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ABSTRACT

The Hume River section northwest of the town of Norman Wells, Northwest Territories consists of a 2-km-thick succession of Cretaceous strata deposited in a foreland basin ahead of the advancing Mackenzie Mountains thrust-and-fold belt. Rocks in the section have been assigned (from bottom to top) to the Martin House, Arctic Red, Slater River and Trevor formations. The Martin House Formation rest unconformably on Paleozoic strata, and an unconformity separates the Arctic Red and Slater River formations. In terms of paleoenvironments, the section represents fluctuating fully marine to non-marine deposits near the margin of the Western Interior Seaway. Previous age determinations have encompassed an Aptian to Turonian age range for the section as a whole. My analyses indicate an early to middle Albian age for the Martin House Formation, a middle to late Albian age for Arctic Red Formation (which accords with a late Albian U–Pb radiometric date for the unit), a late Albian age for the lowest part of the Slater River Formation (in contrast to Cenomanian age determined by the most recent foraminiferal analyses), and a Cenomanian or younger age for the upper part of the Slater River Formation and for the Trevor Formation. I found no conclusive evidence for an age younger than Cenomanian. The Albian–Cenomanian boundary may be within the basal part of the Slater River Formation rather than at the unconformity between that formation and the underlying Arctic Red Formation. Interesting parallels can be drawn with lithological units and dinocyst assemblages in other parts of the Western Interior Basin, notably in northern Alberta. Perhaps there too, the Albian–Cenomanian boundary is within the basal part of the Fish Scales Marker Bed (equivalent to the Slater River Formation) rather than at its base.

INTRODUCTION

The Hume River section is located in the transitional area between the Mackenzie Plain and Peel Plateau, northwest of the town of Norman Wells, Northwest Territories (Fig. 1; Thomson et al 2011). The Cretaceous strata in the Hume River section were deposited in the foreland basin ahead of the advancing Mackenzie Mountains thrust-and-fold belt. The section constitutes an almost continuously exposed 2-km-thick succession of strata dipping at approximately 45° (Figs. 2A–B; Thomson et al. 2011).

Cretaceous strata in the region were assigned by Mountjoy and Chamney (1969) to the Martin House, Arctic Red and Trevor formations, with the Slater River Formation later introduced by Hadlari et al. (2009) between the Arctic Red and Trevor formations. Hadlari et al. (2014) provided an overview of the lithostratigraphy. The Martin House Formation, at the base of the Cretaceous succession overlying pre-Mesozoic rocks, is a transgressive marine sandstone unit generally less than 20 m thick. Above the Martin House Formation, the Arctic Red Formation consists of up to 1000 m of marine mudstone and, in its upper part, sandstone of the Sans Sault Member. Within the Arctic Red Formation is a bentonite radiometrically dated (U–Pb) at 107 ± 1.9 Ma (Thomson et al. 2011). Overlying the Arctic Red Formation with a slight angular unconformity, is the Slater River Formation, a dark-grey mudstone unit with an anomalously radioactive interval at the base (T. Hadlari, pers. comm. 2016). Above that, with gradational transition, the Trevor Formation consists of shoreface (inner neritic?) sandstones and offshore (outer neritic?) mudstones.

The development of age determinations for these formations was reviewed by Thomson et al. (2011). Based on foraminifera, Mountjoy and Chamney (1969) and Chamney (1978) assigned an Aptian to early Albian age to the Martin House Formation, a middle to late Albian age to the Arctic Red Formation, and a latest early to late Albian age to the Trevor Formation. Subsequent biostratigraphic observations of strata now included in the Slater River Formation (presumably previously encompassed by the lower part of the Trevor Formation) and the Trevor Formation have indicated dates ranging from middle Albian to Turonian based on palynomorphs, foraminifera and macrofossils (Yorath and Cook 1981). Thomson et al. (2011) suggested that these age discrepancies are based on proximity to the Keele Arch, leading to diachronous lithostratigraphic units.

Projecting from a regional unconformity in northern Canada between Albian and Cenomanian strata, Dixon (1999) postulated that a similar unconformity should exist in the Peel region. This has been equated with the unconformity separating the Arctic Red and Slater River formations on the Mackenzie Plain (Thomson et al. 2011; Hadlari et al. 2014).

The pre-Mesozoic geology of the Mackenzie Mountains and surrounding areas, including the Peel Plateau and Mackenzie Plain, consists of rocks of a variety of ages — Mesoproterozoic, extensive Neoproterozoic, and Paleozoic (Hadlari et al. 2014 and references therein). Paleozoic rocks include lower–middle Devonian carbonates overlain by middle Devonian to early Carboniferous siliciclastic rocks. The presence in the Hume River section of reworked miospores reflects the proximity of late Palaeozoic rocks; such reworked specimens dominate some samples and form significant percentages of the assemblage in many others.

On the basis of foraminiferal and sedimentological evidence, Thomson et al (2011) established a paleoenvironmental model consisting of facies in a marine profile (Fig. 3) for the Martin House, Arctic Red and Slater River formations succession. Comparisons are made below based on these determinations and those suggested by the palynological assemblages.

MATERIALS AND METHODS

The foraminiferal analyses of Thomson (2009) and Thomson et al. (2011) are based on "107 micropaleontological samples and ten hand samples" collected in 2007 jointly by Carleton University and the Northwest Territories Geoscience Office from the Martin House, Arctic Red, Slater River and Trevor formations along the Hume River, Northwest Territories (65°23'34" N, 129°57'37" W) (Figs 2A-B). The Hume River section is 1869.5 m thick. The present study involves palynological analyses of 27 samples selected from the 2007 suite.

The 27 palynology samples were processed using standard techniques at GSC Calgary. Slides were made for unsieved, -20, +20, +45 and kerogen fractions. Some samples were swamped by amorphous kerogen and a second set of generally much improved preparations were prepared after a modest amount of extra oxidation. The sieved slides were scanned for good specimens to form the basis of a taxonomic study. Then counts were carried out on the unsieved slides based on 200 specimens unless otherwise stated.

RESULTS

This section contains a description of the assemblage from each sample. FO = regional first occurrence (i.e. origination) of a taxon, LO = regional last occurrence (i.e. extinction). In non-quantitative sections the terms rare, frequent, common and abundant refer respectively to 2–5, 6–15, 16–25, and >25 specimens. Appendix 2 provides full authorships for the taxa mentioned. New taxa are cited in quotes and publications describing these are in preparation. An overview of the counts for each sample is augmented by an assessment of the paleoenvironment for the relevant horizon by Thomson et al. (2011; see Fig. 3 herein for a legend to their settings). Details of the counts are provided in Appendix 1 and a visual representation of the proportions of major groups of palynomorphs represented in each sample is presented in Figure 4.

A listing of key taxa for each sample is followed by an initial assessment of age. Unless otherwise stated, ages for individual taxa are from Williams et al (1999). The absolute ages (Ma) in Williams et al. (1999) were based on the timescale in Haq et al. (1987) scale, so the ages here are given as stages based on that scale. All absolute ages are converted to the Gradstein et al. (2012) scale. More extensive age information for selected taxa is provided in the Results section. Taxon names and epithets in quotes are new and will be described in publications in preparation and/or in a open file atlas to be developed. A revised taxonomy of proximate to proximochorate areoligeracean cysts is in preparation; a provisional taxonomic scheme used for the current material is shown in Figure 5. Reference to sieved slides mostly refers to the +45 μm fraction, but sometimes also the + 20 μm fraction.

Samples

07-PEEL-01

C-477051 (P5262-1); 4.1 m from base of section; Martin House Formation

Snapshot: Sample dominated by reworked Paleozoic (mostly Devonian) miospores.

In the count of the unsieved slide, this sample is dominated by reworked Paleozoic (mostly Devonian) miospores (87%), with a significant number of *Stereisporites* (6%). Dinocysts make up only 1.5%. This sample was considered to belong to facies F5 (lower shoreface–offshore) by Thomson et al (2011).

In a broader analysis of sieved slides, rare dinocysts include:
Cyclonephelium vannophorum (rare; middle Albian to late Santonian)
Oligosphaeridium sp. (single).

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is possibly middle Albian or younger based on the presence of rare *Cyclonephelium vannophorum.*

07-PEEL-02

C-477052 (P5262-2); 13 m from base of section; Martin House Formation

Snapshot: Specimens highly corroded. High numbers of bisaccates and reworked miospores may reflect the fact that these are easier to recognize than other types of palynomorph in the corroded state.

In the count of this sample Paleozoic (mostly Devonian) miospores were abundant (46%) and bisaccates common (28%). Dinocysts accounted for 10% of the assemblage. This sample was considered to belong to facies F5 (lower shoreface–offshore) by Thomson et al (2011).

In a broader analysis of sieved slides, rare dinocysts include:

Kiokansium sp. (single; generally Albian–Cenomanian, but can go lower)
Odontochitina costata (rare; FO early Albian)
Oligosphaeridium complex (single)
Palaeoperidinium pyrophorum (supposed FO early Maastrichtian)

Miospores include:
Appendicisporites sp.
Cicatricosisporites sp. (frequent)
Gleicheniidites senonicus (frequent)
Stereisporites antiquasporites (rare)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is Albian or younger based on rare *Odontochitina costata*.

<u>07-PEEL-03</u>

C-477053 (P5262-3); 14.1 m from base of section; Arctic Red Formation

Snapshot: Preservation poor to moderate; increasing species richness of dinocysts.

In the count of the unsieved slide, Paleozoic (mostly Devonian, but one Permian) miospores and Mesozoic (in situ?) bisaccates both made up 24% of the assemblage; spiny acritarchs made up 12% and the fern spore *Gleicheniidites senonicus* 9%. Dinocysts accounted for 14% of the assemblage, including *Dinopterygium* (FO early Albian?), *Gardodinium trabeculosum* (supposed LO Aptian), and *Odontochitina costata* (FO early Albian). This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In a broader analysis of sieved slides, dinocysts include:
Cassiculodinium cassis (single, range to be established)
Cymososphaeridium validum (single, reworked)
"*Tribulodinium cornuspinatum*" (frequent)

Gardodinium trabeculosum (frequent; supposed LO Aptian)
Kiokansium unituberculatum (rare; late Berriasian to late Cenomanian)
Odontochitina costata (rare; FO early Albian)
Oligosphaeridium albertense (rare; LO early Cenomanian according to Fensome et al 2008)
Oligosphaeridium totum (rare; LO basal Cenomanian according to Fensome et al 2008)
Palaeoperidinium pyrophorum (supposed FO early Maastrichtian)

Miospores include:
Appendicisporites sp. (single)
Cicatricosisporites sp. (frequent)
Classopollis classoides (rare)
Gleicheniidites senonicus (common)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is no younger than earliest Cenomanian based on the presence of *Oligosphaeridium totum*. The presence of both *Gardodinium trabeculosum* (LO top Aptian) and *Odontochitina costata* (FO early Albian) is conflicting. That lower samples are already dated as Albian suggests that this sample is Albian to early Cenomanian.

<u>07-PEEL-04</u>

C-477054 (P5262-4); 18.1 m from base of section; Arctic Red Formation

Snapshot: Moderate preservation; increasing abundance of dinocysts, far fewer reworked Paleozoic miospores than in previous samples.

In the count of the unsieved slide, in this sample Paleozoic (mostly Devonian) miospores significantly made up only 2% of the assemblages, and bisaccates 15%. Dinocysts made up 73 percent, with *Sentusidinium myriatrichum* accounting for 39% of the total assemblage. This species has mostly been recorded from the Late Jurassic, but given its general morphology (spheroidal cyst covered in hairs and with an apical archaeopyle), its occurrence in the Cretaceous is not so surprising. Given its frequency in this sample it may have paleoenvironmental significance, though a marginal marine interpretation is countered by high species richness in this sample. Other notable dinocyst taxa in the unsieved slide are *Chlamydophorella*/*Sepispinula* (11%) and *Gardodinium trabeculosum* (8%). This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In a broader analysis of sieved slides, dinocysts include:

Apteodinium granulatum (rare; LO intra Cenomanian)

Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)

Cribroperidinium spp. (frequent)

Dinopterygium sp. (rare: FO early Albian?)

"*Tribulodinium cornuspinatum*" (frequent; range to be established, but as asymmetrical areoligeracean, probably pre-Cenomanian)

Epelidosphaeridia sp. (single; FO probably within Albian)

Gardodinium trabeculosum (frequent; supposed LO Aptian)

Kiokansium unituberculatum (rare; late Berriasian to late Cenomanian)

Kiokansium williamsii (rare; middle to late Albian according to Williams et al. 1999; LO middle Cenomanian according to Fensome et al. (2009)

Nyktericysta davisii (single; LO top Albian according to Fensome et al. 2008; non-marine to marginal marine)

Odontochitina costata (single; FO early Albian)

Oligosphaeridium albertense (frequent; LO early Cenomanian according to Fensome et al 2008)

Spongodinium delitiense (rare; supposed FO middle Campanian)

Miospores did not include any *Gleicheniidites senonicus* (even in the counts), but did include:

Cicatricosisporites sp. (rare)

Classopollis classoides (single)

Stereisporites antiquasporites (rare)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is Albian based on *Dinopterygium* sp. and *Epelidosphaeridia* sp. (both with FOs probably in the Albian), as well as *Odontochitina costata*; and *Nyktericysta davisii* (LO top Albian). The presence of several specimens of the very distinctive species *Spongodinium delitiense* is puzzling, but the sample is clearly older than Campanian. Also, the presence of *Gardodinium trabeculosum* might suggest an older age, but more likely the range of that species needs to be extended higher, at least regionally; it occurs in such high numbers that reworking is unlikely.

07-PEEL-09

C-477055 (P5262-5); 56.6 m from base; Arctic Red Formation

Snapshot: Moderate preservation; dinocysts dominant.

In counts made on the unsieved slide, dinocysts made up 83%, with an indeterminate species labelled *Sentusidinium*/*Impletosphaeridium* making up 63% of the total assemblage. Most of the other dinocyst species individually comprised 1% or less of the count each (including *Sentusidinium myriatrichum* for 0.5%), but areoligeraceans accounted for 6% of the total. Reworked Paleozoic miospores accounted for 2.5% and bisaccates 3.5%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, age-diagnostic dinocysts were scarce; dinocysts include:
areoligeraceans (frequent)
Dinopterygium sp. (rare: base early Albian?)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is Albian or younger.

07-PEEL-14

C-477056 (P5262-6); 117.0 m from base of section; Arctic Red Formation

Snapshot: Mostly poor preservation with many “ghosts”. Lots of small “balls”, not counted; miospores more prominent and dinocysts less prominent than in previous few samples.

In counts made on the unsieved slide, dinocysts made up 22%, bisaccates 37%, and trilete spores 28% (of which *Stereisporites antiquasporites* made up 5% of the total and *Cicatricosisporites* 6%). Reworked Paleozoic miospores made a moderate “comeback”, at 5%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)
Cassiculodinium spp.
Chlamydophorella/*Sepispinula*
Cyclonephelium vannophorum (frequent; FO middle Albian)
Dinopterygium sp. (rare: FO early Albian?)
“*Tribulodinium cornuspinum*” (rare)
Gardodinium trabeculosum (rare; supposed LO Aptian)
Nyktericysta sp. (single; LO top Albian)
Odontochitina costata (rare; FO early Albian)
Oligosphaeridium anthophorum (single; LO middle Albian)
Oligosphaeridium dictyophorum (rare; LO early Albian)
Oligosphaeridium spp.
Palaeoperidinium pyrophorum (supposedly FO early Maastrichtian)
Senoniasphaera microreticulata (common; FO early Aptian, LO middle Albian)
Sentusidinium myriatrichum (frequent)
Subtilisphaera perlucida (single)

Miospores include
Cicatricosisporites spp. (common)
Classopollis classoides (rare)

Eucommiidites minor (rare)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is early to middle Albian based on the range of *Senoniasphaera microreticulata*, perhaps constrained to middle Albian by the presence of *Cyclonephelium vannophorum*. The presence of *Oligosphaeridium* (al. *Stiphrosphaeridium*) *dictyophorum* might indicate a preference for an early Albian call, but this species extends albeit sparsely through the section studied, possibly due to reworking or to a need for re-calibration of its range. A U-Pb zircon age of 107+/- 1.9 Ma was obtained from 07 PEEL-16, close to this sample.

07-PEEL-20

C-477057 (P5262-7); 220.0 m from base of section; Arctic Red Formation

Snapshot: Poor preservation; many small "balls" not counted; reworked Paleozoic and (in situ?) Mesozoic miospores prominent.

In counts made on the unsieved slide, dinocysts accounted for only 5% of the assemblage, whereas bisaccates account for 24%, trilete spores 52% (of which *Cicatricosisporites* is 11% and *Gleicheniidites* is 9%), and Paleozoic miospores for 10%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011); the paucity of dinocysts and abundance of trilete spores suggest a setting closer to shore.

In analyses of sieved slides, dinocysts include:
Chlamydophorella/*Sepispinula* (frequent)
"*Tribulodinium cornuspinum*" (single)

Miospores include
Cerebropollenites macroverrucatus (rare)
Cicatricosisporites spp. (common)
Cycadopites sp. (frequent)

Exesipollenites tumulus (rare)
Gleicheniidites senonicus (common)
Tuberositriletes sp (single)
Zlivisporis sp (single)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is indeterminate.

07-PEEL-23

C-477058 (P5262-8); 313.5 m from base of section; Arctic Red Formation

Snapshot: Specimens were relatively sparse, so only 100 specimens were counted. Dinoflagellates are reasonably diverse.

In counts made on the unsieved slide, dinocysts accounted for 35%, with *Cyclonephelium compactum* alone accounting for 15% of the entire assemblage, bisaccates 23% (and gymnosperm pollen including bisaccates 36%), and trilete spores for 20% (including *Gleicheniidites senonicus* for 13%). The algal taxon *Pterospermella* was notable at 4%, although some of these could be reworked from the Paleozoic. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)
Cribroperidinium spp. (frequent)
Cyclonephelium compactum (abundant; Berriasian to Maastrichtian)
Kleithriasphaeridium cooksoniae (single; Hauterivian to Cenomanian)
Kleithriasphaeridium loffrense (rare; Aptian to Campanian)
Odontochitina costata (single; FO early Albian)
Oligosphaeridium albertense (single; LO early Cenomanian according to Fensome et al 2008)

Palaeoperidinium pyrophorum (frequent; supposedly FO early Maastrichtian)
Pseudoceratium polymorphum (single; commonly misidentified; LO late Albian)
Oligosphaeridium anthophorum (single; LO middle Albian)
Oligosphaeridium dictyophorum (single; LO early Albian)

Miospores include
Araucariacites (frequent)
Classopollis classoides (rare)
Distaltriangulisporites perplexus (single; middle to late Albian of Alberta by Singh 1971)
Gleicheniidites senonicus (common)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is Albian based on the co-occurrence of *Pseudoceratium polymorphum*, *Odontochitina costata* and *Distaltriangulisporites perplexus*. The presence of *Oligosphaeridium dictyophorum* and *Oligosphaeridium anthophorum* suggests that the ages of these two species may need to be extended upwards.

07-PEEL-29

C-477059 (P5262-9); 532.5 m from base of section; Arctic Red Formation

Snapshot: Preservation generally poor with few dinocysts.

In counts made on the unsieved slide, dinocysts accounted for just 3% of the assemblage, bisaccates for 21%, trilete spores for 49% (with *Gleicheniidites senonicus* accounting for 19%), and reworked Paleozoic miospores for 21%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
"*Cassiculodinium reticulatum*" (rare)
Gardodinium trabeculosum (single; supposed LO Aptian)

Odontochitina costata (single; FO early Albian)
Palaeoperidinium pyrophorum (rare; supposedly FO early Maastrichtian)
Pseudoceratium polymorphum (commonly misidentified; single; LO late Albian)
Tanyosphaeridium xanthiopyxides (single)

Miospores include
Densoisporites sp.
Gleicheniidites senonicus (abundant)

Age. Thomson et al. (2011) attributed this sample to the *Gaudryina canadensis* Zone, of middle to earliest late Albian age. Based on the present palynological analysis it is Albian based on the co-occurrence of *Pseudoceratium polymorphum* (restricted to forms with a lateral horn) and *Odontochitina costata*.

07-PEEL-39

C-477060 (P5262-10); 721.0 m from base of section; Arctic Red Formation

Snapshot: Sample dominated by Paleozoic miospores.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 64% of the assemblage, bisaccates for 5%, trilete spores for 27%, and dinocysts for 2%. This sample was considered to belong to facies F6 (terrestrial) by Thomson et al (2011).

In analyses of sieved slides, rare dinocysts include:
Cribroperidinium sp.
Oligosphaeridium totum (single; LO basal Cenomanian according to Fensome et al 2008)
Pseudoceratium sp.

Miospores include
Cicatricosisporites sp. (rare)
Gleicheniidites senonicus (frequent)

Ischyosporites sp. (single)

Age. Thomson et al. (2011) attributed this sample to the *Quadrimorphina albertensis* Zone, of early to earliest middle Albian age. Based on the present palynological analysis it is earliest Cenomanian or older based on the presence of *Oligosphaeridium totum*.

07-PEEL-43

C-477062 (P5262-12); 724.5 m from base of section; Slater River Formation

Snapshot: Difficult to count as much undifferentiable organic material, although many specimens not too badly preserved. (Note that this sample and the next are numbered in reverse order; they are presented here in stratigraphic order.)

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 37% of the assemblage, bisaccates for 15%, dinocysts for 29% and trilete spores for 16%. This sample appears to have been considered to belong to facies F6 (terrestrial) by Thomson et al (2011), but the charts (their figs. 7–8) are slightly ambiguous.

In analyses of sieved slides, rare dinocysts include:

Apteodinium granulatum (rare; LO intra-Cenomanian)
Callaiosphaeridium asymmetricum (single; Berriasian to Campanian)
"*Cassiculodinium cassis*" (frequent)
Cerbia sp. (single)
Chichaouadinium vestitum (single; late early Albian to late Albian)
Coronifera oceanica (single; late Berriasian to Maastrichtian)
"*Tribulodinium cornufilosum*" (rare)
Exochosphaeridium spp. (frequent)
Luxadinium propatulum (rare; middle to late Albian)
Odontochitina "*chelion*" (single)
Odontochitina costata (single; FO early Albian)
Oligosphaeridium anthophorum (rare; LO middle Albian)

Oligosphaeridium perforatum (single)
Operculodinium? "*delicatum*" (frequent)
Operculodinium? "*latidelicatum*" (rare)
Palaeoperidinium pyrophorum (rare; supposedly FO early Maastrichtian)
Spiniferites spp. (frequent–common)
Surculosphaeridium longifurcatum (single; Barremian–Campanian)

Among algae/acritarchs, *Paralecaniella* spp. is frequent.

Miospores include
Gleicheniidites senonicus (frequent)

Age. Thomson et al. (2011) indicated that this sample to be at the top of the Arctic Red Formation, but T. Hadlari (personal communication; see below) confirms that this sample is from the base of the Slater River Formation, which Thomson et al. assigned to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the co-occurrence of *Chichaouadinium vestitum* and *Luxadinium propatulum*.

<u>07-PEEL-40</u>

C-477061 (P5262-11); 727.0 m from base of section; Slater River Formation

Snapshot: Assemblage dominated by dinocysts, especially areoligeraceans and "*Tribulodinium cornufilosum*" in particular.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 6% of the assemblage, bisaccates for 7%, and dinocysts for 78% (including "*Tribulodinium cornufilosum*") 71%). This sample appears to have been considered to belong to facies F4 (offshore) by Thomson et al (2011), but the charts (their figs. 7–8) are slightly ambiguous.

In analyses of sieved slides, dinocysts include:
Callaiosphaeridium asymmetricum (single; Berriasian to Campanian)

“*Cassiculodinium cassis*” (rare)
Chichaouadinium vestitum (single; late early Albian to late Albian)
Cribroperidinium spp. (frequent)
Dinopterygium alatum (rare; FO early Albian?)
“*Tribulodinium cornufilosum*” (abundant)
Lagenorhytis delicatula (rare; supposedly latest Jurassic to Valanginian)
Luxadinium propatulum (frequent; middle to late Albian)
Odontochitina costata (single; FO early Albian)
Pseudoceratium hirsutum (rare)
Pseudoceratium polymorphum (single; commonly misidentified; LO late Albian)
Spiniferites “*tubiferus*” (single)

Miospores include
Gleicheniidites senonicus (frequent)

Age: middle to late Albian based on the co-occurrence of *Chichaouadinium vestitum*, *Luxadinium propatulum* and *Pseudoceratium polymorphum*.

<u>07-PEEL-45</u>

C-477063 (P5262-13); 733.0 m from base of section; Slater River Formation

Snapshot: Good species richness of dinocysts and miospores, with *Luxadinium* and *Gleicheniidites* prominent.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 19.5% of the assemblage, bisaccates for 10.5%, dinocysts for 29% (including *Luxadinium propatulum* for 10.5) and trilete spores for 34%. This sample is near the base of the Slater River Formations, where a transition from terrestrial to marginal marine to offshore facies (F6 to F7 to F8) occurred over a short interval, according to Thomson et al. (2011, figs. 7–8); the exact situation of this sample is unclear from their figures, but T. Hadlari (pers. comm. 2016) confirmed an offshore setting.

In analyses of sieved slides, dinocysts include:

Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)

Bourkidinium psilatum (single)

"*Cassiculodinium cassis*" (frequent)

"*Cassiculodinium reticulatum*" (rare)

"*Cassiculodinium symcassis*" (rare)

Cauca parva (rare; LO middle Albian)

Cribroperidinium spp. (frequent)

Dinopterygium alatum (rare; FO early Albian?)

"*Tribulodinium cornufilosum*" (frequent)

Kleithriasphaeridium cooksoniae (single; Hauterivian to Cenomanian)

Luxadinium propatulum (abundant; middle to late Albian)

Nyktericysta davisii (rare; LO top Albian)

Nyktericysta tripenta (single; LO top Albian)

Odontochitina ancala (single)

Odontochitina costata (rare; FO early Albian)

Oligosphaeridium albertense (rare; LO early Cenomanian according to Fensome et al 2008)

Oligosphaeridium anthophorum (frequent; LO middle Albian)

Oligosphaeridium dictyophorum (rare; LO early Albian)

Oligosphaeridium "*perforoalbertense*" (single)

Oligosphaeridium perforatum (rare)

Oligosphaeridium totum (rare; LO basal Cenomanian according to Fensome et al 2008)

Ovoidinium spp. (rare)

Palaeoperidinium cretaceum (single)

Tenua "*cornudistincta*"

Among algae/acritarchs, *Veryhachium* is frequent.

Miospores include:

Cicatricosisporites sp. (rare)
Distaltriangulisporites perplexus (single; middle to late Albian of Alberta by Singh 1971)
Gleicheniidites senonicus (abundant)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) indicated that this sample to be at the top of the Arctic Red Formation, but T. Hadlari (personal communication; see below) confirms that this sample is from the base of the Slater River Formation, which Thomson et al. assigned to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the co-occurrence of *Cauca parva* and *Luxadinium propatulum*. The presence of *Nyktericysta* spp. and *Distaltriangulisporites perplexus* indicate that this sample is no younger than Albian.

<u>07-PEEL-46</u>

C-477064 (P5262-14); 740.5 m from base of section; Slater River Formation

Snapshot: Although miospores are proportionally greater, dinocysts are diverse.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 14% of the assemblage, bisaccates for 19%, dinocysts for 26% (including *Luxadinium propatulum* for 10.5%) and trilete spores for 39% (with *Gleicheniidites senonicus* and *Stereisporites antiquasporites* for 17% and 7% respectively). This sample is near the base of the Slater River Formations, where a transition from terrestrial to marginal marine to offshore facies (F6 to F7 to F8) occurred over a short interval, according to Thomson et al. (2011, figs. 7–8); the exact situation of this sample is unclear from their figures.

In analyses of sieved slides, dinocysts include:
Batioladinium jaegeri (rare; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)
"*Cassiculodinium cassis*" (frequent)
"*Cassiculodinium reticulatum*" (rare)

Cribroperidinium spp. (frequent)
"*Tribulodinium filosum*" (frequent)
Kleithriasphaeridium cooksoniae (single; Hauterivian to Cenomanian)
Luxadinium propatulum (frequent; middle to late Albian)
Nyktericysta davisii (single; LO top Albian)
Oligosphaeridium anthophorum (single; LO middle Albian)
Ovoidinium spp. (rare)
Pseudoceratium polymorphum (rare; commonly misidentified; LO late Albian)
Senoniasphaera "*latireticulata*" (rare)
Trichodinium spp. (rare)

Miospores include:
Angiosperm pollen (single)
Gleicheniidites senonicus (abundant)
Pilosisporites sp. (single)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the co-occurrence of *Luxadinium propatulum* and *Pseudoceratium polymorphum*.

07-PEEL-47

C-477065 (P5262-15); 750.0 m from base of section; Slater River Formation

Snapshot: Assemblage diverse but preservation not good; among dinocysts, *Subtilisphaera* is prominent.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for just 4% of the assemblage, bisaccates for 14%, dinocysts for 39% (including *Subtilisphaera* for 11%), trilete spores for 30% (with *Gleicheniidites senonicus* for 17%), and angiosperm pollen for 1.6%. This sample is near the base of the Slater River Formation, where a transition from terrestrial to marginal marine to offshore facies (F6 to F7 to F8) occurred over a short interval, according to Thomson et al. (2011, figs. 7–8); the exact situation of this sample is unclear from their figures.

In analyses of sieved slides, dinocysts include:
Batioladinium jaegeri (rare; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)
"*Cassiculodinium cassis*" (frequent)
"*Cassiculodinium reticulatum*" (rare)
Cometodinium sp. (rare)
Sentusidinium myriatrichum (single)
Luxadinium propatulum (frequent; middle to late Albian)
Ovoidinium cinctum (single; LO top Albian)
Palaeoperidinium pyrophorum (rare)
Spiniferites "*tubiferus*" (single)
Subtilisphaera sp. (abundant; estuarine–nearshore??)

Miospores include:
Angiosperm pollen (rare)
Cicatricosisporites sp. (rare)
Densoisporites sp. (rare)
Gleicheniidites senonicus (abundant)
Stereisporites antiquasporites (rare)

Age: middle to late Albian based on the presence of *Luxadinium propatulum*.

07-PEEL-48

C-477066 (P5262-16); 755.7 m from base of section; Slater River Formation

Snapshot: Assemblage diverse but preservation mixed: some good specimens, but many badly corroded.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 0% of the assemblage, bisaccates for 22%, dinocysts for 49% (including *Subtilisphaera* for 6% and "*Tribulodinium* for 13%), trilete spores for 18% (with *Gleicheniidites senonicus* for 13%), and angiosperm pollen for 2%. This sample is near the base of the Slater River Formations, where a transition from terrestrial to marginal marine to offshore facies (F6 to F7 to F8) occurred over a short interval, according to Thomson et al. (2011, figs. 7–8); the exact situation of this sample is unclear from their figures.

In analyses of sieved slides, dinocysts include:

Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)

Canningia reticulata (rare)

"*Cassiculodinium cassis*" (frequent)

"*Cassiculodinium reticulatum*" (rare)

"*Cassiculodinium symcassis*" (single)

Chlamydophorella nyei (rare)

Coronifera striolata (single)

Cribroperidinium spp. (frequent)

Cyclonephelium compactum (rare)

Epelidosphaeridia sp. (single)

Kaiwaradinium ramosum (rare)

Kiokansium unituberculatum (single; late Berriasian to late Cenomanian)

Kleithriasphaeridium cooksoniae (single; Hauterivian to Cenomanian)

Kleithriasphaeridium loffrense (rare; Aptian to Campanian)

Luxadinium propatulum (common; middle to late Albian)

Odontochitina ancala (single)

Odontochitina "*bathron*" (single)

Odontochitina costata (frequent; FO early Albian)

Odontochitina singhii (rare; Albian and Cenomanian of Alberta according to Singh 1983)

Oligosphaeridium "*perforoalbertense*" (single)

Operculodinium? "*delicatum*" (rare)

Operculodinium? “*latidelicatum*” (rare)
Ovoidinium cinctum (rare; LO top Albian)
Ovoidinium sp. (frequent)
Spiniferites “*tubiferus*” (rare)
Subtilisphaera sp. (frequent)
Surculosphaeridium longifurcatum (single)
Trithyrodinium sp. (single)

Among algae/acritarchs, spiny acritarchs are frequent.

Miospores include:
Angiosperm pollen (rare)
Classopollis classoides (single)
Distaltriangulisporites perplexus (single)
Eucommiidites minor (single)
Gleicheniidites senonicus (abundant)

Age. Thomson et al. (2011) assigned this sample to the “fish debris zone” of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the occurrence of *Luxadinium propatulum*. The presence of *Ovoidinium cinctum* supports an age no older than middle Albian and no younger than middle Cenomanian.

07-PEEL-50

C-477067 (P5262-17); 771.0 m from base of section; Slater River Formation

Snapshot: Assemblage diverse and although preservation fuzzy, specimens identifiable for most part.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 2.3% of the assemblage, bisaccates for 30%, dinocysts for 48% (including *Luxadinium propatulum* for 8%, *Ovoidinium* spp. 19% and *Subtilisphaera* 12%), trilete spores for 5% and angiosperm pollen for 0.5%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
"*Cassiculodinium brevispinosum*" (single)
"*Cassiculodinium cassis*" (rare)
Cyclonephelium vannophorum (single)
Luxadinium propatulum (abundant; middle to late Albian)
Ovoidinium cinctum (rare; LO top Albian)
Ovoidinium sp. (abundant)
Palaeoperidinium pyrophorum (rare)
Subtilisphaera perlucida (single)
Subtilisphaera spp. (abundant)

Among algae/acritarchs, *Paralecaniella* is frequent.

Miospores include:
Gleicheniidites senonicus (rare)
Rugubivesiculites sp. (single)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the occurrence of *Luxadinium propatulum*. The presence of *Ovoidinium cinctum* supports an age no older than middle Albian (as does the presence of *Rugubivesiculites*) and no younger than middle Cenomanian.

<u>07-PEEL-51</u>

C-477068 (P5262-18); 786.0 m from base of section; Slater River Formation

Snapshot: Assemblage fairly diverse, with *Subtilisphaera* prominent.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 4% of the assemblage, bisaccates for 35%, dinocysts for 33% (including *Subtilisphaera* for 20% … but *Luxadinium propatulum* and *Ovoidinium* spp. for 0.5 and 1% respectively), trilete spores for 19% and angiosperm pollen for 2%. This sample was considered to belong to facies F4 (offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
Batioladinium jaegeri (rare; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)
"*Cassiculodinium cassis*" (frequent)
Cyclonephelium compactum (single)
Kleithriasphaeridium cooksoniae (rare; Hauterivian to Cenomanian)
Kleithriasphaeridium loffrense (rare; Aptian to Campanian)
Luxadinium propatulum (rare; middle to late Albian)
Nyktericysta pentaradiata (single)
Odontochitina singhii (rare; Albian and Cenomanian of Alberta according to Singh 1983)
Oligosphaeridium albertense (rare; LO early Cenomanian according to Fensome et al 2008)
Ovoidinium cinctum (single; LO top Albian)
Palaeoperidinium pyrophorum (rare)
Pyxidinopsis "*rugosus*" (single)
Subtilisphaera spp. (abundant; estuarine–nearshore??)

Among algae/acritarchs, *Pterospermella* is frequent.

Miospores include:
Callialasporites dampieri (single)
Cerebropollenites macroverrucatus (single)
Gleicheniidites senonicus (common)
Rugubivesiculites sp. (rare)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is middle to late Albian based on the occurrence of *Luxadinium propatulum*. The presence of *Ovoidinium cinctum* supports an age no older than middle Albian (as does the presence of *Rugubivesiculites*) and no younger than middle Cenomanian.

07-PEEL-58

C-477069 (P5262-19); 910.0 m from base of section; Slater River Formation

Snapshot: Poor preservation, dominated by in place terrestrial elements.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 7% of the assemblage, bisaccates for 48%, dinocysts for 3%, trilete spores for 39% (including *Gleicheniidites* for 15%) and angiosperm pollen for 1%. This sample was considered to belong to facies F5 (lower shoreface–offshore) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
"*Tribulodinium cornuspinatum*" (single)
Ovoidinium sp. (single)

Miospores include:
Classopollis classoides (single)
Gleicheniidites senonicus (abundant)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is uncertain; possibly no younger than middle Cenomanian based on occurrence of *Ovoidinium* sp., but this is perhaps a reworked single specimen.

07-PEEL-62

C-477070 (P5262-20); 1005.0 m from base of section; Slater River Formation

Snapshot: Poor preservation, dominated by in place terrestrial elements.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 5% of the assemblage, bisaccates for 63%, dinocysts for 3%, trilete spores for 25% (including *Gleicheniidites* for just 4.5%) and angiosperm pollen for 1%. This sample was considered to belong to facies F5 (lower shoreface–offshore) by Thomson et al (2011).

No age-diagnostic dinocysts were encountered.

Miospores include:
Cerebropollenites macroverrucatus (rare)
Exesipollenites (single)
Gleicheniidites senonicus (frequent)
Neoraistrickia sp. (single)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Cerebropollenites macroverrucatus* may indicate an age no younger that middle Cretaceous.

07-PEEL-69

C-477071 (P5262-21); 1133.0 m from base of section; Slater River Formation

Snapshot: Poor preservation, dominated by in place terrestrial elements.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 5% of the assemblage, bisaccates for 50%, dinocysts for 4% and trilete spores for 38% (including *Gleicheniidites* for 16%); no angiosperm pollen were encountered. This sample was considered to belong to facies F5 (lower shoreface–offshore), transitional to facies F9 (middle shoreface) by Thomson et al (2011).

In analyses of sieved slides, dinocysts include:
Cribroperidinium sp. (rare)
Odontochitina sp. (single)
Oligosphaeridium totum (single; LO basal Cenomanian according to Fensome et al 2008)

Miospores include:
Antulsporites sp. (single)
Callialasporites sp. (single)
Cerebropollenites macroverrucatus (rare)
Classopollis classoides (single)
Gleicheniidites senonicus (abundant)
Rugubivesiculites sp. (single)

Age. Thomson et al. (2011) assigned this sample to the "fish debris zone" of early Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Cerebropollenites macroverrucatus*, *Callialasporites* sp. and *Classopollis classoides* may indicate an age no younger that middle Cretaceous.

07-PEEL-75

C-477072 (P5262-22); 1208.5 m from base of section; Trevor Formation

Snapshot: Poor preservation, still dominated by in place terrestrial elements, but increasing species richness of dinocysts.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 6% of the assemblage, bisaccates for 36%, dinocysts for 8% and trilete spores for 43% (including *Gleicheniidites* for 10% and *Stereisporites* for 6%); no angiosperm pollen were encountered.

In analyses of sieved slides, dinocysts include:

Batioladinium jaegeri (single; LO supposedly Hauterivian, but known to go into the Late Cretaceous in northern regions)

Odontochitina sp. (rare)

Miospores include:

Antulsporites sp. (single)

Classopollis classoides (single)

Foveotriletes sp. (single)

Gleicheniidites senonicus (common)

Neoraistrickia sp. (single)

Stereisporites antiquasporites (frequent)

Vitreisporites pallidus (frequent)

Age. Thomson et al. (2011) assigned this sample to the *Gaudryina irenensis* Zone of late Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Classopollis classoides* may indicate an age no younger that middle Cretaceous.

07-PEEL-83

C-477073 (P5262-23); 1269.0 m from base of section; Trevor Formation

Snapshot: Recognizable specimens relatively sparse and so counted to only 100. Dinocysts almost absent. Lots of dark kerogen.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 5% of the assemblage, bisaccates for 44%, dinocysts for 2% and trilete spores for 38% (including *Gleicheniidites* for just 6% and *Stereisporites* for 4%); no angiosperm pollen were encountered.

No dinocysts worth noting were encountered.

Miospores include:

Cerebropollenites macroverrucatus (single)
Classopollis classoides (single)
Foveotriletes (single)
Gleicheniidites senonicus (frequent)
Rugubivesiculites sp. (single)
Stereisporites antiquasporites (rare)

Age. Thomson et al. (2011) assigned this sample to the *Gaudryina irenensis* Zone of late Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Cerebropollenites macroverrucatus* and *Classopollis classoides* may indicate an age no younger that middle Cretaceous.

07-PEEL-95

C-477074 (P5262-24); 07-PEEL-95; 1533.5 m from base of section; Trevor Formation

Snapshot: Mostly terrestrial assemblage dominated by *Gleicheniidites*.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 0.5% of the assemblage, bisaccates for 7%, dinocysts for 5%, trilete spores for 82% (including *Gleicheniidites* for 58% and bryophytes for 6%), and angiosperm pollen for 0.5%.

In analyses of sieved slides, dinocysts include:
Canningia reticulata (rare)
Leptodinium sp. (single)
Palaeoperidinium pyrophorum (single)
Oligosphaeridium dictyophorum (single; LO early Albian)

Miospores include:
Appendicisporites sp. (single)
Classopollis classoides (single)
Distaltriangulisporites perplexus (rare; middle to late Albian of Alberta by Singh 1971)

Gleicheniidites senonicus (abundant)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) assigned this sample to the *Gaudryina irenensis* Zone of late Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Classopollis classoides* may indicate an age no younger that middle Cretaceous. The presence of *Distaltriangulisporites* suggests an Albian age, but specimens may be reworked, and the age of this species remains to be confidently determined.

<u>07-PEEL-102</u>

C-477075 (P5262-25); 07-PEEL-102; 1630 m from base of section; Trevor Formation

Snapshot: Recognizable specimens relatively sparse and so counted to only 100. Poor preservation. Lots of dark kerogen.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 9% of the assemblage, bisaccates for 30%, dinocysts for 2%, trilete spores for 51% (including *Gleicheniidites* for 20% and bryophytes for 6%), and angiosperm pollen for 1%.

No dinocysts worth noting were encountered.

Miospores include:
Antulsporites sp. (single)
Cerebropollenites macroverrucatus (rare)
Gleicheniidites senonicus (common)
Stereisporites antiquasporites (rare)

Age. Thomson et al. (2011) assigned this sample to the *Gaudryina irenensis* Zone of late Cenomanian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Cerebropollenites macroverrucatus* may indicate an age no younger that middle Cretaceous.

07-PEEL-108

C-477076 (P5262-26); 1733.5 m from base of section; Trevor Formation

Snapshot: Assemblage diverse but preservation mixed.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 1% of the assemblage, bisaccates for 26%, dinocysts for 34% (including *Oligosphaeridium* spp. for 5% and *Odontochitina* spp. for 7%) and trilete spores for 30% (including *Gleicheniidites* for 13% and bryophytes for 6%); no angiosperm pollen were encountered.

In analyses of sieved slides, dinocysts include:
Cauca parva (single; LO middle Albian)
Cribroperidinium spp. (frequent)
Kaiwaradinium sp. (single)
Kleithriasphaeridium cooksoniae (single; Hauterivian to Cenomanian)
Odontochitina "*corpusconus*" (single)
Odontochitina costata (frequent; FO early Albian)
Odontochitina singhii (single; Albian and Cenomanian of Alberta according to Singh 1983)
Oligosphaeridium albertense (rare; LO early Cenomanian according to Fensome et al 2008)
Oligosphaeridium dictyophorum (frequent; LO early Albian)
Surculosphaeridium convocatum (single)
Surculosphaeridium longifurcatum (single)

Among algae/acritarchs, *Baltisphaeridium* is frequent.

Miospores include:
Appendicisporites sp. (single)
Cerebropollenites macroverrucatus (single)
Classopollis classoides (single)
Gleicheniidites senonicus (common)

Stereisporites antiquasporites (rare)

Age. Thomson et al. (2011) assigned this sample to the *Gaudryina irenensis* Zone of late Cenomanian age. Based on the present palynological analysis it is Albian–early Cenomanian based on the co-occurrence of *Odontochitina singhii* and *Oligosphaeridium albertense*, although the rarity of these species suggests that they may be reworked The single occurrence of *Cauca parva* may be reworked.

07-PEEL-116

C-477077 (P5262-27); 1865 m from base of section; Trevor Formation

Snapshot: Assemblage diverse but preservation mixed.

In counts made on the unsieved slide, reworked Paleozoic miospores accounted for 1% of the assemblage, bisaccates for 18%, dinocysts for 14%, trilete spores for 59% (including *Gleicheniidites* for 30% and angiosperm pollen for 0.5%.

In analyses of sieved slides, dinocysts include:
Dinopterygium spp. (rare)
Odontochitina costata (single; FO early Albian)

Miospores include:
Appendicisporites sp. (single)
Classopollis classoides (rare)
Gleicheniidites senonicus (abundant)
Neoraistrickia sp. (single)
Stereisporites antiquasporites (frequent)

Age. Thomson et al. (2011) assigned this sample to the *Pseudoclavulina hastata* Zone of late Turonian age. Based on the present palynological analysis it is largely indeterminate, but the presence of *Classopollis classoides* may indicate an age no younger that middle Cretaceous.

Summary list

The following is a list of determinations for individual samples:

Martin House Formation (Early Albian according to Thomson et al.)

07-PEEL-01: possibly middle Albian or younger.

07-PEEL-02: Albian or younger.

Arctic Red Formation (later early Albian to earliest late Albian according to Thomson et al.)

07-PEEL-03: Albian to earliest Cenomanian.

07-PEEL-04: Albian

07-PEEL-09: Albian or younger.

07-PEEL-14: Early to middle Albian. [Just above is bentonite date of 107.0±1.9 Ma (late middle Albian to early late Albian according to Gradstein et al 2012)]

07-PEEL-20: indeterminate.

07-PEEL-23: Albian.

07-PEEL-29: Albian.

07-PEEL-39: earliest Cenomanian or older.

Slater River Formation (early Cenomanian according to Thomson et al.)

07-PEEL-43: middle to late Albian.

07-PEEL-40: middle to late Albian.

07-PEEL-45: middle to late Albian.

07-PEEL-46: middle to late Albian.

07-PEEL-47: middle to late Albian.

07-PEEL-48: middle to late Albian.

07-PEEL-50: middle to late Albian.

07-PEEL-51: middle to late Albian.

07-PEEL-58: middle Cenomanian or older.

07-PEEL-62: no younger than middle Cretaceous.

07-PEEL-69: no younger than middle Cretaceous.

Trevor Formation (Cenomanian–Turonian according to Thomson et al.)
07-PEEL-75: no younger than middle Cretaceous.
07-PEEL-83: no younger than middle Cretaceous.
07-PEEL-95: no younger than middle Cretaceous.
07-PEEL-102: no younger than middle Cretaceous.
07-PEEL-108: possibly Albian–early Cenomanian.
07-PEEL-116: no younger than middle Cretaceous.

DISCUSSION

Key taxa

In this section I discuss dinocyst taxa whose ranges are potentially key to unravelling the stratigraphy of the Albian-Cenomanian boundary beds in the Hume River section, as well as the Western Interior Basin in general. See Figure 6 for occurrences of key marker taxa in the Hume River section.

Batioladinium jaegeri. This distinctive species is persistent through much of the present material. Williams et al. (1999) gave its range as Portlandian to the top of the Valanginian. However, Costa and Davey (1992) showed its LO as middle Cenomanian, and it appears to have an extended range up to the Campanian in western and northern North America (e.g. Harker *et al*. 1990). Nøhr-Hansen et al. (in press) take it up to the middle Campanian. From the Western Interior Basin, Singh (1983) found it in the Upper Shaftesbury Formation of the Peace River area of Alberta and Schröder-Adams et al. (1996) indicated its LO within the Westgate Formation (probably age-equivalent to the Arctic Red Formation). In the present study, it goes upsection into the Slater River Formation and tentatively into the Trevor Formation.

Chichaouadinium vestitum. This species has a range almost invariably constrained to within the Albian — from the late early Albian to arounds the middle/late Albian boundary according to

Williams et al. (1999). Stover et al. (1996) indicated that the species ranged from early Albian to the top of that stage. Fensome et al. (2008) indicated that it has an LO of late Albian. Schröder-Adams et al. (1996) indicated its LO within the Westgate Formation, but Singh (1983, table 12 — which summarizes data also from his 1971 publication) indicates its presence in both the lower and upper parts of the Shaftesbury Formation, and sometimes abundant in the latter. Based on Singh (1983) the upper Shaftesbury is Cenomanian, the only such age designation for this species that I know of (and possibly incorrect as further discussed below).

Gardodinium trabeculosum. Williams et al. (1999) gave a range of basal Ryazanian (roughly basal Berriasian) to top Barremian for this species. However, in the present material specimens of this species occur in several samples in the lower part of the Arctic Red Formation, their relatively common occurrence suggesting that their presence is not due to reworking. That they are place in the Hume River section is supported by their observation in the lower part of the Westgate Formation by Schröder-Adams et al. (1996) and Albian strata as indicated in Singh (1983, table 12). J. Bujak (personal communication) uses *Gardodinium trabeculosum* as an Albian zonal marker in the Arctic.

Luxadinium propatulum. Williams et al. (1999) indicated that *Luxadinium propatulum* ranges from late early Albian to the top of the middle Albian. Stover et al. (1996) indicated that the species ranged from early Albian to the top of that stage. Schröder-Adams et al. (1996) indicated its LO near the top of the Westgate Formation, but Singh (1983, table 12) shows it as present in the lower Shaftesbury Formation, but rare to dominant in the upper Shaftesbury Formation (as for *Chichaouadinium vestitum*, this would be an unusually late determination). In contrast, Leckie et al. (1992), whose study also involved the Shaftesbury Formation and is co-authored by C. Singh, *Luxadinium propatulum* is strikingly abundant in samples below the Fish Scale Marker Bed, somewhat abundant in the lower part of that Bed, and absent or sparse (perhaps reworked) in higher strata (Figure 7 herein). In the present study, the upper range of *Luxadinium propatulum* is similar to that recorded by Leckie et al., being often significant in assemblages up to and into the Slater River Formation (designated by Thomson et al. 2011 as the ‘fish debris zone’).

Odontochitina singhii. Schröder-Adams et al. (1996) observed this species to have an FO within the Westgate Formation and an LO within the Fish Scales Formation. Singh (1983, table 13 recorded it as rare to abundant in the upper Shaftesbury Formation, but not below. In the present study, it was most common in the lower part of the Slater River Formation, above which it was sparse (possibly reworked).

Oligosphaeridium albertense. According to Williams et al. (1999), this species has a range of basal Valanginian to late Albian. Fensome et al. (2008) gave it an LO of early Cenomanian, as did Costa and Davey (1992). In the present study, it ranges from the Arctic Red Formation upward into the Slater River Formation, and sparsely into the Trevor Formation, possibly through reworking.

Oligosphaeridium totum. According to Williams et al. (1999), this species has a range of early Aptian to top Albian. Fensome et al. (2008) gave it an LO of early Cenomanian. Schröder-Adams et al. (1996) indicated its LO near the top of the Westgate Formation. Singh (1983, table 12) indicates its presence in the lower Shaftesbury Formation, but rare in the upper part of the formation (the latter possibly due to reworking). In the present work it was largely restricted to the Arctic Red Formation, but sparsely extended into the Slater River Formation.

***Ovoidinium* spp.** Both *Ovoidinium cinctum* and *Ovoidinium verrucosum* are verrucate species. Although the nature of the verrucae is variable is size and distribution (see for example Cookson and Hughes 1964, pl. 5, figs. 4–7), any attempt to subdivide this morphology into more than one species doesn’t seem clearcut or useful. Hence *Ovoidinium verrucosum* is here considered a taxonomic junior synonym of *Ovoidinium cinctum*. Williams et al. (1999) gave the range of *Ovoidinium cinctum* as late Valanginian to top Albian, but that of *Ovoidinium verrucosum* as middle Albian to top Albian. Costa and Davey gave the range of *Ovoidinium verrucosum* as late Albian to early Cenomanian; they did not give a range for *Ovoidinium cinctum*. Stover et al. (1996) gave the range of *Ovoidinium verrucosum* as late Albian to middle Cenomanian and *Ovoidinium cinctum* a range of Barremian to late Albian. Costa and Davey gave *Ovoidinium scabrosum* (a distinct species with scabrate rather than verrucate ornament) a range of late Aptian to top Albian.

Singh (1983, table 12) indicated that *Ovoidinium verrucosum* is present in the lower Shaftesbury Formation and often abundant in the upper, but essentially not ranging higher than the Shaftesbury Formation. In contrast to the comparison with the range of *Luxadinium propatulum* in Singh (1983) versus Leckie et al. (1992), the latter authors show *Ovoidinium verrucosum* ranging through their section, and most abundant above the Fish Scale Marker Bed. This compares well with the range of *Ovoidinium verrucosum* in Schröder-Adams et al (1996), who indicate an FO in the upper part of the Westgate Formation and an LO within the Belle Fourche Formation, above the Fish Scales Formation. In the present study, *Ovoidinium cinctum* (and *Ovoidinium* spp.) has a short range within the Slater River Formation.

Pseudoceratium polymorphum. Usually reported in the literature as *Aptea polymorpha*, this species has been used for a range of morphologies including forms with and without a lateral horn. As used herein, and accordant with the morphology of the type, this species can have uniform or marginate ornament distribution and high or low reticulate crests — but always a lateral horn and hence assigned to *Pseudoceratium*. Williams et al. (1999) gave the range for this species as base Barremian to middle Albian. Stover et al. (1996) indicated that this species has an LO of top Albian. If the species does extend in range up to the top of the Albian, it is probably not common in the late Albian.

Senoniasphaera microreticulata. Williams et al. (1999) gave a range for this species of early Aptian to top middle Albian. In the present study it is restricted to the Arctic Red Formation.

<u>The Hume River section</u>

Figure 8 shows the paleogeographic setting for the Hume River section at various times during the middle Cretaceous. Figure 9 shows the ranges of taxa encountered in the Hume River section arranged according to FOs; Figure 10 is a similar plot arranged according to LOs.

Thomson et al. (2011) provided a discussion of the Hume River section based mainly on foraminiferal and sedimentological observations. Although the present study relies on fewer samples than those analyzed by Thomson et al., some interesting comparisons and observations can be made. Thomson et al. noted that the Martin House Formation reflects a marine transgression in the region. The two samples analyzed for palynology from the Martin House Formation support this scenario: the lowest sample (07-PEEL-01) is dominated by reworked Paleozoic (primarily Devonian) miospores (Fig. 4), reflecting erosion of older rocks as the Cretaceous sea advanced. The sample has a sparse in-situ assemblage of palynomorphs with a few dinocysts that tentatively suggest a middle Albian or younger age. The upper sample from the Martin House Formation still has a significant proportion of reworked Paleozoic miospores, but the in-situ palynomorph assemblage is here over 50 percent. The upper sample includes also a sparse dinocyst assemblage that is suggestive of an Albian or younger age. Palynology supports the paleoenvironmental interpretation of Thomson et al. and suggests, albeit not convincingly, a slightly younger age than early Albian foraminiferal determination.

In terms of age, the palynomorphs in the Arctic Red Formation, especially dinocysts, point to an Albian age generally, and a middle to late Albian age for the uppermost samples. A U–Pb radiometric date of 107 ± 1.9 Ma just above sample 07-PEEL-14 (Thomson et al. 2011) indicates a late Albian age, with which the palynological assemblages accord; according to Thomson et al. (2011), the foraminifera in this part of the section indicate an early Albian age. Thomson et al. noted that the Arctic Red Formation represents a mudstone infilling of a (subsiding) foreland basin, with coarser units toward the top of the unit reflecting a shallowing, which is also reflected in the assemblages of benthic foraminifera. They noted that the section is incomplete as part of the section near the top of the formation is covered.

Marine elements among the palynomorphs in the Arctic Red samples analyzed fluctuate in abundance (Fig. 4) and species richness. Two of the lowermost three samples (07-PEEL-04 and 07-PEEL-09) are dominated by dinocysts, but in each sample, one or two species make up large proportions of the dinocysts present. In 07-PEEL-04, the species *Sentusidinium myriatrichum* makes up over half of the dinocyst assemblage and constitutes almost 40 percent of the entire palynomorph assemblage. In the same sample, a problematic form that I've called "*Chlamydophorella*/*Sepispinula*" in the counts makes up 11 percent — so around half the entire palynomorph assemblage is made up of spiny proximochorate dinocysts. Such an assemblage, with few species predominating and relatively low species richness, suggests a marginal marine setting. A similar dinocyst, recorded as "*Sentusidinium*/*Impletosphaeridium*" in the counts, makes up 63 percent of the entire palynomorph assemblage in 07-PEEL-09, and that sample has a very low dinocyst species richness, leading to similar paleoenvironmental conclusions. Within the Arctic Red Formation, above 07-PEEL-09, samples continue to have a low species richness of dinocysts.

The uppermost two samples (07-PEEL-29 and 07-PEEL-39) have a very low representation of (possibly reworked) dinocysts. According to Thomson et al. (2011), sedimentological evidence at the top of the Arctic Red Formation indicates a regression, and the presence of a paleosol convincingly argues for exposure and a terrestrial setting. Thomson et al. noted that "This event [regression and exposure at the top of the Arctic Red Formation] accompanies a nearly complete loss of Albian foraminiferal fauna, corresponding to a faunal turnover widely recognised … [in the Western Interior Basin] at the Albian/Cenomanian boundary …. It is unknown how much time is missing, but the subsequent foraminiferal assemblage established within the seaway is considered to be of Cenomanian age. Thomson et al. (2011) further noted that seismic line A15 (Sigma 15 in Hadlari et al. 2014) shows an angular unconformity separating the Arctic Red and Slater River formations. They concluded that a combination of drop in sea level and tectonic uplift caused exposure at the top of the Arctic Red Formation. They noted that this sequence boundary coincides with a global lowstand at 99.5 Ma. As discussed below, the palynological evidence conflicts somewhat with these conclusions.

A conflict also exists within Thomson et al.'s (2011) paper as to the exact location of the boundary between the Arctic Red and Slater River formations with respect to samples. Their fig. 7 shows samples 07-PEEL-39, 07-PEEL-40 and 07-PEEL-43 in the uppermost Arctic Red Formation and 07-PEEL-45 at the boundary between the two formations. Their figure 17 appears to show 07-PEEL-39 at the top of the Arctic Red Formation, 07-PEEL 43 just above (or perhaps straddling) the boundary, and 07-PEEL-45 clearly within the Slater River Formation. T. Hadlari (personal communication), who collected the samples used in the present study in collaboration with D. Thomson, has indicated that sample 07-PEEL-39 is at the top of the Arctic Red Formation and samples 07-PEEL-43, 07-PEEL-40 (in that stratigraphic order, oldest first) and 07-PEEL-45 are from the lowermost Slater River Formation. With this version of sample locations, the major turnover of species within both the foraminiferal and palynologically assemblages coincides with the unconformity and formation boundary, as would be expected.

The lowermost 8 samples of the Slater River Formation are clustered in the unit's bottom 60 m. The assemblage in sample 07-PEEL-43 contains about 30 percent dinocysts and so is distinctly marine, and includes the FO of the middle to late Albian dinocyst *Luxadinium propatulum.* The next sample upsection, 07-PEEL-40 (the numbering is reversed here) is dominated by dinocysts, and the dinocysts in turn are dominated by a single species, "*Tribulodinium cornufilosum*" (formerly within the range of morphologies included in *Circulodinium distinctum*). Such an assemblage suggests a marginal marine setting. The remaining six of this cluster of lowermost Slater River samples (07-PEEL-45 to 07-PEEL-51) contain relatively common and diverse assemblages indicating fully marine settings of middle to late Albian age. The age of the remainder of the Slater River Formation (from sample 07-PEEL-58 upward) and the entire Trevor Formation is difficult to assess from palynology due to generally poorer assemblages, fewer diagnostic (especially dinocyst) taxa, and probably extensive reworking. The second from topmost sample in the Trevor Formation returned an Albian to early Cenomanian date, but a younger date could be masked by reworking. No species with restricted Cenomanian or younger ranges were found in the entire section. Thomson et al. (2011), who noted that "The upper 400 m of [the] Slater River Formation is a gradual upward shallowing succession from an offshore marine to lower shoreface setting." The palynomorph assemblage possibly suggests marginal marine conditions for the upper part of the Slater River Formation. Given that the Albian/Cenomanian boundary generally is represented by a lowstand, could the interval between samples 07-PEEL-51 and 07-PEEL-58 encompass an alternate level for that boundary in the Hume River section?

The palynomorph assemblages in the Trevor Formation are mostly dominated by miospores and the dinocysts are sparse and possibly largely reworked. The assemblages thus suggest non-marine to marginal marine settings, although sample 07-PEEL-108 has an assemblage consisting of 34 percent dinoflagellates, with species of *Oligosphaeridium* and *Odontochitina* prominent, indicating a neritic setting. Thomson et al. (2011) noted that the Trevor Formation represents a series of prograding upward-coarsening parasequences reflecting high-frequency sea-level fluctuations at a time of eastward and northward migration of the Cordilleran deformation front (Cenomanian–Turonian). The palynomorph assemblages are in approximate accord with this scenario.

The Albian–Cenomanian boundary in the Western Interior Basin

The Cretaceous paleogeography of western North America is dominated by the expansions and contractions of the Western Interior Seaway, which for parts of the period extended from the Gulf of Mexico to the nascent Arctic Ocean, and at other times was more restricted. These fluctuations had fundamental impacts on the paleoenvironments and fossil assemblages of the western interior of the continent. The strata of the Western Interior Basin are better known from the Prairie Provinces than from northern Canada.

Singh (1971, 1983) studied the palynofloras of the late Early Cretaceous and early Late Cretaceous respectively in the Peace River area of north-central Alberta, generating a rich taxonomy and dataset. However, he did not focus specifically on the Albian–Cenomanian boundary, so important observations from those works are discussed in the section above on key taxa. It is worth noting, however, that Singh (1983) indicated a "Fish Scale" marker separating the upper and lower Shaftesbury Formation.

Leckie et al. (1992) studied the "Fish Scale Marker Bed" (FSMB), part of the Shaftesbury Formation near the town of Peace River, Alberta. They noted that the unit (under various but similar names — for example "Fish Scales" by Selwyn as early as 1877) is widely distributed, from northeastern British Columbia to Manitoba; this widespread unit in the Prairies also correlates with "fish debris zone" in the Hume River Section (Thomson et al. 2011), which in turn equates with the Slater River Formation. Leckie et al. noted that the FSMB commonly occurs as a sandstone or sandstone–siltstone bed with abundant fish remains. Based on a comparison of ammonites found in northeastern British Columbia with those from the Western Interior of the United States (Reeside and Cobban 1960 and Cobban and Kennedy 1989, summarized in Leckie et al. 1992), the Albian–Cenomanian, and thus the Lower–Upper Cretaceous, boundary should be at or near the base of the FSMB. Leckie et al. reported that elements of the *Verneulina canadensis* foraminifera zone were present in their section beneath the FSMB, supporting a latest Albian age for that interval. Further support came from the FO of *Ovoidinium verrucosum* (= *Ovoidinium cinctum*), first described from the ammonite-controlled upper Albian strata of France. Leckie et al. (1992) recorded the occurrence of selected taxa in their table 2, repeated here as Figure 7. *Luxadinium propatulum* is strikingly common beneath the FSMB, somewhat common in the lower of their two divisions (unit 2A) within the FSMB, and absent or rare (most probably reworked) in the upper unit (2C) of the FSMB and above the FSMB. *Ovoidinium verrucosum* remains somewhat common throughout the section, though generally more common higher in the section, above the FSMB.

Bloch et al. (1993) revised the stratigraphy for the Albian to early Turonian interval for the "central and southern Plains of Alberta and Saskatchewan" (caption to their fig. 2), but considered a broader area, from the Foothills to Manitoba. Their scheme included, from oldest to youngest: the Westgate Formation, considered Albian in age; the Fish Scales Formation, considered earliest Cenomanian in age; the Belle Fourche Formation, considered Cenomanian in age; and the Second White Specks Formation, considered earliest Turonian in age. Bloch et al. (1993) incorporated dinocyst and other microfossil data, but they did not provide a range chart or quantitative data for dinocysts. Species that they reported from the Westgate Formation included *Chichaouadinium vestitum*, *Florentinia cooksoniae* (= *Kleithriasphaeridium cooksoniae*), *Luxadinium propatulum, Ovoidinium verrucosum* (= *Ovoidinium cinctum*), and *Oligosphaeridium totum*, all of which, they stated, also appear in the Cenomanian, with *Luxadinium propatulum* and *Ovoidinium verrucosum* first appearing in the late Albian, as well as *Bourkidinium psilatum*. They recorded the LO of *Senoniasphaera microreticulata* in the Westgate Formation.

For the Fish Scales Formation, Bloch et al. again listed *Chichaouadinium vestitum*, *Florentinia cooksoniae, Luxadinium propatulum,* and *Ovoidinium verrucosum*, as well as *Odontochitina singhii,* among others, as characteristic dinocysts. Bloch et al. (1993, p.338–339) stated that their palynological data "… do not definitively distinguish the Fish Scale Formation from the underlying Westgate [Formation] …." They noted, however, that data in Singh (1983) and Leckie et al. (1992) "show a change in dinoflagellate assemblage between the Westgate and Fish

Scales formations and suggest an early Cenomanian age for the Fish Scales Formation." Bloch et al's assemblages from the lower part of the Belle Fourche Formation include *Chichaouadinium vestitum*, *Gardodinium trabeculosum*, *Ginginodinium evittii*, *Luxadinium propatulum*, *Odontochitina singhii* and *Oligosphaeridium totum.* They noted that *Ovoidinium verrucosum* has its LO in the Fish Scales Formation or lowest Belle Fourche Formation.

Schröder-Adams et al. (1996) focussed on paleoenvironmental changes in the Albian–Turonian Colorado Group, which includes the Westgate, Fish Scales and Belle Fourche formations. Their fig. 12 is a range chart for dinocyst species, reproduced here as Figure 11. The caption to their figure emphasizes "the numerous taxa which range across the boundary between the Westgate and Fish Scales Formations". Of equal or greater interest however are the FO and LO events illustrated by the chart. Among the species that have LOs in the Westgate Formation are *Batioladinium jaegeri*, *Catastomocystis spinosa*, *Chichaouadinium vestitum*, *Gardodinium trabeculosum* and *Oligosphaeridium totum*. Among the FOs in the Westgate Formation are *Florentinia cooksoniae* (now *Kleithriasphaeridium cooksoniae*), *Odontochitina singhii* and *Ovoidinium verrucosum* (= *Ovoidinium cinctum*). According to the chart, *Ginginodinium evittii* and *Odontochitina singhii* have LOs within the Fish Scales Formation. *Ovoidinium verrucosum* has its LO in the Belle Fourche Formation. And numerous taxa, including *Chatangiella* spp., *Heterosphaeridium difficile*, *Isabelidinium* spp. and *Surculosphaeridium longifurcatum*, have FOs in the Second White Specks Formation.

Hadlari et al. (2014) examined three samples from around the Albian–Cenomanian boundary. Sample 2009TH02A is mudstone from the Arctic Red Formation, beneath the pisolitic ironstone bed (interpreted as a paleosol) at the base of the Slater River Formation. This sample contained a non-definitive palynomorph assemblage suggestive of an Albian age. Samples 2009TH02B and 2009TH02C are from marine Slater River mudstone overlying the pisolitic ironstone. Hadlari et al. noted that the presence of *Luxadinium propatulum* in both samples and of *Ovoidinium verrucosum* (=*Ovoidinium cinctum*) and *Oligosphaeridium albertense* in 2009TH02B, plus the absence of *Chatangiella* restrict the assemblage to a late Albian to early Cenomanian age. They noted that although the Slater River Formation is largely barren of foraminifera, the discovery of a single specimen of *Textularia alcesensis* in the middle part of the Slater River succession by

Thomson et al. (2011) indicates an early Cenomanian age and supports the equivalency of the Slater River Formation with the "fish debris marker" (i.e. Fish Scales Formation) in Alberta.

CONCLUSIONS

Figures 4 and 6 show overviews of paleoenvironmental and biostratigraphic data respectively. Based on palynomorph assemblages, the Martin House Formation is early to middle Albian in age and represents a marine transgression over a late Paleozoic basement, attested to by abundant reworked Devonian to ?early Carboniferous palynomorphs. The palynological assemblages indicate a middle to late Albian age for Arctic Red Formation; this determination combined with a late Albian U–Pb radiometric date in the lower part of the formation indicates a late Albian age for the unit. The Arctic Red Formation shows increasing marine influence in its lower part (maximum flooding surface?), with fluctuating dinocyst content reflecting fluctuating proximity to shoreline. The uppermost sample (07-PEEL-39) identified as terrestrial by Thomson et al. (2011), does indeed show strong terrestrial and reworked palynomorph components and a low percentage of probably reworked dinoflagellates.

Assemblages in the basal part of the Slater River Formation show a marked increase in dinocysts. Accepting that *Luxadinium propatulum* is an Albian taxon (the predominant viewpoint among specialists), the lowest part of the Slater River Formation is late Albian in age. This conclusion is supported by the presence of other "Albian" dinocysts in these samples, such as *Chichaouadinium vestitum*. The marine component of the Slater River assemblages declines higher in the Formation, where miospores dominate and the palynomorph assemblages suggest marginal marine conditions even in samples considered to represent middle shoreface to offshore conditions by Thomson et al. (2011).

Dinocysts, especially biostratigraphic markers, are sparse in the upper Slater River and Trevor formations, and no markers unequivocally younger than early Cenomanian were encountered, though these could be reworked given their sparsity. The palynological evidence is in accordance with the foraminiferal occurrence indicating an early Cenomanian age in the middle of the Slater River Formation.

From the above, it would seem that the Albian–Cenomanian boundary may be within the basal part of the Slater River Formation rather than at the boundary or that formation with the underlying Arctic Red Formation. Interesting parallels can be drawn with lithological units and dinocyst assemblages in other parts of the Western Interior Basin, notably in northern Alberta. Perhaps there too, the Albian–Cenomanian boundary is within the basal part of the Fish Scales Marker Bed (equivalent to the Slater River Formation) rather than at its base.

Examination of similar nearby sections and the establishment of an event stratigraphy for the region, incorporating multidisciplinary evidence, would likely refine the age determinations. Such an event stratigraphy might also be applicable across the Western Interior Basin.

SUPPLEMENTAL ANALYSES

Following completion of advanced drafts of this report, three further samples were provided and analyzed. The results confrim the previous conclusions. Three samples were collected from the Hume River section by Thomas Hadlari in 2009. Sample 2009TH02A (P5153-36) was collected from Arctic Red Formation below the sub-Slater River Formation unconformity. Samples Samples 2009TH02B (P5153-37) and 2009TH02C (P5153-38) are from the base of Slater River Formation directly above the unconformity. Previous analyses of these samples was recorded by Hadlari et al. (2014).

Sample P5153-36 (Arctic Red Formation) is dominated by fragmented kerogen. The most numerous recognizable palynomorphs are reworked, poorly preserved Paleozoic spores, though some sporadic Mesozoic spores are present, mostly *Gleicheniidites*. I did not find confirmed dinocysts in this sample, (cf. Hadlari et al. 2014), but I was unable to examine the coarse fraction slide as it is missing.

Sample P5153-37 (basal Slater River Formation) has a palynomorph assemblage dominated by dinocysts, which in turn is dominated overwhelmingly by specimens' of "*Tribulodinium*" (formerly circumscribed by *Cyclonephelium distinctum*). Also present are *Oligosphaeridium* spp. (including *Oligosphaeridium albertense*), *Cymososphaeridium*? sp. and single specimens of *Luxadinium propatulum*, *Ovoidinium scabrosum* and *Batioladinium jaegeri.*

Sample P5153-38 (basal Slater River Formation) contains a diverse assemblage of dinocysts. Most common are areoligeraceans/ceratiaceans, mainly "*Cassiculodinium*" and *Pseudoceratium*, but with relatively uncommon "*Tribulodinium*" (in contrast to sample P5153-37G). There is a diverse range of *Oligosphaeridium* species, including *Oligosphaeridium albertense* and *Oligosphaeridium totum*. The frequent presence in *Nyktericysta* and *Luxadinium propatulum* indicates an age no younger than late Albian.

Thus, the new analyses support the conclusion that the basal part of the Slater River Formation is below the Albian–Cenomanian boundary. Alternatively, the ranges of some key tax need to be extended upward at least regionally.

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Figure captions

Figure 1. Map showing the location and geological setting of the Hume River section. Adapted from Hadlari et al. (2014, figs. 1–2).

Figure 2. Details of the Hume River section, showing samples analyzed in the present study: A — Martin House and Arctic Red formations; B — Slater River and Trevor formations. Adapted from Thomson et al. 2011, figs. 7–9.

Figure 3. Basic paleoenvironmental model used by Thomson et al. (2011).

Figure 4. Relative percentages of major palynomorph groups in samples from the present study.

Figure 5. Outline of the revised taxonomic scheme for proximate to proximochorate dinocysts used in the present study. A taxonomic paper based on these ideas is in preparation.

Figure 6. Key taxa and age determinations from the present study, contrasted with the zonation and age determinations of Thomson et al. (2011).

Figure 7. Selected data from table 2 of Leckie et al. (1992) showing counts of taxa in and around the Fish Scale Marker in the Shaftesbury Formation in northern Alberta. Adapted from Leckie et al. (1992)

Figure 8. Paleogeographical setting of the Hume River section (red star) at various times during the middle Cretaceous. Redrawn after Thomson et al. (2011).

Figure 9. Ranges of selected taxa from the present study arranged according to FOs.

Figure 10. Ranges of selected taxa from the present study arranged according to LOs.

Figure 11. Ranges from of figure 11 of Schröder-Adams et al. (1995) showing dinoflagellate ranges in a section from southwestern Alberta. Key species (discussed in text) in red. Adapted from Schröder-Adams et al. (1995).

Plate captions

Plate 1

All scale bars = 20 μm.

Figure 1. *Achomosphaera ramulifera* from sample 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figures 2–4. *Apteodinium granulatum* from sample 07-PEEL-43, Slater River Formation. Ventral view of ventral surface (Figure 2), ventral medial view (Figure 3) and ventral view of dorsal surface (Figure 4).

Figure 5. *Batioladinium jaegeri* from sample 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 6. *Batioladinium jaegeri* from sample 07-PEEL-46, Slater River Formation. Dorso-ventral view.

Figure 7. *Apteodinium* cf. *granulatum* from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 8. *Apteodinium spongiosum* from 07-PEEL-48, Slater River Formation. Oblique-lateral view.

Figure 9. *Bourkidinium psilatum* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 10. *Callaiosphaeridium* "*latispinum*" from 07-PEEL-40, Slater River Formation. Antero-posterior view.

Figures 11. *Callaiosphaeridium* "*latispinum*" from 07-PEEL-46, Slater River Formation. Antero-posterior view.

Figure 12. *Callaiosphaeridium* "*spinulosum*" from sample 07-PEEL-48, Slater River Formation. Antero-posterior view.

Figure 13. *Canningia reticulata* from 07-PEEL-09, Arctic Red Formation. Ventral view of ventral surface.

Figures 14–15. *Canningia reticulata* from 07-PEEL-48, Slater River Formation. Ventral view of ventral surface (Figure 14) and ventral view of dorsal surface (Figure 15).

Figure 16. *Canninginopsis* sp. from 07-PEEL-14, Arctic Red Formation. Dorso-ventral view.

Figure 17. "*Cassiculodinium*" *brevispinosum* from 07-PEEL-04, Arctic Red Formation. Dorsal view.

Figure 18. "*Cassiculodinium*" *brevispinosum* from 07-PEEL-04, Arctic Red Formation. Dorsal view.

Figure 19. "*Cassiculodinium cassis*" from 07-PEEL-43, Slater River Formation. Ventral view.

Figure 20. "*Cassiculodinium cassis*" from 07-PEEL-43, Slater River Formation. Ventral view.

Plate 2

All scale bars = 20 µm.

Figures 1–3. "*Cassiculodinium cassis*" from 07-PEEL-40, Slater River Formation. Ventral view of ventral surface (Figure 1), medial optical section in ventral view (Figure 2) and ventral view of dorsal surface (Figure 3).

Figure 4. "*Cassiculodinium cassis*" from 07-PEEL-43, Slater River Formation. Ventral view.

Figure 5. "*Cassiculodinium cassis*" from 07-PEEL-43, Slater River Formation. Ventral view.
.
Figure 6. "*Cassiculodinium cassis*" from 07-PEEL-45, Slater River Formation. Dorso-ventral view.

Figure 7. "*Cassiculodinium cassis*" from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 8. "*Cassiculodinium cassis*" from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 9. "*Cassiculodinium reticulatum*" from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 10. "*Cassiculodinium reticulatum*" from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 11. “*Cassiculodinium reticulatum*” from 07-PEEL-46, Slater River Formation. Apical view of detached operculum.

Figure 12. “*Cassiculodinium reticulatum*” from 07-PEEL-45, Slater River Formation. Ventral view.

Figure 13. “*Cassiculodinium symcassis*” from 07-PEEL-45, Slater River Formation. Ventral view.

Figure 14. “*Cassiculodinium symcassis*” from 07-PEEL-48, Slater River Formation. Ventral? view.

Figure 15. *“Cassiculodinium reticulatum*” from 07-PEEL-45, Slater River Formation. Ventral view.

Figure 16. *“Cassiculodinium reticulatum*” from 07-PEEL-40, Slater River Formation. Dorsal view.

Figure 17. “*Cassiculodinium symcassis*” from 07-PEEL-51, Slater River Formation. Dorsal? view.

Figure 18. “*Cassiculodinium symreticulatum*” from 07-PEEL-14, Arctic Red Formation. Ventral? view.

Figure 19. *Chichaouadinium vestitum* from 07-PEEL-40, Slater River Formation. Dorso-ventral view.

Figure 20. *Chichaouadinium vestitum* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Plate 3

All scale bars = 20 μm.

Figure 1. *Cauca parva* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 2. *Cauca parva* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 3. *Cerbia* sp.from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 4. *Chlamydophorella nyei* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 5. *Coronifera oceanica* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 6. *Coronifera striolata* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 7. *Cribroperidinium cooksoniae* from 07-PEEL-48, Slater River Formation. Oblique ventral view.

Figure 8. *Cribroperidinium cooksoniae* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 9–11. *Cribroperidinium edwardsii* from 07-PEEL-45, Slater River Formation. Ventral view at high focus (Figure 9), medial focus (Figure 10) and low focus (Figure 11).

Figure 12. *Cribroperidinium edwardsii* from 07-PEEL-45, Slater River Formation. Dorso-ventral view.

Figure 13. *Cribroperidinium orthoceras* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figures 14–15. *Cribroperidinium edwardsii* from 07-PEEL-45, Slater River Formation. Right-lateral view, high focus (Figure 14) and low focus (Figure 15).

Figure 16. *Cribroperidinium edwardsii* from 07-PEEL-46, Slater River Formation. Ventral view.

Figure 17. *Cribroperidinium orthoceras* from 07-PEEL-43, Slater River Formation. Dorsal view of dorsal surface.

Figures 18–19. *Cribroperidinium orthoceras* from 07-PEEL-48, Slater River Formation. Apical? view, high focus (Figure 18) and low focus (Figure 19).

Figure 20. *Cribroperidinium orthoceras* from 07-PEEL-48, Slater River Formation. Oblique left-lateral? view.

Plate 4

All scale bars = 20 μm.

Figure 1. *Cribroperidinium orthoceras* from 07-PEEL-46, Slater River Formation. Isolated operculum.

Figure 2. *Cribroperidinium sepimentum* from 07-PEEL-45, Slater River Formation. Right lateral view.

Figure 3. *Cribroperidinium sepimentum* from 07-PEEL-43, Slater River Formation. Dorso-ventral view of dorsal surface.

Figure 4. *Cyclonephelium compactum* from 07-PEEL-23, Arctic Red Formation. Dorsal view.

Figure 5. *Cyclonephelium compactum* from 07-PEEL-23, Arctic Red Formation. Dorso-ventral view.

Figure 6. *Cyclonephelium compactum* from 07-PEEL-23, Arctic Red Formation. Dorsal? view.

Figure 7. *Cyclonephelium compactum* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 8. *Cyclonephelium compactum* from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 9. *Cymososphaeridium validum* from 07-PEEL-03, Arctic Red Formation. View uncertain.

Figure 10. *Dinopterygium cladoides* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 11. *Cyclonephelium vannophorum* from 07-PEEL-14, Arctic Red Formation. Dorsal view.

Figure 12. *Cyclonephelium compactum* from 07-PEEL-51, Slater River Formation. Dorsal view.

Figure 13. *Dinopterygium alatum* from 07-PEEL-40, Slater River Formation. Dorso-ventral? view.

Figure 14. *Dinopterygium alatum* from 07-PEEL-40, Slater River Formation. Dorso-ventral? view.

Figure 15. "*Tribulodinium cornupilosum*" from 07-PEEL-40, Slater River Formation. Ventral view.

Figure 16. "*Tribulodinium cornupilosum*" from 07-PEEL-40, Slater River Formation. Ventral? view.

Figure 17. "*Tribulodinium cornupilosum*" from 07-PEEL-40, Slater River Formation. Dorsal view.

Figure 18. "*Tribulodinium cornupilosum*" from 07-PEEL-43, Slater River Formation. Ventral view.

Figure 19. "*Tribulodinium cornupilosum*" from 07-PEEL-43, Slater River Formation. Dorsal view.

Figure 20. "*Tribulodinium cornupilosum*" from 07-PEEL-45, Slater River Formation. Ventral view.

Plate 5

All scale bars = 20 µm.

Figure 1. "*Tribulodinium cornuspinatum*" from 07-PEEL-03, Arctic Red Formation. Dorsal view.

Figure 2. "*Tribulodinium cornuspinatum*" from 07-PEEL-04, Arctic Red Formation. Ventral view.

Figure 3. "*Tribulodinium cornuspinatum*" from 07-PEEL-04, Arctic Red Formation. Dorsal view.

Figure 4. "*Tribulodinium cornuspinatum*" from 07-PEEL-14, Arctic Red Formation. Ventral view.

Figure 5. *Catastomocystis* "*rasilis*" from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 6. "*Tribulodinium cornuspinatum*" from 07-PEEL-45, Arctic Red Formation. Ventral view.

Figure 7. "*Tribulodinium pilosum*" from 07-PEEL-46, Slater River Formation. Dorso-ventral view.

Figure 8. "*Tribulodinium cornuspinatum*" from 07-PEEL-20, Martin River Formation. Dorsal view.

Figure 9. *Catastomocystis* "*rasilis*" from 07-PEEL-50, Slater River Formation. Dorso-ventral view.

Figure 10. *Catastomocystis* "*rasilis*" from 07-PEEL-51, Slater River Formation. Dorso-ventral view.

Figure 11. *Catastomocystis* "*rasilis*" from 07-PEEL-45, Slater River Formation. Dorso-ventral view.

Figure 12. *Catastomocystis* "*rasilis*" from 07-PEEL-45, Slater River Formation. Dorso-ventral view.

Figure 13. *Exochosphaeridium* "*spheriphragmites*" from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 14. *Exochosphaeridium* "*spheriphragmites*" from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 15. *Exochosphaeridium* "*spheriphragmites*" from 07-PEEL-43, Slater River Formation. Oblique left-lateral view.

Figure 16. *Stephodinium*? sp. from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 17. *Exochosphaeridium phragmites* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 18. *Exochosphaeridium phragmites* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 19. *Exochosphaeridium* "*spheriphragmites*" from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 20. *Exochosphaeridium* "*spheriphragmites*" from 07-PEEL-48, Slater River Formation. Right lateral view.

<u>Plate 6</u>

All scale bars = 20 μm.

Figure 1. *Escharisphaeridia pocockii* from 07-PEEL-03, Arctic Red Formation. View uncertain.

Figure 2. *Escharisphaeridia pocockii* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 3. *Escharisphaeridia pocockii* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 4. *Hystrichodinium pulchrum* from 07-PEEL-23, Arctic Red Formation. View uncertain.

Figure 5. *Gardodinium trabeculosum* from 07-PEEL-03, Arctic Red Formation. View uncertain.

Figure 6. *Gardodinium trabeculosum* from 07-PEEL-09, Arctic Red Formation. View uncertain.

Figure 7. *Gardodinium trabeculosum* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Figure 8. *Gardodinium trabeculosum* from 07-PEEL-43, Slater River Formation. Dorsal? view.

Figure 9. *Kalyptea diceras* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 10. *Hystrichostrogylon* sp. from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 11. *Kaiwaradinium* "*contentum*" from 07-PEEL-40, Slater River Formation. View uncertain.

Figure 12. *Kaiwaradinium* "*contentum*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 13. "*Kleithriasphaeridium mantellii*" from 07-PEEL-43, Slater River Formation. Left lateral? view.

Figure 14. "*Kleithriasphaeridium mantellii*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 15. "*Kleithriasphaeridium mantellii*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 16. *Kiokansium unituberculatum* from 07-PEEL-03, Arctic Red Formation. View uncertain.

Figure 17. *Kleithriasphaeridium cooksoniae* from 07-PEEL-46, Slater River Formation. Oblique dorso-ventral view.

Figure 18. "*Kleithriasphaeridium cf. deanei*" from 07-PEEL-108, Trevor Formation. View uncertain.

Figure 19. *Lagenorhytis delicatula* from 07-PEEL-40, Slater River Formation. View uncertain.

Figure 20. *Lagenorhytis delicatula* from 07-PEEL-40, Slater River Formation. Oblique right-lateral view.

<u>Plate 7</u>

All scale bars = 20 µm.

Figure 1. *Leptodinium* sp. from 07-PEEL-51, Slater River Formation. Oblique dorsal view of ventral surface.

Figure 2. *Leptodinium* sp. from 07-PEEL-116, Trevor Formation. Oblique dorsal view of ventral surface.

Figure 3. *Leptodinium* sp. from 07-PEEL-47, Slater River Formation. Dorso-ventral? view.

Figure 4. *Meiourogonyaulax* sp. from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 5. *Luxadinium propatulum* from 07-PEEL-40, Slater River Formation. Ventral view of dorsal surface.

Figure 6. *Luxadinium propatulum* from 07-PEEL-43, Slater River Formation. Ventral view of dorsal surface.

Figure 7. *Luxadinium propatulum* from 07-PEEL-45, Slater River Formation. Dorsal view of dorsal surface.

Figure 8. *Luxadinium propatulum* from 07-PEEL-45, Slater River Formation. Dorsal view of dorsal surface.

Figure 9. *Luxadinium propatulum* from 07-PEEL-45, Slater River Formation. Ventral view of dorsal surface.

Figure 10. *Luxadinium propatulum* from 07-PEEL-45, Slater River Formation. Dorsal view of dorsal surface.

Figure 11. *Luxadinium propatulum* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 12. *Luxadinium propatulum* from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 13. *Microdinium* sp. from 07-PEEL-95, Trevor Formation. Dorsal view? of dorsal surface.

Figure 14. *Nyktericysta davisii* from 07-PEEL-45, Slater River Formation. Dorso-ventral view.

Figure 15. *Nyktericysta davisii* from 07-PEEL-46, Slater River Formation. Dorso-ventral view.

Figure 16. *Nyktericysta tripenta* from 07-PEEL-45, Slater River Formation. Dorsal view.

Figure 17. *Odontochitina ancala* from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 18. *Odontochitina costata* from 07-PEEL-14, Arctic Red Formation. Dorsal view.

Figure 19. *Odontochitina costata* from 07-PEEL-48, Slater River Formation. Operculum.

Figure 20. *Odontochitina costata* from 07-PEEL-48, Slater River Formation. Dorsal view.

Plate 8

All scale bars = 20 μm.

Figure 1. *Odontochitina singhii* from 07-PEEL-48, Slater River Formation. Oblique lateral? view.

Figure 2. *Odontochitina singhii* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 3. *Odontochitina singhii* from 07-PEEL-51, Slater River Formation. Oblique ventral? view.

Figure 4. *Odontochitina* "*appendicula*" from 07-PEEL-03, Arctic Red Formation. Dorsal view.

Figure 5. *Odontochitina* "*chelion*" from 07-PEEL-43, Slater River Formation. Dorsal view.

Figure 6. *Odontochitina* "*corpucorna*" from 07-PEEL-108, Trevor Formation. Dorsal view.

Figure 7. *Oligosphaeridium asterigerum* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Figure 8. *Oligosphaeridium asterigerum* from 07-PEEL-14, Arctic Red Formation. Oblique left-lateral? view.

Figure 9. *Oligosphaeridium albertense* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 10. *Oligosphaeridium albertense* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 11. *Oligosphaeridium albertense* from 07-PEEL-108, Trevor Formation. View uncertain.

Figure 12. *Oligosphaeridium anthophorum* from 07-PEEL-45, Slater River Formation. Operculum.

Figure 13. *Oligosphaeridium anthophorum* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Figure 14. *Oligosphaeridium anthophorum* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 15. *Oligosphaeridium anthophorum* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 16. *Oligosphaeridium anthophorum* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 17. *Oligosphaeridium complex* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 18. *Oligosphaeridium complex* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Figure 19. *Oligosphaeridium dictyophorum* from 07-PEEL-95, Trevor Formation. View uncertain.

Figure 20. *Oligosphaeridium dictyophorum* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Plate 9

All scale bars = 20 µm.

Figure 1. *Oligosphaeridium dictyophorum* from 07-PEEL-14, Arctic Red Formation. Operculum.

Figure 2. *Oligosphaeridium* "*perforoalbertense*" from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 3. *Oligosphaeridium* "*tenuipoculum*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 4. *Oligosphaeridium totum* from 07-PEEL-03, Arctic Red Formation. View uncertain.

Figure 5. *Oligosphaeridium pulcherrimum* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 6. *Oligosphaeridium pulcherrimum* from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 7. *Oligosphaeridium pulcherrimum* from 07-PEEL-46, Slater River Formation. View uncertain.

Figure 8. *Oligosphaeridium pulcherrimum* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 9. *Oligosphaeridium* "*recurvatum*" from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 10. *Oligosphaeridium* "*recurvatum*" from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 11. *Oligosphaeridium* "*recurvatum*" from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 12. *Oligosphaeridium* "*perforototum*" from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 13. *Oligosphaeridium* sp. from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 14, 18. *Ovoidinium cinctum* from 07-PEEL-48, Slater River Formation. Dorsal view, high (14) and low (18) focus.

Figure 15. *Ovoidinium cinctum* from 07-PEEL-50, Slater River Formation. Dorsal view.

Figure 16. *Ovoidinium cinctum* from 07-PEEL-50, Slater River Formation. Ventral view.

Figure 17. *Palaeoperidinium cretaceum* from 07-PEEL-45, Slater River Formation. Dorsal view.

Figure 19. *Ovoidinium cinctum* from 07-PEEL-50, Slater River Formation. Dorsal view.

Figure 20. *Ovoidinium scabrosum* from 07-PEEL-45, Slater River Formation. Dorsal view.
Plate 10

All scale bars = 20 µm.

Figure 1. *Operculodinium*? “*delicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 2. *Operculodinium*? “*delicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 3. *Operculodinium*? “*delicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 4. *Operculodinium*? “*delicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 5. *Operculodinium*? “*delicatum*” from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 6. *Operculodinium*? “*delicatum*” from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 7. *Operculodinium*? “*latidelicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 8. *Operculodinium*? “*latidelicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 9. *Pareodinia ceratophora* from 07-PEEL-47, Slater River Formation. Right-lateral? view.

Figure 10. *Pareodinia* sp. from 07-PEEL-45, Slater River Formation. Oblique dorso-ventral view.

Figure 11. *Operculodinium*? “*latidelicatum*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 12. *Operculodinium*? “*latidelicatum*” from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 13. *Palaeoperidinium pyrophorum* from 07-PEEL-29, Arctic Red Formation. Ventral view.

Figure 14. *Palaeoperidinium pyrophorum* from 07-PEEL-40, Slater River Formation. Ventral view.

Figure 15. *Palaeoperidinium pyrophorum* from 07-PEEL-45, Slater River Formation. Dorsal view.

Figure 16. *Palaeoperidinium pyrophorum* from 07-PEEL-48, Slater River Formation. Ventral? view.

Figure 17. *Pervosphaeridium* "*copis*" from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 18. *Pervosphaeridium* "*copis*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 19. *Pervosphaeridium* "*copis*" from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 20. *Pervosphaeridium* "*copis*" from 07-PEEL-48, Slater River Formation. Right lateral view.

Plate 11

All scale bars = 20 μm.

Figure 1. *Pervosphaeridium cenomaniense* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 2. *Pervosphaeridium cenomaniense* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 3. *Pervosphaeridium cenomaniense* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 4. *Pseudoceratium* "*hirsutum*" from 07-PEEL-40, Slater River Formation. Dorsal? view.

Figure 5. *Pseudoceratium polymorphum* from 07-PEEL-45, Slater River Formation. Dorsal view.

Figures 6-7. *Pseudoceratium polymorphum* from 07-PEEL-29, Slater River Formation. Dorsal view, high (6) and low (7) focus.

Figure 8. *Pseudoceratium polymorphum* from 07-PEEL-40, Slater River Formation. Dorsal view.

Figure 9. *Pseudoceratium polymorphum* from 07-PEEL-46, Slater River Formation. Dorsal view.

Figure 10. *Pseudoceratium polymorphum* from 07-PEEL-46, Slater River Formation. Dorsal view.

Figure 11. *Pseudoceratium polymorphum* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 12. *Pterodinium*? sp. from 07-PEEL-40, Slater River Formation. View uncertain.

Figure 13. *Pyxidinopsis* "*rugosus*" from 07-PEEL-51, Slater River Formation. Right-lateral view.

Figure 14. *Pyxidinopsis* ? sp. from 07-PEEL-51, Slater River Formation. Operculum.

Figure 15. *Sepispinula huguoniottii* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 16. *Sepispinula huguoniottii* from 07-PEEL-09, Arctic Red Formation. View uncertain.

Figure 17. *Sentusidinium myriatrichum* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 18. *Sentusidinium myriatrichum* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 19. *Sentusidinium myriatrichum* from 07-PEEL-04, Arctic Red Formation. View uncertain.

Figure 20. *Sentusidinium myriatrichum* from 07-PEEL-48, Slater River Formation. View uncertain.

Plate 12

All scale bars = 20 µm.

Figure 1. *Senoniasphaera* “*latireticulata*” from 07-PEEL-46, Slater River Formation. Ventral? view.

Figure 2. *Senoniasphaera microreticulata* from 07-PEEL-14, Arctic Red Formation. Dorsal view.

Figure 3. *Senoniasphaera microreticulata* from 07-PEEL-14, Arctic Red Formation. Dorsal? view.

Figure 4. *Senoniasphaera microreticulata* from 07-PEEL-14, Arctic Red Formation. Ventral view.

Figure 5. *Senoniasphaera* “*latireticulata*” from 07-PEEL-46, Slater River Formation. Dorsal view.

Figure 6. *Sentusidinium rioultii* from 07-PEEL-09, Arctic Red Formation. View uncertain.

Figure 7. *Sentusidinium rioultii* from 07-PEEL-09, Arctic Red Formation. View uncertain.

Figure 8. *Sentusidinium* “*panniculus*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 9. *Spiniferites* “*digitatus*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 10. *Spiniferites* “*furcatus*” from 07-PEEL-40, Slater River Formation. Dorso-ventral? view.

Figure 11. *Spiniferites* “*furcatus*” from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 12. *Sentusidinium* “*paniculus*” from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 13. *Spiniferites* “*displosus*” from 07-PEEL-45, Slater River Formation. View uncertain.

Figure 14. *Spiniferites* "*displosus*" from 07-PEEL-48, Slater River Formation. Right-lateral view.

Figure 15. *Spiniferites* "*displosus*" from 07-PEEL-108, Trevor Formation. Right-lateral view.

Figure 16. *Spiniferites membranaceus* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 17. *Spiniferites* "*tubiferus*" from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 18. *Spiniferites* "*tubiferus*" from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 19. *Spiniferites* "*tubiferus*" from 07-PEEL-48 Slater River Formation. Left-lateral view.

Figure 20. *Spiniferites* "*tubiferus*" from 07-PEEL-48, Slater River Formation. View uncertain.

Plate 13

All scale bars = 20 µm.

Figure 1. *Spiniferites ramosus* from 07-PEEL-48, Slater River Formation. View uncertain.

Figure 2. *Spiniferites ramosus* from 07-PEEL-48, Slater River Formation. View uncertain.

Figures 3–4. *Spongodinium delitiense* from 07-PEEL-04, Arctic Red Formation. View uncertain, high (3) and low (4) focus.

Figure 5. *Subtilisphaera cheit* from 07-PEEL-51, Slater River Formation. Dorsal view.

Figure 6. *Subtilisphaera cheit* from 07-PEEL-51, Slater River Formation. Ventral view.

Figures 7–8. *Spongodinium delitiense* from 07-PEEL-04, Arctic Red Formation. Ventral view of ventral (7) and dorsal (8) surfaces.

Figure 9. *Subtilisphaera senegalense* from 07-PEEL-50, Slater River Formation. View uncertain.

Figure 10. *Subtilisphaera perlucida* from 07-PEEL-14, Arctic Red Formation. View uncertain.

Figure 11. *Subtilisphaera perlucida* from 07-PEEL-45, Slater River Formation. Ventral view.

Figure 12. *Subtilisphaera perlucida* from 07-PEEL-50, Slater River Formation. Dorsal view.

Figure 13. *Subtilisphaera senegalense* from 07-PEEL-50, Slater River Formation. Ventral view.

Figure 14. *Subtilisphaera* "*symsenegalense*" from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 15. *Subtilisphaera* "*symsenegalense*" from 07-PEEL-48, Slater River Formation. Dorsal? view.

Figure 16. *Surculosphaeridium convocatum* from 07-PEEL-108, Trevor Formation. View uncertain.

Figure 17. *Subtilisphaera senegalense* from 07-PEEL-48, Slater River Formation. Ventral view.

Figure 18. *Subtilisphaera senegalense* from 07-PEEL-51, Slater River Formation. Dorsal view.

Figure 19. *Subtilisphaera senegalense* from 07-PEEL-48, Slater River Formation. Dorsal view.

Figure 20. *Surculosphaeridium longifurcatum* from 07-PEEL-43, Slater River Formation. View uncertain.

Plate 14

All scale bars = 20 µm.

Figures 1–2. *Trichodinium* "*muratispinum*" from 07-PEEL-23, Arctic Red Formation. Right-lateral view, high (1) and low (2) focus.

Figures 3–4. *Trichodinium* "*muratispinum*" from 07-PEEL-45, Arctic Red Formation. Oblique left-lateral view, high (1) and low (2) focus.

Figure 5. *Trichodinium castanea* from 07-PEEL-43, Slater River Formation. Dorso-ventral view.

Figure 6. ?*Trichodinium spinosum* from 07-PEEL-43, Slater River Formation. Right-lateral view.

Figure 7. *Tanyosphaeridium xanthiopyxides* from 07-PEEL-43, Slater River Formation. View uncertain.

Figure 8. *Trithyrodinium* sp. from 07-PEEL-48, Slater River Formation. Dorso-ventral view.

Figure 9. *Baltisphaeridium*? sp. from 07-PEEL-04, Arctic Red Formation.

Figure 10. *Baltisphaeridium* sp. from 07-PEEL-43, Slater River Formation.

Figure 11. *Baltisphaeridium* sp. from 07-PEEL-45, Slater River Formation.

Figure 12. *Baltisphaeridium* sp. from 07-PEEL-48, Slater River Formation.

Figure 13. *Leiosphaeridia* sp. from 07-PEEL-51, Slater River Formation.

Figure 14. *Leiosphaeridia* sp. from 07-PEEL-51, Slater River Formation.

Figure 15. *Micrhystridium* sp. from 07-PEEL-51, Slater River Formation.

Figure 16. *Solisphaeridium* sp. from 07-PEEL-45, Slater River Formation.

Figure 17. *Paralecaniella indentata* from 07-PEEL-43, Slater River Formation.

Figure 18. *Paralecaniella indentata* from 07-PEEL-23, Arctic Red Formation.

Figure 19. *Paralecaniella indentata* from 07-PEEL-50, Slater River Formation.

Figure 20. *Paralecaniella* "*pilosa*" from 07-PEEL-43, Slater River Formation.

Plate 15

All scale bars = 20 µm.

Figure 1. *Palambages* sp. from 07-PEEL-45, Slater River Formation.

Figure 2. *Pterospermella* sp. from 07-PEEL-48, Slater River Formation.

Figure 3. *Pterospermella* sp. from 07-PEEL-48, Slater River Formation.

Figure 4. *Veryhachium* sp. from 07-PEEL-45, Slater River Formation.

Figure 5. *Veryhachium* sp. from 07-PEEL-48, Slater River Formation.

Figure 6. *Veryhachium* sp. from 07-PEEL-69, Slater River Formation.

Figure 7. *Veryhachium* sp. from 07-PEEL-48, Slater River Formation.

Figure 8. Angiosperm pollen grain from 07-PEEL-47, Slater River Formation.

Figure 9. *Antulsporites regius* from 07-PEEL-95, Trevor Formation.

Figure 10. *Antulsporites regius* from 07-PEEL-95, Trevor Formation.

Figure 11. *Antulsporites regius* from 07-PEEL-69, Slater River Formation.

Figure 12. *Baculatisporites* sp. from 07-PEEL-03, Arctic Red Formation.

Figure 13. *Callialasporites segmentatus* from 07-PEEL-51, Slater River Formation.

Figure 14. *Cerebropollenites macroverrucatus* from 07-PEEL-83, Trevor Formation.

Figure 15. *Concavisporites toralis* from 07-PEEL-75, Trevor Formation.

Figure 16. *Cycadopites follicularis* from 07-PEEL-83, Trevor Formation.

Figure 17. *Cicatricosisporites* sp. from 07-PEEL-14, Arctic Red Formation.

Figure 18. *Cicatricosisporites* sp. from 07-PEEL-14, Arctic Red Formation.

Figure 19. *Cicatricosisporites* sp. from 07-PEEL-116, Trevor Formation.

Figure 20. *Ischyosporites disjunctus* from 07-PEEL-43, Slater River Formation.

<u>Plate 16</u>

All scale bars = 20 µm.

Figures 1–2. *Rugubivesiculites convolutus* from 07-PEEL-69, Slater River Formation. High (1) and low (2) focus.

Figure 3. Bisaccate pollen grain from 07-PEEL-14, Arctic Red Formation.

Figure 4. Bisaccate pollen grain from 07-PEEL-45, Slater River Formation.

Figure 5. Bisaccate pollen grain from 07-PEEL-48, Slater River Formation.

Figure 6. Bisaccate pollen grain from 07-PEEL-51, Slater River Formation.

Figure 7. Bisaccate pollen grain from 07-PEEL-51, Slater River Formation.

Figure 8. Bisaccate pollen grain from 07-PEEL-51, Slater River Formation.

Figure 9. *Dictyophyllidites harrisii* from 07-PEEL-102, Trevor Formation.

Figure 10. *Distaltriangulisporites perplexus* from 07-PEEL-48, Slater River Formation.

Figure 11. *Foveotriletes scrobiculatus* from 07-PEEL-83, Trevor Formation.

Figure 12. Bisaccate pollen grain from 07-PEEL-116, Trevor Formation.

Figure 13. *Gleicheniidites senonicus* from 07-PEEL-95, Trevor Formation.

Figure 14. *Gleicheniidites senonicus* from 07-PEEL-95, Trevor Formation.

Figure 16. *Gleicheniidites senonicus* from 07-PEEL-95, Trevor Formation.

Figure 17. *Laevigatotosporites haardtii* from 07-PEEL-95, Trevor Formation.

Figure 18. *Ornamentifera echinata* from 07-PEEL-46, Slater River Formation.

Figure 19. *Plicatella* sp. from 07-PEEL-46, Slater River Formation.

Figure 20. *Staplinisporites caminus* from 07-PEEL-58, Slater River Formation.

Plate 17

All scale bars = 20 µm.

Figure 1. *Stereisporites antiquasporites* from 07-PEEL-95, Trevor Formation.

Figure 2. *Stereisporites antiquasporites* from 07-PEEL-95, Trevor Formation.

Figure 3. *Vitreisporites pallidus* from 07-PEEL-50, Slater River Formation.

Figure 4. *Acinosporites* sp. (reworked Paleozoic miospore) from 07-PEEL-39, Arctic Red Formation.

Figure 5. *Ancyrospora* sp. (reworked Paleozoic miospore) from 07-PEEL-29, Arctic Red Formation.

Figure 6. *Ancyrospora* sp. (reworked Paleozoic miospore) from 07-PEEL-43, Slater River Formation.

Figure 7. *Ancyrospora* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 8. *Archaeoperisaccus* sp. (reworked Paleozoic miospore) from 07-PEEL-39, Arctic Red Formation.

Figure 9. *Archaeozonotriletes* sp. (reworked Paleozoic miospore) from 07-PEEL-03, Arctic Red Formation.

Figure 10. *Dibolisporites* sp. (reworked Paleozoic miospore) from 07-PEEL-39, Arctic Red Formation.

Figure 11. *Grandispora* sp. (reworked Paleozoic miospore) from 07-PEEL-39, Arctic Red Formation.

Figure 12. *Grandispora* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 13. *Projectispora* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 14. *Raistrickia* sp. (reworked Paleozoic miospore) from 07-PEEL-43, Slater River Formation.

Figure 15. *Striatites* sp. (reworked Paleozoic miospore) from 07-PEEL-46, Slater River Formation.

Figure 16. *Verrucosisporites* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 17. *Retispora* sp. (reworked Paleozoic miospore) from 07-PEEL-03, Arctic Red Formation.

Figure 18. *Retispora* sp. (reworked Paleozoic miospore) from 07-PEEL-14, Arctic Red Formation.

Figure 19. *Trilobozonotriletes* sp. (reworked Paleozoic miospore) from 07-PEEL-43, Slater River Formation.

Figure 20. *Trilobozonotriletes* sp. (reworked Paleozoic miospore) from 07-PEEL-46, Slater River Formation.

Plate 17

All scale bars = 20 µm.

Figure 1. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-29, Arctic Red Formation.

Figure 2. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-29, Arctic Red Formation.

Figure 3. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-39, Arctic Red Formation.

Figure 4. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-40, Slater River Formation.

Figure 5. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-43, Slater River Formation.

Figure 6. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 7. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 8. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-45, Slater River Formation.

Figure 9. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-46, Slater River Formation.

Figure 10. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-46, Slater River Formation.

Figure 11. *Densposporites* sp. (reworked Paleozoic miospore) from 07-PEEL-48, Slater River Formation.

Figure 12. Reworked Paleozoic miospore from 07-PEEL-45, Slater River Formation.

Figure 13. Reworked Paleozoic miospore from 07-PEEL-39 Arctic Red Formation.

Figure 14. Reworked Paleozoic miospore from 07-PEEL-39, Arctic Red Formation.

Figure 15. Reworked Paleozoic miospore from 07-PEEL-43, Slater River Formation.

Figure 16. Reworked Paleozoic miospore from 07-PEEL-45, Slater River Formation.

Figure 17. Reworked Paleozoic miospore from 07-PEEL-29, Arctic Red Formation.

Figure 18. Reworked Paleozoic miospore from 07-PEEL-29, Arctic Red Formation.

Figure 19. Reworked Paleozoic miospore from 07-PEEL-39, Arctic Red Formation.

Figure 20. Reworked Paleozoic miospore from 07-PEEL-43, Arctic Red Formation.

APPENDIX 1 --- COUNTS

I intended to count 200 specimens per sample, but sometimes the assemblage was too sparse to attain that number. Also sometime the count ended up being slightly less or slightly more than 200, but downstream products such as Figure 4 are based on a percentage of the number counted. Some taxonomic concepts were actively evolving during the course of this study, especially those related to areoligeracean genera (*Tenua*, *Cyclonephelium*, "*Cassiculodinium*" and "*Tribulodinium*") and *Baltisphaeridium* versus *Impletosphaeridium*. This may cause some confusion in the fine detail, but do not affect the major results of the study.

07-Peel-01 (B slide)

Biretisporites	001
Bisaccates	002
Cicatricosisporites	002
Dictyophyllidites	001
Dinoflagellates indet	002
Oligosphaeridium/*Stiphrosphaeridium*	001
Paleozoic spores	171
Pterospermella	001
Stereisporites	006
Trilete spores (some may be reworked)	009
	196

07-Peel-02 (B slide)

Acritarchs (spiny)	005
Appendicisporites	001
Bisaccates	056
Chlamydophorella/*Sepispinula*	004
Cicatricosisporites	007
Cribroperidinium	001
Dinoflagellates indet	007
Exesipollenites	001
Gleicheniidites	007
Kiokansium	001
Odontochitina	001
Oligosphaeridium	003
Palaeoperidinium	001
Paleozoic spores	091
Stereisporites	005
Tenua	001
Trilete (some may be reworked)	008
	200

07-Peel-03 (B slide)

Acritarchs (spiny)	027
Apteodinium	002
Baculatisporites	001
Bisaccates	053
Chlamydophorella/*Sepispinula*	004
Cicatricosisporites	004
Classopollis	002
Dinocysts indet	012
Dinopterygium	001
Gardodinium trabeculosum	003
Gleicheniidites	020
Kiokansium unituberculatum	001
Odontochitina costata	004
Oligosphaeridium complex	001
Palaeoperidinium	001
Paleozoic spores	053
Permian bisaccate	001
Pterospermella	002
Retitriletes	001
Sentusidinium	001
Stereisporites	007
Tenua cornuspinata	001
Tenua cassicula	001
Triletes (some may be reworked)	020
	223

07-Peel-04 (B slide)

Acritarchs (spiny)	003
Apteodinium granulatum	002
Batioladinium jaegeri	001
Bisaccates	030
Chlamydophorella/*Sepispinula*	021
Cicatricosisporites	002
Classopollis	001
Dinocysts indet	017
Dinopterygium	002
Escharisphaeridia granulata	001
Escharisphaeridia pellifera	078
Gardodinium trabeculosum	013
Impletosphaeridium	005
Kiokansium unituberculatum	001
Leiosphaeridia	002
Odontochitina	001
Oligosphaeridium albertense	002
Osmundacidites	001
Paleozoic spores	004
Pterospermella	001
Retitriletes	001

Spiniferites	001
Stereisporites	002
Tenua cornuspinata	007
Tenua cassicula	001
Triletes (may be reworked)	001
	201

07-Peel-09 (B slide)

Acritarchs (spiny)	009
Bisaccates	007
Canningia reticulata	001
Chlamydophorella/Sepispinula	005
Cribroperidinium	003
Cycadopites	001
Cyclonephelium vannophorum	002
Dinocysts indet	012
Dinopterygium	001
Escharisphaeridia pellifera	001
Foram liner	001
Gardodinium	001
Gardodinium trabeculosum	002
Gleicheniidites	004
Impletosphaeridium/Sentusidinium	126
Leptodinium	003
Oligosphaeridium	001
Oligosphaeridium asterigerun	001
Paleozoic spores	004
Permian pollen	001
Retitriletes	001
Tenua	006
Tenua cornuspinata	001
Triletes (may be reworked)	005
Vitreisporites	001
	200

07-Peel-14 (B slide)

Acritarchs (spiny)	002
Baculatisporites	004
Batioladinium jaegeri	001
Bisaccates	073
Chlamydophorella/Sepispinula	007
Classopollis	002
Cicatricosisporites	011
Cycadopites	001
Cribroperidinium	002
Dinocysts indet	012
Escharisphaeridia pellifera	009
Eucommiidites minor	003
Gardodinium trabeculosum	002
Gleicheniidites	005
Impletosphaeridium/Sentusidinium	006
Laevigatosporites	001
Oligosphaeridium	002
Osmundacidites	003
Paleozoic spores	010
Retitriletes	003
Senoniasphaera microreticulata	009
Spiniferites	001
Stereisporites	010
Triletes (may be reworked)	020
Vitreisporites	001
	200

07-Peel-20 (B slide)

Araucariacites	003
Baculatisporites	001
Bisaccates	049
Cerebropollenites	004
Chlamydophorella/Sepispinula	006
Cicatricosisporites	023
Classopollis	006
Concavissimisporites	001
Dinocysts indet	005
Exesipollenites	005
Gleicheniidites	018
Ischyosporites	001
Osmundacidites	001
Paleozoic spores	021
Plicatella	001
Retitriletes	001
Stereisporites	004
Triletes (may be reworked)	053
Tuberositriletes	001
Zlivisporis	001
	205

07-Peel-23 (K slide)

Araucariacites	014
Bisaccates	036
Cerebropollenites	001
Chlamydophorella/Sepispinula	002
Classopollis	003
Cribroperidinium	003
Cyclonephelium compactum	023
Deltoidospora	001
Dinocysts indet	010
Distaltriangulisporites	001
Eucommiidites	001

Exochosphaeridium	001
Gleicheniidites	021
Impletosphaeridium/*Sentusidinium*	002
Kleithriasphaeridium loffrense	001
Leptodinium	001
Oligosphaeridium complex	001
Oligosphaeridium/*Stiphrosphaeridium*	001
Osmundacidites	001
Palaeoperidinium pyrophorum	002
Paleozoic spores	004
Paralecaniella	001
Paralecaniella granulata	001
Pterospermella	006
Rotverrusporites	001
Spiniferites	001
Spiniferites displosus	001
Stereisporites	001
Stiphrosphaeridium anthophorum	001
Tenua	004
Trichodinium	001
Triletes (may be reworked)	008
Veryhachium	002
Vitreisporites	001
	159

07-Peel-29 (K slide)

Acritarchs (spiny)	006
Araucariacites	002
Bisaccates	041
Chichaouadinium?	002
Cribroperidinium	001
Cycadopites	002
Deltoidospora	001
Densoisporites	001
Gardodinium trabeculosum	001
Gleicheniidites	037
Impletosphaeridium/*Sentusidinium*	001
Ischyosporites	001
Laevigatosporites	001
Paleozoic spores	041
Stereisporites	002
Tenua	001
Triletes (may be reworked)	057
Vitreisporites	002
	200

07-Peel-39 (B slide)

Acritarchs (spiny)	001
Bisaccates	010
Cicatricosisporites	002
Dinocysts indet	002
Gleicheniidites	011
Ischyosporites	001
Leiosphaeridium	002
Oligosphaeridium totum	001
Paleozoic spores	135
Pseudoceratium	001
Pterospermella	001
Retitriletes	001
Stereisporites	001
Triletes (may be reworked)	040
Vitreisporites	001
	210

07-Peel-40 (B slide)

Acritarchs (spiny)	001
Biretisporites	001
Bisaccates	013
Cribroperidinium	002
Dinocysts indet	004
Gleicheniidites	008
Leptodinium	001
Luxadinium propatulum	006
Paleozoic spores	012
Tenua spp.	142
Triletes (may be reworked)	010
	200

07-Peel-43 (B slide)

Acritarchs (spiny)	002
Angiosperm pollen?	001
Bisaccates	033
Chlamydophorella/*Sepispinula*	006
Cicatricosisporites	002
Chichaouadinium?	001
Cribroperidinium	002
Deltoidospora	001
Dinocysts indet	020
Escharisphaeridia	002
Exochosphaeridium/*Pervosphaeridium*	004
Gleicheniidites	008
Hystrichodinium	001
Kaiwaradinium	001
Kleithriasphaeridium	001
Kleithriasphaeridium mantellii	001
Odontochitina	003
Oligosphaeridium complex	002
Operculodinium? *delicatum* complex	002

Paleozoic spores	081
Paralecaniella	003
Spiniferites	006
Stiphrosphaeridium anthophorum	001
Tenua	010
Tenua cassicula	001
Tetraporina	001
Triletes (may be reworked)	024
	220

07-Peel-45 (K slide)

Acritarchs (spiny)	003
Bisaccates	023
Chlamydophorella/*Sepispinula*	002
Cicatricosisporites	003
Cometodinium	003
Cycadopites	003
Dinocysts indet	010
Dinopterygium alatum	001
Distaltriangulisporites	001
Escharisphaeridia	001
Gleicheniidites	033
Impletosphaeridium/*Sentusidinium*	002
Luxadinium propatulum	023
Odontochitina	001
Oligosphaeridium	001
Osmundacidites	001
Ovoidinium	002
Paleozoic spores	043
Paralecaniella	003
Pterospermella	001
Retitriletes	002
Spiniferites	001
Stereisporites	008
Subtilisphaera	004
Tenua cassicula	004
Tenua cornuspinata	001
Tenua filosa/*cornufilosa*	008
Triletes (may be reworked)	027
Veryhachium	005
	220

07-Peel-46 (K slide)

Acritarchs (spiny)	001
Angiosperm pollen	001
Araucariacites	001
Baltisphaeridium	002
Batioladinium jaegeri	001
Bisaccates	038
Cribroperidinium	001
Dinocysts indet	011
Gleicheniidites	034
Luxadinium propatulum	010
Oligosphaeridium asterigerum	001
Ovoidinium	001
Palaeoperidinium pyrophorum	003
Paleozoic spores	028
Pilosisporites	001
Senoniasphaera latireticulata	001
Spiniferites	001
Stereisporites	014
Subtilisphaera	002
Tenua cassicula	007
Tenua reticulata	003
Tenua filosa/*cornufilosa*	009
Trichodinium	001
Triletes (may be reworked)	030
Veryhachium	001
Vitreisporites	001
	204

07-Peel-47 (B slide)

Acritarchs (spiny)	003
Angiosperm pollen	004
Araucariacites	008
Baltisphaeridium	001
Batioladinium jaegeri	003
Bisaccates	035
Cicatricosisporites	003
Cometodinium	002
Cribroperidinium	003
Cycadopites	002
Deltoidospora	001
Densoisporites	002
Dinocysts indet	006
Escharisphaeridia pellifera	001
Eucommiidites minor	001
Exochosphaeridium/*Pervosphaeridium*	003
Gleicheniidites	041
Impletosphaeridium/*Sentusidinium*	007
Leiosphaeridia	002
Leptodinium	001
Luxadinium propatulum	010
Oligosphaeridium	001
Oligosphaeridium pulcherrimum	001
Operculodinium? *delicatum*	001
Ovoidinium	005
Palaeoperidinium pyrophorum	005

Paleozoic spores	010
Paralecaniella	002
Pareodinia	001
Plicatella	001
Pterospermella	002
Spiniferites	001
Spiniferites tubiferus	001
Stereisporites	004
Subtilisphaera	027
Tenua	002
Tenua cassicula	010
Tenua reticulata	003
Tenua filosa/*cornufilosa*	001
Triletes (may be reworked)	020
Veryhachium	005
Vitreisporites	001
	243

07-Peel-48 (K slide)

Acritarchs (spiny)	007
Angiosperm pollen	004
Araucariacites	003
Baltisphaeridium	004
Bisaccates	043
Chichaouadinium? sp.	002
Chlamydophorella/*Sepispinula*	002
Classopollis	001
Cometodinium	001
Cribroperidinium	002
Dinocysts indet	020
Eucommiidites	001
Eucommiidites minor	001
Exochosphaeridium/*Pervosphaeridium*	003
Florentinia	001
Fromea	001
Gleicheniidites	026
Kiokansium unituberculatum	001
Luxadinium propatulum	006
Odontochitina costata	003
Odontochitina singhii	001
Oligosphaeridium	004
Ovoidinium	007
Palaeoperidinium pyrophorum	002
Pareodinia (with kalyptra)	001
Spiniferites displosus	001
Spiniferites tubiferus	001
Subtilisphaera	012
Tenua	016
Tenua cassicula	010
Triletes (may be reworked)	010
Trithyrodinium	001
Veryhachium	002
	200

07-Peel-50 (K slide)

Acritarchs (spiny)	001
Angiosperm pollen	001
Araucariacites	004
Baltisphaeridium	001
Bisaccates	065
Chlamydophorella/*Sepispinula*	003
Cribroperidinium	002
Cyclonephelium vannophorum	001
Dinocysts indet	017
Exochosphaeridium/*Pervosphaeridium*	002
Fromea	001
Gleicheniidites	005
Luxadinium propatulum	018
Oligosphaeridium pulcherrimum	001
Ovoidinium	041
Palaeoperidinium pyrophorum	001
Paleozoic spores	005
Paralecaniella	006
Pterospermella	001
Rotverrusporites	001
Rugubivesiculites	001
Spiniferites	003
Subtilisphaera	026
Tenua	003
Tenua cassicula	005
Triletes (may be reworked)	004
Veryhachium	001
	220

07-Peel-51 (K slide)

Acritarchs (spiny)	002
Angiosperm pollen	004
Araucariacites	001
Baltisphaeridium	003
Bisaccates	069
Callialasporites dampieri	001
Cerebropollenites	001
Dictyophyllidites	002
Dinocysts indet	008
Exochosphaeridium/*Pervosphaeridium*	002
Fromea	001
Gleicheniidites	016
Luxadinium propatulum	001

Odontochitina	003
Odontochitina singhii	002
Osmundacidites	001
Ovoidinium	002
Palaeoperidinium pyrophorum	003
Paleozoic spores	007
Pediastrum	001
Pterospermella	004
Rugubivesiculites	001
Stereisporites	002
Subtilisphaera	039
Tenua	002
Tenua cassicula	003
Triletes (may be reworked)	017
Vitreisporites	002
	<u>200</u>

07-Peel-58 (B slide)

Acritarchs (spiny)	003
Angiosperm pollen	002
Bisaccates	096
Cibotiumspora	001
Cicatricosisporites	001
Classopollis	001
Cycadopites	001
Deltoidospora	003
Dinocysts indet	005
Gleicheniidites	030
Osmundacidites	002
Ovoidinium	001
Paleozoic spores	013
Retitriletes	002
Staplinisporites	001
Stereisporites	009
Triletes (may be reworked)	028
Veryhachium	001
	<u>200</u>

07-Peel-62 (B slide)

Acritarchs (spiny)	001
Angiosperm pollen	002
Bisaccates	125
Bisaccate (Permian)	001
Cerebropollenites	003
Cicatricosisporites	002
Cycadopites	001
Deltoidospora	002
Dinocysts indet	005
Exesipollenites	001
Gleicheniidites	009
Neoraistrickia	001
Osmundacidites	003
Paleozoic spores	009
Retitriletes	002
Rotverrusporites	001
Stereisporites	007
Triletes (may be reworked)	023
Veryhachium	001
Vitreisporites	001
	<u>200</u>

07-Peel-69 (B slide)

Acritarchs (spiny)	001
Araucariacites	004
Bisaccates	099
Cerebropollenites	002
Cicatricosisporites	001
Classopollis	001
Cribroperidinium	002
Dinocysts indet	001
Gleicheniidites	032
Ischyosporites	001
Oligosphaeridium asterigerum	001
Oligosphaeridium totum	001
Osmundacidites/*Baculatisporites*	002
Paleozoic spores	010
Pareodinia	001
Retitriletes	002
Staplinisporites	001
Stereisporites	004
Tenua filosa/*cornufilosa*	001
Triletes (may be reworked)	032
Veryhachium	001
	<u>200</u>

07-Peel-75 (B slide)

Acritarchs (spiny)	003
Antulsporites	001
Batioladinium jaegeri	001
Bisaccates	071
Cicatricosisporites	001
Classopollis	001
Concavisporites	001
Cycadopites	002
Dictyophyllidites	003
Dinocysts indet	003
Foveotriletes	001
Gleicheniidites	019

Ischyosporites	001
Leptodinium	001
Neoraistrickia	001
Odontochitina	002
Oligosphaeridium	002
Osmundacidites/*Baculatisporites*	005
Paleozoic spores	011
Saccates	002
Spiniferites	002
Stereisporites	012
Subtilisphaera	001
Tenua	001
Tenua brevispinata	001
Tenua cornuspinata	001
Triletes (may be reworked)	041
Veryhachium	001
Vitreisporites	008
	<u>200</u>

07-Peel-83 (B slide)

Acritarchs (spiny)	002
Angiosperm pollen	001
Araucariacites	001
Bisaccates	044
Cerebropollenites	001
Cicatricosisporites	001
Classopollis	001
Cycadopites	003
Deltoidospora	001
Dictyophyllidites	003
Dinocysts indet	001
Foveotriletes	001
Gleicheniidites	006
Gonyaulacysta?	001
Osmundacidites/*Baculatisporites*	001
Paleozoic spores	005
Retitriletes	002
Rugubivesiculites	001
Stereisporites	004
Triletes (may be reworked)	019
Vitreisporites	001
	<u>100</u>

07-Peel-95 (B slide)

Acritarchs (spiny)	001
Angiosperm pollen	001
Antulsporites	003
Baltisphaeridium	005
Bisaccates	015
Cicatricosisporites	002
Classopollis	001
Cometodinium	001
Cyclonephelium vannophorum	001
Dictyophyllidites	002
Dinocysts indet	004
Distaltriangulisporites	003
Gleicheniidites	122
Laevigatosporites	001
Leptodinium	001
Oligosphaeridium	001
Osmundacidites/*Baculatisporites*	005
Palaeoperidinium pyrophorum	001
Paleozoic spores	001
Paralecaniella (vermiculate)	002
Stereisporites	009
Stiphrosphaeridium dictyophorum	001
Triletes (may be reworked)	026
Veryhachium	001
	<u>210</u>

07-Peel-102 (B slide)

Acritarchs (spiny)	001
Angiosperm pollen	001
Antulsporites	001
Araucariacites	002
Bisaccates	030
Cerebropollenites	002
Cicatricosisporites	001
Cribroperidinium	001
Deltoidospora	001
Dictyophyllidites	002
Dinocysts indet	001
Fungal entity	001
Gleicheniidites	020
Paleozoic spores	009
Retitriletes	001
Spiniferites	001
Stereisporites	004
Triletes (may be reworked)	021
	<u>100</u>

07-Peel-108 (B slide)

Appendicisporites	001
Baltisphaeridium	010
Bisaccates	052
Cauca	001
Cerebropollenites	001
Chlamydophorella/*Sepispinula*	002

Cicatricosisporites	002
Classopollis	001
Concavissimisporites	001
Cribroperidinium	006
Cycadopites	003
Dictyophyllidites	001
Dinocysts indet	016
Escharisphaeridia	001
Gleicheniidites	026
Ischyosporites	001
Kaiwaradinium	001
Monolete with tubercles	001
Odontochitina	006
Odontochitina costata	006
Odontochitina singhii	001
Oligosphaeridium	006
Oligosphaeridium complex	001
Oligosphaeridium pulcherrimum	003
Osmundacidites/*Baculatisporites*	001
Paleozoic spores	002
Paralecaniella	001
Spiniferites	015
Stereisporites	002
Stiphrosphaeridium dictyophorum	002
Tenua	001
Triletes (may be reworked)	026
	200

07-Peel-116 (B slide)

Acritarch (spiny)	001
Angiosperm pollen	001
Appendicisporites	001
Araucariacites	003
Baltisphaeridium	002
Batioladinium	001
Bisaccates	035
Chlamydophorella/*Sepispinula*	002
Cicatricosisporites	003
Classopollis	002
Costatoperforosporites	001
Cribroperidinium	001
Cycadopites	001
Deltoidospora	001
Dictyophyllidites	002
Dinocysts indet	011
Dinopterygium	001
Dinopterygium alatum	001
Dinopterygium cladoides	001
Escharisphaeridia	001
Exochosphaeridium/*Pervosphaeridium*	002
Gleicheniidites	059
Neoraistrickia	001
Odontochitina	003
Ornamentifera	001
Osmundacidites/*Baculatisporites*	002
Paleozoic spores	002
Paralecaniella	003
Retitriletes	003
Spiniferites	003
Stereisporites	009
Triletes (may be reworked)	037
Veryhachium	001
Vitreisporites	002
	200

APPENDIX 2 – TAXA CITED, WITH AUTHORSHIPS

List of taxa cited in main text and plates, with authorships. Unless otherwise indicated, references can be found in DINOFLAJ2: http://dinoflaj.smu.ca/wiki/Main_Page); > see Fensome 1983; ** see Fensome et al. 1990; # see Fensome et al. in press; # see Fensome (2016); ^ see Jansonius and Hills card catalogue; ^^ see Nilsson 1958; * see Singh 1971.

DINOCYSTS

Achomosphaera Evitt 1963

Achomosphaera ramulifera (Deflandre 1937b) Evitt 1963

Apteodinium Eisenack 1958a

Apteodinium granulatum Eisenack 1958a

Apteodinium spongiosum McIntyre and Brideaux 1980

Batioladinium Brideaux 1975

Batioladinium jaegeri (Alberti 1961) Brideaux 1975

Bourkidinium psilatum Singh 1983

Callaiosphaeridium Davey and Williams 1966b

Callaiosphaeridium asymmetricum (Deflandre & Courteville 1939) Davey & Williams 1966b

Callaiosphaeridium "latispinosum" sp. nov.

Callaiosphaeridium "spinulosum" sp. nov.

Canningia reticulata Cookson and Eisenack 1960b

Canninginopsis Cookson and Eisenack, 1962b, p.488

"Cassiculidinium" gen. nov.

"Cassiculodinium" brevispinosum (Pocock 1962) comb. nov.

"Cassiculodinium cassis" sp. nov.

"Cassiculodinium reticulatum" sp. nov.

"Cassiculodinium spherispinosum" sp. nov.

"Cassiculodinium symcassis" sp. nov.

"Cassiculodinium symreticulatum" sp. nov.

Catastomocystis spinosa Singh 1983

Catastomocystis "*rasilis*" sp. nov.

Cauca Davey and Verdier 1971

Cauca parva (Alberti 1961) Davey and Verdier 1971

Cerbia Below 1981a

Chatangiella Vozzhennikova 1967

Chichaouadinium Below 1981a

Chichaouadinium vestitum (Brideaux 1971) Bujak and Davies 1983

Chlamydophorella Cookson and Eisenack 1958

Chlamydophorella nyei Cookson & Eisenack 1958

Circulodinium distinctum (Deflandre and Cookson 1955) Jansonius 1986

Cometodinium Deflandre and Courteville 1939

Coronifera oceanica Cookson and Eisenack 1958

Coronifera striolata (Deflandre 1937b) Stover and Evitt 1978

Cribroperidinium Neale & Sarjeant 1962

Cribroperidinium cooksoniae Norvick 1976

Cribroperidinium edwardsii (Cookson and Eisenack 1958) Davey 1969a

Cribroperidinium orthoceras (Eisenack 1958a) Davey 1969a

Cribroperidinium sepimentum Neale and Sarjeant 1962

Cyclonephelium compactum Deflandre and Cookson 1955

Cyclonephelium vannophorum Davey 1969a

Cymososphaeridium Davey 1982b

Cymososphaerdium validum Davey 1982b

Dinopterygium Deflandre 1935

Dinopterygium alatum (Cookson and Eisenack 1962b Fensome et al. 2009

Dinopterygium cladoides Deflandre 1935

Epelidosphaeridia Davey 1969a

Escharisphaeridia Erkmen and Sarjeant 1980

Escharisphaeridia granulata (Courtinat in Courtinat and Gaillard 1980) Stover and Williams 1987

Escharisphaeridia pocockii (Sarjeant 1968) Erkmen and Sarjeant 1980

Exochosphaeridium Davey et al. 1966

Exochosphaeridium phragmites Davey et al. 1966

Exochosphaeridium spheriphragmites sp. nov.

Florentinia Davey and Verdier 1973

*Florentinia cooksoniae (*Singh 1971) Duxbury 1980 (now *Kleithriasphaeridium cooksoniae*)

Gardodinium Alberti

Gardodinium trabeculosum (Gocht 1959) Alberti 1961

Ginginodinium evittii Singh 1983

Gochteodinia Norris 1978

Gonyaulacysta Deflandre 1964

Hapsocysta Davey 1979b

Heterosphaeridium difficile (Manum and Cookson 1964) Ioannides 1986

Hystrichodinium Deflandre 1935

Hystrichodinium pulchrum Deflandre 1935

Hystrichostrogylon Agelopoulos 1964

Impletosphaeridium Morgenroth 1966a,

Isabelidinium Lentin and Williams 1977a

Kaiwaradinium Wilson 1978

Kaiwaradinium "*contentum*" sp. nov.

Kaiwaradinium ramosum Wilson 1984a

Kalyptea diceras Cookson and Eisenack 1960b

Kiokansium Stover and Evitt 1978

Kiokansium unituberculatum (Tasch in Tasch et al. 1964) Stover and Evitt 1978

Kiokansium williamsii Singh 1983

Kleithriasphaeridium Davey 1974

Kleithriasphaeridium cooksoniae (Singh 1971) Fensome et al. 2009

Kleithriasphaeridium deanei (Davey and Williams 1966b) comb. nov.

Kleithriasphaeridium loffrense Davey and Verdier 1976,

Kleithriasphaeridium mantellii (Davey and Williams 1966b) comb nov.

Lagenorhytis delicatula (Duxbury 1977) Duxbury 1979b

Leptodinium Klement 1960

Luxadinium Brideaux and McIntyre 1975

Luxadinium propatulum Brideaux and McIntyre 1975

Meiourogonyaulax Sarjeant 1966b

Mendicodinium Morgenroth 1970

Microdinium Cookson and Eisenack 1960a

Nyktericysta Bint 1986

Nyktericysta davisii Bint 1986

Nyktericysta pentaradiata (Singh, 1983) Williams and Fensome 2016

Nyktericysta tripenta (Bint 1986) Fensome et al. 2009

Odontochitina Deflandre 1937b

Odontochitina ancala Bint 1986

Odontochitina bathron sp. nov.

Odontochitina chelion sp. nov.

Odontochitina corpusconus sp. nov.

Odontochitina costata Alberti 1961

Odontochitina singhii Morgan 1980

Oligosphaeridium Davey and Williams 1966b

Oligosphaeridium albertense (Pocock 1962) Davey and Williams 1969

Oligosphaeridium anthophorum (Cookson and Eisenack 1958) Davey 1969a

Oligosphaeridium asterigerum (Gocht 1959) Davey and Williams 1969

Oligosphaeridium complex (White 1842) Davey and Williams 1966b

Oligosphaeridium dictyophorum (Cookson and Eisenack 1958) Davey and Williams 1969

Oligosphaeridium perforatum (Gocht 1959) Davey and Williams 1969

Oligosphaeridium "*perforoalbertense*" sp. nov.

Oligosphaeridium "*perforototum*" sp. nov.

Oligosphaeridium pulcherrimum (Deflandre and Cookson 1955) Davey and Williams 1966b

Oligosphaeridium "*recurvatum*" sp. nov.

Oligosphaeridium "*tenuipoculum*" sp. nov.

Oligosphaeridium totum Brideaux 1971

Operculodinium? "*delicatum*" sp. nov.

Operculodinium? "*latidelicatum*" sp. nov.

Ovoidinium Davey 1970

Ovoidinium cinctum (Cookson and Eisenack 1958) Davey 1970

Ovoidinium scabrosum (Cookson and Hughes 1964) Davey 1970

Ovoidinium verrucosum (Cookson and Hughes 1964) Davey 1970

Palaeoperidinium Deflandre 1934 ex Sarjeant 1967b

*Palaeoperidinium cretaceum (*Pocock 1962 ex Davey 1970) Lentin and Williams 1976

*Palaeoperidinium pyrophorum (*Ehrenberg 1838 ex Wetzel 1933a) Sarjeant 1967b

Pareodinia Deflandre 1947d

Pareodinia ceratophora Deflandre 1947d

Pervosphaeridium Yun Hyesu 1981

Pervosphaeridium copis sp. nov.

Pervosphaeridium cornucopis sp. nov.

Phoberocysta Millioud 1969

Pseudoceratium Gocht 1957

Pseudoceratium hirsutum sp. nov.

Pseudoceratium polymorphum (Eisenack 1958a) Bint 1986

Pseudoceratium reticulatum sp. nov.

Pterodinium Eisenack 1958a

Pyxidinopsis rugosus sp. nov.

Reculadinium gen. nov.

Senoniasphaera Clarke and Verdier 1967

Senoniasphaera latireticulata sp. nov.

Senoniasphaera microreticulata Brideaux and McIntyre 1975

Sentusidinium Sarjeant and Stover 1978

Sentusidinium myriatrichum Fensome 1979

Sepispinula Islam 1993

Sepispinula huguoniottii (Valensi 1955a) Islam 1993

Spiniferites Mantell 1850

Spiniferites digitatus sp. nov.

Spiniferites displosus sp. nov.

Spiniferites furcosus sp. nov.

Spiniferites membranaceus (Rossignol 1964) Sarjeant 1970

Spiniferites ramosus (Ehrenberg 1838) Mantell 1854

Spiniferites tubiferus sp. nov.

Spongodinium delitiense (Ehrenberg 1838) Deflandre 1936b

Stephodinium Deflandre 1936a

Stiphrosphaeridium Davey 1982b

Stiphrosphaeridium anthophorum (Cookson and Eisenack 1958) Lentin and Williams 1985

Stiphrosphaeridium dictyophorum (Cookson and Eisenack 1958) Lentin and Williams 1985

Subtilisphaera Jain and Millepied 1973

Subtilisphaera cheit Below 1981a

Subtilisphaera perlucida (Alberti 1959b) Jain and Millepied 1973

Subtilisphaera senegalensis Jain and Millepied 1973

Subtilisphaera symsenegalensis sp. nov.

Surculosphaeridium Davey et al., 1966,

Surculosphaeridium convocatum Fensome et al. in press

Surculosphaeridium longifurcatum (Firtion 1952) Davey et al. 1966

Tanyosphaeridium xanthiopyxides (Wetzel 1933b ex Deflandre 1937b) Stover and Evitt 1978

Tenua Eisenack 1958a

Tenua brevispinata (Millioud 1969) comnb. nov.

Tenua cassicula sp. nov.

Tenua cornudistincta sp. nov.

Tenua cornufilosa sp. nov.

Tenua cornuspinata sp. nov.

Tenua filosa sp. nov.

Tenua reticulata sp. nov.

Tribulodinium gen. nov.

Tribulodinium brevispinatum (Millioud 1969) comb. nov.

Tribulodinium cornufilosum sp. nov.

Tribulodinium cornuspinatum sp. nov.

Tribulodinium cornuspinum sp. nov.

Tribulodinium filosum sp. nov.

Trichodinium Eisenack and Cookson 1960

Trichodinium castanea Deflandre 1935 ex Clarke and Verdier 1967

Trichodinium muratispinum sp. nov.

Trichodinium spinosum Singh 1971

Trithyrodinium Drugg 1967

Trithyrodinium evittii Drugg 1967

Vesperopsis Bint 1986

ACRITARCHS & ALGAE

Baltisphaeridium Eisenack 1958a

Fromea Cookson and Eisenack 1958

Fromea granulate Lentin and Williams 1977b

Fromea laevigata Drugg 1977

Leiosphaeridia Eisenack 1958c

Micrhystridium Deflandre 1937b

Palambages Wetzel 1961#

Paralecaniella Cookson and Eisenack 1970b

Paralecaniella granulata

Paralecaniella indentata (Deflandre and Cookson 1955) Cookson and Eisenack 1970b

Pediastrum Meyen 1829#

Pterospermella Eisenack 1972

Schizosporis reticulatus Cookson and Dettmann 1959**

Solisphaeridium Staplin et al 1965

Tetraporina Naumova 1950 ex Bolkhovitina 1953#

Veryhachium Deunff 1954b

MIOSPORES

Antulsporites Archangelsky and Gamerro 1966^

Appendicisporites Weyland and Krieger 1953^

Araucariacites Cookson 1947 ex Couper 1953^

Baculatisporites Pflug and Thomson in Thomson and Pflug 1953^

Baculatisporites comaumensis (Cookson 1953) Potonié 1956*

Biretisporites Delcourt and Sprumont 1955^

Callialasporites Dev 1961^

Callialasporites dampieri (Balme 1957) Dev 1961[#]

Cerebropollenites Nilsson 1958^

Cerebropollenites macroverrucatus (Thiergart 1949) Schulz 1967^

Cibotiumspora Chang 1965^

Cicatricosisporites Potonié and Gelletich 1933^

Classopollis Pflug 1953^

Classopollis classoides Pflug 1953^

Concavisporites Pflug in Thomson and Pflug 1953^

Concavissimisporites Delcourt and Sprumont 1955^

Costatoperforosporites Deák 1962^

Cycadopites Wodehouse 1933^

Deltoidospora Miner 1935^

Densoisporites Weyland and Krieger 1953^

Dictyophyllidites Couper 1958^

Distaltriangulatisporites Singh 1971^

Distaltriangulatisporites perplexus Singh 1971^

Eucommiidites Erdtman 1948 ex Potonié 1958^

Eucommiidites minor Groot and Penny 1960*

Eucommiidites troedssonii (Erdtman 1948) Potonié 1958^

Exesipollenites Balme 1957^

Exesipollenites tumulus Balme 1957^

Foveotriletes van der Hammen 1955 ex Potonié 1956^

Gleicheniidites Ross 1949^

Gleicheniidites senonicus Ross 1949^

Ischyosporites Balme 1957^

Laevigatosporites Ibrahim 1933^

Ornamentifera Bolkhovitina in Neishtadt 1966^

Osmundacidites Couper 1953^

Pilosisporites Delcourt and Sprumont 1955^

Pilosisporites trichopapillosus (Thiergart 1949) Delcourt and Sprumont 1955^

Plicatella Maljavkina 1947^

Retitriletes Pierce 1961^

Retitriletes austroclavatidites (Cookson 1953) Dőring, Krutzsch, Mai and Schulz in Krutzsch 1963>

Rotverrusporites Döring 1964^

Rugubivesiculites Pierce 1961^

Stereisporites Pflug in Thomson and Pflug 1953^

Stereisporites antiquasporites (Wilson and Webster 1946) Dettmann 1963 >

Tuberositriletes Döring 1964^

Vitreisporites Leschik 1956a^

Vitreisporites pallidus (Reissinger 1950) Nilsson 1958^^

Zlivisporis Pacltová 1961^

FORAMINIFERA

Textularia alcesensis

Verneulina canadensis

Appendix 3: Details of the specimens figured in the plates

Taxon name	Plate	Fig	Sample	Slide	Coordinates	Mag/lens	GSC Type No.
Achomosphaera ramulifera	Pl 01	Fig 01	07-PEEL-43	5262-012C	157x0926	x40 Ph	GSC 138687
Apteodinium granulatum	Pl 01	Fig 02	07-PEEL-43	5262-012C	136x0793	x40 Ph	GSC 138688
Apteodinium granulatum	Pl 01	Fig 03	07-PEEL-43	5262-012C	136x0793	x40 Ph	GSC 138688
Apteodinium granulatum	Pl 01	Fig 04	07-PEEL-43	5262-012C	136x0793	x40 Ph	GSC 138688
Batioladinium jaegeri	Pl 01	Fig 05	07-PEEL-48	5262-016L	095x0760	x40 Ph	GSC 138689
Batioladinium jaegeri	Pl 01	Fig 06	07-PEEL-46	5262-014L	184x0767	x40 Ph	GSC 138690
Apteodinium granulatum cf	Pl 01	Fig 07	07-PEEL-48	5262-016L	151x0779	x40 Ph	GSC 138691
Apteodinium spongiosum	Pl 01	Fig 08	07-PEEL-48	5262-016L	096x0714	x40 Ph	GSC 138692
Bourkidinium psilatum	Pl 01	Fig 09	07-PEEL-45	5262-013L	149x1000	x40 Ph	GSC 138693
Callaiosphaeridium latispinum	Pl 01	Fig 10	07-PEEL-40	5262-011C	160x0889	x40 Ph	GSC 138694
Callaiosphaeridium latispinum	Pl 01	Fig 11	07-PEEL-46	5262-014L	141x0960	x40 Ph	GSC 138695
Callaiosphaeridium spinulosum	Pl 01	Fig 12	07-PEEL-48	5262-016L	157x0735	x40 Ph	GSC 138696
Canningia reticulata	Pl 01	Fig 13	07-PEEL-09	5262-005C	172x0915	x40 Ph	GSC 138697
Canningia reticulata	Pl 01	Fig 14	07-PEEL-48	5262-016L	196x0819	x40 Ph	GSC 138698
Canningia reticulata	Pl 01	Fig 15	07-PEEL-48	5262-016L	196x0819	x40 Ph	GSC 138698
Canninginopsis sp	Pl 01	Fig 16	07-PEEL-14	5262-006C	199x0830	x40 Ph	GSC 138699
Cassiculodinium brevispinosum	Pl 01	Fig 17	07-PEEL-04	5262-004C	106x0790	x40 Ph	GSC 138700
Cassiculodinium brevispinosum	Pl 01	Fig 18	07-PEEL-04	5262-004C	120x0916	x40 Ph	GSC 138701
Cassiculodinium cassis	Pl 01	Fig 19	07-PEEL-43	5262-012C	150x0746	x40 Ph	GSC 138702
Cassiculodinium cassis	Pl 01	Fig 20	07-PEEL-43	5262-012C	186x0879	x40 Ph	GSC 138703
Cassiculodinium cassis	Pl 02	Fig 01	07-PEEL-40	5262-011C	160x0713	x40 Ph	GSC 138704
Cassiculodinium cassis	Pl 02	Fig 02	07-PEEL-40	5262-011C	160x0713	x40 Ph	GSC 138704
Cassiculodinium cassis	Pl 02	Fig 03	07-PEEL-40	5262-011C	160x0713	x40 Ph	GSC 138704
Cassiculodinium cassis	Pl 02	Fig 04	07-PEEL-43	5262-012C	187x0890	x40 Ph	GSC 138705
Cassiculodinium cassis	Pl 02	Fig 05	07-PEEL-43	5262-012C	190x0909	x40 Ph	GSC 138706
Cassiculodinium cassis	Pl 02	Fig 06	07-PEEL-45	5262-013L	200x0795	x40 Ph	GSC 138707
Cassiculodinium cassis	Pl 02	Fig 07	07-PEEL-48	5262-016L	161x0812	x40 Ph	GSC 138708
Cassiculodinium cassis	Pl 02	Fig 08	07-PEEL-48	5262-016L	201x0898	x40 Ph	GSC 138709
Cassiculodinium reticulatum	Pl 02	Fig 09	07-PEEL-48	5262-016L	137x0805	x40 Ph	GSC 138710
Cassiculodinium reticulatum	Pl 02	Fig 10	07-PEEL-48	5262-016L	122x0954	x40 Ph	GSC 138711
Cassiculodinium reticulatum	Pl 02	Fig 11	07-PEEL-46	5262-014M	200x0713	x40 Ph	GSC 138712
Cassiculodinium reticulatum	Pl 02	Fig 12	07-PEEL-45	5262-013L	201x0960	x40 Ph	GSC 138713
Cassiculodinium symcassis	Pl 02	Fig 13	07-PEEL-45	5262-013L	157x0846	x40 Ph	GSC 138714
Cassiculodinium symcassis	Pl 02	Fig 14	07-PEEL-48	5262-016L	201x0924	x40 Ph	GSC 138715
Cassiculodinium reticulatum	Pl 02	Fig 15	07-PEEL-45	5262-013L	175x0690	x40 Ph	GSC 138716
Cassiculodinium reticulatum	Pl 02	Fig 16	07-PEEL-40	5262-011C	141x0790	x40 Ph	GSC 138717
Cassiculodinium symcassis	Pl 02	Fig 17	07-PEEL-51	5262-018L	117x0830	x40 Ph	GSC 138718
Cassiculodinium symreticulatum	Pl 02	Fig 18	07-PEEL-14	5262-006D	147x0863	x40 Ph	GSC 138719
Chichaouadinium vestitum	Pl 02	Fig 19	07-PEEL-40	5262-011D	202x0699	x40 Ph	GSC 138720
Chichaouadinium vestitum	Pl 02	Fig 20	07-PEEL-43	5262-012D	157x0995	x40 Ph	GSC 138721
Cauca parva	Pl 03	Fig 01	07-PEEL-45	5262-013C	172x0985	x40 Ph	GSC 138722
Cauca parva	Pl 03	Fig 02	07-PEEL-45	5262-013C	187x0846	x40 Ph	GSC 138723
Cerbia sp	Pl 03	Fig 03	07-PEEL-43	5262-012D	168x0717	x40 Ph	GSC 138724
Chlamydophorella nyei	Pl 03	Fig 04	07-PEEL-48	5262-016M	180x0750	x40 Ph	GSC 138725
Coronifera oceanica	Pl 03	Fig 05	07-PEEL-43	5262-012C	098x0986	x40 Ph	GSC 138726
Coronifera striolata	Pl 03	Fig 06	07-PEEL-48	5262-016L	151x0857	x40 Ph	GSC 138727
Cribroperidinium cooksoniae	Pl 03	Fig 07	07-PEEL-48	5262-016L	164x0829	x40 Ph	GSC 138728
Cribroperidinium cooksoniae	Pl 03	Fig 08	07-PEEL-48	5262-016L	184x0726	x40 Ph	GSC 138729
Cribroperidinium edwardsii	Pl 03	Fig 09	07-PEEL-45	5262-013L	124x0936	x40 Ph	GSC 138730
Cribroperidinium edwardsii	Pl 03	Fig 10	07-PEEL-45	5262-013L	124x0936	x40 Ph	GSC 138730
Cribroperidinium edwardsii	Pl 03	Fig 11	07-PEEL-45	5262-013L	124x0936	x40 Ph	GSC 138730
Cribroperidinium edwardsii	Pl 03	Fig 12	07-PEEL-45	5262-013L	144x0803	x40 Ph	GSC 138731
Cribroperidinium orthoceras	Pl 03	Fig 13	07-PEEL-43	5262-012C	146x0690	x40 Ph	GSC 138732
Cribroperidinium edwardsii	Pl 03	Fig 14	07-PEEL-45	5262-013L	195x0750	x40 Ph	GSC 138733
Cribroperidinium edwardsii	Pl 03	Fig 15	07-PEEL-45	5262-013L	195x0750	x40 Ph	GSC 138733
Cribroperidinium edwardsii	Pl 03	Fig 16	07-PEEL-46	5262-014L	152x0727	x40 Ph	GSC 138734
Cribroperidinium orthoceras	Pl 03	Fig 17	07-PEEL-43	5262-012C	146x0690	x40 Ph	GSC 138735
Cribroperidinium orthoceras	Pl 03	Fig 18	07-PEEL-48	5262-016L	167x0917	x40 Ph	GSC 138736
Cribroperidinium orthoceras	Pl 03	Fig 19	07-PEEL-48	5262-016L	167x0917	x40 Ph	GSC 138736
Cribroperidinium orthoceras	Pl 03	Fig 20	07-PEEL-48	5262-016L	118x0709	x40 Ph	GSC 138737
Cribroperidinium orthoceras	Pl 04	Fig 01	07-PEEL-46	5262-014M	199x0855	x40 Ph	GSC 138738
Cribroperidinium sepimentum	Pl 04	Fig 02	07-PEEL-45	5262-013C	202x0728	x40 Ph	GSC 138739
Cribroperidinium sepimentum	Pl 04	Fig 03	07-PEEL-43	5262-012C	178x0690	x40 Ph	GSC 138740
Cyclonephelium compactum	Pl 04	Fig 04	07-PEEL-23	5262-008L	165x0965	x40 Ph	GSC 138741
Cyclonephelium compactum	Pl 04	Fig 05	07-PEEL-23	5262-008L	175x0990	x40 Ph	GSC 138742
Cyclonephelium compactum	Pl 04	Fig 06	07-PEEL-23	5262-008L	200x0741	x40 Ph	GSC 138743

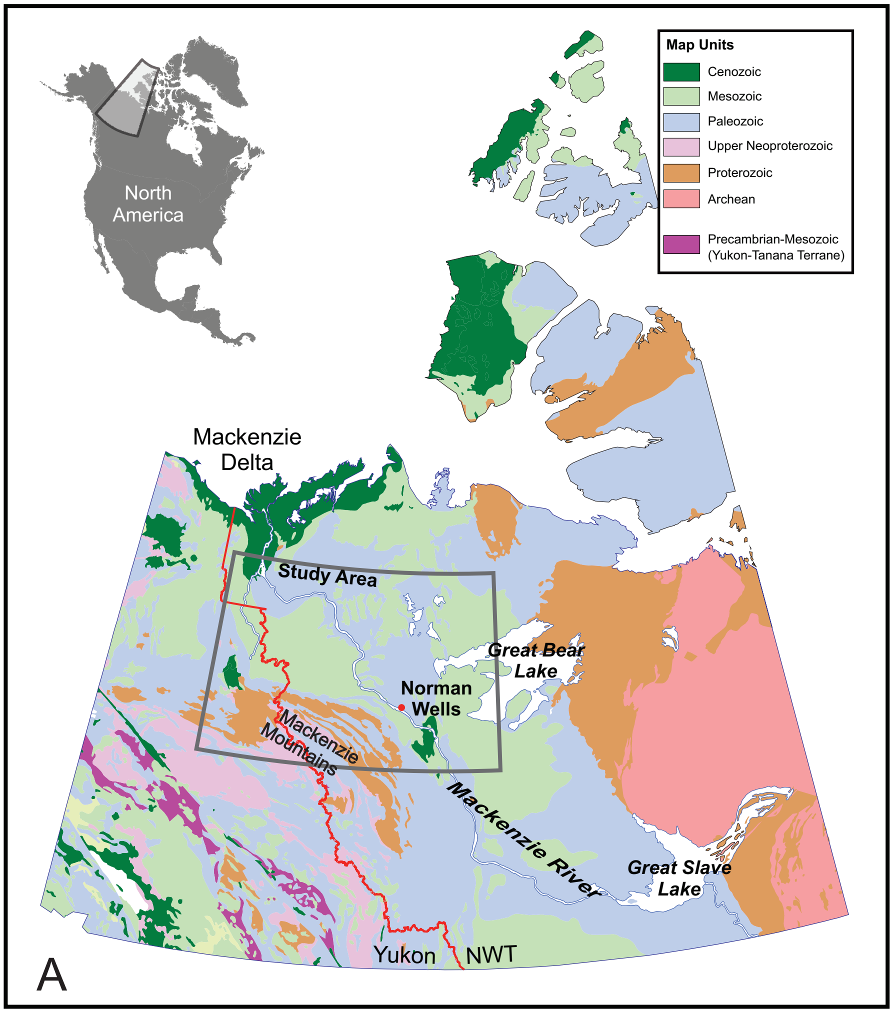
Cyclonephelium compactum	Pl 04	Fig 07	07-PEEL-48	5262-016L	163x0913	x40 Ph	GSC 138744
Cyclonephelium compactum	Pl 04	Fig 08	07-PEEL-48	5262-016L	194x0918	x40 Ph	GSC 138745
Cymososphaeridium validum	Pl 04	Fig 09	07-PEEL-03	5262-003C	188x0917	x40 Ph	GSC 138746
Dinopterygium cladoides	Pl 04	Fig 10	07-PEEL-43	5262-012C	148x0795	x40 Ph	GSC 138747
Cyclonephelium vannophorum	Pl 04	Fig 11	07-PEEL-14	5262-006C	137x0885	x40 Ph	GSC 138748
Cyclonephelium compactum	Pl 04	Fig 12	07-PEEL-51	5262-018L	121x0914	x40 Ph	GSC 138749
Dinopterygium alatum	Pl 04	Fig 13	07-PEEL-40	5262-011C	182x0864	x40 Ph	GSC 138750
Dinopterygium alatum	Pl 04	Fig 14	07-PEEL-40	5262-011C	202x0892	x40 Ph	GSC 138751
Tribulodinium cornupilosum	Pl 04	Fig 15	07-PEEL-40	5262-011C	171x0985	x40 Ph	GSC 138752
Tribulodinium cornupilosum	Pl 04	Fig 16	07-PEEL-40	5262-011C	206x0910	x40 Ph	GSC 138753
Tribulodinium cornupilosum	Pl 04	Fig 17	07-PEEL-40	5262-011D	189x0908	x40 Ph	GSC 138754
Tribulodinium cornupilosum	Pl 04	Fig 18	07-PEEL-43	5262-012C	132x0767	x40 Ph	GSC 138755
Tribulodinium cornupilosum	Pl 04	Fig 19	07-PEEL-43	5262-012C	180x0814	x40 Ph	GSC 138756
Tribulodinium cornupilosum	Pl 04	Fig 20	07-PEEL-45	5262-013L	111x0732	x40 Ph	GSC 138757
Tribulodinium cornuspinatum	Pl 05	Fig 01	07-PEEL-03	5262-003C	137x0787	x40 Ph	GSC 138758
Tribulodinium cornuspinatum	Pl 05	Fig 02	07-PEEL-04	5262-004C	150x0902	x40 Ph	GSC 138759
Tribulodinium cornuspinatum	Pl 05	Fig 03	07-PEEL-04	5262-004C	180x0878	x40 Ph	GSC 138760
Tribulodinium cornuspinatum	Pl 05	Fig 04	07-PEEL-14	5262-006C	171x0836	x40 Ph	GSC 138761
Catastomocystis rasilis	Pl 05	Fig 05	07-PEEL-45	5262-013L	177x0788	x40 Ph	GSC 138762
Tribulodinium pilosum	Pl 05	Fig 06	07-PEEL-45	5262-013L	198x0891	x40 Ph	GSC 138763
Tribulodinium pilosum	Pl 05	Fig 07	07-PEEL-46	5262-014L	142x0807	x40 Ph	GSC 138764
Tribulodinium cornuspinatum	Pl 05	Fig 08	07-PEEL-20	5262-007C	148x0927	x40 Ph	GSC 138765
Catastomocystis rasilis	Pl 05	Fig 09	07-PEEL-50	5262-017M	100x0836	x40 Ph	GSC 138766
Catastomocystis rasilis	Pl 05	Fig 10	07-PEEL-51	5262-018M	180x0882	x40 Ph	GSC 138767
Catastomocystis rasilis	Pl 05	Fig 11	07-PEEL-45	5262-013L	178x0970	x40 Ph	GSC 138768
Catastomocystis rasilis	Pl 05	Fig 12	07-PEEL-45	5262-013M	170x0658	x40 Ph	GSC 138769
Exochosphaeridium spheriphragmites	Pl 05	Fig 13	07-PEEL-43	5262-012B	138x0821	x40 Ph	GSC 138770
Exochosphaeridium spheriphragmites	Pl 05	Fig 14	07-PEEL-43	5262-012B	138x0821	x40 Ph	GSC 138770
Exochosphaeridium spheriphragmites	Pl 05	Fig 15	07-PEEL-43	5262-012B	173x0693	x40 Ph	GSC 138771
Stephodinium? sp.	Pl 05	Fig 16	07-PEEL-45	5262-013L	100x0940	x40 Ph	GSC 138772
Exochosphaeridium phragmites	Pl 05	Fig 17	07-PEEL-43	5262-012C	098x0862	x40 Ph	GSC 138773
Exochosphaeridium phragmites	Pl 05	Fig 18	07-PEEL-43	5262-012C	202x0766	x40 Ph	GSC 138774
Exochosphaeridium spheriphragmites	Pl 05	Fig 19	07-PEEL-43	5262-012C	188x0770	x40 Ph	GSC 138775
Exochosphaeridium spheriphragmites	Pl 05	Fig 20	07-PEEL-48	5262-016L	171x0786	x40 Ph	GSC 138776
Escharisphaeridia pocockii	Pl 06	Fig 01	07-PEEL-03	5262-003C	202x0786	x40 Ph	GSC 138777
Escharisphaeridia pocockii	Pl 06	Fig 02	07-PEEL-43	5262-012C	163x0912	x40 Ph	GSC 138778
Escharisphaeridia pocockii	Pl 06	Fig 03	07-PEEL-45	5262-013L	195x0855	x40 Ph	GSC 138779
Hystrichodinium pulchrum	Pl 06	Fig 04	07-PEEL-23	5262-008L	198x0736	x40 Ph	GSC 138780
Gardodinium trabeculosum	Pl 06	Fig 05	07-PEEL-03	5262-003D	157x0784	x40 Ph	GSC 138781
Gardodinium trabeculosum	Pl 06	Fig 06	07-PEEL-09	5262-005D	137x0779	x40 Ph	GSC 138782
Gardodinium trabeculosum	Pl 06	Fig 07	07-PEEL-14	5262-006D	130x0705	x40 Ph	GSC 138783
Gardodinium trabeculosum	Pl 06	Fig 08	07-PEEL-43	5262-012D	147x0930	x40 Ph	GSC 138784
Kalyptea diceras	Pl 06	Fig 09	07-PEEL-48	5262-016L	140x0829	x40 Ph	GSC 138785
Hystrichostrogylon sp.	Pl 06	Fig 10	07-PEEL-43	5262-012C	153x0745	x40 Ph	GSC 138786
Kaiwaradinium contentum	Pl 06	Fig 11	07-PEEL-40	5262-011C	138x0863	x40 Ph	GSC 138787
Kaiwaradinium contentum	Pl 06	Fig 12	07-PEEL-48	5262-016L	193x0806	x40 Ph	GSC 138788
Kleithriasphaeridium mantellii	Pl 06	Fig 13	07-PEEL-43	5262-012C	197x0845	x40 Ph	GSC 138789
Kleithriasphaeridium mantellii	Pl 06	Fig 14	07-PEEL-48	5262-016L	137x0875	x40 Ph	GSC 138790
Kleithriasphaeridium mantellii	Pl 06	Fig 15	07-PEEL-48	5262-016L	152x0825	x40 Ph	GSC 138791
Kiokansium unituberculatum	Pl 06	Fig 16	07-PEEL-03	5262-003C	160x0919	x40 Ph	GSC 138792
Kleithriasphaeridium cooksoniae	Pl 06	Fig 17	07-PEEL-46	5262-014L	178x0837	x40 Ph	GSC 138793
Kleithriasphaeridium cf. deanei	Pl 06	Fig 18	07-PEEL-108	5262-026C	152x0874	x40 Ph	GSC 138794
Lagenorhytis delicatula	Pl 06	Fig 19	07-PEEL-40	5262-011C	172x0818	x40 Ph	GSC 138795
Lagenorhytis delicatula	Pl 06	Fig 20	07-PEEL-40	5262-011C	186x0965	x40 Ph	GSC 138796
Leptodinium sp.	Pl 07	Fig 01	07-PEEL-51	5262-018L	148x0935	x40 Ph	GSC 138797
Leptodinium sp.	Pl 07	Fig 02	07-PEEL-116	5262-027C	176x0876	x40 Ph	GSC 138798
Leptodinium sp.	Pl 07	Fig 03	07-PEEL-47	5262-015B	081x0978	x40 Ph	GSC 138799
Meiourogonyaulax sp.	Pl 07	Fig 04	07-PEEL-45	5262-013L	112x0800	x40 Ph	GSC 138800
Luxadinium propatulum	Pl 07	Fig 05	07-PEEL-40	5262-011C	118x0998	x40 Ph	GSC 138801
Luxadinium propatulum	Pl 07	Fig 06	07-PEEL-43	5262-012D	157x1007	x40 Ph	GSC 138802
Luxadinium propatulum	Pl 07	Fig 07	07-PEEL-45	5262-013C	162x0975	x40 Ph	GSC 138803
Luxadinium propatulum	Pl 07	Fig 08	07-PEEL-45	5262-013C	182x0916	x40 Ph	GSC 138804
Luxadinium propatulum	Pl 07	Fig 09	07-PEEL-45	5262-013L	154x1003	x40 Ph	GSC 138805
Luxadinium propatulum	Pl 07	Fig 10	07-PEEL-45	5262-013L	180x0679	x40 Ph	GSC 138806
Luxadinium propatulum	Pl 07	Fig 11	07-PEEL-48	5262-016L	150x0864	x40 Ph	GSC 138807
Luxadinium propatulum	Pl 07	Fig 12	07-PEEL-48	5262-016L	177x0756	x40 Ph	GSC 138808
Microdinium? sp	Pl 07	Fig 13	07-PEEL-95	5262-024B	050x0974	x40 Ph	GSC 138809
Nyktericysta davisii	Pl 07	Fig 14	07-PEEL-45	5262-013L	155x0700	x40 Ph	GSC 138810

Nyktericysta davisii	Pl 07	Fig 15	07-PEEL-46	5262-014L	177x0925	x40 Ph	GSC 138811
Nyktericysta tripenta	Pl 07	Fig 16	07-PEEL-45	5262-013L	173x0933	x40 Ph	GSC 138812
Odontochitina ancala	Pl 07	Fig 17	07-PEEL-48	5262-016L	167x0733	x40 Ph	GSC 138813
Odontochitina costata	Pl 07	Fig 18	07-PEEL-14	5262-006C	140x0872	x40 Ph	GSC 138814
Odontochitina costata	Pl 07	Fig 19	07-PEEL-48	5262-016L	160x0896	x40 Ph	GSC 138815
Odontochitina costata	Pl 07	Fig 20	07-PEEL-48	5262-016L	140x1014	x40 Ph	GSC 138816
Odontochitina singhii	Pl 08	Fig 01	07-PEEL-48	5262-016L	100x0855	x40 Ph	GSC 138817
Odontochitina singhii	Pl 08	Fig 02	07-PEEL-48	5262-016L	151x0779	x40 Ph	GSC 138818
Odontochitina singhii	Pl 08	Fig 03	07-PEEL-51	5262-018L	194x0899	x40 Ph	GSC 138819
Odontochitina appendicula	Pl 08	Fig 04	07-PEEL-03	5262-003C	100x0836	x40 Ph	GSC 138820
Odontochjitina chelion	Pl 08	Fig 05	07-PEEL-43	5262-012C	160x0848	x40 Ph	GSC 138821
Odontochitina corpucorna	Pl 08	Fig 06	07-PEEL-108	5262-026C	186x0929	x40 Ph	GSC 138822
Oligosphaeridium asterigerum	Pl 08	Fig 07	07-PEEL-14	5262-006C	148x0794	x40 Ph	GSC 138823
Oligosphaeridium asterigerum	Pl 08	Fig 08	07-PEEL-14	5262-006C	170x0780	x40 Ph	GSC 138824
Oligosphaeridium albertense	Pl 08	Fig 09	07-PEEL-04	5262-004C	199x0848	x40 Ph	GSC 138825
Oligosphaeridium albertense	Pl 08	Fig 10	07-PEEL-45	5262-013L	178x0996	x40 Ph	GSC 138826
Oligosphaeridium albertense	Pl 08	Fig 11	07-PEEL-108	5262-026C	182x0828	x40 Ph	GSC 138827
Oligosphaeridium anthophorum	Pl 08	Fig 12	07-PEEL-45	5262-013L	131x0687	x40 Ph	GSC 138828
Oligosphaeridium anthophorum	Pl 08	Fig 13	07-PEEL-14	5262-006C	128x0990	x40 Ph	GSC 138829
Oligosphaeridium anthophorum	Pl 08	Fig 14	07-PEEL-43	5262-012C	187x0686	x40 Ph	GSC 138830
Oligosphaeridium anthophorum	Pl 08	Fig 15	07-PEEL-45	5262-013L	113x0900	x40 Ph	GSC 138831
Oligosphaeridium anthophorum	Pl 08	Fig 16	07-PEEL-45	5262-013L	183x0976	x40 Ph	GSC 138832
Oligosphaeridium complex	Pl 08	Fig 17	07-PEEL-04	5262-004C	186x0864	x40 Ph	GSC 138833
Oligosphaeridium complex	Pl 08	Fig 18	07-PEEL-14	5262-006C	159x0949	x40 Ph	GSC 138834
Oligosphaeridium dictyophorum	Pl 08	Fig 19	07-PEEL-95	5262-024B	050x0863	x40 Ph	GSC 138835
Oligosphaeridium dictyophorum	Pl 08	Fig 20	07-PEEL-14	5262-006C	182x0934	x40 Ph	GSC 138836
Oligosphaeridium dictyophorum	Pl 09	Fig 01	07-PEEL-14	5262-006C	130x0980	x40 Ph	GSC 138837
Oligosphaeridium perforoalbertense	Pl 09	Fig 02	07-PEEL-45	5262-013L	192x0728	x40 Ph	GSC 138838
Oligosphaeridium tenuipoculum	Pl 09	Fig 03	07-PEEL-48	5262-016L	120x0799	x40 Ph	GSC 138839
Oligosphaeridium totum	Pl 09	Fig 04	07-PEEL-03	5262-003C	200x0687	x40 Ph	GSC 138840
Oligosphaeridium pulcherrimum	Pl 09	Fig 05	07-PEEL-43	5262-012C	170x0788	x40 Ph	GSC 138841
Oligosphaeridium pulcherrimum	Pl 09	Fig 06	07-PEEL-45	5262-013L	160x0998	x40 Ph	GSC 138842
Oligosphaeridium pulcherrimum	Pl 09	Fig 07	07-PEEL-46	5262-014L	133x0700	x40 Ph	GSC 138843
Oligosphaeridium pulcherrimum	Pl 09	Fig 08	07-PEEL-48	5262-016L	190x0788	x40 Ph	GSC 138844
Oligosphaeridium recurvatum	Pl 09	Fig 09	07-PEEL-04	5262-004C	191x0963	x40 Ph	GSC 138845
Oligosphaeridium recurvatum	Pl 09	Fig 10	07-PEEL-04	5262-004C	196x0719	x40 Ph	GSC 138846
Oligosphaeridium recurvatum	Pl 09	Fig 11	07-PEEL-45	5262-013L	120x0905	x40 Ph	GSC 138847
Oligosphaeridium perforototum	Pl 09	Fig 12	07-PEEL-43	5262-012C	150x0758	x40 Ph	GSC 138848
Oligosphaeridium sp.	Pl 09	Fig 13	07-PEEL-48	5262-016L	180x0774	x40 Ph	GSC 138849
Ovoidinium cinctum	Pl 09	Fig 14	07-PEEL-48	5262-016M	156x1002	x40 Ph	GSC 138850
Ovoidinium cinctum	Pl 09	Fig 15	07-PEEL-50	5262-017L	163x0991	x40 Ph	GSC 138851
Ovoidinium cinctum	Pl 09	Fig 16	07-PEEL-50	5262-017M	176x0878	x40 Ph	GSC 138852
Palaeoperidinium cretaceum	Pl 09	Fig 17	07-PEEL-45	5262-013L	198x0984	x40 Ph	GSC 138853
Ovoidinium cinctum	Pl 09	Fig 18	07-PEEL-48	5262-016M	156x1002	x40 Ph	GSC 138850
Ovoidinium cinctum	Pl 09	Fig 19	07-PEEL-50	5262-017K	081x0792	x40 Ph	GSC 138854
Ovoidinium scabrosum	Pl 09	Fig 20	07-PEEL-45	5262-013L	186x0695	x40 Ph	GSC 138855
Operculodinium? delicatum	Pl 10	Fig 01	07-PEEL-43	5262-012D	108x0769	x40 Ph	GSC 138856
Operculodinium? delicatum	Pl 10	Fig 02	07-PEEL-43	5262-012D	110x0989	x40 Ph	GSC 138857
Operculodinium? delicatum	Pl 10	Fig 03	07-PEEL-43	5262-012D	157x0957	x40 Ph	GSC 138858
Operculodinium? delicatum	Pl 10	Fig 04	07-PEEL-43	5262-012D	171x0755	x40 Ph	GSC 138859
Operculodinium? delicatum	Pl 10	Fig 05	07-PEEL-48	5262-016M	171x0807	x40 Ph	GSC 138860
Operculodinium? delicatum	Pl 10	Fig 06	07-PEEL-48	5262-016M	196x0987	x40 Ph	GSC 138861
Operculodinium? latidelicatum	Pl 10	Fig 07	07-PEEL-43	5262-012D	126x0850	x40 Ph	GSC 138862
Operculodinium? latidelicatum	Pl 10	Fig 08	07-PEEL-43	5262-012D	136x0708	x40 Ph	GSC 138863
Pareodinia ceratophora	Pl 10	Fig 09	07-PEEL-47	5262-015B	052x0816	x40 Ph	GSC 138864
Pareodinia sp.	Pl 10	Fig 10	07-PEEL-45	5262-013C	173x0692	x40 Ph	GSC 138865
Operculodinium? latidelicatum	Pl 10	Fig 11	07-PEEL-43	5262-012D	176x0948	x40 Ph	GSC 138866
Operculodinium? latidelicatum	Pl 10	Fig 12	07-PEEL-48	5262-016M	197x0930	x40 Ph	GSC 138867
Palaeoperidinium pyrophorum	Pl 10	Fig 13	07-PEEL-29	5262-009L	194x0879	x40 Ph	GSC 138868
Palaeoperidinium pyrophorum	Pl 10	Fig 14	07-PEEL-40	5262-011C	151x0918	x40 Ph	GSC 138869
Palaeoperidinium pyrophorum	Pl 10	Fig 15	07-PEEL-45	5262-013L	132x0862	x40 Ph	GSC 138870
Palaeoperidinium pyrophorum	Pl 10	Fig 16	07-PEEL-48	5262-016L	105x0842	x40 Ph	GSC 138871
Pervosphaeridium copis	Pl 10	Fig 17	07-PEEL-45	5262-013L	201x0923	x40 Ph	GSC 138872
Pervosphaeridium copis	Pl 10	Fig 18	07-PEEL-48	5262-016L	093x0918	x40 Ph	GSC 138873
Pervosphaeridium copis	Pl 10	Fig 19	07-PEEL-48	5262-016L	180x0818	x40 Ph	GSC 138874
Pervosphaeridium copis	Pl 10	Fig 20	07-PEEL-48	5262-016L	190x0877	x40 Ph	GSC 138875
Pervosphaeridium cenomaniense	Pl 11	Fig 01	07-PEEL-43	5262-012C	120x0819	x40 Ph	GSC 138876
Pervosphaeridium cenomaniense	Pl 11	Fig 02	07-PEEL-48	5262-016L	130x0785	x40 Ph	GSC 138877
Pervosphaeridium cenomaniense	Pl 11	Fig 03	07-PEEL-48	5262-016L	150x0779	x40 Ph	GSC 138878

Pseudoceratium hirsutum	Pl 11	Fig 04	07-PEEL-40	5262-011C	118x0704	x40 Ph	GSC 138879
Pseudoceratium polymorphum	Pl 11	Fig 05	07-PEEL-45	5262-013L	166x0682	x40 Ph	GSC 138880
Pseudoceratium polymorphum	Pl 11	Fig 06	07-PEEL-29	5262-009L	110x0780	x40 Ph	GSC 138881
Pseudoceratium polymorphum	Pl 11	Fig 07	07-PEEL-29	5262-009L	110x0780	x40 Ph	GSC 138881
Pseudoceratium polymorphum	Pl 11	Fig 08	07-PEEL-40	5262-011C	130x0807	x40 Ph	GSC 138882
Pseudoceratium polymorphum	Pl 11	Fig 09	07-PEEL-46	5262-014L	122x0982	x40 Ph	GSC 138883
Pseudoceratium polymorphum	Pl 11	Fig 10	07-PEEL-46	5262-014L	132x0974	x40 Ph	GSC 138884
Pseudoceratium polymorphum	Pl 11	Fig 11	07-PEEL-48	5262-016L	178x0754	x40 Ph	GSC 138885
Pterodinium? sp.	Pl 11	Fig 12	07-PEEL-40	5262-011C	150x0965	x40 Ph	GSC 138886
Pyxidinopsis rugosus	Pl 11	Fig 13	07-PEEL-51	5262-018L	101x0958	x40 Ph	GSC 138887
Pyxidinopsis? sp	Pl 11	Fig 14	07-PEEL-51	5262-018K	052x0748	x40 Ph	GSC 138888
Sepispinula huguoniottii	Pl 11	Fig 15	07-PEEL-04	5262-004D	130x0809	x40 Ph	GSC 138889
Sepispinula huguoniottii	Pl 11	Fig 16	07-PEEL-09	5262-005D	142x0866	x40 Ph	GSC 138890
Sentusidinium myriatrichum	Pl 11	Fig 17	07-PEEL-04	5262-004C	098x1009	x40 Ph	GSC 138891
Sentusidinium myriatrichum	Pl 11	Fig 18	07-PEEL-04	5262-004C	154x0736	x40 Ph	GSC 138892
Sentusidinium myriatrichum	Pl 11	Fig 19	07-PEEL-04	5262-004D	147x0978	x40 Ph	GSC 138893
Sentusidinium myriatrichum	Pl 11	Fig 20	07-PEEL-48	5262-016L	123x0918	x40 Ph	GSC 138894
Senoniasphaera latireticulata	Pl 12	Fig 01	07-PEEL-46	5262-014L	100x0830	x40 Ph	GSC 138895
Senoniasphaera microreticulata	Pl 12	Fig 02	07-PEEL-14	5262-006C	110x0985	x40 Ph	GSC 138896
Senoniasphaera microreticulata	Pl 12	Fig 03	07-PEEL-14	5262-006C	140x0989	x40 Ph	GSC 138897
Senoniasphaera microreticulata	Pl 12	Fig 04	07-PEEL-14	5262-006C	148x0774	x40 Ph	GSC 138898
Senoniasphaera latireticulata	Pl 12	Fig 05	07-PEEL-46	5262-014K	048x0855	x40 Ph	GSC 138899
Sentusidinium rioultii	Pl 12	Fig 06	07-PEEL-09	5262-005D	130x0718	x40 Ph	GSC 138900
Sentusidinium rioultii	Pl 12	Fig 07	07-PEEL-09	5262-005C	183x0804	x40 Ph	GSC 138901
Sentusidinium paniculus	Pl 12	Fig 08	07-PEEL-43	5262-012D	200x1009	x40 Ph	GSC 138902
Spiniferites digitatus	Pl 12	Fig 09	07-PEEL-43	5262-012C	154x0999	x40 Ph	GSC 138903
Spiniferites furcatus	Pl 12	Fig 10	07-PEEL-40	5262-011C	190x0813	x40 Ph	GSC 138904
Spiniferites furcatus	Pl 12	Fig 11	07-PEEL-48	5262-016L	110x1008	x40 Ph	GSC 138905
Sentusidinium paniculus	Pl 12	Fig 12	07-PEEL-43	5262-012B	050x0796	x40 Ph	GSC 138906
Spiniferites displosus	Pl 12	Fig 13	07-PEEL-45	5262-013L	095x0943	x40 Ph	GSC 138907
Spiniferites displosus	Pl 12	Fig 14	07-PEEL-48	5262-016L	100x0950	x40 Ph	GSC 138908
Spiniferites displosus	Pl 12	Fig 15	07-PEEL-108	5262-026C	186x0934	x40 Ph	GSC 138909
Spiniferites membranaceus	Pl 12	Fig 16	07-PEEL-43	5262-012C	100x0817	x40 Ph	GSC 138910
Spiniferites tubiferus	Pl 12	Fig 17	07-PEEL-43	5262-012C	200x0798	x40 Ph	GSC 138911
Spiniferites tubiferus	Pl 12	Fig 18	07-PEEL-48	5262-016L	110x0847	x40 Ph	GSC 138912
Spiniferites tubiferus	Pl 12	Fig 19	07-PEEL-48	5262-016L	186x0925	x40 Ph	GSC 138913
Spiniferites tubiferus	Pl 12	Fig 20	07-PEEL-48	5262-016L	187x0814	x40 Ph	GSC 138914
Spiniferites ramosus	Pl 13	Fig 01	07-PEEL-48	5262-016L	122x0720	x40 Ph	GSC 138915
Spiniferites ramosus	Pl 13	Fig 02	07-PEEL-48	5262-016L	162x0957	x40 Ph	GSC 138916
Spongodinium delitiense	Pl 13	Fig 03	07-PEEL-04	5262-004C	133x0802	x40 Ph	GSC 138917
Spongodinium delitiense	Pl 13	Fig 04	07-PEEL-04	5262-004C	133x0802	x40 Ph	GSC 138917
Subtilisphaera cheit	Pl 13	Fig 05	07-PEEL-51	5262-018L	119x0962	x40 Ph	GSC 138918
Subtilisphaera cheit	Pl 13	Fig 06	07-PEEL-51	5262-018M	186x0924	x40 Ph	GSC 138919
Spongodinium delitiense	Pl 13	Fig 07	07-PEEL-04	5262-004C	185x0826	x40 Ph	GSC 138920
Spongodinium delitiense	Pl 13	Fig 08	07-PEEL-04	5262-004C	185x0826	x40 Ph	GSC 138920
Subtilisphaera senegalensis	Pl 13	Fig 09	07-PEEL-50	5262-017K	060x0982	x40 Ph	GSC 138921
Subtilisphaera perlucida	Pl 13	Fig 10	07-PEEL-14	5262-006D	147x0838	x40 Ph	GSC 138922
Subtilisphaera perlucida	Pl 13	Fig 11	07-PEEL-45	5262-013M	201x0738	x40 Ph	GSC 138923
Subtilisphaera perlucida	Pl 13	Fig 12	07-PEEL-50	5262-017M	193x0950	x40 Ph	GSC 138924
Subtilisphaera senegalensis	Pl 13	Fig 13	07-PEEL-50	5262-017K	061x0939	x40 Ph	GSC 138925
Subtilisphaera symsenegalensis	Pl 13	Fig 14	07-PEEL-48	5262-016M	190x0791	x40 Ph	GSC 138926
Subtilisphaera symsenegalensis	Pl 13	Fig 15	07-PEEL-48	5262-016M	191x0849	x40 Ph	GSC 138927
Surculosphaeridium convocatum	Pl 13	Fig 16	07-PEEL-108	5262-026C	160x0908	x40 Ph	GSC 138928
Subtilisphaera senegalensis	Pl 13	Fig 17	07-PEEL-48	5262-016M	176x0773	x40 Ph	GSC 138929
Subtilisphaera senegalensis	Pl 13	Fig 18	07-PEEL-51	5262-018L	097x0830	x40 Ph	GSC 138930
Subtilisphaera senegalensis	Pl 13	Fig 19	07-PEEL-48	5262-016K	060x0768	x40 Ph	GSC 138931
Surculosphaeridium longifurcatum	Pl 13	Fig 20	07-PEEL-43	5262-012C	138x0780	x40 Ph	GSC 138932
Trichodinium muratispinum	Pl 14	Fig 01	07-PEEL-23	5262-008L	140x0887	x40 Ph	GSC 138933
Trichodinium muratispinum	Pl 14	Fig 02	07-PEEL-23	5262-008L	140x0887	x40 Ph	GSC 138933
Trichodinium muratispinum	Pl 14	Fig 03	07-PEEL-45	5262-013L	110x0673	x40 Ph	GSC 138934
Trichodinium muratispinum	Pl 14	Fig 04	07-PEEL-45	5262-013L	110x0673	x40 Ph	GSC 138934
Trichodinium castanea	Pl 14	Fig 05	07-PEEL-43	5262-012D	141x0816	x40 Ph	GSC 138935
Trichodinium spinosum?	Pl 14	Fig 06	07-PEEL-43	5262-012D	122x0864	x40 Ph	GSC 138936
Tanyosphaeridium xanthiopyxides	Pl 14	Fig 07	07-PEEL-43	5262-012C	157x0766	x40 Ph	GSC 138937
Trithyrodinium sp	Pl 14	Fig 08	07-PEEL-48	5262-016K	062x0754	x40 Ph	GSC 138938
Baltisphaeridium? sp	Pl 14	Fig 09	07-PEEL-04	5262-004D	159x0800	x40 Ph	GSC 138939
Baltisphaeridium sp	Pl 14	Fig 10	07-PEEL-43	5262-012D	157x0903	x40 Ph	GSC 138940
Baltisphaeridium sp	Pl 14	Fig 11	07-PEEL-45	5262-013L	152x0700	x40 Ph	GSC 138941
Baltisphaeridium sp	Pl 14	Fig 12	07-PEEL-48	5262-016M	186x0854	x40 Ph	GSC 138942

Leiosphaeridia sp	Pl 14	Fig 13	07-PEEL-51	5262-018L	153x0854	x40 Ph	GSC 138943
Leiosphaeridia sp	Pl 14	Fig 14	07-PEEL-51	5262-018L	156x0828	x40 Ph	GSC 138944
Michrystridium sp	Pl 14	Fig 15	07-PEEL-51	5262-018K	061x0933	x40 Ph	GSC 138945
Solisphaeridium sp	Pl 14	Fig 16	07-PEEL-45	5262-013L	185x0777	x40 Ph	GSC 138946
Paralecaniella indentata	Pl 14	Fig 17	07-PEEL-43	5262-012D	198x0894	x40 Ph	GSC 138947
Paralecaniella indentata	Pl 14	Fig 18	07-PEEL-23	5262-008L	138x0898	x40 Ph	GSC 138948
Paralecaniella indentata	Pl 14	Fig 19	07-PEEL-50	5262-017M	191x0769	x40 Ph	GSC 138949
Paralecaniella pilosa	Pl 14	Fig 20	07-PEEL-43	5262-012D	176x0944	x40 Ph	GSC 138950
Palambages sp	Pl 15	Fig 01	07-PEEL-45	5262-013L	173x0948	x40 Ph	GSC 138951
Pterospermella sp	Pl 15	Fig 02	07-PEEL-48	5262-016L	165x0743	x40 Ph	GSC 138952
Pterospermella sp	Pl 15	Fig 03	07-PEEL-48	5262-016L	181x0839	x40 Ph	GSC 138953
Veryhachium sp	Pl 15	Fig 04	07-PEEL-45	5262-013M	170x0873	x40 Ph	GSC 138954
Veryhachium sp	Pl 15	Fig 05	07-PEEL-48	5262-016M	158x0737	x40 Ph	GSC 138955
Veryhachium sp	Pl 15	Fig 06	07-PEEL-69	5262-021B	097x0866	x40 Ph	GSC 138956
Veryhachium sp	Pl 15	Fig 07	07-PEEL-48	5262-016K	070x0898	x40 Ph	GSC 138957
Angiosperm	Pl 15	Fig 08	07-PEEL-47	5262-015B	078x0684	x40 Ph	GSC 138958
Antulsporites regius	Pl 15	Fig 09	07-PEEL-95	5262-024B	051x0995	x40 Ph	GSC 138959
Antulsporites regius	Pl 15	Fig 10	07-PEEL-95	5262-024B	066x0861	x40 Ph	GSC 138960
Antulsporites regius	Pl 15	Fig 11	07-PEEL-69	5262-021B	137x0785	x40 Ph	GSC 138961
Baculatisporites sp	Pl 15	Fig 12	07-PEEL-03	5262-003D	186x0976	x40 Ph	GSC 138962
Caliallasporites segmentatus	Pl 15	Fig 13	07-PEEL-51	5262-018K	050x0854	x40 Ph	GSC 138963
Cerebropollenites macroverrucosus	Pl 15	Fig 14	07-PEEL-83	5262-023B	101x0800	x40 Ph	GSC 138964
Concavisporites toralis	Pl 15	Fig 15	07-PEEL-75	5262-022B	051x0947	x40 Ph	GSC 138965
Cycadopites follicularis	Pl 15	Fig 16	07-PEEL-83	5262-023B	098x0946	x40 Ph	GSC 138966
Cicatricosisporites sp	Pl 15	Fig 17	07-PEEL-14	5262-006D	126x0900	x40 Ph	GSC 138967
Cicatricosisporites sp	Pl 15	Fig 18	07-PEEL-14	5262-006D	138x0674	x40 Ph	GSC 138968
Cicatricosisporites sp	Pl 15	Fig 19	07-PEEL-116	5262-027B	089x0995	x40 Ph	GSC 138969
Ischyosporites disjunctus	Pl 15	Fig 20	07-PEEL-43	5262-012D	160x0821	x40 Ph	GSC 138970
Rugubivesiculites convolutus	Pl 16	Fig 01	07-PEEL-69	5262-021B	120x0707	x40 Ph	GSC 138971
Rugubivesiculites convolutus	Pl 16	Fig 02	07-PEEL-69	5262-021B	120x0707	x40 Ph	GSC 138971
Bisaccate	Pl 16	Fig 03	07-PEEL-14	5262-006D	126x0971	x40 Ph	GSC 138972
Bisaccate	Pl 16	Fig 04	07-PEEL-45	5262-013L	150x0750	x40 Ph	GSC 138973
Bisaccate	Pl 16	Fig 05	07-PEEL-48	5262-016M	201x0940	x40 Ph	GSC 138974
Bisaccate	Pl 16	Fig 06	07-PEEL-51	5262-018L	147x0941	x40 Ph	GSC 138975
Bisaccate	Pl 16	Fig 07	07-PEEL-51	5262-018M	176x0908	x40 Ph	GSC 138976
Bisaccate	Pl 16	Fig 08	07-PEEL-51	5262-018M	188x0913	x40 Ph	GSC 138977
Dictyophyllidites harrisii	Pl 16	Fig 09	07-PEEL-102	5262-025B	078x0907	x40 Ph	GSC 138978
Distaltriangulisporites perplexus	Pl 16	Fig 10	07-PEEL-48	5262-016M	158x0870	x40 Ph	GSC 138979
Foveotriletes scrobiculatus	Pl 16	Fig 11	07-PEEL-83	5262-023B	067x0814	x40 Ph	GSC 138980
Bisaccate	Pl 16	Fig 12	07-PEEL-116	5262-027D	175x0963	x40 Ph	GSC 138981
Gleicheniidites senonicus	Pl 16	Fig 13	07-PEEL-95	5262-024B	103x0922	x40 Ph	GSC 138982
Gleicheniidites senonicus	Pl 16	Fig 14	07-PEEL-95	5262-024B	104x0724	x40 Ph	GSC 138983
Gleicheniidites senonicus	Pl 16	Fig 15	07-PEEL-95	5262-024B	113x0782	x40 Ph	GSC 138984
Gleicheniidites senonicus	Pl 16	Fig 16	07-PEEL-95	5262-024B	206x0728	x40 Ph	GSC 138985
Laevigatosporites haardtii	Pl 16	Fig 17	07-PEEL-95	5262-024B	049x0882	x40 Ph	GSC 138986
Ornamentifera echinata	Pl 16	Fig 18	07-PEEL-46	5262-014L	148x0733	x40 Ph	GSC 138987
Plicatella sp.	Pl 16	Fig 19	07-PEEL-46	5262-014L	180x0818	x40 Ph	GSC 138988
Staplinisporites caminus	Pl 16	Fig 20	07-PEEL-58	5262-019B	082x0764	x40 Ph	GSC 138989
Stereisporites antiquasporites	Pl 17	Fig 01	07-PEEL-95	5262-024B	060x0999	x40 Ph	GSC 138990
Stereisporites antiquasporites	Pl 17	Fig 02	07-PEEL-95	5262-024B	071x0852	x40 Ph	GSC 138991
Vitreisporites pallidus	Pl 17	Fig 03	07-PEEL-50	5262-017M	166x0924	x40 Ph	GSC 138992
Acinosporites	Pl 17	Fig 04	07-PEEL-39	5262-010C	166x0836	x40 Ph	GSC 138993
Ancyrospora	Pl 17	Fig 05	07-PEEL-29	5262-009M	190x0964	x40 Ph	GSC 138994
Ancyrospora	Pl 17	Fig 06	07-PEEL-43	5262-012D	160x0820	x40 Ph	GSC 138995
Ancyrospora	Pl 17	Fig 07	07-PEEL-45	5262-013L	156x0855	x40 Ph	GSC 138996
Archaeoperisaccus	Pl 17	Fig 08	07-PEEL-39	5262-010C	180x0770	x40 Ph	GSC 138997
Archaeozonotriletes	Pl 17	Fig 09	07-PEEL-03	5262-003C	190x0754	x40 Ph	GSC 138998
Dibolisporites	Pl 17	Fig 10	07-PEEL-39	5262-010C	160x1001	x40 Ph	GSC 138999
Grandispora	Pl 17	Fig 11	07-PEEL-39	5262-010C	190x0988	x40 Ph	GSC 139000
Grandispora	Pl 17	Fig 12	07-PEEL-45	5262-013L	124x0802	x40 Ph	GSC 139001
Projectispora	Pl 17	Fig 13	07-PEEL-45	5262-013M	200x0917	x40 Ph	GSC 139002
Raistrickia	Pl 17	Fig 14	07-PEEL-43	5262-012C	138x0823	x40 Ph	GSC 139003
Striatites	Pl 17	Fig 15	07-PEEL-46	5262-014L	147x0813	x40 Ph	GSC 139004
Verrucosisporites	Pl 17	Fig 16	07-PEEL-45	5262-013L	175x0797	x40 Ph	GSC 139005
Retispora	Pl 17	Fig 17	07-PEEL-03	5262-003C	158x0948	x40 Ph	GSC 139006
Retispora	Pl 17	Fig 18	07-PEEL-14	5262-006D	143x0825	x40 Ph	GSC 139007
Trilobozonotriletes	Pl 17	Fig 19	07-PEEL-43	5262-012D	171x0840	x40 Ph	GSC 139008
Trilobozonotriletes	Pl 17	Fig 20	07-PEEL-46	5262-014L	110x0805	x40 Ph	GSC 139009
Densosporites	Pl 18	Fig 01	07-PEEL-29	5262-009L	158x0842	x40 Ph	GSC 139010

Densosporites	Pl 18	Fig 02	07-PEEL-29	5262-009L	200x0808	x40 Ph	GSC 139011
Densosporites	Pl 18	Fig 03	07-PEEL-39	5262-010C	191x0861	x40 Ph	GSC 139012
Densosporites	Pl 18	Fig 04	07-PEEL-40	5262-011C	146x0821	x40 Ph	GSC 139013
Densosporites	Pl 18	Fig 05	07-PEEL-43	5262-012C	170x0820	x40 Ph	GSC 139014
Densosporites	Pl 18	Fig 06	07-PEEL-45	5262-013L	116x0765	x40 Ph	GSC 139015
Densosporites	Pl 18	Fig 07	07-PEEL-45	5262-013L	156x0819	x40 Ph	GSC 139016
Densosporites	Pl 18	Fig 08	07-PEEL-45	5262-013L	163x0822	x40 Ph	GSC 139017
Densosporites	Pl 18	Fig 09	07-PEEL-46	5262-014L	100x0840	x40 Ph	GSC 139018
Densosporites	Pl 18	Fig 10	07-PEEL-46	5262-014L	170x0968	x40 Ph	GSC 139019
Densosporites	Pl 18	Fig 11	07-PEEL-48	5262-016M	200x0930	x40 Ph	GSC 139020
Paleozoic spore	Pl 18	Fig 12	07-PEEL-45	5262-013L	171x0856	x40 Ph	GSC 139021
Paleozoic spore	Pl 18	Fig 13	07-PEEL-39	5262-010C	187x0882	x40 Ph	GSC 139022
Paleozoic spore	Pl 18	Fig 14	07-PEEL-39	5262-010C	187x0883	x40 Ph	GSC 139022
Paleozoic spore	Pl 18	Fig 15	07-PEEL-43	5262-012C	150x0776	x40 Ph	GSC 139024
Paleozoic spore	Pl 18	Fig 16	07-PEEL-45	5262-013L	120x0748	x40 Ph	GSC 139025
Paleozoic spore	Pl 18	Fig 17	07-PEEL-29	5262-009L	194x0791	x40 Ph	GSC 139026
Paleozoic spore	Pl 18	Fig 18	07-PEEL-29	5262-009L	200x0766	x40 Ph	GSC 139027
Paleozoic spore	Pl 18	Fig 19	07-PEEL-39	5262-010D	178x0853	x40 Ph	GSC 139028
Paleozoic spore	Pl 18	Fig 20	07-PEEL-43	5262-012D	189x0810	x40 Ph	GSC 139029


Map Units
Cenozoic
Mesozoic
Paleozoic
Upper Neoproterozoic
Proterozoic
Archean
Precambrian-Mesozoic
(Yukon-Tanana Terrane)
North
America
Mackenzie
Delta
Study Area
Great Bear
Lake
Norman
Wells
Mackenzie
Mountains
Mackenzie River
Great Slave
Lake
Yukon
NWT
A

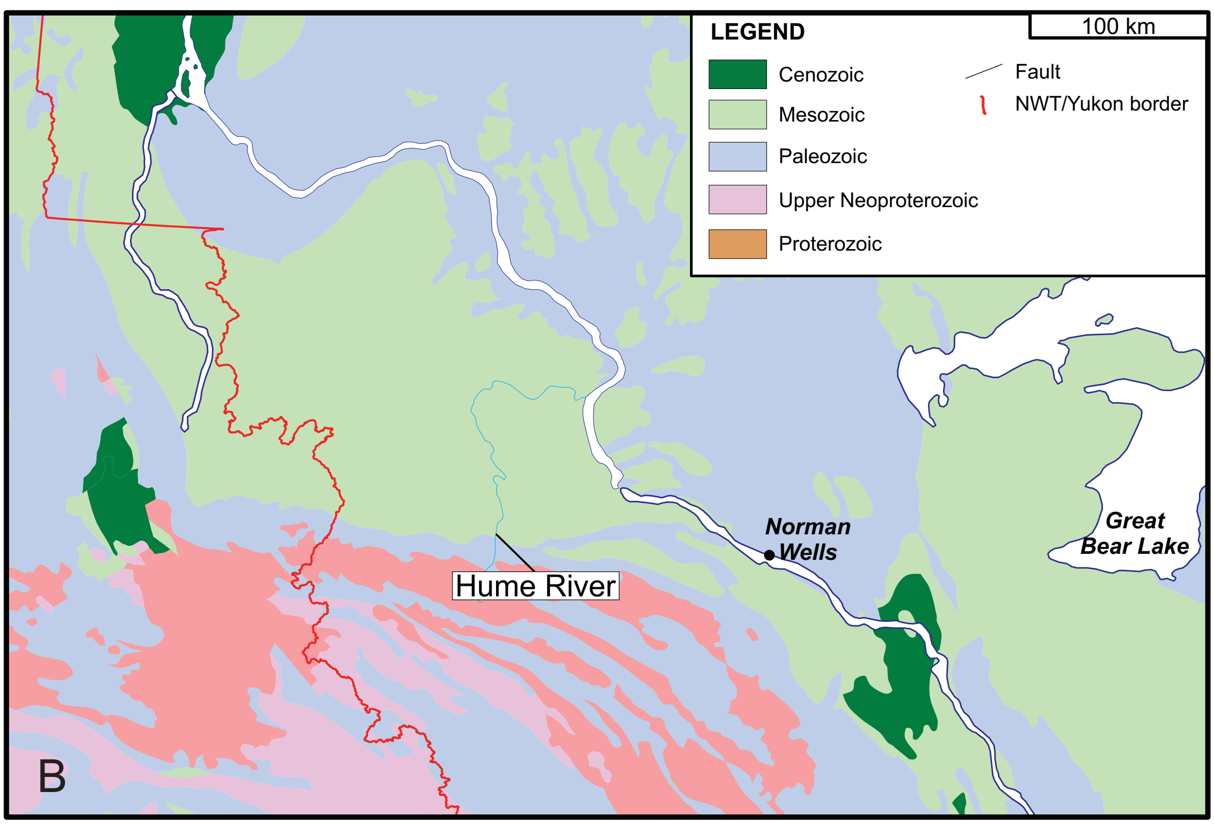
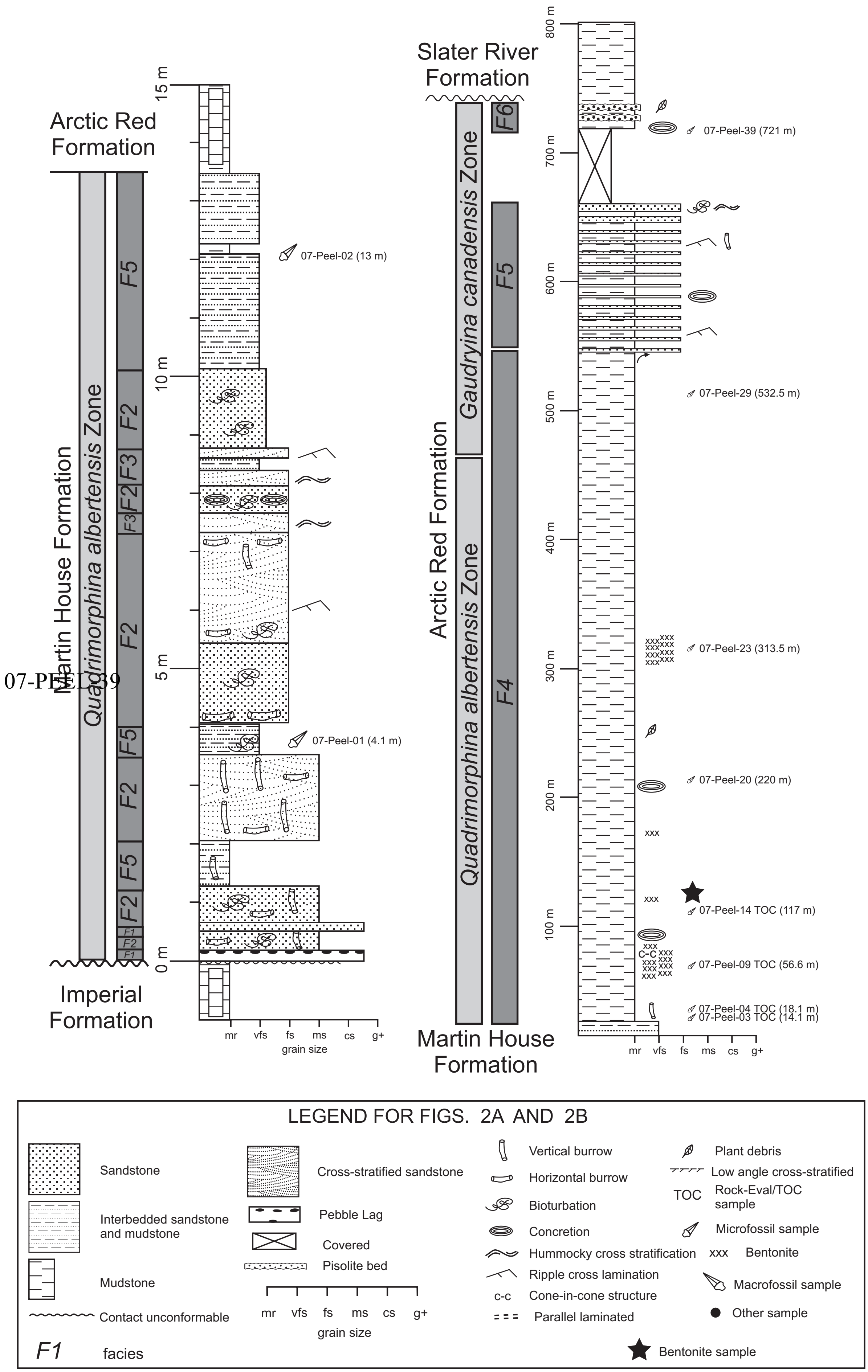

LEGEND
100 km
Cenozoic
Mesozoic
Paleozoic
Upper Neoproterozoic
Proterozoic
Fault
NWT/Yukon border
Norman
Wells
Great
Bear Lake
Hume River
B

Figure 1



Arctic Red Formation
Martin House Formation
Quadrimorphina albertensis Zone
F5
F2
F3
F2
F3
F2
F5
F2
F5
F2
F1
F2
F1
Imperial Formation
15 m
10 m
5 m
0 m
07-Peel-02 (13 m)
07-Peel-01 (4.1 m)
07-PEEL39
mr vfs fs ms cs g+
grain size
Slater River Formation
Arctic Red Formation
Gaudryina canadensis Zone
Quadrimorphina albertensis Zone
F6
F5
F4
Martin House Formation
800 m
700 m
600 m
500 m
400 m
300 m
200 m
100 m
07-Peel-39 (721 m)
07-Peel-29 (532.5 m)
07-Peel-23 (313.5 m)
07-Peel-20 (220 m)
07-Peel-14 TOC (117 m)
07-Peel-09 TOC (56.6 m)
07-Peel-04 TOC (18.1 m)
07-Peel-03 TOC (14.1 m)
xxx
c-c
mr vfs fs ms cs g+
LEGEND FOR FIGS. 2A AND 2B
Sandstone
Interbedded sandstone and mudstone
Mudstone
Contact unconformable
F1 facies
Cross-stratified sandstone
Pebble Lag
Covered
Pisolite bed
mr vfs fs ms cs g+
grain size
Vertical burrow
Horizontal burrow
Bioturbation
Concretion
Hummocky cross stratification
Ripple cross lamination
c-c Cone-in-cone structure
Parallel laminated
Plant debris
Low angle cross-stratified
TOC Rock-Eval/TOC sample
Microfossil sample
xxx Bentonite
Macrofossil sample
Other sample
Bentonite sample

Figure 2A

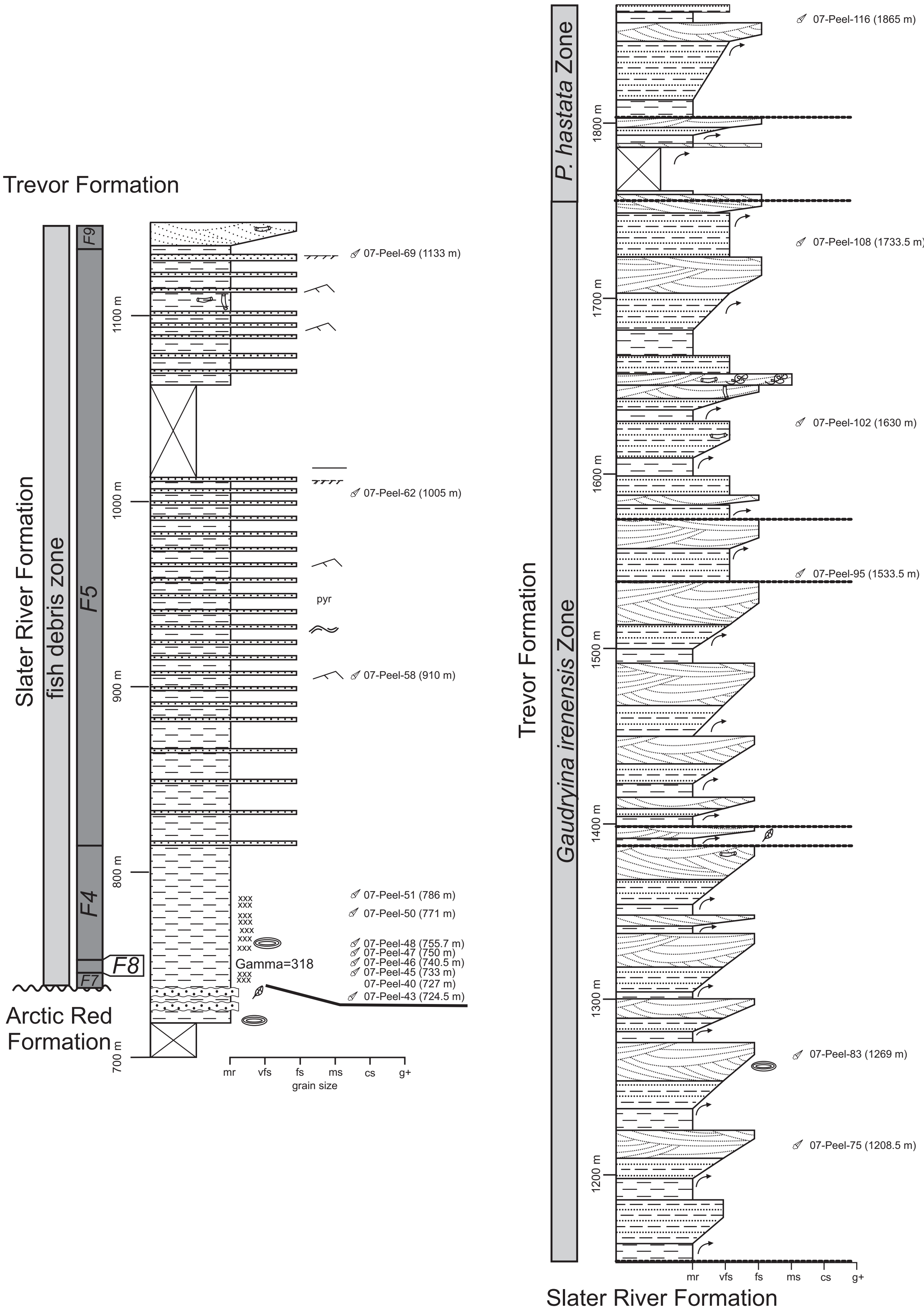

Trevor Formation
Slater River Formation
fish debris zone
F9
F5
F4
F8
F7
Arctic Red Formation
1100 m
1000 m
900 m
800 m
700 m
07-Peel-69 (1133 m)
07-Peel-62 (1005 m)
pyr
07-Peel-58 (910 m)
07-Peel-51 (786 m)
07-Peel-50 (771 m)
07-Peel-48 (755.7 m)
07-Peel-47 (750 m)
07-Peel-46 (740.5 m)
07-Peel-45 (733 m)
07-Peel-40 (727 m)
07-Peel-43 (724.5 m)
Gamma=318
mr vfs fs ms cs g+
grain size
P. hastata Zone
Gaudryina irenensis Zone
Trevor Formation
1800 m
1700 m
1600 m
1500 m
1400 m
1300 m
1200 m
07-Peel-116 (1865 m)
07-Peel-108 (1733.5 m)
07-Peel-102 (1630 m)
07-Peel-95 (1533.5 m)
07-Peel-83 (1269 m)
07-Peel-75 (1208.5 m)
mr vfs fs ms cs g+
Slater River Formation

Figure 2B

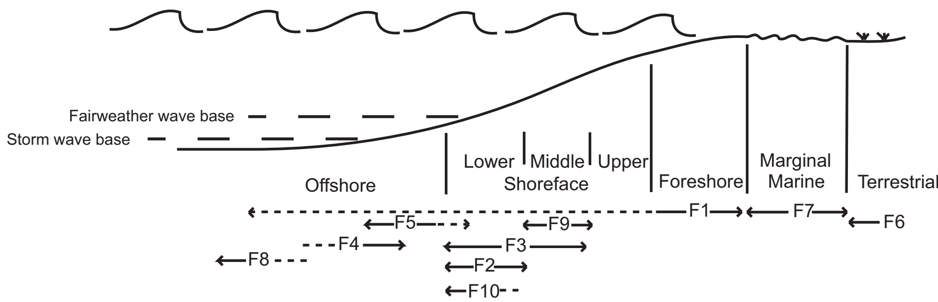
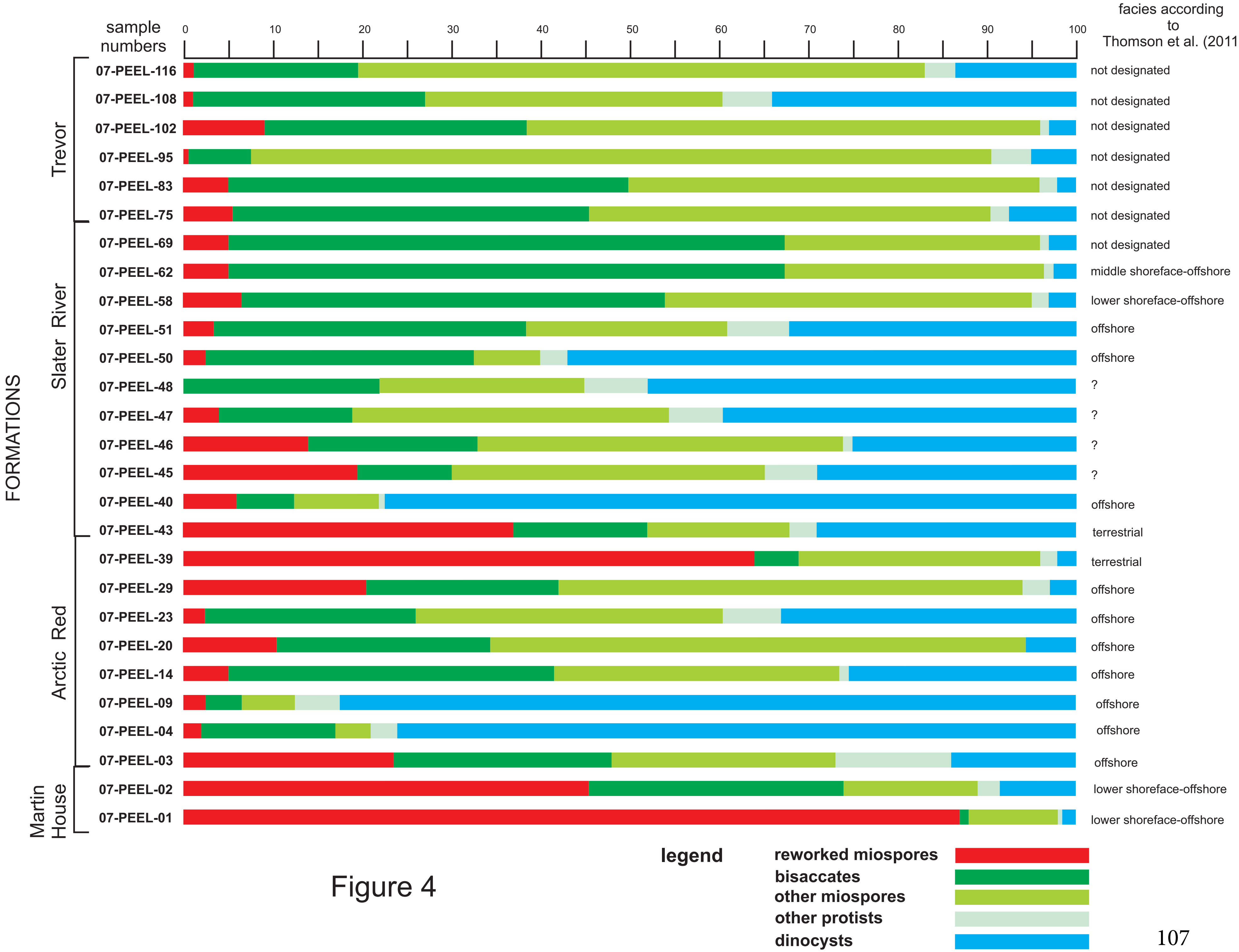

Fairweather wave base
Storm wave base
Lower
Middle
Upper
Offshore
Shoreface
Foreshore
Marginal Marine
Terrestrial
F1
F7
F6
F5
F9
F4
F3
F8
F2
F10

Figure 3



sample numbers
0
10
20
30
40
50
60
70
80
90
100
facies according to Thomson et al. (2011)
FORMATIONS
Trevor
Slater River
Arctic Red
Martin House
07-PEEL-116
07-PEEL-108
07-PEEL-102
07-PEEL-95
07-PEEL-83
07-PEEL-75
07-PEEL-69
07-PEEL-62
07-PEEL-58
07-PEEL-51
07-PEEL-50
07-PEEL-48
07-PEEL-47
07-PEEL-46
07-PEEL-45
07-PEEL-40
07-PEEL-43
07-PEEL-39
07-PEEL-29
07-PEEL-23
07-PEEL-20
07-PEEL-14
07-PEEL-09
07-PEEL-04
07-PEEL-03
07-PEEL-02
07-PEEL-01
not designated
not designated
not designated
not designated
not designated
not designated
not designated
middle shoreface-offshore
lower shoreface-offshore
offshore
offshore
?
?
?
?
offshore
terrestrial
terrestrial
offshore
offshore
offshore
offshore
offshore
offshore
offshore
lower shoreface-offshore
lower shoreface-offshore
legend
reworked miospores
bisaccates
other miospores
other protists
dinocysts

Figure 4

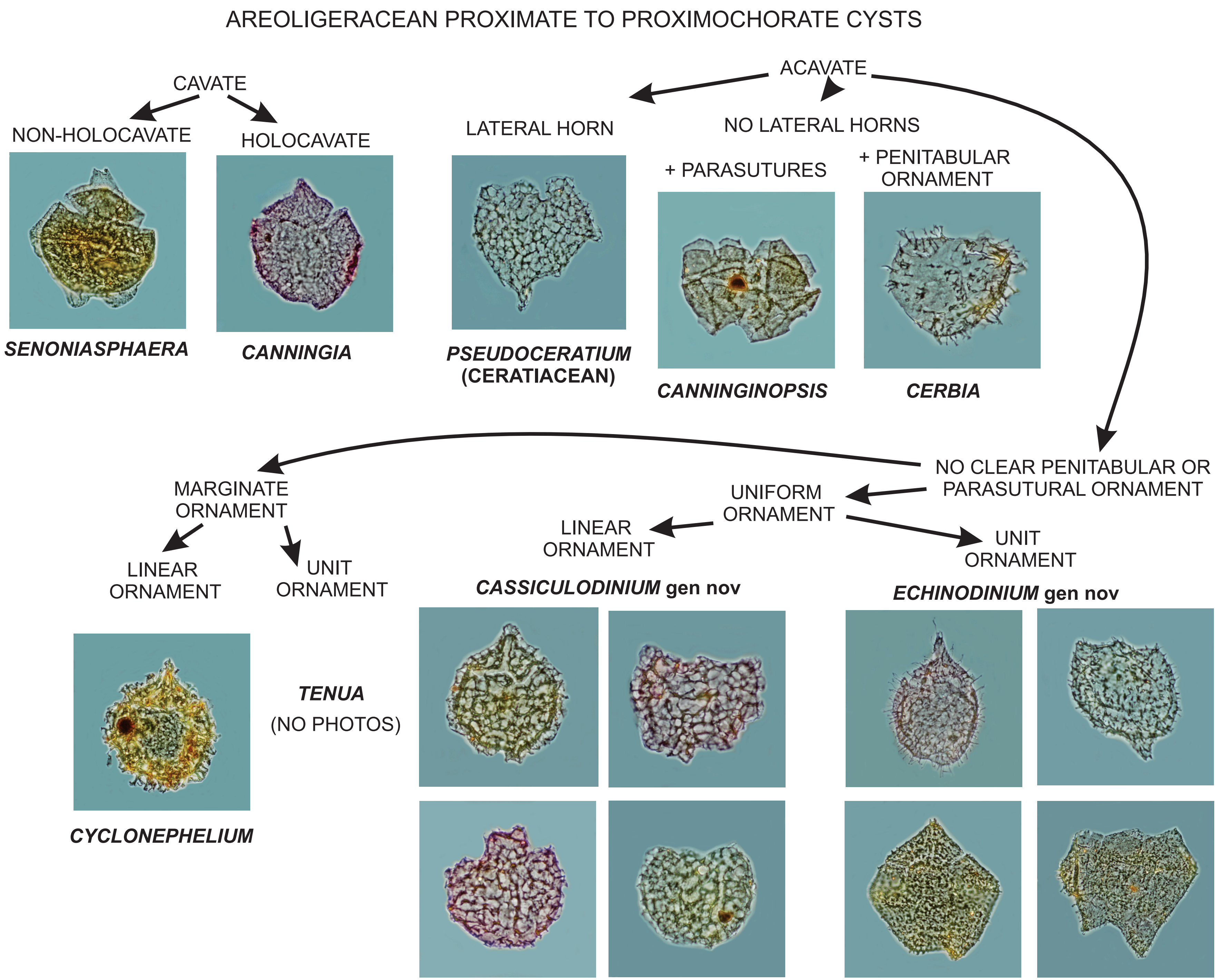
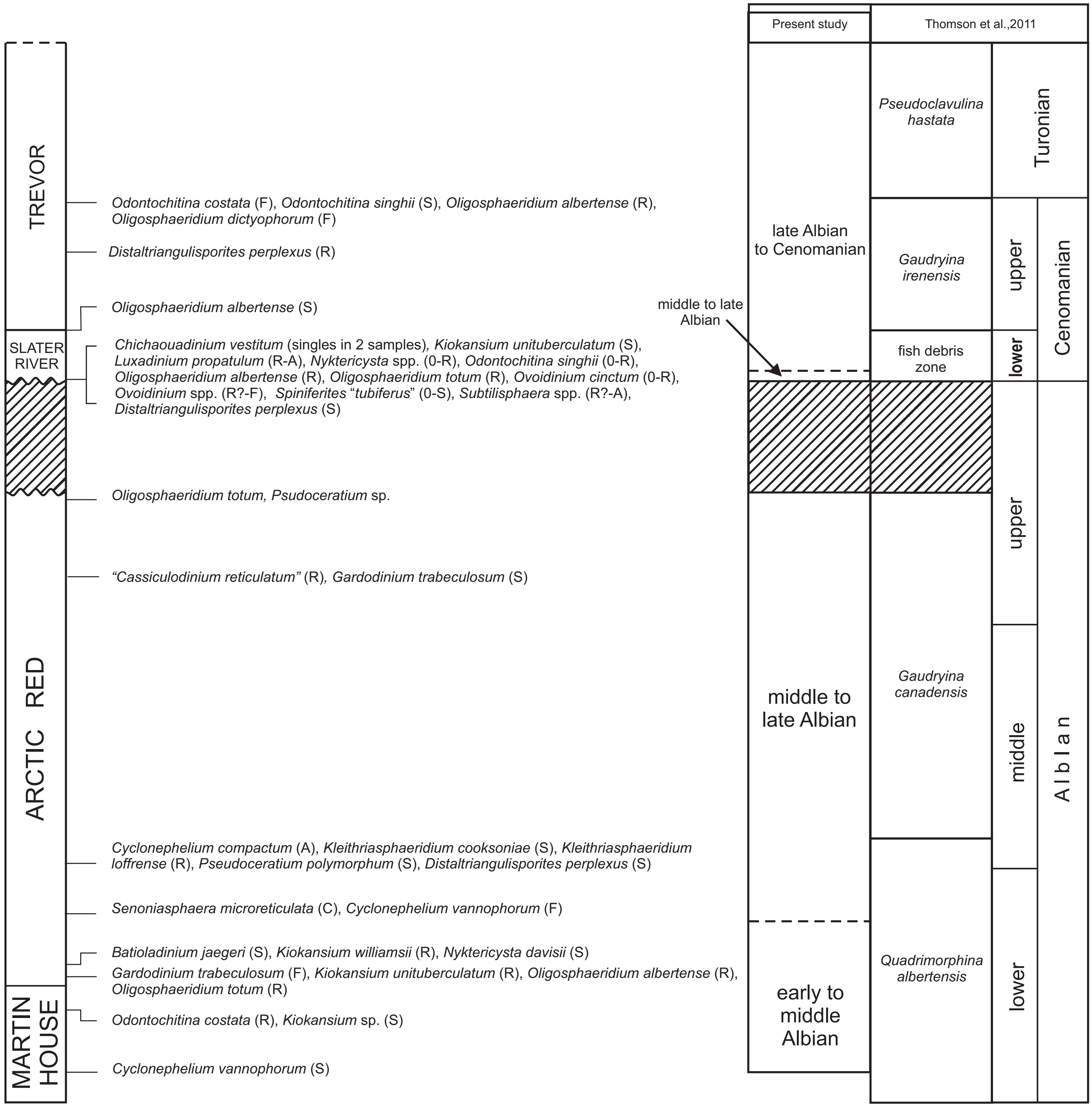

AREOLIGERACEAN PROXIMATE TO PROXIMOCHORATE CYSTS
CAVATE
NON-HOLOCAVATE
HOLOCAVATE
SENONIASPHAERA
CANNINGIA
ACAVATE
LATERAL HORN
NO LATERAL HORNS
+ PARASUTURES
+ PENITABULAR ORNAMENT
PSEUDOCERATIUM (CERATIACEAN)
CANNINGINOPSIS
CERBIA
NO CLEAR PENITABULAR OR PARASUTURAL ORNAMENT
MARGINATE ORNAMENT
UNIFORM ORNAMENT
LINEAR ORNAMENT
UNIT ORNAMENT
LINEAR ORNAMENT
UNIT ORNAMENT
CASSICULODINIUM gen nov
ECHINODINIUM gen nov
TENUA
(NO PHOTOS)
CYCLONEPHELIUM

Figure 5



TREVOR
SLATER RIVER
ARCTIC RED
MARTIN HOUSE
Odontochitina costata (F), Odontochitina singhii (S), Oligosphaeridium albertense (R), Oligosphaeridium dictyophorum (F)
Distaltriangulisporites perplexus (R)
Oligosphaeridium albertense (S)
Chichaouadinium vestitum (singles in 2 samples), Kiokansium unituberculatum (S), Luxadinium propatulum (R-A), Nyktericysta spp. (0-R), Odontochitina singhii (0-R), Oligosphaeridium albertense (R), Oligosphaeridium totum (R), Ovoidinium cinctum (0-R), Ovoidinium spp. (R?-F), Spiniferites "tubiferus" (0-S), Subtilisphaera spp. (R?-A), Distaltriangulisporites perplexus (S)
Oligosphaeridium totum, Psudoceratium sp.
"Cassiculodinium reticulatum" (R), Gardodinium trabeculosum (S)
Cyclonephelium compactum (A), Kleithriasphaeridium cooksoniae (S), Kleithriasphaeridium loffrense (R), Pseudoceratium polymorphum (S), Distaltriangulisporites perplexus (S)
Senoniasphaera microreticulata (C), Cyclonephelium vannophorum (F)
Batioladinium jaegeri (S), Kiokansium williamsii (R), Nyktericysta davisii (S)
Gardodinium trabeculosum (F), Kiokansium unituberculatum (R), Oligosphaeridium albertense (R), Oligosphaeridium totum (R)
Odontochitina costata (R), Kiokansium sp. (S)
Cyclonephelium vannophorum (S)
Present study
Thomson et al.,2011
late Albian to Cenomanian
middle to late Albian
middle to late Albian
early to middle Albian
Pseudoclavulina hastata
Gaudryina irenensis
fish debris zone
Gaudryina canadensis
Quadrimorphina albertensis
Turonian
upper
lower
Cenomanian
upper
middle
lower
A l b i a n

Figure 6

Formation	Unit	Sample depth (m)	*Luxadinium propatulum*	*Ovoidinium verrucosum*	*Odontochitina* spp.	*Aptea* sp.	*Aptea eisenackii*	*Cyclonephelium vannophorum*
SHAFTESBURY FORMATION		19.1	1	17	17		34	8
		18.1	8	30	17		5	85
		17.1		65	23			39
		16.1	8	34	30		17	
		15.1	4	35	41		7	
		14.6	1	30	47		6	
	FISH SCALE MARKER BED	14.1	1	23	13		10	
		13.6		34	1		4	
		13.4		6	6		10	
		13.1			5	1	6	
		12.95	28	28	4	41	8	
		12.8	15	25	1	17	1	
		12.65	65	28	38		24	
		12.5	58	23	26		15	
		12.0	44	15	12		7	
		11.0	52	22	12		8	
		10.0	54	24	24		13	
		9.0	53	26	14		10	
		8.0	59	28	17		2	
		7.0	47	21	11		2	
		6.0	41	17	24		2	
		5.0	43	18	23			
		3.0	39	20	18	1	3	
		0.0	27	6	10	3	1	

Figure 7

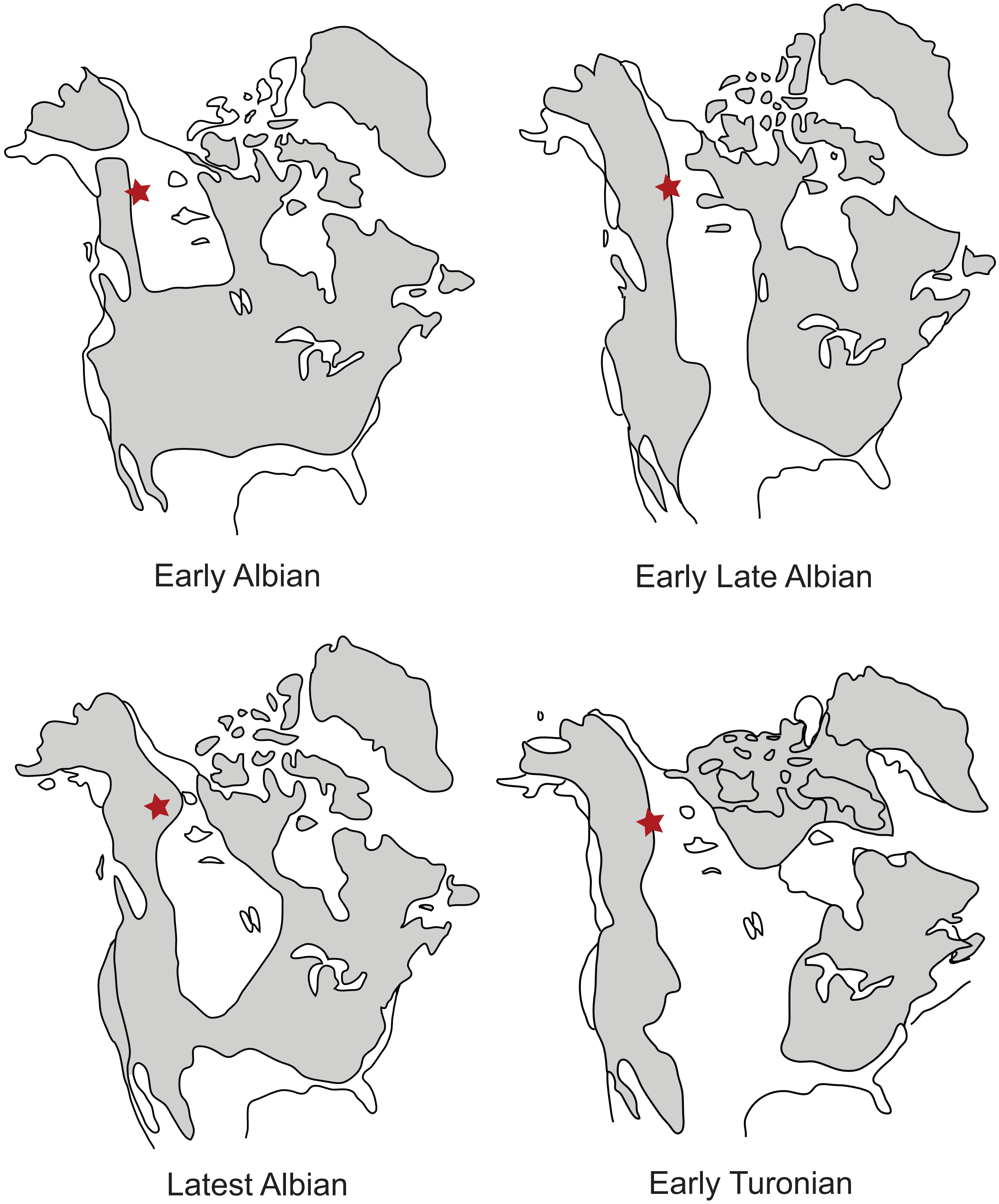

Early Albian
Early Late Albian
Latest Albian
Early Turonian

Figure 8

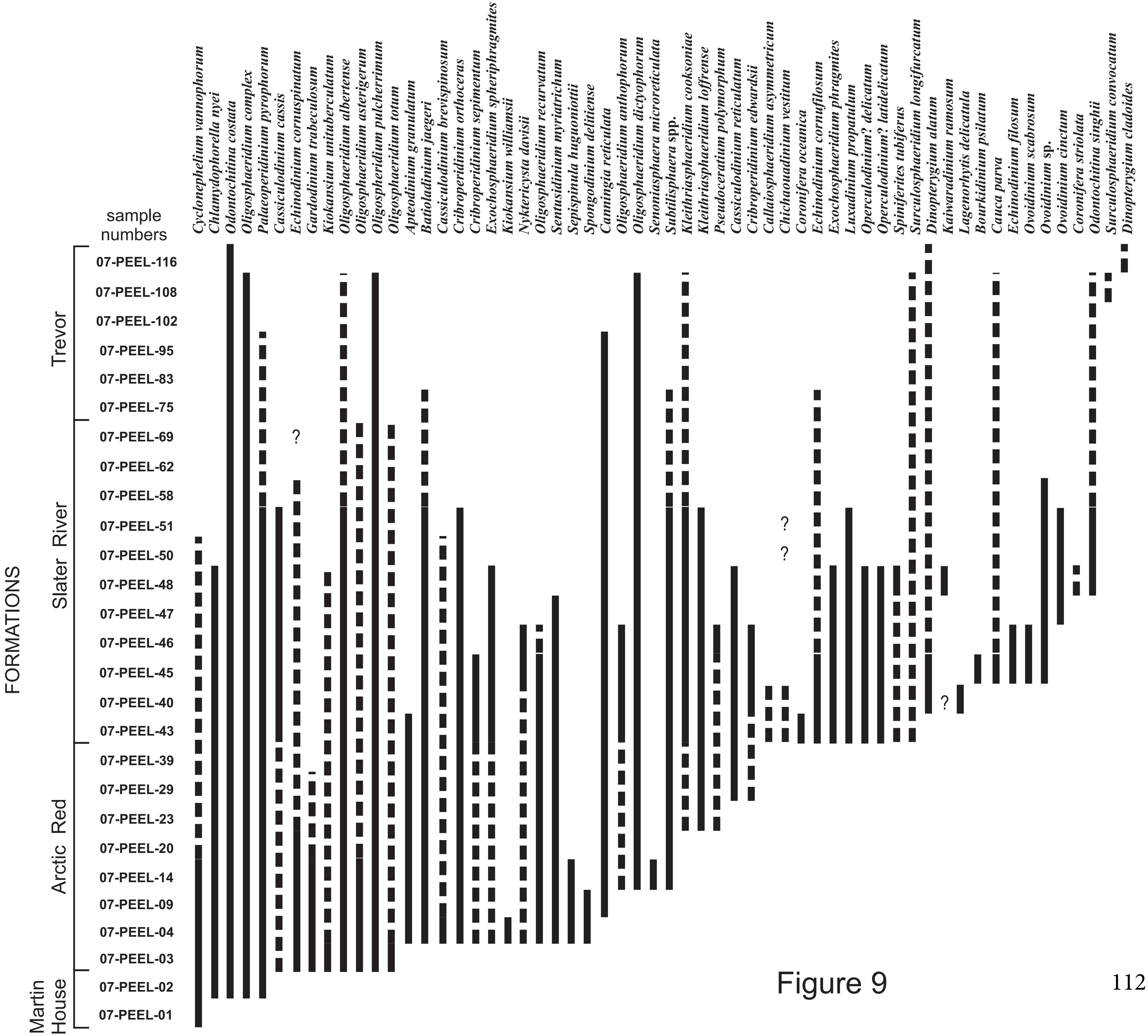

sample numbers
FORMATIONS
Trevor
Slater River
Arctic Red
Martin House
07-PEEL-116
07-PEEL-108
07-PEEL-102
07-PEEL-95
07-PEEL-83
07-PEEL-75
07-PEEL-69
07-PEEL-62
07-PEEL-58
07-PEEL-51
07-PEEL-50
07-PEEL-48
07-PEEL-47
07-PEEL-46
07-PEEL-45
07-PEEL-40
07-PEEL-43
07-PEEL-39
07-PEEL-29
07-PEEL-23
07-PEEL-20
07-PEEL-14
07-PEEL-09
07-PEEL-04
07-PEEL-03
07-PEEL-02
07-PEEL-01
Cyclonephelium vannophorum
Chlamydophorella nyei
Odontochitina costata
Oligosphaeridium complex
Palaeoperidinium pyrophorum
Cassiculodinium cassis
Echinodinium cornuspinatum
Gardodinium trabeculosum
Kiokansium unituberculatum
Oligosphaeridium albertense
Oligosphaeridium asterigerum
Oligosphaeridium pulcherrimum
Oligosphaeridium totum
Apteodinium granulatum
Batioladinium jaegeri
Cassiculodinium brevispinosum
Cribroperidinium orthoceras
Cribroperidinium sepimentum
Exochosphaeridium spheriphragmites
Kiokansium williansii
Nyktericysta davisii
Oligosphaeridium recurvatum
Sentusidinium myriatrichum
Sepispinula huguoniotii
Spongodinium delitiense
Canningia reticulata
Oligosphaeridium anthophorum
Oligosphaeridium dictyophorum
Senoniasphaera microreticulata
Subtilisphaera spp.
Kleithriasphaeridium cooksoniae
Kleithriasphaeridium loffrense
Pseudoceratium polymorphum
Cassiculodinium reticulatum
Cribroperidinium edwardsii
Callaiosphaeridium asymmetricum
Chichaouadinium vestitum
Coronifera oceanica
Echinodinium cornufilosum
Exochosphaeridium phragmites
Luxadinium propatulum
Operculodinium? delicatum
Operculodinium? latidelicatum
Spiniferites tubiferus
Surculosphaeridium longifurcatum
Dinopterygium alatum
Kaiwaradinium ramosum
Lagenorhytis delicatula
Bourkidinium psilatum
Cauca parva
Echinodinium filosum
Ovoidinium scabrosum
Ovoidinium sp.
Ovoidinium cinctum
Coronifera striolata
Odontochitina singhii
Surculosphaeridium convocatum
Dinopterygium cladoides
?

Figure 9

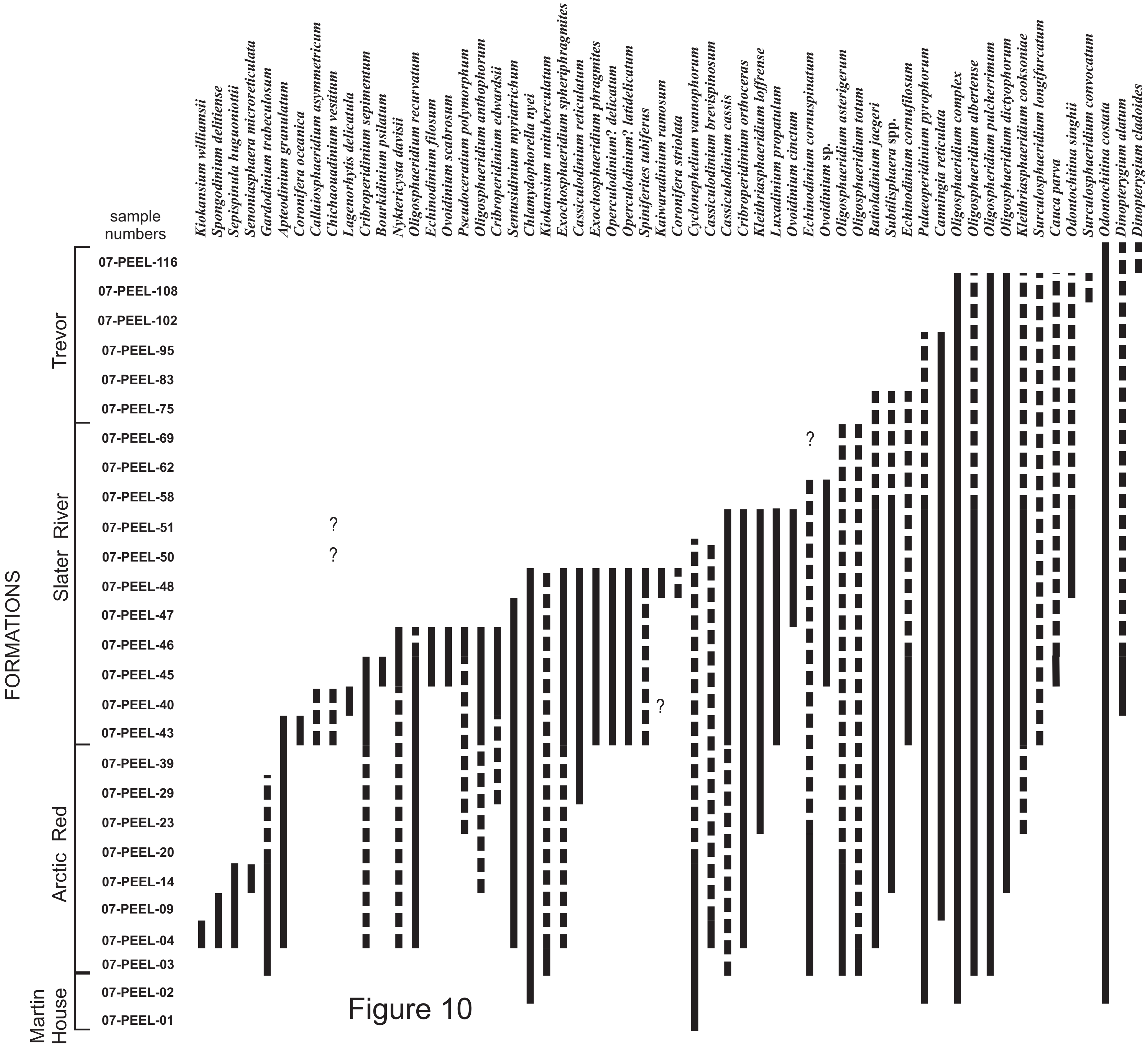
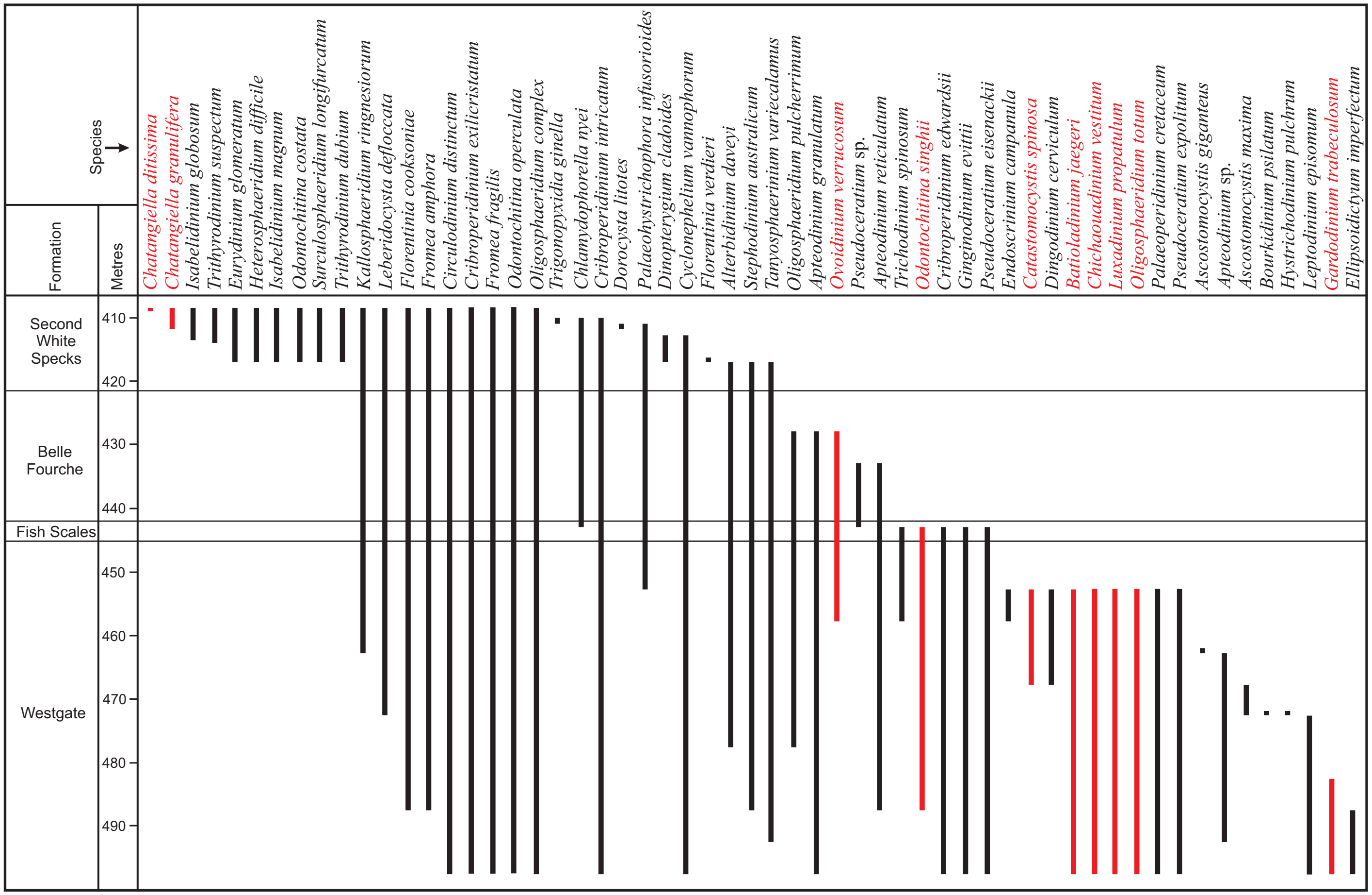

sample numbers
Kiokansium williamsii
Spongodinium delitiense
Sepispinula huguoniotii
Senoniasphaera microreticulata
Gardodinium trabeculosum
Apteodinium granulatum
Coronifera oceanica
Callaiosphaeridium asymmetricum
Chichaouadinium vestitum
Lagenorhytis delicatula
Cribroperidinium sepimentum
Bourkidinium psilatum
Nyktericysta davisii
Oligosphaeridium recurvatum
Echinodinium filosum
Ovoidinium scabrosum
Pseudoceratium polymorphum
Oligosphaeridium anthophorum
Cribroperidinium edwardsii
Sentusidinium myriatrichum
Chlamydophorella nyei
Kiokansium unituberculatum
Exochosphaeridium spheriphragmites
Cassiculodinium reticulatum
Exochosphaeridium phragmites
Operculodinium? delicatum
Operculodinium? latidelicatum
Spiniferites tubiferus
Kaiwaradinium ramosum
Coronifera striolata
Cyclonephelium vannophorum
Cassiculodinium brevispinosum
Cassiculodinium cassis
Cribroperidinium orthoceras
Kleithriasphaeridium loffrense
Luxadinium propatulum
Ovoidinium cinctum
Echinodinium cornuspinatum
Ovoidinium sp.
Oligosphaeridium asterigerum
Oligosphaeridium totum
Batioladinium jaegeri
Subtilisphaera spp.
Echinodinium cornufilosum
Palaeoperidinium pyrophorum
Canningia reticulata
Oligosphaeridium complex
Oligosphaeridium albertense
Oligosphaeridium pulcherrimum
Oligosphaeridium dictyophorum
Kleithriasphaeridium cooksoniae
Surculosphaeridium longifurcatum
Cauca parva
Odontochitina singhii
Surculosphaeridium convocatum
Odontochitina costata
Dinopterygium alatum
Dinopterygium cladoides
FORMATIONS
Trevor
Slater River
Arctic Red
Martin House
07-PEEL-116
07-PEEL-108
07-PEEL-102
07-PEEL-95
07-PEEL-83
07-PEEL-75
07-PEEL-69
07-PEEL-62
07-PEEL-58
07-PEEL-51
07-PEEL-50
07-PEEL-48
07-PEEL-47
07-PEEL-46
07-PEEL-45
07-PEEL-40
07-PEEL-43
07-PEEL-39
07-PEEL-29
07-PEEL-23
07-PEEL-20
07-PEEL-14
07-PEEL-09
07-PEEL-04
07-PEEL-03
07-PEEL-02
07-PEEL-01
?

Figure 10



Species
Formation
Metres
Second White Specks
Belle Fourche
Fish Scales
Westgate
410
420
430
440
450
460
470
480
490
Chatangiella ditissima
Chatangiella granulifera
Isabelidinium globosum
Trithyrodinium suspectum
Eurydinium glomeratum
Heterosphaeridium difficile
Isabelidinium magnum
Odontochitina costata
Surculosphaeridium longifurcatum
Trithyrodinium dubium
Kallosphaeridium ringnesiorum
Leberidocysta defloccata
Florentinia cooksoniae
Fromea amphora
Circulodinium distinctum
Cribroperidinium exilicristatum
Fromea fragilis
Odontochitina operculata
Oligosphaeridium complex
Trigonopyxidia ginella
Chlamydophorella nyei
Cribroperidinium intricatum
Dorocysta litotes
Palaeohystrichophora infusorioides
Dinopterygium cladoides
Cyclonephelium vannophorum
Florentinia verdieri
Alterbidinium daveyi
Stephodinium australicum
Tanyosphaerinium variecalamus
Oligosphaeridium pulcherrimum
Apteodinium granulatum
Ovoidinium verrucosum
Pseudoceratium sp.
Apteodinium reticulatum
Trichodinium spinosum
Odontochitina singhii
Cribroperidinium edwardsii
Ginginodinium evittii
Pseudoceratium eisenackii
Endoscrinium campanula
Catastomocystis spinosa
Dingodinium cerviculum
Batioladinium jaegeri
Chichaouadinium vestitum
Luxadinium propatulum
Oligosphaeridium totum
Palaeoperidinium cretaceum
Pseudoceratium expolitum
Ascostomocystis giganteus
Apteodinium sp.
Ascostomocystis maxima
Bourkidinium psilatum
Hystrichodinium pulchrum
Leptodinium episomum
Gardodinium trabeculosum
Ellipsoidictyum imperfectum

Figure 11

Plate 1

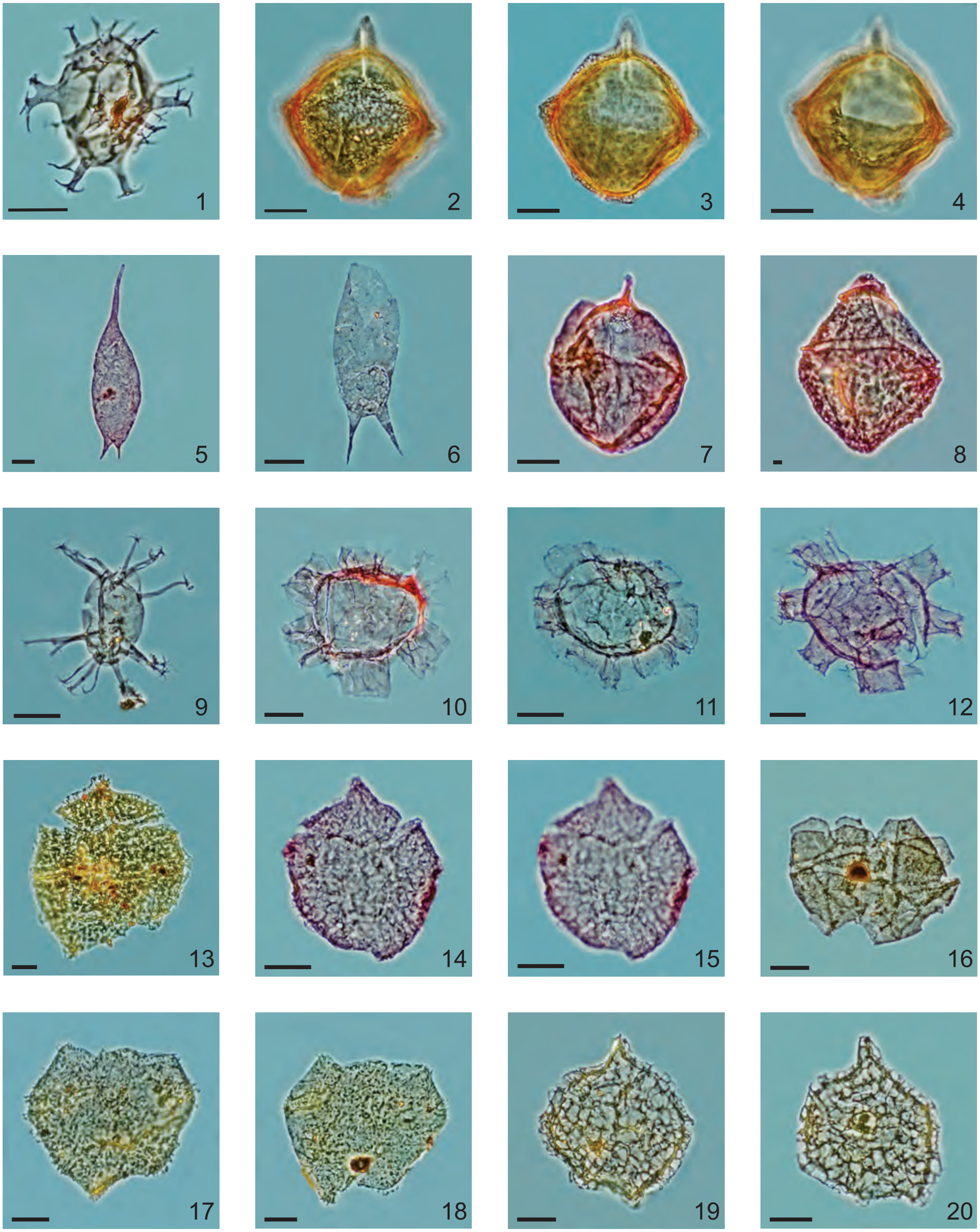


Plate 2

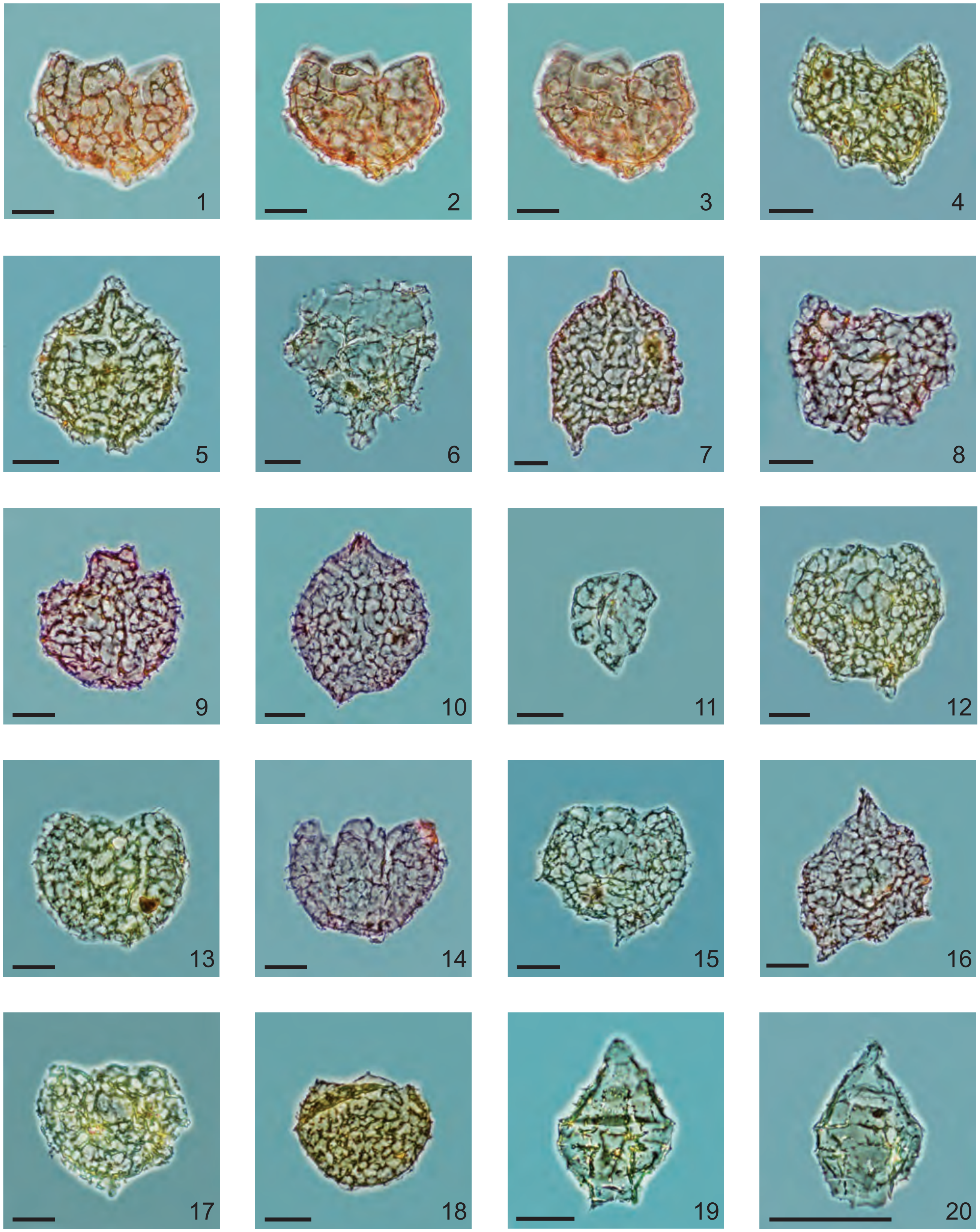


Plate 3

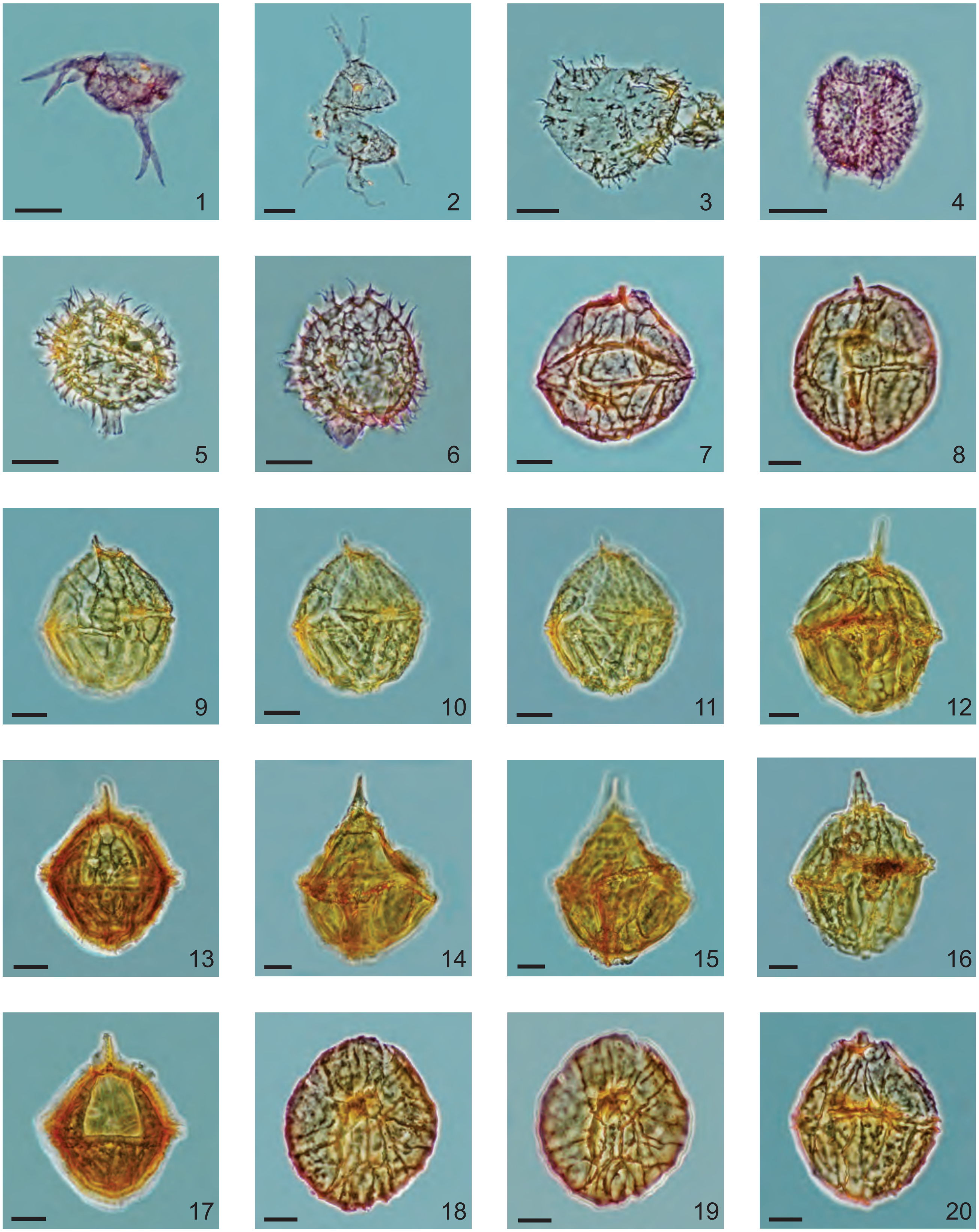


Plate 4

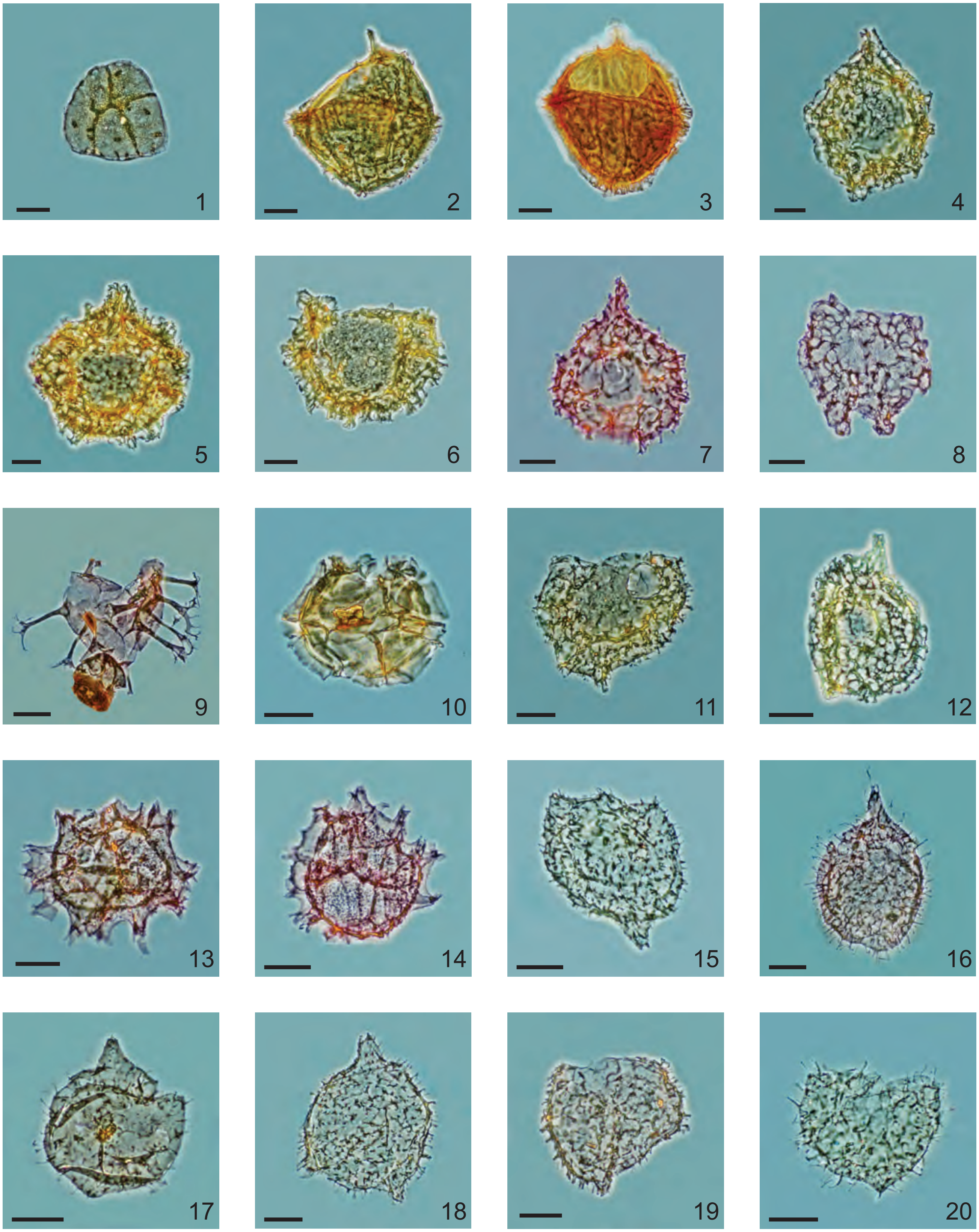


Plate 5

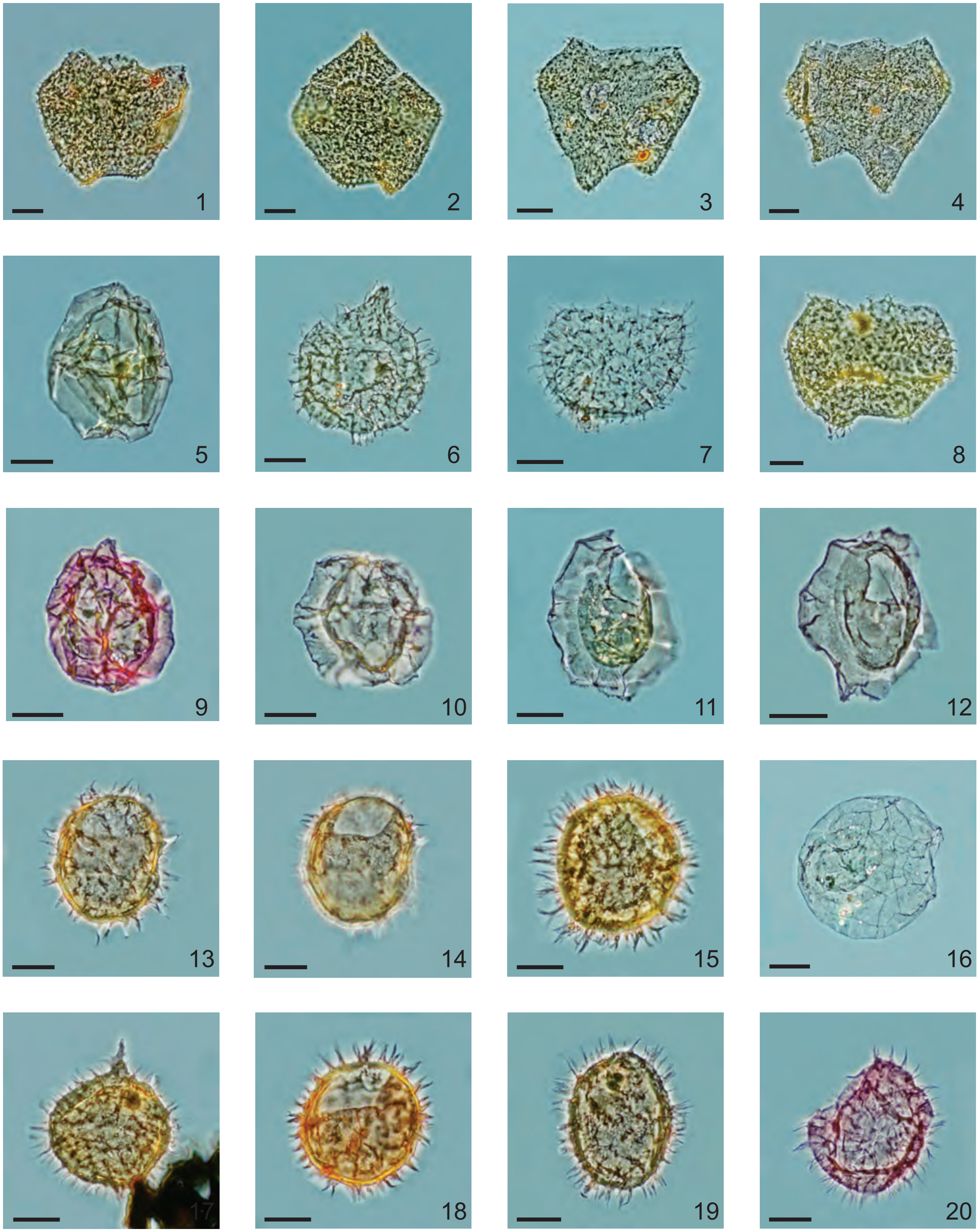


Plate 6

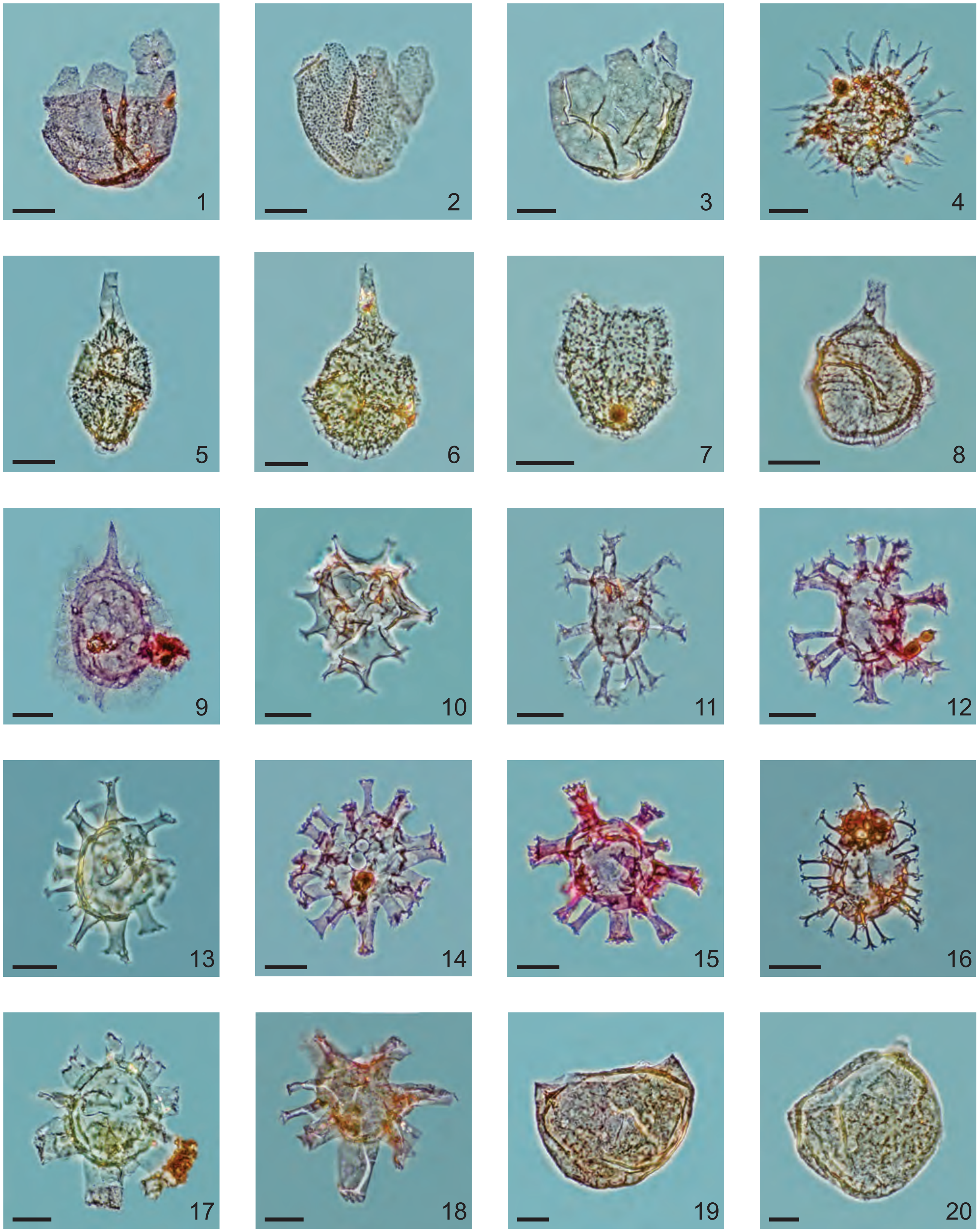


Plate 7

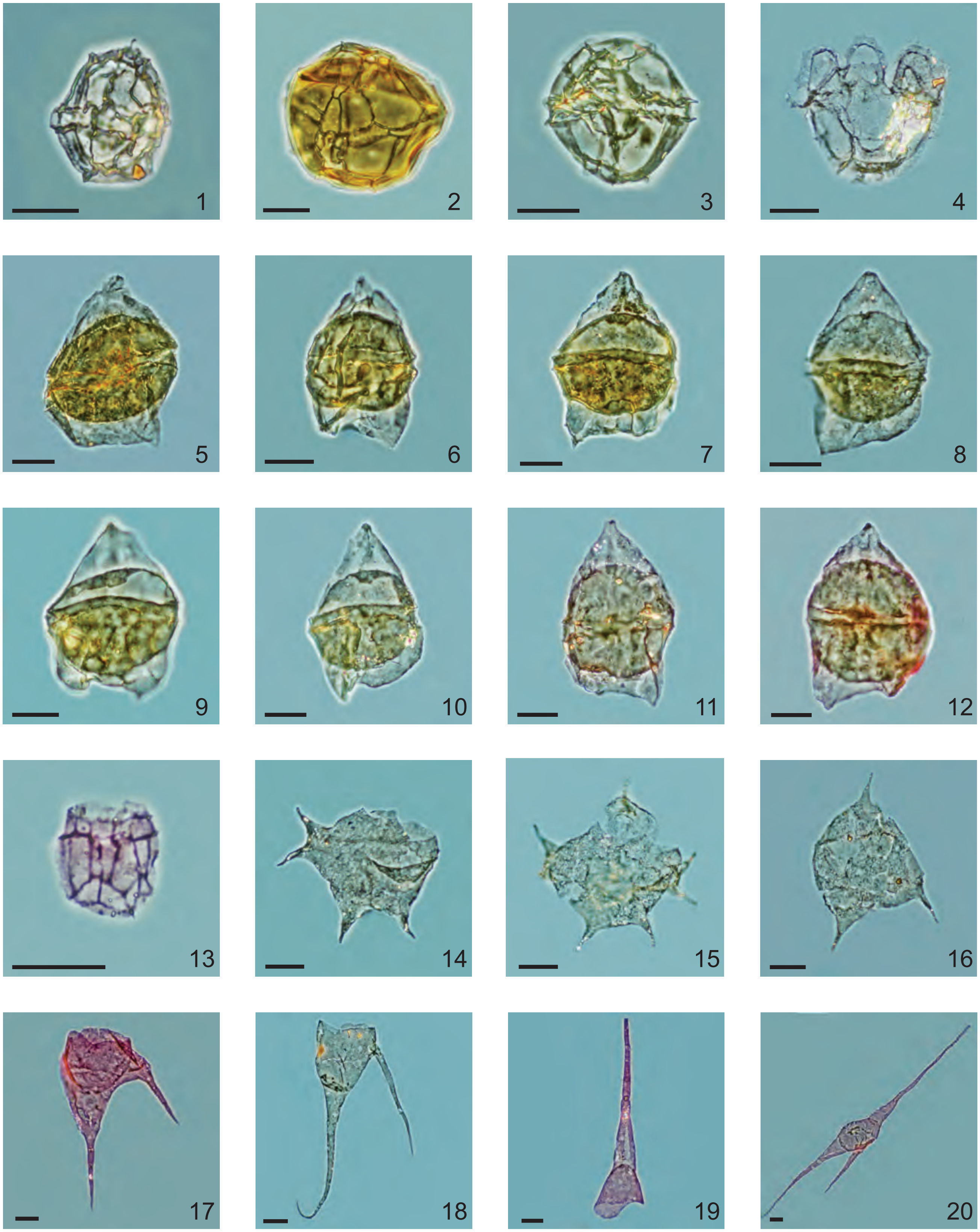


Plate 8

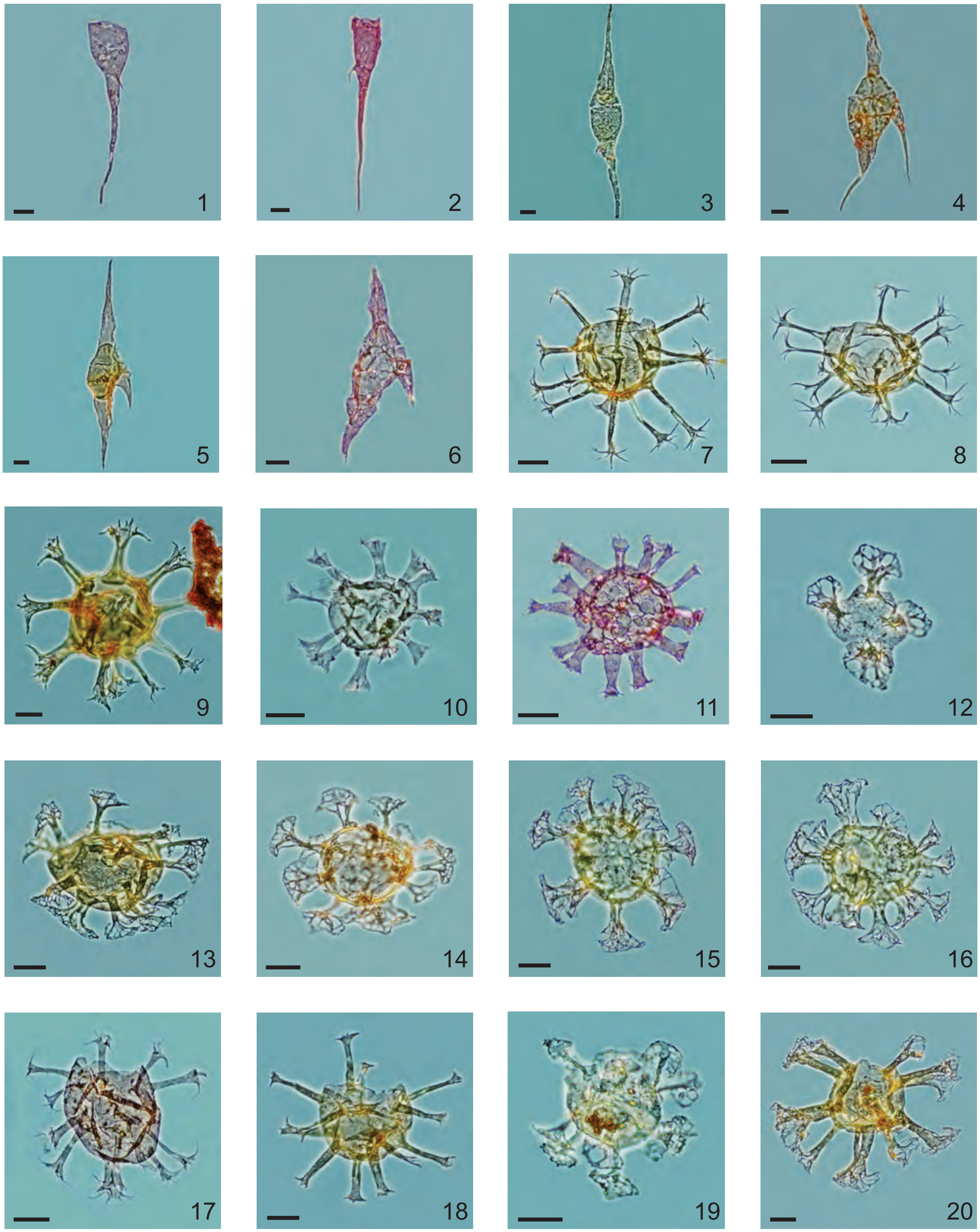


Plate 9

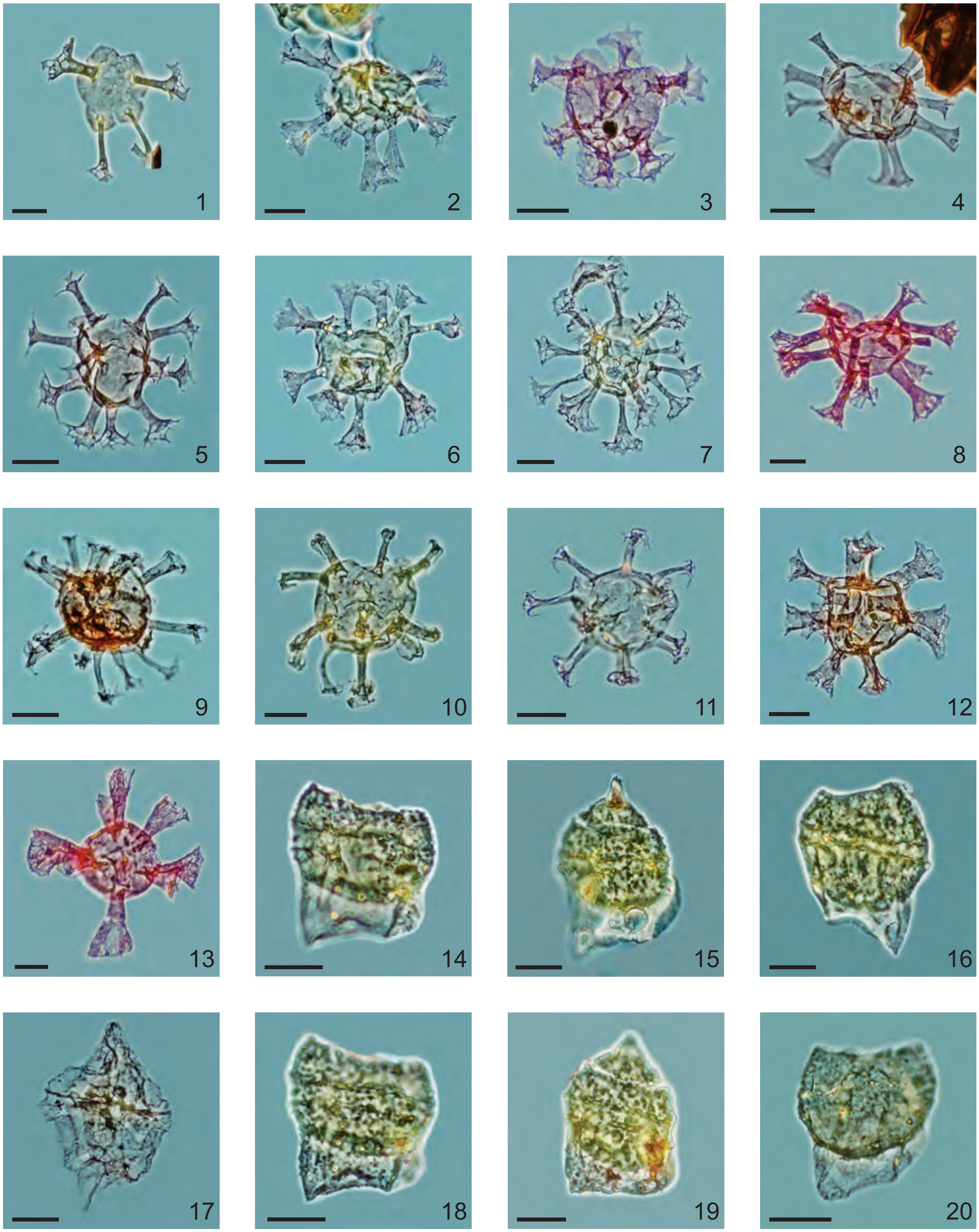


Plate 10

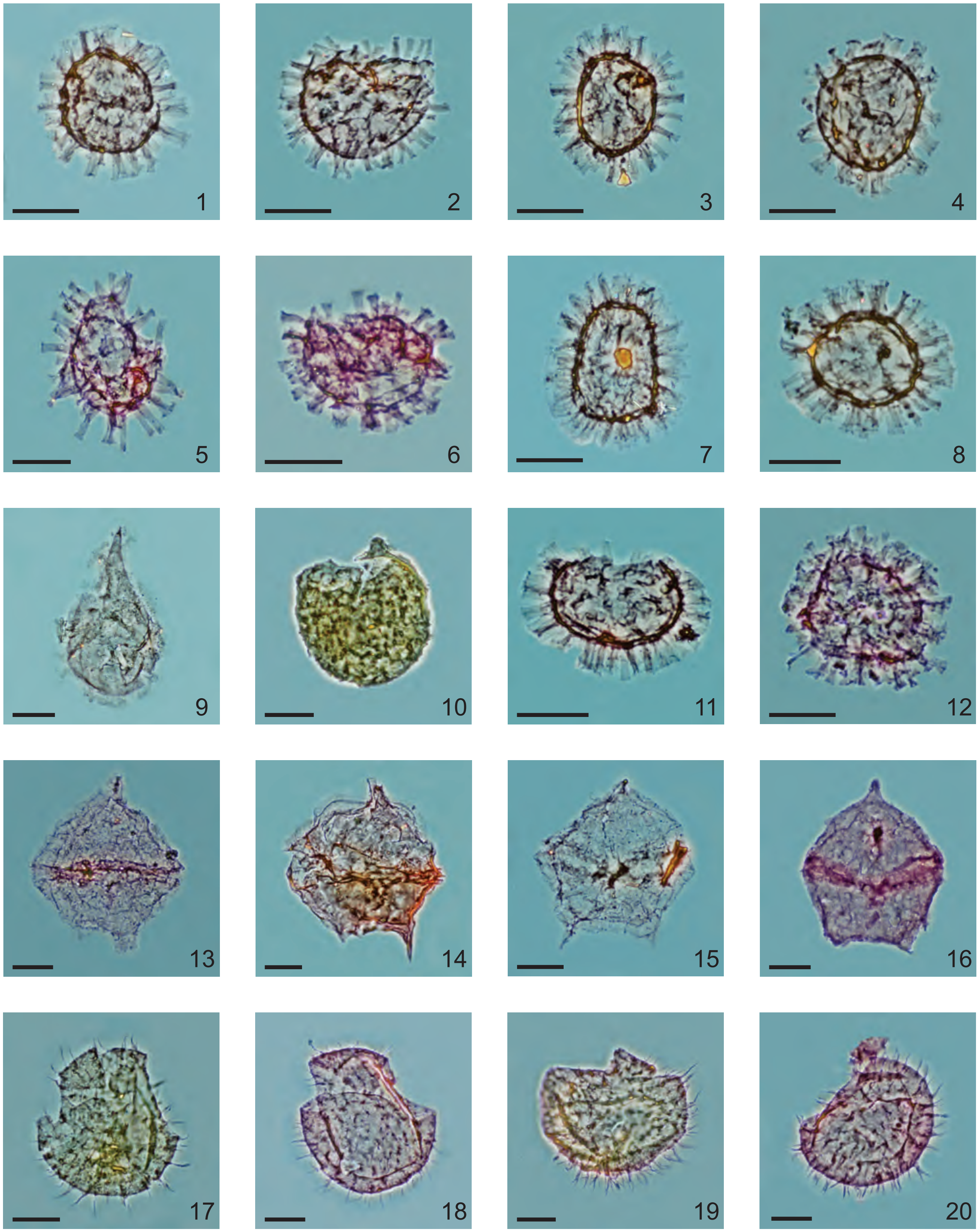


Plate 11

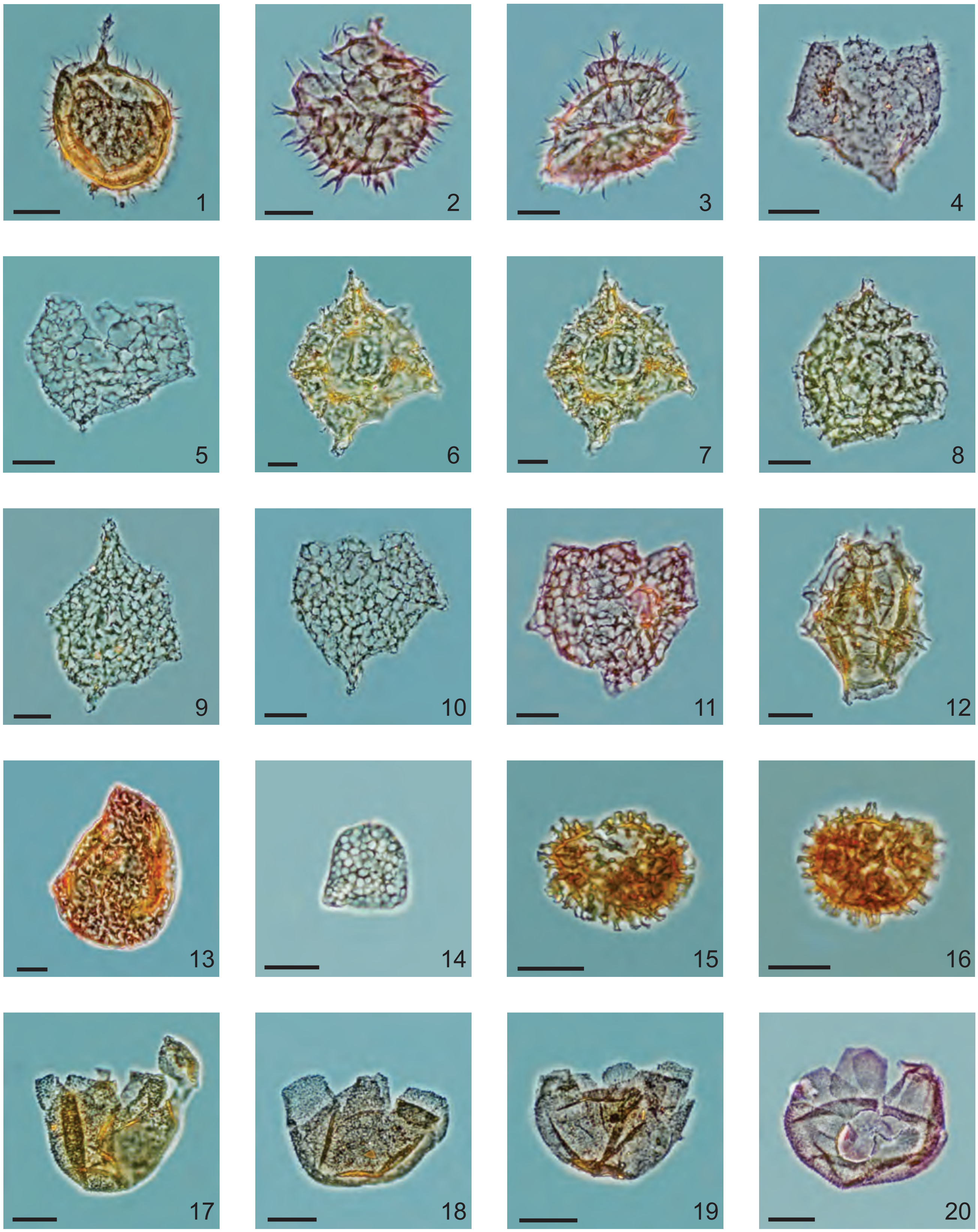


Plate 12

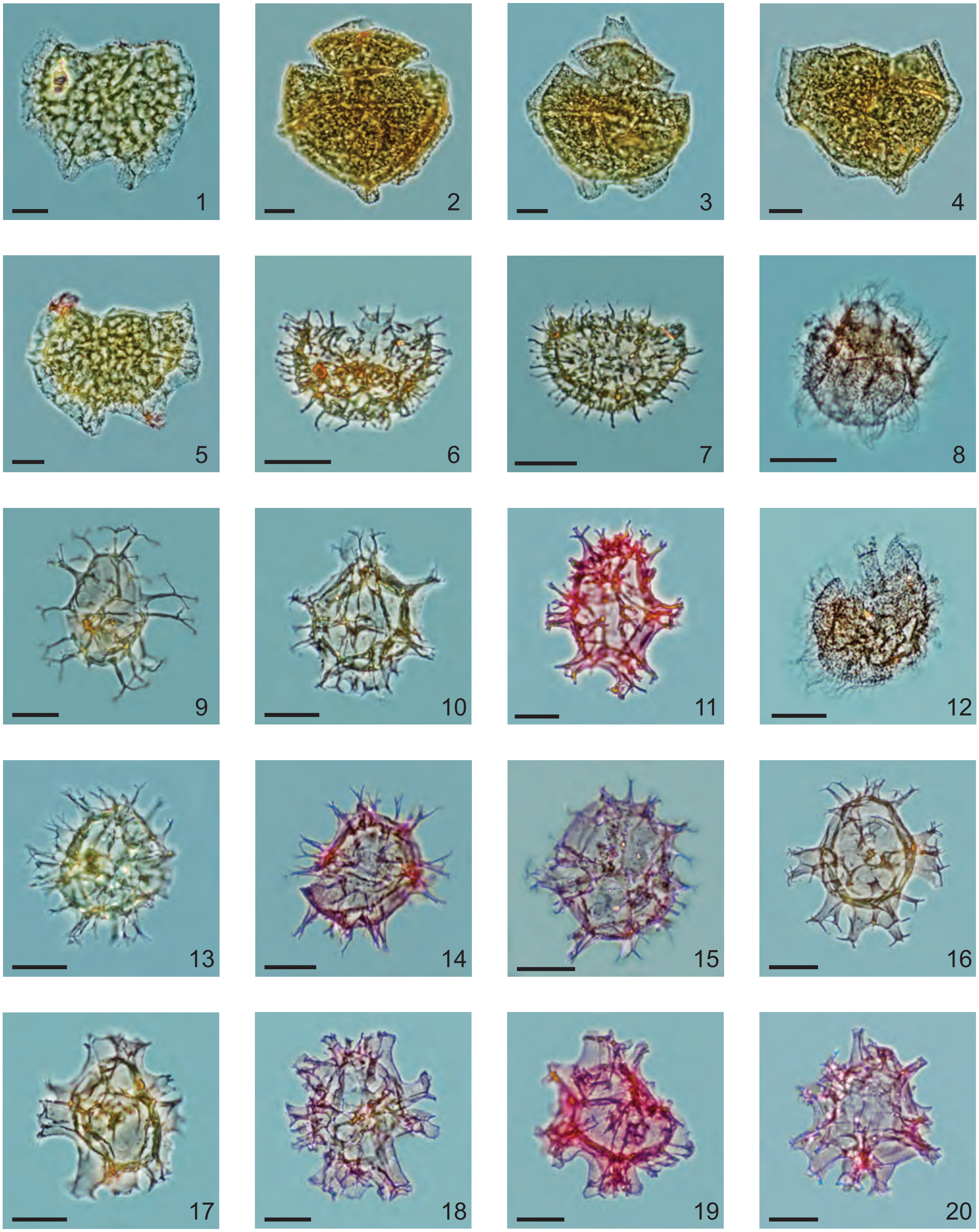


Plate 13

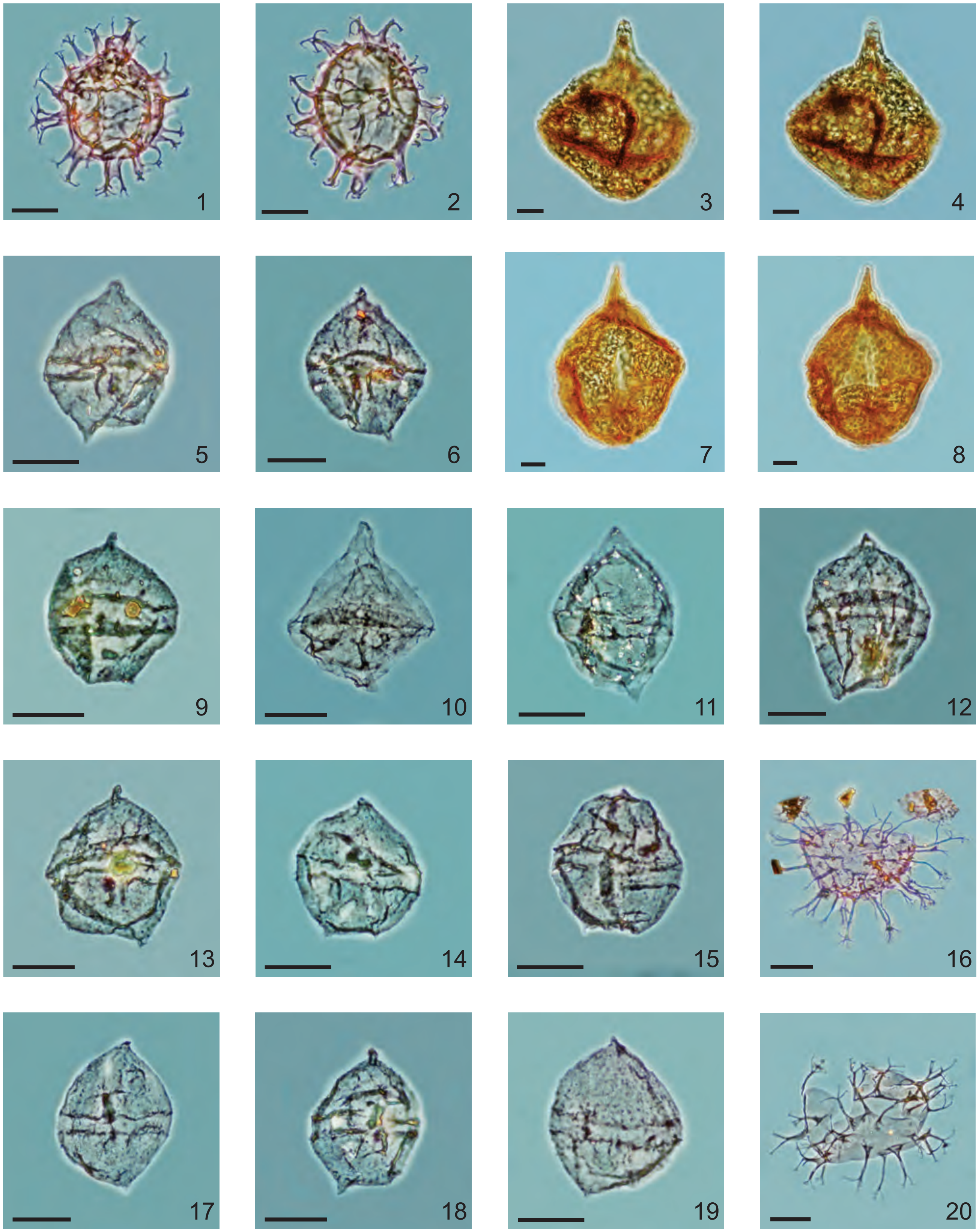


Plate 14

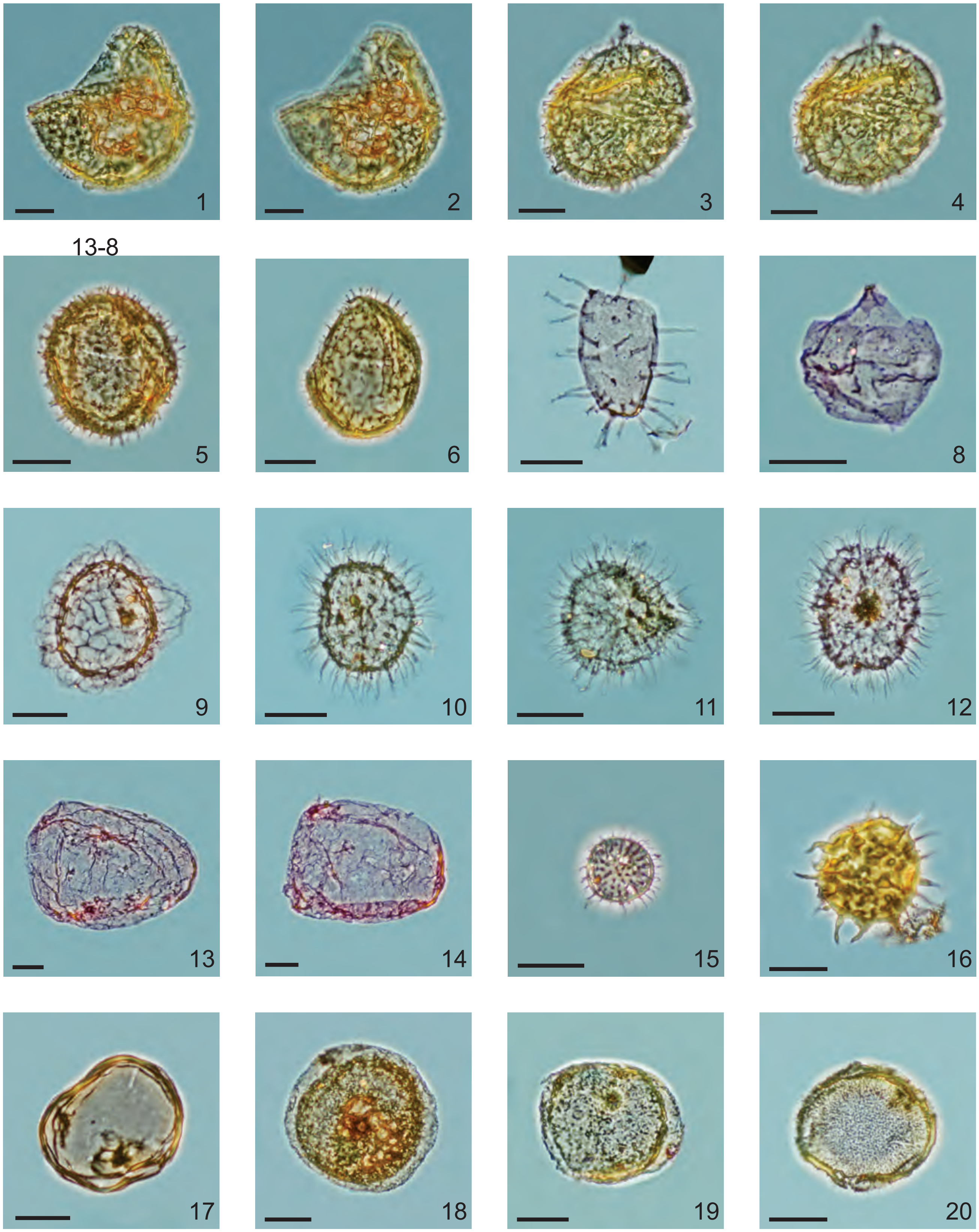


Plate 15

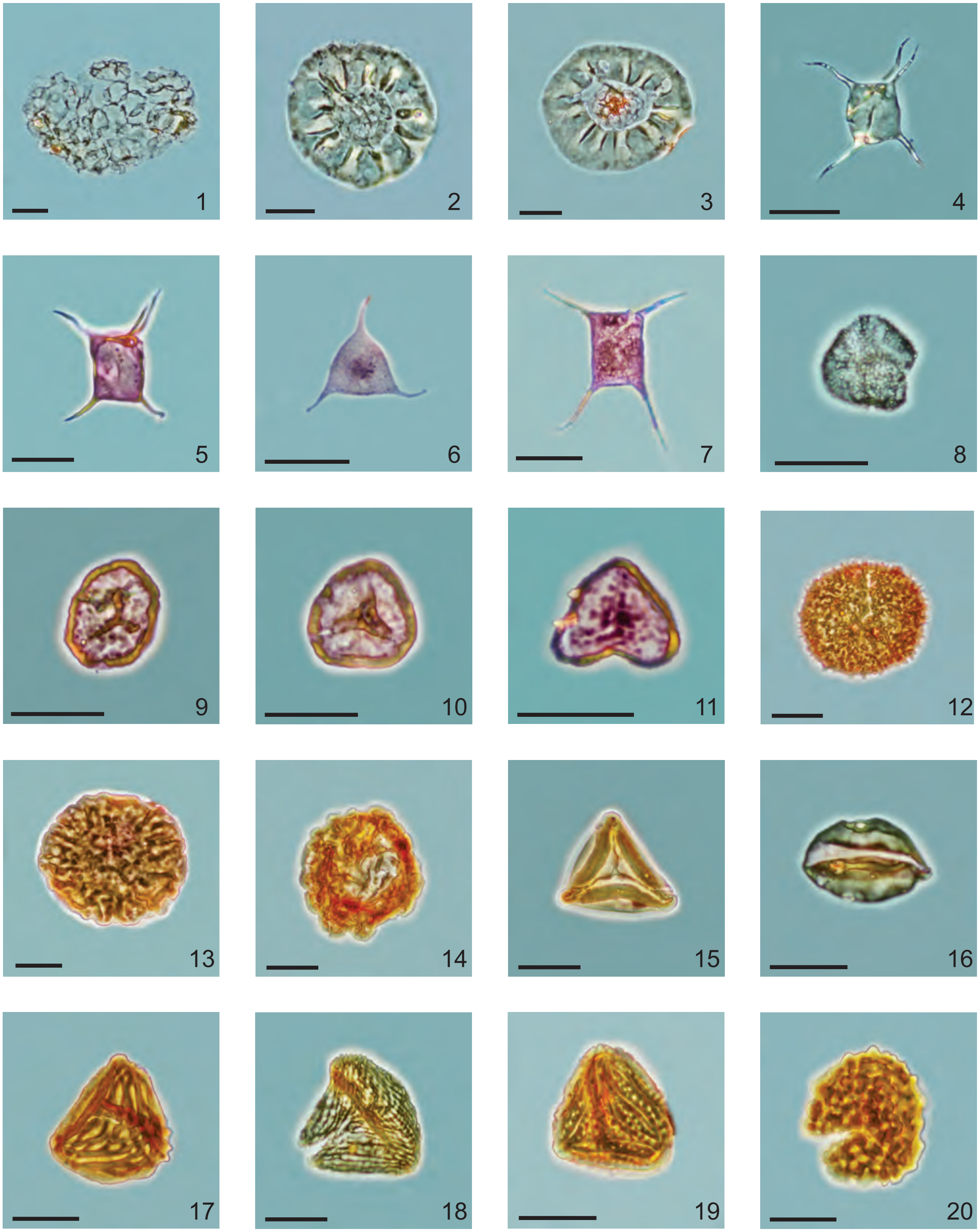


Plate 16

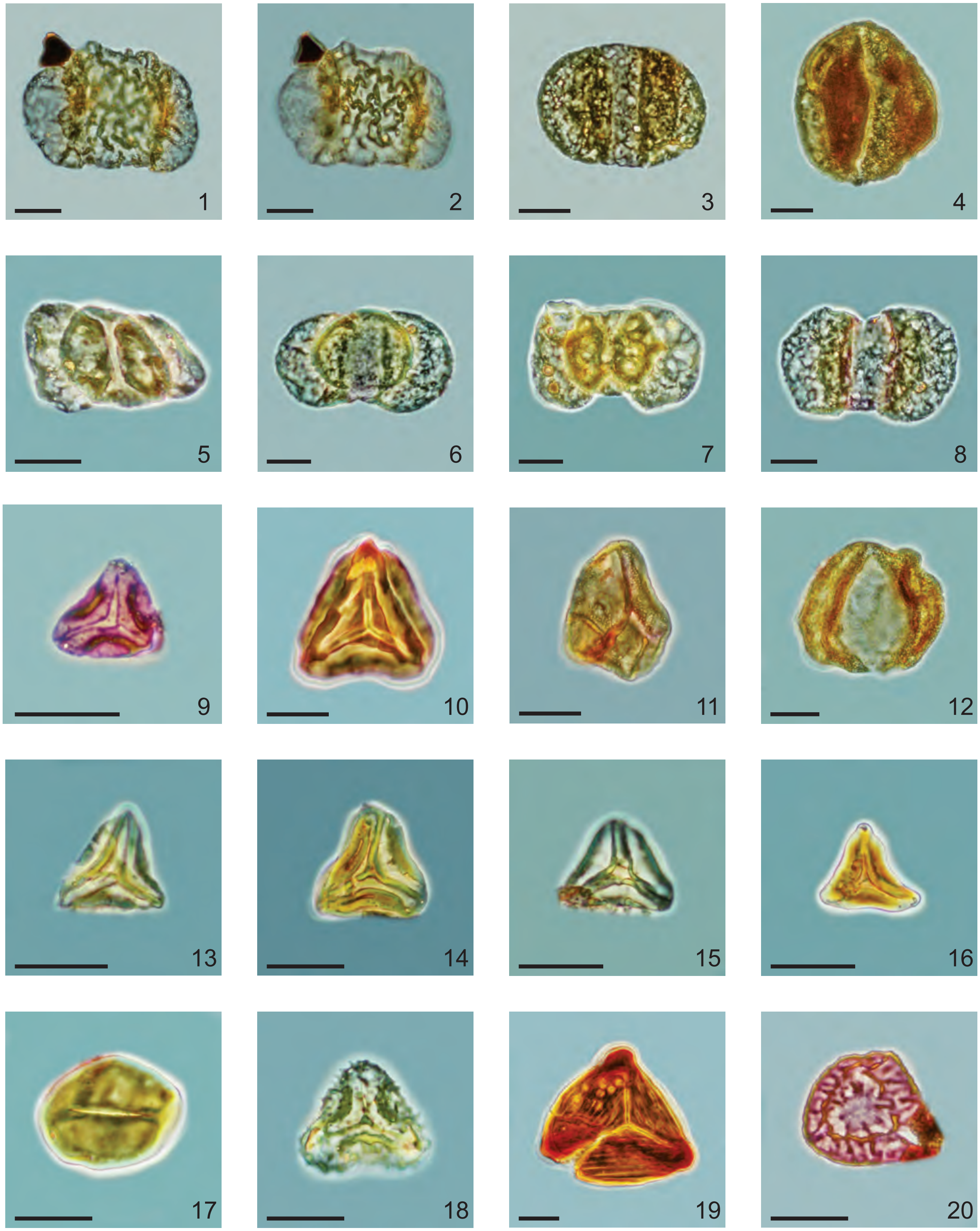


Plate 17

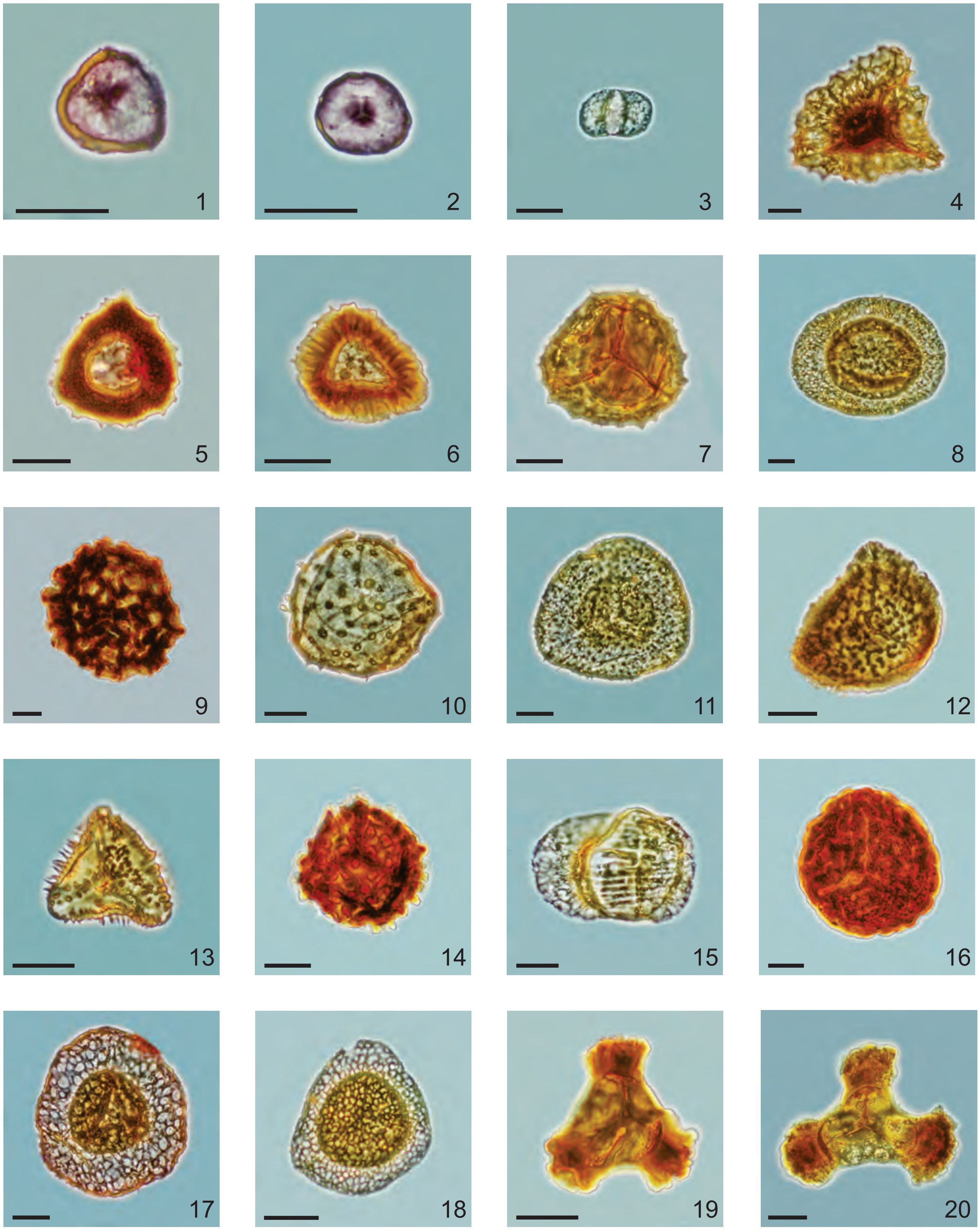


Plate 18