrichosphaeropsis) borussica* Eisenack 1954 (original designation).

Remarks—*Rottnestia* has bicavate, elongate ellipsoidal cysts with a precingular archeopyle, an ellipsoidal to ovoidal endocyst, gonyaulacacean paratabulation, and short gonal processes. It differs from *Hystrichosphaeropsis* and *Psaligonyaulax* in having gonal processes.

Rottnestia borussica (Eisenack) Cookson & Eisenack 1961b

Pl. 36, figs 1-2

1954 *Hystrichosphaera (Hystrichosphaeropsis) borussica* Eisenack, p. 62, pl. 9, figs 5-7

1961b *Rottnestia borussica* (Eisenack) Cookson & Eisenack, p. 42, pl. 1, figs 8-10; pl. 2, figs 1-2; fig. 1a-d.

Size measurements—Pericyst length 48-76 µm, endocyst diameter 28-50 µm (Bujak *et al.*, 1980); overall length × breadth 78 × 65 µm, endocyst 39 × 44 µm in one specimen of this study.

Previous records—Paleocene-Early Oligocene Paleocene-Eocene, Australia (Cookson & Eisenack, 1961b, 1965); Eocene-Oligocene, Europe (Eisenack, 1954; de Coninck, 1975a; Bujak *et al.*, 1980).

Genus—*Senoniasphaera* Clarke & Verdier 1967

1967 *Senoniasphaera* Clarke & Verdier, p. 61

Type species—*Senoniasphaera protrusa* Clarke & Verdier 1967 (original designation).

Remarks—*Senoniasphaera* consists of proximate, circumcavate, lenticular to compressed peridinioid cysts having one apical and two unequal antapical protrusions, an apical archeopyle, an offset parasulcal notch and incomplete parasutural features indicating a probable gonyaulacacean paratabulation. *Senoniasphaera* is distinct from *Membranophoridium* in having indications of paratabulation, an archeopyle ornamentation between endophragm and periphragm and lateral horns; and from *Renidinium* in having pericoels not limited to the ventral surface.

Senoniasphaera protrusa Clarke & Verdier 1967

Pl. 36, figs 3-9; Pl. 37, figs 1-7

1967 *Senoniasphaera protrusa* Clarke & Verdier, p. 61, pl. 14, figs 7-9, text-fig. 24.

Size measurements—Overall length × breadth 80-110 × 55 -82 µm, endocyst 50-69 × 44-66 µm (Clarke & Verdier, 1967); 70-115 × 43-71 µm, endocyst 45-80 × 35-50 µm (Foucher, 1976); 78-124 × 55-83 µm, endocyst 55-83 × 39-80 µm in 14 specimens of this study

Previous records—Santonian-Campanian, Santonian, Isle of Wight, England (Clarke & Verdier, 1967), Belgium (Foucher & Robaszynski, 1977); Santonian-Early Campanian, France (Foucher, 1976); Santonian, Grand Banks, Canada (Millioud *et al.*, 1975). Harker *et al.* (1990) reported its common occurrence in a sample from the lower Taylor Marl (Campanian) of Texas, U.S.A.

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 having a subspherical body 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.

Silicisphaera ferox (Deflandre) Davey & Verdier 1976

Pl. 38, figs 1-2

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

PLATE 36 →

1-2. *Rottnestia borussica* (Eisenack) Cookson & Eisenack 1961; × 40, CRC 32142-3, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian

3-9. *Senoniasphaera protrusa* Clarke & Verdier 1967; 3, 4, × 40, CRC 32135-3, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian; 5, × 40, CRC 32135-5, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian; 6, 7, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County, Santonian; 8, 9, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

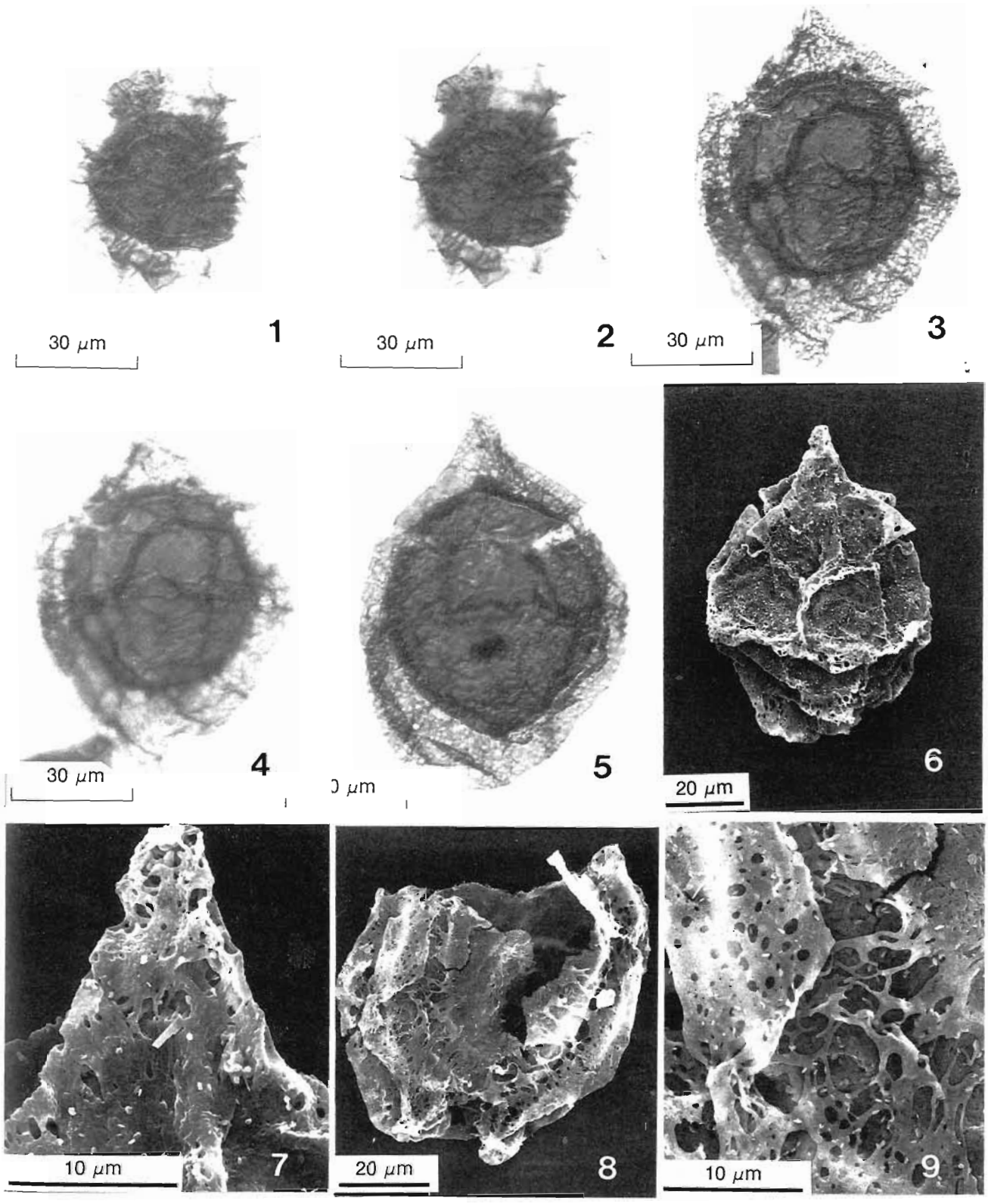

PLATE 36

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

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

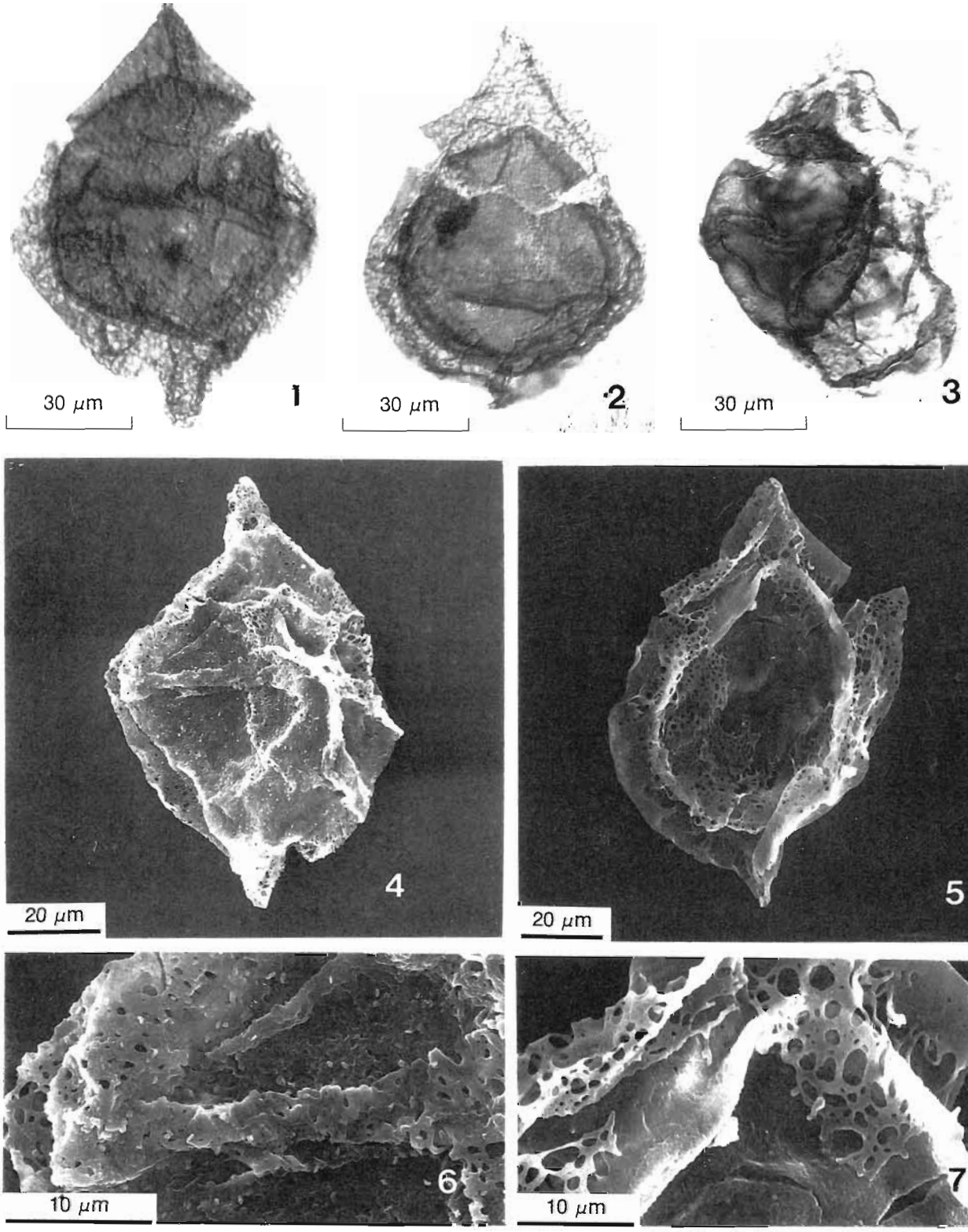

PLATE 37

1-7 *Senoniasphaera protrusa* Clarke & Verdier 1967; 1. × 40, CRC 32135-4, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian, 2. × 40, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian; 3. × 40; CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian; 4, 6 and 5, 7, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

1976 *Silicisphaera ferox* (Deflandre) Davey & Verdier, p. 322, pl. 3, figs 1-2; text-fig. 4.
1980 *Florentinia ferox* (Deflandre) Duxbury, p. 121

Size measurements—Holotype-overall diameter 78 µm, body 36 × 46 µm, process length 15-17 µm (Davey & Verdier, 1976); central body 40-49 × 40-49 µm, process length 10-16 µm (May, 1980); maximum diameter of central body 42-50 µm, process length × width 17-25 × 13-16 µm (Yun, 1981); overall diameter 55-86 µm, body 35-52 µm, process length × breadth 11-26 × 12-16 µm (Srivastava, 1991); overall dimensions 91-96 × 78-94 µm, body 52-57 × 49-52 µm, process length 29-31 µm, process breadth up to 16 µm in three specimens of this study

Previous records—Aptian-Danian. Late Aptian, Santonian and Danian, Germany (Wetzel, 1952; Eisenack, 1958; Yun, 1981); Late Albian-Maastrichtian, North America (Singh, 1971; Williams & Brideaux, 1975; May 1980; Srivastava, 1991); Cenomanian, England (Davey, 1969); Cenomanian-Senonian, France (Deflandre, 1937; Deflandre & Courteville, 1939; Foucher, 1972, 1974, 1983; Davey, 1969; Davey & Verdier, 1976; Robaszynski *et al.*, 1982); Late Santonian or Early Campanian, Australia (Cookson & Eisenack, 1968).

Genus—*Spinidinium* Cookson & Eisenack emend. Lentin & Williams 1976

1962 *Spinidinium* Cookson & Eisenack, p. 489.
1976 *Spinidinium* Cookson & Eisenack emend. Lentin & Williams, p. 62.

Type species—*Spinidinium styloniferum* Cookson & Eisenack 1962 (original designation).

Remarks—*Spinidinium* consists of proximochorate, cornucavate or circumcavate, compressed peridinioid to nearly lenticular cysts with an apical and two unequally developed antapical horns, peridiniacean hexa-style paratabulation indicated on periphragm by intratabular sculpture, and Type I or Ia intercalary archeopyle. *Spinidinium* differs from *Vozzhennikova* in having paratabular sculpture on its periphragm, and from *Ginginodinium* in having Type I intercalary archeopyle.

Spinidinium densispinatum Stanley 1965

Pl. 38, fig. 3

1965 *Spinidinium densispinatum* Stanley, p. 226, pl. 21, figs 1-5.

Size measurements—Length × breadth 50-65 × 40-50 µm (Stanley, 1965); 53-68 × 40-61 µm (Drugg, 1967); 48-67 × 37-50 µm (Stone, 1973); 65-73 × 43-57 µm in two specimens of this study.

Previous records—Campanian-Paleocene. Campanian Wyoming, U.S.A. (Stone, 1973); Paleocene, South Dakota (Stanley, 1965) and California (Drugg, 1967); Middle Paleocene, Morocco (Doubinger, 1979).

Spinidinium echinoideum (Cookson & Eisenack) Lentin & Williams 1976

Pl. 38, figs 4-5

1960b *Deflandrea echinoidea* Cookson & Eisenack, p. 2, pl. 1, figs 5-6.
1976 *Spinidinium echinoideum* (Cookson & Eisenack) Lentin & Williams, p. 64.

Size measurements—Length × breadth 67-86 × 50-57 µm (Cookson & Eisenack, 1960b); 60-71 × 45-50 µm (Harland, 1973); pericyst 59-74 × 44-56 µm, endocyst 37-56 × 32-49 µm (Benson, 1976); Pericyst 60-83 × 42-65 µm, endocyst 35-39 × 31-65 µm in 13 specimens of this study.

Previous records—Senonian. Santonian, Isle of Wight, England (Clarke & Verdier, 1967); Santonian-Campanian, Australia (Cookson & Eisenack, 1960b); Campanian-Maastrichtian, North America (Harland, 1973; Millioud *et al.*, 1975; Benson, 1976; Aurisano & Habib, 1977; Harker *et al.*, 1990); Campanian-Early Maastrichtian, off southwestern Africa (Davey, 1978).

Spinidinium lanternum Cookson & Eisenack 1970

Pl. 38, figs 6-9

1970 *Spinidinium lanterna* Cookson & Eisenack, p. 144, pl. 12, figs 1-4 (err. orth. pro *lanternum*).

Size measurements—Length × breadth 55-78 × 37-57 µm (Cookson & Eisenack, 1970); 55 × 45-55 µm, spinules 5-7 µm long in two specimens of this study.

Previous records—Senonian, Western Australia (Cookson & Eisenack, 1970).

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 compactus Cookson & Eisenack 1974

Pl. 39, fig. 1

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

Size measurements—Overall dimensions 58 × 52 µm, body 38 × 28 µm (Cookson & Eisenack, 1974); 62-96 × 57-91 µm, body 39-60 × 34-53 µm, process length 13-16 µm in five specimens of this study

Remarks—*Spiniferites compactus* can be distinguished from *S. katatonos* Corradini in having width of the body less than the height of the body.

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

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

Pl. 39, fig. 2

1966 *Hystrichosphaera ramosa* var. *gracilis* Davey & Williams in Davey *et al.*, p. 34, pl. 1, fig. 5; pl. 5, fig. 6.

1973 *Spiniferites ramosus* subsp. *gracilis* (Davey & Williams) Lentin & Williams, p. 130.

1973 *Spiniferites ramosus* var. *gracilis* (Davey & Williams) Corradini, p. 165, pl. 26, fig. 3.

Size 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. Campanian, Saskatchewan and Manitoba, Canada and Texas, U.S.A. (Harker *et al.*, 1990).

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

Pl. 39, figs 3-4

1966 *Hystrichosphaera ramosa* var. *granomembranacea* Davey & Williams in Davey *et al.*, p. 37, pl. 4, fig. 4.

1973 *Spiniferites ramosus* var. *granomembranaceus* (Davey & Williams) Lentin & Williams, p. 130.

1973 *Spiniferites ramosus* var *granomembranaceus* (Davey & Williams) Corradini, p. 166, pl. 26, fig. 4.

Size 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 × breadth 75-99 × 70-91 µm, body 50-57 × 45-52 µm, process length 15-26 µm (Srivastava, 1991).

Previous records—Aptian-Lower Eocene. Middle Aptian-Lower Albian, Australia (Burger, 1980); Senonian-Eocene, Europe (Corradini, 1973; de Coninck, 1975a; Bujak *et al.*, 1980); Maastrichtian, Arctic Canada (Wilson, 1978); Campanian, western interior of Canada, and Texas, U.S.A. (Harker *et al.*, 1990); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

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

Pl. 39, fig. 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.

Size measurements—Body diameter 31-61 µm, process length 12-19 µm (Davey & Williams in Davey *et al.*, 1966); body dimensions 27-68 × 25-65 µm, processes up to 10 µm long (Srivastava, 1984); overall dimensions 47-68 × 45-55 µm, process length up to 10 µm (Srivastava, 1991).

Previous records—Hauterivian-Eocene. Campanian, Saskatchewan and Manitoba, Canada, and Texas, U.S.A. (Harker *et al.*, 1990).

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

Pl. 39, fig. 6

1838 *Xanthidium ramosum* Ehrenberg, pl. 1, figs 1-2, 5.

PLATE 38 →

1-2. *Silicisphaera ferox* (Deflandre) Davey & Verdier 1976; 1. × 40, CRC 32134-1, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian; 2. × 40, CRC 32135-1 D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

3. *Spinidinium densispinatum* Stanley 1965; × 40, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.

4-5. *Spinidinium echinoideum* (Cookson & Eisenack) Lentin & Williams 1976; 4. × 100, CRC 32134-4, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian; 5, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

6-9. *Spinidinium lanternum* Cookson & Eisenack 1970; 6, 7, × 100, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian, 8, 9, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

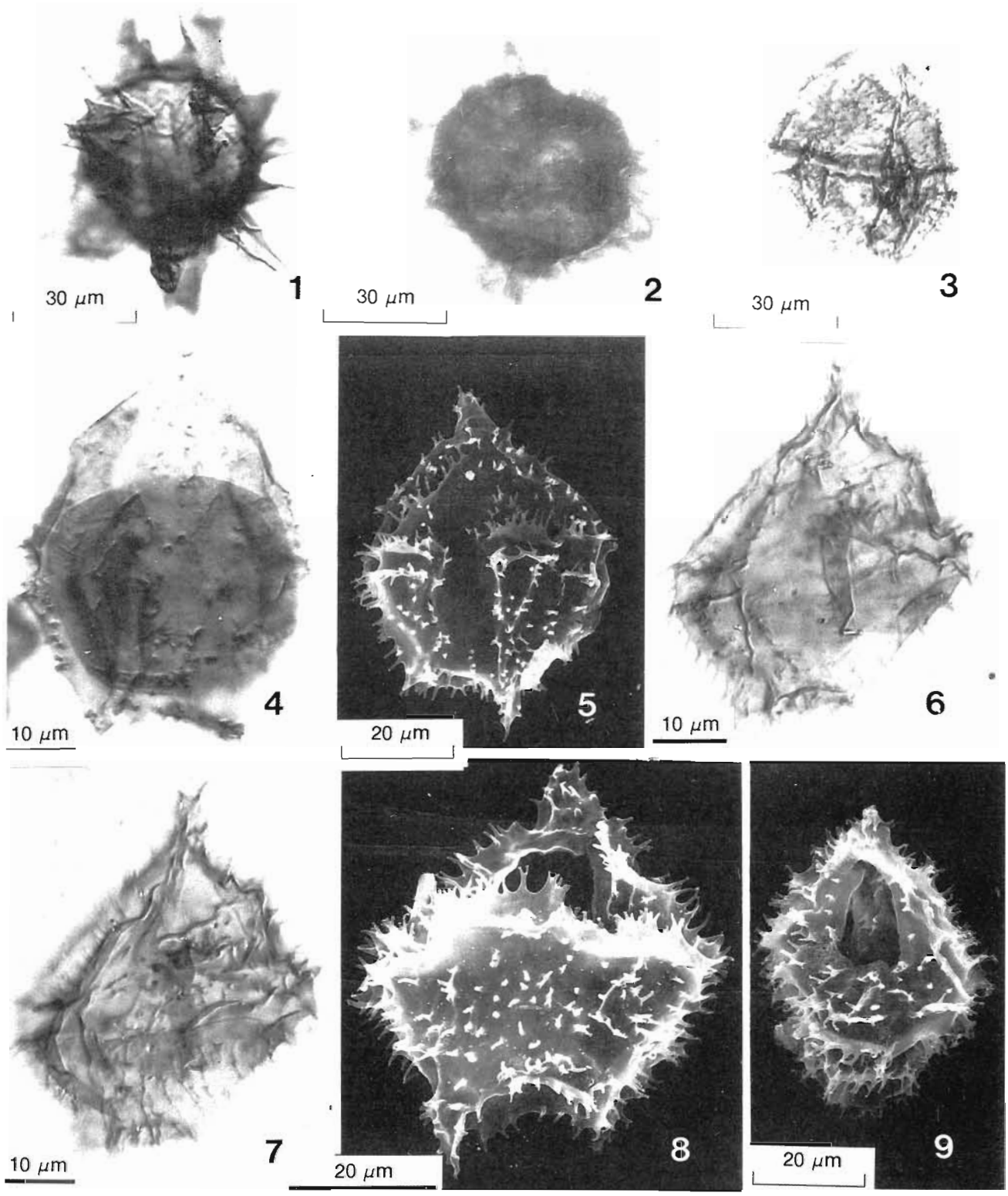

PLATE 38

1854 *Spiniferites ramosus* (Ehrenberg) Mantell, p. 239.
1966 *Hystrichosphaera 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.

Size measurements—Body diameter 30-56 µm, process length 5-27 µm (Davey & Williams in Davey *et al.*, 1966); overall dimensions 56-84 × 55-77 µm, main body 39-55 × 33-50 µm (Duxbury, 1977); overall 50-67 × 46-55 µm, body 30-50 × 30-50 µm (Srivastava , 1984); overall 52-60 × 55-57 µm, body 40 × 35-47 µm, process length 6-14 µm (Srivastava, 1991).

Previous records—Valanginian-Hauterivian, offshore Denmark (Davey, 1982b); Valanginian, northwestern Germany (Below, 1981b); Barremian stratotype, France (de Renéville & Raynaud, 1981; Srivastava, 1984; Albian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991); Campanian, western interior of North America (Harker *et al.*, 1990; see also Duxbury, 1977).

Spiniferites supparus (Drugg) Sarjeant 1970

Pl. 39, fig. 7

1967 *Hystrichosphaera suppara* Drugg, p. 24, pl. 4, figs 5-6.

1970 *Spiniferites supparus* (Drugg) Sarjeant, p. 77.

Size measurements—Body 42-67 µm, process length about 17 µm (Drugg, 1967); overall 42-52 µm, process length 10-12 µm (Ashraf, 1979); body 38 × 37 µm, process length 5-6 µm (May, 1980); overall 70 × 65 µm, body 43 × 34 µm, process length about 18 µm in one specimen of this study.

Previous records—Lower-Cretaceous-Danian. Lower Cretaceous, Afghanistan (Ashraf, 1979); Maastrichtian-Danian, California (Drugg, 1967); and Campanian-Maastrichtian, New Jersey, U.S.A. (May, 1980).

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

1936 *Spongodinium* Deflandre, p. 169.

1978 *Spongodinium* Deflandre, emend. Stover & Evitt, p. 191.

Type species—*Spongodinium delitiense* (Ehrenberg) Deflandre 1936 = *Peridinium delitiense* Ehrenberg 1838 (original designation).

Remarks—*Spongodinium* consists of proximate, subspherical to subpolyhedral cysts with a prominent apical horn and vesicular autophragm. Vesicle distribution indicates paracingulum and other traces of paratabulation. It has precingular archeopyle with a free operculum. The vesicular autophragm distinguishes *Spongodinium* from other genera.

Spongodinium delitiense (Ehrenberg) Deflandre 1936b

Pl. 39, figs 8-9

1938 *Peridinium delitiense* Ehrenberg, p. 110, pl. 1, fig. 1-6.

1936b *Spongodinium delitiense* (Ehrenberg) Deflandre, p. 170, pl. 4, figs 1-3.

Size measurements—Diameter 75-130 µm (Deflandre, 1936b); 90-144 µm (Wetzel, 1952); 75-106 × 64-112 µm (Morgenroth, 1968); 114-159 × 103-140 µm (May, 1980); 70-120 × 70-110 µm (Corradini, 1973); 125-130 × 101-111 µm (Benson, 1976); 85-128 × 85-112 µm (Foucher & Robaszynski, 1977); 78-83 × 68-83 µm in specimens of this study.

Previous records—Senonian-Danian (Deflandre, 1936b; Wetzel, 1952; Morgenroth, 1968; Wilson, 1971; Corradini, 1973; Kjellström, 1973; McIntyre, 1974; Millioud *et al.*, 1975; Doerenkamp *et al.*, 1976; Benson, 1976; Foucher & Robaszynski, 1977; May, 1980); Campanian, Saskatchewan and Manitoba, Canada and Wyoming, U.S.A. (Harker *et al.*, 1990).

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

PLATE 39 →

1. *Spiniferites compactus* Cookson & Eisenack 1974; CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.
2. *Spiniferites ramosus* subsp. *gracilis* (Davey & Williams) Lentin & Williams 1973; CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.
3-4. *Spiniferites ramosus* subsp. *granomembranaceus* (Davey & Williams) Lentin & Williams 1973; CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.
5. *Spiniferites ramosus* subsp. *multibrevis* (Davey & Williams) Lentin & Williams 1973; CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.
6. *Spiniferites ramosus* (Ehrenberg) Mantell 1854, subsp. *ramosus*; CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.
7. *Spiniferites supparus* (Drugg) Sarjeant 1970; CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.
8-9. *Spongodinium delitiense* (Ehrenberg) Deflandre 1936; × 40, CRC 32134-2, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

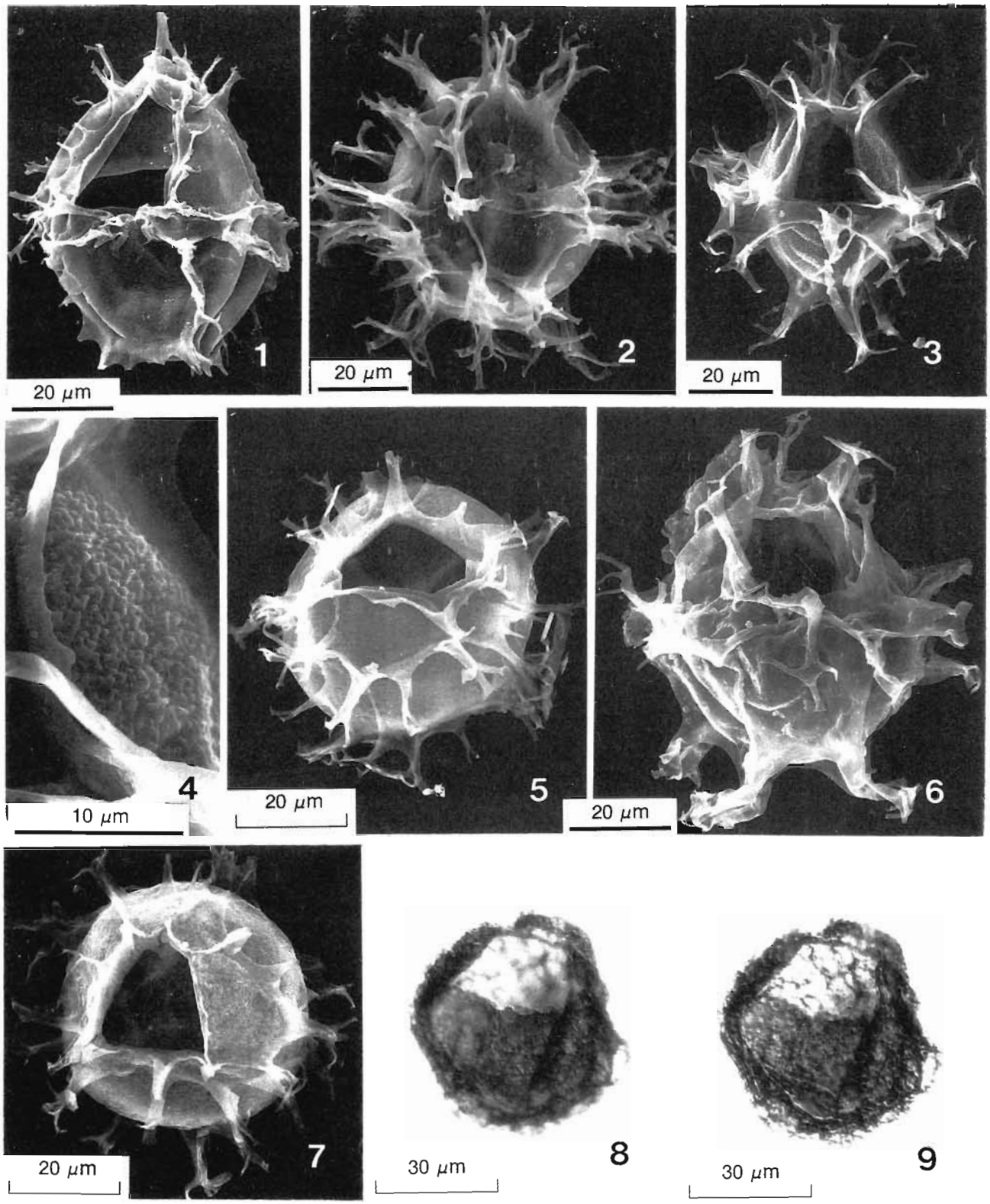

PLATE 39

round peridinioid shape. It lacks any discernible archeopyle, but may have an apical and two antapical horns. Its paratabulation is generally indicated by paracingulum only. *Subtilisphaera* is distinct from

Saeptodinium and *Geiselodinium* in lacking any definite type of archeopyle

Subtilisphaera cheit Below 1981

Pl. 40, figs 1-4

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

Size measurements—Pericyst length × breadth 48-78 × 28-48 µm, endocyst length × breadth 36-50 × 24-48 µm; spinule length 2.5-6 µm (Below, 1981a); pericyst 60-70 × 40-52 µm, endocyst diameter 36-42 µm, spinule length ca 6 µm (Srivastava, 1991); pericyst 50-107 × 40-70 µm, endocyst 31-60 × 32-62 µm, spinule length 6-8 µm in three specimens of this study

Previous records—Aptian-Albian, Morocco (Below, 1981a); Late Aptian-Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Cenomanian, Texas, U.S.A. (Srivastava, 1991).

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 cribrotubiferum* (Sarjeant) Davey, Downie, Sarjeant & Williams in Davey *et al.*, 1966 = *Hystrichosphaeridium cribrotubiferum* Sarjeant, 1960 (original designation).

Remarks—*Surculosphaeridium* consists of skolochorate cysts having a spherical body with an apical archeopyle and several discrete solid and distally branched intratabular processes indicating a gonyaulacacean paratabulation. 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. 40, fig. 5

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

1963 *Baltisphaeridium longifurcatum* (Firtion) Downie & Sarjeant, p. 91 (basionymo 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.

Size measurements—Shell 30-50 µm, process length 14-29 µm (Davey *et al.*, 1966); overall 62-93 × 50-65 µm, shell 30-45 × 24-36 µm and process length 5-20 µm (Srivastava, 1984); overall 65 µm, body 44 µm, process length 13 µm (Srivastava, 1991); overall 101 × 86 µm, body 52 × 44 µm, process length 26 µm in one specimen of this study

Previous records—Hauterivian, offshore eastern Canada (Williams, 1975); Lower Barremian, southeastern France (Srivastava, 1984); Upper Barremian-Upper Aptian, northern Germany (Below, 1982b); Aptian, offshore southeastern Canada (Bujak & Williams, 1978); Albian-Coniacian (Firtion, 1952; Davey *et al.*, 1966; Fauconnier, 1975, 1979; Davey, 1969a; Davey & Verdier, 1971, Foucher, 1972, 1976; Foucher & Taugordeau, 1975; Williams, 1975; Millioud *et al.*, 1975; Jain, 1977; Duxbury, 1983); Santonian, Germany (Yun, 1981); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991); Early Coniacian-Early Campanian, Utah and Wyoming, U.S.A. (Nichols & Jacobson, 1982), Paleocene, Belgium (Schumacker-Lambry, 1978).

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—*Tanyosphaeridium* has 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. 40, fig. 6

PLATE 40 →

1-4. *Subtilisphaera cheit* Below 1981; 1, 2 × 40, CRC 32135-1A, D7 the Taylor Group, upper Taylor Clay Dallas County; Campanian, 3, × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 4, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Santonian.

5. *Surculosphaeridium longifurcatum* (Firtion) Davey *et al.* in Davey *et al* 1966; × 40, CRC 32135-4A, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian.

6. *Tanyosphaeridium regulare* Davey & Williams in Davey *et al.* 1966; 40, CRC 32135-1 D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian

7-8. *Thalassiphora bononiensis* Corradini 1973; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay Falls County; Late

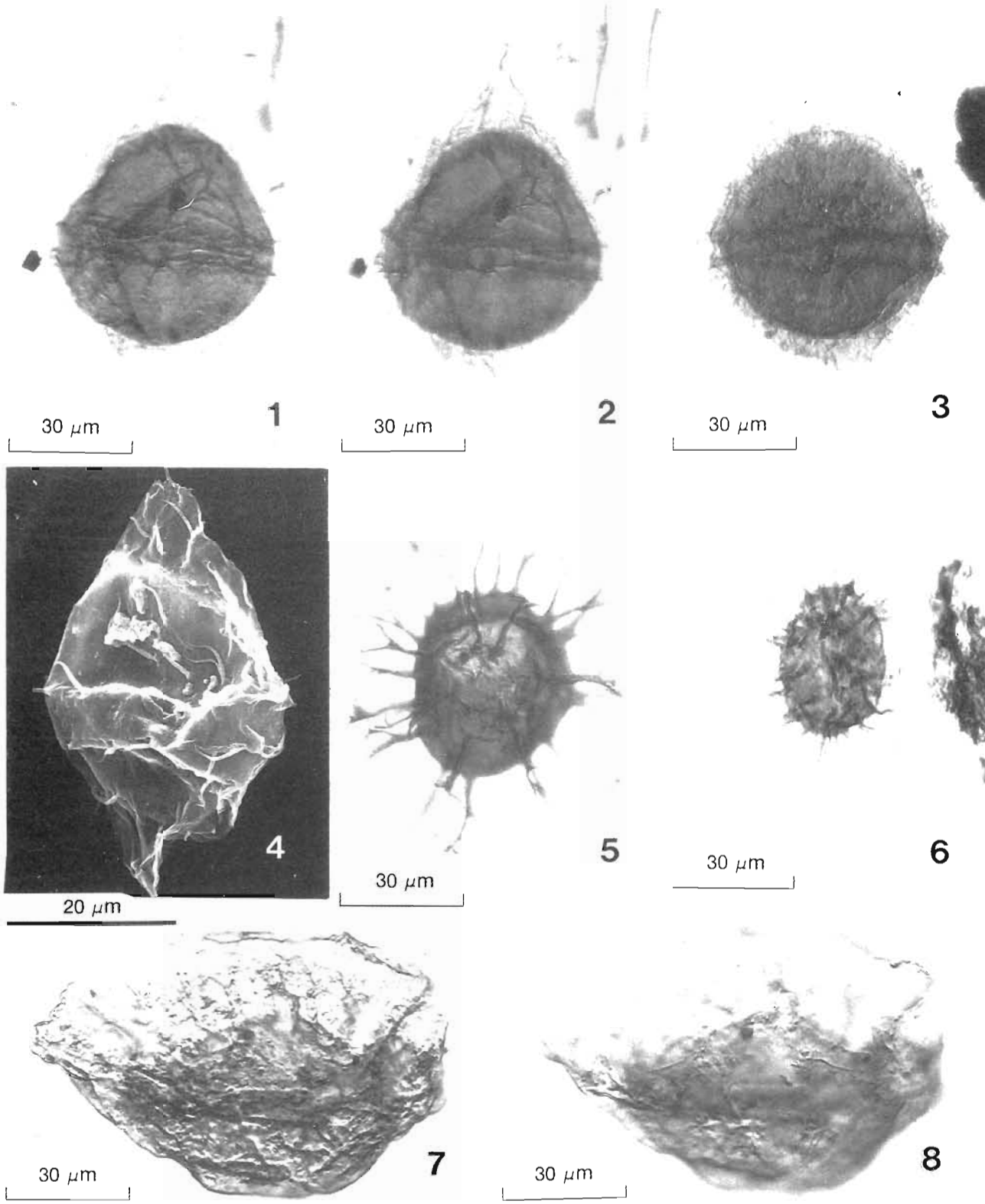

PLATE 40

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

Size measurements—Central body length × breadth 30-44 × 21-24 μm, process length 12-19 μm (Davey &

Williams in Davey *et al.*, 1966); body 34-38 × 22-23 µm, process length 14-15 µm (Srivastava, 1991); body 42-44 × 29-31 µm, process length 13-18 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); Cenomanian-Coniacian, Texas, U.S.A. (Srivastava, 1991).

Genus—*Thalassiphora* Eisenack & Gocht emend. Gocht 1968

1960 *Thalassiphora* Eisenack & Gocht, p. 512.
1966 *Erikania* Morgenroth, p. 27.
1968 *Thalassiphora* Eisenack & Gocht emend Gocht, p. 153.

Type species—*Thalassiphora pelagica* (Eisenack) Eisenack & Gocht 1960 = *Pterospermopsis pelagica* Eisenack 1954 (original designation).

Remarks—*Thalassiphora* consists of proximate cavate cysts having subspherical endocyst, subspherical to lenticular pericyst, and a precingular archeopyle. Its endophragm and periphragm are appressed or close together dorsally and paratabulation is generally indicated by archeopyle only. *Thalassiphora* is distinct from *Stephodinium* in having endophragm and periphragm appressed or close together dorsally and separated elsewhere, and in lacking prominent paracingular band-like protrusion.

Thalassiphora bononiensis Corradini 1973

Pl. 40, figs 7-8; Pl. 41, figs 1-7

1973 *Thalassiphora bononiensis* Corradini, p. 185, pl. 30, figs 5, 6a, 6b, 8a, 8b; pl. 37, figs 5a, 5b; pl. 38, fig. 1; pl. 39, fig. 1.

Size measurements—Overall 70-125 × 80-170 µm, body 46-64 × 55-74 µm (Corradini, 1973); 99-117 × 78-86 µm, body 52-78 × 52-55 µm, flange 26-29 µm wide in specimens of this study.

Previous records—Maastrichtian, Italy (Corradini, 1973).

Genus—*Triblastula* O. Wetzel emend. Eisenack 1969

1933b *Triblastula* O. Wetzel, p. 54.
1969 *Triblastula* O. Wetzel emend. Eisenack, p. 107.

Type species—*Triblastula utinensis* O. Wetzel 1933b (monotypic).

Remarks—*Triblastula* consists of bicavate, longitudinally elongate cysts having subspherical endocyst and pericyst with constrictions near apical and antapical ends. Its wall layers are appressed in paracingular and adjacent areas. It has an apical and short antapical protrusion, and a precingular Type P archeopyle. *Triblastula* is distinct from *Rottnestia* in lacking *Spiniferites*-type furcate processes, and having periphragm constricted near the apical and antapical ends of the endocyst; and from *Amphidiadema* in having processes and a precingular archeopyle.

Triblastula utinensis O. Wetzel 1933

Pl. 42, figs 1-4; Pl. 43, figs 1-3

1932 *Triblastula utinensis* O. Wetzel, p. 136, pl. 2, fig. 11 (nom. nud.).
1933b *Triblastula utinensis* O. Wetzel, p. 54, pl. 6, figs 5, 6.
1961 *Triblastula utinensis* O. Wetzel, p. 339, pl. 2, fig. 1 (neotype designated by Sarjeant, 1985b).

Size measurements—Length × breadth 105-130 × 50-60 µm (O. Wetzel, 1961); central body 68-71 × 45-60 µm, apical pericoel length 40-43 µm, antapical pericoel length 19-32 µm, spine length 9-23 µm (May, 1980); overall length × breadth 65-96 × 45-91 µm, central body 39-44 × 45-91 µm in five specimens of this study.

Previous records—Senonian; most probably Campanian-Maastrichtian, Cretaceous, Baltic area (O. Wetzel, 1933b, 1961); Campanian-Maastrichtian boundary, New Jersey, U.S.A. (May, 1980); Maastrichtian, Denmark (Wilson, 1971) and Sweden (Kjellström, 1973).

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. 43, figs 4-7

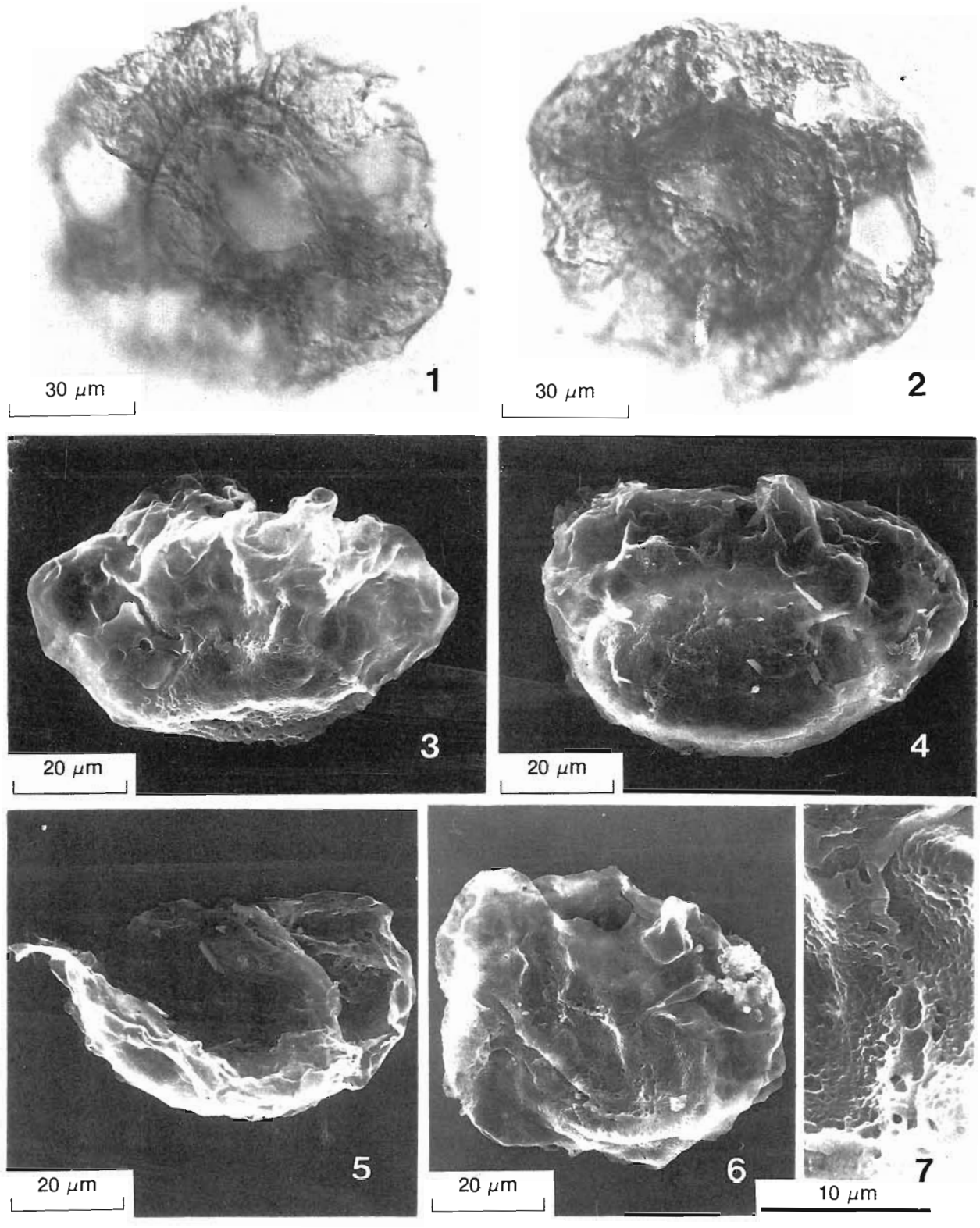

PLATE 41

1-7 *Thalassiphora bononiensis* Corradini 1973. 1, 2 × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian; 3, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian; 4-7, CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian

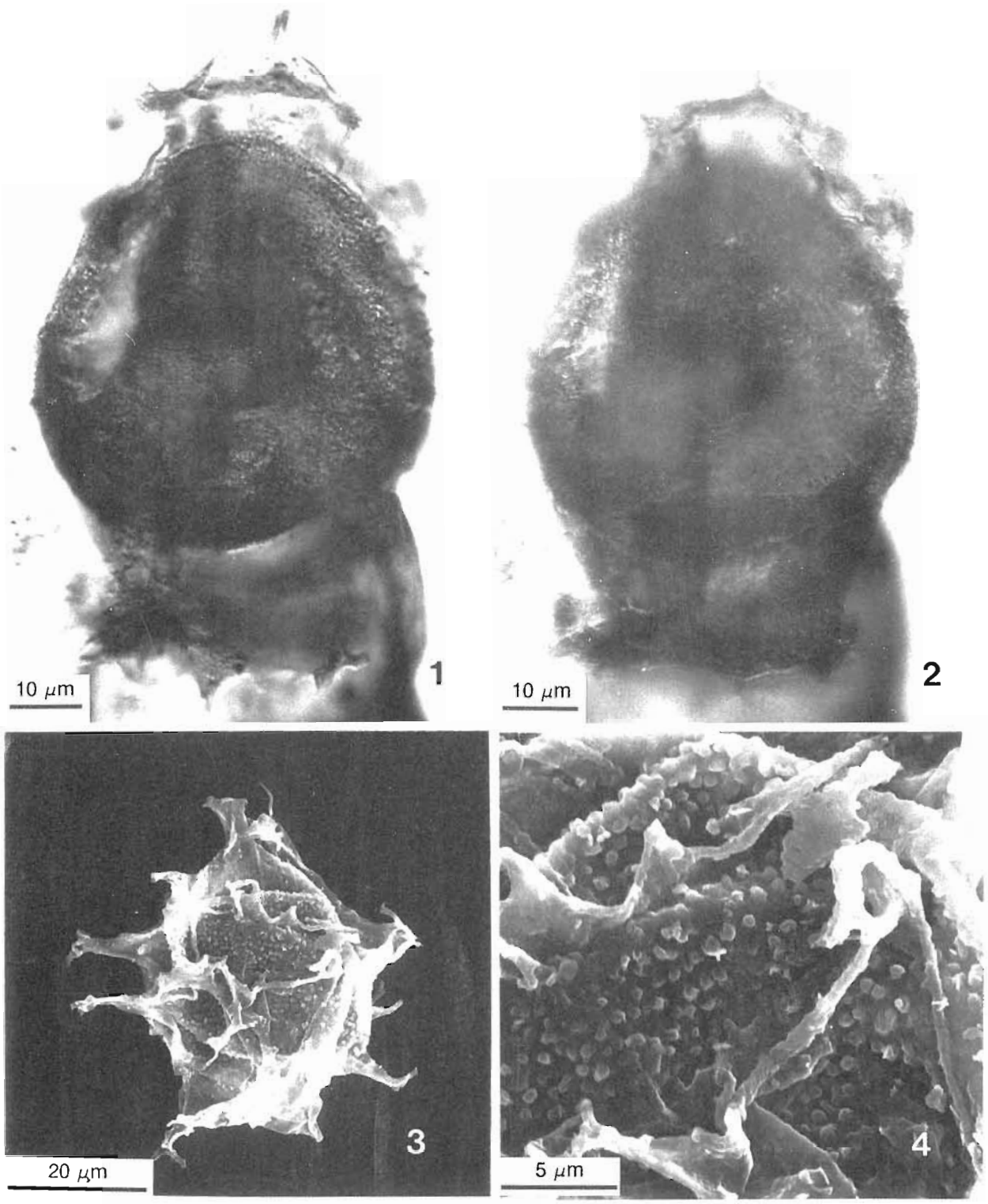

PLATE 42

1-4. *Triblastula utinensis* O. Wetzel 1933: 1, 2. × 100, CRC 32135-1, D7 the Austin Chalk, upper Chalk member, Dallas County; Santonian. 3, 4. CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

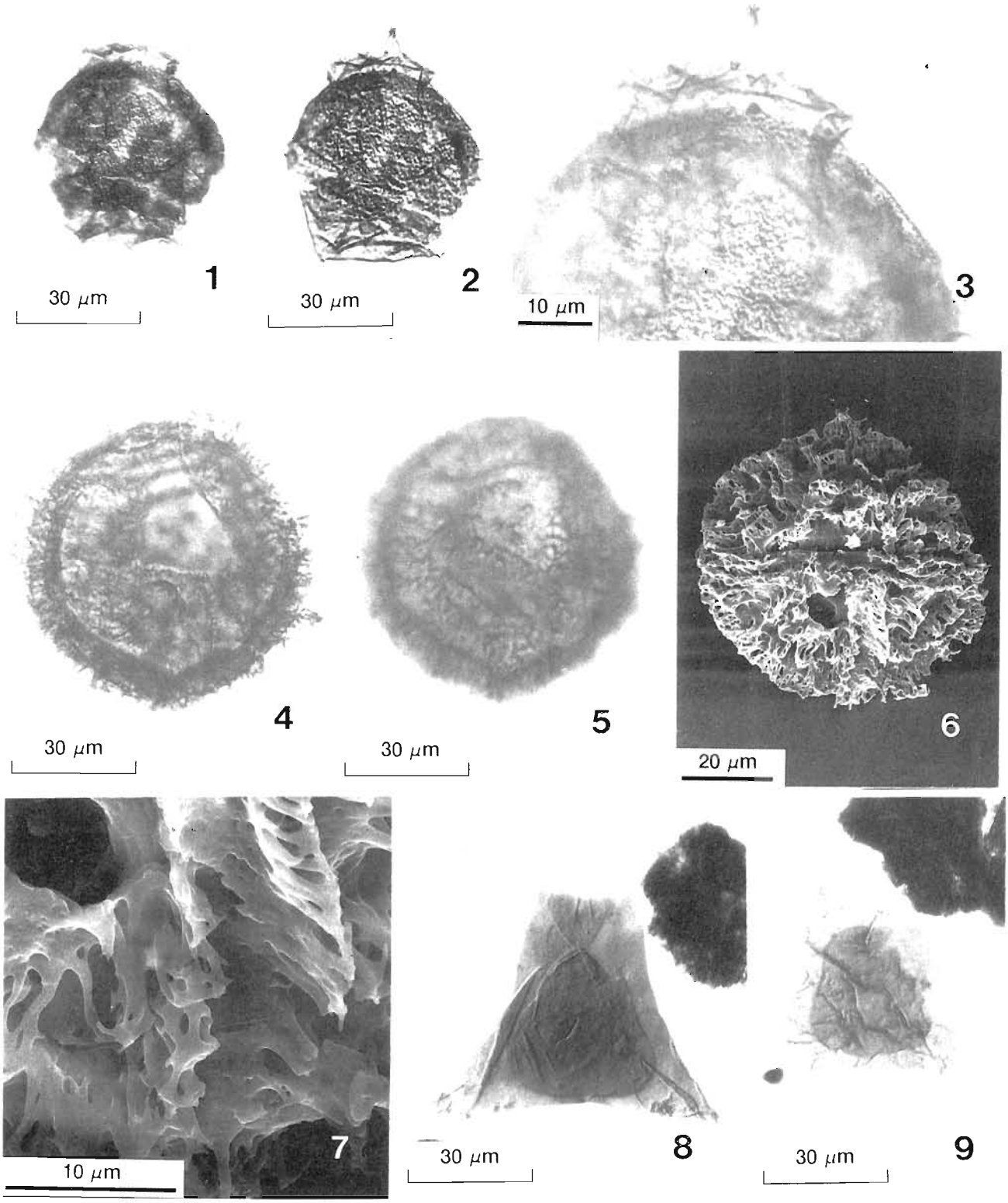

PLATE 43

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

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

Size measurements—Body diameter 35-64 µm, process length 1-5 µm (Davey, 1969a); body dimensions 45-50 × 39-49 µm, process length 1-4 µm (Foucher, 1974); body 70-83 × 62-66 µm (McIntyre & Brideaux, 1980); body 42-65 × 36-60 µm, process length 1.4-3.6 µm (Below, 1981); body diameter 46-63 µm, process length 3-5 µm (Srivastava, 1991); 60-78 µm, process length 7-8 µm in 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, 1969a, 1974; Duxbury, 1980); Albian-Senonian, France (Deflandre, 1935; Mercier, 1938; Davey, 1969a; 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 & Berger, 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 in Loeblich, Jr. & Loeblich, III 1966) p. 11.
1961 *Trigonopyxidia* Cookson & Eisenack, p. 75 (basionymo 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—*Trigonopyxidia* consists of triangular, proximate, circumcavate and compressed cysts with a round endocyst and an archeopyle at the apex of the outer shell wall. *Trigonopyxidia* is distinct from *Palaeotetradinium* in having a concave triangular outline.

Trigonopyxidia ginella (Cookson & Eisenack) Manum & Cookson 1964

Pl. 43, figs 8-9

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 (basionymo non cit.).
1964 *Trigonopyxidia ginella* (Cookson & Eisenack, 1960a) Downie & Sarjeant, p. 149 (basionymo 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.

Size measurements—Shell 50-66 µm, inner body 30-43 µm (Cookson & Eisenack, 1960b); shell 48 × 47 µm, inner body 25 µm (Srivastava, 1991); shell 50-78 µm, inner body 25-40 µm in five specimens of this study.

Previous records—Albian-Maastrichtian. Harker *et al.* (1990) reported its rare occurrence in one sample from the upper Pierre Shale (Campanian) of Wyoming, U.S.A. (see also 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 and two poorly developed antapical horns of nearly equal size. Periphragm is usually fragile and sometimes only the endocyst is found preserved.

← **PLATE 43**

1-3. *Triblastula utinensis* O. Wetzel 1933; 1, 2. × 40, 3. × 100, CRC 32135-1, D7, the Austin Chalk, upper Chalk member, Dallas County; Santonian.
4-7. *Trichodinium castaneum* (Deflandre) Clarke & Verdier 1967; 4, 5- × 40, CRC 32142-3, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 6, 7-CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.
8-9. *Trigonopyxidia ginella* (Cookson & Eisenack) Manum & Cookson 1964; 8. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 9. × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

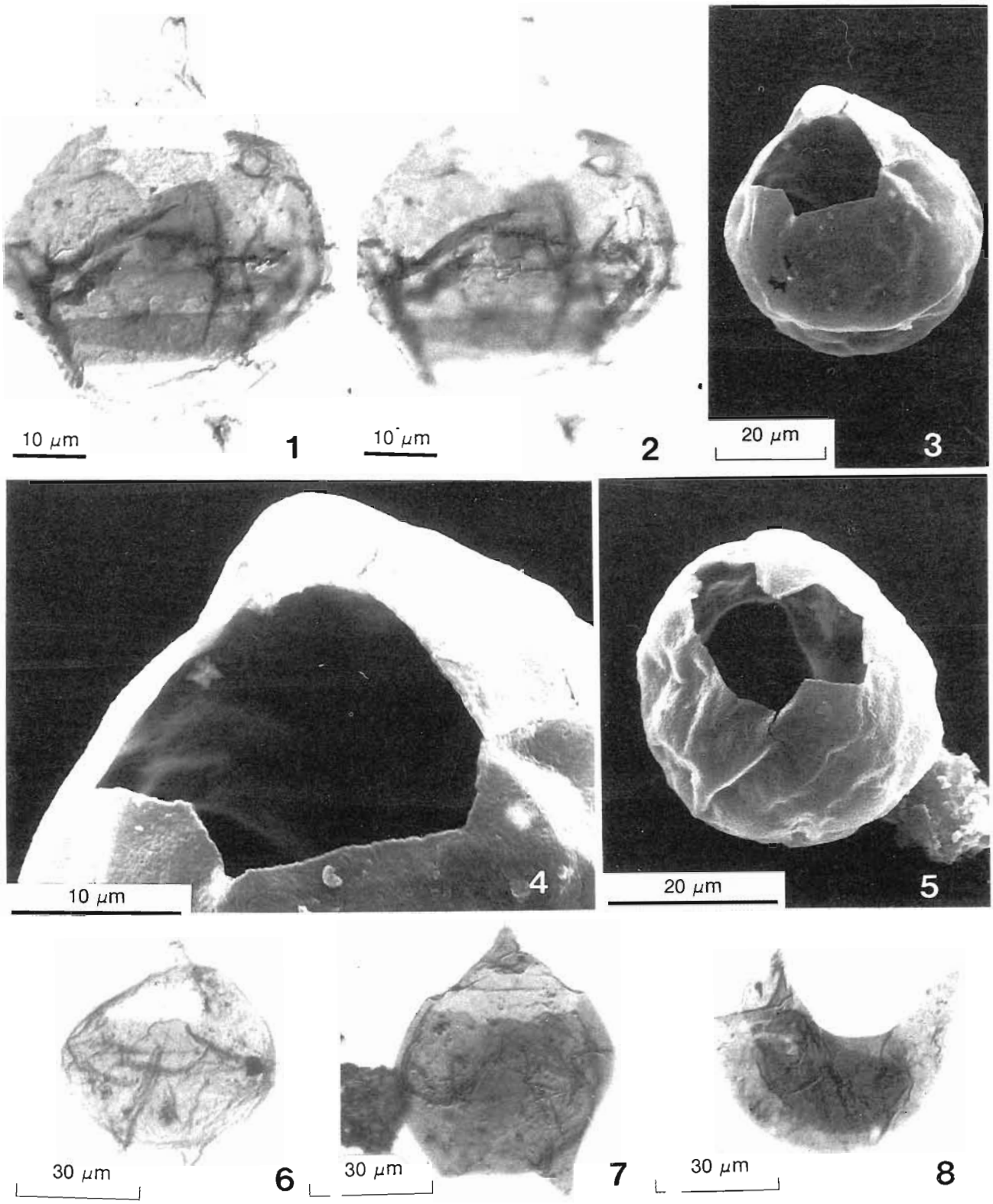

PLATE 44

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.

Trithyrodinium druggii Stone 1973

Pl. 44, figs 1-5

1973 *Trithyrodinium druggii* Stone, p. 54, figs 18-19.

Size measurements—Length × breadth, pericyst 95-130 × 62 µm, endocyst 58-81 × 62 µm (Stone, 1973); pericyst 62 × 50 µm, endocyst 33-55 × 45-65 µm in five specimens of this study

Remarks—*Trithyrodinium druggii* appears to have larger apical and antapical pericoels than those of *T evittii*. The specimens recorded in this study are smaller than reported from the Campanian of Wyoming (Stone, 1973).

Previous records—Late Campanian, Wyoming, U.S.A. (Stone, 1973).

Trithyrodinium evittii Drugg 1967

Pl. 44, figs 6-7

1967 *Trithyrodinium evittii* Drugg, p. 20, pl. 3, figs 2, 3; pl. 9, fig. 2.

Size measurements—Length × breadth, pericyst 75-95 × 60-80 µm (Drugg, 1967); 60-89 × 50-71 µm (May, 1980); 68-117 × 60-65 µm in six specimens of this study.

Previous records—Maastrichtian, New Jersey, U.S.A. (May, 1980); Danian, California, U.S.A. (Drugg, 1967); Paleocene, Romania (Antonescu & Alexandrescu, 1982).

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

1960a *Diplotesta* Cookson & Eisenack, p. 256 (non *Diplotesta* Brongniart, 1874).

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

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

Remarks—*Wallodinium* has ellipsoidal, elongate, cavate cysts with an apical archeopyle and a considerably small endocyst. *Wallodinium* is distinct from *Svalbardella* in having an apical archeopyle and in lacking paratabulation.

Wallodinium lunum (Cookson & Eisenack) Lentin & Williams 1973

Pl. 44, fig. 8

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

Size measurements—Previously recorded range of length × breadth, pericyst 52-135 × 29-50 µm (see Srivastava, 1984); overall 70-34 µm in one specimen of this study

Previous records—*Wallodinium lunum* has been reported throughout in the Cretaceous but Hauterivian-Cenomanian may be its reliable range. Specimens found in the Late Maastrichtian of Texas may be reworked examples from older strata.

Genus—*Xenascus* Cookson & Eisenack 1969

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

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

Remarks—*Xenascus* is a ceratioid proximate to proximochorate, cornucavate cyst with an apical archeopyle and a subspherical to ellipsoidal endocyst. Its periphragm has one apical, one antapical and rarely one lateral horn or, more commonly, 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* is distinct from *Phoberocysta* in having wider-based horns and differently shaped lateral horns.

Xenascus ceratioides (Deflandre) Lentin & Williams 1973

Pl. 45, figs 1-5

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

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

1971 *Phoberocysta ceratioides* (Deflandre) Millioud in Davey & Verdier, p. 26, pl. 5, fig. 12.

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

Size measurements—Overall dimension 172 × 40 µm

←

PLATE 44

1-5. *Trithyrodinium druggii* Stone 1973; 1, 2, × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 3, 4, 5, × 40, CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

6-7 *Trithyrodinium evittii* Drugg 1977; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

8. *Wallodinium lunum* (Cookson & Eisenack) Lentin & Williams, 1973; × 40, CRC 32140-4, DW12, the Navarro Group, the Corsicana Clay, Navarro County; Maastrichtian.

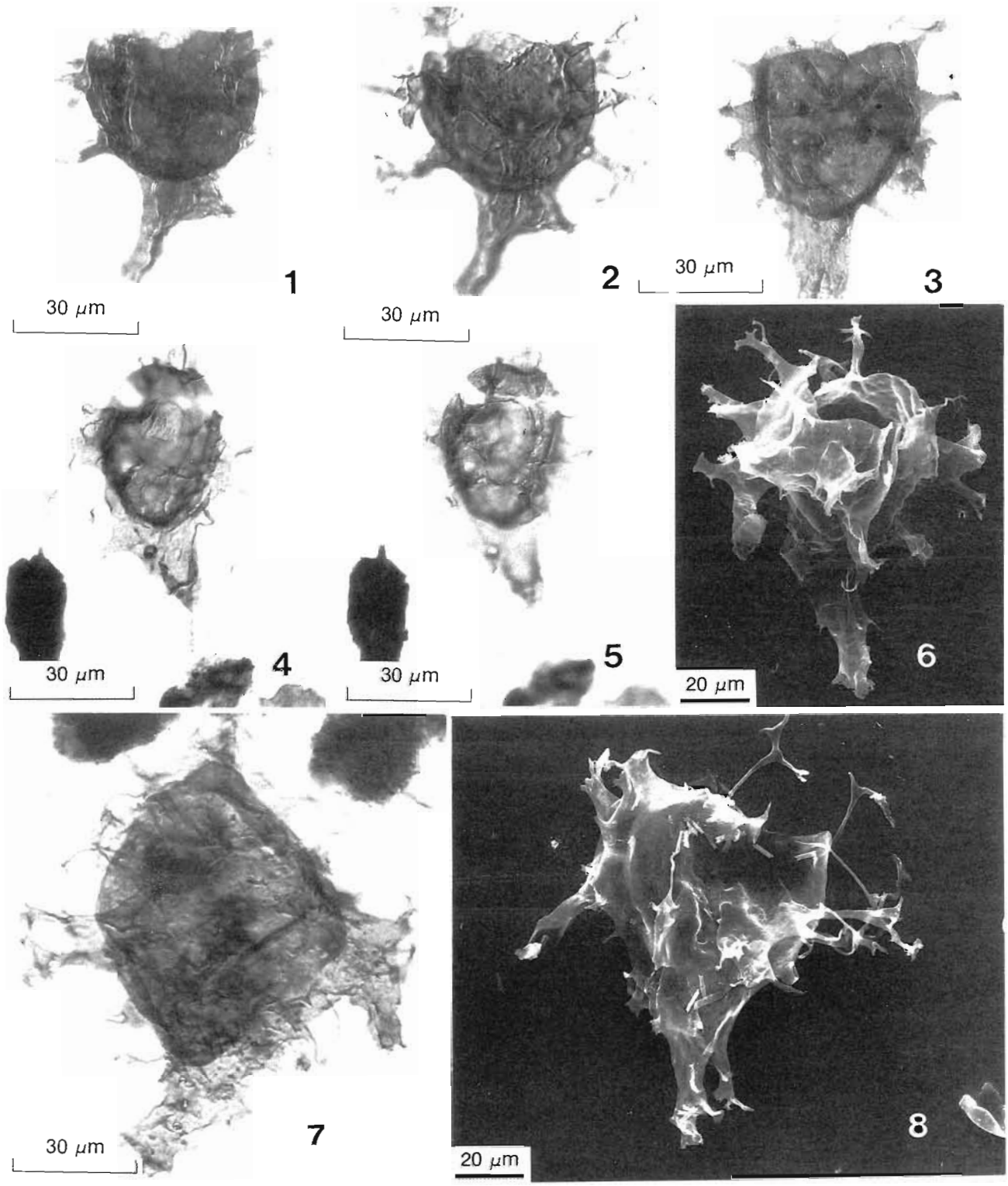

PLATE 45

1-5. *Xenascus ceratioides* (Deflandre) Lentin & Williams 1973: 1, 2, ×40, CRC 32134-3, D6, the Austin Chalk member, Dallas County; Santonian; 3, 4, 5, CRC 32142-4, DW14, ×40, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

6-8. *Xenascus gochtii* (Corradini) Stover & Evitt 1978: 6, CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian; 7, ×40, CRC 32142-1, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 8, CRC 32173-1, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

(Deflandre, 1937); central body 64-70 × 72-80 µm, length of apical horn 80-120 µm, antapical horn 84-120 µm, lateral horns 60-86 µm, process length × breadth 33-36 × ca 12 µm; archeopyle diameter 48-60 µm (Yun , 1981); overall 50-78 × 52-70 µm (Srivastava, 1991); 104-182 × 78-109 µm in four complete specimens of this study.

Previous records—Late Albian-Maastrichtian, Late Albian-Senonian, France (Deflandre, 1937; Davey & Verdier, 1973; Fauconnier, 1979); Late Cenomanian, Portugal (Berthou *et al.*, 1980); Early Cenomanian, Mazagan Plateau, offshore northwestern Africa (Below, 1984); Santonian, Germany (Yun, 1981); Turonian-Maastrichtian, Argentina (Gamerro & Archangelsky, 1981); Santonian-Early Maastrichtian offshore southwestern Africa (Davey, 1978); Cenomanian, Bathurst Island, Northern Territory, Australia (Norvick & Burger, 1976); Cenomanian, southeastern Gulf of Mexico (Riley & Fenton, 1984); Santonian-Campanian, Grand Banks, Canada (Millioud *et al.*,1975; Williams, 1975); Campanian, U.S.A (Millioud *et al.*, 1975; May, 1980); Maastrichtian, Baja California, Mexico (Helenes, 1984). *Xenascus ceratioides* has generally been reported it from Late Albian-Maastrichtian strata, but Davey and Verdier (1971) recorded it from the lower and middle Albian also, which may be due to their treatment of synonymy being much wider and general. Verdier's (1975) range of *X. ceratioides* may be based on the above data.

Xenascus gochtii (Corradini) Stover & Evitt 1978

Pl. 45, figs 6-8

1973 *Phoberocysta gochtii* Corradini, p. 179, pl. 29, figs 1a, 1b, 3; text-fig. 9.

1978 *Xenascus* (Corradini) Stover & Evitt, p. 88.

Size measurements—Length × width 70-110 × 80-110 µm (Corradini, 1973); 143 × 109 µm in one specimen of this study.

Previous records—Senonian, Italy (Corradini, 1973).

Acritarchs

Genus—*Baltisphaeridium* Eisenack 1958

1958 *Baltisphaeridium* Eisenack, p. 398.

1969b *Baltisphaeridium* Eisenack emend. Eisenack, p. 249.

Type species—*Baltisphaeridium longispinosum* (Eisenack) Eisenack 1958 = *Hystrichosphaeridium longispinosum* Eisenack 1931 (original designation).

Baltisphaeridium crameri C. Singh 1971

Pl. 46, figs 1-3

1971 *Baltisphaeridium crameri* C. Singh, p. 393, pl. 73, figs 1-3.

Size measurements—Total diameter 54-78 µm, body 19-26 µm, process length 22-29 µm (Singh, 1971); 78-91 µm, body 21-26 µm, process length 31-36 µm in five specimens.

Previous records—Aptian-Cenomanian, Australia (Cookson & Eisenack, 1982); Middle Albian, Alberta, Canada (Singh, 1971).

Baltisphaeridium infulatum Wall 1965

Pl. 46, figs 4-9

1965 *Baltisphaeridium infulatum* Wall, p. 155, pl. 1, figs 5-7; pl. 7, fig. 3.

Size measurements—Shell dimensions 18-28 µm, spines up to 33 µm (Wall, 1965); diameter 18-33 µm, spines up to 35 µm (Srivastava, 1984); diameter 16-23 µm, spine length 8-13 µm in four specimens of this study.

Previous records—Lower Jurassic, England (Wall, 1965); Barremian, France (Srivastava, 1984).

Genus—*Horologinella* Cookson & Eisenack 1962b

1962 *Horologinella* Cookson & Eisenack, p. 271.

Type species—*Horologinella lineata* Cookson & Eisenack 1962b (original designation).

Remarks—*Horologinella* consists of small, smooth, or sculptured hour glass-shaped biconvex cysts with or without an opening or tabulation.

Horologinella extrema Cookson & Eisenack 1962b

Pl. 46, figs 10-11

1962 *Horologinella extrema* Cookson & Eisenack, p. 272, pl. 37, fig. 10.

PLATE 46 →

1-3. *Baltisphaeridium crameri* C. Singh 1971; 1, 2. × 40, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 3. CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

4-9. *Baltisphaeridium infulatum* Wall 1965; 4, 5, 6. × 100, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; 7, 8, 9. CRC 32173-2, WA19, the Austin Group, Burditt Formation, Travis County; Santonian.

10-11. *Horologinella extrema* Cookson & Eisenack 1962; × 100, CRC 32145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.

12-13. *Micrhystridium exilium* Wall 1965; × 100, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

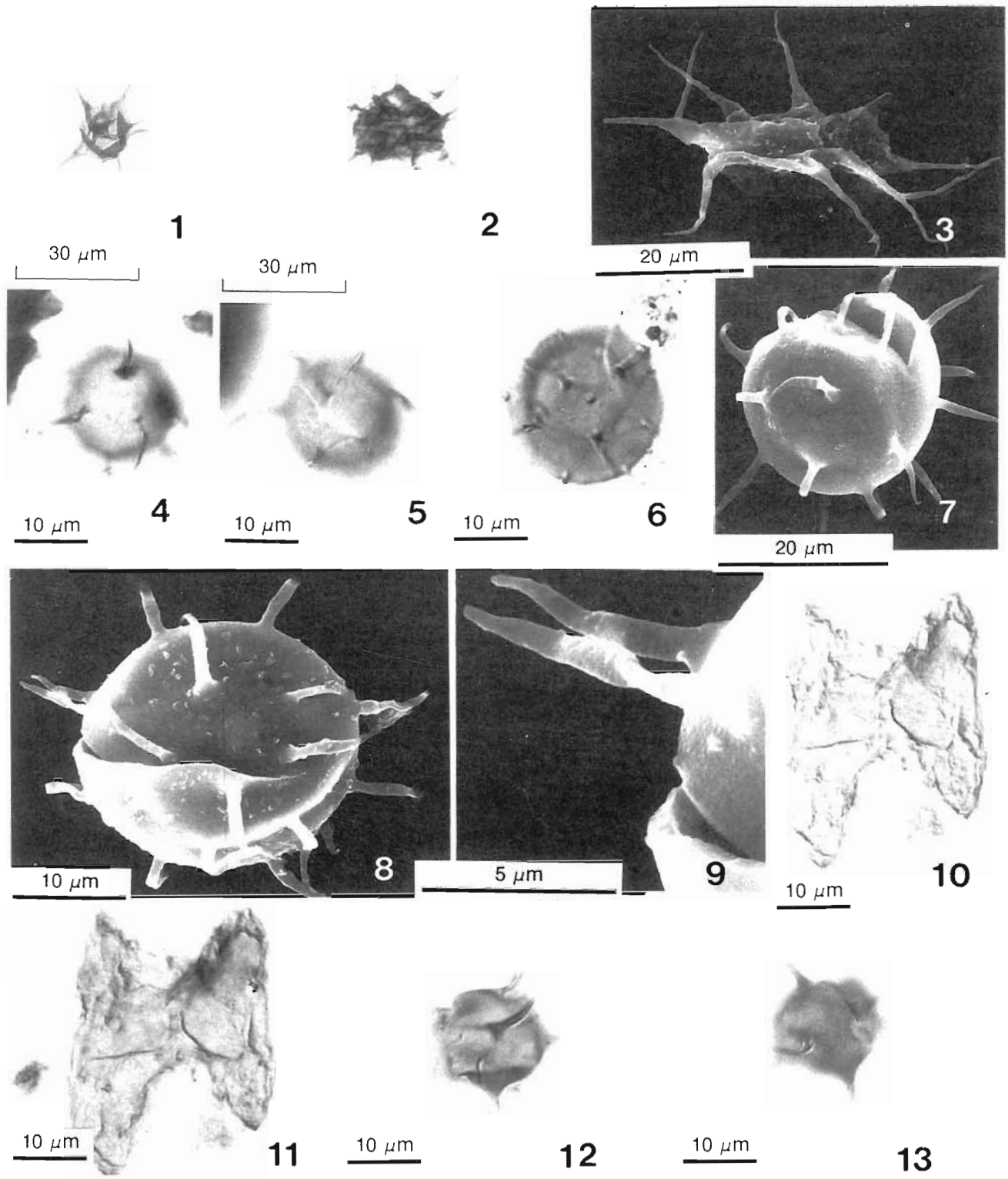

PLATE 46

Size measurements—Dimensions 30 × 52-55 μm (Cookson & Eisenack, 1962b); 40 × 27 μm in a specimen of this study.

Previous records—Cenomanian, Western Australia (Cookson & Eisenack, 1962b).

Genus—*Micrhystridium* Deflandre 1937

1937 *Micrhystridium* Deflandre, p. 79.

Type species—*Micrhystridium inconspicuum* (Deflandre) Deflandre 1937 = *Hystrichosphaera*

inconspicua Deflandre 1935 (original designation).

Micrhystridium exilium Wall 1965

Pl. 46, figs 12-13

1965 *Micrhystridium exilium* Wall, p. 158, pl. 2, figs 18-23; pl. 8, fig. 4.

Size measurements—Shell diameter 13-19 µm, spines 2-40 µm (Wall, 1965); 16 µm, spines 4 µm (Srivastava, 1984); 16-18 µm, spine length 15 µm in five specimens of this study.

Previous records—Lower Jurassic, England (Wall, 1965); Barremian, France (Srivastava, 1984).

Genus—*Palambages* O. Wetzel 1961

1961 *Palambages* O. Wetzel, p. 338.

Type species—*Palambages morulosa* O. Wetzel 1961 (original designation).

Remarks—Wetzel (1961) proposed the genus *Palambages* to include spheroidal bodies composed of 8-18 oval membranous cells. Manum and Cookson (1964) observed that colonies of *Palambages* are spheroidal and consist of a single peripheral layer of cells. They considered that *Palambages* represents green algal colonies that multiply in the powers of 2. Thus, species distinctions should not be based on the number of cells for each colony as it depends on the maturity of the colony. On the basis of a detailed study of the type species *P. morulosa*, Gocht and Wille (1972) revised the generic diagnosis that included the occurrence of a clover-leaf like operculum in the center of the external surface of peripheral cells, and that the colonies consist of a binary number of cells, i.e., 8, 16, 32, 64, etc. Genus *Gambangia*, proposed by Cookson and Eisenack (1979), and *Palambages* may be congeneric.

Palambages morulosa O. Wetzel 1961

Pl. 47, figs 1-6

1961 *Palambages morulosa* O. Wetzel, p. 338.

Size measurements—Colony diameter 80-120 µm, single cell diameter 30-50 µm (O. Wetzel, 1961); 45-87.5 µm, cells 20-30 µm (Górka, 1963); 61-110 µm, cells 21-42 µm (Gocht & Wille, 1972); 75-110 µm, cells 15-40 µm (Corradini, 1973); 48-135 µm, cells 5-28 µm in ten specimens of this study.

Previous records—Albian-Paleocene. Upper Cretaceous-Paleocene, Europe (Wetzel, 1961; Górka, 1963; Davey, 1970; Gocht, 1970; Gocht & Wille, 1972; Corradini, 1973; de Coninck, 1975b); Albian-Paleocene, Canada and U.S.A. (Manum & Cookson, 1964; Drugg, 1967; Davey, 1970; Zaitzeff & Cross, 1971; Harker *et al.*, 1990); uppermost Campanian-Maastrichtian, DSDP Site 275, southeastern Campbell Plateau (Wilson, 1975); Albian-Cretaceous/Tertiary boundary, DSDP Leg 29, off southeastern Australia and western New Zealand (Cookson, 1965a; Haskell & Wilson, 1975); Turonian-Paleocene, Argentina (Heisecke, 1970; Gamerro & Archangelsky, 1981).

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. 47, fig. 7

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

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

Size 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 (Srivastava, 1991); overall 73 × 57 µm, body 26 × 21 µm in one specimen of this study.

Previous records—Kimmeridgian, England (Ioannides *et al.*, 1977); Barremian, France (Srivastava, 1984); Cenomanian-Turonian, Texas, U.S.A. (Srivastava, 1991).

Spores

Genus—*Aequitriradites* Delcourt & Sprumont emend. Cookson & Dettmann 1961

PLATE 47 →

1-6. *Palambages morulosa* O. Wetzel 1961: 1, 2, 3. × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian; 4. × 40, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian; 5. × 100, CRC 32134-3, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian; 6. × 40, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian.

7 *Pterospermella aristotelesii* (Ioannides *et al.*) S.K. Srivastava 1984: × 40, CRC 32135-3, D7, the Taylor Group, upper Taylor Clay, Dallas County; Campanian.

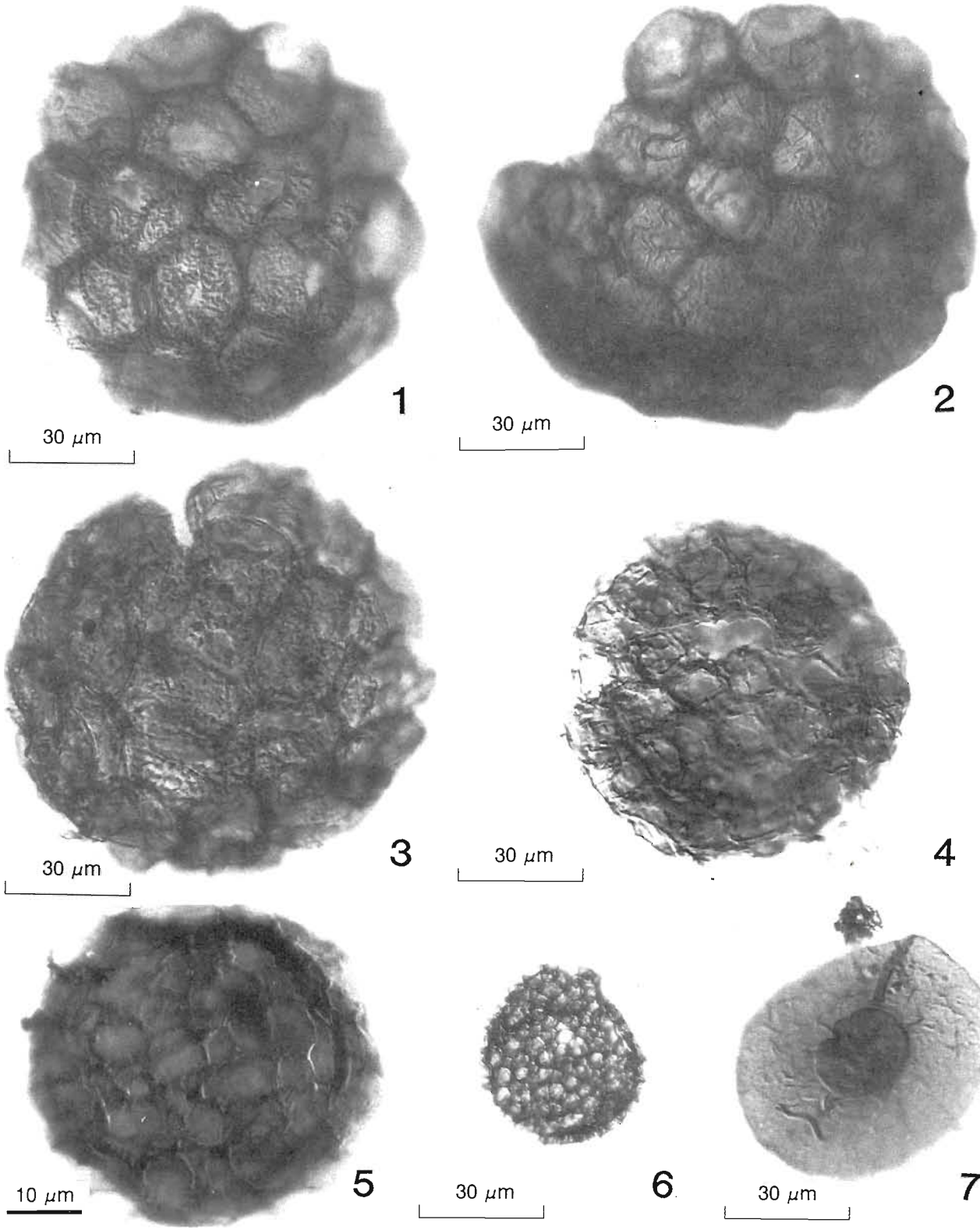

PLATE 47

Aequitriradites spinulosus (Cookson & Dettmann) Cookson & Dettmann 1961

Pl. 48, figs 1-2

Occurrence—The Upper Austin Chalk, the Lower Taylor Clay; Late Campanian.
Remarks—Reworked.

Genus—*Appendicisporites* Weyland & Krieger 1953

Appendicisporites bilateralis C. Singh 1964

Pl. 48, fig. 3

Occurrence—The Pecan Gap Formation; Late Campanian.
Remarks—May be reworked.

Appendicisporites potomacensis Brenner 1963

Pl. 48, fig. 4

Occurrence—The Lower Taylor Clay, McLennan County, Texas; Campanian.
Remarks—May be reworked.

Appendicisporites sp.

Pl. 48, fig. 5.

Genus—*Camarozonosporites* Pant ex R. Potonié emend. Klaus 1960

Camarozonosporites concinnus S.K. Srivastava 1972a

Pl. 48, figs 6-7

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Cicatricosisporites* R. Potonié & Gelletich 1933

Cicatricosisporites sp.

Pl 48, fig. 8

Occurrence—The Corsicana Clay; Late Maastrichtian.

Cicatricosisporites hallei Delcourt & Sprumont 1955

Pl. 48, fig. 9

Occurrence—The Lower Austin Chalk; Early Campanian.

Genus—*Echinatisporis* Krutzsch 1959

Echinatisporis levidensis (Balme) S.K. Srivastava 1972a

Pl. 48, fig. 10

Occurrence—The Upper Taylor Clay; Late Campanian.

Genus—*Gabonisporis* Boltenhagen emend. S.K. Srivastava 1972a

Gabonisporis bacaricumulus S.K. Srivastava 1972a

Pl. 48, fig. 11

Occurrence—The Lower Taylor Clay; Early Campanian.

PLATE 48 →

1-2. *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann 1961, × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.
3. *Appendicisporites bilateralis* C. Singh 1964; × 40, CRC 32142-4, DW14, the Taylor Group, the Pecan Gap Chalk, McLennan County; Campanian; may be reworked.
4. *Appendicisporites potomacensis* Brenner 1963; × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian; may be reworked
5. *Appendicisporites* sp.; × 100, CRC 32137-2, D9, the Taylor Clay, Ellis County; Campanian.
6-7. *Camarozonosporites concinnus* S.K. Srivastava 1972a; × 100, CRC 32143-1, DW15, the Taylor Group , lower Taylor Clay, McLennan County; Campanian.
8. *Cicatricosisporites* sp.; × 40, CRC 32140-1, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.
9. *Cicatricosisporites hallei* Delcourt & Sprumont 1955; × 40, 2145-5, WA17, the Austin Chalk, lower Chalk member, McLennan County; Santonian.
10. *Echinatisporis levidensis* (Balme) S.K. Srivastava 1972a; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.
11. *Gabonisporis bacaricumulus* S.K. Srivastava 1972a; × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.
12. *Ghoshispora scollardiana* S.K. Srivastava 1966; × 40, CRC 32137-2, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.
13. *Hamulatisporis rugulatus* (Couper) S.K. Srivastava 1972a; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

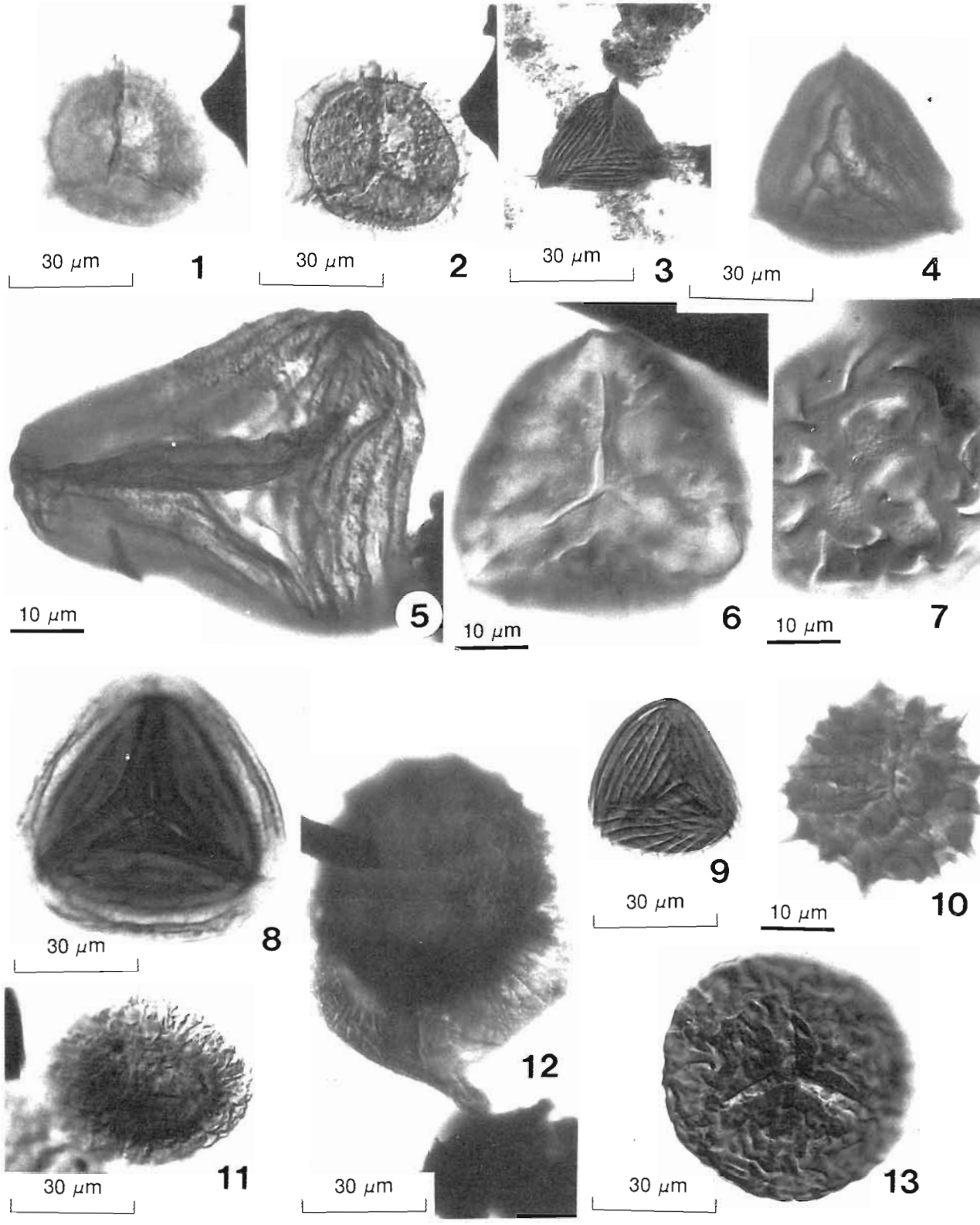
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PLATE 48

Genus—*Ghoshispora* S.K. Srivastava 1966

Ghoshispora scollardiana S.K. Srivastava 1966

Pl. 48, fig. 12

Occurrence—The Upper Taylor Clay, Late Campanian.

Genus—*Hamulatisporis* Krutzsch emend. S.K. Srivastava 1972a

Hamulatisporis rugulatus (Couper) S.K. Srivastava 1972a

Pl. 48, fig. 13

Occurrence—The Kemp Clay; Late Maastrichtian.

Genus—*Kuylisporites* R. Potonié 1956

Kuylisporites scutatus Newman 1965

Pl. 49, figs 1-2

Occurrence—The Upper Austin Chalk; Late Santonian.

Genus—*Pilosisporites* Delcourt & Sprumont 1955

Pilosisporites trichopapillosus (Thiergart) Delcourt & Sprumont 1955

Pl. 49, fig. 3

Occurrence—The Lower Taylor Clay; Early Campanian.
Remarks—May be reworked.

Genus—*Retitriletes* van der Hammen ex Pierce emend. Döring, Krutzsch, Mai & E. Schulz in Krutzsch 1963

Retitriletes saxatilis S.K. Srivastava 1972a

Pl. 49, figs 4-5

Occurrence—The Lower Taylor Clay; Early Campanian.

Trilete spore *Incertae sedis*

Pl. 49, fig. 6

Occurrence—The Upper Taylor Clay; Late Campanian.
Remarks—May be reworked.

Genus—*Uvaesporites* Döring 1965

Uvaesporites sp.

Pl. 49, fig. 7

Occurrence—The Upper Taylor Clay; Late Campanian.
Remarks—May be reworked.

Gymnosperm Pollen

Genus—*Classopollis* Pflug 1953

Classopollis classoides Pflug 1953

Pl. 49, fig. 8

Occurrence—The Lower Taylor Clay; Early Campanian.
Remarks—May be reworked.

Genus—*Eucommiidites* (Erdtman) Couper emend. Hughes 1961

Eucommiidites sp.

Pl. 49, figs 9-10

Occurrence—The Upper Taylor Clay; Late Campanian.
Remarks—May be reworked.

PLATE 49 →

1-2. *Kuylisporites scutatus* Newman 1965; × 100, CRC 32139-3, D11, the Austin Chalk member, Ellis County; Late Santonian.
3. *Pilosisporites trichopapillosus* (Thiergart) Delcourt & Sprumont 1955; × 100, CRC 32143-1, DW15, the Taylor Group, lower Tayor Clay, McLennan County; Campanian.
4-5. *Retitriletes saxatilis* S.K. Srivastava 1972a; × 100, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.
6. Trilete spore (reworked); × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.
7 *Uvaesporites* sp.; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.
8. *Classopollis classoides* Pflug 1953 (reworked); × 100, CRC 32127-4, A25, the Taylor Group, lower Taylor Clay, Travis County; Campanian.
9-10. *Eucommiidites* sp. (reworked); × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.
11. *Rugubivesiculites reductus* Pierce 1961; × 40, CRC 32138-2, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

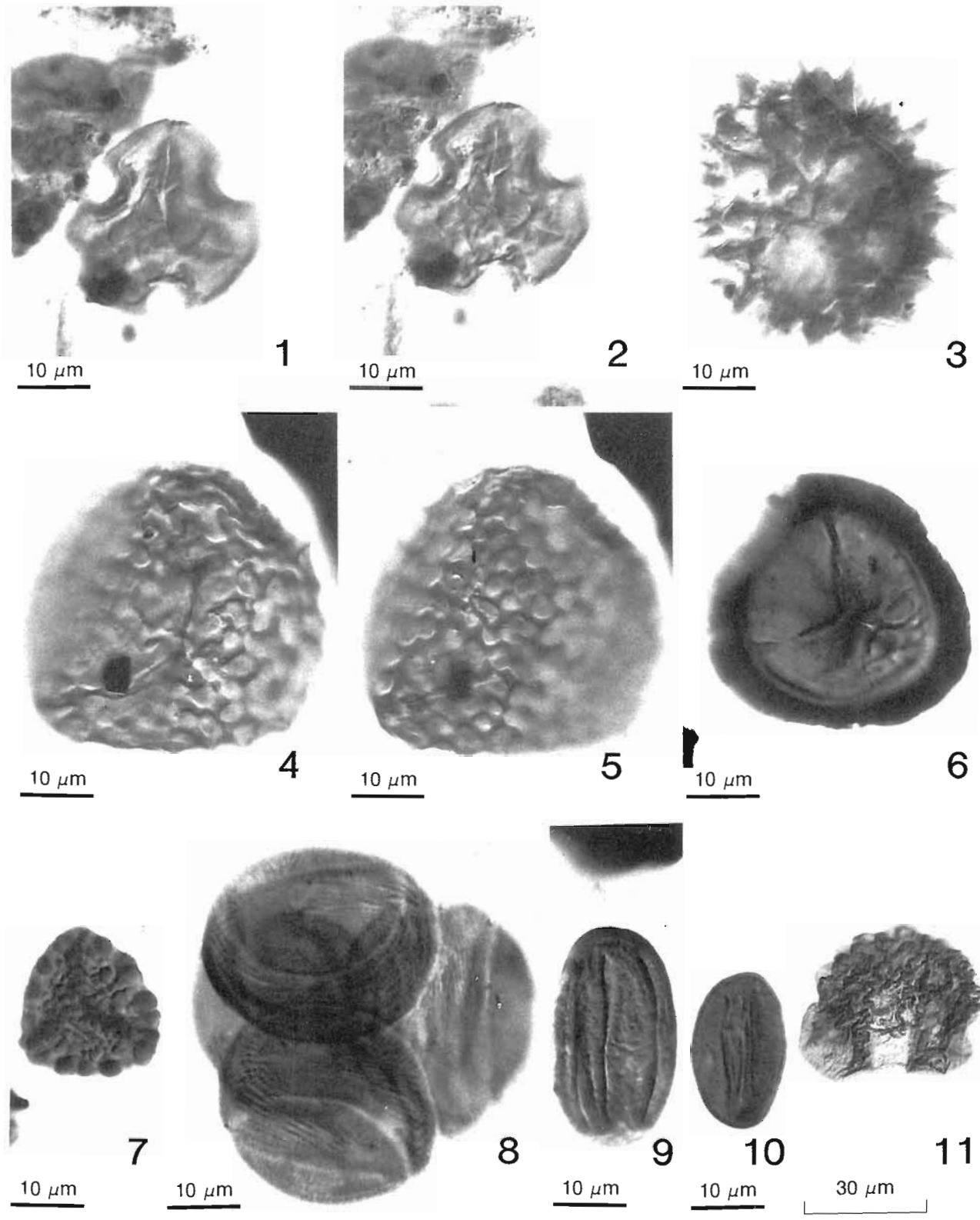
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PLATE 49

Genus—*Rugubivesiculites* Pierce 1961

Rugubivesiculites reductus Pierce 1961

Pl. 49, fig. 11

Occurrence—The Lower Taylor Clay; Early Campanian.

Angiosperm Pollen

Genus—*Albertipollenites* S.K. Srivastava 1969a

Albertipollenites sp.

Pl. 50, fig. 1

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Aquilapollenites* Rouse emend. S.K. Srivastava 1968

Aquilapollenites amplus Stanley 1961a

Pl 50, figs 2-3

Occurrence—The Middle Austin Chalk; Early Santonian.

Aquilapollenites delicatus var *collaris* Tschudy & Leopold 1971

Pl. 50, figs 4-5

Occurrence—The uppermost Kemp Clay; Late Maastrichtian.

Genus—*Bolchovitinaepollenites* Kedves & Diniz 1981

Bolchovitinaepollenites miniverrucatus Kedves & Diniz 1981

Pl. 50, fig. 6

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Complexiopollis* Krutzsch 1959

Complexiopollis exigua Christopher 1979

Pl. 50, fig. 7

Occurrence—The Lower Taylor Clay, Corsicana Clay; Early Campanian, Late Maastrichtian.

Genus—*Extratriporopollenites* Pflug emend. Skarby 1968

Extratriporopollenites fossulotrudens Pflug 1953

Pl. 50, fig. 8

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Extremipollis* Krutzsch in Góczán *et al.* 1967

Extremipollis versatilis R. Tschudy 1975

PLATE 50 →

1 *Albertipollenites* sp.; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

2-3. *Aquilapollenites amplus* Stanley 1961a; × 100, CRC 32134-4, D6, the Austin Chalk, middle Chalk member, Dallas County; Santonian.

4-5. *Aquilapollenites delicatus* var *collaris* Tschudy & Leopold 1971; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

6. *Bolchovitinaepollenites miniverrucatus* Kedves & Diniz 1981; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

7 *Complexiopollis exigua* Christopher 1979; × 100, CRC 32140-2, DW12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

8. *Extratriporopollenites fossulotrudens* Pflug 1953; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

9. *Extremipollis versatilis* R. Tschudy 1975; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

10-11. *Margocolporites cribellatus* S.K. Srivastava 1972b; × 100, CRC 32138-3, D 10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

12. *Margocolporites* sp. 1; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

13. *Margocolporites* sp. 2; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

14. *Minoripollis minimus* Krutzsch 1959; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

15. *Plicapollis incisa* Christopher 1979; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

16. *Plicapollis retusus* R. Tschudy 1975; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

17. *Plicapollis rusticus* R. Tschudy 1975; × 100, CRC 32139-3, D11, the Austin Chalk, upper Chalk member, Ellis County; Late Santonian.

18. *Polyporina cribraria* S.K Srivastava 1969; × 100, CRC 32140-2, DW 12, the Navarro Group, the Corsicana Clay, Navarro County, Maastrichtian.

19-20. *Proteacidites retusus* Anderson 1960; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

21 *Proteacidites thalmannii* Anderson 1960; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

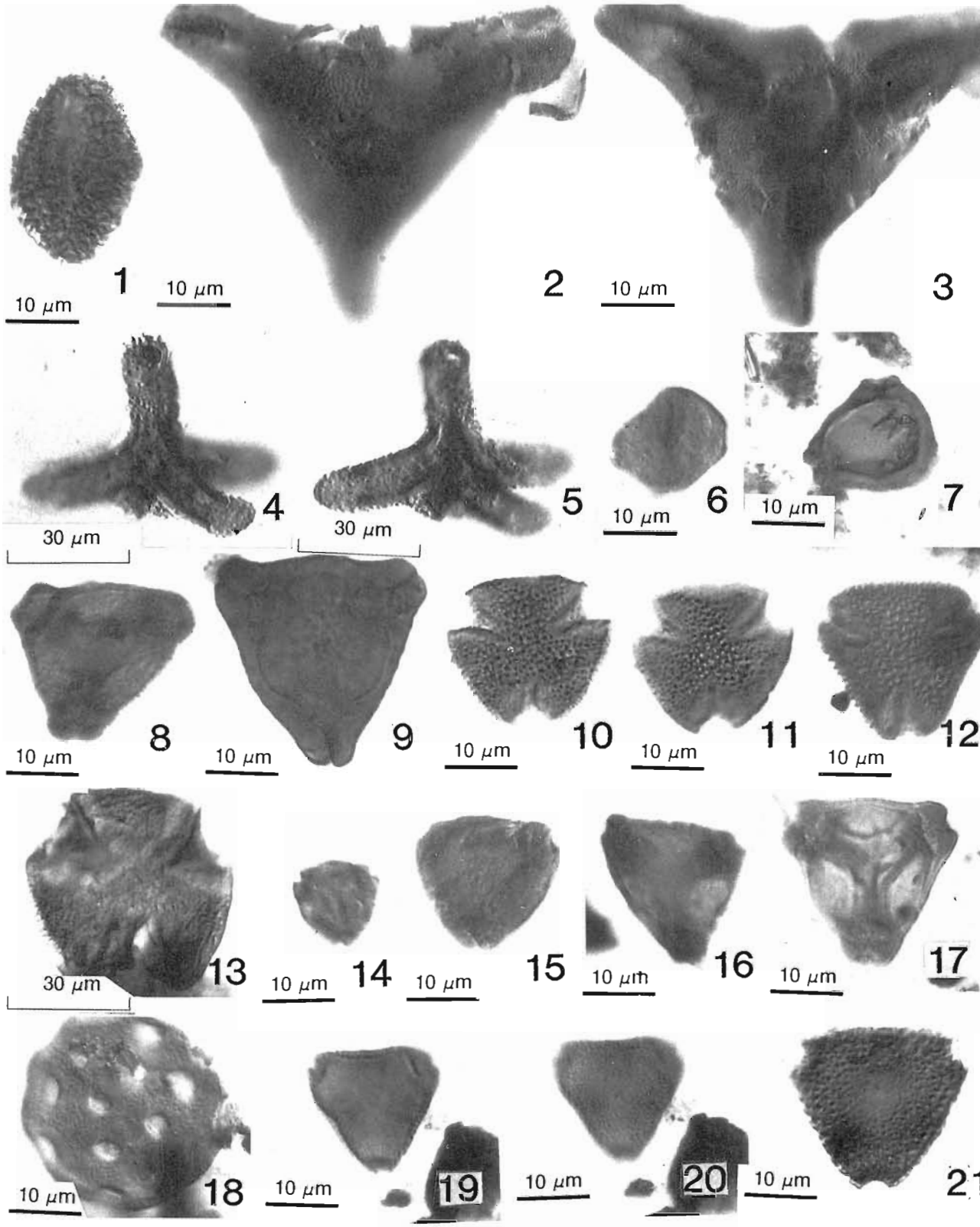
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PLATE 50

Pl. 50, fig. 9

Occurrence—The Upper Taylor Clay; Late Campanian.

Genus—*Margocolporites* Ramanujam ex S.K. Srivastava 1969b

Margocolporites cribellatus S.K. Srivastava 1972b

Pl. 50, figs 10-11

Occurrence—The Taylor Clay; Late Campanian.

Margocolporites Sp. 1

Pl. 50, fig. 12

Occurrence—The Lower Taylor Clay; Early Campanian.

Margocolporites sp. 2

Pl 50, fig. 13

Occurrence—The uppermost Kemp Clay; Late Maastrichtian.

Genus—*Minorpollis* Krutzsch 1959

Minorpollis minimum Krutzsch 1959

Pl. 50, fig. 14

Occurrence—The Upper Taylor Clay; Late Campanian.

Genus—*Plicapollis* Pflug 1953

Plicapollis incisa Christopher 1979

Pl. 50, fig. 15

Occurrence—The Upper Taylor Clay; Late Campanian.

Plicapollis retusus R. Tschudy 1975

Pl. 50, fig. 16

Occurrence—The Lower Taylor Clay; Early Campanian.

Plicapollis rusticus R. Tschudy 1975

Pl. 50, fig. 17

Occurrence—The Upper Austin Chalk, Taylor Clay; Late Santonian-Campanian.

Genus—*Polyporina* Naumova ex Potonié 1960

Polyporina cribraria S.K. Srivastava 1969b

Pl. 50, fig. 18

Occurrence—The Corsicana Clay; Late Maastrichtian.

Genus—*Proteacidites* Cookson ex Couper 1953

Proteacidites retusus Anderson 1960

Pl. 50, figs 19-20

Occurrence—The Lower Taylor Clay; Early Campanian.

Proteacidites thalmannii Anderson 1960

Pl. 50, fig. 21; Pl. 51 figs 1-3

Occurrence—The Upper Austin Chalk, The Taylor Clay; Late Santonian, Campanian.

PLATE 51 →

1-3. *Proteacidites thalmannii* Anderson 1960; 1. × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian; 2, 3. × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

4. *Rhoipites cryptoporus* S. K. Srivastava 1972b; × 100, CRC 32139-3, D11, the Austin Chalk, upper Chalk member, Ellis County; Late Santonian.

5. *Santalacites minor* Christopher 1979; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

6. *Striatopollis* sp.; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

7 *Tricolpites hians* Stanley, 1965; × 100, CRC 32137-4, D9, the Taylor Group, upper Taylor Clay, Ellis County; Campanian.

8-9. *Tricolpites micromunus* (Groot & Penny) C. Singh 1971; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

10-11. *Tricolpites mutabilis* Leffingwell 1971; × 100, CRC 32138-1, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

12-13. *Tricolpopollenites compactus* Norton in Norton & Hall, 1969; × 100, CRC 32139-3, D11, the Austin Chalk, upper Chalk member, Ellis County; Late Santonian.

14-16. *Tricolporopollenites affluens* (Stanley) Stone 1973; × 100, CRC 32138-3, D10, the Taylor Group, lower Taylor Clay, Ellis County; Campanian.

17-18. *Wodehouseia spinata* Stanley 1961b; × 40, CRC 32146-1, WA18, the Navarro Group, Kemp Clay, Falls County; Late Maastrichtian.

19-20. Pollen tetrad *incertae sedis*; × 40, CRC 32143-1, DW15, the Taylor Group, lower Taylor Clay, McLennan County; Campanian.

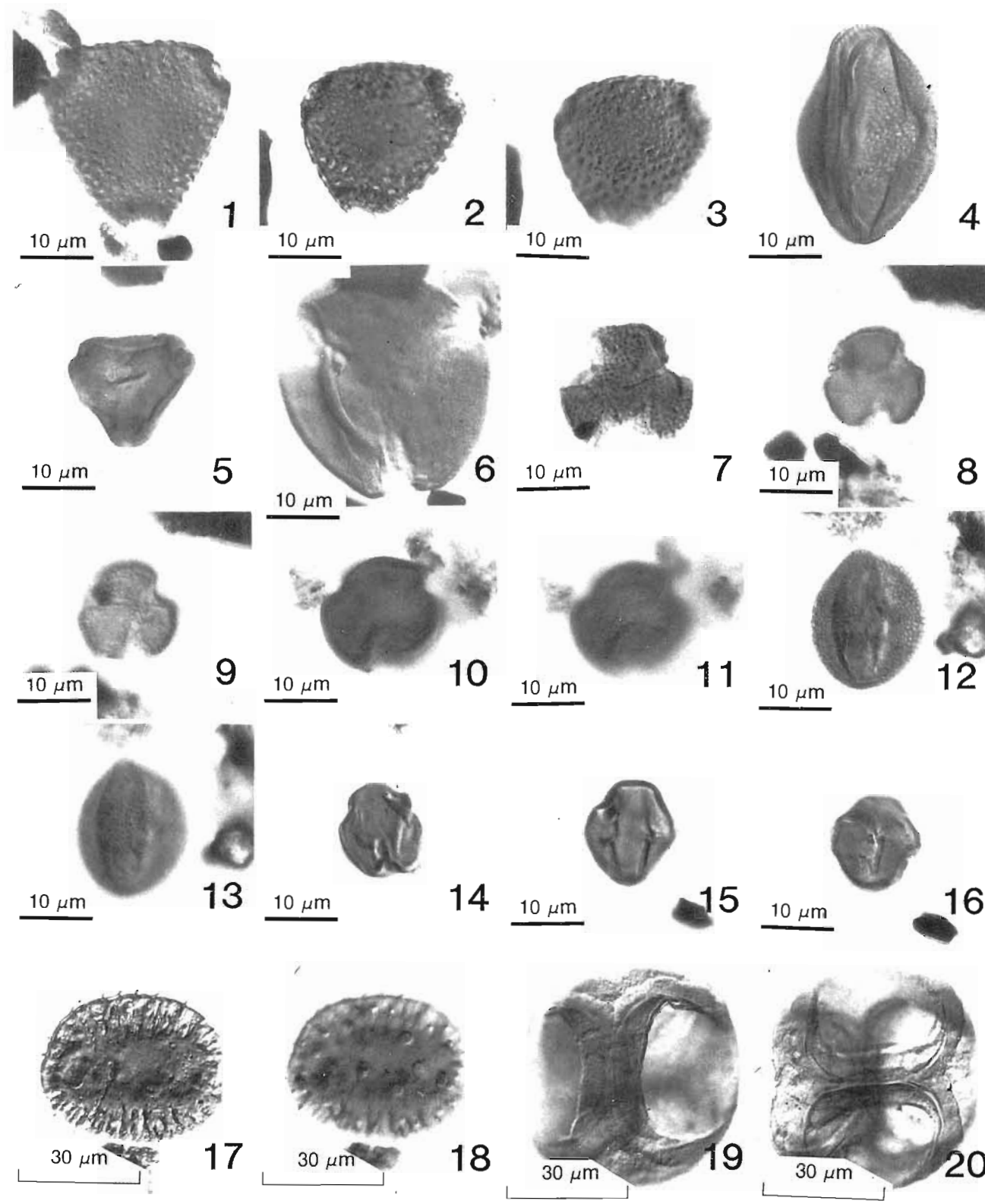
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PLATE 51

Genus—*Rhoipites* Wodehouse 1933

Rhoipites cryptoporus S.K. Srivastava 1972b

Pl. 51, fig. 4

Occurrence—The Upper Austin Chalk, Lower Taylor Clay; Late Santonian, Early Campanian.

Genus—*Santalacites* Stelmak in Pokrovskaya & Stelmak 1960

Santalacites minor Christopher 1979

Pl. 51, fig. 5

Occurrence—The Taylor Clay; Campanian.

Genus—*Striatopollis* Krutzsch 1959

Striatopollis sp.

Pl. 51, fig. 6

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Tricolpites* Cookson ex Couper emend. Potonié 1960

Tricolpites hians Stanley 1965

Pl. 51, fig. 7

Occurrence—The Upper Taylor Clay; Late Campanian.

Tricolpites micromunus (Groot & Penny) C. Singh 1971

Pl. 51, figs 8-9

Occurrence—The Lower Taylor Clay; Early Campanian.

Tricolpites mutabilis Leffingwell 1971

Pl. 51, figs 10-11

Occurrence—The Lower Taylor Clay; Early Campanian.

Genus—*Tricolpopollenites* Pflug & Thomson in Thomson & Pflug 1953

Tricolpopollenites compactus Norton in Norton & Hall, 1969

Pl. 51, figs 12-13

Occurrence—The Upper Austin Chalk, Late Santonian.

Genus—*Tricolporopollenites* Pflug & Thomson in Thomson & Pflug, 1953

Tricolporopollenites affluens (Stanley) Stone 1973

Pl. 51, figs 14-16

Occurrence—The Taylor Clay; Campanian.

Genus—*Wodehouseia* Stanley 1961b

Wodehouseia spinata Stanley 1961b

Pl. 51, figs 17-18

Occurrence—The uppermost Kemp Clay; Late Maastrichtian.

Pollen tetrad *incertae sedis*

Pl. 51, figs 19-20

Occurrence—The Lower Taylor Clay; Early Campanian.

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