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PALYNOLOGY OF THE JURASSIC SEDIMENTS OF WESTERN CANADA

PART 2

MARINE SPECIES

BY

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With Plates 22-29 and 45 Figures in the text

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INTRODUCTION

This paper forms the second, and concluding, portion of the Palynology of the Jurassic Sediments of Western Canada. The first part, including an outline of the geological history of the area, systematic descriptions of terrestrial palynological species, their ranges, and a general bibliography for the whole work appeared in Palaeontographica Abt. B, vol. 30, Liefg. 1-6, p. 12-136, pls. 5-26, 1970.

In this part are described the marine elements of the palynological flora and their ranges, followed by a brief discussion on palynological zonation, an account of the geological interpretation of the results as they apply to the Jurassic sediments of Western Canada and some concluding remarks on the interpretation of Jurassic paleoclimates by means of palynology.

In addition to the acknowledgments listed on pages 120-121 of the first part of this work, the author would like to express special thanks to Dr. MARCEL MILLIOUD of Esso Production Research Co., Houston, Texas, U.S.A., for valuable advice and assistance in the preparation and the revision of the section on the systematic description of marine species.

SECTION 2. MICROPLANKTON Glossary

A few terms, because of special use or need of more precise definition, are defined below.

AdanateTerm applied to an operculum that is partially attached to a vesicle.ArcheopyleAn opening in the vesicle of a dinoflagellate that has a regular shape and constant location for

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	a given species. On plated forms the archeopyle is normally referable in shape and position to a definite vesicle plate
Cansule	The inner layer of a vesicle.
Equatorial girdle or furrow	The furrow, composed of modified vesicle plates in plated species, encircling the equator of a dinoflagellate and, in life, carrying the transverse flagellum.
Horn	A projecting structure on a dinoflagellate. Many dinoflagellates possess one apical and one or two antapical horns.
Longitudinal furrow	Modified longitudinal plates or vesicle area of a dinoflagellate carrying, in life, the longitudi- nal flagellum.
Operculum	Plate or plates covering an archeopyle or pylome. May be free or partially attached to the vesicle (adanate) and made up of one (simple) or more (compound) plates.
Outer layer	The layer of a vesicle overlying the capsule.
Plates	Units composing the test of some dinoflagellates. They may be clearly defined or almost invisible.
Process	A projecting structure which may be either simple or complex. Typically smaller than a horn.
Ridge	A low, linear thickening on the surface of a vesicle.
Suture	Dividing line between plates on a plated dinoflagellate. They may either represent the actual dividing line or the reflection of such a line on the vesicle surface.
Tabulation	The arrangement of plates on a plated dinoflagellate. Plates are normally disposed in five files encircling the vesicle. These are termed: apical, precingular, girdle, postcingular and antapical, expressed in formulae as ', ", g, "', "'' respectively. Additional plates may be inter- calated between apical and precingular, and postcingular and antapical files and these are expressed by the letter "P" in formulae. The complete tabulation is given by citing the number of plates in each file followed by the appropriate symbol, e.g. 1', 6", 6g, 5"'', 1 P, 1"''.
Vesicle	The shell or test of a planctonic organism. It may be one- or multi-layered.

PHYLUM ALGAE

Class Dinophyceae

Genus Gonyaulacysta DEFLANDRE

1938 Gonyaulacysta jurassica DEFL.; p. 688, fig. 2, type species. 1964 Gonyaulacysta DEFL. p. 5.

D i a g n o s i s : Encysted stages with precingular archaeopyle usually in the plate 3" position and with reflected plating of the pattern typical of *Gonyaulax*: vesicle two-layered, spheroidal, polyhedral or broadly fusiform with apical and antapical prolongations or dorso-ventrally flattened. Apex rounded or truncate, symmetrically or asymetrically pointed. Antapex rounded, flattened, or pointed symmetrically or asymetrically. Girdle usually equatorial, descending, displaced distally one to seven times its own width and sometimes with slight overhang. Transverse furrow impressed or not; longitudinal furrow usually slightly indenting the epitheca, often flaring distally, well developed, reaching to, or approaching the antapex. Tabulation 3-6', 0-4a, 6'', 6g, 6''', 0-1p, 0-1pp1, 1''''. Surface smooth or rugose with major thickening along suture lines and minor ones on plates forming a regular or irregular polygonal mesh of varying size. One or more antapical spines sometimes present.

Gonyaulacysta cladophora (DEFL.) n. comb.

Pl. 22, fig. 4, 231, slide -5 (32.8-11.2) P.N. 14194; fig. 3, 231, slide -5 (32.8-115.2); text-fig. 1.

1938 Gonyaulax cladophora DEFL.; p. 688, fig. 4.

Description: Vesicle more or less isodiametric; epitheca rounded conical; terminated by a very short, blunt horn: hypotheca hemispherical; equatorial girdle well developed, helicoidal; longitudinal furrow narrow in its epithecal portion, becoming wider towards the antapex; tabulation 4', 6", 6"', 1P, 1""; sutures well defined, forming low ridges bearing simple spines or spines bifurcating at their tips of varying length spaced about 6.0μ apart; spines flanking equatorial furrow longer than those flanking the other plates, sometimes in tufts; apical horn terminated by a tuft of spines about 10.0μ long which may bifurcate at the tips or be differentiated in some other manner from the other spines of the test; test granulose; color pale yellow; length of test $80.8 (84.0) 90.0\mu$; equatorial diameter $80.0 (84.7) 90.0\mu$; length of spines (average) 4.0μ ; length of spines on equatorial furrow average 9.0μ .

Fig. 1. Plating of G. cladophora DEFL.



Gonyaulacysta downiei n. sp.

Pl. 22, figs. 1-3, 231, slide 1 (32.4-115.2) Holotype P.N, 14195; text-fig. 2.

Description: Vesicle longer than it is wide; epitheca hemispherical; terminated by a short, blunt process up to 10.0μ long and 10.0μ wide; hypotheca more elongate; antapex rounded; no processes developed; transverse furrow well developed; helicoidal, longitudinal furrow more or less parallel-sided; tabulation 4', 6", 6", 1P, 1""; archeopyle simple, precingular, with simple free operculum; comprises plate 3"; sutures reflected onto surface of vesicle as low raised ridges about 1.5μ wide; bearing rows of pinnate spines 1.5 (3.8) 5.5μ long, rising from bases about 1.5μ wide, spaced $2.0-5.0\mu$ apart; similar spines flank transverse and longitudinal furrows; vesicle two-layered; capsule thin-walled; smooth, tightly appressed to outer layer; outer layer about 1.5μ thick; granulose; color pale yellow; length of vesicle $91.3-99.0\mu$ (excluding spines); equatorial diameter 72.6 (80.0) 88.0 μ .



Fig. 2. Gonyaulacysta downiei n. sp. illustrating tabulation.

Discussion: Similar to G. cladophora DEFL., but relatively longer and with more regular spines. Although the tabulation of the two species is the same, there is considerable difference in the shape of individual plates and in the shape of the longitudinal furrows of the two species.

Gonyaulacysta ornata (EISENACK) n. comb.

Pl. 22, figs. 5-6, 392, slide 1 (41.3-118.7), P.N. 14196; text-fig. 3.

- 1955 Lithodinia jurassica var. ornata n. var. EISENACK; pp. 175-177, pl. 4, figs. 9-10.
- 1938 Ctenodinium ornatum (EISEN.) DEFLANDRE; pp. 181-182, pl. 9, figs. 1-7.

1957 Gonyaulax ornata (EISEN.) KLEMENT; pp. 30-33, pl. 2, figs. 11-15.

Description: Vesicle longer than it is wide; epitheca hemispherical; somewhat elongate; apex smoothly rounded; no horn developed; hypotheca hemispherical; smoothly rounded, no antapical processes; transverse furrow well developed; helicoidal; longitudinal furrow usually clearly visible; wider antapically than apically; tabulation 4', 6", 6"', 1P, 1""; archeopyle simple precingular with simple free operculum which comprises plate 3"; tabulation somewhat variable; above formula is the most complex encountered, corresponding with that in KLEMENT's description; other grains studied lacked included plates or possessed only five pre- or post-cingular plates; the archeopyle was only seen in a minority of specimens; sutures reflected onto the outer layer as prominent raised crests up to 2.0μ wide and $3.0-5.0\mu$ high; pinnate spines $1.5-5.0\mu$ long with a basal width of $1.0-2.5\mu$, spaced $2.0-5.5\mu$ apart line the top of the crests; similar spinose crests flank the transverse and longitudinal furrows; vesicle two-layered; capsule less than 0.5μ thick; smooth; appressed to outer layer; outer layer $1.0-1.5\mu$ thick; smooth; ornamented with very scattered rounded granules $0.5-1.5\mu$ in diameter; colour pale yellow; length of vesicle 62.7 (66.7) 71.5μ ; length of capsule 48.0 (54.6) 60.5μ ; width of vesicle 44.0 (60.0) 66.0μ ; width of capsule 40.7 (48.4) 55.0μ .



Discussion: Despite an abundance of specimens in the top most strata of the Shaunavon formation. none showed the complete tabulation. It was therefore determined from a number of fragmentary grains.

Gonyaulacysta jurassica (DEFL.) DEFL.

Pl. 22, fig. 9, 100, slide -2 (36.5-116.7)

1938 Gonyaulax jurassica DEFL.; p. 688, fig. 2.

1964 Gonyaulacysta jurassica (DEFL.) DEFL.; p. 5.

Description: Vesicle longer than it is broad; epitheca hemispherical; terminated by a prominent, blunt-tipped horn made up of three elongate thecal plates (1', 2', and 3'); equatorial furrow well developed, helicoidal; hypotheca hemispherical; longitudinal furrow widest towards the antapex, narrowing to a point on the epitheca were it abuts against the antapical end of plate 1'; tabulation 3', 6'', 6''', 1''''; sutures well defined, forming relatively wide ridges, usually finely serrate at their crests; test thin-walled; smooth; colourless to pale yellow; length of test (inclusive of apical horn and crest to plate 1'''') 103.0—105 μ (ridges shortest at equator; longest on plate 1'''').

Discussion: The Canadian specimens are larger, on average, than European ones, but there can be little doubt as to their identity. The smoothly ovoid test with prominent apical horn, wide sutural ridges and comparatively simple plating are characteristic of this species.

Conyaulacysta jurassica (DEFL.) DEFL. var. longicornis DEFL.

Pl. 22, fig. 8, 100, slide 1 (41.8-123.1), P.N. 14198

1938 Gonyaulax jurassica var. longicornis DEFL.; p. 71, pl. 6, fig. 6.

Description: Theca considerably longer than it is broad; epitheca hemispherical to rounded conical; terminated by a prominent blunt-tipped horn; thecal plating as in G. jurassica; hypotheca hemispherical; sutures of plates form relatively wide ridges, serrate at their crests (see fig. 9); test thin-walled, smooth, colour-less to pale yellow; length of test (inclusive of apical horn and ridge to plate 1^(''')) 91.0 (98.3) 110.0 μ ; equatorial diameter (including ridges) 56.0 (57.7) 60.0 μ ; length of apical horn 30.0-35.0 μ ; height of ridges to sutures 5.0-10.0 μ .

Discussion: The principal difference between G. jurassica and G. jurassica var. longicornis is that the apical horn in the latter variety is relatively longer and the test is also frequently relatively narrower.

Gonyaulacysta canadensis n. sp.

Pl. 24, fig. 1, 231, slide 2 (29.0-125.7), Holotype P.N. 14202; fig. 2, 100, slide 1 (37.3-110.3); text-fig. 4.

Description: Vesicle more or less isodiametric; epitheca and hypotheca hemispherical; epitheca tapers towards the apex, being terminated by a short apical horn about 10.0μ long and 12.0μ wide (see diagram); hypotheca smoothly rounded; no antapical processes; transverse furrow helicoidal; strongly developed, longitudinal furrow less well marked; parallel-sided; tabulation 4', 6", 6"'', 1"''; archeopyle precingular with a simple free operculum, comprises plate 3", not always developed; sutures reflected onto surface of vesicle as low raised ridges up to 1.0μ wide; rows of thin, pinnate spines 2.5 (4.5) 7.7 μ long and up to 1.0μ wide, spaced 2.0 (4.1) 8.8 μ apart line the crests of the ridges; vesicle two-layered; capsule very thin, smooth; outer layer 1.0— 1.5μ thick; scabrate; colour pale yellow; length of vesicle 99.0 (104.5) 110.0 μ ; width of vesicle 77.0 (91.4) 106.0μ .



Discussion: Similar to G. cladophora DEFL but possesses a much larger $1^{\prime\prime\prime}$ plate and shows no included plates. The vesicle is also relatively more elongate and slightly more strongly ornamented.

Gonyaulacysta sp. A.

Pl. 23, fig. 5, 231, slide 6 (30.0-117.7), P.N. 14203; text-fig. 5

Description: Vesicle longer than it is wide; epitheca hemispherical; terminated by a horn about 10.0μ long and 8.0μ wide; hypotheca more elongate; antapex somewhat flattened and slightly thickened; transverse and longitudinal furrows well developed; transverse furrow somewhat helicoid; more or less parallel-sided; tabulation ?4', 6", 6"', 1P, 1""; archeopyle simple, precingular with simple free operculum; comprises plate 3"; sutures reflected onto surface of vesicle as low raised ridges $1.0-1.5\mu$ wide; ridges flanking transverse furrow up to 5.0μ high; vesicle two-layered; capsule thin-walled, exact thickness indeterminate; smooth; tightly appressed to outer layer; outer layer foveolate; foveae up to 3.0μ wide, spaced less than 1.0μ apart; colour pale yellow; length of vesicle 114.0μ ; width of vesicle 90.0μ .



Discussion: A very rare species from the Middle Vanguard, only one specimen being observed in the sample examined.

Genus Scriniodinium KLEMENT

1938 Gymnodinium crystallinum DEFL.; p. 165, figs. 1-3, type species. 1957 Scriniodinium KLEMENT; pp. 408-410.

Diagnosis: Vesicle comprises a circular to ellipsoidal capsule enclosed in a thin outer wall. Apical horn may, or may not, be developed. Girdle and plate sutures may be reflected by ridges on the outer wall, or may be invisible. Tabulation 3-4', 6'', 5-6''', 1P, 0-1''''. Archeopyle apical or simple precingular.

Discussion: Extremely variable but characterized by the circular to ellipsoidal capsule being readily visible within the outer wall, and where visible, by the distinctive plating. Some species of *Scriniodinium* are closely similar to *Gonyaulax* and the two genera probably merge, since species of *Gonyaulax* may be selected showing a progressive reduction of the 6^{'''} plate to almost nothing.

Scriniodinium gochtii n. sp.

Pl. 22, fig. 12, 3732 (6934-35), slide 2 (29.3-115.8) Holotype, P.N. 14204; text-fig. 6

Description: Vesicle more or less isodiametric; epitheca and hypotheca hemispherical; no apical or antapical processes developed; transverse furrow well defined; helicoidal; longitudinal furrow more or less parallel-sided; tabulation 1', 6", 5", 1""; no archeopyle seen; suture reflected onto surface of vesicle as low ridges about 1.5μ wide surmounted by narrow crests $5.0-7.0\mu$ high, supported by thickened rods spaced $2.0-5.0\mu$ apart; rods straight; joined at their tips; sometimes bifurcating (see diagram); vesicle two-layered; capsule thin-walled; smooth; tightly appressed to outer layer; outer layer about 1.0μ thick; granulose; colour pale yellow; length of vesicle $90.0-93.5\mu$; equatorial diameter $84.0-88.0\mu$.



Fig. 6. Scriniodinium gochtii n. sp. illustrating the structure of crests to sutural ridges and tabulation.

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Scriniodinium luridum (DEFL.) KLEMENT

Pl. 22, fig. 11, 2251, slide 4 (34.6-110.7); fig. 10, slide 1 (33.6-125.7); fig. 15, 2251, slide 1 (29.5-109.8)

1938 Gymnodinium luridum DEFL.; p. 166, pl. 5, figs. 4–6. 1957 Scriniodinium luridum (DEFL.) KLEMENT; p. 110.

Description: Theca comprises an irregularly spheroidal capsule enclosed in a thin outer wall; dorsoventrally flattened; outer wall carries a fairly prominent transverse furrow; longitudinal furrow and plating obscure; tabulation indeterminate; hypothecal extension of outer wall asymmetric; extending about 6.0μ apically of the capsule; epithecal extensions double and of different sizes, extending about 3.0μ and 5.0μ apically of the capsule; archeopyle precingular; capsule about 1.0μ thick; smooth to scabrate; outer wall less than 0.5μ thick; smooth and transparent; color of capsule amber; length of theca 63.0 (72.3) 80.0μ ; width of theca 55.0 (66.3) 74.0μ ; length of capsule 48.0 (57.0) 63.0μ ; width of capsule 50.0 (58.0) 62.0μ .

Discussion: This species appears to correspond closely with DEFLANDRE's original description and figures of G. luridum, and with SARJEANT's photographs of specimens assigned to the same species. The grains assigned to S. luridum by KLEMENT (1960, pp. 21-22, pl. 1, figs. 2-3) may represent a distinct species.

Scriniodinium klementii n. sp.

Pl. 23, figs. 1-2, 301, slide 1 (36.8-115.5) Holotype, P.N. 14206; text-fig. 7

Description: Vesicle ovoid; wall two-layered; capsule about 0.5μ thick; smooth to finely granulose; outer wall envelopes capsule and comprises a reticulum with walls about 0.25μ wide and brocci 0.5 (2.0) 3.5μ wide, more or less rounded, supporting a very thin microgranulose membrane; outer wall about 1.0μ thick; epitheca more or less hemispherical, terminated by a projection of the outer wall about 8.0μ high; hypotheca rounded with an irregular, tending to bilobate, extension of the outer wall, about 5.0μ long; at the antapex; transverse girdle and longitudinal furrow visible on most specimens; archeopyle simple precingular with free operculum occupying the position of plate 3"; plating, transverse girdle and longitudinal furrow reflected on surface of vesicle by strongly developed crests about 5.0μ high and up to 2.0μ wide; crests internally radially striate; tabulation 3', 6", 6"'', 1"''; colour yellow; length of vesicle 113.3 (120.0) 132.0 μ ; width of vesicle 84.7 (99.0) 105.0 μ ; thickness (compressed) 25.0 (27.0) 35.0 μ ; length of capsule 90.0 (99.0) 111.0 μ ; width of capsule 70.0 (72.6) 87.0 μ ; thickness of capsule (compressed) 16.0 (25.0) 27.0 μ .



Fig. 7. Scriniodinium klementii n. sp. illustrating tabulation.

Discussion: Similar to Scriniodinium subvallare SARJ., but relatively longer and with different tabulation, Named for Dr. KARL W. KLEMENT.

Scriniodinium reticulatum n. sp.

Pi. 23, fig. 3, 304, slide -1 (31.1-117.4) Holotype, P.N. 14207

Description: Vesicle two-layered, comprising a rounded capsule overlain by an infrareticulate outer membrane; epitheca hemispherical; no apical spine developed; hypotheca elongate hemispherical; base somewhat flattened; transverse girdle detectable as a distinct thickening encircling the equator; longitudinal furrow not detectable; some indication of plating reflected onto the outer surface; not sufficiently developed to termine tabulation; archeopyle simple, precingular, with a free operculum; capsule 0.5μ thick; smooth; outer layer 5.0μ ; infrareticulate; brocci rounded; 2.0 (4.4) 8.0μ wide; muri up to 1.0μ wide; surface of vesicle scabrate; colour pale yellow; length of grain 37.4; width of grain 35.2μ length of capsule 31.9μ ; width of capsule 27.5μ .

Scriniodinium cf. S. subvallare SARJEANT

Pl. 23, fig. 4, 231 A, slide -2 (34.6-114.9); P.N. 14202; fig. 6, 231, slide -4 (32.9-124.8); text-fig. 8

1962 Scriniodinium subvallare SARJ.; pp. 202-203, pl. 1, fig. 10.

Description: Vesicle somewhat flattened dorso-ventrally; more or less circular in outline; wall twolayered; capsule less than 1.0μ thick; granulose; overlain by a reticulum with rounded brocci 1.0 (2.3) 4.0μ wide and muri up to 1.0μ wide and 2.2μ high, supporting a thin smooth outer membrane; epitheca terminated by a short apical horn 5.0 (9.0) 11.0μ long; hypotheca smoothly rounded; no horns developed; transverse girdle well marked and longitudinal furrow visible on most specimens; archeopyle simple precingular with free operculum; position corresponds to plate 3"; on well preserved specimens plating reflected by well developed crests up to 5.0 high and 2.5μ wide; crests appear to be internally radiate, striate; tabulation 4', 6", 6"'', 0"''; capsule brown; outer layer pale yellow; length of vesicle 100.0 (109.2) 125.0μ ; width of vesicle 92.0 (102.9) 115.0μ .



Fig. 8. Scriniodinium cf. S. subvallare SARJ. illustrating tabulation.

Discussion: Plating and morphology of the Canadian specimens agree closely with those of SAR-JEANT'S species. Similar in many respects to S. dictyophorum DEFL., but the latter lacks the well developed crests reflecting the plate sutures shown by S. subvallare SARJ.

Genus Leptodinium KLEMENT

1960 Leptodinium subtile KLEMENT; p. 45, pl. 6, figs. 1-4.

Diagnosis: Attenuated to compact polyhedral or oval rounded theca without ornamentation by spines or winged fringes, tabulate according to the following scheme: 4', 6", 5", 1P, 1"". Apex without horn. Plates plane to convex. Sutures ornamented with low to moderately high ridges. Spiral girdle furrow. Longitudinal furrow continues first apical plate extending to antapex, undifferentiated, or divided into 1 upper, 5 middle, and one lower plate.

Leptodinium norrisii n. sp.

Pl. 24, fig. 1, 404, slide 11 (40.8-116.2); fig. 10, 404, slide -5 (41.1-125.4); fig. 12, 404, slide 1 (36.1-111.3); fig. 9, 301, slide 1 (38.0-115.9) (Holotype); P.N. 14200; text-fig. 9

Description: Theca more or less isodiametric; both hypotheca and epitheca more or less hemispherical; apical horn reduced or absent; represented by the small plate 4'; slightly helicoidal equatorial girdle well developed; forms a band of weakness along which the theca splits into two hemispheres (epithecal archeopyle with a simple operculum); longitudinal furrow more or less same width on epitheca and hypotheca; tabulation 4', 1a, 6", 5"'', 1""; sutures well delineated; cingular plates shield-shaped, each with a very narrow ridge developed on the face of the plate parallel to the suture (see diagram); sutures mark lines of weakness and isolated plates readily split off from the theca resulting in the presence of loose plates in most preparations; thecal wall



Fig. 9. Leptodinium nerrisii n. sp. illustrating tabulation and, right, the form of isolated thecal plates.

Discussion: It is extremely difficult of determine the tabulation for the hypotheca of this species. Very few complete specimens were seen and all of these where imperfect. The tabulation was determined from isolated hemispheres and, for some unknown reason, isolated epithecas were common and hypothecas rare.

Genus Evittia n. gen.

1958 Deflandrea cincta COOKS. & EISEN.; p. 26, pl. 4, figs. 1-3. 1912 Evittia cincta (COOKS. & EISEN.) n. comb. type species, here designated.

Diagnosis: Elongate amphipolar outline. Capsule distinct, spherical to sub-spherical. No distinct tabulation. Archeopyle apical with operculum that includes three reflected intercalary plates.

Named for Dr. W. R. EVITT of Stanford University.

Evittia waltonii n. sp.

Pl. 22, fig. 14, 2251, slide -4 (38.2-115.9); fig. 13, 430, slide -1 (46.1-117.1) Holotype; P.N. 14208

Description: Vesicle somewhat flattened dorso-ventrally; capsule ovoid to sub-spherical; scabrate; $1.0-1.5\mu$ thick; enveloped by a thin outer wall that is appressed to the capsule equatorially but separated from it at the poles; epitheca hemispherical with a conical projection at the apex about 10.0μ long and 20.0μ wide, analogous with the apical horn present on many other dinoflagellates; hypotheca extended beyond the capsule antapically in the form of an irregular bilobed structure; vesicle surrounded equatorially by a well developed transverse furrow about 6.0μ wide; furrow comprises two parallel ridges enclosing a concave groove; longitudinal furrow marked by a fold about 5.0μ wide; archeopyle apical with simple free operculum; vesicle unplated; color yellow; length of vesicle 60.0 (66.1) 73.0μ ; width of vesicle 38.0 (44.1) 48.4; length of capsule 38.0 (42.4) 49.5μ ; width of capsule 35.0 (40.1) 45.0μ .

Discussion: Named for H. WALTON, California Standard Oil Company, Calgary Canada.

Genus Cornudinium n. gen.

Diagnosis: Vesicle biconical, horn-shaped, the cones being joined mouth to mouth. Epitheca elongate, more or less smooth, or with much reduced ornamentation. Hypotheca relatively short, thickened and strongly ornamented. Transverse furrow prominent, probably uninterrupted. Longitudinal furrow obscure. No tabulation, archeopyle or operculum visible. Type species: *Cornudinium stavelyense* n. sp.

Discussion: The strongly biconical shape, lack of plating and strongly ornamented hypotheca are characteristic. Genera such as *Tenua* and *Pareodinia* also lack plating but are rounded in outline and lack differentiation between hypotheca and epitheca.

Cornudinium stavelyense n. sp.

Pl. 24, fig. 15, 3732 (6906-10), slide 2 (26.1-119.4) Holotype, P.N. 14209; fig. 16, 3732 (6909-10), slide 2 (32.8-118.5), P.N. 1410; text-fig. 10

Description: Vesicle biconical, the cones being joined mouth to mouth; epitheca elongate; somewhat asymmetric, one side being straight, the other exhibiting a distinct break of slope corresponding to the base of the epithecal spine; hypotheca relatively shorter than epitheca; outline symmetrical; epithecal edge of transverse furrow marked by a belt of thickening separating hypotheca from epitheca; remainder of furrow only visible on corroded specimens where a part of the thick external ornamentation has been removed (fig. 24); furrow about 14.0μ wide; longitudinal furrow obscure; plating absent; epitheca shows two longitudinal lines of ornamentation:

- 1. An area of closely packed, irregular, anastomosing vertucae up to 2.0μ high giving the surface a very roughened appearance.
- 2. A somewhat smaller area of reduced, scabrate to granulose ornament which is an area of thinning of the vesicle wall, the area of greatest reduction of ornament being the area of greatest thinning; the area is torn on some specimens, suggesting that it may function as archeopyle.

Hypotheca much thickened and strongly ornamented, the ornamentation having a spongy appearance with irregular strands of tissue projecting at random from the main mass; the removal of much of the ornament from corroded specimens with no associated damage to the rest of the thecal wall suggests that it forms a distinct second layer to the grain; color yellow-brown; length 87.0 (100.4) 144.0 μ ; width 47.0 (56.0) 69.0 μ ; length of epithecal horn 21.0 (33.7) 45.0 μ ; length of epitheca 42.0 (59.4) 84.0 μ ; length of hypotheca 36.0 (49.6) 63.0 μ .



Fig. 10. Structure of Cornudinium stavelyense n. sp.

Genus Tenua (EISENACK) emend.

1958 Tenua hystrix EISENACK; p. 410, pl. 23, figs. 1-4, text-fig. 10, type species.

Diagnosis: Vesicle dorso-ventrally flattened. Archeopyle apical with offset sulcal notch and six precingular plates which are not always visible. Outline varies from more or less circular or oval without indications of horns, to rounded sub-triangular with one apical and one or two antapical horns indicated by rounded lobes or angles. Vesicle smooth or with processes, some of which may be in sutural or tabular arrangement. Tips of processes free or interconnected.

Discussion: This emendation of the original diagnosis of EISENACK somewhat widens the original concept of the genus and appears to circumscribe a more practical grouping.

Canningia Cooks. & EISEN, 1960, may be synonymous with Tenua EISENACK emend.

Tenua evittii n. sp.

Pl. 24, fig. 6, 2258, slide 1 (29.3-122.8); fig. 8, 3732, slide 3 (21.6-125.2) Holotype, P.N. 14212; text-fig. 11

Description: Vesicle dorso-ventrally flattened; outline oval with short projecting apical horn; archepyle apical, suture indicating offset sulcal notch; apical portion of test plated, six hexagonal precingular plates normally being detectable; test about 1.0μ thick; ornamented with small, closely packed granules; granules all about the same size $(0.5\mu$ diameter approx.) except at the tip of the apical horn where one or two

small blunt-tipped processes may be developed (see diagram); colour yellow orange. Grain size $45.0-52.0 \times 59.0-60.0\mu$, Holotype $45.0 \times 59.0\mu$ (including apical horn). Apical horn 10.0μ approximately, Holotype 10.0μ .

Fig. 11. Tenua evitti n. sp. illustrating, left, ornamentation on apical horn and, right, precingular tabulation.

Discussion: The various, fairly persistent, curved folds observed on grains of this species appear to be compression features and have no structural significance.

More strongly developed apical horn and less pronounced ornamentation than *Tenua hystrix* Eis. or T. *hystricella* Eis.

Genus Evansia n. gen.

Diagnosis: Vesicle dorso-ventrally flattened, outline oval to ovoid. Apex with apical horn. Archeopyle intercalary with simple free operculum. No tabulation or prominent ornamentation. Equatorial girdle not visible, or only faintly visible.

Type species: Evansia granulata n. sp.

Discussion: Very similar to Apteodinium EISENACK, but the latter possesses a simple precingular archeopyle. Tenua EISENACK possesses an apical archeopyle, and six precingular plates.

Named for Dr. C. R. EVANS, Imperial Oil Ltd., Calgary Canada.

Evansia granulata n. sp.

Pl. 24, fig. 7, slide #304-2 (38.5-118.5) Holotype, P.N. 14213; text-fig. 12

Description: Vesicle dorso-ventrally flattened; outline oval with short projecting apical horn; archeopyle intercalary with simple free operculum; no plating visible; transverse and longitudinal furrows not detectable; theca two-layered comprising an inner smoothly rounded capsule about 0.5μ thick overlain by a tightly enveloping outer granulose layer $1.0-1.5\mu$ thick; finely and closely granulose, giving the surface a spongy appearance; apical horn solid; about 10.0μ long; antapically a small process about 2.0μ long formed by thickening of the outer layer; colourless; theca $58.3 \times 40.7\mu$; capsule $44.0 \times 37.4\mu$.



Fig. 12. Evansia granulata n. sp. illustrating position of archeopyle.

Genus Pareodinia DEFLANDRE

1947 Pareodinia ceratophora DEFL.; pp. 8-4; text-figs. 1-8, type species.

Diagnosis: Vesicle ellipsoidal to elongate with a prominent, digitiform apical horn, usually without antapical horns. Transverse furrow unmarked or only faintly indicated; without other distinct indications of



tabulation. Archeopyle intercalary, represents two plates; operculum divided by a median suture into two discrete parts that are mirror images. Vesicle smooth or ornamented, the ornamentation never being very strong.

Pareodinia ceratophora DEFL.

Pl. 24, fig. 3, slide #213-4 (37.8-118.6), P.N. 14215; fig. 5, slide #231-4 (39.6-123.3); text-fig. 13

1947 Pareodinia ceratophora DEFL.; pp. 3-4, text-figs. 1-3.

Description: Theca longer than it is wide; rounded to somewhat clongate ellipsoidal with prominent, slightly curved, finger-shaped, epithecal horn frequently terminated by a small, solid, more or less spherical granule about 1.5μ in diameter; theca single-layered; less than 0.5μ thick; scabrate to finely granulose; no visible indication of equatorial girdle or plating; intercalary archeopyle, comprising two identical plates (see diagram), present immediately below the epithecal horn; theca usually carries one or more internally attached, spherical, punctate, yellow-green bodies; well preserved specimens frequently enveloped in a formless mass of diffuse transparent tissue; colour pale yellow; length of theca 45.1 (51.3) 55.0 μ ; width of theca 38.0 (40.7) 45.0 μ ; length of horn 8.8 (16.4) 25.0 μ ; width of horn 4.4 (5.1) 6.0 μ .



Fig. 13. Apical aspect of Pareodinia ceratophora.

Discussion: As may be seen from the illustrations and from the diagrams in SARJEANT, 1962, p. 484, the shape of these grains is very variable. The presence of diffuse tissue enveloping these and similar grains has been used by SARJEANT as a basis for generic differentiation. The author concludes, from an examination of both well and poorly preserved specimens, that the presence or absence of such tissue is a function of preservation and the presence or absence of the character is therefore not sound for generic separation except on a purely form basis.

Pareodinia cf. P. nuda (Downie) n. comb.

Pl. 24, fig. 4, slide #1816-15 (35.5-120.2), P.N. 14215

(?) 1957 Palaeoperidinium nudum DOWNIE; p. 424, pl. 20, fig. 11.

1962 Palaeoperidinium nudum DOWNIE; in POCOCE; pp. 80-81, pl. 14, fig. 225.

Description: Vesicle ellipsoidal with a well developed, hollow, digitiform apical horn; vesicle twolayered; capsule about 0.5μ thick, appressed to outer wall; outer wall 1.2μ thick, amorphous; surface between the two layers roughened; no longitudinal furrow developed, tranverse furrow about 20.0μ wide, only faintly delineated; vesicle unplated; suitable orientated specimens show an intercalary archeopyle at the base of the apical horn; apical horn frequently faintly striate at the base and may, or may not, possess a deep spiral groove at the tip; length of vesicle 48.0 (73.0) 88.0 μ ; width of vesicle 33.0 (43.0) 48.0 μ ; length of apical horn 10.0 (19.0) 23.0 μ .

Discussion: This species is probably the same as that described by Downie as *Palaeoperidinium nu*dum from the Kimmeridge Clay of Norfolk and Dorset England, and its stratigraphic position is about the same.

Genus Opaeopsomus Evitt n. gen.

1964 Opaeopsomus wapellensis n. sp., type species here designated.

Diagnosis: Vesicle ellipsoidal to spherical, usually relatively small. Archeopyle apical. Wall bears a series of ridges or septa which may only reflect tabulation, or may be supplemented by additional ridges or septa which may result in the formation of a coarse or fine reticulum. A thin membrane, supported by the ridges or septa, may, or may not be developed.

Opaeopsomus wapellensis n. sp.

Pl. 24, fig. 14, slide #403-3 (31.4-121.0) Holotype, P.N. 14218

Description: Vesicle ellipsoidal to spherical; epitheca and hypotheca hemispherical; no apical or antapical processes developed; transverse furrow well delineated; parallel-sided; helicoidal; 6.0μ wide; longitudinal furrow only faintly visible over part of its length; archeopyle apical with simple free operculum; vesicle two-layered; capsule smooth; about 0.5μ thick; tightly appressed to outer layer; sutures reflected by narrow raised ridges, 4.0μ high and less than 0.25μ wide; accessory ridges developed in addition to the sutural ridges, making determination of tabulation impossible; brocci of reticulum resulting from intersection of ridges, rounded and very variable in size; $1.0 \times 5.0\mu$ wide; thin membrane developed completely enveloping the vesicle and supported by the ridges; colourless to pale yellow; size range 42.9—45.0 x 39.6—43.0 μ .

Discussion: Differs from *Fovilarnax* SARJEANT in possessing transverse and longitudinal furrows, thus indicating definite dinoflagellate affinity.

Genus Jansonia n. gen.

Diagnosis: Vesicle small, more or less pear-shaped in outline. Epitheca terminated by a smoothly rounded, hollow, apical horn which is normally lost through apical archeopyle formation. Capsule very thin and tightly appressed to outer wall. Tabulation (?'), 6'', 6g, 6''', 0-1P, 1''''. Vesicle wall characteristically dark brown.

Type species: Jansonia jurassica n. sp.

Discussion: The tabulation of this genus corresponds to that of Gonyaulax but the very small size of the vesicle and the apical archeopyle are characteristic.

Named for Dr. J. JANSONIUS, Imperial Oil Ltd. in recognition of his considerable contributions to Canadian palynology.

Jansonia jurassica n. sp.

Pl. 29, fig. 8, slide #405-7 (36.7-116.0) Holotype, P.N. 14219; fig. 9, slide #405-7 (38.6-117.3); text-fig. 14-15

Description: Vesicle small; more or less isodiametric; pear-shaped in outline; epitheca terminated by a smoothly rounded hollow apical horn about 10.0μ long which is only very rarely preserved (seen on only one of over two hundred specimens examined); hypotheca hemispherical; smooth; no antapical processes developed; transverse furrow about 6.0μ wide; parallel-sided; slightly helicoidal; longitudinal furrow rarely seen; sutures reflected onto surface of vesicle of some specimens as very faint lines of minute granules; invisible on others; tabulation impossible to determine from any one specimen; partial tabulation, determined from several grains, appears to be (?'), 6'', 6g, 6''', 1P, 1''''; archeopyle apical with simple free operculum; vesicle two-layered; capsule less than 0.25μ thick; smooth; tightly appressed to outer layer; outer layer $0.5-1.0\mu$ thick; surface finely and closely granulose; colour brown; length 25.0 (33.0) 40.0μ (excluding apical horn); width 23.0 (33.0) 43.0μ .



Fig. 14. A-B, Tabulation of Jansonia jurassica n. sp. C. Complete specimen.



Fig. 15. Analysis of grain size data for *Jansonia jurassica* n. sp. Graphs based upon measurement of 100 grains. Length of vesicle does not include length of apical process, which is only very rarely preserved.

Discussion: A very easily recognizable species that is abundant towards the top of the Upper Bajocian. The tabulation corresponds to that of some species of *Gonyaulax* but, in view of the small size, obscure sutures apical archeopyle and different colour and texture of the vesicle wall, the latter being unique among Jurassic dinoflagellates, the erection of the new genus *Jansonia* is considered to be warranted. This species is very abundant in assemblages carrying few, or no, other species of microplankton but with dominant *Classopollis* spp. and cuticle of gymnospermous character. The colour and texture of the vesicle differ from that of other Jurassic dinoflagellates described, suggesting that it may have a somewhat different composition. From these observations it appears that the species lived in fresh or brackish water rather than in a purely marine environment.

Genus Cyclonephelium DEFL. & COOKSON

1955 Cyclonephelium compactum DEFL. & COOKS.; pp. 48-49, pl. 12, figs. 7-8, type species

Diagnosis: Vesicle rounded, may or may not show dorso-ventral flattening. Archeopyle apical. No elongate horns developed but reduced apical and antapical processes may be present. Ornamentation of vesicle comprises short processes which are fairly crowded in marginal area but reduced in size and widerspaced or missing from central areas. Tips of processes free or interconnected by trabeculae or a thin surrounding membrane.

Cyclonephelium areolatum COOKS. & EISEN.

Pl. 23, fig. 7, slide #402-6 (32.7-120.7); fig. 8, no coordinates (wet mount)

1960 Cyclonephelium areolatum Cooks. & EISEN.; p. 253, pl. 38, figs. 7-8.

Description: Vesicle circular to oval; dorso-ventrally flattened; wall two-layered; inner layer less than 0.5μ thick; granulose; forming a more or less circular internal cyst; overlain by a transparent, finely granulose to smooth, outer layer $0.5-1.5\mu$ thick; peripheral zone $12.0-20.0\mu$ wide; infrareticulate; brocci rounded,

about 3.0μ wide; transverse furrow 16.5μ wide, usually visible; epitheca terminated by a very reduced apical horn $3.5-5.0\mu$ long; hypotheca smoothly rounded; no horns developed; colour pale yellow; length of theca 96.8μ ; width of theca 83.6μ ; length of capsule 88.0μ ; width of capsule 73.7μ .

D is c ussion: The Canadian specimens are slightly larger than those described by COOKSON & EISENACK, but in others respects are very similar. The "vermiculate or areolate" membrane described by the above authors is clearly seen on the Canadian specimens to be an internally reticulate structure.

Genus Dingodinium Cooks. & EISEN.

1958 Dingodinium jurasiscum COOKS. & EISEN.; p. 39, pl. 1, figs. 10-11, type species

Diagnosis: Vesicle comprises an ovoid to spherical capsule, either smooth or, more often, covered with short pinnate spines, overlain by a thin, membranous outer wall. The outer wall is extended apically to form a hollow apical horn and may extend beyond the antapex to form a bilobate extension. Outer wall possesses a well defined helicoid transverse girdle.

Dingodinium cooksonii n. sp.

Pl. 23, fig. 9, slide #100-2 (39.0-120.8) Holotype; P.N. 14221; text-fig. 16

Description: Vesicle ovoid, equatorial section circular; epitheca hemispherical, extended at the apex to form a hollow horn which may be $3.0-4.0\mu$ long and rounded at the tip, or may be only $1.5-2.0\mu$ long and flattened; hypotheca hemispherical, antapex flattened, the outer layer extended to form two unequal, not very well defined lobes which represent reduced antapical horns; transverse girdle well defined, bounded on the outer edges by distinct folds; longitudinal girdle not detectable and plating not visible; capsule smoothly ovoid to pear-shaped, covered with closely crowded conical processes about 3.0μ high, rising from bases 2.0- 2.5μ in diameter, disposed radially over the capsule, the spacing being very regular and even; capsule about 1.5μ thick, enveloped in a smooth membranous outer layer less than 0.5μ thick; capsule pale brown to yellow; outer layer colourless; size range 51.0 (64.3) 78.0 x 36.0 (51.3) 69.0 μ .

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Fig. 16. Dingodinium cooksonii n. sp. Structures and ornament.

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Discussion: An abundant and easily recognizable species in marine beds of the Upper Jurassic. The capsule frequently becomes detached from the outer layer and may, in this condition, be mistaken for a spinose cyst.

Genus Chytroeisphaeridia (SARJEANT) emend.

1962 Leiosphaeridia (Chytroeisphaeridia) chytroeides SABJEANT; p. 492, pl. 70, fig. 13, text-fig. IId, l.c. type species.

Diagnosis: Vesicle sub-spherical or, more frequently, ovoid (outline circular to oval). Wall singlelayered, usually relatively thin: smooth or carrying relatively subdued granulose or papillate ornament; vesicle may, or may not, show traces of polygonal plating (some individuals in a species may show traces of plating, some may not); shield-shaped or polygonal aperture which may be closed by an operculum present in most species. Members of this genus frequently contain yellow-green punctate bodies within the vesicle.

Discussion: Study of abundant, well preserved material from the Jurassic of Canada indicates that the type species of the above genus is, in all probability, a dinoflagellate in which the characteristic apical and antapical horns are not developed and in which plating of the vesicle is very obscure or invisible. Some of the Canadian specimens show faint traces of plating and some are split into two unequal parts, the line of splitting having an angular outline indicative of more than one polygonal plate in each hemisphere being involved in the separation.

Chytroeisphaeridia variabilis n. sp.

Pl. 23, fig. 14, slide #404—5 (45.8—116.0); fig. 15, slide #400—2 (44.1—123.1) Holotype, P.N. 14222; fig. 16, slide #394—C (39.9—121.1)

Description: Vesicle ovoid; sometimes differentiated into two portions, an epitheca with a, more or less pointed, solid apex and a hypotheca with a somewhat blunted antapex (Figs. 1-2); wall about 0.5μ thick; transparent; ornamented with scattered, low, rounded granules spaced $1.0-3.0\mu$ apart; vesicle plated; plating too faint to determine tabulation; epitheca rounded; apex frequently marked by a short, wide horn up to 6.5μ long with a basal diameter of about 10.0μ ; horn solid; penetrated by an apical pore; simple precingular archeopyle developed which may be closed with a shield-shaped operculum; helicoidal equatorial girdle present; frequently well developed; hypotheca smoothly rounded (pl. 2, fig. 1) or asymmetrically blunted at the antapex (pl. 2, fig. 2); antapical horns not developed; punctate yellow-green bodies present, fused to the inside of the vesicle wall; folds characteristically developed parallel to the sides of the grain which may give the grain the appearance of enclosing a spherical cyst; colourless to pale yellow; size range 60.0 (68.1) 81.0 x 45.0 (53.7) 57.0μ .

Discussion: A very variable species although the size range is reasonably narrow. In appearance the grains vary from typical 'peridinoid' form with faint, but distinctly visible, plating to rounded ovoid granulose cysts. The archeopyle is present on all specimens although when the operculum is preserved it is not always obvious. All grains carry punctate yellow-green bodies.

Chytroeisphaeridia chytroeides SARJEANT

Pl. 25, fig. 9, slide #304-1 (40.3-120.8); pl. 27, fig. 22, slide #304-4 (35.3-115.8); fig. 21, slide #304-4 (34.0-120.9), P.N. 14223. 1962 Chytroeisphaeridia chytroeides SARJEANT; p. 492, pl. 70, fig. 13.

Description: Vescile spherical with a somewhat flattened area over an operculum; operculum polygonal; $23.0-30.0\mu$ wide, covering a polygonal aperture (pylome); vesicle single-layered; less than 0.5μ thick; smooth and transparent; may carry internally a circular, punctate, yellow-green body about 7.5μ in diameter tightly appressed to the wall; colour pale yellow; diameter of vesicle 45.0(50.4) 56.0μ .

Discussion: These grains, as noted by SARJEANT, probably have disophyte affinities. The presence of a polygonal operculum together with the internal yellow-green bodies, present on the majority of grains, are strongly suggestive of such affinity.

No apylomate specimens assignable to the species were observed in any of the samples examined.

Chytroeisphaeridia scabrata n. sp.

Pl. 27, fig. 23, slide #304-2 (38.6-120.0); figs. 24-25, slide #304-4 (85.5-115.0) Holotype, P.N. 14224.

Description: Vesicle ovoid; apical portion normally somewhat arched; wall single-layered; less than 0.5μ thick; scabrate; shield-shaped aperture pointed, portion directed apically, developed over one definite area of the vesicle, frequently covered by an operculum; most specimens possess a circular yellow-green punctate body, $8.0-10.0\mu$ in diameter, appressed to the inside of the vesicle wall; well preserved examples show a small, rounded area of wall thickening occupying the apex of the grain (see figs. 4 and 6); vesicle transparent; colourless to pale yellow; size range 39.0 (45.5) 49.0 x 54.0 (57.5) 66.0 μ .

Discussion: There can be little doubt as to the dinophyte affinities of this species. The shape and position of the aperture, or pylome, together with the polarity of the grain and the presence of yellow-green punctate bodies within the vesicle all suggest relationship with the dinoflagellates. The thickened apical boss may represent a very reduced apical horn.

Genus Cyclodictyon Cookson & EISENACK

1958 Cyclodictyon paradoxus COOKS, & EISEN.; p. 58, pl. 12, figs. 1-2, type species.

Diagnosis: Vesicle spherical to ovoid. Two-layered. Capsule smooth to scabrate, overlain by a reticulate outer layer which is absent over a more or less circular area of the vesicle. No girdles or furrows present. Unplated.

Cyclodictyon minor n. sp.

Pl. 23, fig. 10, slide #1957-2 (28.0-126.0) Holotype, P.N. 14225

Description: Vesicle spherical; two-layered; inner layer less than 0.5μ thick; outer layer closely appressed to inner layer; reticulate; brocci 1.0 (3.9) 6.6μ wide; muri less than 0.5μ thick and $1.5-2.0\mu$ high; vesicle penetrated by a circular archeopyle $18.0-20.0\mu$ in diameter; colourless; equatorial diameter $44.0-46.2\mu$.

Discussion: Differs from Cyclodictyon paradoxus COOKS. & EISEN. in its smaller size and in the close contact between the two layers making up the vesicle.

Marine cysts

not illustrated

Description: Vesicle spherical; about 1.5μ thick; smooth; transparent or translucent; frequently much folded; surrounded by a formless mass of diffuse tissue; pale yellow to colourless; diameter of vesicle $37.4-44.0\mu$.

Discussion: Similar instances of vesicles surrounded by formless tissue of this type have been recorded by a number of workers. COOKSON & EISENACK (1960) base the genus *Kalyptea* in part upon this character and SARJEANT (1961) separates *Netrelytron* from *Pareodinia* on this basis. Since such tissue is only observed enveloping well preserved specimens the author suspects that its absence or presence is a factor of preservation.

Genus Cannosphaeropsis WETZEL

1933 Cannosphaeropsis utinensis WETZEL; pp. 6-7, pl. 3, figs. 9-17; text-fig. 12, type species.

Diagnosis: Central body spherical to ellipsoidal, probably two-layered. A number of hollow, tubular processes arise radially from the central body and support a thin reticulum.

Discussion: The processes arising from the central body may, as suggested by EVITT (1963) reflect tabulation. This cannot be established from the species described in this paper and it is undesirable to include such features in the above diagnosis.

Cannosphacropsis caulleryi (DEFL.) SARJEANT

Pl. 27, fig. 1, slide #1857-4 (27.6-122.6), P.N. 14228

1938 Hystrichosphaeridium caulleryi DEFL.; p. 189, pl. 9, figs. 2-3. 1960 Cannosphaeropsis caulleryi (DEFL.) SARJ. ex SARJ.; pl. 14, fig. 5.

Description: Vesicle spherical; thin-walled (less than 0.5μ); granulose; covered with radially disposed, narrow, cylindrical processes 4.4 (9.6) 13.2μ long and up to 1.0μ wide; terminated by flared, trumpetshaped tips $2.0-3.0\mu$ wide; processes smooth; solid apart from capillary axes to a few processes; tips of processes joined by narrow strands forming a meshwork concentric with the vesicle; yellow-green spherical punctate bodies attached to the inner wall of the vesicle; colour pale brown; diameter of vesicle $45.0-60.0\mu$; spacing of processes $3.0-5.0\mu$.

Discussion: The smooth spines of this species appear to be a different texture to the punctate vesicle. This suggests the possibility that the vesicle may be two-layered, the smooth transparent layer being invisible when in close contact with the punctate layer.

Genus Polystephanosphaera SARJEANT

1960 Polystephanosphaera valensii SARJEANT; pp. 142-143, pl. 6, fig. 5, type species.

Diagnosis: Vesicle spheroidal, bearing processes of varied character but always solid or with closed tips whose points of origin are arranged in rings. The bases of adjacent processes may be coalescent and adjacent processes may be linked by trabeculae at points along their length or at their tips, all processes of each ring sometimes being linked together by a single trabecula.

Polystephanosphaera sp. A

Pl. 28, fig. 39, slide #394A-B (28.9-108.9)

Description: Vesicle sub-spherical, smooth; about 1.0μ thick; processes solid; arranged over the surface of the vesicle in seven or eight circles; individual processes variable simple or branched; processes in each group tend to flare outwards from the centre of the circle; diameter of vesicle $21.0-24.0\mu$; length of processes approx. 5.0μ .

Discussion: Much smaller than any previously described species. Since only two specimens were encountered, a new specific name for these forms is not as yet warranted.

Dinoflagellate species not attributable to genus

Certain dinoflagellate species investigated in this study were found to have very characteristic morphological features and limited ranges, making them valuable for purpose of zonation, and yet were never well enough preserved to permit generic assignment.

In the past these species would have been assigned to the genus *Palaeoperidinium* DEFLANDRE which was proposed as a waste-basket genus for such species. This type of usage of a genus, with no type species cited, is invalid and the species are therefore here assigned letter designations pending the investigation of better preserved specimens that can be assigned to valid genera.

Dinoflagellate sp. A

Pl. 24, fig. 13, slide #231-2 (33.4-125.1), P.N. 14216; text-fig. 17

Description: Vesicle spherical; outline circular; epitheca terminated by a horn about 10.0μ long and 15.0μ wide; tip of horn solid; ornamented with a tuft of short spines and verucae (see diagram); hypotheca smoothly rounded; no processes developed; transverse and longitudinal furrows well developed; plating reflected onto outer layer, but not sufficiently well preserved on specimens studied to permit determination of tabulation; sutures reflected by low raised ridges $1.0-1.5\mu$ wide; lines of pinnate spines about 2.0μ long and 0.5μ wide spaced $1.0-3.0\mu$ apart along the crests of the ridges; similar rows of spines flank the transverse girdle: no archeopyle visible, but a tendency for the grain to split around the equator suggests that archeopyle formation may be epithecal with a simple free operculum; vesicle two-layered; capsule thin-walled; smooth; tightly appressed to outer layer; outer layer granulose; about 1.5μ thick; color pale-yellow; size range 75.9- $85.0 \times 79.2-90.0\mu$.



Fig. 17. Dinoflagellate sp. A. Ornamentation of apical horn.

Dinoflagellate sp. B

Pl. 23, fig. 11, slide #100-5 (42.9-126.1), P.N. 14217, text-fig. 18

Description: Vesicle circular in equatorial outline, two-layered; capsule smooth; tightly appressed to outer layer, thickness indeterminate; outer layer scabrate to microgranulose, over 1.5μ thick; plating reflect-

ed onto outer layer in the form of raised ridges up to 3.0μ wide and 2.0μ high; tabulation indeterminate owing to poor preservation of specimens studied; transverse and longitudinal girdles well developed; transverse girdle flanked by raised ridges up to 4.0μ high topped by rows of processes up to 9.0μ high, bifurcating and joining at their tips (see diagram); colour deep brown (carbonized); equatorial diameter 90.0 (95.6) 105.0 μ .

Fig. 18. Dinoflagellate sp. B. Structure of Crests,



Discussion: No well preserved specimens of this species have been seen and the tabulation cannot at present be determined. The species is fairly common in the upper beds of the Fernie formation of the eastern Rocky Mountain area. The strongly, and characteristically, ornamented ridges flanking the transverse girdle are readily recognizable even on fragmentary specimens.

Group Acritarcha EVITT

Grouped under the Acritarcha are those species of microplankton which cannot, at the present time, be assigned to any natural group. Some of the forms, particularly among the thin-walled leiospheres such as *Leiosphaeridia hyalina*, are almost certainly dinoflagellate cysts whilst others, such as many species of *Tasmanites*, and some of the thickwalled leiospheres, are probably chlorophyte algae. It appears possible that vesicles of various forms with small circular, sub-spherical punctate yellow-green bodies internally attached may be assigned to the dinoflagellates. These bodies are not the same as those recorded by EISENACK from some Paleozoic acritarchs. It is probable that a meaningful split of Leiosphaeridia could be made on the criterion of absence or presence of these bodies, but this must await further investigation.

The speciation of small acritatchs presents special problems due both to difficulties in examination resulting from small size and lack of optical contrast, and to difficulty in determining diagnostic characters. The first problem may be solved by the use of high quality oil-immersion optics, combined with such contrast improving methods as colour filters, embedding media of different contrasts and phase contrast illumination whilst the graphical approach to speciation shows promise of solving the second.

The subgroup system for classifying the Acritarcha proposed by DOWNIE, EVITT & SARJEANT (1963) is adopted in this work. It has value in splitting up the various groups of taxa and making them more understandable although better groupings of some genera could possibly be achieved.

Subgroup Netromorphitae Downie, Evitt & Sarjeant

Genus Leiofusa Eisenack

1938 Leiofusa fusiformis EISEN.; p. 28, pl. 4, fig. 10, type species.

Diagnosis: Vesicle one- or two-layered, usually relatively thin. Ovoid to fusiform in shape (oval outline). Surface smooth to scabrate or finely granulose; never strongly ornamented.

Leiofusa deunffii n. sp.

Pl. 25, fig. 14, slide #2258-1 (37.3-116.2), P.N. 14230 Holotype; fig. 15, slide #2258-2 (42.5-118.4)

Description: Vesicle single-layered, about 1.0μ thick; outline oval-elongate, surface smooth; may show indications of longitudinal or transverse splitting, but this does not appear to follow any regular pattern; colour yellow; size range $61.5-74.8 \ge 26.5-30.0\mu$.

Discussion: It is impossible to be certain that this species represents marine organisms, but since it is always found in assemblages rich in microplankton and has not been recorded from any completely terrestrial assemblage a planktonic affinity appears probable.

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Leiofusa cf. L. bacillum DEUNFF

Pl. 25, fig. 13, slide #5055 (2514b) --3 (44.0-113.0)

1955 Leiofusa bacillum DEUNFF; p. 148, pl. 4, fig. 2.

Description: Vesicle elongate fusiform; sides more or less parallel, ends rounded; no slits or apertures developed; wall single-layered, less than 1.0μ thick, frequently folded; colour light brown; size range $405.0 \times 72.0\mu$.

Discussion: A very rare, but easily recognizable, species. Distinguished from other Jurassic species of *Leiofusa* by its elongate form and large size. Much larger than the true *L. bacillum* but otherwise identical.

Subgroup Sphaeromorphitae DOWNIE, EVITT & SARJEANT

Genus Leiosphaeridia EISENACK

1958 Leiosphaeridia baltica Eisens; p. 8, pl. 2, fig. 5, type species. 1959 Leiosphaeridium Тімогееv; p. 27.

Diagnosis: Vesicle-spherical to sub-spherical. Wall single- or multi-layered, thick or thin. Radial canals or pores not developed. Surface smooth, punctate or with other relatively subdued ornamentation.

Discussion: A genus including miscellaneous spherical to sub-spherical non-porate cysts. Includes dinoflagellate cysts, chlorophyte algae and other organisms of unknown affinity. No pylomes have been observed in any of the species included in this study. The genus is capable of considerable sub-division.

Leiosphaeridia hyalina (DEFL.) DOWNIE

Pl. 25, fig. 12, slide #404-5 (37.7-120.8), text-fig. 19

1941 Leiosphaeridia hyalina DEFL.; p. 24, pl. 6, figs. 12-13.

Description: Vesicle spherical; without apertures; single-layered; less than 0.5μ thick; smooth; transparent; vitreous; characteristically much folded; a yellow-green, punctate body about 10.0μ in diameter, circular in outline, tightly appressed to the interior of the vesicle; vesicle colourless to pale yellow; diameter of vesicle 36.0 (56.3) 75.0μ .

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Fig. 19. Leiosphaeridia hyalina (DEPL.) DOWNIE. Size distribution (25 specimens).

Discussion: Relatively common in marine Upper Jurassic sediments. Torn specimens are common, suggesting release of the contents of the cyst by simple rupture of the wall. The circular body appressed to the inside of the vesicle wall is the structure referred to by DEFLANDRE as "yellow-green crystalline bodies" and by DOWNIE as "yellow-green granular bodies".

Leiosphaeridia staplinii n. sp.

Pl. 25, fig. 11, slide #404-8 (39.7-127.5) Holotype, P.N. 14233

Description: Vesicle spherical; without visible apertures; characteristically much folded; twolayered; about 0.5μ thick; inner layer smooth; amorphous; overlain by tightly appressed, very finely granulose outer layer; granules less than 0.25μ in diameter; spaced about 0.5μ apart; circular yellow-green punctate body, or bodies, $8.0-10.0\mu$ in diameter appressed to the inside of the vesicle, forming a cluster if more than one present; vesicle colourless to pale-yellow; diameter vesicle 48.0 (6.14) 72.0μ , holotype 72.0μ . Discussion: These inaperturate, unplated cysts appear to grade into faintly plated forms and these, in turn, grade into distinctly plated grains with a definite polarity and possessing an equatorial girdle which have obvious dinophyte affinities. This species includes those forms with no indication of plating.

Named for Dr. F. L. STAPLIN, Imperial Oil Limited, Calgary, Canada.

Leiosphaeridia eisenackii n. sp.

Pl. 25, fig. 8, slide #1977-2 (29.4-113.6) Holotype, P.N. 14235; text-fig. 20

1957 Leiosphaeridia ? sp. EISENACK; p. 246, pl. 20, fig. 7.

Description: Vesicle spherical; wall 6.6μ thick; two-layered, made up of (1) an inner layer about 3.5μ thick, amorphous; (2) an outer spongy, granulose layer about 3.0μ thick (varying from 2.2 to 4.5μ); surface of vesicle granulose; granules $1.0-1.5\mu$ in diameter; more or less circular in cross section; colour amber; diameter of vesicle $93.5-100.0\mu$.

Discussion: Similar in appearance to species of *Tasmanites* and *Tytthodiscus* but lacks radial canals. Named for Professor A. EISENACK, Tübingen, Germany.

Leiosphaeridia spongiosa n. sp.

Pl. 25, fig. 4, slide #1977--1 (85.5--115.9) Holotype, P.N. 14237; text-fig. 21

Description: Vesicle spherical; wall about 12.0μ thick composed of two layers (1) an amorphous inner layer about 2.5μ thick overlain by (2) a spongy layer apparently composed of close-packed more or less spherical granules about 9.5μ thick; outer layer somewhat variable in thickness giving the grain an irregular circular outline; granules less than 1.0μ in diameter; colour yellow; diameter of vesicle $105.0-110.0\mu$.

Discussion: Similar to L. eisenackii n. sp. but thicker walled and larger in size.

Fig. 21. Leiosphaeridia spongiosa n. sp. Wall structure



Leiosphaeridia sarjeantii n. sp.

Pl. 25, figs. 6-7, slide #2420-6 (35.8-119.0) Holotype, P.N. 14238

Description: Vesicle spherical; wall $3.5-4.0\mu$ thick, composed of two layers; (1) an amorphous inner layer about 1.5μ thick overlain by (2) a porous outer layer about 2.0μ thick; outer layer somewhat variable in thickness giving the vesicle a somewhat irregular outline; surface of vesicle ornamented with closely packed, very narrow anastomosing ridges; a narrow slit visible in some specimens may represent a mechanism facilitating release of contents of cyst; colour yellow-brown; diameter of vesicle $90.0-100.0\mu$.

Discussion: Similar to *L. eisenackii* but possessing a thinner vesicle wall and an ornamentation of anastomosing ridges instead of granules.

Named for Dr. W. A. S. SARJEANT, University of Saskatchewan, Canada,

Leiosphaeridia granulosa n. sp.

Pl. 26, fig. 10, slide #400-3 (49.8-119.4); fig. 11, slide #400-4 (43.2-121.1); fig. 12, slide #400-1 (38.7-121.4) Holotype, P.N. 14241

Description: Vesicle spherical; probably two-layered; inner layer amorphous; translucent; $1.5-2.0\mu$ thick; outer layer less than 0.5μ thick; tightly appressed to inner layer; ornamented with small, hemispherical granulae which are very regular in size and shape; about 1.0μ wide, 0.5μ high and spaced $1.0-2.0\mu$ apart;

Fig. 20. Leiosphaeridia eisenackii n. sp. Wall structure

slits visible on some specimens appear to mark lines of weakness and possibly act as apertures for release of cell content. Vesicle diameter 25.0 (37.3) 50.6μ , holotype 39.0μ .

Discussion: Similar to L. minutaespinosa n. sp. but larger and ornamented with granules instead of spines.

Leiosphaeridia minutaespinosa n. sp.

Pl. 26, (ig. 13, slide #404-1 (45.8-118.1) Holotype, P.N. 14242; fig. 14, slide #404-3 (42.2-120.6)

Description: Vesicle spherical; probably two-layered; inner layer amorphous; translucent; possibly slightly roughened; relatively thick; outer layer very thin; tightly appressed to the inner layer; ornamented with short pinnate spines; spines circular in plan; about 1.0μ wide at their bases and 1.0μ high; spaced up to 1.0μ apart; slits visible on many grains may be structures facilitating cell content release; colour pale yellow; diameter of vesicle 15.0 (22.75) 27.0 μ ; diameter of holotype 21.0 μ .

Discussion: It is difficult to be certain if these grains are one or two layered. Examination of torn grains under high magnifications shows what appears to be an outer, very thin layer torn away from a thicker, amorphous inner layer. L. granulosa n. sp. is smaller and non spinose.

Leiosphaeridia variabilis n. sp.

Pl. 26, figs. 24-25, slide #4231-1 (17.3-116.2); fig. 27, slide #4231-1 (23.7-120.0); fig. 28, slide #4231-1 (26.5-109.8) Holotype, P.N. 14246

Description: Vesicle spherical to sub-spherical; surface undulose, thin-walled; wall probably twolayered but this is not determinable on the specimens examined; ornamentation comprises pinnate spines intermixed with spines with clavate tips and granules; spines $1.0-2.0\mu$ long with a basal width of $0.5-1.0\mu$; granules about 1.0μ high and rounded; elements of ornamentation spaced $1.0-3.0\mu$ apart; no apertures visible; equatorial diameter 27.0 (31.0) 33.0μ , Holotype 33.0μ .

Discussion: Similar to L. minutaespinosa n. sp. but with less regular ornamentation and larger in size.

Leiosphaeridia tangentensis n. sp.

Pl. 26, fig. 32, slide #3729 (2970-72) -1 (23.0-126.0) Holotype, P.N. 14245; figs. 33-34, slide #3729 (2970-72) -1 (28.0-127.4)

Description: Vesicle spherical; $1.5-2.5\mu$ thick; ornamented with closely packed, low, rounded granules $0.5-1.0\mu$ in diameter and 0.5μ high rising from hexagonal bases; grains show some tendency to developed folds parallel to their sides; colour pale yellow. Diameter of holotype 63.5μ .

Variety A — Description as above; size range 39.0 (63.0) 100.0μ ; overlaps Variety B at about 78.0 μ and above that size is indistinguishable from it. Variety B — Description as above; size range 60.0 (87.0) 112.0μ ; overlaps Variety A at about 78.0 μ and below that size is indistinguishable from it.



Discussion: The accompanying graph (based upon 200 specimens) illustrates the two peaks which are the reason for differentiation of two varieties. The two size groups are clearly separable in all samples examined. Since individuals of the two groups are, apart from size, identical and appear to have no stratigraphic significance, two distinct species are unwarranted. The minor peak at 117.0μ on the graph represents a distinct, rare species of thick-walled, granulose leiospheres.

Leiosphaeridia asymmetrica n. sp.

P1. 26, fig. 29, slide #100-1 (45.3-121.3) Holotype, P.N. 14247; fig. 30, slide #100-2 (34.0-123.5), P.N. 14248

Description: Vesicle spherical, extended at one end in the form of a conical process about 5.0μ long and with a basal width of 5.0μ ; densely spinose; spines pinnate; less than 0.5μ wide and $2.5-3.0\mu$ long; spines spaced about 1.0μ apart over most of the vesicle but less closely packed over an area about 5.0μ wide situated immediately below the process frequent tears around the vesicle at the base of the process together with its complete absence from many specimens, suggests apical archeopyle formation; vesicle very thin; singlelayered; colourless to pale yellow; size range 35.2 (36.6) 40.0×27.0 (31.0) 33.0μ .

Discussion: Pyriform shape and dense covering of spines characterize L. asymmetrica. The possible presence of an archeopyle suggests possible dinoflagellate affinity.

(?) Leiosphaeridia sp. A

Pl, 25, fig. 10, slide #424-4 (34.9-120.0), P.N. 14249

Description: Vesicle spherical; about 1.5μ thick; single-layered; smooth; a simple slit-like aperture about three-quarters of the diameter of the vesicle appears to be present; no internal features; transparent; colour brown; diameter of vesicle $57.0-69.0\mu$.

Discussion: The affinities, and even the marine habitat, of these grains are doubtful. They are most abundant in marine assemblages, hence the present interpretation. They could almost equally well be monolete spores of a previously unrecognized species or deviant grains of a simple trilete spore.

Subgroup Tasmanititae STAPLIN, JANSONIUS & POCOCK

Genus Tasmanites Newton

1875 Tasmanites punctatus Newton; pl. 10, figs. 2, 3, 5, 8 & 9, type species.

1886 Protosalvinia DAWSON; p. 115.

1955 Tytthodiscus Norem; pp. 694-695.

Diagnosis: Relatively thick-walled, spherical, sub-spherical or ovoid vesicles, usually amber in colour and with a vitreous appearance. Wall single or multi-layered, completely or partially penetrated by straight-sided radial canals which may be cylindrical or may taper toward the inside of the vesicle. Canals may be of one order, or may comprise a series of scattered major canals and one or more series of hair-like, crowded minor canals. Vesicle diameter varies from 25.0 to over 800.0μ and the wall thickness from 2.0 to over 70.0μ (WINSLOW, 1962). Surface of vesicle smooth, pitted or ornamented with conical depressions; never strongly ornamented.

Discussion: As defined above, *Tasmanites* includes only species possessing wall canals. Forms lacking such canals are placed in the genus *Leiosphaeridia*. There appears to be no essential difference between *Tasmanites* and *Tytthodiscus*. Species assigned to the latter genus exhibit a clustering of minor canals in more or less hexagonal groups at the surface of the vesicle. Under lower magnifications this gives the vesicles the appearances of being composed of hexagonal plates. Despite its very wide size range, *Tasmanites* embraces a characteristic and distinct group of organisms. The Jurassic species are all quite distinct. Within any one species morphological characters are more or less constant and the size range is surprisingly restricted.

Tasmanites suevicus (EISENACK) n. comb.

Pl. 26, fig. 7, slide #404-2 (37.3-122.8), P.N. 14250; text-fig. 23

1957 Tytthodiscus suevicus Ets.; pp. 241-243, pl. 19, figs. 1-3, pl. 20, figs. 1-2.

Description: Vesicle spherical; 7.0 (10.0) 13.0μ thick; wall two-layered, penetrated radially by two sets of canals; (1) a series of straight cylindrical canals about 1.0μ wide, radially disposed, penetrating both wall layers and appearing as pits on the surface of the vesicle; these canals spaced 8.4 (14.2) 26.4μ apart; (2) very closely spaced straight, narrow, hair-like canals also radially disposed, occurring in two sets, one penetrating the inner and one the outer wall; at the boundary between the two walls the two sets of canals alternate (see diagram); surface of vesicle ornamented with closely spaced, regular, hemispherical vertucae, each about 2.4μ in diameter and 1.3μ high; colour amber; vesicle diameter 100.0 (120.0) 130.0 μ .



Fig. 23. Wall structure of Tasmanites suevicus EISEN.

Discussion: The dimensions and the general morphology are those of T. suevicus described by EI-SENACK from the Lias / of Swabia.

Tasmanites eisenackii n. sp.

Pl. 26, fig. 8, slide #404--4 (42.4-119.2) Holotype, P.N. 14251; text-fig. 24

Description: Vesicle spherical; $4.8-5.0\mu$ thick; wall single-layered, penetrated by conical, elongate pits which do not always completely pierce the wall; surface diameter of pits about 1.0μ , length $3.0-5.0\mu$; pits spaced about 1.5 apart; surface of vesicle smooth apart from pitting; colour amber; vesicle diameter 90.0 (100.0) 105.0μ .

VVVV

Fig. 24. Tasmanites eisenuckii n. sp. Wall structure

Discussion: A relatively simple species comprising a single-layered vesicle penetrated by regularly disposed, radial wall canals. Differs from *T.rushlakensis* in possessing conical instead of cylindrical wall canals.

Tasmanites rushlakensis n. sp.

Pl. 25, fig. 1, slide #1977-8 (37.5-121.5) Holotype, P.N. 14252; text-fig. 25

Description: Vesicle ovoid; wall about 3.5μ thick; single-layered; amorphous; penetrated by fairly regularly scattered radial cylindrical canals about 0.25μ wide, spaced $5.5-7.7\mu$ apart; surface of vesicle scabrate; colour amber; size range $85.0-99.0\mu$.

Fig. 25. Tasmanites rushlakensis n. sp. Wall structure

Discussion: A very rare species included as an example of a simple, thick-walled vesicle possessing radial canals.

Tasmanites yarboensis n. sp.

Pl. 25, figs. 2-3, slide #4102 (1327-33) -3 (30.5-117.0) Holotype, P.N. 14253; text-fig. 26

Description: Vesicle spherical; wall 11.0μ thick; three-layered; made up of (1) inner layer about 5.0μ thick; amorphous, penetrated by radially disposed, straight, cylindrical canals about 0.5μ wide spaced 7.7 (10.2) 12.6μ apart; (2) a middle layer 2.2μ thick penetrated by the canals previously mentioned and also by crowded (less than 0.25μ apart), straight, radially disposed, hair-like canals; (3) an outer layer about 4.0μ thick;



Fig. 26. Wall structure of Tasmanites yarboensis

amorphous; penetrated by the major canals previously discussed which terminate at the surface of the grain as conical depressions; outer layer also penetrated by straight, radially disposed, hair-like canals regularly spaced about 0.5μ apart; these canals, as far as can be seen, do not penetrate the middle layer; surface of grain smooth apart from depressions where canals cut the surface; colour amber; grain size 88.0—96.0 μ .

Tasmanites clairmontensis n. sp.

Pl. 26, figs. 1-3, slide #856-1 (36.9-116.5); fig. 4, slide #3579 (2750) -4 (32.7-119.6) Holotype; text-fig. 27

Description: Vesicle ovoid to spherical; wall about 5.0μ thick; three-layered, made up of (1) inner layer about 2.4μ thick partially penetrated by radially disposed, straight, cylindrical canal about 0.5μ wide, spaced 7.2 (10.8) 13.2μ apart; (2) a middle layer about 2.0μ thick penetrated by straight, hair-like radial canals spaced less than 0.5μ apart. The larger canals of the inner layer also traverse this layer. (3) An outer layer about 0.5μ thick, amorphous, penetrated radially by straight, very thin, hair-like canals which are spaced very regularly about 1.2μ apart; it is impossible to determine if these canals are continuous with those penetrating the middle layer; the large canals penetrating the other two layers do not penetrate the outer layer; surface of vesicle smooth, colour amber; grain size $84.0 \times 77.0\mu$ (reasonably constant for all specimens).

rig. 27. 1 asmanues clairmontensis. Wall structur	Fig. 27.	. Tasmanites	clairmontensis.	Wall structure
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Note: Due to the ovoid shape of most specimens of this species, a very characteristic invaginated fold is frequently developed parallel to the long axis of the grain.

Subgroup Herkomorphitae Downie, Evitt & Sarjeant

Genus Lophodictyotidium n. gen.

Diagnosis: Vesicle spherical to sub-spherical. Wall probably single-layered, relatively thick. Surface divided into equidimensional fields by low crests. Entire surface of vesicle may or may not be ornamented with evenly spaced rounded granules.

Type species: Lophodictyotidium sarjeantii n. sp.

Discussion: Differs from *Dictyotidium* (WETZEL) STAPLIN in possessing fields of equal area and, where present, in the even granulation of the vesicle. The single-layered structure of the vesicle is also distinctive.

Lophodictyotidium sarjeantii n. sp.

Pl. 25, fig. 5, slide #2420 (3797-98) -6 (41.0-115.5) Holotype, P.N. 14255

1960 Organism B SARJEANT; p. 404, pl. 14, fig. 21.

Description: Vesicle spherical; wall about $2.0\,\mu$ thick; probably single-layered; crests do not cross granules and are not deflected by them; divided into more or less equidimensional polygonal fields by low crests; crests about $1.5\,\mu$ wide and $1.0\,\mu$ high; hemispherical in cross section; fields granulose; granules circular in cross section; rounded; about $0.75\,\mu$ high and $2.0\,\mu$ in diameter; spaced evenly $3.25\,\mu$ apart; colour yellow-brown; diameter $52.0~(54.0)~58.0\,\mu$.

Discussion: No girdle structure is visible, no apertures are present and no internal yellow-green bodies have been observed. Relationship with the dinoflagellates or with *Cymatiosphaera*, as suggested by SARJEANT (1960) is considered improbable. The thick wall, lack of apertures and regular ornamentation is suggestive of some relationship with the thick-walled leiospheres, possibly *Tasmanites*.

Genus Dictyotidium (WETZEL) STAPLIN

1938 Leiosphaera dictyota EISENACK; p. 27, pl. 3, figs. 8a-c, type species.

1955 Dictyotidium WETZEL; p. 179.

1961 Dictyotidium (WETZEL) STAPLIN; p. 417.

Diagnosis: Vesicle spherical, usually two-layered. Surface reticulate. Ridges low and distinct, dividing the vesicle into polygonal fields. Some species may show a single modified, rounded field over which the outer wall layer is thinned or possibly absent. Small apiculae or spines may rise from the ridges. Papillae may be present in the floors of the lumina.

Dictvotidium eastendense n. sp.

Pl. 26, fig. 15, slide #404-3 (45.2-122.1); fig. 16, slide #404-1 (37.1-125.4) Holotype P.N. 14256; figs. 17-18, slide #424-1 (36.5-119.2); figs. 20-22, slide #2139 (water mounts - non permanent); text-fig. 28

Description: Vesicle spherical; two-layered; inner layer smooth or faintly roughened; outer layer very thin; membranous and transparent; enveloping inner layer and forming raised ridges up to 1.0μ high breaking the surface of the vesicle into polygonal fields 2.2 (4.7) 7.5 μ wide; separated by ridges less than 0.25μ wide; outer layer thinned or absent over the area of one modified, more or less circular, field about 4.5μ wide; colour pale yellow; vesicle diameter 12.0 (33.0) 49.5μ ; diameter of holotype 31.0μ .



Fig. 28. Dictyotidium eastendease. Size distribution (200 individuals).

Discussion: The modified field observed in this species appears similar to the tenuitas observed on specimens of *Cymatiosphaera teichophera* SARJEANT. The two-layered structure of the two species is also similar, suggesting the possibility of natural affinity.

Dictyotidium shaunavonense n. sp.

Pl. 26, fig. 19, slide #400-1 (42.0-112.3) Holotype P.N. 14257; fig. 23, slide #400-5 (42.7-115.0)

Description: Vesicle spherical to sub-spherical; two-layered; inner layer less than 0.5μ thick; smooth; overlain by an outer layer $1.0-1.5\mu$ thick; tightly appressed to inner layer; outer layer broken up into numerous circular to sub-circular fields 1.5 (3.1) 5.0μ in diameter; intervening ridges about 1.0μ high and $0.5-2.0\mu$ wide; some grains show internal spherical punctate yellow-green bodies; colourless to pale yellow; equatorial diameter 39.0 (46.7) 57.0 μ .

Subgroup Acanthomorphitae DOWNIE, EVITT & SARJEANT

Genus Cymatiosphaera (WETZEL) DEFL.

1933 Cymatiosphaera radiata WETZEL; p. 27, pl. 4, fig. 8, type species.

1954 Cymatiosphaera (WETZEL) DEFLANDRE; pp. 257-258.

Diagnosis: Vesicle spherical, ellipsoidal, or lenticular, often with radiating ribs. Wall two-layered. Outer layer forms an enveloping membrane which is gathered into polygonal areas on the vesicle surface that may extend considerably beyond the vesicle margin. One modified circular area is present on all Mesozoic species examined over which the outer layer is absent. This area forms a tenuitas and gives the grains a definite polarity.

Discussion: Jurassic species of *Cymatiosphaera* and *Dictyotidium* are morphologically similar, the latter species possessing much lower ridges delineating the areas or fields of the vesicle than the former. There is probably a biological relationship between these.

Cymatiosphaera teichophera SARJEANT

Pl. 28, figs. 37 & 43, slide #392-1 (42.8-114.3), P.N. 14258

1961 Cymatiosphaera teichosphera SARL; pp. 107-108, pl. 15, fig. 9.

Description: Vesicle broadly ellipsoidal, about 0.75μ thick; two-layered; inner layer laevigate; very thin; outer layer less than 0.5μ thick, tightly appressed to inner layer and gathered to form membranes which

divide the vesicle into eleven polygonal fields of somewhat variable size and one circular field about 8.0μ in diameter; outer layer absent over this field which forms a tenuitas; membranes delineating fields 4.4 (6.8) 9.9μ high, transparent; finely striate in a direction normal to the surface of the vesicle; colour pale yellow; overall dimensions $49.5 \times 42.5 \times 19.0\mu$; dimensions of vesicle $38.5 \times 29.7 \times 5.5\mu$.

Discussion: The dimensions of this species are very close to those of the holotype. The circular tenuitas seen on the Canadian specimens is also visible, although not described, on SARJEANT's holotype. It gives the grains a definite polarity.

Cymatiosphaera hancevilliana n. sp.

Pl. 28, figs. 40-41, slide #4231 (62-62-16-11) 104-108-2 (23.3-118.5) Holotype

Description: Vesicle spherical to broadly ovoid, about 1.0μ thick; two-layered; capsule laevigate, thin; outer layer less than 0.5μ thick, tightly appressed to capsule and gathered to form membranes which divide the vesicle into about ten polygonal fields of varying size; one field, about 10.0μ in diameter, differentiated from the rest and forming a tenuitas over which the outer layer is absent; membranes delineating fields 5.5 (6.6) 9.0μ high, 0.5μ thick, transparent and smooth; vesicle colourless to pale yellow; overall dimensions 36.3 x 34.1 x 10.0μ ; dimensions of vesicle 27.5 x 26.4 x 5.0μ .

Discussion: Similar in size to C. teichophaera SARJ., but lacks its characteristic radial striation of the membranes.

Genus Baltisphaeridium (Eisen.) STAPLIN, JANSONIUS & POCOCK

Diagnosis: Vesicle finely punctate or roughened; spines differentiated from vesicle by texture of spine wall and by angle between spine and vesicle which usually approaches 90° ; spines hollow in young stages, gradually becoming solid in more mature forms. A more or less open channel through the centre of the spine may be left hollow, but this channel is usually plugged at the junction between the spine base and the vesicle by wall thickening. The spines are always relatively simple although simple branching may occur.

Remarks: The above restriction of *Baltisphaeridium* removes the artificial and meaningless size differentiation between it and *Micrhystridium* and at the same time restricts it to comprise a group of species that appear to have definite biological affinity.

In the above sense the genus differs from *Hystrichosphaeridium* in the closed tips of the spines and from *Micrhystridium* in the differentiation between spine and vesicle wall.

Baltisphaeridium jansonii n. sp.

Pl. 28, fig. 26, slide #404-1 (42.0-117.9); fig. 27, slide #404-2 (43.4-126.2); fig. 31, slide #404-2 (44.3-138.4); fig. 32, slide #404-4 (44.2-122.3); fig. 33, slide #404-1 (42.6-112.2) Holotype, P.N. 14260

Description: Vesicle spherical; roughened; translucent; about 0.5μ thick; spines 14 (15) 18 in number; 7.0 (8.8) 12.0μ long; usually hollow and always closed at the tips; spine base about 1.2μ wide; usually solid; spines pinnate; colour pale yellow; diameter of vesicle $15.0 (17.9) 24.0\mu$.

Discussion: Differs from Solisphaeridium stimuliferum (DEFL.) n. comb. in possessing partially hollow spines and in the roughened nature of the vesicle wall.

Genus Micrhystridium (DEFL.) STAPLIN, JANSONIUS & POCOCK

Diagnosis: Vesicle sub-circular to polygonal, of small to moderate size. Ornamented with several to numerous hollow spines which are continuous with, and open into, the vesicle. Spines simple, straight or concavely conical with closed tips. No differentiation in texture between spines and vesicle.

Remarks: Baltisphaeridium differs in the variation among vesicle spines and in the closure between spines and vesicle. Veryhachium and Wilsonastrum grade into Micrhystridium and the separation between these genera is discussed under Wilsonastrum.

Micrhystridium inconspicuum (DEFL.) DEFL.

Pl. 28, fig. 7. slide #1849-5 (25.4-117.7); fig. 8, slide #424-1 (29.8-121.9); fig. 9, slide #424-1 (87.6-114.3)

1935 Hystrichosphaera inconspicua DEFL.; p. 283, pl. 91, figs. 11-12.

1937 Micrhystridium inconspicuum (DEFL.) DEFL.; p. 80, pl. 12, fig. 11.

Description: Vesicle sub-circular; very thin-walled; smooth; spines 15 to 20 in number; $3.6-6.0\mu$ in length with a basal diameter of $1.0-1.5\mu$; hollow with closed tips; pinnate; opening into the vesicle and not clearly differentiated from it at their bases; colourless and transparent; diameter of vesicle 10.0 (12.0) 14.0μ .

Micrhystridium ovale n. sp.

Pl. 27, fig. 9, slide #1977-1 (37.8-125.8) Holotype. P.N. 14263; text-fig. 29

Description: Vesicle ovoid; very thin-walled; smooth and hyaline; ornamented with scattered, short, broad, hollow, pinnate spines; spines 2.2 (3.0) $3.3.\mu$ long, arising from bases $1.0-1.5\mu$ wide; spines are curved towards their tips all spines curving in the same direction; spacing of spines $2.5-3.3\mu$; number of spines about 20; transparent and colourless; size of grain 20.0 x 12.0 μ .



Fig. 29. Micrhystridium ovale. Structure.

Discussion: A very rare species unlike, as far as the author is aware, any previously described.

Micrhystridium echinoides VAL.

Pl. 28, fig. 10, slide #404-4 (41.8-119.3); fig. 11, slide #404-2 (40.0-1260.6); fig. 35, slide #404-3 (38.6-123.4) 1948 Micrhystridium echinoides VAL; p. 544, pl. 1, fig. 5.

Description: Vesicle sub-spherical; very thin-walled; spines hollow; pinnate; 11 (22) 42 in number; 5.0 (6.0) 8.0μ long and $1.5-2.0\mu$ wide at their bases; tapering rapidly towards their tips; spines usually somewhat curved; transparent and colourless; diameter of vesicle 8.4 (9.4) 10.8μ .

Discussion: The larger average number of spines and their characteristic slightly curved form distinguish this species from M. inconspicuum.

Micrhystridium polyedricum VAL.

Pl. 28, fig. 1, slide #424-1 (29.8-121.9); P.N. 14265; fig. 2, slide #424-4 (39.5-127.1); fig. 3, slide #424-1 (30.0-123.9)

1953 Micrhystridium polyedricum VAL.; p. 60, pl. 9, figs. 7-10 & 13-16 & 18 & 22; pl. 14, figs. 13, 17 & 29. non 1953 M. polyedricum forma reducta VAL.; p. 60, pl. 9, fig. 228.

Description: Vesicle polygonal to sub-circular; thin-walled; smooth; ornamented with short, broadbased, hollow, conical spines which are continuous with the vesicle; spines 8 (10) 12 in number, about 3.0μ long and 2.0μ broad at their bases; transparent and colourless; diameter of vesicle $8.0-10.0\mu$.

Discussion: It is difficult to measure spine length and width with accuracy since there is no clear line of demarcation between spine base and vesicle.

The grain *M. polyedricum* VAL. f. reducta VAL. does not appear to be co-specific with *M. polyedricum* VAL. and should possibly be transferred to the genus *Wilsonastrum* JANSONIUS (1962).

Micrhystridium sydus VAL.

Pl. 28, fig. 31A, slide #1849-5 (22.5-124.5)

1953 Micrhystridium sydus VAL.; p. 59, pl. 9, figs. 3-5, 11, 17, 23 & 24; pl. 14, figs. 11-12; pl. 8, fig. 40.

Description: Vesicle spherical to polygonal, very thin-walled; smooth; spines hollow; continuous with vesicle wall; 8 to 10 in number; pinnate; $5.0-7.0\mu$ long with a basal diameter averaging 2.0μ ; transparent and colourless, diameter of vesicle 8.0 (10.0) 15.0 μ .

Discussions: The relatively long, wide-based spines give this species a very characteristic stellate appearance.

Micrhystridium stellatum DEFL.

Pl. 28, fig. 28, slide #424-1 (29.9-115.1); P.N. 14267; fig. 34, slide #424-1 (28.4-122.8)

1942 Micrhystridium stellatum DEFL.; p. 476, figs. 7-8.

Description: Vesicle polyhedral; thin-walled; smooth; spines slightly curved; pinnate; hollow, continuous with vesicle; about 12 in number; 6.0 (8.8) 12.0μ long arising from broad bases $3.0-5.0\mu$ wide; transparent and colourless; diameter of vesicle 15.0 (17.7) 20.0μ .

Discussion: Similar to *M. echinoides* VAL. but with much broader-based spines which are relatively shorter than in that species.

Genus Solisphaeridium Staplin, JANSONIUS & POCOCK

1938 Micrhystridium stimuliserum DEFL.; p. 192, pl. 10, fig. 10.

1965 Solisphaeridium stimuliferum (DEFL.) STAPL., JANS. & Poc.; p. 183-184.

Diagnosis: Vesicle spherical; smooth, wall fairly firm and rigid; ornamented with several to numerous spines; spines usually at least half the diameter of the vesicle; relatively narrow and tapering continuously towards the pinnate closed tips; spines firm and rigid to somewhat flexible; hollow or solid; where hollow, spines have a tendency to reduce the cavity through the secondary deposition of wall material, but the cavity does communicate freely with the vesicle.

R e m a r k s: Differs from *Micrhystridium* in the contrast between the regular circular outline of the vesicle and the relatively long, narrow spines radiating out from it, the spines being distinctly separate from the vesicle. Differs from *Filisphaeridium* principally in possessing more robust spines.

Solisphaeridium stimuliferum (DEFL.) n. comb.

Pl. 28, fig. 21, slide #2258-1 (34.0-113.5); P.N. 14271; fig. 22, slide #2258-2 (31.5-115.0); fig. 23, slide #2258-2 (31.5-125.0)

1938 Micrhystridium stimuliferum DEFL.; p. 192, pl. 10, fig. 10.

1965 Solisphaeridium stimuliferum (DEFL.) STAP., JANS. & POC.; p. 183-184.

Description: Vesicle spherical; smooth; thin-walled (approx. 1.5μ); spines solid; about 15 in number; relatively rigid and straight; pinnate; spine length 5.0 (8.3) 13.0μ ; spines elongate conical arising abruptly from the vesicle; transparent and colourless; diameter of vesicle $18.0 (21.3) 25.0\mu$.

Discussion: Differs from Solisphaeridium recurvatum (VAL.) n. comb. in fewer, but relatively longer, straighter and more rigid spines.

Solisphaeridium recurvatum (VAL.) n. comb.

Pl. 28, fig. 24, slide #2258-2 (40.6-122.9); P.N. 14268; fig. 29, slide #2258-1 (28.9-120.0); fig. 30, slide #87-4 (29.1-116.9); fig. 36, slide #87-5 (42.5-121.4); fig. 21A, slide #75-4 (35.4-117.9)

1953 Micrhystridium recurvatum VAL.; p. 43, pl. 6, fig. 2.

Description: Vesicle spherical; less than 0.5μ thick; smooth; spines 20 (29) 42 in number; solid; averaging 10.0μ in length; pinnate; basal diameter less than 1.0μ ; spines show a tendency to slight curving at their tips; transparent and colourless; diameter of vesicle 24.0 (26.0) 27.0 μ .

Discussion: This species appears to be distinct from all others in the Canadian Jurassic. VALENSI'S varieties, however, appear to have no significance in Canada.

Solisphaeridium deflandrei (VAL.) n. comb.

Pl. 27, figs. 3-4, slide #892-6 (35.4-122.4); P.N. 14273

1953 Micrhystridium deflandrei VAL.; p. 51, pl. 7, figs. 19-22.

Description: Vesicle spherical; smooth; about 1.0μ thick; covered with crowded, but very evenly distributed, small, conical, pinnate spines, $1.5-2.0\mu$ long, rising from circular bases less than 0.5μ in diameter; spines spaced about 1.0 apart; show some tendency to curve at their tips; colour pale yellow; diameter of vesicle $22.0-23.1\mu$.

Solisphaeridium watrousense n. sp.

Pl. 27, fig. 8, slide #426-6 (38.1-116.8) Holotype; P.N. 14274

Description: Vesicle spherical; smooth; wall 1.5μ thick; probably two-layered; spines solid; conical; pinnate; $3.5-4.0\mu$ long, with a basal diameter of $1.0-1.5\mu$, spaced 2.0 (3.7) 5.5μ apart; spines show a tendency to slight curving at their tips; vesicle internally pitted, the pitting apparently occurring between two wall layers; colour pale yellow; equatorial diameter 26.4 (30.5) 34.0μ .

Discussion: Differs from F. piveteaui (VAL.) n. comb. in having a considerably larger vesicle and thicker spines and from *Micrhystridium inconspicuum* DEFL. on account of its larger size.

Solisphaeridium fragile (DEFL.) n. comb.

Pl. 28, fig. 18, slide #404-1 (40.3-115.1); P.N. 14275; fig. 16, slide #404-5 (38.8-123.4); fig. 17, slide #404-4 (51.4-124.4) 1947 Micrhystridium fragile DEFL; p. 8, fig. 13.

Description: Vesicle spherical; thin-walled; smooth; spines hollow with closed pinnate tips; 18 to 20 in number; each $3.0-6.0\mu$ long with a basal diameter of $0.5-1.0\mu$; transparent and colourless; diameter of vesicle 10.0 (12.0) 15.0μ .

Discussion: Somewhat similar to *Baltisphaeridium jansonii* n. sp. in general appearance, but lacking the vesicle granulation and smaller in size than that species. DEFLANDRE's original description makes no mention of this species possessing hollow spines but the very small size of the spines makes observation difficult and this feature may have escaped notice.

Genus Filisphaeridium Staplin, Jansonius & Pocock

1962 Micrhystridium setasessitante JANS.; p. 85, pl. 16, fig. 50. 1965 Filisphaeridium setasessitante (JANS.) STAP., JANS. & POC.; p. 192.

Diagnosis: Vesicle thin-walled; spherical; smooth; ornamented with numerous, more or less stiff, solid, very thin, thread-like spines; spines cylindrical; usually unbranched; may be pinnate or may have a thickening or swelling at either, or both ends.

Remarks: The solid, cylindrical, thin, rod-like spines distinguish this genus from *Micrhystridium*. *Baltisphaeridium* differs in the punctate wall of the vesicle and the differentiation of the wall structure between the vesicle wall and spine walls.

Filisphaeridium helios (VAL.) n. comb.

Pl. 28, fig. 4, slide #404-1 (45.9-117.8); fig. 5, slide #404-1 (48.4-117.9); fig. 6, slide #404-4 (51.4-124.4)

1953 Micrhystridium inconspicuum DEFL. var. helios VAL.; p. 54, pl. 2, fig. 10, Lectoholotype.

Description: Vesicle spherical; very thin-walled; smooth; spines solid; fimbriate; pinnate; 11 (13) 18 in number; 2.0 (3.1) 5.0μ long with a basal diameter of less than 0.25μ ; transparent; colourless; diameter of vesicle 8.0 (9.6) 12.0μ .

Discussion: These grains appear to agree in all respects with VALENSI'S *M. inconspicuum* DEFL. var. *helios* which is here elevated to a full species.

Filisphaeridium bullosum (VAL.) n. comb.

Pl. 28, fig. 12, slide #2266-5 (35.5-124.5); P.N. 14277; fig. 13, slide #394C-D (33.4-120.7); fig. 14, slide #404-1 (45.5-111.1); fig. 15, slide #400-1 (41.2-119.1)

1953 Mitchystridium inconspicuum DRFL. forma bullosa VAL.; p. 53, pl. 7, fig. 14, Lectoholotype.

Description: Vesicle spherical; smooth; less than 0.25μ thick; spines fimbriate; pinnate; 20 (25) 30 in number; 5.0 (6.3) 8.0μ long, arising from bases less than 0.25μ wide; colourless and transparent; diameter of vesicle $16.0 (17.s) 21.0\mu$.

Discussion: The spherical vesicle and radiating fimbriate spines distinguish this species from all others recorded from the Jurassic.

Filisphaeridium cf. F. piveteaui (VAL.) n. comb.

Pl. 28, fig. 19, slide #424-4 (39.6-127.3); fig. 20, slide #424-1 (37.6-114.3)

1953 Micrhystridium pivetaui VAL.; p. 56, pl. 7, fig. 37.

Description: Vesicle spherical to ovoid; thin-walled; smooth; covered with a large number (over 45) hair-like spines $5.0-7.0\mu$ long and less than 0.25μ wide; transparent and colourless; diameter of vesicle $11.0 (12.7) 14.0\mu$.

Discussion: Similar to Micrhystridium inconspicuum DEFL. and M. castanium VAL. but narrowerspined than the former and longer-spined than the latter.

Genus Acanthodiacrodium Tim.

1958 Acanthodiacrodium dentiferum Tim.; p. 831, pl. 1, fig. 2; pl. 3, fig. 2.

Diagnosis: Vesicle spherical, or more often, ovoid; smooth, scabrate or granulose. Ornamented with hollow or solid spines which are concentrated at two opposite extremities of the vesicle.

R emarks: Grains assigned to this genus have previously only been reported from the Lower Paleozoic but the following species appears to fit the genus satisfactorily.

Acanthodiacrodium jurassicum n. sp.

Pl. 28, fig. 25, slide #404-4 (41.8-119.3) Holotype; P.N. 14279

Description: Vesicle spherical; thin; smooth; spines possibly hollow; very thin and hair-like; about 15 in number; averaging 5.0μ long and concentrated at two opposite extremities of the vesicle, leaving the remainder of the vesicle unornamented; transparent; pale yellow; diameter of vesicle approx. 12.0 μ .

Genus Multiplicisphaeridium Staplin

1961 Multiplicisphaeridium ramispinosum STAPLIN; pl. 48, fig. 24, text-fig. 9g-h, type species.

Diagnosis: Vesicle ellipsoidal to spherical. Processes separate, narrow-based, tips multifurcate, expanded, dissected, or otherwise modified but not open. Processes all of one type, not differentiated into distinctive orders or kinds of processes. Wall surface exclusive of processes, smooth to finely granulose.

Discussion: Differs from *Baltisphaeridium* in that the processes are always hollow and open into the vesicle. They are not strengthened at their bases and the spine interior never becomes closed off from the interior of the vesicle. In *Baltisphaeridium* the spines are always simple, either branching or unbranching. In *Multiplicisphaeridium* the spines always branch and frequently exhibit quite complex multifurcation.

Multiplicis phaeridium vestitum (DEFL.) n. comb.

Pl. 27, fig. 20, slide #1857-2 (20.0-121.7); P.N. 14282; text-fig. 30.

1938 Hystrichosphaeridium vestitum DEFL.; p. 189, pl. 11, figs. 4-6.

Description: Vesicle spherical; granulose; wall 0.5-1.0 thick; processes radially disposed with respect to the vesicle; narrow; cylindrical; 7.7 (9.9) 11.0μ long; spaced $1.0-3.0\mu$ apart; processes bifurcate, frequently more than once, towards their tips (see diagram); smooth; hollow with closed tips; colour pale brown; diameter of vesicle $44.3-47.0\mu$.



Fig. 30. Multiplicisphaeridium vestitum (DEFL.) n. comb. Structure of processes,

Discussion: The bent condition of the processes on the illustrated specimen cause them to appear to be shorter than they actually are. The species has been provisionally assigned to *Multiplicisphaeridium* in the absence of a more suitable taxon. It is recognized that it will probably have to be transferred to a new genus eventually, but it is not considered desirable to erect one on the basis of this one species.

Genus Comasphaeridium STAPLIN, JANSONIUS & POCOCK

1948 Micrhystridium cometes VALENSI; p. 545, fig. 5.

1965 Comasphaeridium cometes (VAL.) STAPL., JANS. & POC.; p. 192.

Diagnosis: Vesicle spherical or ovoid, frequently reaching relatively large size. Ornamented with crowded, thin, solid, usually unbranched, more or less flexible, fimbriate spines.

Discussion: Fineness and density of hair-like spines and their relatively dense spacing are characteristic. Differs from *Filosphaeridium* which has less crowded, somewhat stiffer and firmer spines and is usually of smaller size.

(?) Comasphaeridium sp. A

Pl. 28, fig. 38, slide #2258-2 (31.6-128.5)

1962 Baltisphaeridium parvispinosum (DEFL.) COOKS. & EISEN.; in SARJEANT; p. 488, fig. 9d.

Description: Vesicle ovoid; translucent; finely granulosc; spines solid, about 6.0μ long and less than 0.25μ wide; all about the same length; fimbriate; cylindrical; pinnate; spaced $2.0-4.0\mu$ apart and covering the entire vesicle; colourless; size of vesicle $40.0 \times 34.0\mu$.

Discussion: The grains described and figured by COOKSON & EISENACK (1957) and SARJEANT (1962) as *Baltisphaeridium parvispinosum* are ovoid in shape. The original *Micrhystridium parvispinosum* DEFL. (1946) and *M. parvispinosum major* DEFL. 1946 (figs. 6—9 & 10 respectively) are spherical grains with exceedingly short spines and do not appear to belong to the same species. In the event of DEFLANDRE's species not being validly published, the specific epithet *parvispinosum* may possibly be valid for COOKSON & EISENACK's (1957) grains but until the matter is satisfactorily sorted out, it is not considered desirable to employ a specific epithet for the latter grains.

Subgroup Pteromorphitae DOWNIE, EVITT & SARJEANT

Genus Pterospermopsis WETZEL

1952 Pterospermopsis danica WETZEL; p. 412, pl. A, fig. 16, text-fig. 34, type species.

D i a g n o s i s : Vesicle spherical to sub-spherical, frequently somewhat flattened. Wall two-layered. Outer layer envelopes vesicle and extends beyond it equatorially in the form of an annular flange. Flange may be relatively narrow to very wide, thick or thin.

Pterospermopsis bulbosa n. sp.

Pl. 23, fig. 13, slide #304-1 (41.3-117.2) Holotype; fig. 12, slide #304-4 (40.9-120.0); P.N. 14284; text-fig. 31

Description: Vesicle comprises a central rounded boss about 10.0μ in diameter surrounded by five, or rarely six, similar rounded bosses, the whole structure having the appearance of a group of closely packed spheres; base of vesicle flat; vesicle surrounded equatorially by a somewhat inflated flange; flange circular in outline; somewhat undulose due to radial folding; folds flat-topped; slightly meandering; 6.6 (9.9) 13.2μ wide; folds most pronounced around the equatorial margin of the flange, dying out towards the vesicle; more strongly developed on lower than on upper side; vesicle two-layered; outer layer infrareticulate; brocci rounded; 0.5- 2.0μ wide; surface scabrate; flange finely granulose; colour pale yellow; diameter of grain 40.0 (47.7) 55.0 μ ; diameter of central body 25.0 (32.0) 38.5 μ ; thickness of grain approx. 16.0 μ ; thickness of flange approx. 5.0 μ .

Fig. 31. Pterospermopsis bulbosa. Section through vesicle.

Pterospermopsis macroptera Döring

Pl. 28, fig. 44, slide #100-5 (45.0-115.3); P.N. 14286; text-fig. 32

1961 Pterospermopsis macroptera Döring; pp. 111-112, pl. 16, figs. 5-8.

Description: Vesicle spherical to sub-spherical; circular to sub-circular in outline; scabrate, surrounded equatorially by a very broad, annular, somewhat inflated flange; flange circular in outline; granulose to scabrate; outline somewhat undulose due to radial folding; folds broad and irregular; continuous from equator to outer margin of vesicle; upper side of grain traversed by a thickened band of tissue of the outer layer about 4.0μ wide which extends the full diameter of the grain but cannot be detected at the equatorial outline; vesicle yellow-brown; flange colourless; equatorial diameter $45.1-50.6\mu$; diameter of vesicle 15.4 -16.5μ .

Fig. 32. Pterospermopsis macroptera Döring. Section through vesicle.

Discussion: Döring described this species from strata of Portlandian age.

Pterospermopsis doeringii n. sp.

Pl. 28, fig. 45, slide #1857-6 (26.6-113.1) Holotype; text-fig. 33

Description: Vesicle flattened ovoid; oval in outline; 1.5μ thick; enveloped in a transparent outer layer which extends beyond the equator of the vesicle to form a glange $3.6-6.0\mu$ wide completely encircling the vesicle; outer layer about 2.0μ thick; punctate; punctations spaced about 1.5μ apart; a thickened band of tissue of the outer layer about 8.0μ wide traverses the upper face of the grain longitudinally; flange shows little tendency towards radial folding; vesicle amber, flange colourless; size range of grain 51.7 x 35.2; size range of vesicle $39.6 \times 35.2\mu$; thickness of grain 9.0μ ; thickness of flange 2.0μ .

Discussion: Differs from all other species of *Pterospermopsis* in its oval outline combined with thick vesicle and relatively narrow flange.

Named for Dr. H. DÖRING in recognition of this contribution to Jurassic Palynology.

Fig. 33. Sections through the vesicle ot *Pterospermopsis doringii* n. sp.









Pterospermopsis rugosa n. sp.

Pl. 27, fig. 7, slide #1977-1 (43.5-117.2). Holotype; P.N. 14288; text-fig. 34

Description: Vesicle flattened-spherical; circular in outline; scabrate; surrounded equatorially by a broad, annular, somewhat inflated flange; flange circular in outline, scabrate, somewhat undulose due to radial folding; radially wrinkled in a series of flat-topped, somewhat meandering folds, each about 2.5μ wide; folds most pronounced around the margin of the vesicle and dying out towards the outer margin of the flange; colour brown; diameter of vesicle $20.0-22.0\mu$ diameter of flange $57.0-64.0\mu$; thickness of vesicle 6.0μ approx.



Fig. 34. Section through the vesicle of *Pterospermopsis* rugosa n. sp.

Pterospermopsis scabrata n. sp.

Pl. 27, fig. 6, slide #1977-1 (33.0-125.3) Holotype; P.N. 14289; text-fig. 35

Description: Vesicle flattened-spherical; circular in outline; scabrate; one face thinned and frequently torn; surrounded equatorially by a broad, inflated, annular flange; flange circular in outline; margin somewhat undulose; wall about 2.0μ thick; flange scabrate; not clearly differentiated from vesicle; colour orange-brown; diameter of vesicle $20.0-22.0\mu$; diameter of flange $65.0-77.0\mu$; thickness of vesicle (compressed) 4.0μ .



Fig. 35. Section through the vesicle of Pterospermopsis scabrata n. sp.

Discussion: Flange more inflated and lacking the characteristic wrinkling shown by P. rugosa n. sp.

Subgroup Polygonomorphitae Downie, Evitt & Sarjeant

Genus Wilsonastrum JANSONIUS

Text-fig. 36

1962 Wilsonastrum colonicum JANSONIUS; pp. 88-89. 1963 Veryhadnium (DEUNEF) WALL & DOWNIE; pp. 771-775 & 778.

Diagnosis: Vesicle relatively small, tetrahedral, polygonal, lenticular or sub-circular; angles drawn out into a small number of long or short processes which are closed at the tips and hollow and opening into the interior of the vesicle; one or more short, solid, bristles may be present, usually arising from a slightly differentiated area near the centre of one or more faces of the vesicle; vesicle laevigate or with minor ornament.

Discussion: The main differences between this genus and Veryhachium (DEUNFF, 1959) are that the type of the latter genus is much larger and thicker-walled, its test is more hyaline in appearance and it never possesses solid bristles. Veryhachium, in the sense employed by WALL and DOWNIE (1962), is synonymous with Wilsonastrum.

Fig. 36. Variations in one species of Wilsonastrum.

Species assigned to Wilsonastrum grade into Micrhystridium with increasing number of spines. Most common specimens of Wilsonastrum carry three or four spines but extreme forms may have seven to ten. Some authors (e. g. WALL & DOWNIE, 1962) include such forms in *Micrhystridium*. Statistical analysis of *Wilson-astrum colonicum* JANSONIUS indicates that the concept of *Wilsonastrum* and *Micrhystridium* forming a plexus of intergrading forms is oversimplified and somewhat misleading. Although extremes of variation of *Wilson-astrum* fall within the genus *Micrhystridium* on one hand and *Leiofusa* on the other, there is no extensive overlap and individual species form well defined and easily recognizable groups of individuals.

At the lower limit of spina variation *Wilsonastrum* grades into *Leiofusa*. While most species of *Leiofusa* are well defined ad distinct, it can be shown that there is a definite gradation between one form of *Leiofusa* and *Wilsonastrum colonicum*. The accompanying diagram of specimens from the lower member of the Vanguard formation at its type locality illustrates four specimens grading from a normal *Leiofusa* on the left to *Wilsonastrum* on the right.

Wilsonastrum colonicum JANSONIUS

Pl. 27, fig. 14, slide #1967-6 (41.0-122.8); figs. 12 and 18, slide #1967-9 (35.0-120.5); P. N. 14305; text-fig. 37

1953 (?) Micrhystridium polyedricum VAL. var reducta VAL.; p. 60, pl. 9, fig. 7. 1962 Wilsonastrum colonicum JANSONIUS; p. 89, pl. 16, figs. 42-49.

Description: Vesicle polygonal to sub-lenticular (outline triangular to sub-circular); wall 0.5— 1.0μ thick; laevigate to faintly scabrate; corners drawn out into tapering, hollow spines with closed tips; spines may be either broadly conical processes continuous with, and not sharply differentiated from, the vesicle or relatively long, narrow, pinnate processes fairly sharply differentiated from the vesicle; spines three to ten in number; about twenty percent of the specimens have a thin stiff bristle, or bristles, projecting from a small thickening or fold at the middle of one of the faces; colourless.

Grains of this species may be grouped into two forms, neither of which is sufficiently distinct to warrant separate specific assignment.

Form A: Vesicle tetrahedral to polygonal; spines broadly conical; not sharply differentiated from the vesicle; spines may, or may not, be terminated with solid fimbriae of varying length; spines 3 (4) 7 in number with a length of 3.0 (6.0) 15.0μ ; vesicle 11.0 (15.0) 21.0μ in diameter.



Fig. 37. Size range and spine counts for Wilsonastrum colonicum Jaxs. Forms A and B.

Form B: Vesicle sub-lenticular; spines at least partly hollow, relatively long, narrow and pinnate: sharply differentiated from the vesicle; spines 2 (3) 10 in number with a length of 3.0 (6.0) 15.0μ ; vesicle 9.0 (15.0) 21.0μ in diameter.

D is cussion: Specimens of the two forms of \mathcal{W} . colonicum occur in about equal numbers in the assemblages studied. The accompanying graphs, based upon measurement of 200 specimens of each form, illustrate variations in overall diameter, number and length of spines for each form. All three graphs show that although the extremes of variation are about the same for both forms, form A is better defined than form B. The graphs for spine length and vesicle diameter show curves with pronounced "tails" of abnormally large forms.

Genus Veryhachium DEUNFF

1951 Hystrichosphaeridium trisulcatum DEUNFF; p. 822, fig. 9, type species.

1954 Ueryhachium trisulcatum (DEUNFF); pp. 305-306.

1959 U. trisulcatum (DEUNIF); pp. 26-27, pl. 1, figs. 4-13, validation of type species.

Diagnosis: Vesicle tetrahedral, polygonal, leaticular or subcircular. Small or relatively large. Angles drawn out into a number of long or short processes which are closed at the tips and hollow and opening into the interior of the vesicle. Bristles never developed. Vesicle wall transparent or translucent; smooth and hyaline.

Discussion: For differences between this genus and Wilsonastrum, see under the latter genus.

Veryhachium pyriforme n. sp.

Pl. 27, fig. 27, slide #1967-9 (43.4-123.7) Holotype; P.N. 14290; fig. 28, slide #1967-9 (36.9-126.5)

Description: Vesicle more or less pear-shaped, the narrow end being extended into a relatively long, pinnate spine; wall about 0.5μ thick; laevigate to finely scabrate; three or four pinnate spines, each about 12.0μ long and 5.0μ wide at their bases, symmetrically disposed around the widest portion of the vesicle; spines hollow; continuous with the vesicle; colourless to pale yellow; length of vesicle (including spines) $27.0-27.5\mu$; width of vesicle $12.0 (12.1) 13.0 \mu$.

Discussion: The grains are very similar to *Wilsonastrum colonicum* JANSONIUS in general appearance and structure. The typical pear-shaped vesicle, symmetrical disposition of spines and lack of the bristle present in *Wilsonastrum* are characteristic of the species.

Veryhachium sp. A

Pl. 27, fig. 26, slide #1967-9 (33.8-124.5)

Description: Vesicle relatively small, pear-shaped, drawn out at the narrow end into a pinnate spine about 16.0μ long and at the wider end into a shorter spine about 5.0μ long; spines hollow; equatorially two slightly curved hollow, pinnate spines are developed; each spine about 4.0 long and up to 1.0μ wide; one spine arises from a distinct outfold of the vesicle wall about 7.0μ long and 3.0μ high; vesicle singlelayered; less than 0.25μ thick; scabrate; colourless to pale yellow; length (including spines) 27.5; width (including spines) 13.0μ .

Veryhachium reductum (DEUNFF) JEKHOWSKY

Pl. 27, fig. 19 slide #1824-2 (47.0-124.9)

1958 Veryhachium trisulcatum (DFF.) 1952 var. reductum DFF. 1958. 1961 V. reductum (DFF.) JEKHOWSKY; p. 210, pl. 2, figs. 22—36.

Description: Vesicle outline triangular; sides slightly convex; wall smooth; $1.0-1.5\mu$ thick; corners drawn out into three hollow, tapering, pinnate spines with closed tips; spines may become more or less solid as the result of subsequent deposition of wall material; no bristles were observed on any specimen of this species; transparent and colourless; diameter of vesicle 27.0 (32.0) 39.0μ ; length of spines 15.0 (17.2) 39.0; width of spine bases $6.0-9.0\mu$; width of spines at mid-point 3.0 (3.5) 4.0μ .
Discussion: Similar to *Wilsonastrum colonicum* JANSONIUS but larger in size, always three-spined and never showing the bristle characteristic of *Wilsonastrum*.

Subgroup Partitomophitae POCOCK & SARJEANT

Acritarchs with circular to ovoid vesicles comprising three parts; two more or less equal sized parts forming the main vesicle and a smaller apical cap.

Genus Rugidinium Pocock & Sarjeant

1971 Rugidinium POCOCK & SARJEANT Bull, Geol, Soc. Denmark (in press).

Diagnosis: Vesicle ovoid to sub-sphaerical and comprising three dissimilar portions. Wall two-layered, the outer layer rugulose, giving the surface an overall undulose appearance. Other ornament, when present, comprises anastomosing narrow ridges more or less paralleling the margins of the two portions making up the vesicle.

Type species: Rugidinium ornatum POCOCK & SARJEANT.

Rugidinium ornatum POCOCK & SARJEANT

Pl. 29, figs. 12-13, slide #394-11 (37.0-119.0) P.N. 14296; fig. 14, slide #394-41 (32.3-120.6) P.N. 14297; figs. 15-16, slide #394-11 (37.8-112.0) P.N. 14298; text-fig. 39, slide #394-31 34.8-118.6) Holotype. P.N. 14295

1971 Rugidinium ornatum POCOCK & SARJEANT, Bull. Geol. Soc. Denmark (in Press).

Description: Vesicle oval to sub-circular; longer than it is wide; comprises two dissimilar portions, one smaller than the other and both irregular in shape (see diagrams); vesicle open at the apex, the aperture being covered in complete specimens by a small rounded cap. This has never been observed in position on the Canadian specimens, but isolated caps are present in some preparations. Vesicle two-layered; inner layer about 1.0μ thick; outer layer approximately the same thickness; rugulose; rugulae very low and irregularly disposed giving the surface a broadly undulose appearance; area flanking the sutures between the two portions of the vesicle ornamented with very characteristic elongate anastomosing ridges about 1.5μ wide and 0.5μ high; central area of each portion of the vesicle darker, and presumably somewhat thicker, than the remainder of the vesicle; colour deep yellow-brown.

Size range: Holotype 81.4 x 77.0 μ . Individual vesicle sections: a) Larger 60.0 (69.0) 81.0 x 30.0 (56.6) 77.0 μ



Fig. 38. Larger (left) and smaller (right) portions of vesicle of Rugidinium ornatum SARJ. & POCOCK.

b) Smaller 30.0-33.0 x 40.0-70.0 μ .



Fig. 39. Specimen of Rugidinium ornatum lacking only the small, apical, plate.

Discussion: Very variable, the two halves of the vesicle, in particular, varying in size, shape and ornament. The anastomosing ridges are frequently lacking from the smaller portion. In only one case was a complete specimen observed, but isolated fragments are abundant.

Rugidinium undulatum POCOCK & SARJEANT

Pl. 38, figs. 17-18, slide #394-11 (40.0-121.5) Holotype. P.N. 14299

Rugidinium undulatum Рососк & SARJEANT. Bull. Geol. Soc. Denmark (in press).

Description: Vesicle oval to sub-circular; longer than it is wide; comprises two dissimilar portions, one smaller than the outer but both broadly oval in outline; vesicle two-layered; inner layer about 1.5μ thick; smooth; tightly appressed to outer layer; outer layer about 1.0μ thick; finely rugulose; rugulae very low, narrow and fairly closely packed, giving the surface of the grain an overall finely undulose appearance; co-lour pale yellow; size range $60.5-80.0 \times 90.0-125.0\mu$.

Holotype: $60.5\mu \ge 90.0\mu$.

Discussion: Only one complete specimen (but without cap) was observed. Isolated fragments are fairly common in the upper part of the Shaunavon formation. The aperture at the apex of the vesicle was presumably closed by a third plate, or cap, but this has not yet been observed either in place or loose in palynological preparations. Differs from R, ornatum n. sp. in lacking the surface ornamentation of anastomosing ridges and in possessing more regularly shaped portions making up the vesicle.

Class Acanthophyceae

Genus Botryococcus Kutzing

1849 Botryococcus algarum KUTZING; p. 982.

D i a g n o s i s : Colonial algae of the class Acanthophyceae. Colonies composed of a number of more or less spherical aggregates with radially arranged cells embedded within a mucous envelope which is folded or wrinkled and frequently drawn out into irregular lobes or spine-like processes. In the fossil state the actual cells are not present, only the cups in which they were contained remaining.

Botryococcus luteus TRAVERSE

Pl. 29, figs. 1-4, slide #425-8 (34.3-116.7) P.N. 14301; fig. 5, slide #425-8 (32.0-119.8); fig. 6, slide #425-8 (32.0-119.7)

cf. 1849 Botryococcus braunii Kützing; p. 892.

1955 Botryococcus luteus TRAVERSE; p. 79, pl. 18, fig. 148.

Description: Colonial; comprising a series of rounded conical cups of "thimbles" disposed radially in a mass of amorphous to finely granulose tissue; individual cups 3.3 (5.2) 9.0μ across with walls $1.0-2.0\mu$ thick and 5.2 (8.8) 11.0μ deep; colonies grow by division of cells along the longitudinal axis, daugther cells forming new cups within the old cups of the parent cells; this type of division results in the formation of more or less spherical colonies which develop into large botryoidal masses; in larger colonies there is a tendency for the tissue surrounding individual cups to thicken and become more dense, losing its granulose character; individual cups become more widely separated, being spaced $5.0-10.0\mu$ apart; color pale yellow. Colonies examined range in diameter from 50.0 to 500.0μ .

D is cussion: Morphologically similar colonies to those described above have been recorded from sediments ranging in age from Ordovician to Recent. At certain horizons *Botryococcus* is a rock former, making up the bulk of the substance of Boghead coals and Torbanites. It may be a major contributor to the hydrocarbon content of many oil-shales (see TRAVERSE, 1955). *Botryococcus* appears to have been deposited in shallow, rather muddy, but open water some distance from standing vegetation. TRAVERSE (1955), JESSEN & MIL-THERS (1928), RAISTRICK & MARSHALL (1939) note that boghead coals commonly occur in lenticular bodies and interpret this as indicating accumulation in lakes or pools. The recent deposit, coorongite, formed of *Botryococcus*, accumulates in an inlet of the sea where marine waters are diluted with river water. In the Canadian sediments *Botryococcus* is associated with spores and pollen of land plants and also with a few marine cysts and dinoflagellates, the latter an indication of brackish water or marine elements in the depositional environment. Most probably the colonies lived in a shallow, muddy, brackish water environment, possibly in lagoons and inlets along a relatively low-lying coastline.

PALYNOLOGICAL ZONATION

In all branches of paleontology it is frequently difficult to communicate results in a meaningful and readily understandable manner to those working on stratigraphy or other branches of geology. The geologist works with rocks and tends to think and write in terms of definite lithologic entities which are distinguishable from each other by lithologic differences. Such units are essentially local in character and eventually lose their character when traced far enough away from their type localities. This loss of identity may take place in a distance of a few miles or a few thousand miles, but with all lithic units it will take place. No formation can have worldwide distribution and very few approach continent-wide extent. The paleontologist is not directly concerned with lithologic units. His units are based upon changes in assemblages of organisms due to evolution through time and to environmental variation. Since organic assemblages at any given time under similar environmental conditions tend to be recognizably similar over large (frequently world-wide) areas, units, stages or zones based upon such assemblages are frequently of almost worldwide significance. If correctly established, zones are based upon evolutionary changes within an organic assemblage over a period of time significance. From this fact is developed the abstract concept of 'hemera'.

A consideration of methods of sedimentation indicates that lithologic units can have no such time significance and although deposition of a given stratum may, under some conditions, have taken place at about the same time over relatively large areas, this synchronism cannot have persisted over the entire area of deposition. Thus rock units and paleontological stages and zones are not compatible and cannot be directly correlated. This lack of correlation is the major cause of misunderstanding between paleontologist and stratigrapher.

To be of greatest practical value a zonal system should:

a. be based upon changes in whole assemblages rather than appearance and disappearance of individual species.b. be applicable over as large an area as possible.

The European and American paleontological stage systems based upon marine faunal changes meet both of the above requirements, although in the Canadian Jurassic they are frequently impossible to apply since much of the sediment represents brackish water or continental facies. An additional difficulty in applying these stages to palynological studies arises from the fact that one is dealing with flora and not fauna, and the rates of floral and faunal development do not always correspond.

It is evident, therefore that a system of zones based upon floral changes as reflected by palynological assemblages is required. It is possible either to erect a system of zones applicable only to Canada and based upon Canadian type sections or to modify an existing system to fit the Canadian section. The latter course is preferable since such a system will have wider applicability. The literature of North America and Western Europe failed to yield reference to such an established system but the Russian literature yields more satisfactory information. Considerable work has been carried out on Mesozoic palynology throughout the Soviet Union and many floral provinces have been recognized and delineated. In some instances changes in one-age sporepollen complexes have been studied over large areas. Most important, a floral zonal system has been established which appears to be applicable over almost all of the Soviet Union. Canadian Mesozoic spore-pollen assemblages can be fitted into this system very satisfactorily. An additional advantage is that the system is flexible. permitting closer sub-division as further data becomes available. Fig. 40 shows the position of these florules with respect to the European stages and the Jurassic sequence in Siberia and the Far East. As may be seen from the chart, the designation for each floral zone is made up as follows:

- 1. A letter or letters, designating the geologic system, e.g. J = Jurassic, Cr = Cretaceous, etc.
- 2. A figure indicating the part of the system, e. g. J1 = Lower J urassic, J2 = Middle Jurassic, etc.
- 3. A superscript number to the previous figure indicating the actual zone. These figures increase from base to top of stratigraphic interval, 1¹, 1², 1³ etc.
- 4. A small letter, either m or t, indicating a marine or terrestrial aspect respectively. Thus J2²m indicates a marine Middle Jurassic floral zone which is underlain by one other zone of Middle Jurassic age. J1¹+J1¹ indicates the lowest Jurassic floral zone which, in this case, is terrestrial in character.

A given floral zone may, or may not, have the same limits as a stage and these limits may correspond in one area and not in another. In general, palynological zones in the Canadian Jurassic section have the same limits as stages, this being in large part due to the fact that the limits of Jurassic stages in Canada are marked

SYSTEM	STAGE	FLORA	SERIES		FORMATIONS LENA BASIN	FORMATIONS ZYRYANSK BASIN	FORMATIONS UPPER ALDAN BASIN	FORMATIONS BUREYA BASIN	FORMATIONS SUCHAN BASIN Maritime Province	
LOWER CRET.	VALANGINIAN	Crll			BATYLYKH MANA	SILYAP	KHOLODNIKAN5K	UGRAL'SK		
	UPPER YOLGIAN		СНЕСНОМУК		S YTOGIN			TALYNDZHAN	Major Unconformity	
\$SFC	LOWER VOLGIAN	lł			OZHOGINSK	-				
JURA	KIMMERIDGIAN	ει			GORKITSK	CHAGAN				
UPPE	OXFORDIAN				DZHOSKOY					
	CALLOVIAN									
SSIC	BATHONIAN		IAKUT 92	KHORONG		6 HEAVEY		MARINE JURASSIC		
Idtw Idtw	BAJOCIAN	: J2		ŝ	VERKHEKYSTAT	MARINE	DURATSN	MARINE	Unclassified	
DWER JURASSIC	AALENIAN			SERIE	SERIE	NIZHNEKYSTAT	Unclassified		Unclassified	
	TOARCIAN	3 ار		ILYK		CHEREMKHOV	CHULMAKANSK			
	PLEINSBACHIAN			≦. CHEREMKHO'	CHEREMKHOV		YUKHTA			
	SINEMURIAN	 								
Ľ	HETTANGIAN	л ¹	UKUGUT		ZALAIR					

MMMM UNCONFORMITY. Magnitude of unconformities not indicated on this chart.

Fig. 40. Correlation chart - Eastern Siberia and Vladivostok areas

by unconformities which also influence palynological florules. It is of interest to note that in the Cretaceous of Canada this correspondence is not so close.

The approximate stage equivalents of the floral zones recognized in Canada are as follows:

- J³⁸ Post Kimmeridgian
- J3² Oxfordian & Kimmeridgian
- J31 Callovian
- J²² Upper Bajocian
- J21 Lower Bajocian
- J1³ Lower Jurassic (upper part)
- J1? Lower Jurassic undivided (older than]18)

GEOLOGICAL INTERPRETATION OF RESULTS

In the discussion of geologic ranges, species have been divided into three categories:

- 1. Species previously described with relatively limited stratigraphic ranges.
- 2. New species with relatively limited stratigraphic ranges.
- 3. Species, both new and previously described, with long stratigraphic ranges.

Species in the first two categories are valuable for purposes of correlation, those in the first being also invaluable for dating and zonation. Since many of the species in the first category have only previously been recorded from one or two localities, new records, as expected, extend the known ranges. Conversely, those recorded species whose ranges remain unaltered gain value as zonal species. In time sufficient data will have been collected to indicate those species whose world ranges are sufficiently restricted to make them of value as zone fossils and at such time zonation by key species will be possible. This stage has not yet been achieved in Jurassic palynology and dating by florule is the best that is at present possible. Species in the third category are individually of no value for any but the grossest dating or correlation. Very frequently they form the bulk of an assemblage and their relative proportions may be of value for purposes of correlation. Their main value, however, is in environment and paleobotanical interpretation. Such species have not been listed separately in the following paragraphs but they are readily found in the range chart.

I. Lower Jurassic

a. Floral zone Jt?

Key species for dating: Nil Key species for local correlation: Latensina mesozoica n. sp.

The oldest Jurassic assemblage investigated in the present study, that from the Lower Member of the Watrous Formation of southern Saskatchewan, was not sufficiently large or distinctive, comprising only five species, to permit accurate age determination. *Classopollis classoides* PFLUG is the dominant species, making up over seventy per cent of the total population. *Obtusisporis canadensis* n. sp. is fairly common and *Latensina mesozoica* n. sp., the only other continental species, is exceedingly rare. Of the two species of microplankton, *Leiosphaeridia hyalina* (DEFL.) n. comb. is most abundant although *Evittia waltonii* n. sp. is also quite common.

The dominance of *C. classoides* in this assemblage, together with the presence of *Obtusisporis canadensis* and *Evittia waltonii* which have not been recorded outside the Jurassic System, indicates a Jurassic age for the Lower Watrous. The overlying Upper Member can be dated as upper Lower Jurassic (J1³) with reasonable certainty. Therefore the Lower Watrous must be Lower Jurassic. CHALONER (1962, pp. 25-26) considers dominance of *Classopollis* in Lower Jurassic sediments, at least in Europe, as evidence of basal Jurassic or Rhaetic age. In the present instance it would be difficult to reconcile a basal Jurassic age for the Lower Watrous with other palynological evidence. No palynological break is detectable between the Lower and Upper Watrous, the sparsely fossiliferous strata of the former gradually passing upwards into more richly fossiliferous beds. The presence of the very distinctive dinoflagellate *Evittia waltonii* in both members is also evidence of more or less continuous sedimentation at this time. It would thus appear reasonable to assign the Lower Watrous to the upper part of the Lower Jurassic J1² or the lower part of J1³ florule.

Depositional environment: Ecologically there is reason to suppose that *Cheirolepis*, the plant producing *Classopollis* pollen, favoured coastal environment (POCOCK & JANSONIUS, 1962). From the available palynological evidence it appears that a somewhat restricted terrestrial flora of xerophytic type occupied a relatively dry, narrow, coastal strip backed by extensive desert areas. This concept is in accord with geologic evidence previously cited.

b. Floral zone J1³

The uppermost Lower Jurassic strata of the area under study comprise, in southern Saskatchewan, the UpperMember of the Watrous and the Lower Member of the Gravelbourg Formation which overlies it conformably. The latter correlates with the Nordegg Formation of the Alberta trough.

Upper Watrous

Key species for dating

Species	Previous	Published
	Published	Range
	Record	
Deltoidospora lineata (Волкн.) п. comb.	Viluisk Basin Siberia	J1
Murospora bicollateralis (Rog.) n. comb.	Poland	Ji
Perotriletes variabilis (MAL.) n. comb.	W. Siberia	Jı
Concavissimisporites trichopunctatus (THIERG.) n. comb.	Germany	J1—J2
Key species for local correlations:		
Ovalipollis minor n. sp.		
Cedripites minor n. sp.		
Solisphaeridium watrousense n. sp.		

Palaeontographica Bd. 137. Abt. B

The Upper Watrous of Saskatchewan has yielded sixteen terrestrial and four marine species and is generally more richly fossiliferous than the Lower Member of the formation. These species are not sufficiently distinctive to permit any closer dating although the occurrence of C. trichopunctatus, which is confined to the uppermost Lias and Dogger in Germany, is suggestive of an horizon in the upper part of the interval. The fact that there is a smooth gradation between assemblages from the Upper Watrous and the overlying Lower Gravelbourg, and that there is geologic conformity between the two members, indicates that their ages are probably very close. Since the Lower Gravelbourg carries an uppermost Lower Jurassic assemblage it is reasonable to assign the Upper Watrous to the upper part of the Lower Jurassic.

Depositional environment: Classopollis classoides is still the most abundant species in all Upper Watrous assemblages and possibly indicates that the climate was still fairly dry. The majority of other spores are of types produced by pteridophytes which probably lived in low-lying, swampy areas. Bisaccate pollen of types produced by the Coniferales occurs in the Upper Watrous but it is very rare, indicating either that the climate was too dry to permit these plants to thrive in abundance or that there was insufficient relief to permit the efficient drainage needed by many Gymnosperm species.

Lower Gravelbourg

Key species for dating:

Previous Published Species Published Range Record Concavissimisporites subgranulosus (COUPER) n. comb. Brit. Isles J1-J2 = Trachysporites fuscus Nilsson Sweden]1 Ceratosporites rotundiformis (KARA-MURZA) n. comb. Viluisk Basin & Russian Arctic IL Sweden and Poland Lycopodiumsporites pseudoannotinus NILSSON]1 = Lycopodium annotinum LINN, in ROGALS&A Poland Л W. Australia J1 & J3 Inaperturopollenites turbatus BALME Key species for local correlation: Murospora minor n. sp.

Ceratosporites jurassicus n. sp.

Dictyotidium eastendense n. sp.

Leiosphaeridia staplinii n. sp.

L. tangentensis n. sp.

The Lower Gravelbourg has yielded twenty-one terrestrial, and seven marine species. Although Classopollis is still dominant a variety of other species also occurs in significant quantity and the abundance of spores in the strata is far greater than in the Watrous Formation. The general character of assemblage is not greatly different from that of the Upper Watrous. Species such as Deltoidospora minor (COUPER) n. comb., D. australis (COUPER) n. comb. var. rimalis BALME, Vitreisporites spp., Excsipollenites tumulus BALME, and E. scabratus (COUPER) n. comb. which become abundant in the Middle Jurassic, first appear in the Lower Gravelbourg and indicate some approach to Middle Jurassic conditions. The key species named above indicate a definite Lower Jurassic dating for the member, but the presence of forms typical of higher horizons indicates an horizon in the upper part of the Lower Jurassic.

The depositional environment for the Lower Gravelbourg was, as for the Watrous Formation, marine. Acritarcha belonging to a limited number of species are extremely abundant at some horizons, the two species *Dictyotidium eastendense* and *Leiosphaeridia tangentensis* frequently making up the bulk of an assemblage. No dinoflagellates have been recorded. The ecology of these forms is unknown and the significance of the somewhat unusual assemblages, apart from suggesting a somewhat restricted environment, is therefore not determinate. The increasing number of terrestrial species in the assemblage, together with the larger variety of forms, indicates more favourable, presumably less arid, climatic conditions. The top of the Lower Gravelbourg is frequently marked by a bed carrying abundant *Botryococcus* associated with terrestrial species. This bed is indicative of a freshwater, or at most only slightly brackish water, environment and marks the end of Lower Jurassic marine conditions in Western Canada.

Nordegg Formation

Key species for dating: Nil Key species for local correlations: Leiosphaeridia tangentensis n. sp. vars. A. and B. n. vars. Dictyotidium eastendense n. sp. Micrhystridium polyedricum (DEFL.) DEFL.

Palynological assemblages from the Nordegg formation are, like those of the Lower Gravelbourg, abnormal. Terrestrial species, apart fom *Classopollis* spp., which are fairly common, are rare or absent although fragments of more or less decayed wood cuticle are fairly abundant. The same species of Acritarcha as are dominant in Lower Gravelbourg marine assemblages are dominant in the Nordegg, sometimes occurring in enormous numbers. Associated with these fossils are large quantities of yellow sapropel which wrap round the fossils and frequently make clean extraction impossible. The presence of well preserved cysts and unaltered organic matter indicates deposition in a non-oxidizing environment. The wood remains and *Classopollis* grains which always appear to be more or less corroded may have suffered some oxidization during transportation, in which case their source was probably a relatively long distance from their final resting place, or they may have suffered post depositional bacterial decay. The better preservation of the microplankton could be explained in the latter case by assuming that their cuticles were more resistant to bacterial action than those of terrestrial plants. The Nordegg Formation cannot be dated accurately on the basis of included microflora. Fortunately, however, the leiospheres recorded from the Nordegg also occur in the Lower Gravelbourg in association with other more widely distributed microfloral species and a J1³ dating can be assigned with relative certainty.

2. Middle Jurassic

D 111-1-3

a. Floral zone J2¹ (Upper Gravelbourg)

Key species for dating:

.

Species	Previous	Published
	Published	Range
	Record	
Lycopodiumsporites subrotundus (KARA-MURZA) n. comb.	Viluisk Basin	J2
Calamospora mesozoica COUPER	Brit. Isles	J1—J2
Todisporites rotundiformis (MAL.) n. comb.	Siberia	J2
$= \mathcal{T}.$ minor Couper	Brit. Isles	J2
Murospora bicollateralis (Rog.) n. comb.	Poland	J1
Ceratosporites rotundiformis (KARA-MURZA) n. comb.	Russian Arctic]1
Lycopodiumsporites pseudoannotinus NILSSON	Sweden]1
= Lycopodium annotinum LINN. in ROGALSKA	Poland	Jı
Tigrisporites cf. T. halliensis (KLAUS)	Germany	Triassic
Distalanulisporites incertus (BOLKH.) n. comb.	Viluisk	J1—J2
Corrugatisporites anagrammensis (KARA-MURZA) n. comb.	Siberia	J1—J2
= Cicatricosisporites dunrobiensis COUPER	Brit. Isles & Sweden]1
Inaperturopollenites turbatus BALME	W. Australia	J1—J2
Paleoconiferous asaccatus BOLKH.	Viluisk Basin, Siberia	JI—J2
Protoconiferus microsaccus (COUPER) n. comb.	Brit. Isles, Canada	J2—]Ց
Protopicea exiliaides (BOLKH.) n. comb.	Siberia	J3—Cr1
Protoconiferus funarius (NAUM.) BOLKH.	Viluisk Basin	J2—J3
P. flavus Bolkh.	Viluisk Basin	յլ
Pityosporites divulgatus (BOLKH.) n. comb.	Siberia	J١
P. similis BALME	W. Australia	J2—J3

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5.00.0	0100
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Ovalipollis bitorosa (REISS.) POC. & JANS. O. enigmatica (COOPER) POC. & JANS. O. limbata (MAL.) POC. & JANS. = Chasmatosporites radiatus NILSSON Gerebropollenites macroverrucosus (THIERG.) Bennettiteacpollenites lucifer THIERG. Concentrisporites sulcatus (ROG.) n. comb. Lycopodiumsporites dejerseyi n. sp.

Key species for local correlation: Gleicheniidites nilssonii n. sp. Walchites minor n. sp. Podocarpidites convolutus n. sp. Concentrisporites chilcotensis n. sp. Manumia verrucatus n. sp. Concavissimisporites delcourtii n. sp. C. southeyensis n. sp. Verrucosisporites staplinii n. sp. Converrucosisporites hughesii n. sp. Dictyotriletes arkellii n. sp. Lycopodiumsporites microreticulatus n. sp. Trilobosporites jurassicus n. sp.

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Previous
                                   Published
Published
                                   Range
Record
Germany
                                  ]2-[3]
Brit. Isles
                                  J١
Siberia
                                  J2
Sweden
                                  J2
Germany
                                  11
Germany
                                  J2
                                  J2 & ?Cr1
Poland
Oueensland
                                  11
                                  210
Paleoconiferus minor n. sp.
Protoconiferus gaussenianus n. sp.
P. bolchovitina n. sp.
Piceites townrowii n. sp.
Pseudowalchia landesii n. sp.
Vitreisporites jansonii n. sp.
V. jurassicus n. sp.
Podocarpidites florinii n. sp.
Leuckisporites crickmayi n. sp.
Ovalipollis findlaterensis n. sp.
Cerebropollenites findlaterensis n. sp.
Bennettiteaepollenites canadensis n. sp.
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Of the previously described species of limited vertical range occurring in the Upper Gavelbourg, twelve have been recorded from the Lower and Middle, six from the Middle, five from the Middle and Upper and one from the Upper Jurassic. These quoted ranges are probably somewhat more restricted than the true ranges since in some cases (e. g. ROGALSKA, 1956), species have only been described from one-age assemblages and probably will be found to have a longer range when more data become available. It is reasonably certain from the above evidence, however, that the Upper Gravelbourg is Middle Jurassic in age and the abundance of forms previously only recorded from the Lower Jurassic, together with the relative scarcity of Upper Jurassic species, suggests a low Middle Jurassic horizon.

There is a very abrupt change in the character of palynological assemblages at the boundary between the Lower and Upper Gravelbourg, indicating an abrupt change in depositional environment and also suggesting unconformity between the two members. Lithological evidence for unconformity at this horizon is cited in the outline of geological history (pt 1, p. 19). Marine species which are abundant and sometimes dominant in Lower Gravelbourg assemblages are absent or excessively rare in the Upper Member. Bisaccate pollen, which is rare in the Canadian Lower Jurassic, becomes very abundant and frequently dominant in J2¹ assemblages and actual volume of organic matter in the sediment is usually much greater than in the Lower Jurassic. *Classopollis* species, although still quite abundant, are never dominant in the Upper Gravelbourg and C. itunensis replaces C. classoides as the dominant species. The most striking features of the Upper Gravelbourg assemblages are the abundance of fossils in the average sample and the great diversity of species, particularly among pollen of the gymnosperms and pteridosperms. A thin, but very extensive, coal seam is developed in the Yarbo-Findlater area of southeastern Saskatchewan, which is composed in large part of leaf cuticle and small stem fragments. This seam has yielded the fragments of *Cheirolepis* and araucarian leaf cuticle (T. M. HARRIS, personal communication) and also the sporangial fragment with associated Classopollis classoides grains. The seam has also yielded numbers of excellently preserved, fully inflated spores and pollen which were invaluable for the interpretation of detailed spore morphology.

There is little palynological evidence for any extensive marine sedimentation in the Upper Gravelbourg strata. The few marine forms were recovered from locations in the extreme south of Saskatchewan and over the bulk of the area of sedimentation the beds are in fresh water or terrestrial facies. The abundance of saccate pollen grains in all samples indicates the presence of gymnosperms and pteridosperms in the vicinity. The former group, judging from the ecology of Recent species, favours a well drained environment with a moderate to heavy rainfall, the amount of rain which a given species will tolerate frequently varying with the quality of the drainage. Taken together, palynological and lithological evidence suggest that whilst the Upper Gravelbourg was being deposited, the bulk of the area was above sea level, only the extreme southernmost part of Saskatchewan being submerged. This sea was bordered by a relatively flat, swampy area lying at, or just above, sea level over which plant material accumulated. This material was washed into the swamp from well drained upland areas to the north and, possibly, east which supported a relatively rich flora. The richness and diversity of the palynological assemblages from this interval suggest that this upland area was fertile and probably experienced moderate rainfall.

Chilcotin area, Coast Range trough

Key species for dating:

Species

Obtusisporites lineatus (BOLKH.) n. comb. Pityosporites similis BALME Key species for local correlation: Gleicheniidites nilssoni n. sp. Walchites minor n. sp. Podocarpidites convolutes n. sp. Concentrisporites chilcotinensis n. sp. Cynatiosphaera hancevilliana n. sp. Leiosphaeridia variabilis n. sp.

Previous	Published
Published	Range
Record	
Viluisk Basin, Siberia	J۱
W. Australia	J2—J3

Only two species recorded from the Chilcotin area are of sufficiently short range for dating purposes and these suggest an upper Lower or Middle Jurassic age for the assemblage. The first four of the short ranging local species cited above are sufficiently distinctive to permit correlation of the assemblage with the Upper Gravelbourg, and a J2¹ dating to be assigned.

Middle Jurassic assemblages have been recorded from a number of localities in the Chilcotin area, but the variety of species is usually very restricted and the state of preservation poor. The two marine species, *Cymatiosphaera hancevilliana* and *Leiosphaeridia variabilis*, appear to be confined to Middle Jurassic and to date have only been recorded from the Chilcotin and Yukon areas where they are frequently abundant. These two species permit correlation and dating of many isolated Middle Jurassic occurrences where the variety of species is restricted. The best assemblage of this age so far recorded from the Chilcotin area was recovered from a volcanic tuff collected a few miles north of Alexis Creek, a settlement on the William's Lake Bella Coola highway about 40 miles west of William's Lake. The assemblage was fairly rich in species and the grains excellently preserved. It has been used in this work as a reference assemblage for the Middle Jurassic of the Coast Range trough.

The Middle Jurassic assemblages from the Chilcotin area are marine in character. Leiosphaeridia variabilis and various unidentified simple acritarchs were recorded in all assemblages in varying abundance. It is significant that assemblages carrying the greatest proportion of marine material also contained *Classopollis classoides* as dominant terrestrial species whilst those with only rare marine grains carried the greatest variety of terrestrial species and the greatest abundance of bisaccate grains. It is also significant that the abundance of marine forms in the Middle Jurassic assemblages decreases from south to north across the northern portion of the Chilcotin area, marine species being relatively rare in assemblages recovered from outcrops and from the Nazko well, north of the Chilcotin valley. This suggests that at this time a land barrier may have existed separating the Chilcotin area from the Hazleton — Takla basin, further north, where Middle Jurassic strata also occur.

Lower Fernie

Towards the base of the Fernie formation of Alberta, the palynological assemblages become less strongly marine in character. Due to tectonism, individual species are rarely identifiable and dating by means of palynology is frequently impossible. In a few instances, however, shales below the Rock Creek member of southern

Alberta and the Wanham sand of northeastern British Columbia have yielded assemblages with abundant *Classopollis itunensis*, *C. classoides* and *Callialasporites* ssp. which also carry the typical Upper Gravelbourg species *Calamospora mesozoica* and *Concentrisporites chilcotinensis*. These assemblages are frequently rich in bisaccate pollen as are the typical Upper Gravelbourg assemblages. They are probably J2¹ in age.

Associated with the terrestrial species in these assemblages are marine cysts of the *Leiosphaeridia hyalina* type and microforaminifera of several unidentified types indicating that the shales are of marine origin.

Other localities

A Middle Jurassic (J2¹) assemblage of general Upper Gravelbourg type has been recorded from the base of the Jurassic section exposed in the Miner Anticline on the Yukon-Alaska border. Only a limited number of species were recorded, all of them terrestrial. The assemblage was too small to justify assumption of a non-marine origin for the deposit.

It is probable that strata of J2¹ age occur fairly extensively in other parts of the Yukon and also in the Canadian Arctic, but too little work has, as yet, been carried out on these deposits to be certain.

b. Floral zone J2² (Shaunavon Formation)

The Shaunavon formation has been divided into two members which carry significantly different assemblages and these will be discussed separately.

Lower Shaunavon

Key species for dating: Published Previous Species Published Range Record W. Australia J2—J3 Baculatisporites truncatus BALME Ш Sweden and Poland Lycopodiumsporites pseudoannotinus NILSSON L. subrotundus (KARA-MURZA) n. comb.]2 Viluisk Basin & Russian Arctic Pityosporites divulgatus (BOLKIL) n. comb. Siberia J2—J3 W. Siberia J3 Platysaccus lopsinensis (MAL.) n. comb. Brit. Isles, Canada 12-13 Protoconiferus microsaccus (COUPER) n. comb. 13 & Cr1 Viluisk Basin Podocarpidites unicus (BOLKH.) n. comb. J2—J3 Viluisk Basin J1-J2 Palaeoconiferus asaccatus BOLKH. N. France]\$ Gonyaulacysta pachyderma DEFL. Australia JS Cyclonephelium areolatum Cooks. & EISEN. Brit. Isles J2—J3 Pareodinia ceratophora DEFL. Germany Jĭ Tasmanites suevicus (EISENACK) n. comb. J₽ Solisphaeridium fragile (DEFL.) n. comb. France Filosphaeridium helios (VAL.) n. comb. France J2 J2 F. bullosa (VAL.) n. comb. France France]2—]3 Solisphaeridium stimuliferum (DEFL.) n. comb. Brit. Isles J2—J3 S. recurvatum (VAL.) n. comb. France J2 Brit. Isles J2—J3 Key species for local correlation: Podocarpidites rousei n. sp. Triangulopsis minor n. sp.

Verrucosisporites eastendensis n. sp. Endosporites jurassicus n. sp. Podocarpidites rousei n. sp. P. langii n. sp. Chasmatosporites canadensis n. sp.

The Lower Shaunavon has yielded twenty six non-marine and twenty four marine species. The assemblage is sufficiently distinctive to be assigned a Middle Jurassic (J2) age with complete confidence. Lower Jurassic species are comparatively rare in the assemblage, but a considerable number of the key species range into the Upper Jurassic. This suggests the possibility of the member belonging to a relatively high horizon in the Middle Jurassic, possibly as high as Bathonian. There is, however, no paleontological evidence for the occurrence of Bathonian strata north of the California Coast and typical Bathonian ammonites are not present in the Fernie formation although J2² palynological assemblages occur. The Bathonian dating of the Shaunavon by WALL (1960) is based upon the assumption of a Bathonian age for its correlatives, the Piper and Sawtooth formations in Montana, and not upon direct paleontological evidence. As discussed in the outline of geological history (pt. 1, p. 20-21), there is considerable evidence of an unconformity involving the entire Bathonian stage over most of western North America and it is considered most probably, therefore, that the Shaunayon formation is Upper Bajocian in age.

As may be seen from the section and vertical variability diagram (fig. 41), the transition from the dominantly terrestrial Upper Gravelbourg to the marine Lower Shaunavon strata is fairly abrupt and there may be slight non-sequence at the boundary although there is little or no lithological evidence for this. The abundance of dinoflagellates, which are dominant in many samples, indicates the proximity of a source of nutrient and the possibility of a not-too-far-distant shoreline. The good preservation of the terrestrial species, together with their moderate abundance, also supports the above suggestion. Too little is known regarding the ecology of fossil microplankton to permit deductions regarding water salinity or temperature. The occurrence of lithographic limestones, onlites and, in some localities, corals suggests, however, that the water must have been relatively warm and shallow.

The most obvious difference between the terrestrial florules and those of the underlying Upper Gravelbourg strata is the increase in the relative abundance of trilete spores, possibly indicating growth in a less well drained environment. The occurrence of Botryococcus in moderate abundance in most Lower Shaunavon samples suggests that the shoreline may have been backed in many areas by extensive fresh water marshes in which algae abounded. *Classopollis classoides* and *C. minor* are more abundant that in the Upper Gravelbourg and may locally form the dominant element of the terrestrial palynological florule. As previously mentioned, they represent pollen grains of plants which probably favoured a fairly dry, coastal environment and indicate that some parts of the Lower Shaunavon coastline must have been dry and reasonably well drained.

Upper Shaunavon

Key species for dating:

Species	Previous Published Record	Published Range
Gonyaulacysta ornata (EISENACK) n. comb. Cymatiosphaera teichophera SARJEANT Filisphaeridium bullosum (VAL.) n. comb. Solisphaeridium deflandrei (VAL.) n. comb.	Germany & France Brit. Isles France France	J2—J3 J3 J2 J2
Key species for local correlation:		
Verrucosisporites eastendensis n. sp. Endosporites jurassicus n. sp. Podocarpidites rousei n. sp. P. langii n. sp.	Chytroeisphaeridia variab Pterospermopsis bulbosa n Rugudinium ornatum n. sy R. undulatum n. sp.	<i>vilis n.</i> sp. 1. sp. 2.

Upper Shaunavon assemblages are very similar to those recovered from the Lower Member and are certainly of almost the same age (J2²). Outside the area of southern Saskatchewan the members cannot be separated on a palynological basis.

The most obvious difference between assemblages from the two members is that the Upper Shaunavon assemblages contain a much higher percentage of terrestrial species and evidently represent deposition in a near-shore environment. The change from predominantly carbonate to a sand-shale lithology supports such a conclusion. Trilete spores and Classopollis spp. increase fairly rapidly from the bottom towards the top of the member. Bisaccate pollen grains first increase in relative abundance and then decrease again towards the top of the member. These variations in the various fossil groups (see fig. 41) probably indicate a retreat of the sea which left large tracts of low lying marshy land along the coastline where ferns and other plants favouring a humid environment thrived. Towards the top of the member an abrupt change of environment must have taken place which may mark the climax of the period of uplift beginning at the close of the Lower Shaunavon and



Fig. 41. Type section Shaunavon and Gravelbourg formation

marking the end of Middle Jurassic sedimentation in Western Canada. This change is marked in palynological assemblages by a corresponding increase in non-marine forms. Over a large area of southern Saskatchewan a bed carrying an abundance of *Botryococcus* (up to twenty five per cent of the total assemblage) marks this horizon. Associated with this bed are large numbers of well preserved trilete spores and pollen grains of the genus *Callialasporites*. The abundance of *Classopollis* sp. shows a fairly sharp decline at this horizon (see fig. 41). This "*Botryococcus* bed" is of fresh water (or very much diluted brackish water) origin and the abundance of trilete spores also suggests a swampy environment. It appears to be identical to the Charophyte-ostracod zone described from southern Saskatchewan by WALL (1960, p. 37) and is probably time equivalent of the Fernie belemnite bed (Rock Creek Member) of the Fernie Formation of southern Alberta and the Wanham Sand of the Dawson Creek region of British Columbia.

Sawtooth Formation

Key species for dating:

As for Shaunavon formation.

Key species for local correlation:

Walchites minor n. sp. Lophodictyotidium sarjeantii n. sp. Leiosphaeridia sarjeantii n. sp. Scriniodinium gochtii n. sp. Gornudinium stavelyense n. sp. Tenua evittii n. sp.

The palynological assemblages from the Sawtooth formation of southern Alberta are essentially similar to those from the Shaunavon of Saskatchewan. Marine species are dominant in all samples examined but the marine content shows less variation through the interval than it does trough the Shaunavon. Among the species of microplankton, *Cornudinium stavelyense* and *Scriniodinium godtii* are very easily recognizable and are useful for correlation throughout the area of the Alberta trough. *C. stavelyense* has been recognized in samples from as far north as the Yukon-Alaska border.

Fernie Formation

Shales towards the base of the Fernie Formation carrying J^{21} assemblages pass upwards into beds with J^{22} palynological floras. The change from one to the other is gradual and no sharp boundary can be picked

between the two. Typical J2¹ species such as Concentrisporites chilcotinensis and Calamospora mesozoica disappear, and Classopollis itunensis and Callialasporites ssp. are much less frequent. Species such as Baculatisporites truncatus and Solisphaeridium recurvatum first occur in J2² assemblages and microforaminifera, which are characteristically abundant in local assemblages of this age, make their appearance. Fernie assemblages of J2² age carry a somewhat higher proportion of marine species than those of J2¹ age which possibly indicates deposition somewhat further from a shoreline. Cornudinium stavelyense and Scriniodinium gochtii have been recorded from the Rock Creek Member which marks the top of the Middle Jurassic part of the Fernie Formation.

Deer Bay Formation, Amund Ringnes Island. Canadian Arctic.

Key species for dating:		
Species	Previous Published Record	Published Range
Distalanulisporites incertus (BOLKH.) n. comb.	Viluisk Basin	J1J2
Lycopodiumsporites subrotundus (KARA-MURZA) n. comb.	Viluisk Basin	J2
	Russian Arctic	J2—J3
Podocarpidites micus (BOLKH.) n. comb.	Viluisk Basin	31
Lycopodiumsporites pseudoannotinum Nilsson	Sweden & Poland	J2J3
Protoconiferus microsaccus (COUPER) n. comb.	Brit. Isles	J3Cr1
	Canada	J1-J2
Palaeoconiferus asaccatus BOLKH.	Viluisk Basin	[2]3
Protopicea exilioides (BOLKH.) n. comb.	Siberia	J2 J3
Pityosporites similis BALME	W. Australia	J2
Cerebropollenites macroverrucosus THIERG.	Germany]2
Filisphaeridium bullosum (VAL.) n. comb.	France	J2
Solisphaeridium recurvatum (VAL.) n. comb.	France, Brit. Isles	J3J3
Key species for local correlation:		
Podocarpidites rousei n. sp.		

There is no doubt as to the $J2^2$ age of this assemblage, or to its correlation with the Shaunavon Formation of southern Saskatchewan. The Deer Bay Formation, in its type area on Ellef Ringnes Island, carries several species of *Aucella, Acroteuthis, Inoceramus* and *Arctica* (HEYWOOD, 1956). These fossils indicate an uppermost Jurassic, or even Neocomian dating for the strata. Only the upper 600 feet, however, are exposed at the type area and on Axel Heiberg Island over 2,500 feet of sediment have been assigned to the same formation. The Amund Ringnes exposures may correlate with the lower part of the Axel Heiberg section, or alternatively, may represent a completely different formation with similar lithology. The latter possibility may be the true solution to the age difference since geologic exploration of the Canadian Arctic is in its infancy and large areas are still completely unknown.

Assemblages of J2² age from the Arctic and other parts of Canada are, considering the enormous distances involved, remarkably similar. The most noticeable differences between the Arctic assemblages and those from further south are that in the former *Classopollis* spp. are exceedingly rare and *Callialasporites* species completely absent. Saccate pollen grains of the pteridosperms and gymnosperms are more abundant in the Arctic assemblages than in either the Shaunavon or Fernie Formations. Examination of published records of Jurassic palynological assemblages from other parts of the world supplemented by a study of preparations from other areas, indicates that these variations have a worldwide significance which is probably most easily explained as a result of plant zonation due to latitudinal temperature variation. This is discussed in more detail in the section on Jurassic climate.

Other areas

Marine assemblages comprising poorly preserved fossils of a very limited number of species have been recovered from a number of scattered localities in the Chilcotin area of the Coast Range trough. The various

Pseudowalchia landesii n. sp. Pseudowalchia ovulis n. sp. Leiosphaeridia asymmetrica n. sp. Plerospermopsis doringii n. sp. assemblages carry sufficiently similar assemblages of Acritarcha, dinoflagellates and lesser numbers of spores and pollen to permit the assumption that they are of the same age. Several of these assemblages have yielded species such *Filisphaeridium helios*, *F. bullosum*, *Solisphaeridium stimuliferum* and *Endosporites jurassicus* which suggest a J2² dating but cannot be considered sufficiently distinctive to make it completely certain. The assemblages are dominantly marine in character and the abundance of Acritarcha and relative scarcity of non-marine species suggests an offshore environment.

Middle Jurassic marine assemblages, including the very distinctive species Cornudinium stavelyense, have been recorded from a few isolated localities in the Yukon area. The known distribution of Upper Jurassic sediments in this general area, together with the relative abundance of $J2^2$ species as derived fossils in Lower Cretaceous assemblages, indicates that future geologic exploration will probably considerably extend the known outcrops of this age.

3. Upper Jurassic

Previous

Published

a. Floral zone J31 (Lower Vanguard)

Key species for dating:

Species

	Published Record	Range
Obtusisporis corniger (Волкн.) n. comb.	Viluisk Basin	J3
Harrisispora subsimplex (BOLKH.) n. comb.	Viluisk Basin	J3
Baculatisporites truncatus (COOKS.) BALME	W. Australia]2—J3
Pilosisporites brevipapillosus Couper	Brit. Isles	J2
Ceratosporites rotundiformis (KARA-MURZA) n. comb.	Viluisk Basin	Jı
Dictyotriletes crateris (BALME) n. comb.	W. Australia	J3
= Klukisporites variegatus COUPER	Brit. Isles	J2
Lycopodiumsporites pseudoannotinus NILSSON	Poland and Sweden	JI
Distalanulisporites incertus (BOLKH.) n. comb.	Viluisk	
Corrugatisporites anagrammensis (KARA-MURZA) n. comb.	Viluisk Basin	J1—J2
- ·	Russian Arctic	J1— J2
Lycopodiacidites baculatus Pocock	Canada	J8
Callialasporites infrapunctatus (LANTZ) n. comb.	Brit. Isles	J8
Triangulopsis discoidalis Döring	Germany	J3
Pityosporites divulgatus (BOLKH.) n. comb.	Viluisk Basin	J3
Cerebropollenites macroverrucosus (THJERG.) n. comb.	Germany	J2
Concentrisporites sulcatus ROGALSKA	Poland	J 1
Gonyaulacysta ornata (EIS.) n. comb.	Germany & France	J2J3
Chytroeisphaeridia chytroeides SARI.	Brit. Isles	J3
Solisphaeridium recurvatum (VAL.)	France	J2
Filisphaeridium bullosum (VAL.) n. comb.	France	J2
Solisphaeridium stimuliferum (DEFL.) n. comb.	France and Brit. Isles	J2 J3
Wilsonastrum colonicum JANSONIUS	Canada	Triassic
Key species for local correlation:	Bennettiteaepollenites shau	<i>navonensis</i> n. sp.
Manumia irregularis n. sp.	Scriniodinium klementii n.	sp.
Undulatisporites pflugii n. sp.	S. reticulatum n. sp.	
Acanthotriletes midwayensis n. sp.	Leptodinium norrisii n. sp.	
Bellisporites pallescens (BOLKH.) n. comb.	Opaeopsomus wapellensis r	ı. sp.
Ceratosporites dettmannii n. sp.	Tenua evittii n. sp.	
Staplinisporites jurassicus n. sp.	Chytroeisphaeridia scabrat	a n. sp.
Distalanulisporites schulzii n. sp.	Cyclodictyon minor n. sp.	
Lycopodiacidites spinatus n. sp.	Leiosphaeridia eisenackii n.	sp.
Verrucosisporites variabilis n. sp.	L. granulata n. sp.	
Callialasporites crenulatus n. sp.	Tasmanites rushlakensis n.	sp.
Padocarpidites wapellensis n. sp.	Pterospermopsis rugosa n. s	sp.
Vitreisporites craigii n. sp.	P. scabrata n. sp.	
Ovalipollis canadensis n. sp.	Micrhystridium ovale n. sp.	
Ovalipollis minor n. sp.	Tenua granulata n. sp.	
Ginkgoretectina ferraei n. sp.		

Although the Lower Vanguard Member of southern Saskatchewan has yielded very large and distinctive palynological assemblages, relatively few of the species are of value for long distance correlation and dating. The reason for this is that comparatively few papers have been published on the palynology of sediments of this age and therefore little control is available. Of the twenty-two species considered of possible value for dating, five have been recorded from the Lower, ten from the Middle and eleven from the Upper Jurassic, some being common to more than one interval. On this basis the member can be placed either in the upper Middle or lower Upper Jurassic. As noted in connection with the Upper Shaunavon, there is lithologic evidence for unconformity between that member and the Lower Vanguard. As may be observed from the fossil lists, there is also a considerable difference between Upper Shaunavon and Lower Vanguard palynological assemblages. This change is abrupt, indicating a definite time break between the two assemblages. An abrupt change is also observable in the abundance of various groups making up the florules at one point. Some of these changes, particularly noticeable in some of the marine groups, are shown on fig. 40 above the "Botryococcus bed" towards the top of the Upper Shaunavon. On the basis of this evidence it would appear reasonable to assign the florule to the basal part of the Upper Jurassic, with the designation J3¹. The Callovian microfaunal dating for this member (WALL, 1960, pp. 28-31) supports the palynological dating.

The J3¹ floral zone comprises a relatively large proportion of marine species in all localities studied, with the exception of Cornwall Island in the Canadian Arctic where a terrestrial florule, apparently of J3¹ age, has been found. The Lower Vanguard was probably deposited further offshore than were marine sediments of the Upper Shaunavon. The consistently marine nature of J3¹ assemblages over large areas of Western Canada supports the conclusion reached from other geologic criteria that this was the period of maximum Jurassic marine transgression over the North American continent. The non-marine element in the zone is relatively rich in the number of species of trilete spores although the actual abundance of such spores in the total assemblage is not great. *Classopollis* is always abundant, *G. classoides* frequently dominating the non-marine element. Saccate pollen are relatively rare, although frequently very well preserved.

The marine content of Lower Vanguard assemblages increases fairly regularly from the bottom of the member upwards. Towards the top, a sudden burst of abundance marks a dinoflagellate zone dominated by the species *Leptodinium norrisii*. This zone forms a good marker horizon across southern Manitoba, Saskatchewan and Alberta. Above it there is a sharp decline in the marine content of assemblages with a correspond-



Fig. 42. Type section Lower Member Vanguard formation

ing increase in non-marine groups. The dinoflagellate zone is probably to be interpreted as indicative of the beginning of a period of regional uplift (the Agassiz orogeny) which resulted in erosion and an influx of nutrients into the J3¹ sea, providing conditions favourable to dinoflagellate 'bloom' (for an account of dinoflagellate 'bloom' in recent seas, see KOFOID, 1911). The increase in the proportion of non-marine species in the assemblages immediately overlying the dinoflagellate zone at the top of the Lower Vanguard (fig. 42), indicates further uplift and probably nearer shore depositional environment.

In southern Alberta the Rierdon Formation is the lateral stratigraphic equivalent of the Lower Vanguard and carries assemblages identical to those recovered from the latter member.

Fernie Formation

 $J3^{1}$ assemblages have not been recovered from the Fernie Formation in some parts of southern Alberta. Detailed palynological examination of the Fernie in some well sections southwest of Calgary failed to yield assemblages of this age despite close sampling and the fact that the underlying $J2^{2}$ and overlying $J3^{2}$ zones were well represented, whilst other wells revealed very reduced sections. This indicates the possibility that the strata of $J3^{1}$ age have, at some localities, been completely cut out between the Bathonian and Callovian-Oxfordian unconformities. Further north, the $J3^{1}$ zone is extensively represented within the Fernie Formation both in western Alberta and northeastern British Columbia.

Yukon area

Key species for dating:

Species	Previous Published Record	Published Range
Dictyotriletes crateris (BALME) n. comb. Cicatricosisporites dorogensis POT. & GELL. Distalanulisporites incertus (BOLK.) n. comb. Corrugatisporites anagrammensis (KARA-MURZA) n. comb. Protoconiferus microsaccus (COUPER) n. comb. Pityosporites divulgatus (BOLKH.) n. comb. Gonyaulacysta cladophora DEFL. G. jurassica DEFL. Chytroeisphaeridia diytroeides SARJ. Pareodinia ceratophora DEFL. Scriniodinium subvallare SARJ. Tasmanites suevicus EIS.	W. Australia & Brit. Isles Europe, N. America & Australia Viluisk Basin Viluisk Basin & Russian Arctic Brit. Isles & Canada Viluisk Basin France & Germany France, Germany & Brit. Isles Brit. Isles France & Brit. Isles Brit. Isles Germany	2
Key species for local correlation:		
Obtusisporis canadensis n. sp. Dictyotidium eastendense n. sp. Cvathidites dewintonensis n. sp.	Podocarpidites florinii n. sp. Ceratosporites dettmannii n. sp. Gleicheniidites nilssonii n. sp.	

Callovian strata, carrying the $J3^1$ assemblages, are extensively developed in the Yukon-Alaska border area. As yet they have only been identified from a few localities, but these are sufficiently scattered and cover a sufficiently long vertical interval to indicate the presence of extensive outcrops. The florules are marine in character and remarkably similar to those of the Lower Vanguard of Saskatchewan and the depositional environment must have been closely similar. The $J3^1$ assemblages from the Yukon area differ from those from other parts of Canada in including a moderate percentage of reworked spores from older formations. Such reworked spores also occur in younger Jurassic sediments in the same area and indicate that older rocks in the vicinity were undergoing erosion during Upper Jurassic time. They also, indirectly, suggest the presence of an emergent area in the vicinity with unusually great relief for the Canadian region at this time.

Podocarbidites rousei n. sp.

Deer Bay Formation, amund Ringnes Island, Canadian Arctic

Key species for dating:

Pseudowalchia ovalis n. sp.

Published Previous Species Published Range Record W. Australia Crl Stereisporites clavus (BALME) n. comb. Brit. Isles J1-Je Alisporites thomasii (COUPER) NILSSON Swedcn]1—J2 J3—Cr1 Canada Viluisk Basin JS. Podocarpidites unicus (BOLKH.) n. comb. J8 Siberia Platysaccus lopsiensis (MAL.) n. comb.

Key species for local correlation:

Endosporites jurassicus n. sp. Concentrisporites chilcotinensis n. sp. Micrhystridium ovale n. sp.

Although not as rich in species as the previous J^{31} assemblages described, there can be no doubt as to the age of the florule.

The principal differences between this and J3¹ florules from southern Canada are the rarity or absence of Classopollis and Callialasporites and the greater numerical abundance of saccate pollen in the Arctic florules These features appear to have a supra-continental significance and are discussed in the chapter on Jurassic climate. The J3¹ florules from the Deer Bay formation are, like those previously discussed, marine and indicative of an offshore open sea facies.

An Upper Jurassic florule carrying an abundance of spores and pollen grains and being particularly rich in saccate grains, has been recovered from coals exposed on the eastern side of Cornwall Island. This florule, which is listed among the assemblages from control localities at the end of this work, cannot be dated with complete certainty despite the variety of species and extremely good preservation of the fossils. On the basis of current data, it is probably of J31 age, but there is a possibility that future study may indicate a somewhat older or younger age. This florule carries no definitely marine species although a few cysts and algal colonies have been recorded. Most probably the assemblage is indicative of an emergent region, swampy in part, but including areas of moderate relief and moderately good drainage.

Coast Range trough

As mentioned in the introduction, extensive outcrops of shales, agglomerates and tuffaceous greywackes, dated by means of ammonites, occur in the Coast Range trough. Palynological assemblages have been recovered from these strata outcropping on the shores of Chilko and Tatlyoka lakes in the Chilcotin area of central British Columbia. Unfortunately, these assemblages carry no characteristic species of value for dating or correlation. Classopollis spp., Callialasporites spp. and Deltoidospora spp. are the most common terrestrial forms and simple acritatchs dominate the marine spectrum. The marine forms always dominate the assemblage and the depositional environment was probably open marine.

b. Floral zone J3² (Middle Vanguard - Lower part)

Key species for dating:

Species	Previous	Published	
	Published	Range	
	Record		
Lycopodiacidites baculatus Pocock	W. Canada	J3	
Gonyaulacysta cladophora (DEFL.) n. comb.	France, Germany, Brit. Isles	J2—J3	
Gonyaulacysta crassicornuta (KLEMENT) n. comb.	Germany	Ĵ2	
Scriniodinium subvallare SARJ.	Brit. Isles	J3	
Cannosphaeropsis caullieryi (DEFL.) SARI.	France, Brit. Isles	- Ĵ3	
Multiplicisphaeridium vestitum (DEFL.) n. comb.	France	<u>J</u> 3	
Solisphaeridium stimuliferum (DEFL. n. comb.	France, Brit. Isles	J2—J3	
Key species for local correlation:	Gonyaulacysta canadensis n. sp),	
Anapiculatisporites cooksonii n. sp.	G. downie n. sp.		
Reticulatisporites jurassicus n. sp.	Chytroeisphaeridia variabilis n. sp.		
Chasmatosporites cf. C. stelchii n. sp.	Pterospermopsis doringii n. sp.	-	

J3² assemblages have been recorded from the Middle Member of the Vanguard Formation and pass upwards into the basal part of the Upper Member. The Middle Vanguard is separated from the Upper Vanguard on the basis of lithology, the former being a sand deposit, the latter a shale. There is little or no evidence for unconformity between the two. The non-marine species from the Middle Vanguard are not particularly distinctive for purposes of dating. The marine part of the assemblages is closely similar to assemblages described from the Oxfordian and Kimmeridgian of Europe.

The depositional environment for the unit was marine and the microplankton are indicative of offshore, relatively shallow water conditions. The Middle Vanguard sands and associated thin shales carry assemblages dominated by species of *Gonyaulacysta* and *Scriniodinium* and, in particular, species closely related to *G. cladophora*. These very characteristic assemblages can be traced completely across southern Manitoba, Saskatchewan and Alberta at this horizon. They are easily recognizable in the upper part of the Fernie shale of southwest Alberta and can be traced northwards into the Peace River and Dawson Creek areas. They mark the marine transgression following the uplift associated with the Agassiz orogeny previously discussed, and the last marine transgression in the Canadian area during Jurassic time. The marine content of J3² assemblages abruptly decreases at the top of the Middle Vanguard due to a decrease in the abundance of *Gonyaulacysta*: this is probably the result of facies change rather than of any extensive shallowing or influx of terrestrial species. In the lower part of the Upper Vanguard, the marine content of J3² assemblages continues a gradual and fairly regular decrease upwards, probably as a result of a gradually increasing influx of non-marine species. This, in turn, indicates a probably gradual recession of the seas.

Swift Formation (Lower part)

In southern Alberta J3² assemblages, identical to those recorded from southern Saskatchewan, occur in the lower part of the Swift Formation. Vertical variability diagrams for Jurassic sections in this area (see Fig. 43) show the dinoflagellate bed at the base of the Swift which correlates with the Middle Vanguard dinoflagellate bed, and the gradual decrease in marine content above this horizon. In some areas, particularly in the vicinity of the Sweetgras Arch, J3² assemblages are not present, the strata of this age cutting out against a high on the Lower Vanguard surface that may have been emergent during J3² time.



Fig. 43. Compagnie Française des Pétroles Stavely 1

Fernie Formation

Key species for dating:

Species

latysaccus lopsinense (MAL.) n. comb.
iceites latens (BOLKII.) n. comb.
ycopodiumsporites pseudoannotinus NILSSON
. subrotundus (KARA-MURZA) n. comb.
onyaulacysta cladophora (DEFL.) n. comb.
onyaulcysta jurassica (DEFL.) DEFL.
. jurassica DEFL. var. longicornis DEFL.
areodinia ceratophora DEFL.
Uilsonastrum colonicum JANSONIUS
terospermopsis macroptera Döring

Previous Published	Published Range
Record	
Siberia]3
Viluisk Basin	J1—J3
Sweden & Poland]1
Russian Arctic	J1J2
France Germany, Brit. Isles	J2—J3
France, Germany, Brit. Isles]2—J3
France, Germany, Brit. Isles	J2—J3
France and Brit. Isles	J2—J3
Canada	Triassic
Germany	J3

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Species	Previous Published Record	Published Range	
Key species for local correlation:			
Gleicheniidites pflughii n. sp.	Verrucosisporites man	<i>umii</i> n. sp.	
Undulatisporites pflughii n. sp.	Gonyaulax canadensis n. sp.		
Acanthotriletes variabilis n. sp.	Palaeoperidinium ornatum n. sp.		
Couperisporites jurassica n. sp.	Dingodinium cooksonii n. sp.		
Convolutriletes rousei n. sp.	Cymatiosphaera hancevilliana n. sp.		
Foveolatisporites ferniensis n. sp.	Leiosphaeridia asymmetrica n. sp.		

 J^{3^2} assemblages from the Fernie Formation are similar in most respects to those from the Middle Vanguard. They carry a larger variety of species and the total marine content remains more or less constant troughout the interval, an indication that the marine environment in the Alberta trough changes little through J^{3^2} time. Towards the top of the interval, in areas in the extreme west of Alberta, the J^{3^2} strata begin to change facies, the marine content of assemblages dropping off sharply and saccate pollen grains becoming dominant. In these areas the top of the beds of J^{3^2} age mark the top of the dominantly marine regime of Jurassic sedimentation and the oncoming of terrestrial conditions which prevailed at the end of Jurassic time. Fuller discussion of this topic will be found in ZIEGLER & POCOCK, 1960.

Other localities

Definite $J3^2$ assemblages have not been recorded from other Canadian localities. Marine Upper Jurassic assemblages, probably of $J3^2$ age and including *Gonyaulacysta cladophora* and *G. jurassica*, have been extracted from a few isolated samples in the Yukon-Alaska border area and *G. cladophora*, the most abundant dinoflagellate in assemblages of this age, is of common occurrence as a reworked fossil in Lower Cretaceous sediments in the same general area. No assemblages definitely younger than $J3^1$ have yet been recovered from samples from the Canadian Arctic, but it is known from other paleontological evidence that sediments of late Jurassic age occur in the area. Late Jurassic assemblages have been recovered from samples collected in the Chilcotin area of the Coast Range trough, but none could be dated $J3^2$ with certainty.

c. Floral zone J3³ (Upper Vanguard - Upper part)

Key species for dating:

Species	Previous	Published
	Published	Range
	Record	Ŭ
Concavissimisporites subgranulatus (COUPER) n. comb.	Brit. Islcs	J1—J2
Convertucosisporites utriculosus (KRASN.) n. comb.	W. Siberia	Crl
Lycopadiumsporites subrotundus (KARA-MURZA) n. comb.	Siberia and Russian Arctic	j 1— j 2
Lycopodiacidites baculatus Pocock	W. Canada	J3
Murospora mesozoica Pocock	W. Canada	J3
Callialasporites infrapunctatus (LANTZ) n. comb.	Brit. Isles	Ĵ3
Paleoconiferus asaccatus BOLKH.	Viluisk Basin & W. Siberia	J1—J2
Ginkgoretectina couperii (Pocock)	W. Canada	J3
Gonyaulacysta jurassica (DEFL.) DEF.	France, Germany & Brit. Isles	J2—J3
Scriniodinium luridum (DEFL.) KLEMENT	France, Germany & Brit. Isles]2—J3
Pareodinia ceratophora DBFL.	France, Germany & Brit. Isles	J2—J3
Key species for local correlation:		

Acanthotriletes midwayensis n. sp. Verrucosisporites carlylensis n. sp. Reticulatisporites jurassicus n. sp. Corrugatisporites wallii n. sp. Dettmannites ornatus n. sp. Couperisporites vanguardensis n. sp. Lycopodiacidites irregularis n. sp. L. spinatus n. sp. Evittia waltonii n. sp. It is not proposed to discus J^3 assemblages in detail in this work since they have already been described in some detail in the author's previous (1962) work on the Jurassic-Cretaceous boundary in Western Canada. The sediments carrying these assemblages become increasingly less marine from bottom to top and were the last sediments deposited in Canada prior to extensive uplift associated with the Nevadan orogeny which brought the period to an end. The upper part of the Upper Vanguard of Saskatchewan is Post Kimmeridgian in age and the absence of species of Neocomian aspect, such as Pilosisporites trichopapillosus and Concavissimisporites punctatus, from the assemblages, together with the rarity of Cicatricosisporites dorogensis which is quite common in the uppermost Jurassic in some areas, would suggest that a Lower Volgian age is more probable than an Upper Volgian age assignment.

Swift Formation

The upper part of the Swift Formation of southern Alberta carries J^{3^3} assemblages. As with the Upper Vanguard, the marine content of assemblages decreases steadily from bottom to top of the interval (see Fig. 42). At some localities in the western part of the area, the top of the formation is marked by a bed characterized by increased marine content. This bed is traceable into the upper part of the Fernie Formation and evidently represents a local and temporary marine transgression from the southern part of the Alberta trough. Evidence of this local transgression can be seen in the topmost beds of the Swift Formation shown in Fig. 44. The extent of this transgression has not yet been determined and the microplankton which appears from the few samples studied to have some distinctive characters, has not been investigated in detail.



Fig. 44. Abundance of Jurassic Microfossil Groups South West Alberta

Fernie Formation

Key species for dating: Species

Species	Previous	Published
	Published	Range
	Record	
Lycopodiumsporites subrotundus (KARA-MURZA) n. comb.	Russian Arctic	J1—J2
Lycopodiumsporites pseudoannotinus Nilsson	Sweden & Poland	JL
Cerebropollenites mucroverrucosus THIERG.	Germany	Ĵ1
Podocarpidites multesimus (BOI.KH.) POCOCK	Siberia	J8-Crl
Piceites pseudorotundiformis (MAL.) n. comb.	W. Siberia	<u>]</u> 3
Gonyaulacysta jurassica (DEFL.) DEFL.	France, Germany, Brit. Isles	J2-J3
G. jurassica DEFL. var. longicornis DEFL.	France, Germany, Brit. Isles	J2-J3

The uppermost beds of the Fernie Formation in southern Alberta carry a J3³ florule and these strata can be traced northward along the Rocky Mountain foothills into the Peace River and Dawson Creek areas of northeastern British Columbia.

To the west and nort, as the mountain front is approached, the marine shales of the upper Fernie pass into sandstones of shallow marine, freshwater and terrestrial origin. The marine strata form the Nikanassin Formation and the freshwater and terrestrial beds of the Kootenay formation.

These two formations have been grouped together by Ziegler & POCOCK (1960) as two facies of the Minnes Formation. The Nikanassin Formation is post Oxfordian in age and the Kootenay Formation at its type section at Grassy Mountain carries a terrestrial spore-pollen assemblage of Lower and, possibly, Upper Volgian age (POCOCK 1964).

Other localities

Palynological assemblages of J3³ type have not, as yet, been recorded from either Yukon territory or from the Canadian Arctic. It is known, however, that sediments of late Jurassic age outcrop on Ellef Ringnes and other of the Arctic islands and there is good reason to believe that strata of the same age await discovery in the Yukon since extensive outcrops of late Jurassic strata are known to occur in Alaska close to the Yukon border.

Late Jurassic palynlogical assemblages have been recovered from dark marine shales outcropping in a gorge at the northwest end of Sapeye Lake in the Chilcotin area of British Columbia. All assemblages recovered contain simple spinose acritarchs and marine cysts of simple types. Microforaminifera, Gonyaulacysta jurassica, Pareodinia ceratophora, Hystrichosphaeridium sp., Palaeohystrichophora sp. are among the marine forms recorded. Classopollis classoides and C. minor dominate the non-marine spectrum and frequently dominate the entire assemblage. Callialasporites spp., another typical Jurassic genus, also occurs in most samples, in a few instances associated with the Cretaceous genus Cooksonites. Species of Cicatricosisporites, Appendicisporites degeneratus, and other forms more often associated with the Cretaceous, have been recorded from isolated samples, suggesting a late Jurassic age for the deposit.

CLIMATE

The interpretation of paleoclimates by means of palynology, or any other branch of paleontology, involves a certain amount of speculation and great caution must be exercised to avoid conclusions based upon too little fact and too much speculation. It should also be noted that, even if the ecology of the plants producing the spores and pollen from Jurassic sediments were known in detail, there would still be insufficient data to make any but the broadest interpretation of Jurassic climatic conditions. In fact, the detailed ecology of very few Jurassic plants is known and only a small number of Jurassic spore species have been associated with their parent plants. Nevertheless, several broad conclusions regarding climatic conditions in the Jurassic period may be drawn from palynological evidence. The similarity of Jurassic assemblages of a given age from different parts of the world is much greater than would be supposed by reference to present-day floras. Even taking into account the fact that many assemblages would tend to be from a similar biotype, that of coastal lowlands, river basins and estuaries, the general similarities are striking. This suggests that during Jurassic time local and regional (latitudinal) climatic zones were not so sharply defined as they are at the present time. One reason for this lack of zonal definition was the lack of continental relief, a major factor in determining present-day climates. The other factor was probably temperature. Jurassic floras rich in both numbers and variety of



species have been recorded from Greenland, northern Norway and the Russian and Canadian Arctic. These regions do not support such rich floras at the present time and, unless there has been an unbelievably drastic change in the tolerance of plants to low temperatures and permafrost conditions since the Jurassic, it must be concluded that temperate climatic conditions extended further north than at the present time. The occurrence of coral reefs in the Jurassic of Europe and the development of oolitic and lithographic limestones with some coral in Canada at least 20° north of the most northerly occurrence of present-day deposits of this type also supports this conclusion. This does not imply that tropical temperatures were any higher than at the present. The implication is that temperate conditions extended much further north than at the present, resulting in wider, less well defined, climatic zones. The lack of detailed information regarding the world distribution of Jurassic spore and pollen groups makes attempts to determine the presenc or absence of latitudinal climatic zonation extremely difficult. Sufficient distribution data are available for three Jurassic genera to warrant the plotting of world distribution patterns. These genera are Classopollis, Callialasporites and Ovalipollis, For Classopollis and Callialasporites Upper Jurassic records were plotted and for Ovalipollis only Middle Jurassic occurrences were used. Of the three groups, Classopollis shows the widest distribution, only being absent from Ceylon, northern Norway, the Russian Arctic and the Alaska peninsula. It is extremely rare, although present, in the Canadian Arctic and both in Canada and Europe increases in abundance in sediments of the same age in a fairly regular manner from north to south. There are insufficient records from the southern hemisphere to determine if there is a south to north increase in Classopollis in that area.

Callialasporites has a considerably more restricted distribution. It has not been recorded in any assemblages from the Arctic regions of either Canada or Russia. It is absent from Alaska, northern and eastern Europe and from northern Asia. In Canada there is a steady increase in the abundance of *Callialasporites* in assemblages from north to south, paralleling the distribution pattern of *Classopollis*. In the southern hemisphere *Callialasporites* is abundant in Australia, from where it was first recorded, and less common in Ceylon, India, Arabia and South Africa. The absence of the genus from an isolated assemblage examined from Florida cannot be considered significant.

Ovalipollis has the most restricted distribution of the three genera, its recorded occurrences all falling be-



Fig. 45

tween 50° and 75° north. Even within this zone *Ovalipollis* is absent from Alaska, Yukon territory, the Canadian Coast Range trough and northern Norway.

All three distribution patterns have one feature in common, a general increase in the abundance of the taxon under consideration in the northern hemisphere in a north to south direction. This indicates the possibility that environmental conditions were less favourable for the three taxa in the extreme northern part of the northern hemisphere and gradualy became more favourable further south.

North south variations in other spore pollen taxa have been detected in Canada and Russia, records from the latter area having been summarized by KARA-MURZA (1960). In both regions the decrease in the abundance of *Classopollis* from south to north is associated with an increase in the abundance of saccate pollen in the reverse direction. Also, in both regions, monosulcate pollen of the *Cycadopites* type is more abundant in the south than in the north. It should be noted, however, that monosulcate pollen are generally much less common in Canadian than in Russian assemblages.

Little is known regarding the ecology of *Ovalipollis* or *Callialasporites*. *Classopollis* probably favoured a coastal environment (POCOCK & JANSONIUS).

The association of *Classopollis* with *Cycadopites* which, at least in part, is composed of cycad pollen, suggests that it also favoured a temperate to warm climate. Saccate pollen was produced by the pteridosperms and conifers. Since pteridosperms are an extinct group, it is hazardous to use them to interpret paleoclimates. Conifers, on the other hand, are abundant at the present time and, in general, favour a temperate climate. It is reasonable to assume that Jurassic conifers were not greatly different from present day forms in this respect and the increasing abundance of saccate pollen from south to north in the Jurassic period may reasonably be supposed to correlate with cooling in this direction. Greater abundance of cycad pollen in the southern part of the northern hemisphere would also support such a conclusion. The world distribution patterns of *Classopollis* and *Callialasporites* in the northern hemisphere can also be most satisfactorily interpreted as resulting from latitudinal climatic zonation, temperatures being cooler in the north than in the south. Such an interpretation would also imply that for the northern continents the poles were in about the same position in Jurassic time that they occupy today.

The distribution of *Ovalipollis* cannot be explained completely on a basis of latitudinal zonation. Its northern limit may well have been controlled by climate but this does not explain the southern limit of the genus. It could be that the mother plants were extremely sensitive to temperature and could only survive within restricted limits of temperature, neither too hot nor too cold. Such taxa, if confined within a narrow climatic zone in the northern hemisphere could conceivably be prevented from migrating to the southern hemisphere by a tropical climatic barrier. This, however, is speculation and must await the accumulation of further data before it can be proved or disproved.

The absence of *Callialasporites* from large areas of eastern Europe and Asia is not easily explicable. There does not appear to have been any insuperable geographic barrier preventing migration of plants into the area from the south or west and, since the genus is quite abundant at the same latitudes in Canada and Western Europe, temperatures do not appear to have been unfavourable. Further data regarding affinities of the genus will have to be collected before a solution to this problem is forthcoming.

Attempts to determine precipitation during Jurassic times are even less satisfactory. The most abundant pollen species, *Classopollis elassoides*, was almost certainly produced by *Cheirolepis*. This plant was somewhat similar to the recent *Juniperus* in structure and appearance although not closely related botanically and, like *Juniperus*, it was possibly adapted to a relatively dry environment. Abundant *Classopollis* in a sample may indicate either an area of relatively low rainfall or that the plants grew in a well drained environment where rain soaked away rapidly. Dominance of *Classopollis* in an assemblage may, or may not, reflect a semi-arid environment. In the Canadian Jurassic *Classopollis* is dominant throughout the Watrous and very abundant in the lower part of the Lower Gravelbourg. It does not again attain dominance until the upper part of the Upper Vanguard. In Europe, zones of *Classopollis* dominance occur in the Rhaetic and Upper Volgian stages. These periods of dominance occur either immediately after or before a period of continental sedimentation. They evidently represent periods when large areas were in process of marine inundation, or when marine waters were receding from large areas and the land climate was relatively dry or, alternatively, the soil on which *Cheirolepis* thrived was well drained. During the remainder of Jurassic time, fairly rich terrestrial palynological assemblages appear to indicate the presence of moderately rich land floras and imply at least adequate rainfall.

JURASSIC RANGES OF SPECIES OF MICROPLANKTON

	J1,	JI2	J21	$J2^2$	J31	J 32]33
Leiosphaeridia hyalina (DEFL.) n. comb.	×	×	×	×	×	×	×
Evittia waltonii n. sp.	×						×
Dictyotidium eastendense n. sp.		×		×			
Leiosphaeridia granulosa n. sp.		×		×	×		
L. staplinii n. sp.		×		×			
L. tangentensis n. sp.		×					
Micrhystridium pivetaui VAL.		×					
M. polyedricum (DEFL.) DEFL.		×					
M. stellatum DEFL.		×					
Solisphacridium watrousensis n. sp.		×					
Cymatiosphaera hancevilliana n. sp.			×				×
LeioJusa ci. L. bacillum DEUNFF			×				
Leiosphaeridia variabilis n. sp.			~	~			
Acanthoaiacroaium jurassicum n. sp.				Û			
Baltisphaeriaium jansonii n. sp.				Ŷ			
Cornualnium stavelyense h. sp.				x		~	
Constructionapphaeriana variavitis fi. sp.				×		~	
Cyclonephettam areolatam COOKS & Els.				×			
Dictionation sharparonense n sp				×			
Filosphaeridium hullosum (V 11) n. comb				×	×		
F heliot (VAX) p comb				×			
Convaular ornata (FIS) KLEMENT				×	×		
G bachyderma DEFI				×	×		
Leiosphaeridia asymmetrica n. sn.				×		×	
L. minutaespinosa p. sp.				×			
Iansonia iurassica E18.				×			
Lophodictvotidium sarieantii n. sp.				×			
Micrhystridium echinoides VAL.				×			
M. inconspicuum DEFL.				×			
Pareodinia ceratophora DEFL.				×		×	×
Polystephanosphaera sp. A				×			
Pterospermopsis doringii n. sp.				×		×	
Rugidinium ornatum n. sp.				×			
R. undulatum n. sp.				×			
Scriniodinium goditii n. sp.				×			
Solisphaeridium deflandrei (VAL.) n. comb.				×			
S. fragile (DEFL.) n. comb.				×			
S. recurvatum (VAL.) n. comb.				×	×		
S. stimuliferum (DEFL.) n. comb.				×	×	×	
Pterospermopsis bulbosa n. sp.				×			
Tasmanites eisenäckn n. sp.				Ĵ			
T. suevicus (Eis.) n. comb.				Û	Ų.		
Tenua evitin n. sp.				Ŷ	<u>^</u>		
Veryhachium pyriforme n. sp.				Ŷ	~		
Chutus sixth anidia chutus aidea Sana				A	×		
Chyleoelsphaetiana chyleoelaes SXRJ.					x		
Caelodictuor minor n. sp.					×		
Laiofusa dountiti n sp.					×		×
Leiosphaeridia eisenackii n. sp					×		
Microvstridium ovale n. sp.					×		
Obacobsomus wabellensis n. sp.					×		
Pterospermopsis rugosa n. sp.					×		
Pterospermopsis scabrata n. sp.					×		
Scriniodinium klementii n. sp.					×		
S. reticulatum n. sp.					×		
Tasmanites rushlakensis n. sp.					×		
Tenua granulata n. sp.					×		

]1;	J12	J21	$J_{2^{2}}$	331	$J3^2$]3a
Veryhadium granulata n. sp.					×		
Cannosphaeropsis caulleryi (DEFL.) SARJ.						×	
Dingodinium cooksonii n. sp.						×	
Conyaulax canadensis n. sp.						×	
G. cf. G. cladophora DEFL						×	
G. crassicornuta KLEMENT						×	
G. downiei n. sp.						x	
G. jurassica DEFL.						×	×
G. jurassica DEFL. var. longicornis DEFL.						×	×
Multiplicisphaeridium vestitum (DEFL.) n. comb						×	
Palaeoperidinium carlylense n. sp.						×	
P. ornatum n. sp.						×	
Pterospermopsis macroptera Döring						×	
Scriniodinium subvallare SARJ.						×	
S. luridum (DEFL.) KLEMENT							×

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Cymatiosphaera hancevilliana, p. 111, pl. 28, figs. 40-41	granulata, Evansia, p. 25, text-fig. 12, pl. 24, fig. 7
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klementii, Scriniodinium, p. 91, text-fig. 7, pl. 23, figs. 1-2

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- Leiofusa cf. L. bacillum, p. 104, pl. 25, fig. 13
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Leiosphaeridia asymmetrica. p. 107, pl. 26, figs. 29-30

Leiosphaeridia eisenackii, p. 105, text-fig. 20, pl. 25, fig. 8

- Leiosphueridia granulosa, p. 105-106, pl. 26, figs. 10-12
- Leiosphaeridia hyalina, p. 104, text-fig. 19, pl. 25, fig. 12
- Leiosphaeridia minutaespinosa, p. 106, pl. 26, figs. 13-14
- Leiosphaeridia sarjeantii, p. 105, pl. 25, figs. 6-7 (?) Leiosphaeridia sp. A, p. 107, pl. 25, fig. 10

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- Micrhystridium ovale, p. 112, text-fig. 29, pl. 27, fig. 9
- Micrhystridium polyedricum, p. 112, pl. 28, figs. 1-3
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- nuda, Pareodinia cf. P., p. 96, pl. 24, fig. 4

Opaeopsomus, p. 96-97, text-fig. 3, pl. 22, fig. 5-6

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Polystephanosphaera sp. A, p. 102, pl. 28, fig. 39

Pterospermopsis, p. 116-118

- Pterospermopsis bulbosa, p. 117, text-fig. 31, pl. 23, figs. 12-13
- Pterospermopsis doeringii, p. 117, text-fig. 33, pl. 28, fig. 45
- Pterospermopsis macroptera, p. 117, text-fig. 32, pl. 28, fig. 44
- Pterospermopsis rugosa, p. 118, text-fig. 34, pl. 27, fig. 7
- Pterospermopsis scabrata, p. 118, text-fig. 35, pl. 27, fig. 6 pyriforme, Veryhachium, p. 120, pl. 27, figs. 27-28

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- Scriniodinium gochtii, p. 90, text-fig. 6, pl. 22, fig. 12
- Scriniodinium klementii, p. 91, text-fig. 7, pl. 23, figs. 1-2
- Scriniodinium luridum, p. 91, pl. 22, figs. 10, 11 and 15
- Scriniodinium reticulatum, p. 91-92, pl. 23, fig. 3 Scriniodinium cf. S. subvallare, p. 92, text-fig. 8, pl. 23,

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- Solisphaeridium fragile, p. 114, pl. 28, figs. 16-18
- Solisphaeridium recurvatum, p. 113, pl. 28, figs. 24, 29, 30, 36 and 21A
- Solisphaeridium stimuliferum, p. 113, pl. 28, figs. 21-23
- Solisphaeridium watrousense, p. 114, pl. 27, fig. 8
- sp. A, (?) Comasphaeridium, p. 116, pl. 28, fig. 38
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- sp. A, Gonyaulacysta, p. 89-90, text-fig. 5, pl. 23, fig. 5
- sp. A, (?) Leiosphaeridia, p. 107, pl. 25, fig. 10
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- stavelyense, Cornudinium, p. 93-94, text-fig. 10, pl. 22, figs. 13-14
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Tasmanites clairmontensis, p. 109, text-fig. 27, pl. 26, figs. 1-3	Veryhachium reductum, p. 120-121, pl. 27, fig. 19
Tasmanites eisenackii, p. 108, text-fig. 24, pl. 26, fig. 8	Ueryhachium sp. A, p. 120, pl. 27, fig. 26
Tasmanites rushlakensis, p. 108, text-fig. 25, pl. 25, fig. 1	vestitum, Multiplicisphaeridium, p. 116, text-fig. 30, pl. 27, fig. 20
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yarboensis, Tasmanites, p. 108, text-fig. 26, pl. 25, figs. 2-3

LITERATURE

The Literature used is already included in the list given in the previous paper (see Paläontographica B 130, p. 121-129, Stuttgart 1970). The following additional references complete this list to the date of the present publication.

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APPENDIX

Corrections to Part 1 of the Palynology of the Jurassic Sediments of Western Canada

Palacontographica Abt. B, Bd. 130, Liefg. 1-6, 1970

- Page 28: Deltoidaspora australis Couper var. rimalis (BALME) n. comb. was omitted from Plate 5. The specimen will be housed at the Geological Survey of Canada, Ottawa (P.N. 13982) where it may be examined.
- Page 32; line 12; slide 1 should read: slide 2.
- Page 33; line 5; add: text-fig. 14.
- Page 35; line 7; (KRUTZSCH) should read: (KRUTZSCH) n. comb. line 29; slide should read: slide 1.

- Page 37; line 31; should read: Pl. 11, fig. 18 A, 426, slide 6 (38.2—118.0); P.N. 14012; pl. 2, figs. 5—6, 2132, slide 11 (32.3—116.2).
- Page 40; line 20; should read: 1953 Undulatisporites microcutis PFLUG in THOMPSON & PFLUG; p. 52, pl. 1, fig. 81. line 25; slide (30.6-126.1) should read: slide 2 (30.6-126.1).
- Page 42; line 8; omit: (here designated).
- Page 48; line 18; figs. 18-29 should read: figs. 18-20.
- Page 49; lines 27, 34, 38; Dettmanites should read: Dettmannites.
- line 37; DETTMAN should read: DETTMANN.
- Page 54; line 5; (IBR.) SCHOPF, WILSON & BENTALL should read: IBRAHIM.
- Page 55; line 33; 1955 should read: 1950
- line 34; 1955 should read: 1956
- Page 58; line 2; figs. 7-8 should read: figs. 7-9.
- Page 59; line 27; Pot. & KREMP should read: Potonié 1956 (Synopsis I, p. 41). line 28; Thoms. & Pflug should read: Weyland & Greif.
- Page 69; Plate 6, Fig. 11; should read: Obtusisporis reticulatus n. sp. Holotype.
- Page 70; Plate 7, Figs. 24, 26; subgranulatus should read: subgranulosus. Fig. 25; Apiculatisporites should read: Apiculatisporis.
 - Plate 8, Fig. 15; Dettmanites should read: Dettmannites.
- Page 71; Plate 11, Figs. 5-6; Corrugatisporites cf. C. curvus Bolkh., n. comb.; Proximal and distal aspects of typical grain. Page 75; between lines 10 and 11; insert:
 - 1934 Pollenites magnus f. dubius Potonić & VENITZ: p. 17, pl. 2, fig. 21. 1953 Inaperturopollenites dubius (Pot. & VEN.) THOM. & PFLUG.
- 1958 designation of lectoholotype; POTONIE; Synopsis II, p. 77.
- Page 85; lines 7, 9; lopsiensis should read lopsinensis.
- Page 90; line 4; fig. 17 should read: fig. 11.
- Page 92; lines 27, 29; KAPYTOVA should read: KOPITOVA.
- Page 94; line 8; pl. 25 should read: pl. 24; fig. II should read: fig. 12.
- line 21; emend. should read: emend. POCOCK & JANSONIUS.
- Page 99; line 33; Tsogaepollenites should read: Cerebropollenites.
- Page 101; line 6; delete at end of line; fig. 5.
- Page 103; line 38; fig. 17 should read: fig. 14.
- Page 105; line 10; add: In POCOCK 1962, in the plate description of Pl. 11, fig. 177 was erroneously identified as the holotype; this should have been fig. 176.

line 12; should read: Pl. 23, fig. 10, 2119, slide 1 (35.6-119.3), P.N. 14303, Holotype.

- Page 105; line 35; delete: fig. 11, 887, slide 1 (39.8-121.7).
- Page 108; line 12; delete: fig. 15, 1816, slide 4 (22.4-111.4).
- Page 109; line 2; Pl. 24, fig. 17, should read: Pl. 23, fig. 24.
- Page 110; line 17; Membranipollenites should read: Concentrisporites.
- Page 111; line 38; ferréi should read: ferreae.
- Page 112; line 29; Pl. 28 should read: Pl. 25.
- Page 127; line 18; MTCHEDLISHVILI, P. A. should read: MTCHEDLISHVILI, N. D.
- Page 133; Plate 9—11, 13; Inapertoropollenites dettmannii should read: Inaperturopollenites cf. l. australis (COOKSON) n. comb. Plate 16; fig. 4: bolchovitinii should read: bolchovitinae.
 - fig. 11: KAPYTOVA should read: KOPITOVA.
 - Plate 17; fig. 3: Piceites latens Bolkh.
- Page 134; Plate 18; figs. 27-28: cragii should read: craigii.
 - Plate 19; fig. 9: wapellaensis should read: wapellensis.
 - Plate 22; fig. 2: Tsugaepollenites should read: Zonalapollenites.
- Page 135; Plate 23; figs. 23-24: fig. 25 should read: fig. 24.
- Plate 28; figs. 5, 6 should read; figs. 5, 7.
 - Plate 24; Figs. 6, 9; (fig. 4, left) should read: (fig. 9, left).
 - Fig. 13; Protoconiferus minor n. sp.; holotype.
- Page 136; Plate 26; Figs. 10, 15 should read: Fig. 10.

Figs. 33—34; Eucommiidites troedssonii.

Page 117: delete last ten lines of first column and first two lines of second column, and insert following addenda:

Sample	Depth	Formation Fl	oral Zone	Sa
No.	-		or Stage	N
Sup. et a	d H.B. Caroline	11-2-36-6W5M		С
2662	8990—95	Fernie Formation	J31	3
2663	902530	Fernie (Rock creek member)	J2²	31
2664	918590	Nordegg Formation	J1	37
Hudson	e Bay Edeon #	10-33-51-19W5M		37
9665	9997—10 000	Fernie Formation	13 ²	н
2000	10.000-10.042	Fernie Formation]3²	32
2000	10,000 10,010			
New Su	perior Solomon	Creek #1 6-17-51-27W5	δM T τ	C
2667	5875—80	Fernie Formation	J1 ³	81
2668	5925—30	Fernie Formation]2 	5
2669	5965 - 70	Fernie Formation	JI	
2670	6270—95	Nordegg Formation	J1	
H.B. Un	ion North Tang	ent 16-6-80-24W5M		
2671	2965-67	Nordegg Formation	J1	
2672	2983—88	Nordegy Formation	J1	
Tidewat	er Manor 9—12	7-1W2M		
3234	3835	Watrous Formation	JI?	
Imperial	Belloy #1 15-	-34—77—1W6M		
8527	3370	Fernie Formation	J22	
3527	3377	Fernie Formation	J2²	
Awingal	k Formation, Ar	nund Ringnes Island		
3717	Spl. 1146	U U	J22	
8717	Spl. 1147		J22	
8717	Spl. 1148			
Deer Ba	v Formation A	mund Ringnes Island		
3717	Spl. 1156	initia itingino itiana	122	
8717	Spl. 1157]~ [22	
8717	Spl. 1158		122	
3717	Spl. 1159		122	
8717	Spl. 1160] <u>3</u> 1	
8717	Spl. 1161		131 181	
3717	Spl. 1162		181	
			10	

ample No.	Depth	Formation	Floral Zone or Stage
	m and side of (omuull Island	
	S = 1 or $S = 1$	Jornwall Island	T 91
217	Spl. 2154A		 Тя≴
217	Spl. 2154D		
5717	Spl. 2154C		J3-
11	Spl. 2154D		12.
I.B. Ur	ion Eaglesham	#2 6—32—77—25W5M	
731	0	Nordegg	
2.F.P. S	tavely 1-31-1	13—26W4W	711
3732	6800-05	Swift Formation	J 33
	6800-01	Swift Formation	_]3³
	680506	Swift Formation	138
	6809—10	Swift Formation	130
	6900-01	Swift Formation	_]3³
	6905-10	Swift Formation]Ց3
	6909—10	Swift Formation	J.38
	691415	Swift Formation	J3²
	691920	Swift Formation	J38
	6924 - 25	Swift Formation	J82
	6930—35	Rierdon Formation	J31
	6934—35	Rierdon Formation	J31
	6937—40	Rierdon Formation	J31
	694445	Rierdon Formation	JS1
	6949 50	Rierdon Formation	J31
	6954 - 55	Rierdon Formation	J31
	6955 - 60	Rierdon Formation	J3¹
	6964—65	Sawtooth Formation	J2²
	6969—70	Sawtooth Formation	J2 ²
	6973—74	Sawtooth Formation]2²
	6978—82	Sawtooth Formation	J2²
	6989—90	Sawtooth Formation	J22
	6992—93	Sawtooth Formation	J2²
	69957000	Sawtooth Formation	J2²

EXPLANATION OF PLATES

Plate 22

Figs. 1-2.	Gonyaulacysta downiei n. sp. Holotype $(84\mu \times 84.7\mu)$. General aspect (fig. 2) and enlargement (fig. 1)
	showing detail of girdle and processes,
Figs. 3—4.	Gonyaulacysta cladophora (DEFL) n. comb. Two specimens (both $80\mu \ge 80\mu$) showing details of reflected
	plating (partially retouched).
Figs. 5-6.	Gonyaulacysta ornata (EISENACK) n. comb. Two photographs of the same specimen 70 x 68.0 µ) Dorsal
	and ventral aspects to show reflected plating and processes.
Fig. 8.	Gonyaulacysta jurassica (DEFL.) var longicornis DEFL. Specimen (110µ x 55µ) showing typical elongate form
	and smoothly ovoid inner wall to test. Note servate crests to ridges which reflect plate sutures.
Fig. 9.	Gonyaulacysta jurassica (DEFL.) DEFL. Specimen (92.0 μ x 56.0 μ) showing typical form of the species. Note
	more squat form and marked notches where equatorial girdle cuts the equatorial outline.
Figs. 10-11 & 15.	Scriniodinium luridum (DEFL.) KLEMENT. Fig. 10 (80µ x 75µ) large specimen showing smooth character of
	test, asymmetrical outline and precingular archeopyle (retouched); Fig. 11 Smaller specimen (60 μ x 50 μ)
	showing similar features. Fig. 15 (60μ x 55 μ similar specimen showing smooth internal outline.
Fig. 12.	Scriniodinium gochtii n. sp. Holotype (90 μ x 84 μ) showing ornamentation and plating.
Figs. 13-14.	Evittia waltonii n. sp. Fig. 13 Holotype (66µ x 44µ) note ovoid capsule with enveloping outer wall. Fig. 14
	$(45\mu \ge 40\mu)$ specimen showing well developed transverse and longitudinal furrows; apex missing due to
	archeopyle formation.

Plate 23

- Figs. 1-2. Scriniodinium klementii n. sp. Holotype $(120\mu \times 99\mu)$. Ventral (fig. 1) and dorsal (fig. 2). Note precingular archeopyle shown in fig. 2.
- Fig.3. Scriniodinium reticulatum n. sp. Holotype $(37.4\mu \ge 35.4\mu)$ dorsal aspect, showing precingular archeopyle and reticulate structure of the test.
- Fig. 4 & 6. Scriniodinium cf. S. subvallare SARJ. fig. 4 $(10.0\mu \times 93\mu)$ showing archeopyle and general structure at test fig. 6 enlargement to show detail of test reticulation.
- Fig. 5. Gonyaulacysta sp. A. Holotype (114 μ x 90 μ). Reflection of plating on test retouched.
- Fig. 7-8. Cyclonephelium areolatum COOKS & EISEN. fig. 7 (\pm 83.0 μ) apical aspect of typical specimen. Fig. 8 (94 μ x 82 μ). Specimen showing transverse furrow and reduction in ornament over central areas of test.
- Fig.9. Dingodinium cooksonii n. sp. Holotype (60.0µ x 50.0µ) showing conical processes overlain by enveloping membrane.
- Fig. 10. Cyclodictyon minor n. sp. Holotype (equatorial diameter 45.0μ) showing reticulation of outer vesicle layer and circular archeopyle.
- Fig. 11. Dinoflagellate sp. B specimen (equatorial diameter $\pm 95\mu$) showing characteristic ornamentation.
- Fig. 12-13. Pterospermopsis bulbosa n. sp. fig. 13. Holotype (diameter 45µ) and second specimen (fig. 12) showing general form.
- Figs. 14-16. Chytroeisphaeridia variabilis n. sp. A series of three specimens (holotype fig. 15) showing range from typical, plated, 'peridinoid' form to rounded, unplated, cyst. (size of holotype $68\mu \ge 54\mu$).

Plate 24

- Figs. 1-2. Gonyaulax canadensis n. sp. fig. 1 (100 μ x 110 μ) Holotype showing reflection of plating and spinose ornamentation. Fig. 2 (100 μ x 70 μ) a similar, somewhat compressed, specimen showing similar features.
- Figs. 3 & 5. Pareodinia ceratophora DEFL. fig. 3 $(95\mu \ge 70\mu)$ and fig. 5 $(120\mu \ge 65\mu)$ both typical specimens showing characteristic shape and absence of plating.
- Fig. 4. Pareodinia cf. P. nuda (DOWNIE) n. comb. fig. 4 ($70\mu \times 43\mu$) specimen showing trace of equatorial and longitudinal girdleson test.
- Figs. 6 & 8. Tenua evittii n. sp. Fig. 6 ($60\mu \ge 45\mu$) and Fig. 8 ($55\mu \ge 45\mu$). Holotype showing ornamentation and apical plating.
- Fig. 7. Evansia granulata n. sp. Fig. 7 (58.8 μ x 44.7 μ) Holotype. Note ornamentation and absence of visible plating. The latter feature distinguishes the genus from *Tenua*.
- Figs 9-12. Leptodinium norrisii n. sp. Fig. 9 (90 μ x 70 μ) Holotype, a slightly crushed, but complete, specimen. Figs. 10 (90 μ x 60 μ), 11 (85 μ x 55 μ) and 12 (85 μ x 75 μ isolated hemispheres of the same species showing reflections of plating on the test and its tendency to separate into two hemispheres along the equatorial girdle in archeopyle formation.
- Fig. 13. Dinoflagellate sp. A $(80\mu \times 85\mu)$.
- Fig. 14. Opaeopsomus wapellensis n. sp. (45µ x 43µ) Holotype.
- Figs. 15-16. Cornudinium stavelyense n. sp. fig. 15 ($100\mu \ge 55\mu$) Holotype fig. 16 ($100\mu \ge 48\mu$) showing general formal ornamentation of species.

Plate 25

Fig. 1,	Tasmanites rushlakensis n. sp. (90 μ equatorial diameter). General aspect of holotype.
Figs. 2-3.	Tasmanites yarboensis n. sp. Fig. 2 (100µ equatorial diameter) Holotype showing general aspect. Fig. 3.
	detail of three layered wall structure.
Fig. 4.	Leiosphaeridia spongiosa n. sp. (100 μ equatorial diameter). General aspect of holotype.
Fig. 5.	Lophodictyotidium sarjeantii n. sp. (54µ equatorial diameter). General aspect of holotype showing polygonal fields.
Figs. 6-7.	Leiosphaeridia sarjeantii n. sp. Fig. 6 (100 μ). General aspect of holotype and (fig. 7) detail of ornamen- tation.
Fig. 8.	Leiosphaeridia eisenachii n. sp. (100 μ). General aspect of holotype showing ornamentation.
Fig. 9.	Chytroeisphaeridia chytroeides SARJEANT ($48\mu \times 40\mu$) general aspect of typical specimen showing aperture at apex.
Fig. 10.	? Leiosphaeridia sp. A (57 μ x 69 μ). General aspect of described specimen.
Fig. 11.	Leiosphaeridia staplinii n. sp. (72 μ equatorial diameter) Holotype showing ornamentation and internal yel- low-green bodies.
Fig. 12.	Leiosphaeridia hyalina (DEFL.) n. comb. 55µ) General aspect of typical grain showing smooth, hyaline,
Fig. 13.	Leiofusa cf. L. bacillum DEUNFF. (405µ x 72.0µ). General aspect of one of the canadian specimens.
Figs. 1415.	Leiofusa deunffü n. sp. Fig. 14 (67 μ x 32 μ) Holotype and fig. 15 (74 μ x 27 μ) a second specimen, showing the general aspect of the species.

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Plate 26

	Figs. 1, 5, 7, 8 Scale A
	Figs. 4, 6, 9, 11, 12, 13, 14, 15-33 - Scale B
	Figs. 2, 3, 10, 34 Scale C
Figs. 1—4.	Tasmanites claimontensis n. sp. Detail of structure of holotype (fig. 4 upper & lower) x 90 and general aspect (fig. 1) and structural detail (figs. $2-3$) of second specimen.
Figs. 5—6.	(?) Tasmanites sp. Thick-walled vesicle with no clearly visible wall canals. General aspect (fig. 5) and detail (fig. 6). Not described in text.
Fig. 7.	Tasmanites suevicus (EIS.) n. comb. General aspect of typical specimen.
Fig. 8.	Tasmanites eisenackii n. sp. Holotype showing general aspect of the vesicle wall.
Figs. 9—12.	Leiosphaeridia granulosa n. sp. General aspect of holotype (fig. 12) and two other specimens (figs. 10-11).
T 1 10 14	Fig. 9 detail of specimen illustrated in fig. 10.
Figs. 15—14. Figs. 15—18 & 20—22.	Dictyotidium eastendensis n. sp. General aspect of holotype (fig. 15) and second spectruch (fig. 14). Fig. 18 detail of differentiated field on specimen figured on fig. 17. Figs. 20-22 grains photographed in
	non-permanent water mount, showing detail of surface ornament.
Figs. 19 & 23.	Dictyotidium shaunavonensis n. sp. General aspect of holotype (fig. 19) and of second grain (fig. 23).
Figs. 24-25 & 27-28.	Leiosphaeridia variabilis n. sp. General aspect of holotype (fig. 28) and three other grains (figs. 24, 25, & 27).
Figs. 2930.	Leiosphaeridia asymmetrica n. sp.; General aspect of holotype (fig. 29) and second specimen (fig. 30).
Fig. 31.	(?) Leiosphaeridia sp. folded grain that may be either a spore or a leiosphaerid. Included to illustrate the
	difficulty of making determinations with imperfect grains. Not described in text.
Figs. 32—34.	Leiosphaeridia tangentensis n. sp. General aspect of holotype and general aspect (fig. 33) and detail (fig. 34) of second specimen.
	Plate 27
Fig. 1.	Cannosphaeropsis caulleryi (DEFL.) SARJ. (Diam. 65µ). General aspect of typical specimen.
Fig. 2.	Cannosphaeropsis sp. Typical grain from the upper part of the Fernie formation.
Figs. 3-4.	Solisphaeridium deflandrei (VAL.) n. comb. fig. 3 (22μ diameter) detail of typical specimen and (fig. 4) general aspect of some grain showing ornamentation.
Fig. 5.	Marine cyst (Diam. 40μ) Typical of variety of membranous cysts common throughout the marine Jurassic and discussed on p. 37.
Fig. 6.	Pterospermosis scabrata n. sp. (Diam. 65.0μ) General aspect of holotype.
Fig. 7.	Pierospermopsis rugosa n. sp. (Diam, 63.0µ) General aspect of holotype.
Fig. 8.	Solisphaeridium watrousense n. sp. (30.4µ Diameter) Holotype showing detail and distribution of orna- mentation.
Fig. 9.	Micrhystridium ovale n. sp. (20.0 μ x 12.0 μ) Holotype showing distribution and form of ornamentation.
Figs. 10—18,	Wilsonastrum colonicum A series of photographs to show the variety of shape and form. Note the pre- sence of bristles shown on figs. 12, 14 and 18. The specimens shown on figs 10, 12, 17 and 18 fail into
	Form A, the remainder into Form B (see p. 80). Size range 11μ — 21μ (vesicle diameter). Photos 10, 12, and 16 taken with 100x all immersion shjective, the remainder with x40 dry.
Fig. 19.	Veryhachium reductum (DEFL.) JEKHOWSKY (32µ vesicle diameter) General aspect of typical specimen.
Fig. 20.	Multiplicisphaeridium vestitum (DEFL.) n. comb. Holotype (45µ x 47µ) General aspect.
Figs. 2122.	Chytroeisphaeridia dytroeides SARJ. Two specimens, both about 50μ in diameter, showing operculate nature of smooth test.
Figs. 23-25.	Chytroeisphaeridia scabrata n. sp. fig. 23 ($55\mu \ge 45\mu$) Specimen showing shield shaped operculum (re- touched) and figs. 24-25 ($55\mu \ge 47\mu$) Holotype showing general aspect and detail of operculum.
Fig. 26.	Veryhachium sp. A $(27\mu \times 13\mu)$ showing detail of grain.
Figs. 27-28.	Veryhadium pyriformis n. sp. Fig. 27 (27 μ x 12 μ) Holotype and Fig. 28 (27.5 μ x 12.5 μ) showing general aspect.
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	Figs. 1-11, 13-31, 32, 34, 36, 38, 39, 41, 42, 44-45 - Scale B
	Figs. 12, 31, 31 A, 33, 35, 37, 40, 43, and 46 - Scale C
Figs. 1-3.	Micrhystridium polyedricium VAL. Typical grains.
Figs. 4—6.	Filisphaeridium helios (VAL.) n. comb. Typical grains.
Figs. 7—9.	Micrhystridium inconspicuum DEFL. Typical grains,

- (fig. 35).
- Figs. 10, 11 & 35. Micrhystridium schinoides VAL. General aspect of typical grains (figs. 10 & 11) and detail of third specimen of three other grains (figs. 13-15).

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Figs. 12-15.	Filisphaeridium bullosum (VAL.) n. comb. Detail of well preserved specimen (fig. 12) x90 and general aspect
Figs 16 18	of three other grains. Solishbaaridium fragila (Den) n comb Three typical grains
Figs. 10-10.	Eilistandidum of E biotoni (Nor) a comb Consel and of the tunited proci-
$r_{\rm Ugs. 13} \rightarrow z_{\rm U.}$	Putspingerundung (I. P. provident (VAL) II. Collid. General aspect of two typical spectments.
Figs. 21-23.	Solisphaeriaium stimuliferum (DEFL.) STAP., JANS. & POC. General aspect of three typical grains.
Figs. 21 A, 24, 29,	
30 & 56.	Solisphaeridium recurvatum (VAL.) n. comb. Four typical grains.
Fig. 25.	Acanthodiacrodium jurassicum n. sp. General aspect of holotype.
Figs. 26-27 & 31-33.	Baltisphaeridium jansonii n. sp. General aspect of holotype (fig. 33) and three other grains (figs. 26-27
	& 32). Detail of surface ornament and spines (fig. 31).
Figs. 28 & 34.	Mierhystridium stellatum DEFL. Two typical grains.
Fig. 31 A.	Micrhystridium sydus VAL. Typical grain.
Figs. 37 & 43.	Cymatiosphaera teichophera SARJ. Two aspects of well preserved grain.
Fig. 38.	(?) Comasphaeridium sp. A. Typical grain.
Fig. 39.	Polystephanosphaera sp. A. General aspect.
Figs. 40-41.	Cymatiosphaera hancevilliana n. sp.; Detail (fig. 40) and general aspect (fig. 41) of holotype.
Figs. 42 & 46.	Hystrichosphaeridium cf. H. deflandrei VAL. General aspect (fig. 42) and detail (fig. 46) of same grain. (Not described in text.)
Fig. 44.	Pterospermopsis macroptera Döring. Typical grain.
Fig. 45.	Pterospermapsis doeringii n. sp. General aspect of holotype.
	Plate 29
	Figs. 1-8, 7-10, 12-13 - Scale B

	r_{123} , r_{-35} , r_{-10} , r_{2} r_{13} r_{-35} r_{-35} r_{-35}
	Figs. 4-6, 11, 14-18 - Scale A
Figs. 1-6.	Botryococcus luteus TRAVERSE. Typical colonies (figs. 4-6 and detail of 'cups' (figs. 1-3).
Figs. 7 & 10.	Fungal cells.
Figs. 89.	Jansonia jurassica EIS. Two typical specimens.
Fig. 11.	Fragment of tissue of unknown origin occuring characteristically in J 2 ¹ assemblages. Not described in text.
Figs. 12—16.	Rugidinium ornatum n. sp. Two aspects of smaller portion of vesicle illustrating ornament (figs. 12-13) aspect of larger portion of vesicle (fig. 14) and two aspects of larger portion (figs. 15-16).
Figs. 17-18.	Rugidinium undulatum n. sp. Two aspects of same portion of vesicle.

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