W H Fritz

GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF ENERGY,
MINES AND RESOURCES

BULLETIN 182

CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

(eleven papers)

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D. H. Collins, W. T. Dean, D. C. McGregor,
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PREFACE

From time to time it has been appropriate to issue several short papers on related paleontological topics in a single Bulletin under the general title of Contributions to Canadian Paleontology. The papers that form this Bulletin describe different groups of fossils that are important to correlation in the sedimentary basins of northern and western Canada, and consequently of relevance to petroleum exploration which is so dependent on accurate stratigraphic interpretation.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, May 15, 1968

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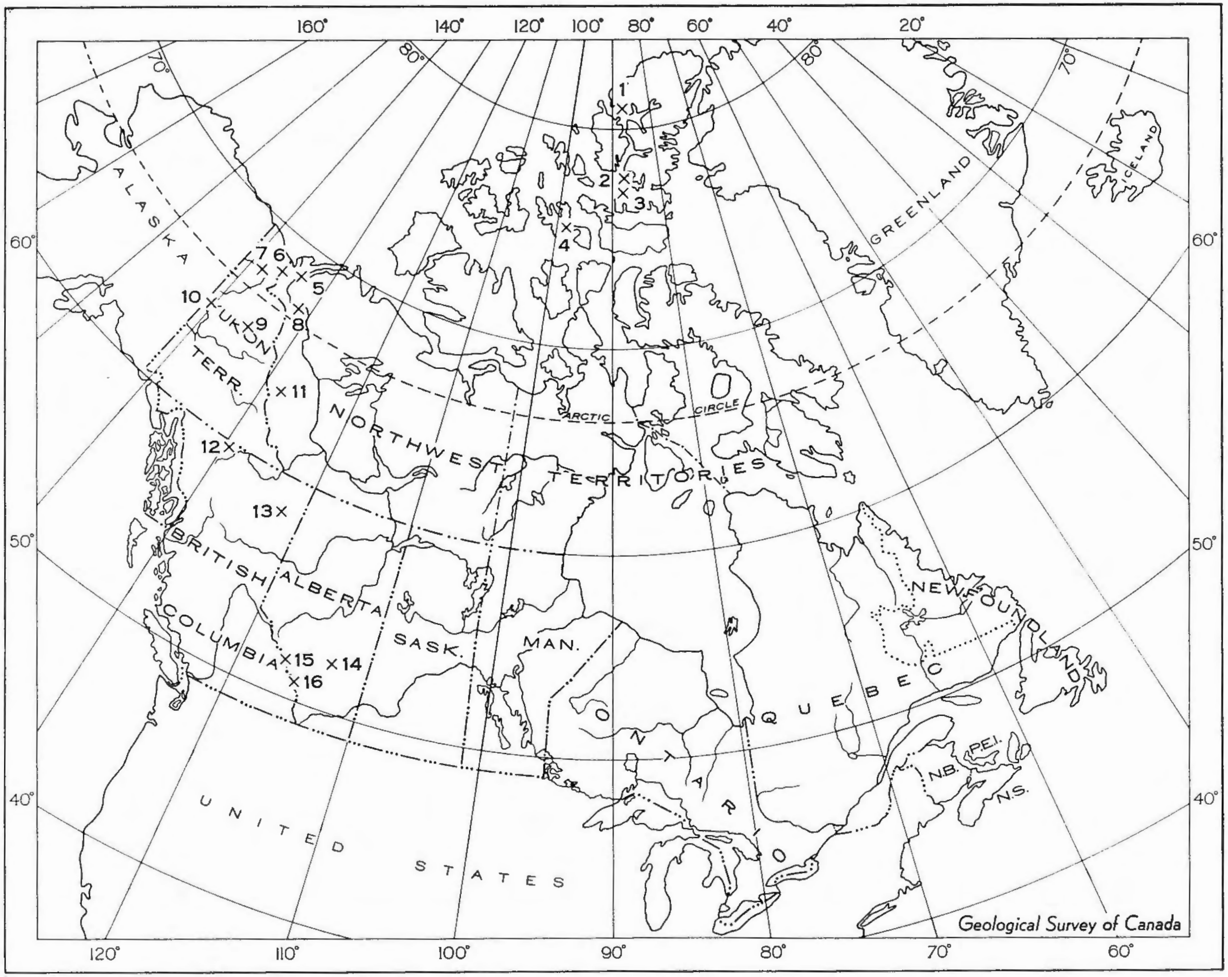

1 GSC loc. 80159, Hare Fiord Fm., Ellesmere Island (Nassichuk, 2nd paper).

2 GSC loc. 57730, Eids Fm., Ellesmere Island (Collins).

3 GSC plant loc. 4713, Okse Bay Fm., Ellesmere Island (McGregor).

4 GSC plant loc. 7277, Eureka Sound Fm., Bathurst Island (Hills and Wallace).

5 Stratigraphic section, Reindeer Fm., Caribou Hills (Hills and Wallace).

6 GSC loc. 53220, unnamed Pennsylvanian rocks (Ross).

7 GSC locs. 53241–53252, Road River Fm., lower Porcupine River (Jackson and Lenz).

8 GSC plant loc. 7831, Imperial Fm., Smith Creek (McGregor).

9 GSC locs. 53089–53094, Prongs Creek Fm., Royal Creek Section (Collins).

10 GSC loc. 47209, "Lower Limestone Unit", Larsen map-area (Ross).

11 GSC locs. 69044 and 75773, Landry Fm., Sekwi map-area (Collins; Dean).

12 GSC loc. 51078, unnamed Permian limestones, McDame map-area (Ross).

13 Imperial Sikanni Chief Number 1 Well (Nassichuk, 1st paper).

14 Imperial Fabian Number 1 Well (Wickenden).

15 Localities in Survey Peak Fm., southwest Alberta and adjacent British Columbia (Norford).

16 Rundle–Cascade Range, Banff (Bamber).

FIGURE 1. Locality map.

THE EARLY CANADIAN (TREMADOCIAN) TRILOBITES *CLELANDIA* AND *JUJUYASPIS* FROM THE SOUTHERN ROCKY MOUNTAINS OF CANADA

by B. S. Norford

Abstract

Five species are described from the lower part of the Survey Peak Formation of southwest Alberta and adjacent British Columbia. *Clelandia texana* Winston and Nicholls, *C. albertensis* new species, and *Jujuyaspis borealis* Kobayashi are from the *Symphysurina–Euloma* Zone (Zone A); *Clelandia utahensis* Ross and the new species *C. wilsoni* are from the *Bellefontia–Xenostegium* Zone (Zone B). These two zones are the basal zones of the Canadian in western North America. They are of Tremadocian age, and are either Lower Ordovician or Upper Cambrian, depending upon whether the Tremadoc Series is included in the Ordovician or in the Cambrian.The bases of these zones are defined by the first appearances of *Symphysurina* and *Bellefontia*. *Clelandia* and *Jujuyaspis* seem to be restricted to rocks of Tremadocian age. The type species of *Clelandia* is redescribed.

Résumé

Description de cinq espèces prélevées dans la partie inférieure de la formation Survey Peak située dans le sud-ouest de l'Alberta et à proximité de la Colombie-Britannique. Le *Clelandia texana* Winston et Nicholls, la nouvelle espèce *C. albertensis* et le *Jujuyaspis borealis* Kobayashi proviennent de la zone *Symphysurina–Euloma* (zone A); le *Clelandia utahensis* Ross et la nouvelle espèce *C. wilsoni* sont tirés de la zone *Bellefontia-Xenostegium* (zone B). Ces deux zones forment la base du Canadien dans le secteur occidental du continent nord-américain. Elles sont du Trémadocien, et appartiennent à l'Ordovicien inférieur ou au Cambrien supérieur, selon que la série Trémadoc est classée dans l'Ordovicien ou dans le Cambrien. Les bases de ces zones sont indiquées par les premières traces de *Symphysurina* et de *Bellefontia*. La présence du *Clelandia* et du *Jujuyaspis* semble se restreindre aux roches du Trémadocien. L'espèce type du *Clelandia* est décrit nouveau.

Introduction

A recent study of the Canadian rocks of southwest Alberta (Fig. 1, loc. 15; Aitken and Norford 1967) has allowed recognition of almost all the Canadian zones established in Utah and adjacent Idaho by Ross (1949 and 1951). The Survey Peak Formation seems to represent continuous deposition from late Trempealeau to G1 time. Species of *Clelandia* and *Jujuyaspis* form minor elements of the trilobite faunas of the two basal Canadian zones (A and B) that are dominated by *Bellefontia, Xenostegium,* and *Symphysurina.*

Biostratigraphy of Basal Canadian Zones in Western North America

The biostratigraphy of Canadian rocks of the carbonate and inner detrital belts seems to be very uniform throughout western North America. The basal two zones of the Canadian Garden City Formation in northeast Utah and southeast Idaho were designated Zone A and Zone B by Ross. His conception of Zone A was primarily based on a stratigraphic section on the east side of Hillyard's Canyon, southeast Idaho (Ross, 1951, pp. 14–16, loc. 5) where species of the trilobite genera *Symphysurina, Hystricurus,* and *Pseudohystricurus* are present about 34 feet below Zone B faunules with *Bellefontia.* A pygidium identified as *Bellefontia*? was reported from Zone A in this section but without precise stratigraphic data (Ross, 1951, p. 29, and Pl. 26, fig. 16). Zone B of the Garden City Formation has an extensive trilobite fauna in Utah and Idaho and includes the earliest appearances of the genera *Xenostegium* and *Bellefontia* with the exception of this questioned pygidium in Zone A, which is the only reported occurrence of *Bellefontia* in Zone A in North America.

Hintze (1953) used Ross's zonal scheme for the Canadian rocks of the Pogonip Group of western Utah and eastern Nevada. He did not recognize an A Zone but his Zone B (or *Symphysurina* Zone) seems to include both Zone B and Zone A of Ross. *Symphysurina* ranges throughout his zone. *Bellefontia* and *Xenostegium* are restricted to the *Symphysurina* Zone of the Pogonip but are not present in the lowest part, faunules of which include *Symphysurina brevispicata* Hintze and *Hystricurus millardensis* Hintze (Hintze, 1953, pp. 6–8, 24–26). These lowest faunules probably correspond to Ross's Zone A.

Lochman (1964) applied the letter zones to early Canadian rocks of the Deadwood Formation of the subsurface of eastern Montana. The base of her Zone A was essentially picked at the first appearance of *Euloma cordilleri* Lochman closely followed by that of *Symphysurina brevispicata. Bellefontia* and *Xenostegium* first appear in her Zone B. *Symphysurina* ranges through Zones A, B, and C in the Deadwood Formation.

Winston and Nicholls (1967) have recognized a *Symphysurina* Zone and an underlying *Missisquoia* Zone in early Canadian beds of the Wilberns Formation of central Texas. *Symphysurina brevispicata* and *S. bubops* Winston and Nicholls are reported to range through both zones; the lower zone was differentiated on the presence of species of *Missisquoia, Parabolinella,* and *Euloma cordilleri*; the upper zone on the presence of *Hystricurus millardensis, Jujuyaspis borealis* Kobayashi, and *Clelandia texana* Winston and Nicholls. The two zones together seem to correspond to most of Zone A as used elsewhere in western North America.

Aitken and Norford (1967) applied Ross's zonation to the Survey Peak Formation of southwest Alberta and bordering British Columbia, where Zone B is characterized by *Bellefontia* and *Xenostegium* and Zone A by *Symphysurina* and *Euloma.* About 40 feet of strata separate the lowest *Symphysurina–Euloma* faunule at Mount Wilson from underlying faunules of the Trempealeaun *Saukia* Zone (Aitken and Norford, 1967, pp. 198–200), but no differentiation of the *Missisquoia* interval of Winston and Nicholls from the rest of Zone A has yet been recognized.

The basal two zones of the Canadian Series in western North America are Zone A (or the *Symphysurina–Euloma* Zone) and Zone B (or the *Bellefontia–Xenostegium* Zone.) The bases of these zones are essentially defined by the first appearance of *Symphysurina* and *Bellefontia.* The *Missisquoia* Zone of Winston and Nicholls can be best regarded as a subzone that can be locally differentiated within the lower part of Zone A.

Range of *Clelandia* and *Jujuyaspis*

In western North America *Clelandia* is present in both Zone A and Zone B but *Jujuyaspis* is known only from Zone A. Species of the genera described from elsewhere in the world are all from Tremadoc horizons.

Clelandia utahensis Ross has been reported from the Garden City Formation of Utah and Idaho (Ross, 1951, pp. 13, 17, 18, 117), the Pogonip Group of western Utah (Hintze, 1953, pp. 25, 30, 147), and the Deadwood Formation of Montana (Lochman, 1964, pp. 455, 456, 473); all from Zone B. The associated trilobites in the Garden City are *Bellefontia chamberlaini* Clark, *Bellefontia*? *acuminiferentis* Ross, *Xenostegium franklinense* Ross, *Remopleuridiella caudalimbata* Ross, *Parahystricurus*? sp. A, *P.*? sp. B, *Hystricurus genalatus* Ross, *H. paragenalatus* Ross, *H. politus* Ross, *H.*? sp. G, and *H.*? sp. H. In the Pogonip Group, *C. utahensis* is found with *Bellefontia chamberlaini, Xenostegium franklinense, Parabellefontia concinna* Hintze, *Symphysurina* cf. *S. spicata* Walcott, *Hystricurus genalatus, H. politus,* and *Praepatokephalus*? sp. A. Associated trilobites in the Deadwood Formation are *Bellefontia nonia* (Walcott), *Xenostegium, Symphysurina* cf. *S. woosteri* Ulrich, and *Praepatokephalus armatus* (Hintze). In Alberta, *Clelandia utahensis* is found with *Bellefontia, Xenostegium,* and *Hystricurus paragenalatus* in Zone B of the Survey Peak Formation at Mount Wilson.

Clelandia texana Winston and Nicholls was described from Zone A of the Wilberns Formation of Texas where it is found with *Symphysurina brevispicata* and *Jujuyaspis* cf. *J. borealis* Kobayashi (identified by Winston and Nicholls as *J. keideli* Kobayashi). It is found with *S. brevispicata, J. borealis,* and the gastropod *Eobucania pulchra* Kobayashi in Zone A of the Survey Peak Formation at Mount Whiterose, British Columbia.

Clelandia aspina Ross and *C. bispina* Ross are found together in the Goodwin Limestone of southeast California (Ross, 1967, pp. D31, D34) associated with *Bellefontia, Xenostegium, Symphysurina, Remopleuridiella,* and *Hystricurus.* The generic association indicates Zone B.

The new species *Clelandia wilsoni* is found with *Xenostegium* in Zone B of the Survey Peak Formation at Mount Wilson, Alberta. *Bellefontia* and *Xenostegium* occur both above and below its type locality (Aitken and Norford, 1967, pp. 196–197).

The other new species, *Clelandia albertensis,* is associated with *Symphysurina* sp. and *Eobucania pulchra* in Zone A of the Survey Peak Formation at Mount Wilson, Alberta.

The only other established species of *Clelandia, C. parabola* (Cleland), comes from the Fonda Member of the Tribes Hill Formation of New York that can be correlated (Fisher, 1954, 1962) with the lower part of the *Adelograptus–Clonograptus* Zone that Berry (1960, p. 39) would correlate with the upper part of the Tremadoc of the British Isles.

Jujuyaspis borealis Kobayashi is the only known species of the genus from North America. Kobayashi (1955) has identified *Eobucania pulchra, Parabolinella bisulcatus* Kobayashi, *Sphaerophthalmella inexpectans* Kobayashi, *Symphysurina* 2 spp. and *Gonioteloides monoceras* Kobayashi from the type locality in the McKay Group on Steamboat Mountain, British Columbia. But, either the identification of *G. monoceras* is questionable or the locality spans several zones, for *G. monoceras* is elsewhere found in Zone E (*Tesselacauda* Zone) including its type locality (Kobayashi, 1955, pp. 366, 447, 448, loc. 2; Aitken and Norford, 1967, pp. 181, 194). In Texas, *J.* cf. *J. borealis* (as *J. keideli* Kobayashi of Winston and Nicholls) is found in Zone A of the Wilberns Formation with the trilobites *Symphysurina bubops* Winston and Nicholls, *S. brevispicata,* and *Clelandia texana. J. borealis* is also associated with these last two species in Zone A of the Survey Peak Formation at Mount Whiterose, British Columbia.

The other described species of *Jujuyaspis* are from South America and Norway. *Jujuyaspis keideli* Kobayashi is known from the Zone of *Parabolina argentina* in Argentina and Bolivia that contains *Dictyonema flabelliforme flabelliforme* Brogger and *D. flabelliforme sociale* (Salter). Harrington and Leanza (1957, pp. 24–26) date this zone as Lower Tremadoc. The other known species of the genus, *J. angusta* Henningsmoen and *J. keideli norvegica* Henningsmoen were described from the Lower Tremadoc Zones of *D. flabelliforme flabelliforme* and *D.flabelliforme socialis* of Norway (Henningsmoen, 1957, pp. 261–264).

Acknowledgments

The manuscript has been critically read by W. H. Fritz of the Geological Survey of Canada and by R. J. Ross, Jr., of the United States Geological Survey. The photographs were taken by E. Thorpe, F. J. Cooke, and D. Harvey. Mrs. Katherine V. W. Porter of the Paleontological Research Institution and W. C. Bell of the University of Texas kindly loaned type specimens for study.

Systematic Paleontology

Prefixes GSC refer to specimens in the type collection of the Geological Survey of Canada, Ottawa; PRI to specimens in the Paleontological Research Institution, Ithaca; and UT to specimens in the paleontological collection of the University of Texas, Austin.

Phylum ARTHROPODA

Class TRILOBITA

Family uncertain

Genus *Clelandia* Cossman 1902

Harrisia Cleland 1900, p. 255, non Robineau-Desvoidy 1830.
Clelandia Cossman 1902, p. 52.
Clelandia Cossman, Ross 1951, pp. 116–117.
Clelandia Cossman, Harrington and others, 1959, p. 0521.
Clelandia Cossman, Ross 1967, p. D30–D31.

Type species: *Harrisia parabola* Cleland from the Lower Canadian Tribes Hill Formation of New York State.

Clelandia parabola (Cleland 1900)

Plate 1, figures 1, 6, 7, 11, 12

Harrisia parabola Cleland 1900, pp. 255–256, Pl. 16, figs. 1–3.
Clelandia parabola (Cleland), Cossman 1902, p. 52.
(?) *Clelandia parabola* (Cleland), Raymond 1937, Pl. 1, fig. 25.
Clelandia parabola (Cleland), Fisher, 1954, Pl. 4, fig. 11.

Material. The description is based entirely on the holotype, a peeled cephalon, PRI 5070, from the Lower Canadian Tribes Hill Formation of New York State. Fisher (1954, p. 90) reported the species only from the Fonda Member of the formation.

Dimensions. The holotype cephalon is damaged but is about 5.9 mm long (*sag.*) including spines and about 6.3 mm wide (*tr.*) at rear of occipital ring.

Description. Cephalon smooth but peeled, slightly wider than long, strongly arched about axis. Cranidial outline trapezoidal, much wider than long, greatest width at rear of occipital ring. Glabella semiconical, elevated, evenly convex in lateral profile, convex with slight mesial arch in transverse profile, with traces of two pairs of lateral furrows (Ross, 1951, p. 117, thought that one pair might be present); axial furrows broad, deep, joining anteriorly in a broad axial depression in front of glabella. Occipital ring and rear part of glabella poorly preserved in holotype. Frontal area slightly convex in front of axial depression, without border furrow. Fixigena narrow forward, wide to rear, slightly convex, without detectable eye ridge, posterior area slightly reflexed, with very small metafixigenal nub at posterolateral corner, border furrow distinct, deep adaxially, low swollen area between border furrow and axial furrow. Eyes small, crescentic, front of eyes level with front of glabella. Facial sutures trend forward from eyes, swing abruptly but evenly at adaxial extremity of yoke to be almost transverse in front of glabella, running along the site of the border furrow, with a slight broad curve forward mesially, joining on dorsal surface of cephalon, behind margin; rearward from the eyes, facial sutures flare posterolaterally to border furrow where they swing rearward across border. Librigena large, gently convex, lateral extremities lying just below dorsal outline of cephalon, with indistinct broad border furrow whose place is taken by the facial suture along the yoke, outline evenly curved with large rearward directed genal spine and minute prolongation of abaxial rear margin to complement the metafixigenal nub; anterior adaxial transverse band joins opposing librigenae to form the yoke of Cleland (1900), Ross (1951 and 1967), and Hintze (1953), no sutures discernible within yoke or separating it from the librigenae, presumably the yoke and the pair of librigenae formed a single skeletal element.

Thorax, pygidium, and hypostoma unknown.

Discussion. This description of *Clelandia parabola* provides a modern assessment of the type species of the genus. Ross (1951, p. 117) previously interpreted the depressions on the glabella of the holotype as probably representing one pair of lateral glabellar furrows, the present description interprets them as two pairs.

Raymond (1937, Pl. 1, fig. 25) illustrated a trilobite from the Tribes Hill Formation that he assigned to *Clelandia parabola.* The specimen has a stout occipital spine. The occipital ring and the rear of the glabella are damaged in the holotype and the presence or absence of such a spine cannot be determined.

Clelandia utahensis Ross 1951

Plate 1, figures 2, 3

Clelandia utahensis Ross, 1951, p. 117, Pl. 29, figs. 1–4, 6–9.
Clelandia utahensis Ross, Hintze 1953, p. 147, Pl. 4, figs. 15–17.
Clelandia utahensis Ross, Lochman 1964, p. 473, Pl. 64, figs. 24–27; Pl. 65, figs. 1–7.
Clelandia sp., Aitken and Norford 1967, pp. 181, 196.

Material. The description is based on three cranidia from GSC loc. 69604; five cranidia are known from GSC loc. 57507 but this material is not silicified and is poorly preserved.

Types and occurrence. Hypotype cranidia GSC 23614 and 23615 and another cranidium collected by J. D. Aitken and B. S. Norford, 1965, from limestones at GSC loc. 69604 within the Lower Canadian *Bellefontia–Xenostegium* Zone (Zone B) at 450–456 feet above the base of the type section of the Survey Peak Formation, Mount Wilson section (52°00′N, 116°45′W), Alberta (Aitken and Norford, 1967, p. 196); associated fauna *Bellefontia* sp., *Xenostegium* sp., *Hystricurus paragenalatus* Ross. Also collected by G. B. Leech, 1963 from GSC loc. 57507 within the *Bellefontia–Xenostegium* Zone of the McKay Group, Mount Queen Mary section (50°38′N, 115°27′W), British Columbia; associated fauna orthid brachiopod, *Bellefontia* sp.

Dimensions. Hypotype cranidium GSC 23614 (Pl. 1, fig. 2) is 2.5 mm long (*sag.*) and about 2.7 mm wide (*tr.*).

Description. Cephalon small, smooth. Cranidial outline a broad-based triangle with evenly rounded front and slightly recessed base, wider than long, greatest width opposite anterolateral part of posterior border of fixigena. Glabella semiconical with broad base, slightly raised, without lateral furrows, axial furrows curving slightly adaxially forward, deeply incised except at occipital ring and where they join in front of glabella. Occipital ring long with blunt rear border and broad-based stubby occipital spine that projects rearward with a very small dorsal component except in small individuals; occipital furrow almost straight. Frontal area gently convex, without border furrow. Fixigena without detectable eye ridge; posterior area gently convex, very slightly reflexed, border trending somewhat posterior of lateral from axial furrow, border furrow distinct. Facial sutures curving very evenly forward and adaxially from small palpebral lobes, meeting axially on dorsal surface of cephalon; rear portions run almost straight posterolaterally to opposite rear third of glabella where they start to curve adaxially, cutting margin adaxial to their intersections with border furrows.

Librigena, hypostoma, thorax, and pygidium not represented.

Discussion. Less well preserved cranidia from the McKay Group (GSC loc. 57507) closely resemble the described material and are thought to be conspecific. A large cranidium has distinct eye ridges that trend almost transverse into the axial furrows at the front of the glabella.

The evenly curved course of the facial sutures in front of the palpebral lobes, the outlines of the glabella and the occipital ring, and the stubby character of the occipital spine are all distinctive features of the species.

The present material very closely resembles the cranidium of *C. utahensis* illustrated by Hintze (1953, Pl. 4, fig. 17) from Zone B of the House Limestone of the Ibex area, western Utah. The holotype cranidium (Ross, 1951, Pl. 29, figs. 1–3) from Zone B of the Garden City Formation of southeast Idaho seems to have a narrower occipital spine. The species has also been described from Zone B of the Deadwood Formation in the subsurface of eastern Montana (Lochman, 1964).

Clelandia texana Winston and Nicholls 1967

Plate 1, figures 4, 5, 8–10, 13, 14, 41, 42; Plate 2, figure 33

Clelandia texana Winston and Nicholls, 1967, pp. 89–90, Pl. 12, figs. 11, 26.
Clelandia texana Winston and Nicholls, Aitken and Norford, 1967, p. 182.

Material. Several cranidia, one small librigena, preserved in limestone.

Types and occurrence. Hypotype cranidia GSC 22889, 22890, hypotype librigena GSC 22891; collected by J. D. Aitken from limestones at GSC loc. 57675 within the Lower Canadian *Symphysurina–Euloma* Zone (Zone A) at 229 feet above the base of the Survey Peak Formation, Mount Whiterose section (51°56½′N, 117°14′W), near Lyell Creek, British Columbia (Aitken and Norford, 1967, p. 182). Associated fauna: fragments of echinoderms and brachiopods, *Eobucania pulchra* Kobayashi, *Symphysurina brevispicata* Hintze, and *Jujuyaspis borealis* Kobayashi. Hypotype cranidium GSC 23616 and other material, collected by J. D. Aitken, 1965, from the Survey Peak Formation of the Chaba River section (52°17′N, 117°47′W; GSC loc. 72815 and 72816), at the Alberta–British Columbia border; associated fauna: echinoderm fragments, inarticulate and orthid brachiopods, ?*Eobucania* sp., *Symphysurina* sp., *Jujuyaspis borealis* Kobayashi.

Dimensions. Hypotype cranidium GSC 22889 (Pl. 1, fig. 4) is 3.4 mm long (*sag.*) and 5.1 mm wide (*tr.*).

Description. Cephalon small, convex, wider than long, with most or all areas of librigenae forming part of dorsal surface, apparently smooth but peeled specimens show extremely fine pits. Cranidial outline trapezoidal, much wider than long, greatest width at occipital ring. Glabella strongly tapering forward, slightly raised, two pairs of rearward curving lateral furrows, rear pair more strongly developed, axial furrows distinct, curving adaxially forward and meeting mesially to form a distinct inflexion. Occipital ring more than a third as long (*sag.*) as glabella, but short adjacent to indistinct axial furrows that lie farther from axis than axial furrows of glabella; occipital furrow laterally incised, slightly bowed forward mesially and at axial furrows; prominent mesial occipital node. Frontal area slightly convex, with faint border furrow and a sliver of a low border. Fixigena large; very faint long palpebral lobe opposite and close to front quarter of glabella, with very faint eye ridge from almost the front of the glabella; posterior area broad, slightly reflexed with wide gently convex border and shallow border furrow that becomes faint both abaxially and adaxially. Facial sutures trend forward from palpebral lobes that are subparallel to axial furrow, curving mesially as approach border furrow and joining mesially on anterior border; rear parts curving laterally and rearward from palpebral lobes, cutting posterior border almost orthogonally. Librigena large, low, with very faint posterior border furrow; with broad short genal spine; anterior band not preserved in the solitary specimen; eyes not discernible.

Thorax and hypostoma unknown. The pygidium here termed *Clelandia* sp. (Pl. 1, figs. 19–21) may belong to *C. texana.*

Discussion. Small specimens have more convex glabellas and stronger lateral and axial glabella furrows. The material from Mount Whiterose closely resembles the types from the Wilberns Formation described and illustrated by Winston and Nicholls but the glabella is less raised and the posterior areas of the fixigenae are less flaring. The holotype (UT 12624; Winston and Nicholls, 1967, Pl. 12, fig. 26) shows no border in front of the frontal area but the illustrated paratype (UT 12623; Winston and Nicholls, 1967, Pl. 12, fig. 11) does have such a border that is similar to that of the present specimens.

Like *C. parabola, C. texana* has two pair of lateral glabellar furrows. The former species has deep, broad axial furrows, a pair of swollen areas adjacent to the rear parts of the axial furrows, and a depressed area in front of the glabella. *C. texana* lacks these features and the posterior areas of the fixigenae are more flaring.

Clelandia albertensis new species

Plate 1, figures 15–18, 22–40

Clelandia sp., Aitken and Norford 1967, pp. 182, 199.

Material. Numerous cranidia, librigenae, thoracic segments, and pygidia from a single collection.

Types and occurrence. Holotype cranidium GSC 23617, paratype cranidia GSC 23618, 23625, 23626, paratype librigenae GSC 23621–23623, paratype thoracic segment GSC 23624, paratype pygidium GSC 23619; collected by J. D. Aitken, B. S.

Norford, W. H. Fritz, R. J. Ross, Jr., and L. A. Wilson, 1965, from limestones at GSC loc. 69776 within the Lower Canadian *Symphysurina–Euloma* Zone (Zone A) at 149–150 feet above the base of the Survey Peak Formation, Mount Wilson North section (52°02′N, 116°50′W), Alberta (Aitken and Norford, 1967, p. 199); associated fauna ?*Lingulepis* sp., orthid brachiopod, *Eobucania pulchra* Kobayashi, *Symphysurina* sp., *Clelandia* sp.

Dimensions. The holotype cranidium (Pl. 1, fig. 40) is 2¾ mm long (*sag.*) and 4 mm wide (*tr.*); paratype pygidium GSC 23619 (Pl. 1, fig. 18) is about ½ mm long and ¾ mm wide.

Description. Cephalon small, strongly arched about axis, smooth, much wider than long, with virtually all of librigenae forming part of dorsal surface. Cranidial outline subtrapezoidal, much wider than long, greatest width at posterior border furrow. Cranidium strongly arched in transverse profile; in longitudinal profile, front half of glabella strongly convex, rear half, occipital ring, and frontal area almost plane (Pl. 1, figs. 34, 35). Glabella semiconical, strongly elevated, arched in transverse profile; with one pair of faint lateral furrows that adaxially curve rearward; axial furrows distinct, forward parts curving adaxially and joining axially at front of glabella. Occipital ring wider than glabella, slightly more than a fourth as long (*sag.*); occipital furrow with a broad mesial depression and a pair of deep pits near lightly impressed axial furrows; low mesial node that continues rearward as a small occipital spine that projects almost entirely rearward. Frontal area convex axially, especially forward, reflexed abaxially; without border furrow. Fixigena almost plane, with faint eye ridge trending from front of glabella to small indistinct palpebral lobes; posterior area broadens rearward, rear margin trending slightly rearward of transverse, strongly reflexed, border furrow distinct except adjacent to facial suture. Facial sutures trend almost directly forward from palpebral lobes, swinging abruptly to run transverse and meet on dorsal surface of cephalon on crest of arched part of frontal area; rear parts trending almost straight posterolaterally, curving sharply at border furrow and running slightly abaxial of sagittal across border. Librigena large, almost plane, without border furrow; outline evenly curved with small rearward directed genal spine and anterior band that is welded to corresponding band on opposing librigena to form an arched continuous yoke (Pl. 1, fig. 32). Eyes not discernible. Hypostoma unknown. Very small cranidia have elongate glabellas and proportionally larger occipital spines that have a stronger dorsal component of projection.

Thoracic segments strongly arched axially, with prominent axial spines that project entirely dorsally; number of segments unknown.

Several very small pygidia (Pl. 1, fig. 17) show the axis not quite reaching rear margin, with five axial rings, each with a large axial spine that curves dorsoposteriorly (Pl. 1, fig. 36); rear margin with small axial scallop and five pairs of short marginal spines. A sole pygidium in the same collection (*Clelandia* sp., Pl. 1, figs. 19–21) is considerably larger than the other specimens and probably belongs to another species.

Discussion. The only described species of *Clelandia* with lateral glabellar furrows are *C. texana* and *C. parabola,* both with two pairs. *C. albertensis* has only one pair. Both *C. parabola* and *C. albertensis* are strongly arched and have similar facial sutures. The occipital furrow and occipital ring of *C. parabola* are poorly known but no pair of pits is present in the occipital furrow and the species also has much longer genal spines than *albertensis*. The laterally incised parts of the occipital furrow of *C. texana* are not as deep as the pits in *C. albertensis,* the species is not strongly arched, and the occipital ring has a mesial node, not an occipital spine.

Clelandia wilsoni new species

Plate 2, figures 1–17

Clelandia sp., Aitken and Norford 1967, pp. 181, 196.

Material. Numerous cranidia, librigenae, and thoracic segments etched from a single collection. One cephalon that is present in the same collection is incomplete and slightly crushed but most probably belongs to the species.

Types and occurrence. Holotype cranidium GSC 22191, paratype cranidia GSC 22192–22194, paratype librigenae GSC 22195–22197, paratype thoracic segment GSC 22198, paratype cephalon GSC 22199. Collected by B. S. Norford, R. J. Ross, Jr., and L. A. Wilson, 1965, from limestones at GSC loc. 69601 within the Lower Canadian *Bellefontia–Xenostegium* Zone (Zone B), at 350–355 feet above the base of the type section of the Survey Peak Formation, Mount Wilson section (52°00′N, 116°45′W), Alberta (Aitken and Norford, 1967, p. 196); associated fauna *Xenostegium* sp.

Dimensions. The holotype cranidium (Pl. 2, fig. 2) is 2.4 mm long (*sag.*) including spines, and 2.5 mm wide (*tr.*) at rear of occipital ring. The paratype cephalon (Pl. 2, fig. 5) is about 3.6 mm long with genal spines and 4.1 mm wide.

Description. Cephalon small, convex, smooth, wider than long, with broad rounded margins in lateral and transverse profiles, with about half of areas of librigenae forming part of ventral surface. Cranidial outline a triangle blunted at apex, slightly wider than long, greatest width at rear of occipital ring. Glabella semiconical, elevated, evenly convex in lateral profile, convex with slight mesial arch in transverse profile; without lateral glabellar furrows; with faint low mesial prolongation at front, separating strongly incised axial furrows that turn abruptly forward at the prolongation to shallow and die out in the rear part of the frontal area; with strong short rearward directed mesial spine at rear of glabella. Occipital ring about a fourth as long (*sag.*) as glabella; axial furrows lightly impressed; occipital furrow abaxially faint, mesially deep with sharp rearward salient behind and below glabellar spine; strong occipital spine extending rearward and forming an even longitudinal profile with glabellar spine (Pl. 2, fig. 3). Frontal area slightly convex at rear, moderately convex at front; without border furrow. Fixigena narrow, slightly convex, without detectable eye ridge; posterior area slightly reflexed with very short blunt metafixigenal nub at posterolateral corner, border furrow distinct, abaxially swinging rearward to join facial suture and delimit nub. Facial sutures subparalleling axial furrows for most of length, with slight undulations at about probable sites of palpebral lobes, curving abruptly in front of glabella to be almost transverse and joining at or just behind front margin but just below dorsal outline of cephalon. Librigena large, gently convex, anterior and anterior-lateral parts lying below dorsal outline of cephalon, without border furrow; outline evenly curved with large rearward directed genal spine and anterior adaxial projecting band that in life was joined to corresponding band on opposing librigena (forming the yoke of Cleland, 1900; Ross, 1951; and Hintze, 1953); eyes not discernible.

Thoracic segments with strongly reflexed pleural regions; numbers of segments unknown. Pygidium and hypostoma unknown.

Discussion. The pair of spines at the rear of the cranidium is very distinctive and immediately indicates comparison with *Clelandia bispina* Ross from the Goodwin Limestone near Pyramid Peak, California. The similarities between the two species are striking and they are obviously very closely related but the pair of spines in *C. bispina* is directed posterodorsally (Ross, 1967, Pl. 10, figs. 9–13) whereas the pair in *C. wilsoni* is directed entirely rearward without any significant dorsal component (Pl. 2, fig. 3). Other but minor differences include the librigena, being narrower in *C. wilsoni,* and the posterior border furrow trending more transverse in *C. bispina* and crossing the facial suture onto the librigena before turning rearward.

The species is named in honour of L. A. Wilson of the United States Geological Survey.

Clelandia sp.

Plate 1, figures 19–21

Material, type, and occurrence. A single pygidium (hypotype GSC 23620); collected by J. D. Aitken, B. S. Norford, W. H. Fritz, R. J. Ross, Jr., and L. A. Wilson, 1965, from limestones at GSC locality 69776 within the Lower Canadian *Symphysurina–Euloma* Zone (Zone A) at 149–150 feet above the base of the Survey Peak Formation, Mount Wilson North section (52°02′N, 116°50′W), Alberta (Aitken and Norford, 1967, p. 199); associated fauna ?*Lingulepis* sp., orthid brachiopods, *Eobucania pulchra* Kobayashi, *Symphysurina* sp., *Clelandia albertensis* new species.

Dimensions. The pygidium (Pl. 1, figs. 19–21) is about $\frac{3}{4}$ mm long and $1\frac{1}{2}$ mm wide.

Description. Pygidium strongly arched, axial furrows indistinct; ring furrows, pleural furrows, and interpleural furrows not visible except for anterior ring furrow and anterior pleural furrows; no axial spines discernible; rear margin with a pronounced mesial scallop at crest of arch; three pairs of short marginal spines.

Discussion. The etched material from locality 69776 of the *Symphysurina–Euloma* Zone contains *Symphysurina* pygidia and two different kinds of pygidia that probably belong to *Clelandia.* Only one type of *Clelandia* cranidium can be recognized, that of *C. albertensis,* and the more common pygidium is considered to belong to that species. The other pygidium is represented by only one specimen. The only species of *Clelandia* known at present from the *Symphysurina–Euloma* Zone in western North America are *albertensis* and *texana* and this present pygidium perhaps may belong to *texana.*

Family OLENIDAE Burmeister 1843

Genus *Jujuyaspis* Kobayashi 1936

Jujuyaspis Kobayashi, 1936, pp. 89–90.
Jujuyaspis Kobayashi, Kobayashi 1955, pp. 466–467.
Jujuyaspis Kobayashi, Henningsmoen 1957, p. 261.
Jujuyaspis Kobayashi, Harrington and Leanza 1957, p. 97.
Jujuyaspis Kobayashi, Harrington and others 1959, p. 0266.

Type species: *Jujuyaspis keideli* Kobayashi 1936 from the zone of *Parabolina argentina* of the Lower Tremadoc Purmamarca Shales, northwest Argentina.

Jujuyaspis borealis Kobayashi 1955

Plate 2, figures 18–34

Jujuyaspis borealis Kobayashi 1955, pp. 467–468, Pl. 7, figs. 12, 13a, 13b.
Sphaerophthalmella inexpectans Kobayashi 1955, p. 464 (pygidium only), Pl. 7, fig. 11, *not* figs. 10a, 10b.
(?) *Jujuyaspis keideli* Kobayashi, Winston and Nicholls 1967, p. 75, Pl. 12, figs. 20, 23.
Jujuyaspis borealis Kobayashi, Aitken and Norford 1967, p. 182.

Material. Numerous cranidia, several librigenae, three pygidia, preserved in limestone.

Types and occurrence. Holotype cranidium GSC 12727, paratype cranidium GSC 12728, hypotype pygidium GSC 12721 (assigned by Kobayashi as a paratype of *Sphaerophthalmella inexpectans*); collected by C. S. Evans, 1925, from limestones at GSC loc. 8173 (Kobayashi's loc. 19) McKay Group, east slope of north end of Steamboat Mountain, British Columbia, at an altitude of 4,250 feet. Hypotype cranidia GSC 22892–22896 (first three are skinned), hypotype pygidium GSC 22897, hypotype librigena GSC 22898, and abundant other material; collected by J. D. Aitken from limestones at GSC loc. 57675 within the Lower Canadian *Symphysurina–Euloma* Zone (Zone A) at 229 feet above the base of the Survey Peak Formation, Mount Whiterose section (51°56½'N, 117°14'W), near Lyell Creek, British Columbia (Aitken and Norford, 1967, p. 182). Associated fauna: fragments of echinoderms and brachiopods, *Eobucania pulchra* Kobayashi, *Symphysurina brevispicata* Hintze, and *Clelandia texana* Winston and Nicholls. Hypotype librigena GSC 22899, hypotype pygidium 23610, and other material collected by J. D. Aitken, 1965, from the Survey Peak Formation of the Chaba River section(52°17'N, 117°47'W, GSC locs. 72815 and 72816), Alberta–British Columbia border. Associated fauna: echinoderm fragments, inarticulate and orthid brachiopods, ?*Eobucania* sp., *Symphysurina* sp., *Clelandia texana* Winston and Nicholls.

Dimensions. The holotype cranidium (Pl. 2, fig. 19) is 4.4 mm long (*sag.*) and 7.1 mm wide (*tr.*), hypotypes 22895 (Pl. 2, fig. 18) and 22894 (Pl. 2, fig. 30) are 6.7 and 10.1 mm long and 11.5 and 16.7 mm wide. Hypotype pygidium 22897 (Pl. 2, fig. 31) is 4.2 mm long and about 10.9 mm wide.

Description. Cephalon about twice as wide as long, strongly convex both in lateral and transverse profile, with most of the areas of the librigenae forming part of ventral surface. Ornament of extremely fine pits that are most pronounced on the librigenae and fixigenae. Cranidium broad at rear, narrow at front. Glabella slightly raised, slightly tapering forward with gently rounded anterolateral corners, axial furrows not strongly incised, preglabellar furrow faint, lateral glabellar furrows absent except for a faint pair of pits in axial furrows midway between posterior border furrow and palpebral lobe. Occipital furrow indistinct except in young forms (Pl. 2, fig. 33) where the median part is broad and shallow but distinct, peeled cranidia of all sizes (Pl. 2, fig. 23) show a broad shallow furrow that delimits a lenticular occipital ring that is medianly broad but abaxially very narrow; a slight swelling is present mesially, peeled specimens show a small node in this position, slightly forward of the ring's midlength. Frontal area without border or border furrow, very short mesially, with a gently rearward arcuate front formed by the facial suture. Palpebral lobes close to and opposite front third of glabella, somewhat raised above the abaxially downturning fixigenae, no eye ridges. Anterior part of fixigena small, depressed, with abrupt but rounded anterolateral corners; posterior part large, abaxially depressed with marked broad posterior border furrow that swings abaxially to trend almost forward; an unillustrated juvenile cranidium (about 2 mm long) bears a large stout metafixigenal spine. Facial sutures trending almost directly forward from front of palpebral lobes, curving abruptly before reaching anterior border furrow and running almost transverse to form a gently arcuate front to cranidium, joining mesially on dorsal surface; trending almost straight from rear of palpebral lobes, rearward of transverse, to posterior border furrow where they curve abruptly rearward and swing adaxially on posterior border to reach margin at about three fourths of the fixigenal width from glabella. Librigenae large, without genal spines, convex, with broad border furrow that is well developed except in front of cranidium; anteriomesial parts slightly bowed forward; genal angle smoothly rounded, an apparent genal spine is actually a part of the posterior border shaved by the reflexed posterior part of the facial suture.

Thoracic segments and hypostoma unknown.

Pygidium much wider than long, posterior margin evenly rounded; ornament of extremely fine pits and terrace lines near border. Axial region not quite as wide as pleural regions, strongly tapering, almost reaching posterior border furrow; composed of an articulating half-ring, four axial rings that bear sharp transverse crests and are separated by furrows that are well marked on the peeled specimen, and a small terminal segment. Pleural regions with broad shallow border furrow, peeled portion shows a set of pleural furrows.

Discussion. Henningsmoen (1957, p. 272) suggested that the pygidium that Kobayashi (1955, p. 464) assigned to *Sphaerophthalmella inexpectans* would be more appropriately placed in *Jujuyaspis borealis* from the same collection. The pygidium bears the same ornament as the holotype cranidium of *J. borealis,* and these two elements are also associated at Mount Whiterose (GSC loc. 57675), and Henningsmoen's suggestion can be accepted.

The species differs from *J. keideli* from Argentina as described by Harrington and Leanza (1957) by having a shorter pygidium with a proportionally smaller axis. The cranidia of the species are very similar but that of *keideli* has a shorter frontal area and is described as plane or very slightly convex but the specimens are preserved in shale and therefore may be somewhat flattened.

Some strongly convex cranidia from Texas have been described and illustrated by Winston and Nicholls (1967, p. 75) and assigned to *J. keideli.* The cranidia were described as lacking a frontal area but the best preserved specimens (UT 12634, Winston and Nicholls, 1967, Pl. 12, fig. 20; and an unfigured large specimen from locality SS 491.5) show that a short frontal area is developed. The Texas material very probably belongs to *J. borealis* but no pygidium was described and thus the specimens cannot be rigorously compared with either *borealis* or *keideli.*

Jujuyaspis angusta and *J. keideli norvegica* were described from Norway by Henningsmoen (1957, pp. 261–264). Both have proportionally longer pygidia than *J. borealis* and the eyes of *angusta* are sited farther back.

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LATEST SILURIAN GRAPTOLITES FROM PORCUPINE RIVER, YUKON TERRITORY

by D. E. Jackson[1] and A. C. Lenz[2]

Abstract

Some previously unrecorded graptolites are described from a section of the uppermost Road River Formation on Porcupine River. They include *Linograptus posthumus tenuis* Jaeger, *Monograptus* aff. *M. angustidens* Přibyl, *M. bugensius* (Teller), *M. chelmiensis* (Teller), ?*M. crinitus* Wood, *M.* aff. *M. kosoviensis* Bouček, and *M. paraformosus* n. sp. These species were collected through approximately 100 feet of section and indicate late Kopaninan ($e\beta^1$) and early Přidolian ($e\beta^2$) ages for the beds. This is the first documentation of faunas of Přidolian age in Canada. Poorly preserved Early Devonian monograptids and abundant tentaculitids are known from rocks higher in the section.

Résumé

Description de certains graptolites non classés antérieurement, provenant d'une coupe de la partie supérieure de la formation Road River, sur la rivière Porcupine. Il s'agit du *Linograptus posthumus tenuis* Jaeger, du *Monograptus* aff. *M. angustidens* Přibyl, du *M. bugensius* (Teller), du *M. chelmiensis* (Teller), du ?*M. crinitus* Wood, du *M.* aff. *M. kosoviensis* Bouček, et du *M. paraformosus* n. sp. Ces espèces ont été recueillies dans une coupe de quelque 100 pieds, et situent l'âge des couches du Kopaninien récent ($e\beta^1$) et au Přidolien ancien ($e\beta^2$). Cette étude constitue la première documentation relative à la faune du Přidolien au Canada. Des monograptidés du Dévonien ancien en piètre état de conservation, et un nombre abondant de tentaculites sont connus dans les roches situées plus haut dans la coupe.

Introduction

Knowledge of the Late Silurian graptolite faunal succession on the mainland of northwestern Canada is rather meagre. Between the widely recognized *M. nilssoni*

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Zone of early Ludlovian age and the Early Devonian *M. yukonensis* Zone, there occurs about 1,000 feet of shale in which are usually found only beds yielding *M. bohemicus* and *M.* cf. *M. leintwardinensis.* In contrast, a dozen or so zones occur in this interval in eastern Europe. No previous publications contain records of Přidolian graptolites from northwestern Canada and the present paper documents Přidolian faunas from the Eagle Plains of Yukon Territory.

Very young Silurian graptolites collected by the Geological Survey of Canada in 1962 were sent to one of us (D.E.J.) for further study. The material was collected by B. S. Norford from the lower Porcupine River (Fig. 1, loc. 7) and is of great value because the faunas were carefully collected through 200 feet of section (Norford, 1964, pp. 121–122, 137). This suite forms the basis of the paper. Reference is made also to material from this same locality collected in 1961 by J. Craig, Imperial Oil Enterprises Ltd. These collections, sent (to A.C.L.) for further study, contain useful supplementary material.

Acknowledgments

The authors wish to thank Imperial Oil Enterprises Ltd. for providing material and for permission to publish data derived from their collections. We are indebted to J. Craig and B. S. Norford for making available pertinent stratigraphic and outcrop data; and to B. Bouček for his comments on Imperial Oil material during his visit to Canada in 1967. Invaluable stenographic and photographic services were provided by Mrs. P. McIntyre and F. Dimitrov of the University of Alberta. The manuscript has been critically read by R. Thorsteinsson of the Geological Survey of Canada.

Stratigraphy

Lithology and faunas. Norford (1964, pp. 119–122) describes the lower Porcupine River section as occurring in "River bluffs . . . (67°34′N, 138°10′W) on the north bank of Porcupine River 7 miles above its junction with Driftwood River." In this vicinity (Fig. 1, loc. 7) Norford measured 247 feet of shales of the upper part of the Road River Formation. These beds dip southeastward at 25–55 degrees. Norford's description of the strata and our identifications of the graptolites follow:

Road River Formation (incomplete)

Unit 2 (78 ft.) "Shale, limy, grey-black, weathers grey-black with off-white mineral dusting, very recessive, fissility poor to excellent (paper-shale); with two thin beds (½ and 1 inch) of limy chert at 237 [ft.]. Covered interval at 169–218 [ft.]."

GSC LOC.	FOOTAGE	FAUNA
53252	238, 0–2 ins.	*Monograptus* aff. *M. yukonensis* Jackson and Lenz *Nowakia*-like tentaculitids
53251	232–234	*Nowakia*-like tentaculitids
53250	219–223	*Monograptus* aff. *M. yukonensis* Jackson and Lenz

Unit 1 (169 ft.) "Shale, non-limy, grey-black, weathers dark grey, recessive, fissility moderate to good; about 15% cherty argillite at 11–20 [ft.] and 8-inch bed of soft, non-fissile, black argillite at 87 [ft.]. Covered intervals at 20–27, 35–44, 57–63, 127–138, 149–150 and 157–162 [ft.]."

Road River Formation, Unit 1 (cont.)

GSC LOC.	FOOTAGE	FAUNA
53249	126–127	*Monograptus* cf. *M. thomasi* Jaeger
53248	107–108	*Monograptus* cf. *M. chelmiensis* (Teller) *M.* sp. indet. ?*Linograptus* sp.
53247	69–70	*Monograptus* cf. *M. chelmiensis* (Teller) ?*Linograptus* sp.
53246	65–66	*Monograptus* cf. *M. chelmiensis* (Teller) ?*Linograptus* sp.
53245	53–54	*Monograptus chelmiensis* (Teller) *M.* aff. *M. paraformosus* n. sp. *M.* sp. indet. ?*Linograptus* sp.
53244	48–49	*Monograptus chelmiensis* (Teller) *Linograptus* cf. *L. posthumus posthumus* (R. Richter)
53243	34–35	*Monograptus* aff. *M. fecundus* Přibyl
53242	11–15	*Monograptus* aff. *M. kosoviensis* Bouček *M. paraformosus* n. sp. *Linograptus posthumus tenuis* Jaeger
53241	2–7	*Monograptus* aff. *M. angustidens* Přibyl ?*M. crinitus* Wood *M.* aff. *M. kosoviensis* Bouček *M. paraformosus* n. sp. *M.* sp. indet. *Linograptus posthumus tenuis* Jaeger

The Imperial Oil collection, from this same general locality, has no exact counterpart in any single or combination of Survey collections but was probably collected from between 15 and 35 feet of Norford's section. Individual slabs of rock carry the following associated forms:

Slab 1 *Monograptus chelmiensis* (Teller), *M.* cf. *M. paraformosus* n. sp., *Linograptus posthumus tenuis* Jaeger
Slab 2 *Monograptus* aff. *M. angustidens* Přibyl, *M. bugensius* (Teller)
Slab 3 *Monograptus bugensius* (Teller), *M. paraformosus* n. sp., *Linograptus posthumus tenuis* Jaeger
Slab 4 *Monograptus paraformosus* n. sp., *Linograptus posthumus tenuis* Jaeger

Age of faunas. The lack of the *M. nilssoni* Zone below the faunas and of definitive marker beds above makes age assignments somewhat difficult. By direct comparison with the continental European successions in Czechoslovakia and Poland, the Porcupine River faunas from the lower 15 feet of the section (GSC locs. 53241 and 53242) most probably represent the *M. formosus* Zone, i.e., latest Kopaninan ($e\beta^1$). This correlation is based on the belief that *M. formosus* and *M. paraformosus* represent vicarious geographic variants. Furthermore, *M. kosoviensis* is last seen at this level and *L. posthumus tenuis* is not known above the basal Přidolian.

The Imperial Oil collection apparently represents, in part (slab 2 and perhaps slab 3) at least, the basal Přidolian *M. bugensius* Zone of Poland (Teller, 1964) where *M. bugensius* is confined to the zone. Some of the material (slabs 1 and 4, respectively) may have come from beds considered time equivalent to the *M. chelmiensis* Zone above and the *M. formosus* Zone below (Fig. 2).

	STAGE / SPECIES	*M. angustidens*	*M. bugensius*	*M. chelmiensis*	*M. formosus*	*L. posthumus posthumus*	Graptolite zones of eastern Poland (Chelm bore-hole, Teller, 1964)
UPPER SILURIAN	PŘIDOLIAN $(e\beta^2)$	×				×	*angustidens*
		?				×	*transgrediens*
						×	*perbrevis*
						×	*admirabilis*
						×	*perneri*
						×	*bouceki*
				×		×	*samsonowiczi*
				×		×	*chelmiensis*
			×		?	×	*bugensius*
	KOPANINAN $(e\beta^1)$				×	×	*formosus*
							?
							leintwardinensis

FIGURE 2. Ranges of some of the European graptolite species conspecific with, or having a close affinity to, graptolites of lower Porcupine River, Yukon Territory.

Faunas from between 48 and 70 feet are assigned to the Přidolian $(e\beta^2)$ Zone of *M. chelmiensis* on the basis of *M. chelmiensis* which ranges through 66 metres of shale in the Chelm bore-hole (Teller, 1964). Linograptid fragments associated with this species exceed the widths normally associated with *L. posthumus tenuis* and probably represent *L. posthumus posthumus,* which adds support to the age assignment.[1]

Beds between 127 and 219 feet are almost entirely covered by modern fluvial deposits and the few beds that are exposed yielded no graptolites. Monograptids and tentaculitids from between 219 and 238 feet (GSC locs. 53250–53252) are indifferently preserved but are suggestive of the *M. yukonensis* Zone of Early Devonian age.

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[1] After the completion of the manuscript of this paper, further field studies have shown that the *M. chelmiensis* Zone is also present at Hart River and Prongs Creek.

Systematic Paleontology

Prefixes GSC refer to specimens in the type collection of the Geological Survey of Canada, Ottawa. Some forms included in the list of identifications have not been described due to poor preservation. These include *Monograptus* aff. *M. fecundus* Přibyl, *M.* cf. *M. thomasi* Jaeger, *M.* cf. *M. yukonensis* Jackson and Lenz, *M.* aff. *M. yukonensis,* and *Linograptus* cf. *L. posthumus posthumus* (R. Richter).

Order GRAPTOLOIDEA

Family MONOGRAPTIDAE Lapworth 1873

Genus *Linograptus* Frech 1897

Linograptus posthumus tenuis Jaeger 1959

Plate 4, figure 3

Linograptus posthumus tenuis Jaeger 1959, p. 153, Pl. 8, figs. 1, 2.

Material. GSC hypotype 21294 and four other partly complete rhabdosomes and many fragmentary stipes preserved as silvery films on black shale.

Description. Rhabdosome poorly preserved, apparently formed of seven to eight branches radiating outwards from a common point of origin. Stipes straight to sinuous, commonly bent or broken; longest observed 13 mm; initial width 0.25–0.3 mm, increasing very gradually to a maximum of 0.4–0.45 mm distally.

Thecae simple, essentially dichograptid or weakly sigmoidal, ventral margin may become essentially parallel to stipe axis distally. Thecae 1.5–1.7 mm long, 0.15–0.25 mm wide, overlap about one sixth proximally to one quarter distally, ten to seven thecae in 10 mm, inclined at about 8 degrees to stipe axis. Sicula not visible.

Discussion. Linograptus posthumus tenuis is characterized by having seven or eight radiating stipes and narrow delicate stipes bearing simple dichograptid thecae. The latter feature immediately distinguishes the *posthumus* group from *L. phillipsi phillipsi* Decker and *L. phillipsi multiramosus* Decker which have retroverted thecae (Decker, 1935).

Occurrence. This subspecies is known from several localities yielding Ludlovian faunas in the Yukon Territory. On the lower Porcupine River it has been positively identified from the lowest 15 feet of the measured section (GSC locs. 53241 and 53242) where it is associated with *Monograptus* aff. *M. angustidens, ?M. crinitus, M.* aff. *M. kosoviensis,* and *M. paraformosus.* The association of this subspecies with *M. bugensius* in the Imperial Oil collection indicates that it does indeed range into the Přidolian Stage as Jaeger (1959) suspected. In Europe, the subspecies has never been positively identified from strata of this age.

Genus *Monograptus* Geinitz 1852

Monograptus aff. *M. angustidens* Přibyl 1940

Plate 3, figures 6–9; Plate 5, figure 7

aff. *Monograptus (Pomatograptus) angustidens* Přibyl 1940, pp. 70-71, Text–figs. 1, 2, Pl. 1, figs. 3, 4.

Material. Three specimens, GSC hypotypes 21274, 21276, 21277, preserved as silvery films on black shale; GSC loc. 53241, 2–7 feet above base of measured section of Road River Formation; collected by B. S. Norford, 1962. Several other specimens are available from the same general locality but lack close stratigraphic control. These include GSC hypotypes 21278 and 21279; field designation PR1-61-143; collected by J. Craig, Imperial Oil Enterprises Ltd., 1961.

Description. Rhabdosome medium sized, largest specimen 33 mm long; dorsal edge displays slight dorsal curvature between th$^{1-8}$, becoming straight distally or with slight ventral curvature beyond th^{10}; a prominent virgula is commonly seen. Width increases gradually from 0.8 mm (range 0.8–1.0; inclusive of hood-like process) at aperture of th^1 to 1.2–1.7 mm at th^{10} and a maximum of 1.6–1.9 mm distally. Interthecal widths at these levels are 0.4–0.5 mm, 1.0–1.4 mm, and 1.1–1.6 mm, respectively. A medial row of pits, possibly coinciding with the bases of the interthecal septa, is prominent between th$^{1-10}$ and in hypotype 21274 extends to th^{20}.

Thecae uniform, of *uncinatus* type, appear hooked especially proximally because of hood-like dorsal shields over thecal apertures. These processes are well developed proximally where they obscure thecal apertures, but distally the hoods become shorter and less down-curved, leaving visible the concave, slightly thickened rims of the thecal apertures. Free ventral walls slightly sigmoidal, inclined at about 10 degrees to axis of rhabdosome; interthecal septa curved strongly near thecal aperture and continuing beyond apertures as hood-like dorsal shields.

Sicula dorsally deflected, 0.3–0.4 mm wide at aperture, apex extends to level of th^2 aperture; carries a short stout dorsal process and short virgella.

Hypotype (GSC)	Length	Total number thecae	Rhabdosome width			Maximum distally	Thecae in 5 mm	
			th^1	th^5	th^{10}		Proximally	Distally
21274	25	25	0.8(0.5)[1]	1.0(0.8)	1.2(1.0)	1.6(1.2)	6	5
21276	25	+22	?0.8(0.5)	1.1(0.9)	1.4(1.1)	1.6(1.2)	6	5
21277	25	27	?0.6(0.4)	1.1(0.6)	1.4(1.0)	1.8(1.1)	6	5
21278	19	+18	0.8(0.5)	1.3(1.0)	1.7(1.4)	1.9(1.4)	5½	4¾
21279	19.5	21	0.8(0.4)	1.4(0.9)	1.7(1.2)	1.9(1.6)	6	5

Measurements in mm

[1] Figures in brackets are interthecal widths measured immediately above aperture.

Discussion. In the delicate nature of the proximal part of the rhabdosome the Yukon species is similar to *M. thomasi* Jaeger, but the stretched appearance of the proximal end (Jaeger, 1966, pp. 404, 407), together with its lesser width distinguish *M. thomasi* from the Yukon species. *Monograptus* aff. *M. angustidens* differs from *M. praehercynicus* Jaeger and *M. uniformis* Přibyl by being narrower and having a more delicately tapered proximal end. Differences which set it apart from *M. uncinatus* Tullberg are its narrow and dorsally curved proximal end and the decreasing size and strength of hoods distally. *Monograptus bouceki* Přibyl has less pronounced proximal dorsal curvature, is wider across th^1, narrower distally, and has thecal extremities of different shape.

While the general shape and dimensions of the rhabdosome and the character of the thecae of *M.* aff. *M. angustidens* suggest a likeness to *M. angustidens,* the pronounced dorso-ventral curvature and the narrowly tapered proximal end of the rhabdosome of the Yukon material seem to exclude it from that species. Furthermore, *M. angustidens* in continental Europe is confined to latest Přidolian strata although Bouček (pers. com. to A.C.L., 1967) suggests that *M. angustidens* may well occur in the older Přidolian and equivalent beds. Because of the relatively few specimens at hand, the Yukon species is only tentatively compared to *M. angustidens,* but Bouček, who has examined some of the specimens, opined that they are very close to *M. angustidens* (*sensu stricto*). The Yukon species differs from descriptions of the Polish species in having an angular relationship between the free ventral wall of the thecae and the rhabdosome axis; however, a close examination of Teller (1964, Pl. VIII, fig. 2) suggests that this may not be an important distinction. Further differences exist in the curved interthecal septa and the coarser character of the thecal hoods of the Yukon material but this may in part be due to the nature of preservation.

An undescribed species of *Monograptus* (Lenz, 1968, p. 593) occurs with the Early Devonian *M. yukonensis* Jackson and Lenz, and bears a resemblance to *M.* aff. *M. angustidens* in the character of its thecae, and in the dorsally curved proximal part. Like other Early Devonian monograptid species (for example, *uniformis* and *praehercynicus*), it is readily distinguished from Silurian species such as *M. angustidens* by its larger size and by possessing only 10–9 thecae in 10 mm.

Occurrence. At GSC loc. 53241, this form is associated on the same bedding plane with *M.* aff. *M. kosoviensis, ?M. crinitus, M.* sp. indet., and *L. posthumus tenuis.* In the collection made by Imperial Oil Enterprises Ltd., *M.* aff. *M. angustidens* occurs alongside *M. bugensius.*

Monograptus bugensius (Teller 1964)

Plate 3, figures 1–4; Plate 5, figures 2–4

Pristiograptus bugensius Teller, 1964, p. 40, Pl. II, figs. 4, 5, 9; Pl. VII, figs. 13–15; Pl. IX, figs. 1–3; Text–figs. 4a–e.

Material. Specimens in various growth stages preserved as silvery films on black shale; Road River Formation; measured specimens include GSC hypotypes 21281–21285; collected by J. Craig, Imperial Oil Enterprises Ltd., 1961.

Description. Rhabdosome short, maximum length observed 10 mm, may be weakly curved dorsally between th^{2-4}, ventrally curved between th^{5-6}, and thereafter straight. Width across aperture of th^1 is 1.1 mm, increasing gradually to a maximum of 1.7 mm (average, 1.5 mm) attained about th^{5-6}, thereafter width may remain constant, or show a slight decrease distally. Interthecal widths above th^1 and th^5 are 0.7 mm and 1.0–1.2 mm, respectively.

Thecae biform, th^1 distinctly hooked, th^2 and th^3 slightly hooked, remainder essentially straight. Free ventral wall of distal thecae typically slightly sigmoidal, 0.7–0.8 mm long, inclined at 30 to 50 degrees (40° common) to dorsal edge of rhabdosome. Apertures of thecae sigmoidal, forming acute angle with longitudinal axes of thecae, with down curved apertural margins, forming distinct thecal lips. Interthecal septa straight in distal thecae but rarely visible, thecae are about 1.2–1.3 mm long proximally, 1.6–1.8 mm long and 0.4–0.5 mm wide distally, present at the rate of 6 to $6\frac{1}{2}$ in 5 mm.

Sicula ventrally deflected, apex reaching to the level of the middle of th^3; about 2.0–2.1 mm long; aperture 0.4 mm wide; virgella 0.5–0.6 mm long.

Hypotype (GSC)	Length	Total number thecae	Rhabdosome width th^1	th^5	Maximum distally	Thecae in 5 mm proximally
21281	10	12	1.1(0.7)[1]	+1.3(0.9)	+1.3(0.9)th^5	6½
21282	8.6	10	1.1(0.75)	1.7(1.2)	1.7(1.2)th^5	6½
21283	7	+ 6	1.1(0.7)	1.6(1.0)	1.6(1.0)th^5	6½?
21284	6	7	1.1(0.7)	1.5(1.1)	1.5(1.1)th^5	6½
21285	5.7	7	1.1(0.8)	1.4(1.0)	1.4(1.0)th^5	6

Measurements in mm

[1] Figures in brackets are interthecal widths measured immediately above aperture.

Discussion. Monograptus bugensius is distinct from any previously recorded species from northwestern Canada. Like the Polish specimens, it is characterized by two to four hooked proximal thecae and by distal thecae whose apertural margins vary from sharp margins to distinct lips. It is worth noting that the term "hooked" used to describe the profile of the proximal thecae in this species and in M. *chelmiensis* may be misleading for it seems quite possible that such thecae are not hooked in the sense of M. *priodon* but have apertures comprising a medial distal cleft as in some three dimensional cyrtograptids. The Yukon specimens differ slightly from the Polish material in that they are, in general, shorter (although most of the Yukon specimens are obviously incomplete), and have the apparent tendency to narrow in the distal portion of the rhabdosome. Although not specifically mentioned by Teller, his illustrations (*see,* for example, Pl. II, fig. 9; Pl. IX, fig. 3) suggest that at least some of the Polish specimens possess this tendency. In all other respects the Yukon and Polish specimens are alike.

Occurrence. In Canada, this species is known only from the lower Porcupine River, where it occurs on the same bedding planes with *M.* aff. *M. angustidens, M. paraformosus,* and *Linograptus posthumus tenuis.*

Monograptus chelmiensis (Teller 1964)

Plate 5, figures 5, 8, 9

Pristiograptus chelmiensis Teller, 1964, p. 45, Pl. III, figs. 5, 6; Pl. IV, figs. 1, 6-8; Pl. VII, figs. 1-7; Pl. XIII, fig. 6; Text–figs. 7a-c.

Material. About twenty specimens in various stages of growth preserved as silvery films on black shale; including measured specimens GSC hypotypes 21286 to 21291; GSC locs. 53244 and 53245, 48 to 54 feet above base of measured section of Road River Formation; collected by B. S. Norford, 1962.

An additional twenty or so specimens from this same general locality were provided by Imperial Oil Enterprises Ltd. These include the measured specimens GSC hypotypes 21292 and 21293, exact stratigraphic position unknown; field designation PR1-61-143, collected by J. Craig, 1961.

Description. Rhabdosome large, maximum observed length 54 mm; straight except for slight ventral curvature between th$^{6-7}$. Width across aperture of th^1 is 1.0 mm

(±0.1), widening to 1.5 to 1.9 mm at th^{10}, and to a maximum width of 2.0 to 2.4 mm beyond th^{12}. Interthecal widths at these levels are 0.6 to 0.8 mm, 1.0 to 1.5 mm, and 1.4 to 2.0 mm, respectively.

Thecae biform, th^{1} distinctly but not strongly hooked, th$^{2-3}$ and rarely th^{4} weakly hooked, remainder of thecae essentially straight and tubular. Free ventral wall of medial thecae straight to slightly sigmoidal; apertural margin concave, and either perpendicular to, or forming an acute angle with free ventral wall, resulting in a sharp slightly protruding apertural margin. Thecae 1.8 to 2.0 mm long proximally, increasing to 3.0 to 3.5 mm distally, 0.5 to 0.6 mm wide; overlapping one half proximally and about two thirds distally; ten to twelve thecae in 10 mm proximally, reducing to nine to seven distally, inclined at 30 to 38 degrees to axis of rhabdosome. A row of several small nodes or pits midway between dorsal and ventral edges can be seen at proximal end of rhabdosome.

Sicula ventrally deflected, apex reaching to base of th^{3}; 2.0–2.3 mm long inclusive of a ventrally curved dorsal process; aperture 0.5 mm wide; virgella up to 0.8 mm long.

Hypotype (GSC)	Length	Total number thecae	Rhabdosome width			Maximum distally	Thecae in 10 mm	
			th^{1}	th^{5}	th^{10}		Proximally	Distally
21286	32	29	1.1(0.7)[1]	1.6(1.3)	1.8(1.3)	2.0(1.5)th^{12}	11	9
21287	+20	+20	1.1(0.75)	1.5(1.3)	1.9(1.5)	2.0(1.7)th^{11}	11	9
21288	+28	+26	0.9(0.7)	1.5(1.3)	1.8(1.5)	2.0(1.5)th^{17}	—	9
21289	+54	+46	?1.0(0.8)	1.9(1.1)	1.5(1.2)	2.4(2.0)th^{39}	10½	7
21290	+26	+25	1.0(0.6)	1.3(0.8)	1.5(1.0)	1.7(1.4)th^{17}	11	10
21291	+12	+11	1.1(0.7)	1.6(1.2)	1.9(1.3)	—	11½	—
21292	47	42	0.9(0.7)	+1.1(0.9)	1.5(1.1)	2.0(1.6)th^{29}	11¾	8
21293	44	41	1.0(0.75)	1.1(0.8)	1.4(1.1)	2.4(1.8)th^{38}	11	8½

Measurements in mm

[1] Figures in brackets are interthecal widths measured immediately above aperture.

Discussion. The Yukon species differs from the Chelm species in only minor aspects, particularly in having a greater range in spacing of thecae, namely, 11¾–7 in 10 mm in the Yukon specimens compared to 10–8 per 10 mm in the Polish material. The Yukon material also seemingly differs in the crowded appearance of the distal thecae of some specimens, and the possession of nodes, or pits at the bases of interthecal septa. An examination of Teller (1964), however, shows that crowded thecae (Pl. III, fig. 6) and possession of thecal nodes or pits (Pl. IV, fig. 8) are characteristic of at least some of the Polish specimens. *Monograptus chelmiensis* can be distinguished from *M. transgrediens* (Perner) only with great difficulty and it would seem probable that the two forms are merely subspecifically distinct. Because of the supposed stratigraphic significance of the two species (lower Přidolian, and upper Přidolian, respectively) the distinction, *albeit* a fine one, may be useful, although Bouček (pers. com. 1967) suggests that *M. transgrediens* has a range considerably beyond that of the *M. transgrediens* Zone. *M. chelmiensis* appears to differ from *M. transgrediens* as conceived by Teller (1964) in being, in general, narrower, and by the smaller inclination of its thecae. The apparent greater crowding of distal thecae and the possession of thecal nodes or pits may be additional criteria.

Occurrence. This is the first recorded occurrence of *M. chelmiensis* in North America. It has a known range through 6 feet of shale at lower Porcupine River where it is associated with *Linograptus* cf. *L. posthumus posthumus, Monograptus* aff. *M. paraformosus* and *M.* sp. indet. In a collection from the same general locality made by J. Craig (*see under* Material), *M. chelmiensis* is associated with *M. bugensius.*

?*Monograptus crinitus* Wood 1900

Plate 3, figure 10

Monograptus crinitus Wood, 1900, pp. 480–481; Text-figs. 23a–d; Pl. 25, figs. 26 a, b.

Material. GSC hypotype 21266 and hundreds of fragments preserved as silvery films on black shale; GSC loc. 53421, 2–7 feet above base of measured section of Road River Formation; collected by B. S. Norford, 1962.

Description. Largest fragment 32 mm long, many fragments straight, proximal details of rhabdosome unknown.

Width of rhabdosome variable depending on position relative to sicula, the most slender fragments being 0.4 mm wide inclusive of apertural hood (0.2 mm excluding hood) and the broadest fragments 0.8 mm wide (0.5 mm excluding hood).

Thecal form obscure, free ventral wall parallel to dorsal edge of rhabdosome, thecal tubes do not expand towards aperture. Thecal apertures appear as slit-like excavations which are usually hidden by a hood which projects 0.2–0.3 mm beyond free ventral edge in largest fragments. Thecae are present at spacings of 5 per 10 mm in distal fragments and 7 per 10 mm in proximal fragments.

Discussion. This material compares closely with *M. crinitus* Wood from the *M. nilssoni* Zone in Britain.

Occurrence. On same bedding plane as *M. paraformosus* n. sp. and *M.* aff. *M. angustidens.*

Monograptus aff. *M. kosoviensis* Bouček 1931

Plate 3, figure 5; Plate 5, figures 1, 6

Monograptus kosoviensis Bouček, 1931, p. 294, Text-figs. 1c, d.

Material. GSC hypotypes 21260–21265, in various stages of growth, preserved as silvery films on black shale; GSC locs. 53421 and 53422, 2–15 feet above base of measured section of Road River Formation; collected by B. S. Norford, 1962.

Description. Rhabdosome large, up to 72 mm long, with straight dorsal margin, widening from 0.7–0.8 across aperture of th^{1} (0.6–0.7 immediately above aperture) to 1.3–1.6 at th^{10} (1.0–1.1 mm immediately above aperture) and attaining a maximum width of 2.3 mm at about th^{30}, thereafter diminishing slightly to 2.0 mm distally. A virgula 3.0 mm long can be seen in hypotype 21260.

Thecae uniform, straight tubes, interthecal septa straight, free ventral wall with slight convex curvature, apertural margin concave. Thecae about th^{30} are 3.5 mm long and 0.6 mm wide, inclined at 30 degrees to the axis of the rhabdosome distally, present at rate of 10 to 11½ per 10 mm proximally reducing to 7 to 8 per 10 mm distally. All specimens display vertical row of pits midway between dorsal and ventral edges of proximal end of rhabdosome. These pits are considered to be areas of thickening at the bases of the interthecal septa.

Hypotype (GSC)	Length	Total number thecae	Rhabdosome width th^{1}	th^{5}	th^{10}	Maximum distally	Thecae in 10 mm Proximally	Distally
21260	72	60	0.7(0.6)[1]	1.2(1.0)	1.5(1.1)	2.3(1.8)th^{32}	11½	7¾
21261	+37	32	0.8(0.6)	1.0(0.7)	1.3(1.0)	2.0(1.6)th^{32}	11	7
21262	15	14	0.8(0.6)	1.1(0.9)	1.3(1.1)	1.5(1.3)th^{13}	10½	—
21263	+12	12	0.7(0.6)	1.1(0.8)	1.3(1.0)	1.4(1.2)th^{11}	11½	—
21264	+12.5	12	0.8(0.7)	1.3(1.0)	1.6(1.1)	1.6(1.2)th^{11}	10	
21265	31	29	0.8(0.6?)	1.2(1.0)	1.6(1.1)	1.8(1.5)th^{13}	10½	8

Measurements in mm

[1] Figures in brackets are interthecal widths measured immediately above aperture.

Sicula slightly ventrally deflected, apex extends to base of th^{3}, 2.0 mm long in hypotype 21264, 0.4–0.5 mm wide at aperture, with short dorsal tongue and delicate virgella.

Discussion. The greater width and larger thecal count of this straight monograptid separates it from *M. fecundus* Přibyl, *M. kolednikensis* Přibyl, *M. spectatus* Přibyl, and varieties of *M. dubius* (Suess), but the thecal count is markedly less than in *M. kosoviensis* itself. The species appears to differ from *M. graciosus* Přibyl in having less pronounced ventral curvature.

Occurrence. Known only from the lower Porcupine River; on the same bedding plane as *M.* aff. *M. angustidens, ?M. crinitus,* and *M. paraformosus,* where the form has a known range through the basal 15 feet of Norford's measured section. It is associated on the same bedding planes with *M.* aff. *M. angustidens, ?M. crinitus,* and *M. paraformosus* at GSC locs. 53421 and 53422.

Monograptus paraformosus new species

Plate 4, figures 1, 2, 4

Monograptus aff. *M. formosus* Bouček, Norford 1964, p. 137.

Material and types. GSC holotype 21267, GSC paratypes 21268–21273, and more than fifty other specimens in various growth stages preserved as silvery films on black shale; GSC loc. 53241, 2–7 feet above base of measured section of Road River Formation; collected by B. S. Norford, 1962.

Description. Rhabdosomes average 20 mm long, probably exceed 40 mm in larger specimens, with dorsal curvature throughout but most pronounced proximally so that rhabdosome turns through 90 degrees before th^{10}. A delicate virgula commonly seen.

Width inclusive of apertural process increases gradually from 0.9 (±0.1) at th^{1} to a maximum of about 1.4 mm between th$^{10-20}$; interthecal width increases from about 0.15 mm above th^{1} aperture, to 0.2 mm above th^{5} and a maximum of 0.5 mm between th$^{10-20}$.

Thecae uniform, of triangulate type, isolate, with slightly reflexed apertures and curved dorsal shield, giving impression that metathecae are strongly hooked, 8 to 10 per 10 mm throughout. Isolate portion increases in length from 0.6 mm at th^{1} to 1.2 mm distally. Several rhabdosomes display apertural processes twisted through 90 degrees during burial indicating dorsal shields are transversely widened as in isolate specimens of *Monograptus spiralis* but are without transverse spinose processes (*see* Pl. 4, fig. 4).

Sicula about 1.3 mm long, apex extending to aperture of th^{2}; aperture of sicula 0.3–0.5 mm wide; with short stout dorsal process and delicate virgella spine 0.7 mm long.

Holotype Paratypes (GSC)	Length	Total number thecae	Rhabdosome width			Maximum distally	Thecae in 5 mm	
			th^{1}	th^{5}	th^{10}		Proximally	Distally
21267	22	21	0.7(0.2)[1]	1.0(0.3)	1.3(0.5)	1.3(0.4)th^{18}	4	5
21268	22	21	0.8(0.15)	1.2(0.25)	1.4(0.4)	1.5(0.5)th^{19}	4	4
21269	16	16	0.6(0.15)	1.1(0.2)	1.1(0.35)	1.35(0.45)th^{13}	4	4½
21270	+14	+13	0.85(0.15)	1.3(0.3)	1.4(0.5)	1.4(0.5)th^{10}	4½	4
21271	9	8	1.0(1.5)	1.2(0.25)	—	1.4(0.35)th^{7}	4	—
21272	37	34	—	—	—	1.6(0.5)	—	4½
21273	16	17	0.8(0.15)	+0.9(0.22)	+1.0(0.4)	1.4(0.45)th^{15}	4½	4

Measurements in mm

[1] Figures in brackets are interthecal widths measured immediately above aperture.

Discussion. This species is comparable to *Monograptus convexus* Přibyl 1940, later considered by Přibyl (1948, p. 49) to be a junior synonym of *M. formosus* Bouček 1931, also from the *M. ultimus* Zone.

Compared to the type series of *M. formosus,* our material is slightly wider with more closely spaced thecae but these differences alone do not necessarily exclude it from that species. The principal criterion which sets it apart from *formosus* is the presence of curved, transversely widened dorsal shields beyond the thecal apertures. In the event that such processes are recognized in the European material of *formosus* this species may be considered a junior synonym of that species.

Occurrence. Presently known only from GSC locs. 53241 and 53242 and from the Imperial Oil collections, all on lower Porcupine River where it is associated with *Linograptus posthumus tenuis, ?Monograptus crinitus, M.* aff. *M. kosoviensis,* and *M.* aff. *M. angustidens.* Some 30 feet above these collections, Norford collected an allied form identified here as *M.* aff. *M. paraformosus* which differs from the new species in having weaker dorsal curvature and being narrower viz., 0.5 (0.1) mm at th^{1}, 0.9(0.22) mm at th^{5}, and 0.95(0.4) mm at th^{10}.

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DEVONIAN NAUTILOIDS FROM NORTHERN CANADA

by D. H. Collins[1]

Abstract

Three faunas of nautiloids are described from the northwestern mainland and the arctic islands.

Five species from the type area of the Eids Formation on Ellesmere Island have elements in common with the Russian Eifelian. Two species from the Landry Formation of western District of Mackenzie are almost identical to species from the Eifel region of Germany. Collections from the Prongs Creek Formation of the northern Yukon include *Leurocycloceras superplenum* new species and two actinocerids that have internal structures intermediate between those of the Devonian Ormoceratidae and the Carboniferous Carbactinoceratidae.

Folioceras segmentum new genus, new species, is described from the Eids Formation. *Folioceras* is the only member of the Folioceratidae, a new family which has greatest affinity with the Orthocerida.

Résumé

Description de trois groupes de nautilidés provenant du nord-ouest du continent et des îles arctiques.

Cinq espèces de la formation Eids de la région typique (île Ellesmere) ont des éléments communs avec ceux rencontrés dans l'Eifélien russe. Deux espèces relevées dans la formation Landry, secteur ouest du district de Mackenzie, sont pratiquement identiques aux espèces de la région Eifel de l'Allemagné. Les exemplaires recueillis dans la formation de Prongs Creek, partie septentrionale du Yukon, comprennent la nouvelle espèce *Leurocycloceras superplenum,* et deux actinocéras dont les structures internes sont intermédiaires entre celles des ormocératidés du Dévonien et les carbactinoceratidés du Carbonifère.

Description du *Folioceras segmentum,* nouveau genre et nouvelle espèce de la formation Eids. Le *Folioceras* est l'unique membre des foliocératidés, de famille nouvelle ayant de nombreuses affinités avec les orthocératidés.

Introduction

Few nautiloid cephalopods have been described from the Devonian of northern Canada although occurrences of nautiloids have commonly been noted in faunal lists. Foerste's (1926) report on the Devonian cephalopods of southwest Ellesmere

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[1] The study commenced while Dr. Collins was with the Geological Survey of Canada, Ottawa, and concluded while he was a Senior Research Fellow at the British Museum (Natural History), London, England. He is now at the Royal Ontario Museum, Toronto.

Island is the only publication restricted to this specific group in northern Canada, although studies of the Devonian nautiloids of Novaya Zemlya (Foerste, 1925; Kuzmin, 1965) are relevant to the arctic faunules described here.

The three faunules comprise:

1. A number of partly crushed, but internally well preserved nautiloids from the type area of the Eids Formation, Ellesmere Island, District of Franklin. The faunule has similarities to faunas from the Russian Eifelian.
2. Two large, well preserved nautiloids from the Landry Formation in the western District of Mackenzie. The two nautiloids are very similar to species from the Eifel region of Germany.
3. Some orthocones from the Prongs Creek Formation of the northern Yukon.

Acknowledgments

The nautiloids were examined at the Geological Survey of Canada in Ottawa in 1965 and revised at the British Museum (Natural History) in 1967. The writer wishes to thank J. A. Jeletzky, D. J. McLaren, and B. S. Norford of the Survey, and M. K. Howarth of the British Museum (Natural History) for their help and encouragement, and B. F. Glenister of the University of Iowa and W. W. Nassichuk of the Survey for reviewing the manuscript. The photographic sections of the first two institutions helped with the illustrations.

C. T. Scrutton of the British Museum (Natural History) and D. J. McLaren identified corals associated with the nautiloids, A. W. Norris of the Survey identified brachiopods, and W. T. Dean and N. J. Morris of the British Museum (Natural History) studied a trilobite and gastropods, respectively. Professor Olaf Holtedahl, Oslo University, and Miss Helen Soot-Ryen, Paelontologisk Museum, Oslo, loaned the types of *Orthoceras* (?) *sulmenevense* Foerste and *O.* (?) *scheii* Foerste for comparison. A. W. A. Rushton of the Geological Survey of the United Kingdom loaned the types of *Hindeoceras tredecimale* (Phillips). H. Ristedt of the Institut für Paläontologie, Friedrich Wilhelms Universität, Bonn, provided details of the stratigraphic occurrence of *Rutoceras*? *eifelense* (d'Archiac and de Verneuil) and *Cyrthoceratites lineatus* d'Archiac and de Verneuil from their collections.

Age and Correlation

Eids Formation, Bjorne Peninsula, Ellesmere Island

Fossils are rare in this, the type area of the Eids Formation (McLaren, 1963a, p. 318) but the following nautiloids have been collected by R. Thorsteinsson from a thin limestone coquina (GSC loc. 57730, Fig. 1, loc. 2):

Spyroceras thoas (Hall)
S. ? aff. *S. karpinskyi* Zhuravleva
Hindeoceras sp.
Folioceras segmentum, new genus, new species
Leurocycloceras superplenum? new species

The Eids nautiloid faunule has two species in common with an Eifelian fauna from southern Novaya Zemlya recently described by Kuzmin (1965). These are *Spyroceras thoas* (Kuzmin's *S.*? *nuntium* (Hall)) and *Folioceras segmentum* (Kuzmin's *Orthoceras* ? *sulmenevense* Foerste). The fauna described by Kuzmin includes several nautiloid species that are directly related to forms from the German Eifel.

An Eifelian age from the Eids faunule is supported by the presence of the form related to *Spyroceras karpinskyi,* which was described from lower Eifelian rocks of the Urals (Zhuravleva, 1962, p. 164). *Spyroceras thoas* is common in the Schoharie and Onondaga Formations of New York State (Kindle and Miller, 1939, p. 122), which are currently considered as upper Emsian and Eifelian respectively (Rickard, 1964). The only two described species of *Hindeoceras* are Givetian: *H. tredecimale* (Phillips) from Devon and *H. canadense* (Whiteaves) from the Winnipegosis Formation of Manitoba. The few remaining nautiloids in the collection are orthocerids with internal structures similar to those of immature individuals of *Leurocycloceras superplenum* new species that is here described from the Devonian Prongs Creek Formation of the northern Yukon. Some tabulate corals encrust the specimen of *Hindeoceras* sp. The corals have been identified by C. T. Scrutton as *Alveolites* sp. and *Aulopora* sp., but both they and some associated euomphalid gastropods are long ranging forms.

The similarity of the Eids nautiloids to faunas from Russian Eifelian rocks indicates that the collection is of Eifelian age.

Some 200 miles southwest of the type area, brachiopods and a goniatite of the Eids Formation of Bathurst Island were originally considered to be Early Devonian (McLaren, 1963b, p. 609). Recent study of the trilobite faunas has suggested the presence of both Emsian and Eifelian horizons (Ormiston, 1967, pp. 13, 18).

Landry Formation, Sekwi Map-area, District of Mackenzie

Two large, well preserved nautiloids have been collected from stratigraphic sections in the Sekwi map-area (Fig. 1, loc. 11), that are about 50 miles apart.

Rutoceras? *eifelense* (d'Archiac and de Verneuil) was collected by S. L. Blusson from near Godlin Lake and is associated with the trilobite *Dechenella* (*Dechenella*) sp. (Dean, this Bulletin). Corals, brachiopods, trilobites, and echinoderm fragments from the Landry Formation of the same stratigraphic section, but about 100 feet above the occurrence of the nautiloid, have been correlated as mid-Eifelian by D. J. McLaren and A. W. Norris.

In the collections at Bonn, which include the specimens in Goldfuss's cabinet described by d'Archiac and de Verneuil, *Rutoceras*? *eifelense* is listed as occurring in the Middle Devonian of Eifel and of the Schwelmer Kalk, Lethmate, Sauerland (Ristedt, *pers. com.*).

Cyrthoceratites aff. *C. lineatus* d'Archiac and de Verneuil was collected by H. Gabrielse from near Divide Lake. Associated corals and brachiopods have been tentatively dated as early Givetian by D. J. McLaren and A. W. Norris. A lower Givetian faunule (GSC loc. 69050) has been identified from the Headless Formation about 500 feet higher in the same stratigraphic section by McLaren and Norris and a faunule (GSC loc. 69042) of probable Eifelian age from the Landry Formation some distance below the nautiloid.

In the collections at Bonn, *Cyrthoceratites lineatus* is listed as occurring in the Givetian Stringocephalenkalk of Gerolstein, Sötenich and Prüm in the German Eifel, and in the lower Upper Devonian Iberger Kalk of Winterberg, Sauerland and of Nordwest Harz (Ristedt, pers. com.).

These two nautiloids are remarkable in that they are both virtually identical to species described from the Middle Devonian of the Eifel region of Germany. The ages of the German species agree with the ages provided by the other groups of fossils both near Godlin Lake and Divide Lakes.

Prongs Creek Formation, Royal Creek Section, Northern Yukon

Straight cephalopods are abundant in several collections made by Norford (1964, p. 40) from a 519-foot interval of Unit 6 of his Royal Creek Section (Fig. 1, loc. 9). This unit was later included in the type section of the Prongs Creek Formation (Norris, *in press*) which elsewhere includes Emsian to Eifelian horizons and possibly also Givetian and Upper Devonian strata (Norris, 1968, p. 770).

Spirigerina sp. has been identified from the Road River Formation of the Royal Creek Section, 172 feet below the base of the Prongs Creek Formation, and dated as Siegenian (GSC loc. 53086; Norris, pers. com. to Norford, 1968). *Monograptus* aff. *M. yukonensis* Jackson and Lenz has been identified from lower in the same section, 347 feet below the base of the Prongs Creek (Norford, 1964, p. 126, GSC loc. 53082). The *Monograptus yukonensis* Zone is Upper Siegenian and, or, Lower Emsian (Lenz, 1967, p. 610), and thus the nautiloid faunules from Unit 6 of the Royal Creek Section are Late Siegenian or younger. Above the nautiloid faunules, a goniatite from high in Unit 6 of the same section has been tentatively identified as cf. *Anetoceras* sp. and an Emsian age suggested (GSC loc. 53095; M. R. House pers. com. to Norris, 1966).

The following species of nautiloids are described from Unit 6:

Leurocycloceras superplenum new species
Ormoceras sp.
Rayonnoceras? sp.

L. superplenum is the most common, occurring throughout the 519-foot interval. The single specimen of *Ormoceras* comes from the top of the interval, 30 feet below the occurrence of cf. *Anetoceras* sp.; *Rayonnoceras*? sp. is present in two collections, 348–389 feet lower than the occurrence of *Ormoceras* sp. The nautiloids do not assist in the correlation of the Unit 6, which can be dated as Late Siegenian to Emsian in age by other groups of fossils, but the presence of actinocerids in strata of this age does help to fill gaps in knowledge of the late evolution of the Actinocerida.

Systematic Paleontology

Prefix GSC refers to specimens in the type collections of the Geological Survey of Canada, Ottawa.

Order ORTHOCERIDA Kuhn 1940

Family PSEUDORTHOCERATIDAE Flower and Caster 1935

Genus *Spyroceras* Hyatt 1884

Type species: *Orthoceras crotalum* Hall, 1861, from the Middle Devonian of New York State.

Spyroceras thoas (Hall 1861)

Plate 6, figures 1–4; Figure 3

Orthoceras thoas Hall, 1861, p. 47.
Orthoceras thoas Hall, Hall 1862, p. 75, Pl. 7, fig. 4.
Orthoceras thoas Hall, Hall 1876, Pl. 41, figs. 1-9.
Orthoceras thoas Hall, Hall 1879, pp. 261-263, Pl. 41, figs. 1-9; Pl. 78B, fig. 5; Pl. 79, fig. 13; Pl. 80, figs. 7, 10, 11; Pl. 112, figs. 7, 8.
Spyroceras thoas (Hall), Grabau and Shimer 1910, p. 64, Text-fig. 1271.
Spyroceras thoas (Hall), Kindle and Miller 1939, pp. 121, 122 (for North American synonymy to 1939).
Spyroceras ? *nuntium* (Hall), Kuzmin 1965, p. 15, Pl. 1, fig. 5.

Material and occurrence. A medium-sized crushed specimen (hypotype GSC 23714) and a smaller phragmocone (hypotype GSC 23713), both collected by R.

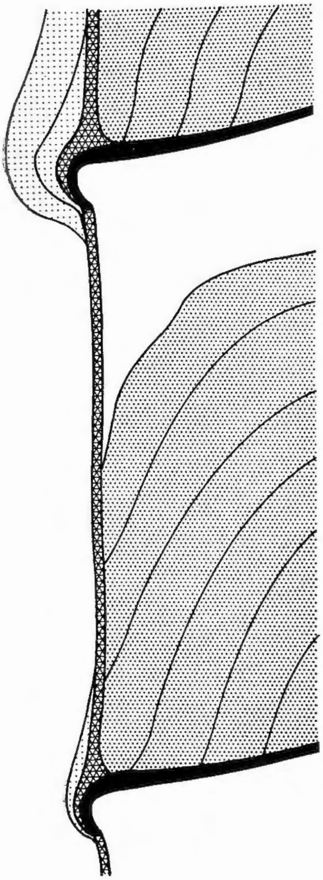

FIGURE 3. Siphuncle and adjacent chambers of *Spyroceras thoas* (Hall) (hypotype GSC 23713); x40; showing short suborthochoanitic septal necks (black), thin simple connecting rings (cross hachure), mural cameral deposits (dark stippling), and siphuncular annuli (light stippling).

Thorsteinsson, 1963, from GSC loc. 57730 (77°29′12″N, 85°55′00″W), Eids Formation, 2.3 miles west of Baumann Fiord, Bjorne Peninsula, Ellesmere Island, District of Franklin.

Description. The smaller specimen is a longiconic orthocone of circular section. Prominent transverse annulations occur on both specimens. Some annulations on the smaller specimen are slightly sinuous. There are four annulations in a length equal to the conch diameter. Numerous longitudinal lirae, crossed by less prominent but just as numerous transverse lirae, ornament the shell of the crushed specimen. Less developed longitudinal and transverse lirae are present on the smaller specimen. Three camerae together have a length equal to the conch diameter. The sutures cannot be seen.

The siphuncle is small and central. Septal necks are short and suborthochoanitic, joined by thin, cylindrical connecting rings which abruptly constrict at the septal foramen. Pseudorthoceroid annuli (Flower, 1939, p. 274) occur around the necks and extend anteriorly along the connecting rings. The chambers are almost completely filled with mural deposits.

Comparisons. The internal structure of *Spyroceras thoas* (Hall) has not previously been figured. Most species of *Spyroceras* have been differentiated by external shape and ornamentation. *S. nuntium* (Hall) and the type species, *S. crotalum* (Hall), are very similar to *S. thoas.* The former differs in possessing alternating prominent and less prominent longitudinal lirae; the latter possesses less prominent surface ornament and more strongly expanded siphuncular segments.

Kuzmin (1965) refers a similar specimen from the Eifelian of Novaya Zemlya to *Spyroceras nuntium* (Hall), but his illustration shows well developed transverse shell ornamentation, which is a characteristic of *S. thoas* but is not found in *S. nuntium* (Flower, 1936, p. 297).

Kindle and Miller (1939, p. 122) report that *S. thoas* has been extensively recorded from the Schoharie and Onondaga Formations of eastern North America.

Spyroceras? aff. *S. karpinskyi* Zhuravleva 1962

Plate 7, figures 1–6; Figure 4

aff. *S. karpinskyi* Zhuravleva, 1962, pp. 163-165, figs. 1, 2.

Material and occurrence. Parts of two crushed phragmocones: hypotype GSC 23717 has been crushed dorsoventrally, hypotype GSC 23718 has been crushed laterally; GSC loc. 57730, Eids Formation, collecting data as for *Spyroceras thoas.*

Description. Both specimens are moderately curved phragmocones of unknown transverse section. The conch surface is ornamented with prominent fluted longitudinal ridges crossed by numerous, irregularly developed transverse growth lines. The camerae are moderately short; seven to eight together have a length equal to the crushed dorsoventral diameter.

The siphuncle is small, and is apparently located midway between the centre and the venter (convex surface). The septal necks are recurved, with a shape intermediate between suborthochoanitic and cyrtochoanitic; the connecting rings are thin

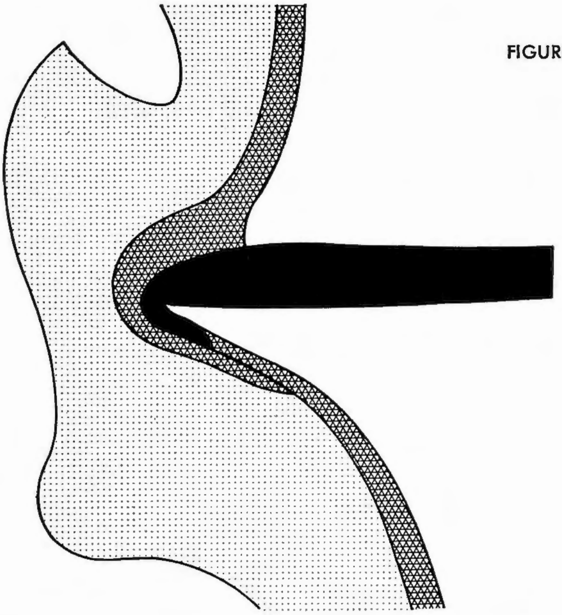

FIGURE 4. Siphuncle of *Spyroceras* aff. *S. karpinskyi* Zhuravleva (hypotype GSC 23718); x40; with recurved septal necks (black), beaded connecting rings (cross hachure), and siphuncular annulus (light stippling).

and simple. The siphuncular segments are subspherical, with the greatest rate of expansion adjacent to the septal foramina. Typical pseudorthoceroid deposits line the inside of the siphuncle, developing from annuli at the septal foramina and extending adaperturally along the connecting ring to fuse with the posterior of the next anterior annulus. The chambers are too disrupted for positive recognition of cameral deposits.

Discussion. Externally, *Spyroceras*? aff. *S. karpinskyi* is a longitudinally ridged cyrtocone. Hyatt (1884, p. 276) proposed *Spyroceras* for longitudinally ridged and annulate longicones, so that apart from the annulations, the Canadian species fulfils the description. At present, however, *Spyroceras* is restricted to annulate orthocones with longitudinal lirae (Sweet, 1964, p. 246) so that assignation of the Canadian species to *Spyroceras* is questionable.

Comparisons. Zhuravleva (1962, p. 163) followed Hyatt's description and assigned the longitudinally ridged, annulate orthocone, *Spyroceras karpinskyi,* from the Eifelian of the Urals, to the genus. Although it differs from the Canadian species in being orthoconic and annulate with a subcentral siphuncle, *S. karpinskyi* similarly bears longitudinal ridges and has similar septal necks and spyroceratinid siphuncular deposits. The two species therefore are related, though not closely.

Cyrtoceras morsum Hall from the Eifelian Onondaga Formation of New York State, which was questionably assigned by Flower to his new genus *Cyrtospyroceras* (Flower, 1938, p. 215) may be related, but it lacks longitudinal ridges and its siphuncular structure is unknown.

In external shape and ornament, *Nephriticerina juvenis* (Hall) (1879, Pl. 56, figs. 5, 6), *Lyrioceras liratum* (Hall) (1879, Pl. 57, fig. 3; Pl. 60, figs. 8, 9), and *L. dubium* Miller (figured as *Cyrtoceras liratum,* by Hall 1879, Pl. 95, fig. 1) from the

Givetian Hamilton Group of New York State are similar to *Spyroceras*? aff. *S. karpinskyi*. However, in all three species the structure of the siphuncle is unknown, so that their relationship to the Canadian species cannot be established.

Family FOLIOCERATIDAE new family

Orthoconic and ?cyrtoconic longicones with moderately large tubular siphuncles, short to hemichoanitic septal necks and simple connecting rings. Foliated deposits oriented dorsoventrally occur in the siphuncle; the deposits are segmented.

Only the Middle Devonian *Folioceras*, new genus, is known to belong in the family. The affinities of the Folioceratidae are those of *Folioceras* discussed below.

Genus *Folioceras* new genus

Type species: *Folioceras segmentum* new species, from the Eids Formation, Ellesmere Island.

Diagnosis. Smooth, longiconic orthocones with circular section and moderately large subventral to subcentral siphuncle. Septal necks orthochoanitic or loxochoanitic, connecting rings thin and simple. Siphuncular annuli at septal foramina. Segmented laminae fill the siphuncle. They are oriented dorsoventrally, but fan slightly like the pages of a slightly open book. Ventrally concentrated cameral deposits present.

Discussion. *Folioceras* has morphologic similarities to genera of the Intejocerida, Actinocerida, and Orthocerida.

Almost half of the relatively large siphuncle of the Middle Ordovician intejocerid, *Padunoceras* Balashov, is filled with foliated laminar deposits oriented at a small angle to the dorsoventral plane (1960, Pl. 30, fig. 1b). In contrast to *Folioceras*, however, the rest of the laminae are radiating, the laminae are continuous, the associated septal necks are holochoanitic, and there are no cameral deposits.

The Carboniferous actinocerid, *Rayonnoceras* Croneis, possesses a siphuncle filled with segmented laminar deposits, but the laminae are radiating and the siphuncle is strongly beaded *(see below)*.

Among the orthocerids, the large tubular siphuncle of *Folioceras* is most similar to that of the Silurian and ?Devonian *Offleyoceras* Foerste. However, no siphuncular deposits are known in *Offleyoceras*.

The typical orthocerid characters of tubular siphuncle, short septal necks, cameral deposits and siphuncular annuli demonstrate that *Folioceras* and the Folioceratidae have the greatest affinity with the Orthocerida.

The foliated siphuncular deposits peculiar to *Folioceras* give the genus its name.

Folioceras segmentum new species

Plate 6, figures 5–9; Figure 5

non *Orthoceras* (?) *sulmenevense* Foerste 1925, pp. 9, 10, Pl. 1, fig. 2; Pl. 4, fig. 2.
Orthoceras (?) sulmenevense Foerste, Kuzmin 1965, p. 29, Pl. 8, figs. 3a, 3b.

Material and occurrence. Two crushed, partly complete phragmocones (holotype GSC 23715 and paratype GSC 23716), both about 60 mm long; GSC loc. 57730, Eids Formation, collecting data as for *Spyroceras thoas*.

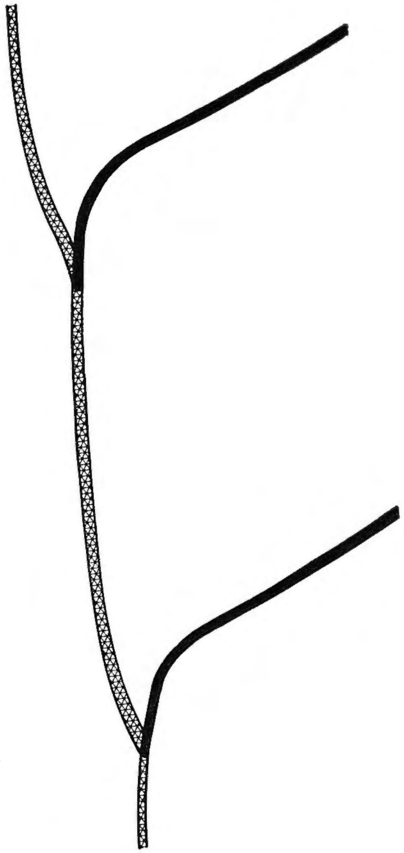

FIGURE 5. Ectosiphuncle of *Folioceras segmentum* new genus, new species (holotype GSC 23715), lateral view; x12; with loxochoanitic septal necks and thin connecting rings.

Description. Phragmocone orthoconic, apparently moderately expanding; only the deposit-filled ventral third of the conch has retained its circular shape in the crushed specimens. The smooth shell has fine, transverse growth striae. Six camerae together have a length equal to the conch diameter.

The tubular subventral siphuncle has a diameter one fourth that of the conch. It is composed of orthochoanitic to loxochoanitic septal necks joined by thin, simple connecting rings. Siphuncular annuli occur at some septal foramina. Almost parallel laminae oriented in the dorsoventral plane fill the siphuncle. The laminae fan slightly from a mid-ventral point. They are regularly segmented, one segment per chamber. Ventrally concentrated mural, episeptal and hyposeptal deposits fill much of the chambers.

Discussion. Kuzmin assigned a specimen from the Eifelian of Novaya Zemlya to *Orthoceras* (?)*sulmenevense* Foerste. He described the siphuncle as central to subcentral, the septal necks as extending one third to one half of the chamber height, and the siphuncular deposits as insignificant (Kuzmin, 1965, p. 29). The longitudinal section (Kuzmin, 1965, Pl. 8, fig. 3b), however, shows a regular siphuncular segmentation and appears almost identical to that of *Folioceras segmentum.*

The holotype of *Orthoceras* (?)*sulmenevense* Foerste (1925, p. 9) from the ?Lower Devonian of Novaya Zemlya is also a crushed specimen. It is similar to *Folioceras segmentum* in its relatively large tubular siphuncle and orthochoanitic septal necks, but does not have recognizable siphuncular deposits.

Offleyoceras arcticum (Foord, 1888, p. 38) from the Silurian of Offley Island, northwest Greenland, also has a relatively large tubular siphuncle, but lacks siphuncular deposits.

Family ORTHOCERATIDAE M'Coy 1844

Genus *Leurocycloceras* Foerste 1928

Type species: *Leurocycloceras raymondi* Foerste, 1928, from the Middle Silurian of Wisconsin.

Leurocycloceras superplenum new species

Plate 7, figures 9–12; Plate 8, figures 9–12; Figure 6

Material and occurrence. Holotype GSC 23720, paratypes GSC 23721, 23725–23727, 23782, and several other specimens, all parts of phragmocones; collected by B. S. Norford, 1962, from GSC loc. 53091 (65°02′N, 135°08′W), Prongs Creek Formation, 166 to 171 feet above the contact with the underlying Road River Formation, Royal Creek, northern Yukon Territory (Norford, 1964, p. 40). Other occurrences: GSC locs. 53089 (0–25 feet), 53090 (130–150 feet), 53093 (321–327 feet), and 53094 (518–519 feet), Prongs Creek Formation of the same stratigraphic section; and a few specimens identified as *L. superplenum*?; GSC loc. 57730, Eids Formation, Ellesmere Island, collecting data as for *Spyroceras thoas*.

Description. The holotype, part of a longiconic orthocone, is 45 mm long. It is circular in transverse section and expands from a diameter of 14.5 mm to 17.0 mm in a distance of 35 mm. The shell surface is smooth. The camerae are moderately long, with the lengths of two to three chambers together equal to the conch diameter. The suture is straight and transverse.

The siphuncle is small and slightly excentric; in a conch with a diameter of 22 mm, the siphuncle has a diameter of 3.0 mm. The orthochoanitic septal necks vary in length from one fifth of the septal interval in early chambers to one half in later chambers. No trace of the connecting rings can be seen.

Thick episeptal and hyposeptal deposits fill the chambers. The cameral deposits in some specimens are remarkable in that they bulge into the siphuncle and encase the septal necks. The deposits appear to have been laid down as if there were no connecting rings present, or if rings were present, they must have been thin and flexible. In support of the latter, there is usually a space at the adapical tip of the septal neck, which separates the hyposeptal and episeptal deposits encasing the neck (Fig. 6). In all such specimens, the continuation of the episeptal deposit over the siphuncular surface of the septal neck is thin. In several specimens, the episeptal deposits thicken into a horn-shape adjacent to the siphuncle (Pl. 8, fig. 10).

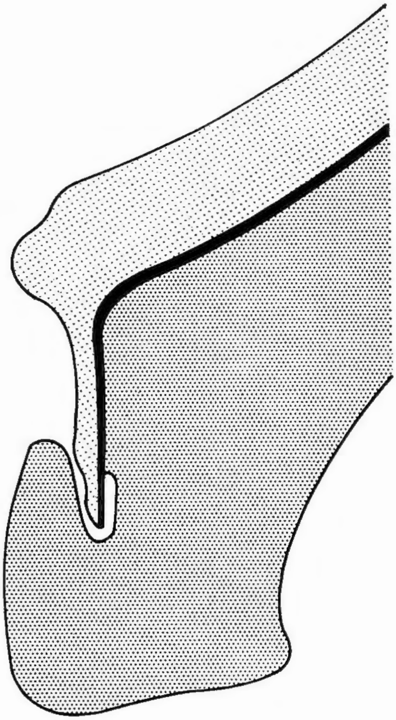

FIGURE 6. Septal neck and encasing cameral deposits of *Leurocycloceras superplenum* new species (paratype GSC 23782); x15; showing interface between episeptal (light stippling) and hyposeptal deposits.

In one small specimen (paratype GSC 23721) branching vein-like structures can be seen in transverse view of the interface between the episeptal deposits and the septum.

The specific name refers to the overflowing chambers.

Discussion. Leurocycloceras superplenum is tentatively assigned to the genus because it has the typical internal structures of long septal necks encased by thick hyposeptal and episeptal deposits, and even the vascular imprints. It differs from other species of *Leurocycloceras* by its smooth exterior. A few specimens with internal structures similar to those of immature *L. superplenum* are known from the Eids Formation of Ellesmere Island.

Leurocycloceras has been reported from Middle Ordovician(?) to Silurian horizons (Sweet, 1964, p. 230). *L. superplenum* extends the range of the genus into the Eifelian.

Comparisons. The most similar species is the Middle Silurian *L. bucheri* Flower from Indiana. It differs in its annulate shell and more excentric siphuncle (Flower, 1941, p. 477).

The Eifelian *Geisonoceras teicherti* Flower is very like *Leurocycloceras superplenum* in its smooth surface and thick cameral deposits. Its septal necks are short, however, and are not encased in the cameral deposits (Flower, 1939, p. 164).

Sinoceras chinense (Foord) from the Middle Ordovician also has long necks and in apical chambers of the holotype, thick cameral deposits apparently cover the necks. It is difficult to determine whether these deposits are primary, secondary, or both. *S. chinense* expands more rapidly than *Leurocycloceras superplenum*.

Order NAUTILIDA Agassiz 1847

Family RUTOCERATIDAE Hyatt 1884

Genus *Hindeoceras* Flower 1945

Type species: *Gyroceras canadense* Whiteaves, 1891, from the Middle Devonian of Manitoba.

Hindeoceras sp.

Plate 7, figures 7, 8

Material and occurrence. Hypotype GSC 23719, part of a crushed phragmocone; GSC loc. 57730, Eids Formation, collecting data as for *Spyroceras thoas*.

Description. The single specimen is part of a cyrtocone and is 68 mm long around its longest dimension. It is evidently a fragment of a phragmocone because what seem to be broken septa can be seen at both ends. The conch expands at a moderate rate; the crushed diameters are 28 mm and 51 mm at the adapical and adapertural ends, respectively.

The shell surface is highly ornamented. Approximately eighteen rows of nodes are evenly spaced longitudinally around the shell. They are also arranged transversely, with seven transverse rows in the length of the specimen. The nodes are of irregular size and are open and spout-like. Prominent growth lines parallel the transverse rows of nodes, producing a wrinkled surface crossing both nodes and internodal areas. No other details can be discerned from the specimen.

Discussion. The spout-like nodes of *Hindeoceras* sp. are its most prominent feature. Similar nodes occur on other species of *Hindeoceras,* and are also described in species of *Rutoceras* (Hyatt, 1884, p. 286). The relationship between these two genera is rather obscure; the only definite distinction seems to be that *Hindeoceras* has ten rows of longitudinal nodes distributed fairly evenly on the ventral and lateral surfaces, whereas *Rutoceras* has two rows flanking the venter, and four lateral rows. The even distribution of nodes over the whole surface distinguishes *Hindeoceras* sp. from described species of both genera, but places it closer to *Hindeoceras* than to *Rutoceras.*

Comparisons. Hindeoceras sp. differs from the type species, *H. canadense* (Whiteaves) from the Givetian Winnipegosis Formation of Manitoba, and from *H. tredecimale* (Phillips) from the Givetian of Devon, in possessing a greater number of longitudinal ridges bearing nodes, and in the even distribution of the nodes around the shell circumference. *H. canadense* has been described as having eight (Whiteaves, 1891, p. 106) and also as having at least ten (Flower, 1945, p. 711) node-bearing longitudinal ridges on its ventral and lateral surfaces. There are more longitudinal ridges on the dorsal surface, but these do not bear nodes. Phillips (1841, p. 115) described *H. tredecimale* as having thirteen longitudinal ridges (hence the specific name). Close study of the slightly distorted holotype shows that it probably has fourteen longitudinal ridges; two of the fourteen are closer together and of lower relief than the rest. Whidborne (1889, p. 97) remarked that the number of ribs "are not always accurately thirteen even in the type specimen" and illustrated a larger specimen (larger than *Hindeoceras* sp.) with sixteen longitudinal ribs (1889, Pl. 10, fig. 6). On specimens of both Phillips and Whidborne, the nodes are better developed on the ventral than on the dorsal surface.

Genus ***Rutoceras*** Hyatt 1884

Type species: *Cyrtoceras jason* Hall, 1879, from the Middle Devonian of New York State.

Rutoceras ? *eifelense* (d'Archiac and de Verneuil 1842)

Plate 10, figures 5–12; Figure 7

Cyrthoceratites Eifelense d'Archiac and de Verneuil, 1842, pp. 349, 350, Pl. 31, figs. 2, 2a.
Gyroceras Eifelense (d'Archiac and de Verneuil), Foord 1891, pp. 59, 60 (for synonymy).

Material and occurrence. The single specimen (hypotype GSC 23728) is a major part of a phragmocone; collected by S. L. Blusson, 1966, from GSC loc. 75773 (63°47′N, 129°00′W), Landry Formation, about 137 feet below the contact with the overlying Headless Formation, 8 miles west of Godlin Lake, Sekwi map-area, District of Mackenzie. Associated fauna *Dechenella (Dechenella)* sp. (Dean, this Bulletin).

Description. Phragmocone, medium-sized, cyrtoconic; the conch expands at a moderate rate from a lateral diameter of 30 mm at the adapical end to one of 70 mm at the adapertural end, over a length of 130 mm. In transverse section, the shell is depressed, with dorsal flattening; at a lateral diameter of 66 mm, the dorsoventral diameter is 46 mm.

The shell surface is highly ornamented. Twenty-eight longitudinal ridges are spaced evenly around the shell surface, although the space between the two ridges bounding the venter is slightly wider than the other inter-ridge spaces. Transverse ridges, spaced about one every three camerae, cross the longitudinal ridges, producing blunt, solid nodes at their junctions. The nodes are well developed ventrally, but poorly developed dorsally. Where they cross the venter, the transverse ridges dip into V-shaped lobes. Well developed transverse growth lines parallel the transverse ridges. The internal mould has low longitudinal and transverse ridges. The chambers are short, with eight together having a length equal to the lateral conch diameter. Sutures are straight and transverse. The septa are shallow.

The siphuncle is small, situated near the ventral (convex) surface of the shell. Where the lateral shell diameter is 66 mm, the siphuncle has a diameter of 4 mm and is situated 4 mm from the venter. In longitudinal section, the siphuncular segments are longer than wide, and are slightly beaded between septa. The septal necks are orthochoanitic ventrally and cyrtochoanitic dorsally. The connecting rings are simple and of moderate thickness.

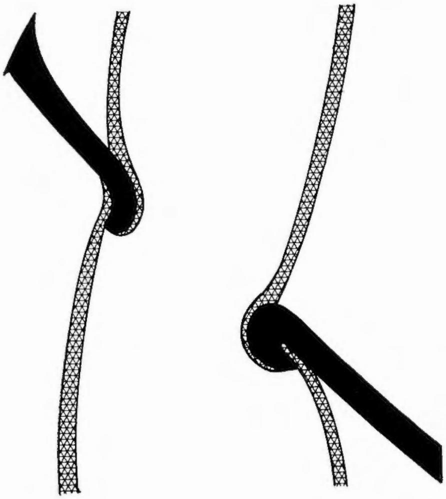

FIGURE 7 Ectosiphuncle of *Rutoceras* ? *eifelense* (d'Archiac and de Verneuil) (hypotype GSC 23728); x15; with orthochoanitic ventral and cyrtochoanitic dorsal septal necks.

Discussion. There is no doubt concerning the specific identification. D'Archiac's and de Verneuil's illustrations could have been taken from the Canadian specimen. The generic assignation is less obvious.

D'Archiac and de Verneuil (1842, p. 349) assigned their new species to *Cyrthoceratites* along with a similar species, *C. ornatus* (Goldfuss). Indeed, so similar are the two species that d'Archiac and de Verneuil thought that they might be varieties of the same species (1842, p. 350). Hyatt subsequently (1884, p. 285) made *C. ornatus* the type species of his new genus, *Kophinoceras.* Foord (1891, pp. 56–60) placed both species in *Gyroceras* de Koninck, but this genus is now thought to be a junior synonym of *Gyroceratites* von Meyer (Miller, Dunbar, and Condra, 1933, p. 53). In the *Treatise,* Kummel (1964, p. 416) considers *Kophinoceras* to be a junior synonym of *Rutoceras* Hyatt (also 1884, p. 285, but before *Kophinoceras*) and from Hyatt's descriptions of the two genera, they are certainly difficult to differentiate.

Comparisons. One obvious difference between *Rutoceras* ? *eifelense* and other species of the genus is the shape of the nodes. In the former, the nodes are blunt, solid structures, whereas in *R. ornatum* (Goldfuss), and *R. jason* (Hall) (the type species), the nodes are open and spout-like (Hyatt, 1884, p. 286). *Rutoceras* ? *eifelense* also has more longitudinal ridges bearing nodes (fourteen on ventral surface) than *R. ornatum* and *R. jason* (each with six on ventral surface), and has a slightly greater rate of expansion.

Order ONCOCERIDA Flower 1950

Family NOTHOCERATIDAE Fischer 1882

Genus *Cyrthoceratites* d'Archiac and de Verneuil 1842

Type species: *Cyrtocera depressa* Bronn, 1835, from the Middle Devonian of Germany.

Cyrthoceratites aff. *C. lineatus* d'Archiac and de Verneuil 1842

Plate 9, figures 1–7

aff. *Cyrtocera lineata* Goldfuss, 1832, p. 536, nomen nudum.
aff. *Cyrthoceratites lineatus*, d'Archiac and de Verneuil, 1842, p. 351, Pl. 30, figs. 2, 2a.
aff. *Cyrtoceras lineatum* Goldfuss, Foord 1888, pp. 267–268.

Material and occurrence. Hypotype GSC 23729, part of a phragmocone; collected by H. Gabrielse, 1965, from GSC loc. 69044 (63°14′N, 128°06′W), Landry Formation, about 475 feet below the contact with the overlying Headless Formation, 15 miles northeast of Divide Lake, Sekwi map-area, District of Mackenzie. Associated fauna, *Alveolites* sp., *Favosites* sp., *Spinulicosta stainbrooki* Crickmay, *Schuchertella*? sp., *Spinatrypa* sp. and other fossils, identified by D. J. McLaren and A. W. Norris.

Description. The single specimen is a small part (five camerae) of a very large phragmocone. The conch appears to expand at a moderate rate and to be straight or nearly straight. In transverse section, the phragmocone is slightly wider laterally than dorsoventrally, with dimensions of 150 mm and 140 mm, respectively. The shell surface away from the siphuncle is flattened, suggesting that the conch may be slightly curved with the siphuncle adjacent to the outer curved surface. The camerae are short; about twenty have a total length equal to the conch diameter. The camerae are a little longer on the side away from the siphuncle, suggesting a slight curvature the reverse to that above. The shell septa are notably shallow, almost flat. Sutures are straight and transverse, with a broad, very shallow saddle across the venter. The internal mould of the shell is smooth.

The siphuncle is of moderate size, with a diameter of 20 mm where the dorsoventral conch diameter is 140 mm. The ventral wall of the siphuncle is 6 mm from the ventral wall of the shell. The siphuncle is composed of short, orthochoanitic septal necks joined by slightly beaded connecting rings. The connecting rings are actinosiphonate. In both transverse and longitudinal sections, the radiating lamellae appear as coarse-textured, irregularly branching structures with a dark coloured core. The lamellae are segmented, commonly with the lamellae of one siphuncular segment fusing with similar lamellae in the next segment. But for the junction, some lamellae would appear to be continuous from one segment to another.

Comparisons. The Canadian species is very similar to *Cyrthoceratites lineatus* d'Archiac and de Verneuil, from the Eifel region of Germany, differing only in possessing a relatively larger siphuncle (one seventh compared to one twelfth conch diameter) slightly closer to the shell margin. In characters such as the shallow septa, orthochoanitic septal necks, and the thick, irregular, branching actinosiphonate lamellae, the two species are identical.

Order ACTINOCERIDA Teichert 1933

Family ORMOCERATIDAE Saemann 1853

Genus *Ormoceras* Stokes 1840

Type species: *Ormoceras bayfieldi* Stokes, 1840, from the Silurian of Drummond Island, Lake Huron, Michigan.

Ormoceras sp.

Plate 8, figures 1–4; Figure 8

Material and occurrence. Hypotype GSC 23722, part of a phragmocone, collected by B. S. Norford, 1962, from GSC loc. 53094, Prongs Creek Formation, 518–519 feet above the contact with the underlying Road River Formation, Royal Creek, northern Yukon Territory (Norford, 1964, p. 40).

Description. The single specimen is part of a straight, longiconic phragmocone. The conch expands from a diameter of 23 mm to 32 mm in a distance of 70 mm. In transverse section, the conch appears approximately circular. Details of suture and shell ornamentation cannot be seen. Three camerae together have a length equal to the conch diameter.

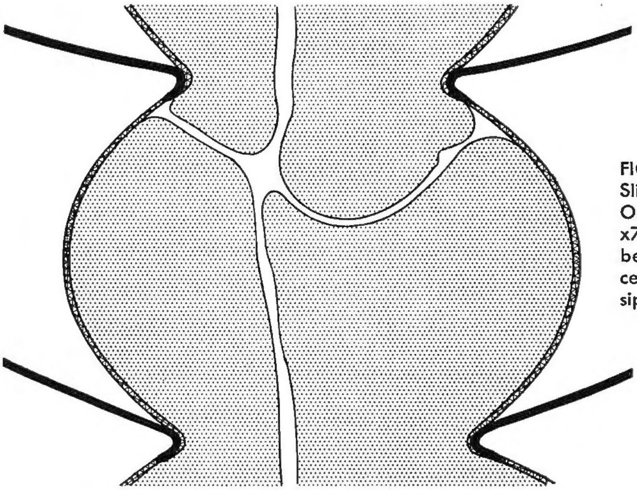

FIGURE 8
Slightly reconstructed siphuncle of *Ormoceras* sp. (hypotype GSC 23722); x7; showing recurved septal necks, beaded connecting rings, and irregular central and radial "canals" through siphuncular deposits (light stippling).

The siphuncle is large and central. It has a diameter of 13 mm where the conch diameter is 30 mm. The siphuncular segments are globular; septal necks are short and recurved; connecting rings appear thin and simple. Narrow, arcuate radial "canals" branch off from a narrow central canal just posterior of the siphuncular foramen. The radial "canals" are probably curved surfaces rather than tubular structures. In longitudinal section, coarse linear structures bunched at the septal foramina and fanning out into mid-segment, can be seen. Other details of the siphuncular deposits have been obscured by recrystallization. Mural and episeptal deposits fill much of the chambers.

Discussion. Ormoceras sp. differs from typical *Ormoceras* and from all other Devonian *Ormoceras* species in its relatively large siphuncle. Its relationship to *Rayonnoceras*? sp. is discussed below.

Family CARBACTINOCERATIDAE Schindewolf 1943

Genus ***Rayonnoceras*** Croneis 1926

Type species: *Rayonnoceras solidiforme* Croneis 1926 from the Upper Mississippian of Arkansas.

Rayonnoceras? sp.

Plate 8, figures 5–8; Figure 9

Material and occurrence. Fragments of siphuncular segments of three individuals collected by B. S. Norford, 1962; hypotype GSC 23724 from GSC loc. 53091, hypotype GSC 23723 and the third specimen from GSC loc. 53090 (both localities 65°02′N, 135°08′W), Prongs Creek Formation, 166–171 feet and 130–150 feet respectively above the contact with the underlying Road River Formation, Royal Creek, northern Yukon Territory (Norford, 1964, p. 40).

Description. The best specimen (hypotype GSC 23723) consists of one and one-half large siphuncular segments, with attached broken septa plastered around their periphery. The segments are globular in outline; a siphuncular segment 32 mm long expands from a diameter of 24 mm at the septal foramen to 32 mm at mid-chamber. Septal necks appear short and recurved.

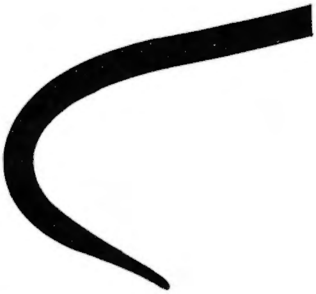

FIGURE 9. Recurved septal neck of *Rayonnoceras*? sp. (hypotype GSC 23724); x30.

Filling the segments are coarse, calcareous laminae radiating from an elongate cavity located subventrally to submarginally (? dorsal side). In longitudinal section, the radiating laminae are seen to be oriented longitudinally and to be segmented, with the segmental interface located a little anterior of mid-chamber.

Discussion. Radiating siphuncular deposits most similar to these described above are those of *Rayonnoceras solidiforme* Croneis and *R. fayettevillensis* Croneis illustrated by Mutvei (1964, Pls. 24–27). There is a gap in knowledge of related forms between the Devonian *Rayonnoceras*? sp. and the exclusively Carboniferous *Rayonnoceras*. The individual laminae in *Rayonnoceras*? sp. are considerably coarser than those figured in *Rayonnoceras* by Mutvei.

The relationship of *Rayonnoceras*? sp. to the described *Ormoceras* sp. is conjectural. The two occur about 350 feet stratigraphically apart in the same section but both are associated with *Leurocycloceras superplenum* new species. In the shape of the septal necks and siphuncular deposits, and in the position of the siphuncular deposit interfaces and radial "canals", they are similar; in features such as size, the radiating deposits in *Rayonnoceras*? sp., and the radial and central "canals" in *Ormoceras* sp., they differ. Much of the siphuncular details in *Ormoceras* sp. has been destroyed by recrystallization so some of these differences may not be real. Conceivably, *Rayonnoceras*? sp. and *Ormoceras* sp. could be conspecific.

Both species possess morphological features intermediate between typical *Ormoceras* and typical *Rayonnoceras*. The siphuncle in *Ormoceras* sp. is relatively as large as that in *Rayonnoceras*, although otherwise typical of *Ormoceras*, whereas the radiating deposits of *Rayonnoceras*? sp. are similar to those of Carboniferous *Rayonnoceras*, although coarser in texture. Possibly, the two species represent transitional stages in the evolution of the Carboniferous Carbactinoceratidae from the Devonian Ormoceratidae suggested by Teichert (1964, p. 202) and Flower (1957, p. 63).

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AN OCCURRENCE OF THE TRILOBITE *DECHENELLA (DECHENELLA)* IN THE MIDDLE DEVONIAN LANDRY FORMATION, WESTERN DISTRICT OF MACKENZIE

by W. T. Dean

Abstract

A single pygidium is described from rock matrix adhering to the Eifelian nautiloid *Rutoceras* ? *eifelense* (d'Archiac and de Verneuil).

Résumé

Description d'un pygidium unique trouvé dans une matrice rocheuse adhérant au nautilidé eifélien *Rutoceras* ? *eifelense* (d'Archiac et de Verneuil).

Introduction

A nautiloid collected from the Landry Formation near Godlin Lake (Fig. 1, loc. 11) in 1966 by S. L. Blusson was referred by B. S. Norford to D. H. Collins for further study. Collins noted that a small pygidium formed part of the matrix of the specimen and referred it to the author for study.

The collection is well dated as Eifelian. The associated nautiloid *Rutoceras* ? *eifelense* (d'Archiac and de Verneuil) is a species originally described from the Eifel region of Germany (Collins, this Bulletin). Corals, brachiopods, trilobites, and echinoderm fragments from the Landry Formation of the same stratigraphic section, but about 100 feet above the occurrence of the nautiloid, have been correlated as mid-Eifelian by D. J. McLaren and A. W. Norris (GSC loc. 75770).

Acknowledgments

The manuscript has been critically read by B. S. Norford of the Geological Survey of Canada.

Systematic Paleontology

The prefix GSC refers to specimens in the type collection of the Geological Survey of Canada, Ottawa.

Class TRILOBITA

Family PROETIDAE Salter 1864

Genus *Dechenella* Kayser 1880

Subgenus *Dechenella (Dechenella)* Kayser 1880

Type species: *Phillipsia verneuili* Barrande, 1852, from the Middle Devonian of Germany.

Dechenella (Dechenella) sp.

Plate 10, figures 1–4, 6

Material and occurrence. A single small pygidium (hypotype GSC 23783) collected by S. L. Blusson, 1966, from GSC loc. 75773 (63°47′N, 129°00′W), Landry Formation, about 137 feet below the contact with the overlying Headless Formation, 8 miles west of Godlin Lake, Sekwi map-area, District of Mackenzie. Associated fauna: *Rutoceras* ? *eifelense* (d'Archiac and de Verneuil) (Collins, this Bulletin).

Description. The length of the pygidium, excluding the large articulating half-ring, is almost three quarters of the maximum breadth, measured across the anterolateral angles. The outline is approximately semielliptical, with a suggestion of subangulation posteriorly and posterolaterally. The front of the axis occupies about one third of the maximum pygidial breadth and its straight sides converge backwards at 19 degrees, bounded by narrow, deeply incised axial furrows. There are fourteen axial rings, most of them strongly or fairly well defined, but becoming less distinct after the eighth or ninth ring. When viewed normal to the dorsal surface of the axis, the ring furrows appear transversely straight except near the axial furrows, where they turn backwards slightly. The axis ends with a small, subrounded terminal piece, the top of which declines gently to a conspicuous, almost smooth pygidial border. The breadth of the border equals one seventh of the pygidial length at the sagittal line, but becomes progressively narrower towards the anterolateral angles, where a pair of large facets is sited. The pleural regions carry, in addition to the anterior half-ribs, eight or nine pair of pleural ribs, separated by pleural furrows which are deep and slightly sigmoidal near the front of the pygidium but become progressively straighter, shallower, and more strongly directed backwards. The interpleural furrows are narrow and faint except at the inner boundary of the pygidial border, near which they become deeper and broader; having extended about half-way across the border they almost die out and can scarcely be traced to the margin. Like the pleural furrows, they become weaker from front to back of the pygidium and are not seen beyond the fifth pair of ribs. The pygidial border is smooth except for a number of thin raised ridges which are developed along the margin and follow the direction of the pleural and rib furrows.

Discussion. It is not possible to assign the limited material to any described species of *Dechenella (Dechenella),* a subgenus confined to the Middle Devonian. Of the numerous forms recorded from North America perhaps the closest comparison may be made with *D.* (*D.*) *spaekkassensis* (Tolmachoff) recently redescribed by Ormiston

(1967, p. 94, Pl. 12, figs. 9–17). The pygidium of this Eifelian species is only slightly shorter than the present specimen and the number of axial rings and pleural ribs is comparable, but segmentation of the axis extends to the tip and more interpleural furrows are visible. Ormiston (1967, pp. 19, 20, 23) points out that although *Dechenella (Dechenella)* is more indicative of the Givetian than the Eifelian in Europe, in Arctic Canada the subgenus appears in abundance in what he regards as Eifelian strata on the basis of non-dechenellid trilobites.

References

Ormiston, A. R.
1967: Lower and Middle Devonian trilobites of the Canadian Arctic Islands; *Geol. Surv., Can.*, Bull. 153.

PLATES 1 to 17

PLATE 1

Clelandia parabola (Cleland) (PAGE 5)

Figures 1, 6, 7, 11, 12. Dorsal, laterally tilted dorsal, front, and lateral views of the holotype cephalon (PRI 5070) from the Tribes Hill Formation of New York State; x4. Figs. 1 and 6 show the low swollen areas at the rear of the fixigenae. Figs. 7, 11, and 12 well show the facial suture. Figs. 11 and 12 show the border furrow and that it is conjunct with the facial sutures along the yoke.

Clelandia utahensis Ross (PAGE 6)

Figures 2, 3. Cranidia (hypotypes GSC 23614, 23615) from GSC loc. 69604; x 10.

Clelandia texana Winston and Nicholls (PAGE 7)

Figures 4, 5. Dorsal and front views of a cranidium (hypotype GSC 22889) from GSC loc. 57675; x4.

Figure 8. Librigena (hypotype GSC 22891) from same locality; x4.

Figures 9, 10, 14, 42. Dorsal, front, lateral, and dorsal views of a cranidium (hypotype GSC 23616) from GSC loc. 72816; x4, except fig. 42 x10.

Figures 13, 41. Cranidium (hypotype GSC 22890) from GSC loc. 57675; x4, x10.

Clelandia albertensis new species (PAGE 8)

Figures 15, 22, 28, 34, 40. Dorsal, rear, front, lateral, and dorsal views of the holotype cranidium (GSC 23617) from GSC loc. 69776; x4, except fig. 40 x10.

Figures 16, 23, 29, 30, 35. Dorsal, ventral, front, dorsal, and lateral views of a small cranidium (paratype GSC 23618) from same locality; fig. 30, x4; others x8.

Figures 17, 24, 31, 36. Tilted dorsal, ventral, tilted dorsal and lateral (rear on left) views of a small pygidium (paratype GSC 23619) from same locality; x20, except fig. 31 x8.

Figures 18, 25–27. Dorsal (figs. 25, 26) and ventral (figs. 18, 27) views of librigenae (fig. 26 is paratype GSC 23621, rest are paratype GSC 23622) from same locality; figs. 18, 25, x8; figs. 26, 27, x4.

Figure 32. Dorsal view of yoke, left librigena, and part of right librigena preserved intact (paratype GSC 23623), same locality; x8.

Figures 33, 39. Rear and dorsal views of a thoracic segment (paratype GSC 23624) from same locality; x20. The specimen broke during transfer.

Figures 37, 38. Dorsal views of two small cranidia (paratypes GSC 23625 and 23626); from same locality; x4.

Clelandia sp. (PAGE 11)

Figures 19–21. Lateral (rear at base), rear, and dorsal views of the pygidium (hypotype GSC 23620) from GSC loc. 69776; x8.

PLATE I


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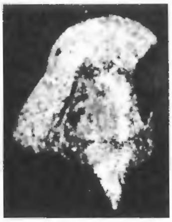
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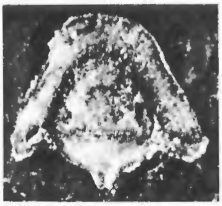
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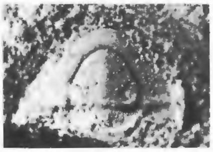
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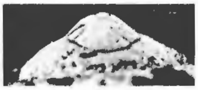
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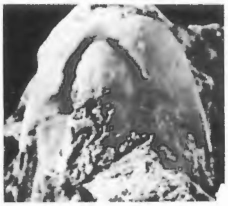
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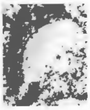
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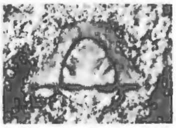
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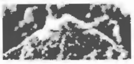
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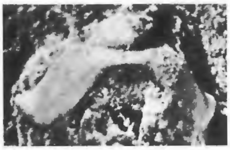
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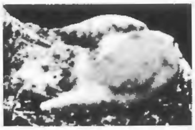
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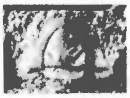
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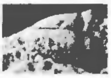
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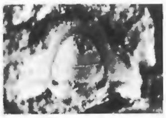
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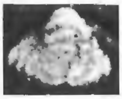
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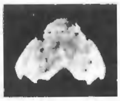
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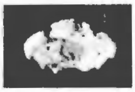
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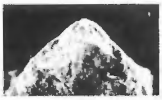
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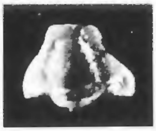
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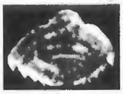
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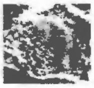
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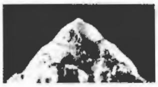
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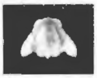
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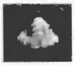
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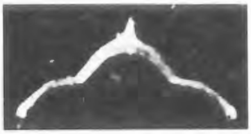
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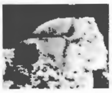
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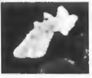
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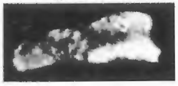
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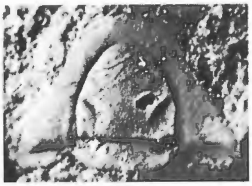
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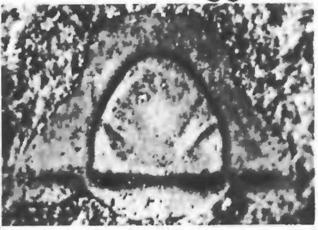
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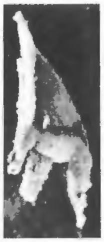
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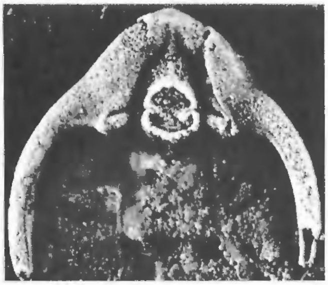
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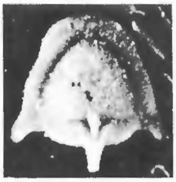
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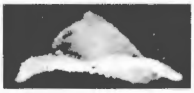
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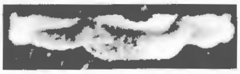
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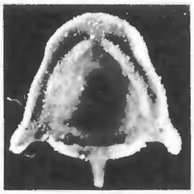
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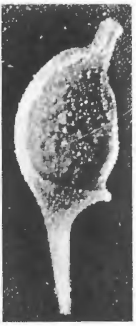
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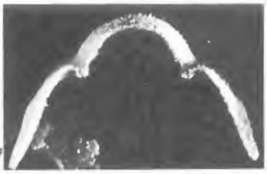
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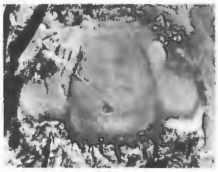
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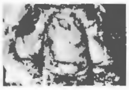
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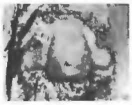
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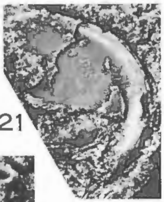
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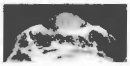
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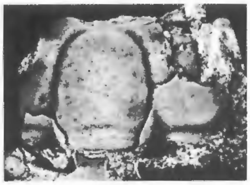
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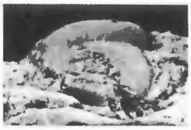
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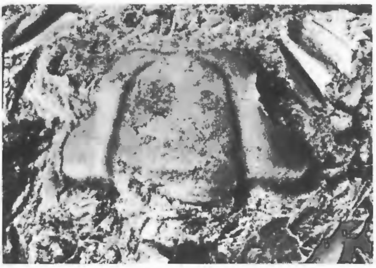
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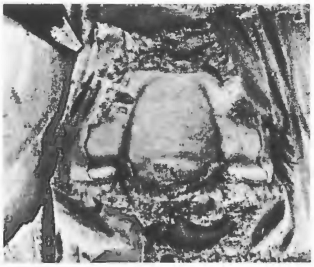
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PLATE 2

Clelandia wilsoni new species (PAGE 10)

Figures 1, 6, 14. Cranidia (paratypes GSC 22193, 22192, 22194) from GSC loc. 69601; x10.

Figures 2, 3, 7. Holotype cranidium (GSC 22191) from same locality; dorsal, lateral, and front views; x10.

Figures 5, 8, 11. Paratype cephalon (GSC 22199) from same locality; dorsal and front views; figs. 5, 11, x10; fig. 8, x2.

Figures 10, 17. Paratype thoracic segment (GSC 22198) from same locality; dorsal and rear views; x10.

Figure 12. View of ventral surface of cranidium shown by fig. 6.

Figures 4, 9, 13, 15, 16. Paratype librigenae (GSC 22197, 22196, 22196, 22195, 22195) from same locality; dorsal views and views of ventral surfaces; x4, except fig. 13 x10.

Jujuyaspis borealis Kobayashi (PAGE 12)

Figures 18, 20, 27, 29. Dorsal, front, and lateral views of a cranidium (hypotype GSC 22895) from GSC loc. 57675; fig. 20 is natural size, others x2.

Figures 19, 22, 24. Dorsal, front, and lateral views of holotype cranidium (GSC 12727), mostly skinned, from GSC loc. 8173; x2.

Figures 21, 34. Librigenae (hypotypes GSC 22899, 22898) from GSC locs. 72816 and 57675; x2. Fig. 21 shows a skinned specimen in which the apparent spine is well shown; the librigena of fig. 34 is not skinned and shows the ornament of very fine pits.

Figures 23, 30. Cranidia (hypotypes GSC 22892, 22894) from GSC loc. 57675; x2.

Figures 25, 31. Pygidia (hypotypes GSC 23610, 22897) from GSC locs. 72816 and 57675; x2. Fig. 31 shows a part of the dorsal exoskeleton preserved at the rear of the specimen and showing the fine terrace lines.

Figure 26. Small pygidium (hypotype GSC 12721; the paratype of *Sphaerophthalmella inexpectans* Kobayashi) from GSC loc. 8173; x2.

Figures 28, 32. Lateral and dorsal views of a skinned cranidium (hypotype GSC 22893) from GSC loc. 57675; x2.

Figure 33. A block of limestone from same locality, showing a small cranidium (hypotype GSC 22896 with dorsal exoskeleton largely intact) and fragments of *Jujuyaspis borealis,* a cranidium (hypotype GSC 22890) of *Clelandia texana* Winston and Nicholls, and a librigena of *Symphysurina brevispicata* Hintze; x2.

PLATE 3

Monograptus bugensius (Teller) (PAGE 23)

Figures 1–4. Hypotypes GSC 21285, 21281, 21284, 21282 from Road River Formation, lower Porcupine River; x5. In fig. 2, note ventrally deflected sicula with short dorsal tongue and delicate virgella. In fig. 3, note hooked nature of th^1, th^2 and th^3.

Monograptus aff. *M. koseviensis* Bouček (PAGE 26)

Figure 5. Hypotype GSC 21264 from GSC loc. 53242, Road River Formation, lower Porcupine River; x5½.

Monograptus aff. *M. angustidens* Přibyl (PAGE 21)

Figures 6–8. Hypotypes GSC 21277, 21274, 21276 from GSC loc. 53241, Road River Formation, lower Porcupine River; x5½.

Figure 9. Hypotype GSC 21279 from Road River Formation, lower Porcupine River; x5½.

?*Monograptus crinitus* Wood (PAGE 26)

Figure 10. Hypotype GSC 21266 from GSC loc. 53241, Road River Formation, lower Porcupine River; x5; showing slit-like thecal apertures and curved apertural dorsal shield.

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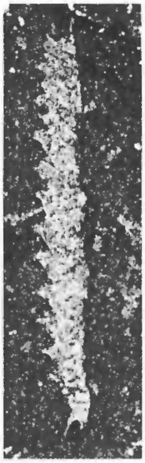

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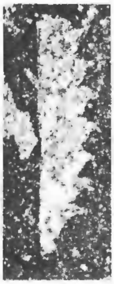

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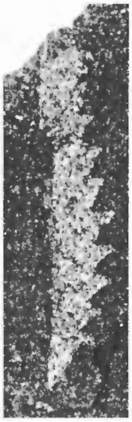

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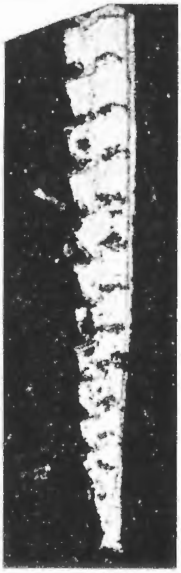

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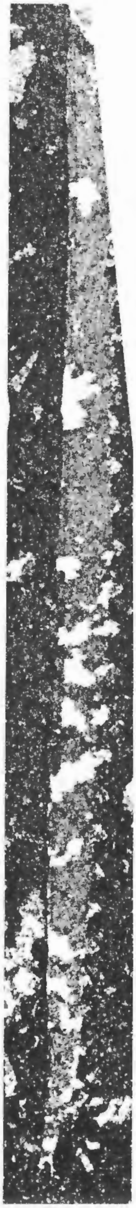

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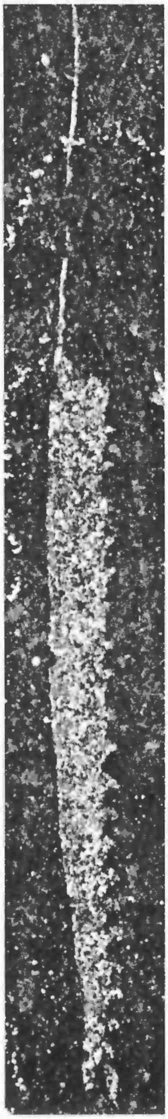

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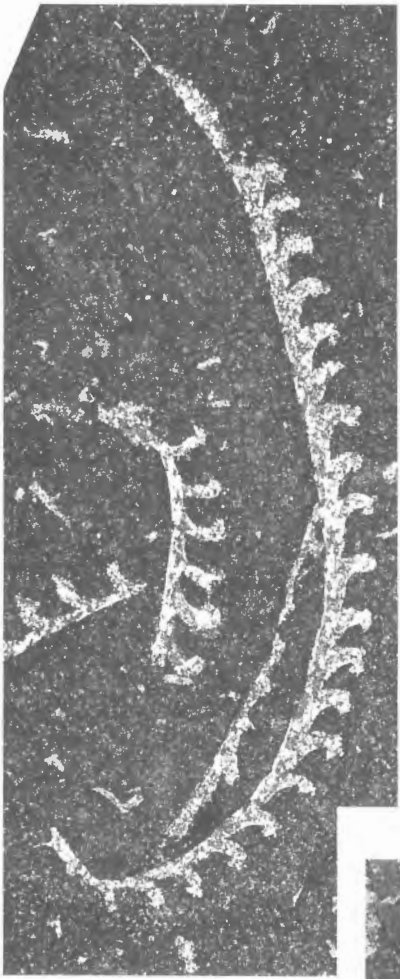
PLATE IV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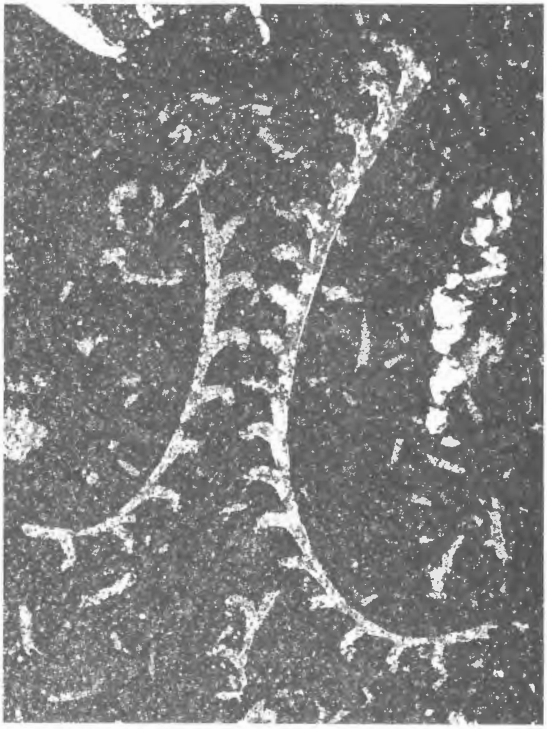
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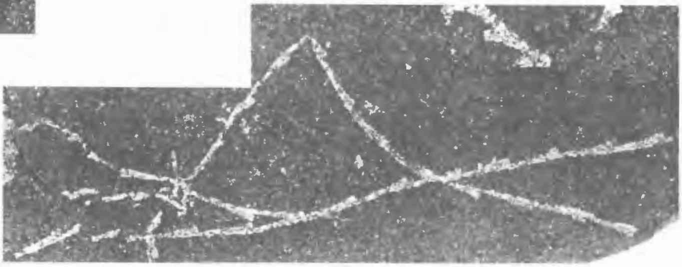
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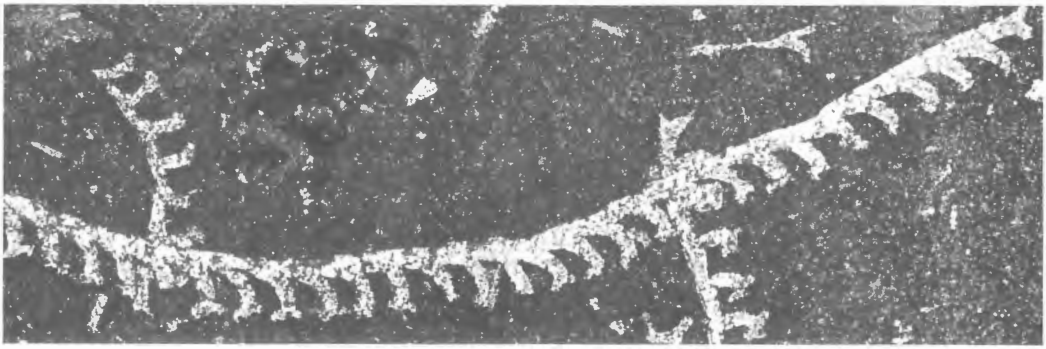


PLATE 4

Monograptus paraformosus new species (PAGE 27)

Figure 1. Holotype GSC 21267 from GSC loc. 53241, Road River Formation, lower Porcupine River; x5½.

Figures 2, 4. Paratypes GSC 21271 (left of fig. 2), 21273 (right of fig. 2), 21272 (fig. 4) from same locality; fig. 2 x5½, fig. 4 x5. Fig. 4 shows a part of a fragment of a rhabdosome; note transversely widened dorsal shields over thecal apertures which have been rotated through 90 degrees.

Linograptus posthumus tenuis Jaeger (PAGE 21)

Figure 3. Hypotype GSC 21294 from GSC loc. 53242, Road River Formation, lower Porcupine River; x5.

PLATE 5

Monograptus aff. *M. kosoviensis* Bouček (PAGE 26)

Figure 1. Hypotype GSC 21260 from GSC loc. 53241, Road River Formation, lower Porcupine River; x2¾.

Figure 6. Hypotype GSC 21261 from GSC loc. 53242, Road River Formation, lower Porcupine River; x5½.

Monograptus bugensius (Teller) (PAGE 23)

Figures 2–4. Drawings of hypotypes GSC 21285 (*see also* Pl. 3, fig. 1), 21282 (Pl. 3, fig. 4), and 21281 (Pl. 3, fig. 2) from Road River Formation, lower Porcupine River; x6.

Monograptus chelmiensis (Teller) (PAGE 24)

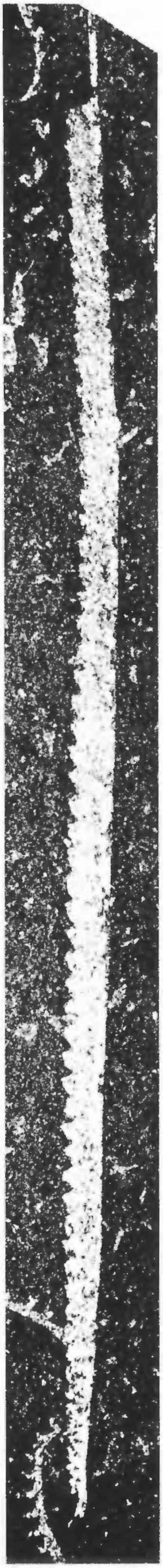
Figures 5, 9. Hypotypes GSC 21287 and 21286 from GSC loc. 53244, Road River Formation, lower Porcupine River; x5. Fig. 5 illustrates the proximal part of a rhabdosome displaying the hooked nature of th^{1}.

Figure 8. Drawing of hypotype GSC 21293 from Road River Formation, lower Porcupine River; x4.

Monograptus aff. *M. angustidens* Přibyl (PAGE 21)

Figure 7. Drawing of hypotype GSC 21278 from Road River Formation, lower Porcupine River; x5⅓.

PLATE V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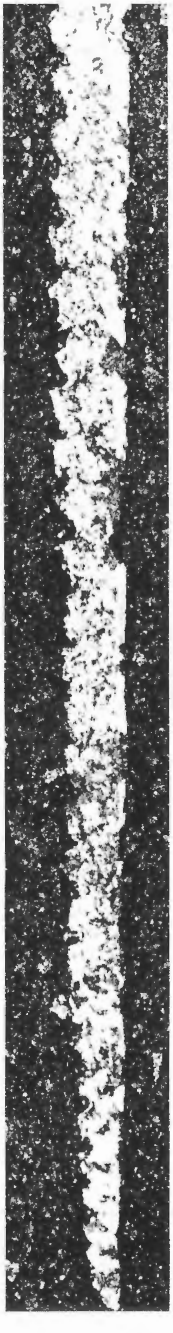
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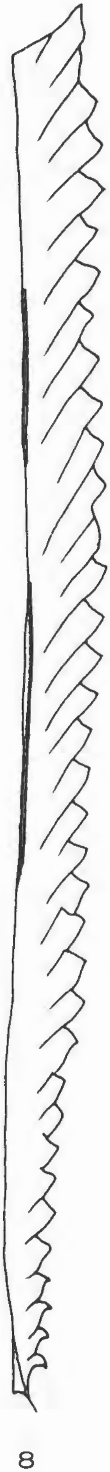
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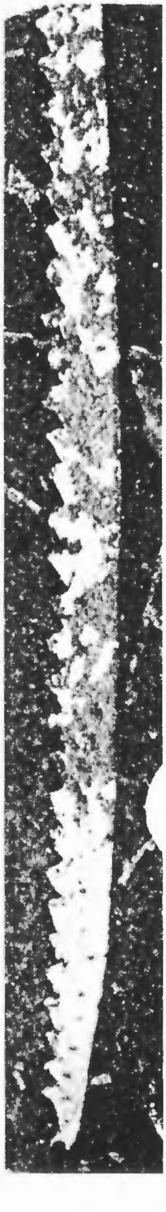
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PLATE VI


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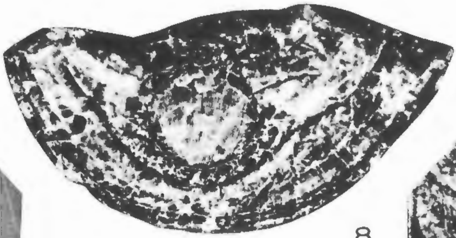
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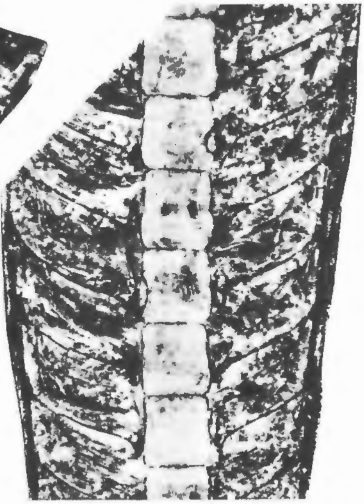
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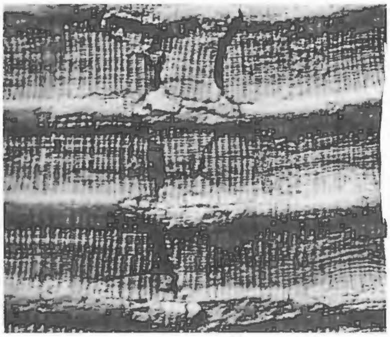
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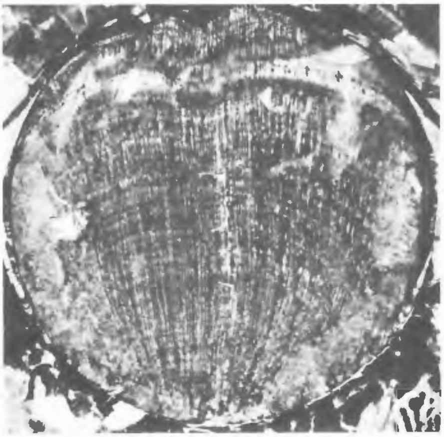
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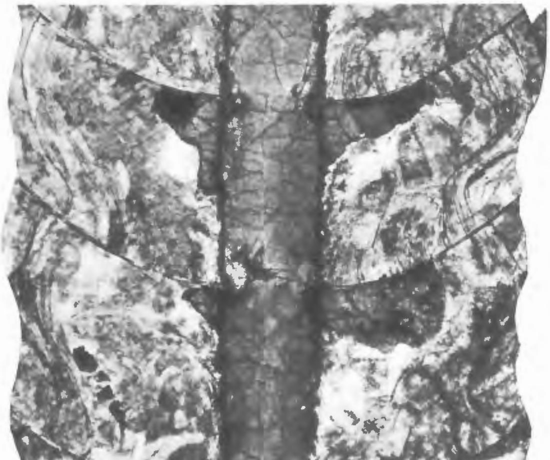
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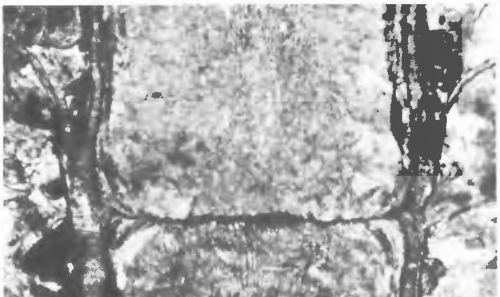
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PLATE 6

Spyroceras thoas (Hall) (PAGE 35)

Figures 1, 2. Longitudinal and transverse views of hypotype GSC 23713 from GSC loc. 57730, Eids Formation, Ellesmere Island; x2.

Figure 3. Longitudinal mid-siphuncular thin section (hypotype GSC 23713a) of the same specimen; x15.

Figure 4. Surficial ornament of hypotype GSC 23714 (fragment from near aperture of a large specimen) from the same locality; x2.

Folioceras segmentum new genus, new species (PAGE 38)

Figure 5. Longitudinal lateral view of holotype GSC 23715 from GSC loc. 57730, Eids Formation, Ellesmere Island; x2.

Figure 6. Longitudinal lateral polished section of the holotype; x2.

Figure 7. Longitudinal lateral thin section (23715a) of the holotype; x10.

Figure 8. Transverse polished section, venter down, of paratype GSC 23716 from the same locality; x2.

Figure 9. Transverse thin section (23716a), venter down, of the same specimen; x8.

PLATE 7

Spyroceras? aff. *S. karpinskyi* Zhuravleva (PAGE 36)

Figures 1, 2. Ventral and transverse views of hypotype GSC 23717 from GSC loc. 57730, Eids Formation, Ellesmere Island; x1⅓.

Figure 3. Lateral view of hypotype GSC 23718 from the same locality; x1⅓.

Figures 4, 5. Dorsoventral thin section (23718a) of the same specimen; x7 and x20. Fig. 5 is an enlarged view of the adapical septal necks visible in the bottom right of fig. 4.

Figure 6. Surface ornament of the specimen shown by figs. 1 and 2; x2⅔.

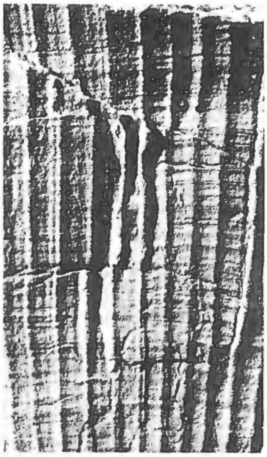
Hindeoceras sp. (PAGE 42)

Figures 7, 8. Longitudinal and slightly oblique transverse views of hypotype GSC 23719 from GSC loc. 57730, Eids Formation, Ellesmere Island; x1⅓. Fig. 8 shows the spout-like nodes; both figures show encrusting corals (*Alveolites* sp. and *Aulopora* sp.) and euomphalid gastropods.

Leurocycloceras superplenum new species (PAGE 40)

Figures 9–11. Lateral, ventral, and transverse adapical views of holotype GSC 23720 from GSC loc. 53091, Prongs Creek Formation, northern Yukon; x1⅓.

Figure 12. Transverse adapical view of paratype GSC 23721 from the same locality, showing vascular structures; x4.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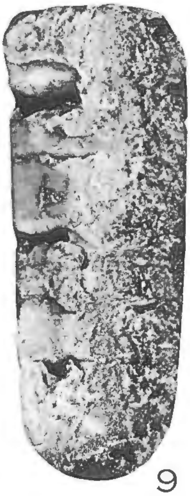
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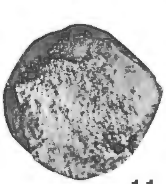
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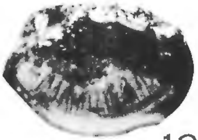
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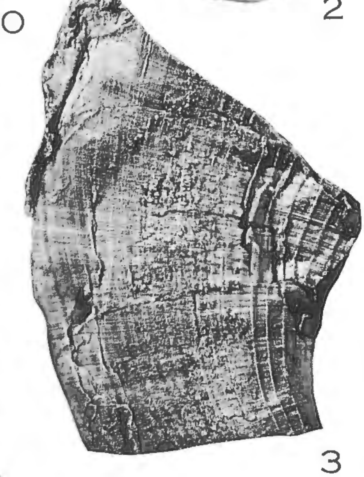
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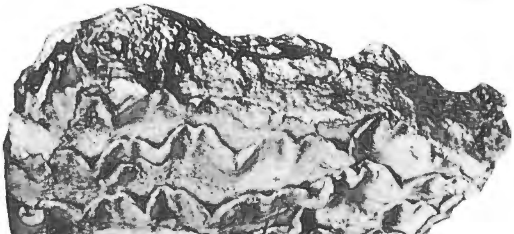
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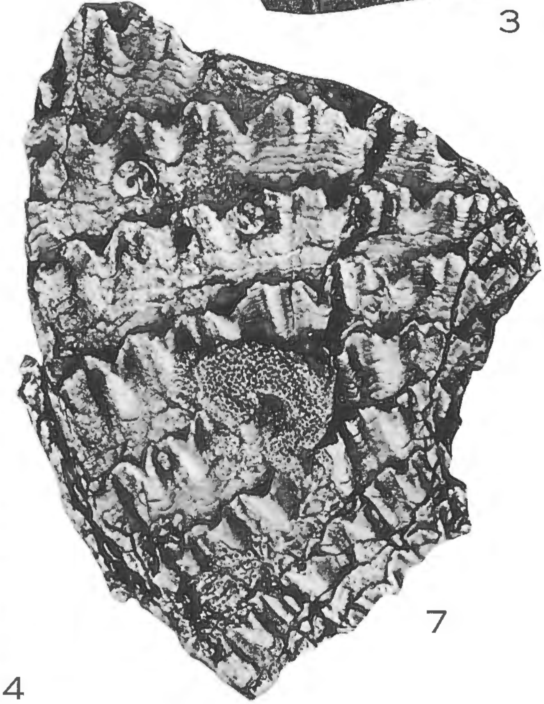
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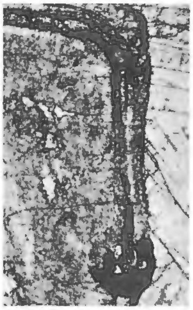
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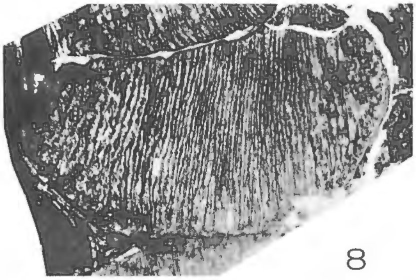
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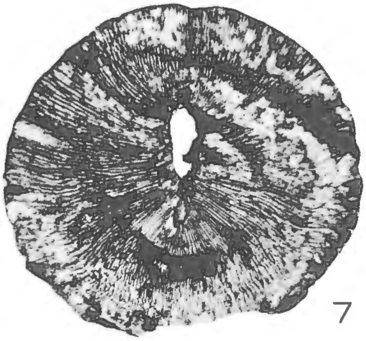
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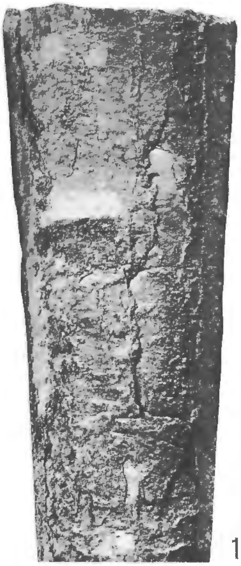
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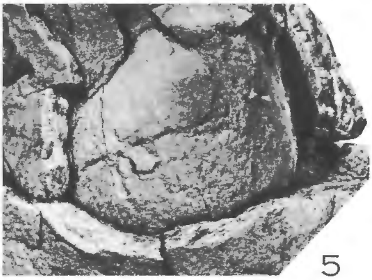
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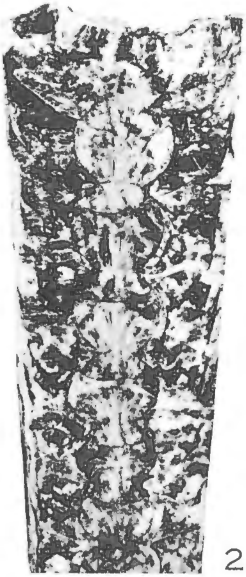
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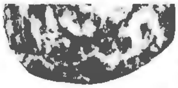
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PLATE 8

Ormoceras sp. (PAGE 46)

Figure 1. Longitudinal view of hypotype GSC 23722 from GSC loc. 53094, Prongs Creek Formation, northern Yukon; x1.

Figures 2, 3. Longitudinal mid-siphuncular and transverse polished sections from the same specimen; x1.

Figure 4. Longitudinal thin section (23722a) of the siphuncle of the same specimen; x5.

Rayonnoceras? sp. (PAGE 47)

Figure 5. Longitudinal view of a siphuncular segment of hypotype GSC 23723 from GSC loc. 53090, Prongs Creek Formation, northern Yukon; x1.

Figure 6. Transverse polished section of the siphuncle of the same specimen; x1.

Figures 7, 8. Transverse (23724a) and longitudinal (23724b) thin sections of the siphuncle of hypotype GSC 23724 from GSC loc. 53091, Prongs Creek Formation, northern Yukon; x2½.

Leurocycloceras superplenum new species (PAGE 40)

Figures 9–12. Longitudinal (23725a, slightly off-centre; 23726a; 23727a) thin sections of the siphuncle of paratypes 23725, 23726, 23727 from GSC loc. 53091, Prongs Creek Formation, northern Yukon; x2½, x5, x5, x12. The section of fig. 9 is slightly off-centre; that of fig. 10 shows "horned" episeptal deposits; that of fig. 12 is an enlarged view of the upper-left septal neck in fig. 11.

PLATE 9

Cyrthoceratites aff. *C. lineatus* d'Archiac and de Verneuil (PAGE 45)

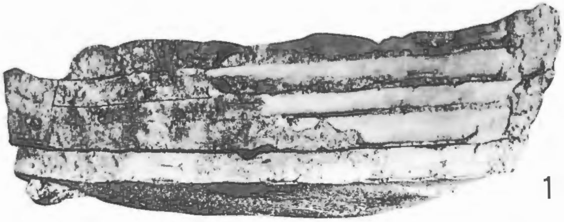
Figures 1, 3, 4. Lateral (venter on left), ventral, and transverse views of hypotype GSC 23729 from GSC loc. 69044, Landry Formation, western District of Mackenzie; x½.

Figure 2. Dorsoventral longitudinal polished section from the same specimen; x½.

Figures 5, 6. Dorsoventral longitudinal mid-siphuncular thin section (23729a), from the same specimen; x8. Fig. 5 shows the dorsal septal necks and actinosiphinate lamellae; fig. 6 shows the ventral septal necks and lamellae.

Figure 7. Transverse thin section (23729b) of siphuncle showing branching siphuncular lamellae; x8.

PLATE IX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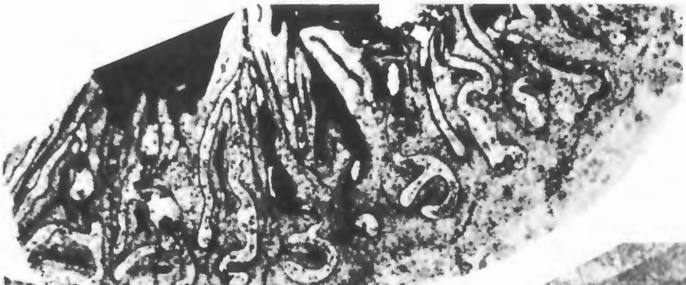
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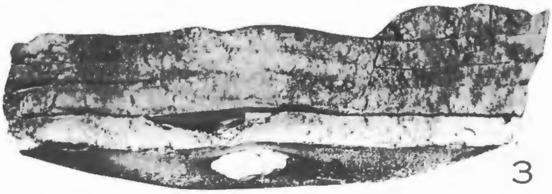
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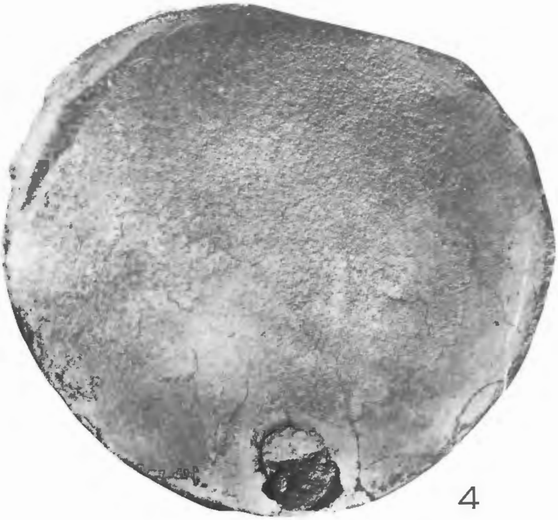
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PLATE X


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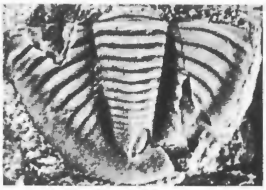
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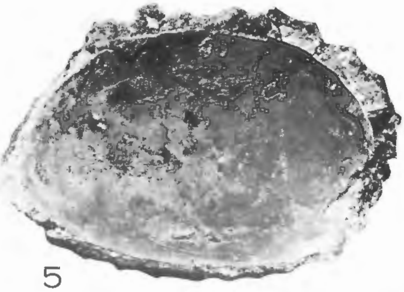
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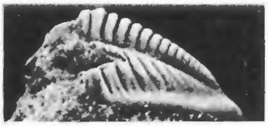
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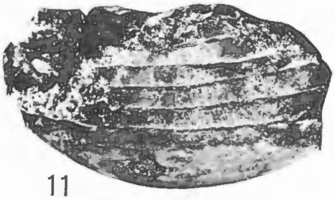
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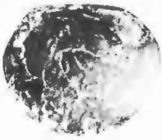
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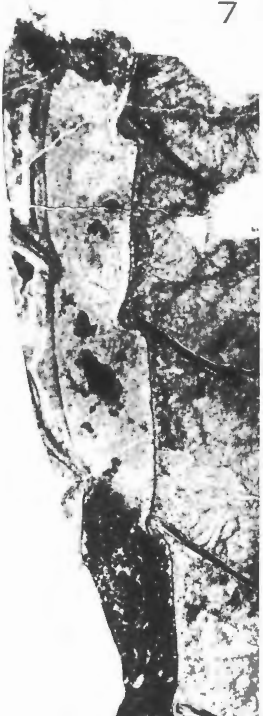
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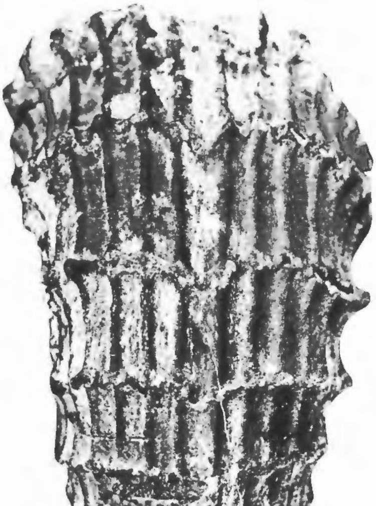
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PLATE 10

Dechenella (Dechenella) sp. (PAGE 52)

Figures 1–4. Plan, anterior, left posterolateral, and left lateral views of the pygidium (hypotype GSC 23783) from GSC loc. 75773, Landry Formation, western District of Mackenzie; x4.

Rutoceras ? eifelense (d'Archiac and de Verneuil) (PAGE 43)

Figures 5–9. Transverse adapertural, dorsal, transverse adapical, lateral and ventral views of the phragmocone (hypotype GSC 23728) from GSC loc. 75773, Landry Formation, western District of Mackenzie; x¾. The pygidium of *Dechenella (Dechenella)* sp. can be seen in the lower left of fig. 6.

Figure 10. Ventral shell ornament, same specimen; x1½.

Figure 11. Dorsal view of internal mould, same specimen; x¾.

Figure 12. Dorsoventral longitudinal thin section (hypotype GSC 23728a) of siphuncle of same specimen; x6.

PLATE 11

Kryshtofovichia africani Nikitin (PAGE 92)

Figure 1. Megaspore from Petino, U.S.S.R., with microspores sticking to its surface; x50; illustration from Nikitin (1934, Pl. I, fig. 2).

Figure 2. Emergences of megaspore from Petino; x200; illustration from Nikitin (1934, Pl. I, fig. 4).

Nikitinsporites ?canadensis Chaloner with adhering miospores (PAGE 95)

Figures 3, 4. Emergences of megaspore (hypotype GSC 15705), from GSC plant locality 7831, Imperial Formation, Smith Creek, District of Mackenzie; x500.

Figures 5, 6. Megaspore (hypotype GSC 15705) from GSC plant locality 7831, Imperial Formation, Smith Creek, District of Mackenzie; x100. In fig. 6 the arrows show the position of four miospores (similar to those of *Kryshtofovichia*) adhering to the surface of the megaspore.

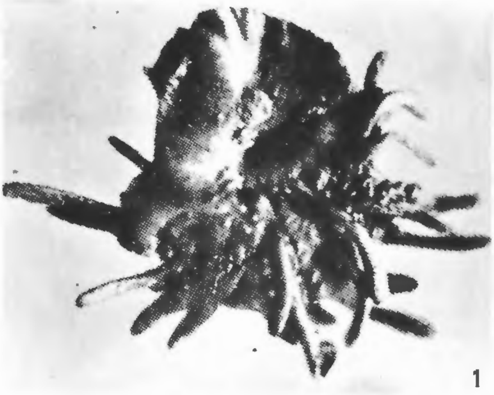
Figures 7, 8. Enlarged views of fig. 6, x250 and x500. Fig. 8 shows the miospores well; fig. 7 shows the four miospores covered by the folded apical prominence of the megaspore.

Archaeoperisaccus spp. (PAGE 96)

Figures 9, 10. An isolated, granulose to finely baculate form (hypotype GSC 15706) from GSC plant locality 7831, Imperial Formation, Smith Creek, District of Mackenzie; polar compression; x500 and x1000.

Figure 11. An isolated laevigate form (hypotype GSC 15707) from the same locality; polar compression; x500.

PLATE XI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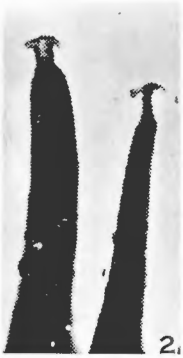
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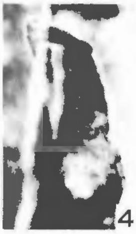
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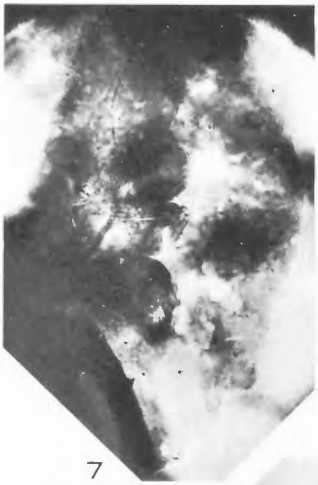
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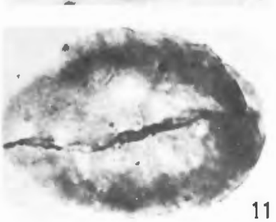
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PLATE XII


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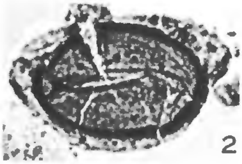
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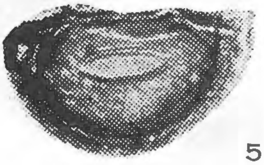
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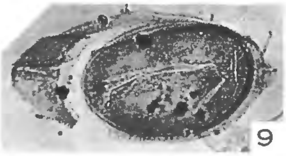
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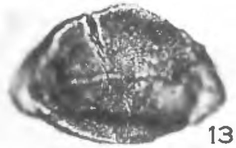
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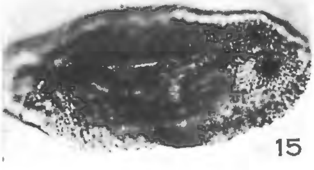
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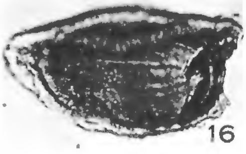
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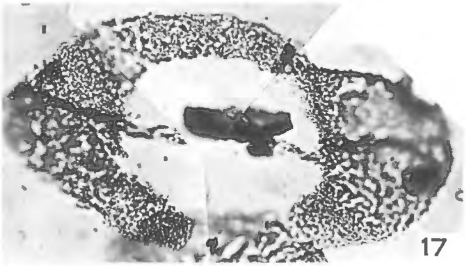
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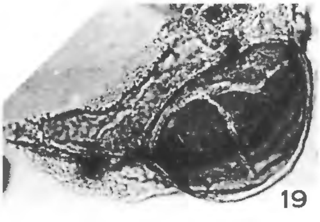
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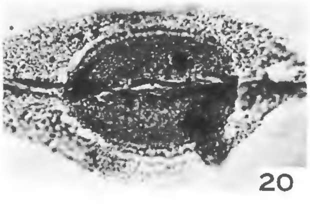
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PLATE 12

Archaeoperisaccus spp. (PAGES 93, 95, 96)

Figures 1–3. Miospores obtained by S. N. Naumova from Petino, U.S.S.R.; x500; in the Stratotype Collection of the Commission Internationale de Microflore du Paleozoique, Creil, France.

Figures 4, 7. Isolated body (hypotype GSC 15708) from Petino; specimen in lateral compression showing curvatural ridges; x500 and x1000.

Figures 13, 15, 16. Specimens (hypotypes GSC 15714, 15715, 15716) from GSC plant locality 4713, Okse Bay Formation, head of Okse Bay, Ellesmere Island, District of Franklin; x500.

Archaeoperisaccus type 1 (*A. ?concinnus* Naumova) (PAGE 93)

Figures 6, 8–10, 12. Specimens (hypotypes GSC 15709, 15710, 15710, 15711, 15713) from Petino. U.S.S.R.; x500 except fig. 8, x1000. Figs. 10 and 12 show specimens in lateral compression; fig. 6 shows a specimen in near-polar compression; figs. 8 and 9 illustrate a broken specimen that shows the upper and lower walls of the sac.

Archaeoperisaccus type 2 (*A. ?completus* Naumova) (PAGE 94)

Figure 11. Specimen (hypotype GSC 15712) in semi-lateral compression, from Petino, U.S.S.R.; x500.

Figure 14. Specimen (lower right) associated with an isolated spine with a constricted tip, cf. *Nikitinsporites* sp., from Petino, U.S.S.R.; hypotype GSC 15715; x500.

Archaeoperisaccus type 3 (*A. ?mirandus* Naumova) (PAGE 94)

Figures 17–20. Specimens (hypotypes GSC 15718, 15719, 15720, 15721) from Petino, U.S.S.R.; x500 except fig. 17, x1000. Figs. 18 and 20 show specimens in polar compression; fig. 19 shows a specimen in lateral compression; fig. 17 shows a fragment in which the body is missing, leaving only the equatorial part of the sac and the proximal flap-like keel.

Kryshtofovichia africani Nikitin (PAGE 92)

Figure 5. Microspore from Petino, U.S.S.R.; x500; illustration from Nikitin (1934, Pl. IV, fig. 27).

PLATE 13

Medlicottia chozaensis Plummer and Scott (PAGE 117)

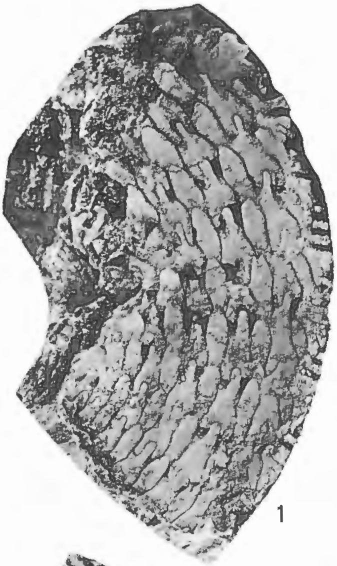
Figures 1, 3, 5. Lateral views of lectotype BEG 8917, syntype BEG 8916, and hypotype SUI 32365 from the upper Clear Fork Group of north-central Texas; x1½.

Figures 2, 4. Lateral views of hypotypes GSC 23606 and 23605 from the Belloy Formation of northeast British Columbia; x2 and x1½.

Ekvasophyllum cascadense (Warren) (PAGE 109)

Figures 6–8. Lectotype GSC 8910 from the Mount Head Formation, southwest Alberta; fig. 6, transverse section, ephebic stage; fig. 7, acetate peel of longitudinal section in counter-cardinal plane through cardinal fossula; fig. 8, acetate peel of transverse section, neanic stage; all x2.

Figure 9. Syntype GSC 8910a from the Mount Head Formation, southwest Alberta; transverse section of neanic stage; x2.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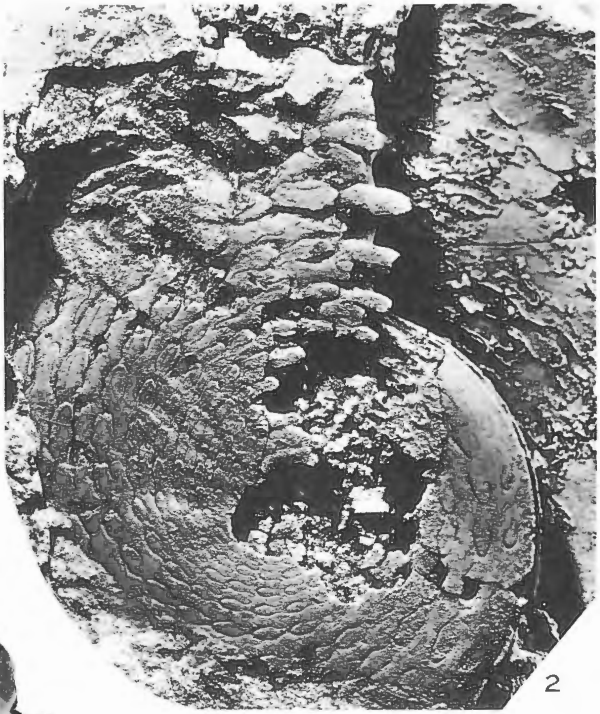
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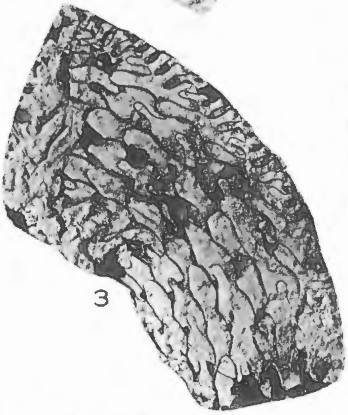
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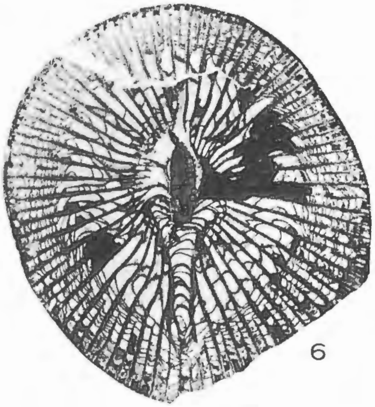
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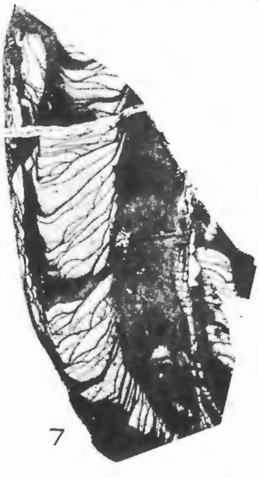
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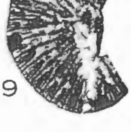
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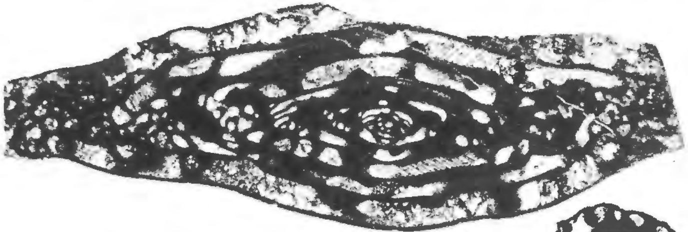
PLATE XIV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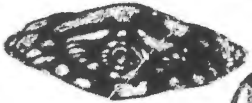
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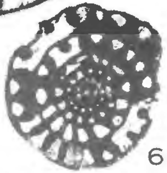
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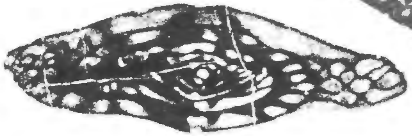
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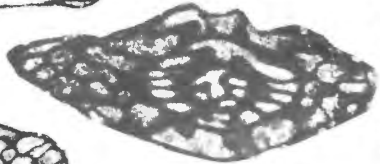
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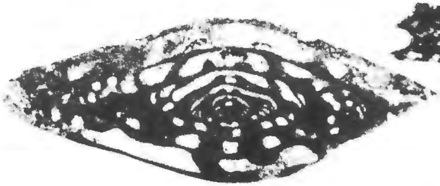
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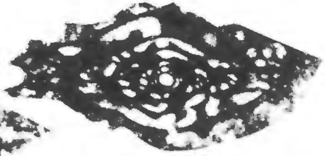
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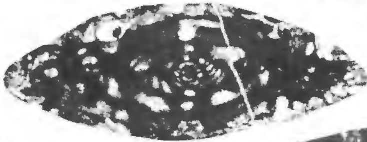
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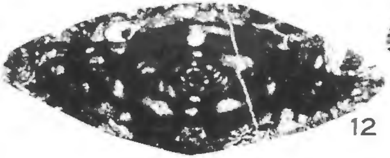
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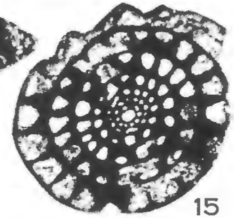
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PLATE 14

Eowaeringella richardsonensis new species (PAGE 130)

Figures 1, 2. Axial section of holotype (GSC 23742) from GSC loc. 53220; x20 and x60.

Figures 3–5, 7, 9–13. Axial sections of paratypes (GSC 23743, 23743, 23744, 23745, 23746, 23747, 23748, 23749, 23750); same locality; fig. 4 x60, others x20.

Figures 6, 15. Sagittal sections of paratypes (GSC 23751, 23752); same locality; x20.

Figures 8, 14. Tangential sections of paratypes (GSC 23753, 23754); same locality; x20.

PLATE 15

Parafusulina macdamensis new species (PAGE 132)

Figure 1. Microspheric individual (paratype GSC 23763) sectioned obliquely through a deformed shell; GSC loc. 51078; x10.

Figures 2, 3. Parts of tangential sections of paratypes (GSC 23764, 23765) showing well developed cuniculi; same locality; x10.

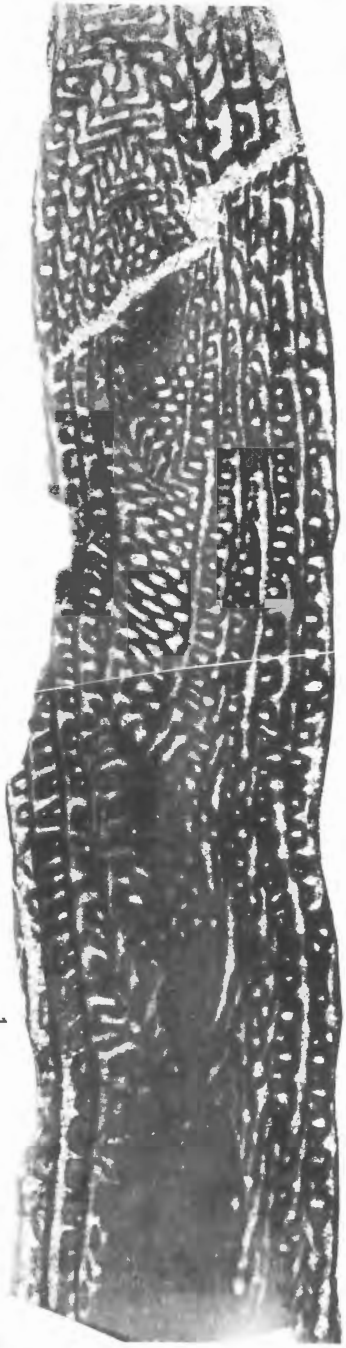
Figure 4. Axial section of immature megalospheric specimen (paratype GSC 23766) with large proloculus; same locality; x10.

Wedekindellina cf. *W. cabezasensis* Ross and Sabins (PAGE 131)

Figures 5–8, 11, 12. Oblique axial sections (hypotypes GSC 23756, 23757, 23758, 23757, 23759, 23760); GSC loc. 47209; fig. 8 x60, others x20.

Figure 9. Oblique tangential section (hypotype GSC 23761) showing nearly planar septa; same locality; x20.

Figure 10. Oblique sagittal section (hypotype GSC 23762) showing closely spaced septa; same locality; x20.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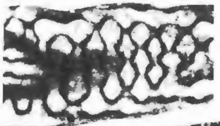
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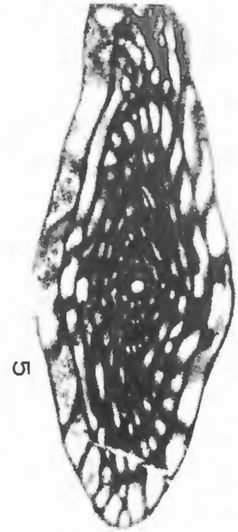
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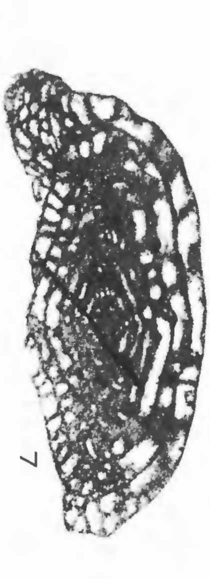
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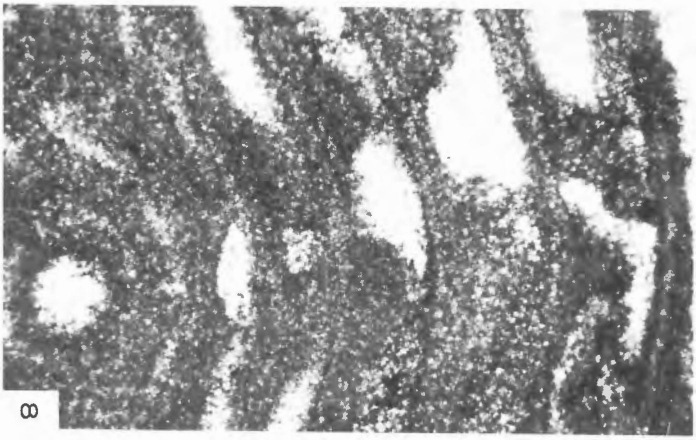
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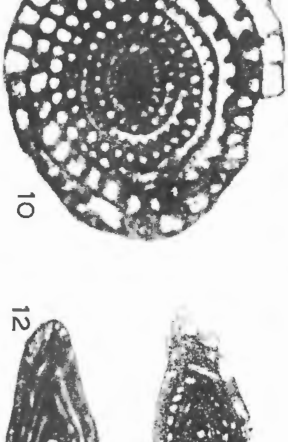
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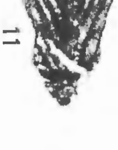
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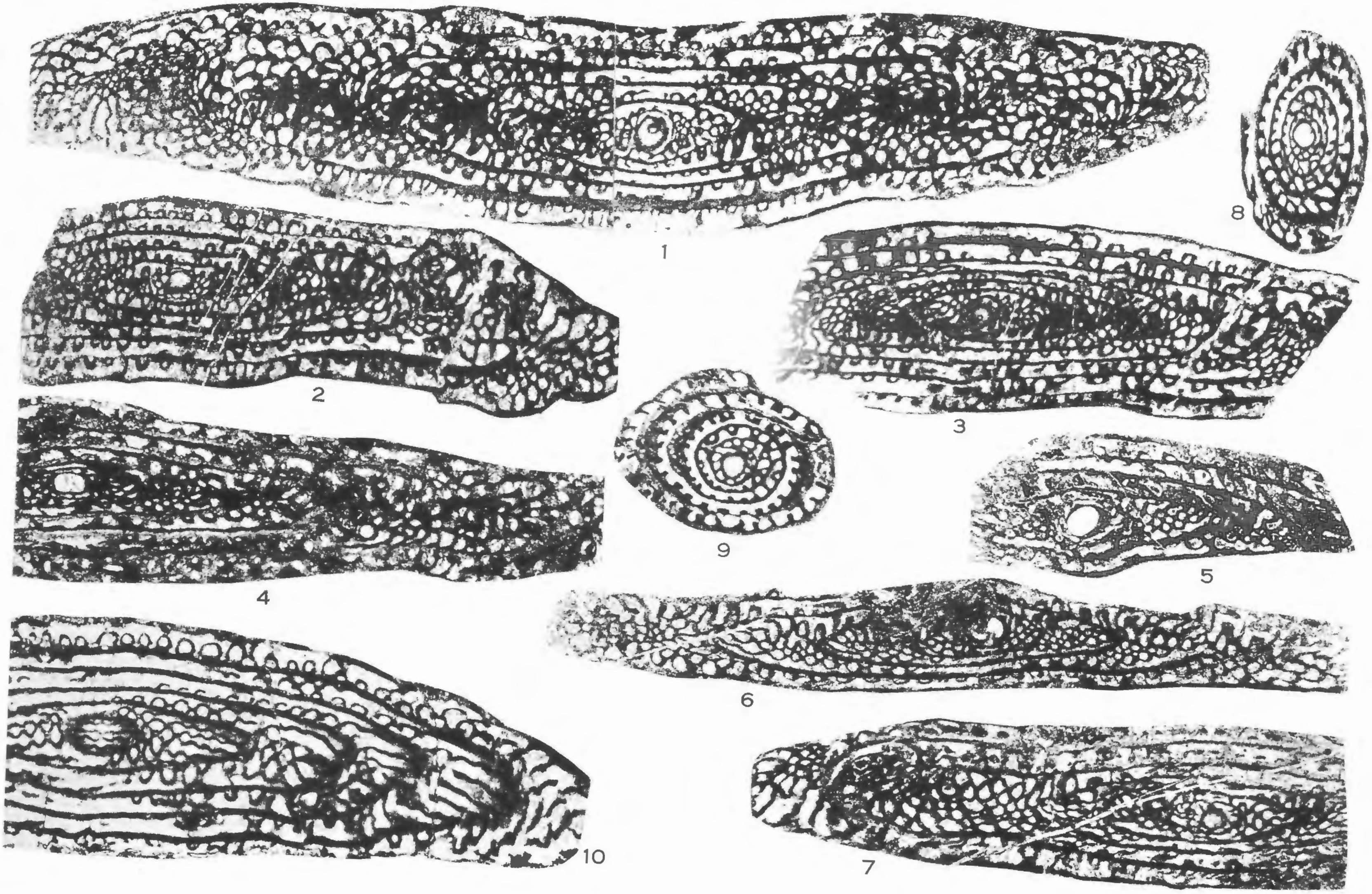
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PLATE 16

(all x10)

Parafusulina macdamensis new species (PAGE 132)

Figure 1. Axial section of holotype (GSC 23767) from GSC loc. 51078.

Figures 2–7. Axial sections of paratypes (GSC 23768, 23769, 23770, 23771, 23772, 23773); same locality.

Figures 8, 9. Sagittal sections of paratypes (GSC 23774, 23775); same locality.

Figure 10. Deep tangential section of paratype (GSC 23776); same locality.

PLATE 17

Paraalnipollenites confusus and associated palynomorphs from the District of Franklin. All specimens from GSC plant locality 7277, Eureka Sound Formation, Bathurst Island.

Paraalnipollenites confusus (Zaklinskaia) n.f. gen. (PAGE 141)

Figures 1, 2. Hypotype GSC 15722, x500; x1200. Note the well developed lower pore; absence of fusion of the arci with pore upper left two false pores middle left and middle right.

Figures 3–5. Hypotype GSC 15723; x500; x1200. Fig. 3, note the false pores and absence of fusion of the arci middle right. Fig. 4 phase contrast, note the development of arci and the annular thickening. Fig. 5, note the development of the false pore middle left.

Figures 6–8. Hypotype GSC 15724; x500; x500, x1200. Fig. 6, note the discontinuous character of the arci. Fig. 7, note the development of the annular thickening. Fig. 8, note the irregular development of the arci.

Alnipollenites spp. (PAGE 139)

Figures 9–11. Hypotypes GSC 15725, 15726, 15727, four-pored, six-pored, and five-pored respectively; all x1000.

cf. *Aquilapollenites* sp. (PAGE 143)

Figure 12. Hypotype GSC 15728; x1000.

Wodehouseia cf. *W. stanleyi* Srivastava (PAGE 143)

Figure 13. Hypotype GSC 15729; x250.

Wodehouseia spinata Stanley (PAGE 143)

Figure 14. Hypotype GSC 15730; x500.

Wodehouseia cf. *W. operculata* Chlonova (PAGE 143)

Figure 15. Hypotype GSC 15731; x100.

Aquilapollenites granulatus Mchedlishvili (PAGE 143)

Figure 16. Hypotype GSC 15732; x500

Schizaea plectilis Stanley (PAGE 143)

Figure 17. Hypotype GSC 15733; x500

Projectoporites magnus Mchedlishvili (PAGE 143)

Figure 18. Hypotype GSC 15734; x500.

Orbiculapollis globosus Chlonova (PAGE 143)

Figure 19. Hypotype GSC 15735; x1000.

PLATE XVII


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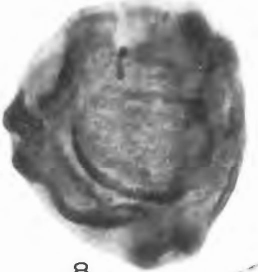
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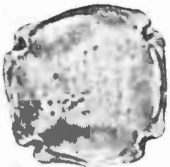
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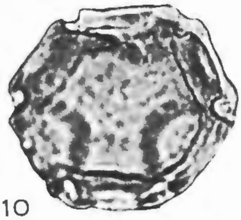
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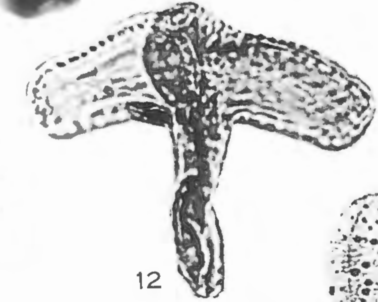
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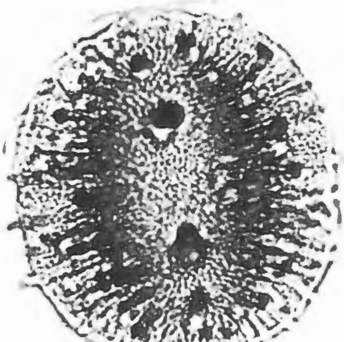
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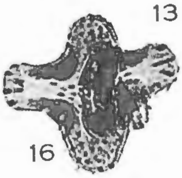
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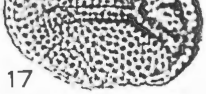
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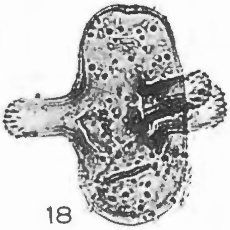
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DEVONIAN PLANT FOSSILS OF THE GENERA *KRYSHTOFOVICHIA, NIKITINSPORITES,* AND *ARCHAEOPERISACCUS*

by D. C. McGregor

Abstract

Information is presented on the structure and occurrence of dispersed miospores of the genus *Archaeoperisaccus* Naumova, of Devonian age, from Canada and the U.S.S.R. The evidence shows that spores similar to *A. concinnus* Naumova are microspores of the Devonian plant *Kryshtofovichia africani* Nikitin. It also supports the proposal of Chaloner that spores referable to Nikitinsporites Chaloner are the megaspores of that plant.

The genus *Archaeoperisaccus* is emended as a result of reinterpretation of the structure of specimens from the Petino beds, Voronezh District, U.S.S.R., the area from which *Archaeoperisaccus* and *Kryshtofovichia* were originally described.

Kryshtofovichia is probably of lycopsid affinity. It may be a precursor of the Triassic–Jurassic group *Lycostrobus–Cyclostrobus–Pleuromeia,* and possibly of the modern plant *Isoetes.*

Archaeoperisaccus has been reported only from rocks assigned to the Frasnian Stage of the Late Devonian of North America and the U.S.S.R., and has considerable promise as an index fossil.

Résumé

Renseignements concernant la structure et la présence de miospores di spersés du genre *Achaeoperisaccus* Naumova, du Dévonien, provenant du Canada et de l'URSS. Il y est prouvé que des spores semblables au *A. concinnus* Naumova sont des microspores du *Kryshtofovichia africani* Nikitin, plante du Dévonien. L'étude support également la thèse de Chaloner, selon laquelle les spores attribuables au *Nikitinsporites* Chaloner sont les mégaspores de cette plante.

Le genre *Archaeoperisaccus* est amendé à la suite de la nouvelle interprétation de la structure de spécimens provenant des couches Petino (district de Voronezh, URSS), région d'où provient la description originale de *l'Archaeoperisaccus* et du *Kryshtofovichia.*

Il est probable que le *Kryshtofovichia* a des affinités avec les lycopsides. Il est possible qu'il s'agisse d'un précurseur du groupe*Lycostrobus–Cyclostrobus–Pleuromeia,* du Trias-Jurassique, et peut-être même de la plante récente *Isoetes.*

L'Archaeoperisaccus n'a été trouvé que dans les roches du Frasnien,(Dévonien récent) de l'Amérique du Nord et de l'URSS, et présente une valeur considérable de fossile-index.

Introduction

In 1930, P. A. Nikitin recorded the presence of fossil megaspores in Upper Devonian rocks near Petino village on the Don River, Voronezh district, in the central European U.S.S.R. Subsequently (1934) he published a description of plant remains from these beds. Besides megaspores, he described megasporangia, some of which contained megaspores, and microsporangia containing microspores. He also observed microspores adherent to the surface of isolated megaspores. He concluded that the spores and sporangia were all parts of one plant, to which he gave the name *Kryshtofovichia africani.* The megaspores (Pl. 11, fig. 1) were trilete, bore a large apical prominence called by Nikitin an "androcamera", and possessed long, thick spines that were constricted abruptly near their tips and bore anchor-shaped terminations (Pl. 11, fig. 2).

According to Nikitin, the microspores of *K. africani* (Pl. 12, fig. 5) were monolete, a condition that is unusual for Devonian spores. They possessed an inner, unornamented layer, and an outer, granulate enveloping structure that was attenuated in the direction of the long axis of the spore.

Up to now, no information has been published concerning similarity between the microspores of *K. africani* and any group of dispersed spores. Such a comparison has, however, been made for the megaspores. Chaloner (1959) found megaspores similar to *K. africani* in Upper Devonian coal (Fig. 1, loc. 3) from Ellesmere Island, in the Canadian arctic islands, and instituted the genus *Nikitinsporites* for ". . . spores of the type contained in *Kryshtofovichia africani,* if found isolated."

The objectives of the present paper are to present evidence of relationship between microspores of the type borne by *Kryshtofovichia africani* Nikitin and dispersed miospores of the genus *Archaeoperisaccus* Naumova (1953), and to consider evidence of alliance between *Archaeoperisaccus* and *Nikitinsporites;* to amend the diagnosis of *Archaeoperisaccus;* and to suggest the stratigraphic significance of *Archaeoperisaccus,* which is somewhat different from that of the other genera included within this taxonomic alliance.

Acknowledgments

The writer is grateful to James M. Schopf of the United States Geological Survey for providing the specimens of *Nikitinsporites* and *Archaeoperisaccus* discovered by M. R. Winslow; to J. B. Richardson of King's College London for helpful discussion; and to Bernard Owens of the Institute of Geological Sciences, Leeds, B. S. Norford of the Geological Survey of Canada, and James M. Schopf for reading and commenting upon the manuscript.

C. de Leuchtenberg and Th. Pidhayny of the Translation Bureau of the Department of the Secretary of State provided translations from Russian and Polish texts respectively.

Dispersed Spores From Petino, U.S.S.R.

Several years ago the writer obtained a sample of light grey-buff shale that had been collected from the Petino beds. When digested in concentrated hydrofluoric acid without further chemical treatment, this sample yielded three types of small, monolete, camerate spores. Twenty specimens of each type were examined and measured in glycerine jelly mounts. All three types are subelliptical in polar view, and boat-shaped in lateral view. The inner body (?intexine) is elliptical, rather rigid, laevigate and about 1 to 4 μ thick.

Type 1 (Pl. 12, figs. 4, 6–10, 12) is 57μ to 80μ in equatorial diameter along its long axis. A scabrate to minutely granular sac-like structure (?exoexine) extends in the equatorial plane up to about 20μ beyond the body margin along the long axis of the spore, but only up to about 8μ beyond the body laterally in polar compression. This sac-like extension is difficult to reconstruct from intact specimens, and can be best understood by examination of those that have been torn or broken. When the sac-like structure is torn, it comes away from the body most readily at the equator following the contour of the body (Pl. 12, figs. 8 and 9). The body, when completely free, resembles a small *Laevigatosporites* except that it bears narrow arcuate ridges about 1μ high near the equator (Pl. 12, figs. 4 and 7). On laterally flattened specimens with the sac still attached, the arcuate attachment-lines can be traced along the body and are continuous with folds of the sac beyond the ends of the body (Pl. 12, figs. 10 and 12). The arcuate ridges therefore evidently represent the locus of attachment of the distal wall of the lateral, wing-like expansion of the sac. The proximal and distal walls of the lateral "wing" are distinguished best on damaged specimens in which the "wing" is torn. On such specimens the camerate nature of the "wing" can be seen clearly (Pl. 12, figs. 8 and 9). The extent of attachment of the sac or exoexine proximally has not been determined, and it may be necessary to cut thin sections in order to determine it accurately. At present I interpret it as not attached, but rather

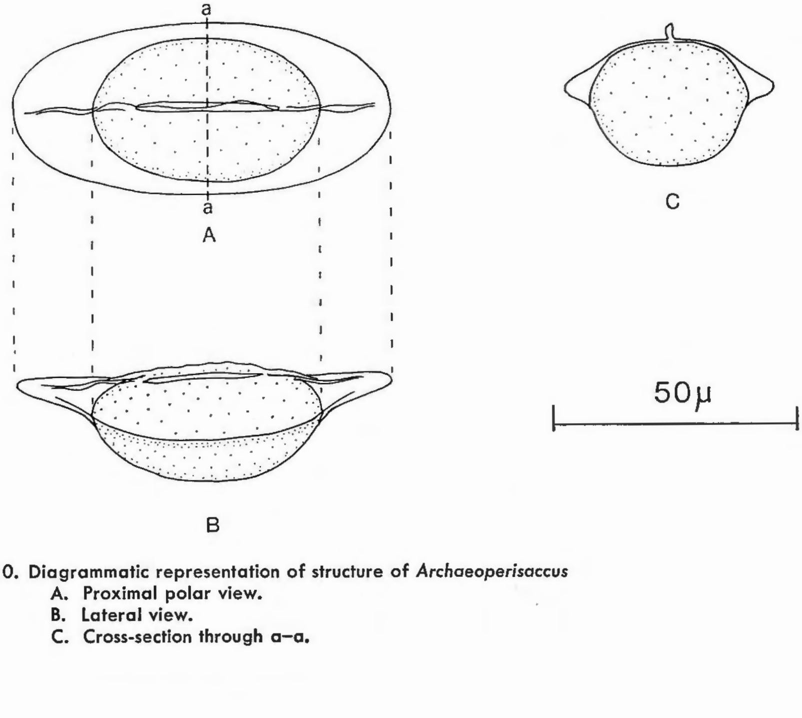

FIGURE 10. Diagrammatic representation of structure of *Archaeoperisaccus*
A. Proximal polar view.
B. Lateral view.
C. Cross-section through a–a.

closely appressed proximally, except along the laesura where it is raised and longitudinally extended to form a flap-like keel (Fig. 10c). In laterally compressed specimens the sac may be seen to adhere closely to the body over most of the distal hemisphere (Fig. 10b, and Pl. 12, figs. 10 and 12).

Type 2 is smaller than type 1 (50μ–68μ), and the sac does not extend beyond the body laterally (Pl. 12, figs. 11 and 14).

Type 3 is larger (77μ–122μ) and the sac, which bears cones or bacula less than 1μ long, extends rather far beyond the body laterally (Pl. 12, figs. 17–20). One specimen of this type was seen in which the body had disappeared, leaving just the equatorial part of the sac and the proximal flap-like keel (Pl. 12, fig. 17).

On some specimens, particularly of types 1 and 3 (Pl. 12, figs. 6, 18, and 20), the body has separated from the sac along most of its periphery, and one gets the impression that the body is embedded like the yolk of an egg in a thick, semitransparent, granular substance. This interpretation would agree with Nikitin's description of the envelope surrounding the body of *Kryshtofovichia* microspores. The description given by Nikitin for the microspores of *Kryshtofovichia* is as follows (translated from Nikitin, 1934, pp. 1083, 1084):

> Microspores (figs. 22–28) when viewed from the side are canoe-shaped, and when viewed from the top are elliptical, having sometimes a straight or acutely elliptical slit along the long axis. Some specimens have the slit on the side. The inner layer is hyaline and thin, the outer thicker and finely granulate, not distinguishable from the mucus-like substance in which the microspores were immersed in the microsporangium. . . . The thickness of the outer cover of the spores is not uniform. Exactly at the ends of the long axis occur local thickenings of the wall. In their outward appearance the microspores resemble most closely the microspores of the present-day *Isoëtes* but are much larger. When macerated, some of the spores when released remain connected by fours in two intersecting pairs. The length of the microspores ranges from 0.042 to 0.045 mm, and the width 0.025 to 0.028 mm. The thickness of the inner layer is about 0.003 to 0.005 mm.

I prefer to interpret the outer structure of the dispersed spores as a thin-walled, partly free sac-like envelope and not a thick "mucus-like" one as suggested by Nikitin for the microspores of *Kryshtofovichia*. Nikitin was impressed by the idea of a fossil periplasmodium. In the light of many subsequent discoveries, one is justified in thinking of the more durable and distinctive outer membranes of spores. Despite the difference in the interpretation presented here from that of Nikitin, there does not seem to be any doubt that the dispersed spores obtained by the writer have basically the same structure as those reported by Nikitin (1934). One of Nikitin's illustrations of a *K. africani* microspore is reproduced for comparative purposes on Plate 12, figure 5. It seems reasonable to conclude that the dispersed spores from the Petino sample are microspores of a plant similar to *K. africani*. No megaspores of the *Nikitinsporites* type were found in the sample from Petino, but one broken spine was recovered bearing the constricted tip characteristic of the spines of the *Kryshtofovichia* megaspore (Pl. 12, fig. 14).

Several years after Nikitin discovered *Kryshtofovichia*, Naumova (1953) macerated samples from the Upper Devonian rocks near Petino, and obtained monolete, double-walled miospores for which she instituted a new form-genus, *Archaeo-*

perisaccus. Her spores were apparently derived from the same stratigraphic interval, the "Petino beds", if not from the same localities, from which Nikitin obtained the *Kryshtofovichia* microspores, and from which I obtained the spores described above. Naumova (1953, p. 17) was aware of Nikitin's work, but she did not draw any comparison between her spores and the microspores of *Kryshtofovichia.*

The basic structure of *Archaeoperisaccus,* as judged from the original description and illustrations, and from available photographs of Naumova's specimens, seems identical to that of the spores obtained by the writer and by Nikitin from the Petino beds, and it therefore seems reasonable to place in the genus *Archaeoperisaccus* microspores similar to those of *Kryshtofovichia africani,* if found dispersed.

Provisionally, I would assign type 1 to *Archaeoperisaccus concinnus* Naumova[1], type 2 to *A. completus* Naumova, and type 3 to *A. mirandus* Naumova. Plate 12, figures 1–3 shows three of Naumova's specimens, possibly of these three species, photographed from the Stratotype Collection of the Commission Internationale de Microflore du Paleozoïque. Type 1 (*A. ?concinnus*) seems most like the microspores of *Kryshtofovichia africani.*

Nikitinsporites with Adhering Miospores, from Northern Canada

In describing *Kryshtofovichia africani*, Nikitin (1934) mentioned that the microspores sometimes adhered in masses to the outer surface of the megaspore. Dr. J. M. Schopf of the United States Geological Survey recently drew my attention to an association of *Nikitinsporites* and *Archaeoperisaccus,* which rather closely duplicates the situation reported by Nikitin. The material in question is from the Upper Devonian Imperial Formation on Smith (Long) Creek (Fig. 1, loc. 8), about 15 airline miles south-southeast of its confluence with Mackenzie River, about 50 miles slightly south of east from the mouth of the Arctic Red River, District of Mackenzie. This locality has been assigned Geological Survey of Canada plant locality 7831. The sample was supplied to Schopf by Dr. Grace Anne Stewart, formerly a consultant at Calgary. Preparations by Schopf from this locality were examined by Marcia R. Winslow who discovered several specimens of *Nikitinsporites,* one of which had adhering to its surface four monolete miospores of the type reported by Nikitin for *Kryshtofovichia.* With Schopf's permission the megaspore with its adhering miospores is illustrated on Plate 11, figs. 5–8. The megaspore is sufficiently well preserved to show some of the constricted spine tips with bifurcations that are characteristic of *Nikitinsporites* (Pl. 11, figs. 3, 4). The spore is 558μ in diameter, and two of the longest spines are respectively 236μ and 246μ long, 42μ and 45μ in diameter at the base, tapering to 22μ and 20μ immediately before the apical constriction. These dimensions agree well with the mean spore diameter of 525μ and the typical spine length of 200μ reported for *N. canadensis* by Chaloner (1959, p. 328), and the average spore diameter of 500μ and spine length of 250μ-350μ given for megaspores of *Kryshtofovichia africani* by Nikitin (1934, pp. 1083 and 1090).

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[1] The specimens resemble *A. concinnus* in size if *A. concinnus* is 55μ to 60μ long, and not 20μ to 30μ long (*see* Naumova, 1953, p. 92).

The adhering miospores are covered by what appears to be an over-fold of the apical prominence of the megaspore (Pl. 11, fig. 7). According to a measurement taken of the widest part of the folded "apical prominence" its height would be about 160μ. This measurement, and in fact the interpretation of the structure as an apical prominence, are open to some doubt because the megaspore is strongly flattened and very dark. The surface of the megaspore which bears the miospores and the overlying structure ("apical prominence"?) does not bear spines and is assumed to be proximal. The opposite side of the megaspore possesses densely distributed, broken spine-bases. The adhering microspores are 60 x 38μ, 58 x 32μ, 69 x 34μ, and 60 x 36μ in diameter. Their structure is somewhat obscure, but they are distinctly monolete, oval in polar compression and boat-shaped in lateral compression (Pl. 11, fig. 8), and contain a poorly defined central body. Wall sculpture, if present, is minute.

Amongst the dispersed spores obtained from the same rock sample that contained the megaspore described above, there are two smooth or finely ornamented types of *Archaeoperisaccus*. One of them, 54–73μ long with a minutely granular to baculate saccus (Pl. 11, figs. 9, 10), resembles the dispersed spores of type 1 found in the Petino sample and is assigned provisionally to *A. concinnus* Naumova. The other form, represented by only one specimen (Pl. 11, fig. 11) is laevigate or very minutely sculptured, and 72μ long.

Nikitinsporites and *Archaeoperisaccus* from Ellesmere Island

Another, third line of investigation provides circumstantial evidence of affinity of *Nikitinsporites* with *Archaeoperisaccus*. In 1955, E. F. Roots of the Geological Survey of Canada obtained a sample of coal from Frasnian beds of the Okse Bay Formation at the head of Okse Bay, southwestern Ellesmere Island, District of Franklin (GSC plant loc. 4713; Fig. 1, loc. 3). The sample was sent to W. G. Chaloner, who subsequently (1959) described several new species based on megaspores from the sample, including *Nikitinsporites canadensis*, the type species of the genus. Recently I macerated a piece of coal from the sample studied by Chaloner, in the hope that it might contain specimens of *Archaeoperisaccus* similar to those associated elsewhere with *Nikitinsporites* and *Kryshtofovichia africani*. The residue yielded six specimens of *Archaeoperisaccus*, 54–82μ long, with a finely granulate saccus (Pl. 12, figs. 13, 15, and 16). As far as can be determined from the few specimens that were found, they are similar to those obtained by the writer from the Petino sample, and may be assigned with caution to *A. concinnus* Naumova. Their presence in this sample, from the type locality of *Nikitinsporites*, taken together with their relative rarity in other Devonian deposits, lends further support to the suggestion of affinity between *Nikitinsporites* and minutely sculptured species of *Archaeoperisaccus*.

Relationship Between *Nikitinsporites* and *Archaeoperisaccus*

In summary, the record bearing on the association of *Nikitinsporites* and *Archaeoperisaccus* is as follows: (1) Nikitin (1934) described *Kryshtofovichia africani*, consisting of monolete, two-walled microspores closely associated with anchor-spined megaspores and sporangia, from the Frasnian Petino beds of Voronezh district, U.S.S.R. (2) Naumova (1953) described monolete, "saccate" miospores, for which she instituted the form-genus *Archaeoperisaccus*, in spore assemblages of early upper Frasnian age, also from the Petino beds. Naumova apparently did not recognize similarity between her *Archaeoperisaccus* specimens and the microspores of *Kryshtofovichia* extracted from the same formation by Nikitin. (3) Chaloner (1959) found isolated anchor-spined megaspores in Frasnian rocks of the Canadian arctic, noted their similarity to those of *Kryshtofovichia,* and instituted the name *Nikitinsporites canadensis* for them. (4) Specimens of *Archaeoperisaccus* similar to those of Naumova, and similar to the microspores of *Kryshtofovichia,* have been recovered from a fragment of the sample from which Chaloner obtained *Nikitinsporites canadensis,* as well as from a sample of rock from the Petino beds. (5) Finally, a specimen of *Nikitinsporites* bearing four adhering *Kryshtofovichia*-like miospores was discovered by Winslow (unpublished) in Frasnian rocks of the District of Mackenzie. There are therefore three records of dispersed *Kryshtofovichia*-like small spores of Frasnian age occurring in various degrees of association with *Nikitinsporites.* In addition, there are several literature records of the occurrence of dispersed *Kryshtofovichia*-like small spores *(Archaeoperisaccus)* in Frasnian rocks (e.g. Tuzova, 1959; McGregor and Owens, 1966). Comparison of drawings and photographs, published descriptions, and where possible specimens of *Archaeoperisaccus,* the microspores of *Kryshtofovichia,* and small spores associated with *Nikitinsporites,* leads to the conclusion that species of *Archaeoperisaccus,* probably similar to *A. concinnus* Naumova, are the microspores, and *Nikitinsporites* the megaspores, of *Kryshtofovichia africani.* Separate generic classification probably should be maintained, however, because specific features of megaspores and microspores, commonly found dissociated, are not comparable.

From the foregoing, one might be tempted to suggest that all species of *Archaeoperisaccus,* even those that are heavily sculptured (*see* Pashkevich, 1964), may be the microspores of plants that produced *Nikitinsporites* megaspores. However, there is insufficient evidence to support this assumption. The specific characters of megaspores and microspores probably are not very closely linked hereditarily and may not evolve at the same rate or synchronously. *Archaeoperisaccus* has been reported by Naumova (1953), Tuzova (1959), Pashkevich (1964), Sennova (1965), McGregor, *in* Kerr *et al.* (1965), McGregor and Owens (1966), McGregor (1967), Scott and Doher (1967), Owens (*in press*), and others, only from assemblages assigned a Frasnian age, from the western U.S.S.R., Alaska, and northern Canada. In contrast, *Nikitinsporites* has been recorded from a much longer stratigraphic range, i.e., the Givetian (*N. spitsbergensis* Allen, 1965), late Givetian or early Frasnian (*N.* sp., Vigran, 1964), and late Devonian or early Mississippian[1] (as *Dicrospora* sp., Winslow, 1962, pp. 55, 56). Furthermore, the heavily ornamented

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[1] *Endosporites lacunosus* Winslow, which occurs with *Dicrospora* sp. in the Bedford Shale, is probably *Hymenozonotriletes lepidophytus* Kedo, now regarded as an indicator of latest Devonian (Tnla., Strunian) age in the western European succession (Streel, 1966).

forms of *Archaeoperisaccus,* e.g., *A. timanicus* Pashkevich (1964), also apparently restricted to Frasnian rocks, have not been found intimately associated with *Nikitinsporites,* although they do occur on Melville Island in an assemblage that also contains specimens of *Nikitinsporites* (Owens, *in press*).

Monolete spores other than *Archaeoperisaccus* have been reported from the Siegenian and Emsian of France (Moreau-Benoît, 1966), the late Eifelian of the southern Urals (Chibrikova, 1962), the (?late) Givetian of Australia (de Jersey, 1966), the early Givetian of northern Timan and the Russian Platform (Andreeva, *et al.,* 1967; Kedo, 1966), and the Late Devonian or Early Mississippian of Ohio (Winslow, 1962). However, there is no reason to suggest that they are related to *Nikitinsporites* or to other anchor-spined spores such as *Hystricosporites* or *Ancyrospora.* Large spores with bifurcate processes are common in certain strata of Emsian to Famennian age throughout the world, but they do not usually occur together with monolete forms.

The possible causes for the distribution patterns of monolete spores in the Devonian must be speculative at this time. A gene mutation may have been responsible for the sudden production of monolete microspores within an alliance in which all spores previously were trilete. A minor change in tetrad organization can produce a striking difference between mature spores. Kremp (1967, p. 316) has made a comment that is appropriate in this connection:

> The switch from trilete . . . to monolete must have happened in the history of plants several times and at several localities, for the following reasons: (1) it not only occurred in the Devonian, but (2) it is occurring in living specimens of ferns, and (3) . . . at least five orders or classes of the pteridophytes in the course of their history have independently developed monolete spores.

It seems clear that many, if not most of the *Archaeoperisaccus*-like spores of Frasnian age had reached the point of hereditary distinctiveness. Nevertheless, a contingency that must be considered is that some may represent aberrant forms of normally trilete types, and not hereditarily persistent forms worthy of recognition as form species. For example, certain specimens of sculptured *Archaeoperisaccus, see* Pashkevich (1964) and Owens (*in press*), could represent teratological forms of zonate/camerate spores like *Hymenozonotriletes deliquescens* Naumova. Playford (1962) discusses probable aberrant specimens of the Lower Carboniferous species *Murospora aurita* (Waltz) Playford, and gives examples of similar divergence in the character of the tetrad mark in certain modern plants.

It is also possible that the grapnel-shaped appendages that have been grouped in *Dicrospora* (for example, those of the *Nikitinsporites* type and those of the *Hystricosporites–Ancyrospora* type) may be a result of convergent evolution between unrelated groups. The answers to these questions depend on much more information than is now available.

Emendation of *Archaeoperisaccus*

In her original diagnosis, Naumova described *Archaeoperisaccus* as follows (translated from Naumova, 1953, p. 90):

> Pollen of this subgroup consists of a dense sac of oval form, with sculpture characteristic of the pollen of conifers. Enclosed in the sac is an oval, dense body. Commissure monolete. In addition, in some species there is observed one longitudinal fold. This pollen resembles that of the pteridosperm type and appears to be a prototype of conifers of the Pinaceae type.

The eight species she described possess some features that were not mentioned in her generic diagnosis, probably because she regarded those features as of specific rather than generic significance. According to her drawings and photographs (ibid., Fig. 5: 1–5; Pl. XIV, figs. 11–19), the saccus extends well beyond the body opposite the ends of the monolete mark, and in some species extends beyond the body margin laterally as well. The sac (exoexine) possesses either granular, finely warty, or chagrenate ornament. The central body (intexine) is unornamented, judging from the illustrations. The body is "thickened at the edge" in *A. mirandus, A. mirus, A. elongatus, A. menneri,* and *A. concinnus.* This "thickening" observed by Naumova may in some species represent the arcuate ridges that mark the attachment of the equatorial wing. In at least one species, however, the entire body wall apparently is thick (*see A. mirus,* Naumova, 1953, Pl. XIV, figs. 14, 15).

Potonié selected *A. menneri* Naumova (1953) as the genotype and gave an emended diagnosis of *Archaeoperisaccus* (translated from Potonié, 1958, p. 45):

> Monosaccate pollen. Central body oval, with a longitudinal fold or split which either does not reach the equator of the central body, or the trace of which reaches to the saccus. The saccus is strongly inflated only in the direction of the extension of the germinal fold, thereby imparting a fusiform shape. Otherwise it calls to mind *Florinites* and *Potonieisporites.*
>
> Naumova also places here species which do not correspond to this diagnosis. Besides the genotype there remain here, among others, *A. elongatus* Naum. 1953, . . . *A. concinnus* Naum. 1953, . . . *A. complectus* Naum. 1953, . . . all coming from the same locality as the genotype.

In his diagnosis Potonié, like Naumova, does not mention ornamentation or infrastructure of the sac. His diagnosis allows inclusion of heavily sculptured forms such as *A. verrucosus* Pashkevich (1964) and *A. timanicus* Pashkevich (1964), that may not be at all closely related to the minutely sculptured forms. On the other hand, the minutely ornamented forms *A. mirandus* Naumova, *A. angustus* Naumova, *A. ovalis* Naumova, and *A. mirus* Naumova are specifically excluded by Potonié, apparently because they lack the fusiform amb which is a condition of his diagnosis.

Recently, Dybova-Jachowiczowa (1966, p. 20) further emended *Archaeoperisaccus,* as a result of discovery of monosaccate specimens from the Lower Carboniferous of Poland. Her diagnosis follows (translated from Polish):

> Sporomorphs with a single germinal aperture and one longitudinal fold, and with one air sac. The central body is thick, oval, elliptical or elliptically elongated, with a distinct thickened margin. The air-sac is either oval or elliptical, and surrounds the central body which occurs within it. In specimens flattened parallel to the longer axis of the sporomorph (no other flattening was observed), the distance between the edge of the central body and the edge of the sac is most frequently greatest at both ends of the longer axis of the sporomorph, and much less near the shorter axis. In some specimens, the sac adheres to the edge of the central body along the shorter axis of the sporomorph. The surface of the exine of the sac is rough, finely granular, granular or with fine protuberances, sometimes with quite small, complex and irregular finely reticulate sculpture. The single germinal aperture, most frequently poorly visible or imperceptible,

> lies parallel to the longer axis of the central body and does not extend beyond its margin. The most characteristic feature of spores of *Archaeoperisaccus,* in general terms, is one lengthwise fold which protrudes onto the sac, and lies parallel to the longer axis of the sporomorph. This fold is sometimes broad, sometimes tapers at both ends, and is longer (sometimes considerably) than the longer axis of the central body. In some specimens this fold covers (or else perhaps replaces) the single germinal aperture. The exine of the sac may display minute wrinkles which most frequently run parallel to the long axis of the sporomorph.

Among the features she includes in her generic diagnosis are the indistinctness of the monolete mark on most specimens, the occasional presence of minute longitudinal wrinkles on the sac, and the presence on all specimens of a single longitudinal fold. In Devonian species of *Archaeoperisaccus,* however, the monolete scar is usually quite distinct on specimens in polar compression, and wrinkles of the type referred to by Dybova-Jachowiczowa (*see* her Fig. 4) have not been recorded. Furthermore, a single (proximal) longitudinal fold or flap is *not* present in at least some specimens of species assigned to *Archaeoperisaccus* by Naumova (e.g., *A. angustus, A. ovalis, A. elongatus, A. menneri,* and *A. completus, see* Naumova, 1953, Pl. XIV, figs. 12, 13, 16, 18, 19), and Naumova noted that fact in her diagnosis of the genus. It is not present on some of the specimens from North America examined by the writer (unpublished).

Archaeoperisaccus was originally instituted with reference to Frasnian specimens. It seems unwise to adopt a generic circumscription which excludes some of the Frasnian species included in the genus by Naumova, especially if the restriction is based on Lower Carboniferous material that is less likely to be genetically related. The Lower Carboniferous specimens may be basically similar in structure to the Devonian *Archaeoperisaccus,* but I believe that the degree of similarity will be open to question until the relationship is more plausibly established. I therefore propose the following emendation of *Archaeoperisaccus,* which I believe more closely follows Naumova's intent. It agrees with the structural interpretation of the genus arrived at in the present paper, following examination of specimens from the Petino beds of the U.S.S.R.

Genus *Archaeoperisaccus* Naumova 1953, emend.

Type species: *A. menneri* Naumova 1953, designated by Potonié, 1958.

Emended diagnosis. Monolete, camerate miospores. Central body (?intexine) rigid, oval, elliptical or subcircular, surrounded by a sac-like outer wall (?exoexine) which is inflated in the equatorial region. The sac may extend to form a flap or fold over the proximal pole along the longitudinal axis of the spore. Equatorially the sac extends beyond the body margin in the regions opposite the ends of the monolete mark, but may be less widely separated from the body, or even be appressed to the body, equatorially near the shorter axis of the spore. The sac is closely appressed to the body proximally except in the area of the proximal fold or flap, and is closely appressed (?attached) to the body in the distal polar region. Laesura straight, simple or labrate, may be obscured by the proximal fold of the exoexine. Sac smooth or sculptured. Body smooth.

Remarks. In species so far described, the sac is chagrenate (?scabrate) (e.g., *A. concinnus* Naum.), small-warted (e.g., *A. menneri* Naum.), minutely wrinkled or corrugated (*A. angustus* Naum.), verrucose (*A. verrucosus* Pashkevich), or rugulate-reticulate (*A. timanicus* Pashkevich). In some species the body, when detached from the sac, bears curvatural ridges near the equator marking the locus of attachment of the distal wall of the equatorial expansion of the sac.

Comparisons. In the Triassic monolete saccate spore *Aratrisporites* (Leschik) Playford and Dettmann (1965), the outer layer is separated from the body distally as well as equatorially, and the sac is not most strongly extended opposite the ends of the monolete mark. *Saturnisporites* Klaus (1960) is a junior synonym of *Aratrisporites* according to Playford and Dettmann (1965), and Helby and Martin (1965). *Peromonolites* Couper (1953) has a sculptured inner wall. *Paleospora* Habib (1966) has a thin, commonly folded central body, and a thin equatorial zona. *Mosulipollenites* Singh (1964) and *Potonieisporites* Bhardwaj (1954) have an intrareticulate sac, and a much broader area of inflation of the sac (*see* Bharadwaj, 1964). The monolete mark in *Potonieisporites* may be a distal sulcus, according to Potonié (1960, p. 74).

Archaeoperisaccus balticus Naumova (1960, p. 115, Pl. 3, fig. 17) from the Lower Cambrian *Eophyton* beds of the Russian Platform apparently is alete. The author does not state her reasons for considering that these fossils represent miospores rather than acritarchs.

Botanical Affinities of *Kryshtofovichia, Archaeoperisaccus,* and *Nikitinsporites*

In discussing the systematic position of *Kryshtofovichia africani,* Nikitin (1934) stated: "The presence in our plant of mega- and microspores while seeds are absent forces us to attribute it to the Pteridophyta. However, until further elucidation of the nature of the fructification, and the particular features of the vegetative parts, more precise parental relationships cannot be convincingly established." He referred to the similarity of the apical prominence of the *Kryshtofovichia* megaspore to that of *Lagenicula* Kidston, but would not commit himself to the statement that *Kryshtofovichia,* like *Lagenicula,* was of lycopsid origin.

Taugourdeau-Lantz (1967) tentatively proposed a relationship between Devonian anchor-spined spores, including *Nikitinsporites,* and the Selaginellales. She based her hypothesis on observations of anchor-tipped spines on the spores of the present-day species *Selaginella kraussiana* A. Braun, *S. selaginoides* (Linnaeus) Link, and *S. spinosa* Spring. The comparison is an interesting one but, as she implied, her conclusion must be regarded with extreme caution until further evidence can be presented to support it.

There is, however, some other evidence which although not conclusive, is at least suggestive of a lycopsid affinity for *Kryshtofovichia,* and hence for *Archaeoperisaccus* and *Nikitinsporites.* The condition of a monolete, double-walled microspore and a trilete megaspore, such as occurs in *Kryshtofovichia,* is paralleled in the early Mesozoic lycopsid cones *Lycostrobus scotti* Nathorst (*see* Jung, 1958) and *Cyclostrobus* spp., Helby and Martin (1965). Isolated megaspores similar to those of *Lycostrobus* are assigned to *Nathorstisporites* Jung, and those similar to *Cyclostrobus* magaspores are assigned to *Banksisporites* Dettmann. In both the microspores are of the *Aratrisporites* type. As indicated above, *Aratrisporites* is comparable to *Archaeoperisaccus* in general structure. Of course, the similar structures of *Archaeoperisaccus* and *Aratrisporites* may have arisen independently, and it may only be coincidental that megaspores of the species *Nathorstisporites hopliticus* Jung, the type allied with *Lycostrobus scotti,* are similar in size and possess certain other features in common with *Nikitinsporites,* i.e., prominent elevated lips and long, sometimes bifurcate processes. On the other hand, the similarities may indicate a degree of phylogenetic relationship.

The association of monolete microspores and trilete megaspores exists in another early Mesozoic lycopsid, *Pleuromeia sternbergii* (Muenster) Corda (*see* Neiburg, 1961). Without reference to the structure of the spores, *Pleuromeia* has been placed by H. Potonié (1912), Mägdefrau (1953), and others in a phylogenetic series culminating in the Mesozoic to recent genus *Isoetes.* The significance for the present argument, however, is that *Isoetes* also has monolete microspores and trilete megaspores, as does *Stylites,* a recently discovered genus of living plants that has been allied with *Isoetes* on evidence other than the form of the spores (Rauh and Falk, 1959). All the above-mentioned plants have lycopsid affinities, and there are no plants of non-lycopsid affinity living or fossil known to the writer that possess this unusual difference between the two types of spores. Tschudy (1966) pointed out that morphological similarity between micro- and megaspores provided one criterion useful in establishing their derivation from a single plant species. Perhaps a consistent association of dissimilar features, especially those involving haptotypic structure of the spores, may also be significant in suggesting phylogenetic relationship.

I suggest, with caution, that the similarity of the microspores and megaspores of *Kryshtofovichia africani* to those of *Lycostrobus scotti, Cyclostrobus* spp., and to a lesser extent to those of *Pleuromeia sternbergii, Isoetes* spp., and *Stylites* spp., may be evidence of lycopsid affinity for *Kryshtofovichia,* and provides some support, perhaps rather tenuous, for the possibility that *K. africani* may be a Devonian relative of the Triassic–Jurassic group *Lycostrobus–Cyclostrobus–Pleuromeia,* and possibly of *Isoetes* and *Stylites.*

Stratigraphic Significance of *Archaeoperisaccus*

Archaeoperisaccus has been reported from Frasnian rocks of the western U.S.S.R., Alaska, and northern Canada in several papers (*see* previous discussion). These reports and other data not yet published (in Geological Survey files) support the contention that the genus occurs only in Frasnian rocks in these regions. So far, the only fossil not of Frasnian age that has been assigned to *Archaeoperisaccus* is *A. balticus* Naumova (1960) from the Lower Cambrian of western U.S.S.R. Because of its age, its apparent lack of haptotypic structures, and its at least superficial resemblance to *Pterospermopsis,* I suspect *A. balticus* is an acritarch, and exclude it from further consideration. Subject to confirmation from further data on the range of *Archaeoperisaccus* in well dated sections, it seems reasonable to predict that this genus will become a reliable indicator of Frasnian age.

Archaeoperisaccus has not yet been reported from the southern hemisphere. Its absence from known southern hemisphere assemblages would be a little surprising as at least one southern hemisphere assemblage of Frasnian age, the "*Geminospora* microflora" of Western Australia, compares rather closely (except for the absence of *Archaeoperisaccus*) with assemblages of Frasnian age from the northern hemisphere (Balme, 1964). Relatively few investigations, however, have been made of spores from securely dated Frasnian deposits of the southern hemisphere. Future work may show that spores assignable to *Archaeoperisaccus* are present there as well as in the north.

According to Naumova (1953), eight species of *Archaeoperisaccus* with minute exoexinal sculpture occur in the Devonian strata of the Russian Platform. All have restricted stratigraphic ranges in rocks of middle and late Frasnian age. Pashkevich (1964) found a similar range for three minutely sculptured species of *Archaeoperisaccus* in Timan, several hundred miles farther north. He also described two new species with coarse sculpture, *A. timanicus* and *A. verrucosus,* that were characteristic of early to mid-Frasnian assemblages of that region. He attached stratigraphic significance to the fact that they were abundant in the earlier Frasnian but rare in the later Frasnian where the minutely sculptured species predominate.

In Canada, heavily sculptured forms of the genus occur in Frasnian rocks of the Richardson Mountains and in the vicinity of Arctic Red River, and of Helena, Byam Martin, and Melville Islands of the Arctic Archipelago (McGregor, 1967; Owens, *in press*; unpubl. data in GSC files). Their stratigraphic ranges and abundances have not yet been determined, but they do occur in both early and late Frasnian strata and are not more abundant in the former. Data so far available therefore indicate that heavily sculptured species of *Archaeoperisaccus* do not have their acme in Canada in the early Frasnian rocks, as they do in the strata studied by Pashkevich.

Specimens of *Archaeoperisaccus* have been extracted from limestone, calcareous and non-calcareous siltstone, shale, carbonaceous shale, and coal. From the data available I have not been able to detect any correlation between sediment type and the occurrence of various forms of *Archaeoperisaccus.* From this observation one might suggest that spores of this genus may not be useful as indicators of the depositional environment of the sediment in which they are found. Instead, their presence in such a variety of sediments probably reflects their remarkable efficiency in dispersal.

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REDESCRIPTION OF TYPE SPECIMENS OF THE UPPER MISSISSIPPIAN CORAL *EKVASOPHYLLUM CASCADENSE* (WARREN) FROM ALBERTA

by E. W. Bamber

Abstract

Ekvasophyllum cascadense is early late Viséan (late Meramecian) in age, and is widespread in the upper Mount Head Formation and the upper Prophet Formation of the Rocky Mountains of Alberta and British Columbia. *Ekvasophyllum turbineum* Parks appears to be a junior synonym of *E. cascadense.*

Résumé

L'*Ekvasophyllum cascadense* date du début Viséen récent (Méramécien récent), se trouve en abondance dans la partie supérieure de la formation Mount Head et dans la partie supérieure de la formation Prophet, situées dans les montagnes Rocheuses de l'Alberta et de la Colombie-Britannique. *Ekvasophyllum turbineum* Parks semble être un synonyme plus récent de *E. cascadense.*

Introduction and Acknowledgments

The solitary coral *Ekvasophyllum cascadense* (Warren) belongs to a group of aulophyllid corals that includes the genera *Ekvasophyllum, Turbophyllum,* and *Faberophyllum.* These genera, which are widespread in upper Meramecian rocks of the Rocky Mountains in Alberta, British Columbia, and the western United States, were first described by Parks (1951) from Utah. *Ekvasophyllum cascadense* was described from the Rundle Group near Banff, Alberta (Fig. 1, loc. 16) by Warren (1927, p. 44), who gave an accurate description of the type specimens and tentatively assigned the species to the genus *Lophophyllum* Milne Edwards and Haime. Sutherland (1958, p. 78) suggested that Warren's species may be a senior synonym of *Ekvasophyllum inclinatum* Parks. The present study, however, shows that *E. turbineum* Parks has mature features similar to those of *E. cascadense* and is probably a junior synonym of that species.

The writer wishes to thank B. Mamet (University of Montreal) who identified the microfossils associated with the lectotype of *E. cascadense.* W. J. Sando (U.S. Geol. Surv.) and D. J. McLaren (Geol. Surv. Canada) provided helpful comments during the preparation of the paper. The types of *Ekvasophyllum cascadense* are stored in the type collection of the Geological Survey of Canada, Ottawa.

Age and Distribution

The type locality for *E. cascadense* (Warren) is given as ". . . upper beds of Rundle limestone in the Rundle–Cascade range . . ." (Warren, 1927, p. 44). The exact location of the collecting site is unknown. The species is common in the Mount Head Formation of southwestern Alberta, where it ranges from the uppermost part of the Loomis Member into the overlying Marston Member and its western equivalents (Macqueen and Bamber, 1968). In northeastern British Columbia this coral occurs in the upper part of Member C of the Prophet Formation (Sutherland, 1958, p. 19). Parks (1951, p. 176) reports *Ekvasophyllum turbineum,* which appears to be a junior synonym of *E. cascadense,* from Upper Mississippian rocks of northern Utah.

At numerous localities in western Canada *Ekvasophyllum cascadense* is associated with late Meramecian corals and brachiopods, the most important of which are listed below:

MOUNT HEAD FORMATION

Ekvasophyllum inclinatum Parks
Lithostrotion (Siphonodendron) warreni Nelson
L. (S.) whitneyi of Meek (*non* White, 1877)
Thysanophyllum astraeiforme (Warren)
Lithostrotionella shimeri (Crickmay)
L. bailliei Nelson
L. mclareni (Sutherland)
Spirifer bifurcatus Hall
S. cf. *S. pellaensis* Weller
Echinoconchus biseriatus (Hall)

PROPHET FORMATION

E. inclinatum
L. (S.) whitneyi of Meek
Lithostrotionella shimeri
L. mclareni

The limestone surrounding the lectotype (GSC 8910) contains numerous microfossils which were identified by B. Mamet (pers. com.) as follows:

Aoujgalia sp.
Archaediscus sp.
A. krestovnikovi Rauzer-Chernoussova
A. sp. of the group *A. krestovnikovi* Rauzer-Chernoussova
Brunsia sp.
Calcisphaera laevis Williamson
C. pachysphaerica (Pronina)
Cornuspira sp.
Earlandia clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
E. vulgaris (Rauzer-Chernoussova and Reitlinger)
Endothyranopsis sp.
E. compressus (Rauzer-Chernoussova and Reitlinger)
Eoendothyranopsis scitulus (Toomey)
E. sp. of the group *E. ermakiensis* (Grozdilova *in* Lebedeva)
E. pressus (Grozdilova *in* Lebedeva)
Eoendothyranopsis utahensis (Zeller)
"Eoendothyranopsis" sp. of the group *"E." banffensis* (McKay and Green)
Eoforschia sp.
E. sp. of the group *E. gigantea* (Lipina)
Globoendothyra sp.
G. arrecta (McKay and Green)
G. sp. of the group *G. tomiliensis* (Grozdilova)
Irregularina? sp.
Koninckopora sp.
Parathurammina sp.
Palaeotextularia sp.
Planoarchaediscus sp.
Propermodiscus sp.
Stacheia and *Stacheoides* spp.
Tuberitina sp.
Vicinesphaera sp.

Dr. Mamet gives the age of this assemblage as "early late Visean (V3A of the Belgian scheme), equivalent to the Marston of Alberta." A discussion of the age relationships between the Mississippian of North America and the Lower Carboniferous of Europe is given by Mamet and Skipp (*in press*).

Systematic Paleontology

Phylum COELENTERATA

Order RUGOSA

Family AULOPHYLLIDAE Dybowski 1873

Genus *Ekvasophyllum* Parks 1951

Type species: *Ekvasophyllum inclinatum* Parks 1951 (Upper Mississippian, Utah).

Ekvasophyllum cascadense (Warren 1927)

Plate 13, figures 6–9

Lophophyllum? *cascadense* Warren, 1927, p. 44, Pl. III, fig. 1.
(?) *Ekvasophyllum turbineum* Parks, 1951, pp. 175, 176, Pl. 30, figs. 3a, b, Text-fig. 3.
Ekvasophyllum inclinatum Parks, Davis 1956, pp. 25, 26, Pl. 3, figs. 1a, b.
Lophophyllum? *cascadense* Warren, Sutherland, 1958, pp. 77, 78.
[Non] *Amygdalophyllum (Ekvasophyllum) turbineum* (Parks), Nelson, 1961, Pl. XVI, figs. 1-3.
Ekvasophyllum cascadense Warren, Crickmay, 1961, p. 10, Pl. 1, fig. 8.

Material. Lectotype (chosen by Sutherland, 1958, p. 78; illustrated by Warren, 1927, Pl. III, fig. 1), GSC 8910, two fragments of a corallum, two thin sections, four acetate peels (*see* Remarks). Syntypes: GSC 8910a, two fragments of a corallum, one thin section; GSC 8910b, one fragment of a corallum.

Description of type specimens. Lectotype GSC 8910: External features. Fragment of solitary, slightly curved, ?ceratoid corallum; length of fragment 30 mm (calice and apical part missing), maximum diameter 25 mm, coral wall not preserved, corallum enclosed in rock.

Internal features. Ephebic stage — At diameter of 25 mm, 49 major septa present, minor septa alternate with majors; major septa generally extend two thirds to five sixths (commonly three quarters) the distance from periphery to axis; length of minor septa one third the length of major septa; columella attached to one of the major septa near counter septum and closely approached from one side by several others; many major septa terminated axially at intercepts of tabulae (*see* Remarks); cardinal septum very short (about one third of radius), counter septum slightly shorter than neighbouring major septa, those along cardinal fossula shorter than others; all septa fairly thin, tapered, thinner toward axis, straight to slightly curved, those along cardinal fossula curve slightly toward it and show slight suggestion of pinnate arrangement, otherwise radially arranged; microstructure poorly preserved but there appear to be fibres at right angles to planes of septa, not grouped into trabeculae.

Cardinal fossula prominent, on convex side of corallum, open, terminated axially by intercepts of tabulae and columella, terminated peripherally by dissepimentarium, contains numerous intercepts of tabulae, narrow at periphery, widens toward axis, peripheral two fifths occupied by short cardinal septum; alar fossulae not distinguishable.

Columella simple, strongly developed, continuous, moderately thick, lens-shaped with greatest transverse dimension in counter-cardinal plane; curved parallel to longitudinal curvature of corallum; appears to be composed of fibres radiating from a median plane.

Dissepimentarium occupies peripheral third of corallum (see transverse section, Pl. 13, fig. 6), narrow at cardinal fossula; dissepiments slightly to moderately convex, most are greatly elongate parallel to corallum length, steeply inclined to vertical, 4 to 6 in 5 mm of corallite length, up to four rows seen (wall missing and total number of rows unknown).

Tabulae incomplete, raised to join columella, moderately to steeply inclined, slope reversed in peripheral part of tabularium. Most tabellae convex upward, some concave upward, composed of a lower dark layer and an upper fibrous layer which is continuous with fibrous material of columella and other skeletal elements; angle between inner tabellae and columella 10 to 42 degrees (commonly 25 to 35 degrees), angle of slope[1] 15 to 25 degrees over inner half of tabularium, decreases to zero at approximately half the distance from columella to dissepimentarium, reversed in outer half of tabularium where tabellae slope upward at 30 to 50 degrees toward dissepimentarium, most tabellae adjacent to dissepimentarium rise very steeply.

Neanic Stage—one half of transverse section (diameter 14 mm) is available (see Pl. 13, fig. 8, and discussion on p. 111); bilateral symmetry assumed and missing half included in description.

At diameter of 14 mm, approximately 38 (twice the observed 19) major septa present, several reach columella and are very thin near it, those in counter quadrants withdrawn along alar fossulae, several adjacent to cardinal fossula also withdrawn; cardinal and counter septa not preserved in section; all septa very thick, interseptal spaces very narrow, major septa relatively thin adjacent to minor septa, but thicken beyond inner ends of minors and then thin toward axis; major septa near cardinal fossula curve slightly to join axial part of that structure; minor septa one quarter to one third the length of major septa, thick, taper from periphery toward axis.

Columella partly missing from section, apparently strongly developed, lens-shaped.

Dissepimentarium absent at this diameter (14 mm).

Tabulae similar to those in mature part of corallum, but slope is greater in inner two thirds of tabularium and is sharply reversed near dissepimentarium.

Syntype GSC 8910a: External features. Fragment of solitary, slightly curved, ?ceratoid corallum, about 30 mm long, calice and apical part missing, longitudinal wedge absent from one side, maximum diameter 25 mm, corallum enclosed in rock.

Internal features. Ephebic stage — similar to that of lectotype (GSC 8910), but columella thicker (wider in alar plane) and appears to be joined by more major septa; configuration of tabulae comparable to that in lectotype.

Neanic stage — more completely preserved than in lectotype (*see* Pl. 13, fig. 9). At diameter of 12 mm, 35 (estimated, section incomplete) major septa present, minor

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[1] Angle of slope – angle between upper surface of tabella and plane perpendicular to corallite axis.

septa alternate with majors; many major septa join outer fibrous sheath of columella, several in counter quadrant withdrawn along the one counter fossula preserved, those next to cardinal fossula also withdrawn, cardinal septum very short, counter septum slightly shorter than adjacent major septa and does not appear to reach columella; length of minor septa one quarter to one third the length of major septa; septa thick and tapered as in neanic stage of lectotype.

Cardinal fossula narrow, on convex side of corallum, open, terminated axially by columella, terminated peripherally by thick septa, contains rare intercepts of tabulae; one alar fossula preserved, weakly expressed.

Columella thick, irregularly lens-shaped, composed of fibres radiating from an irregular median plane, surrounded by thick sheath of fibrous material that is continuous with fibrous wall of cardinal fossula.

Dissepiments absent.

Syntype GSC 8910b: Polished fragment of ephebic stage from solitary corallum, shows features similar to those shown by lectotype; differs slightly, in that a poorly expressed alar fossula is present and major septa form groups, each of which contains two or three septa joined along their axial edges to form one septum which reaches or closely approaches the columella; also, major septa slightly thicker in tabularium than in dissepimentarium.

Remarks. A longitudinal and a transverse thin section had been cut from the lectotype (GSC 8910) of *Ekvasophyllum cascadense* prior to the author's examination of this specimen. The transverse section was apparently taken from near the base of the calice, judging by the presence of limestone matrix within the tabularium (Pl. 13, fig. 6). The longitudinal section was not cut along the coral axis and is of little use. There is no transverse thin section through the neanic stage, and only one half of the lower part of the corallum is preserved. The author removed one wall of the cardinal fossula to expose the tabularium and dissepimentarium in longitudinal section, and prepared three acetate peels from the resulting surface (Pl. 13, fig. 7). A transverse peel was also taken from the incomplete lower surface of the corallum (Pl. 13, fig. 8). A transverse section was cut from the neanic stage of syntype 8910a (Pl. 13, fig. 9), which is more completely preserved than is the corresponding part of the lectotype.

The apparent differences in the lengths of the major septa in the lectotype and the axial termination of the septa at intercepts of tabulae (Pl. 13, fig. 6) indicate that the septa extend to the columella along the tops of the tabulae and are withdrawn slightly between tabulae, but this cannot be confirmed from the available material.

The structural features of the ephebic stage of *Ekvasophyllum cascadense* (Warren) closely match those of *E. turbineum* Parks. The number of septa in Warren's type specimens (49) is slightly smaller than that given by Parks (50–56), but the calices of the Alberta specimens are missing and the maximum number of major septa at the base of the calice is unknown. Parks (1951, p. 175) states that the minor septa in *E. turbineum* are one half the length of the major septa, but his illustration (1951, Pl. 30, fig. 3a) shows that the minors in the holotype are approximately one third the length of the majors, as in *E. cascadense*. The major septa shown in this illustration are withdrawn slightly more than those in the transverse thin section of lectotype GSC 8910 (Pl. 13, fig. 6), but this probably reflects a difference in the levels from which the transverse sections were cut from the two coralla. In specimens of *E. cascadense* other than the types, the author has observed a marked shortening of major septa in late maturity. The young stages of the types of *E. turbineum* are unknown, and therefore a complete comparison between these and the Canadian types cannot be made. On the basis of ephebic characters, however, *Ekvasophyllum turbineum* Parks appears to be the junior synonym of *E. cascadense* (Warren).

The septa in the transverse section illustrated by Nelson (1961, Pl. XVI, fig. 2) are more numerous (72 major septa) than in *E. cascadense,* and Nelson's specimen is therefore excluded from this species.

Ekvasophyllum cascadense is distinguished from all other described species of *Ekvasophyllum* by its large number of septa, its wide dissepimentarium, its long minor septa, and the relatively low slope of its tabulae.

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PERMIAN AMMONOIDS FROM THE BELLOY FORMATION, NORTHEASTERN BRITISH COLUMBIA

by W. W. Nassichuk

Abstract

Three species of Permian ammonoids from the Belloy Formation are described: *Medlicottia chozaensis* Plummer and Scott, *Daraelites* cf. *D. elegans* Tchernow and ?*Daubichites* sp.

The ammonoids indicate a Lower Permian, Artinskian (Leonardian) age.

Résumé

Description de trois espèces d'ammonoïdés du Permien, provenant de la formation Belloy: *Medlicottia chozaensis* Plummer et Scott, *Daraelites* cf. *D. elegans* Tchernow et ?*Daubichites* sp.

Les ammonoïdés sont l'indication d'un Permien inférieur, d'âge artinskien (Léonardien).

Introduction

The Belloy Formation (Halbertsma, 1959) is widespread in the subsurface of the Peace River area of western Canada. The type section was designated at between the depths of 4,087 and 4,246 feet in the Imperial Oil well, Belloy 12–14, in west-central Alberta (lat. 55°46′N, long. 118°03′W) and consists of an Upper Carbonate Member, a Middle Sand Member, and a Lower Carbonate Member. The Permian ammonoids described in this report are from near the top of the Belloy Formation in the Imperial Oil well, Sikanni Chief No. 1 (lat. 58°05′N, long. 121°53′ W, Fig. 1, loc. 13) in northeastern British Columbia, nearly 250 miles northwest of the Belloy type locality. In this well the upper and lower boundaries of the Belloy have been picked at depths of 3,320 and 3,360 feet respectively (Crickmay, 1960). The ammonoids occur at 3,325 feet in a coquinoid dolomite that is comprised mainly of organic spicules. There the Belloy Formation overlies the Mississippian Debolt Formation and is unconformably overlain by Triassic siltstones (R. M. Proctor, pers. com.). Bamber (pers. com.) has identified the lower Meramecian coral, *Lithostrotion (Siphonodendron) oculinum* Sando, 132 feet below the base of the Belloy.

Halbertsma (1959, p. 112) indicated that all the type Belloy is of Permian (Leonardian) age. This assignment was apparently based on identifications of brachiopods and bryozoans by Crickmay (*in* Halbertsma, 1960) from near the top of the type section, at 4,088 feet. Crickmay (1960) later suggested, however, that most of the type Belloy is of Pennsylvanian age and that if any Permian rocks are present they are confined to the upper few feet of the section. Jansonius (1962, and *in* Halbertsma and Staplin, 1960) studied pollen assemblages from near the top, middle, and bottom of the type section and concluded that the entire formation is of Permian age. A brief résumé of information concerning the age of the Belloy Formation and a suggested correlation with surface units is provided by McGugan, *et al.* (1965).

A Permian age for the Belloy Formation in the Sikanni Chief No. 1 well was correctly suggested by Crickmay (1960) who reported a remarkable occurrence of ammonoids from a depth of 3,325 feet. Crickmay identified *Medlicottia* sp. and *Paralegoceras* sp., and on the basis of the *Medlicottia* indicated a Middle Permian age.

The term "Middle Permian" has been used in a general way by Crickmay (1960), Jansonius (1962), and McGugan, *et al.* (1965) to include rocks and fossils of Leonardian and Guadalupian age. A two-fold subdivision of the standard Permian section of North America (West Texas) was adopted by the U.S. Geological Survey in 1960 (Cohee, 1960; Dunbar, 1960) and closely corresponds with the two-fold division of the type Permian in the Soviet Union. Such a division, now generally accepted, is used in this report. In accordance with recent work by Cooper and Grant (1966), the boundary between the Lower Permian and Upper Permian in West Texas is considered to fall between the Leonardian Road Canyon Formation (formerly the "First Limestone" of the Word Formation of P. B. King, 1931) and the Guadalupian Word Formation.

The ammonoid-bearing core from the Sikanni Chief No. 1 well yielded two incomplete specimens of *Medlicottia chozaensis* Plummer and Scott, a single fragment of *Daraelites* cf. *D. elegans* Tchernow and fragments of two small and poorly preserved paragastrioceratids that are tentatively assigned to Popow's (1963) genus *Daubichites.* The specimen that was referred to *Paralegoceras* sp. by Crickmay (1960) is not available for study. *Paralegoceras,* in the restricted sense, is confined to Middle Pennsylvanian (Moscovian) strata but certain morphologic features of this taxon, particularly the suture line, resemble, in gross aspect, those of the Lower Permian *Metalegoceras* Schindewolf (type species: *Paralegoceras sundaicum* form. *evoluta* Haniel, 1915).

All the ammonoids from the Belloy Formation are of Lower Permian aspect. The types of *Medlicottia chozaensis* Plummer and Scott are from the Leonardian (Artinskian) upper Clear Fork Group of north-central Texas. The types occur in association with the Leonardian "index" *Perrinites* Böse and with *Metalegoceras* Schindewolf which is confined to the Lower Permian. Typical representatives of *Daraelites elegans* Tchernow occur in Artinskian strata in the Ural Mountains, Soviet Union.

Acknowledgments

The author is indebted to Imperial Oil Enterprises Ltd., Calgary, for permission to study ammonoids from the Belloy Formation. W. M. Furnish and Brian F.

Glenister of the University of Iowa provided comparative materials from the University of Iowa collection and critically read the manuscript as did B. S. Norford of the Geological Survey of Canada. Additional comparative materials were provided by the Bureau of Economic Geology, University of Texas, through Peter U. Rodda.

Systematic Paleontology

Specimens bearing the prefix "GSC" are in the type collection of the Geological Survey of Canada, Ottawa. Those with the prefix "SUI" are in the repository of the University of Iowa, Iowa City, and those with the prefix "BEG" are in the repository of the Bureau of Economic Geology, University of Texas, Austin, Texas.

Family DARAELITIDAE Tchernow 1907

Genus *Daraelites* Gemmellaro 1887

Type species: *Daraelites meeki* Gemmellaro 1887, p. 66, Pl. 10, figs. 16–23; original designation; from the Upper Permian (Guadalupian) Sosio beds, province of Palermo, Sicily.

Diagnosis. The conch of *Daraelites* is subdiscoidal and moderately evolute; the umbilical diameter of typical mature representatives is at least 20 per cent of the conch diameter. Whorls are rounded ventrally and laterally and are moderately impressed dorsally. Shell ornament comprises delicate, sinuous growth lamellae that form ventral and dorsolateral sinuses and a lateral salient. The external suture is characterized by a broad but shallowly trifid ventral lobe and a relatively narrow first lateral lobe. The ventral lobe and at least the first two lateral lobes are serrate.

Distribution. Daraelites is known to range from Wolfcampian (Asselian, Sakmarian) into the Wordian Substage of the Guadalupian. The type species, *D. meeki* Gemmellaro, is the only known Upper Permian representative of the genus and occurs in the Sosio beds of Sicily (Wordian). *D. submeeki* Haniel has been found in the Artinskian Bitauni beds of Timor and *D. elegans* Tchernow in Artinskian strata in the southern Urals, Soviet Union. *D. kingi* Plummer and Scott is known to occur in the Wolfcampian Lenox Hills and Hueco Formations of West Texas and *D. leonardensis* Miller and Furnish in Leonardian (Artinskian) strata of West Texas and upper Wolfcampian (Sakmarian) strata in Nevada.

Discussion. Daraelites is the most advanced representative of the Daraelitidae. Both *Epicanites* Schindewolf and *Boesites* Miller and Furnish are part of the same lineage: *Epicanites* ranges from late Viséan to early Namurian but *Boesites* ranges practically throughout the Pennsylvanian, from Morrowan to Virgilian. The proportions of ventral and ventrolateral sutural elements serve to distinguish *Daraelites* from *Boesites,* its closest relative within the family. In particular, the ventral lobe of *Daraelites* is proportionally broader and shallower than the comparable element of *Boesites,* and the first lateral lobe of *Daraelites* is proportionally narrower than that of *Boesites.*

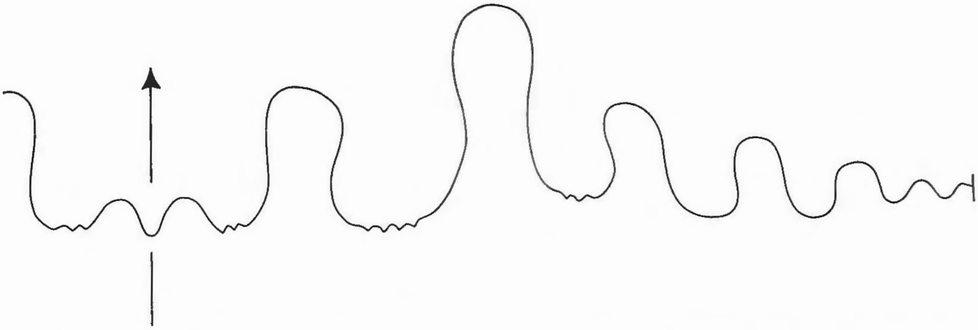

FIGURE 11. Diagrammatic representation of the external suture of *Daraelites* sp. from the Belloy Formation, northeastern British Columbia; based on hypotype GSC 23604, at an approximate conch diameter of 20 mm and a whorl height of 6.5 mm; x12.

Daraelites cf. *D. elegans* Tchernow 1907

Figure 11

cf. *Daraelites elegans* Tchernow, 1907, p. 374, Pl. 1, fig. 9; 1939, p. 172, Pl. 42, fig. 5.

Material and occurrence. The only specimen (GSC hypotype 23604) was recovered from the Belloy Formation of northeastern British Columbia, from drill-core at a depth of 3,325 feet in the Imperial Oil well, Sikanni Chief No. 1.

Description. A small, crushed fragment of *D.* cf. *D. elegans* comprising three septa of a single whorl is available. The whorl is broadly rounded laterally and has a narrowly rounded venter. Only the whorl height (6.5 mm) can be measured, but by reconstruction a conch diameter of at least 20 mm was attained. The external suture (Fig. 11) is moderately well preserved, except in the ventral area where detail of the ventral lobe is partly obscured.

Comparison. The fragmentary nature of the Canadian specimen, particularly the worn venter, precludes direct inclusion in an established species; however, the form of the external suture strongly resembles that of typical *D. elegans* and the closely related *D. leonardensis.* Distinction between *D. elegans* and *D. leonardensis* is not entirely clear and must await more detailed comparative (particularly ontogenetic) studies. The suture of *D.* cf. *D. elegans* differs in gross aspect from that of the type species, *D. meeki* Gemmellaro. In particular, the first lateral lobe and the ventral lobe of *D. meeki* is more prominently constricted. In addition, the ventral lobe of *D. meeki* may be proportionally narrower; however, the ventral lobe on the Canadian specimen is slightly worn.

Family MEDLICOTTIIDAE Karpinsky 1889
Subfamily MEDLICOTTIINAE Karpinsky 1889
Genus *Medlicottia* Waagen 1880

Type species: *Goniatites orbignyanus* Verneuil 1845, pp. 375–376, Pl. 26, figs. 6 a–c; subsequent designation, Foord and Crick 1897, p. 266; from Artinskian strata in the Ural Mountains, Soviet Union.

Diagnosis. The conch of *Medlicottia* is thinly lenticular, highly involute. Shell is typically smooth except for faint growth lines but some species possess ventrolateral ribs. Details of the suture are variable; on typical representatives at least half of the 'lateral' lobes are bifid and corresponding saddles have a moderate median convexity. Sides of the first lateral saddle are nearly parallel; paired adventitious elements are variable in number. The first adventitious element to form on the dorsal side of the first lateral saddle is invariably bifid and variously elongate.

Distribution. Medlicottia is one of the most cosmopolitan of Permian ammonoids but rarely does it dominate an ammonoid fauna. It is known to range throughout most of the Permian, from Sakmarian to Dzhulfian. The only other known Canadian occurrence of the genus is an undescribed species in the Lower Permian Assistance Formation, Devon Island, in the Canadian Arctic Archipelago.

Discussion. A comprehensive discussion of *Medlicottia* was presented in a monographic study of Permian ammonoids from Texas by Miller and Furnish (1940). Ruzhencev (1949) studied the systematics and phylogeny of the Medlicottiidae and later (1956) summarized knowledge concerning Soviet representatives. Nassichuk, Furnish, and Glenister (1965) have recently discussed *Medlicottia* and the closely related genera, *Syrdenites* Nassichuk, Furnish, and Glenister and *Neogeoceras* Ruzhencev.

Medlicottia chozaensis Plummer and Scott 1937

Plate 13, figures 1–5; Figures 12, 13

Medlicottia n. sp. I, Böse, 1919, p. 194.
Medlicottia n. sp. II, Böse, 1919, p. 197.
Medlicottia chozaensis Plummer and Scott, 1937, p. 77, Pl. 6, figs. 4-6.
Medlicottia milleri Plummer and Scott, 1937, p. 79, Pl. 6, figs. 1-3.
Medlicottia sp. Crickmay, 1960, p. 3.

Material and occurrence. Two specimens (GSC hypotypes 23605, 23606) were recovered from the Belloy Formation, northeastern British Columbia, from drill-core at a depth of 3,325 feet in the Imperial Oil well Sikanni Chief No. 1.

Figured types of *M. chozaensis* (*see* Plummer and Scott, 1937, Pl. 6, figs. 4, 5, 6) were made available for study; their figure 4 shows specimen P-1045, figure 5, P-8917, and figure 6, P-8918. According to Peter U. Rodda (pers. com.), the number P-1045 is a typographical error for P-1145. These types were originally catalogued by Helen Jeanne Plummer and numbers prefixed by the letter "P". However, the specimens were reposited with the Bureau of Economic Geology, University of Texas and now according to Rodda (pers. com.) the numbers bear the Bureau's prefix BEG (BEG 1145, BEG 8917, BEG 8918). In addition, three of Plummer and Scott's unfigured types (BEG 8922A, BEG 8916, and BEG 11492) were made available, as were eighteen University of Iowa specimens.

J. W. Beede collected the types of *M. chozaensis* south of the Colorado River, in western Runnells county, Texas; some 4 miles east of the western county line (Böse, 1919, p. 183). According to Plummer and Scott (1937, p. 20), the fossils occur in a dolomite in the Choza Formation, upper Clear Fork Group, 167 feet above the base of the Bullwagon Dolomite Member. They occur with representatives of *Metalegoceras* and *Perrinites hilli* (Smith). Some thirty years after Beede's collection was assembled, Porter Montgomery collected additional material from north of the Colorado River, a mile east of the town of Maverick and at least 4 miles northwest of Beede's principal locality (*see* map in Beede and Waite, 1918). Montgomery's collection is reposited at the University of Iowa.

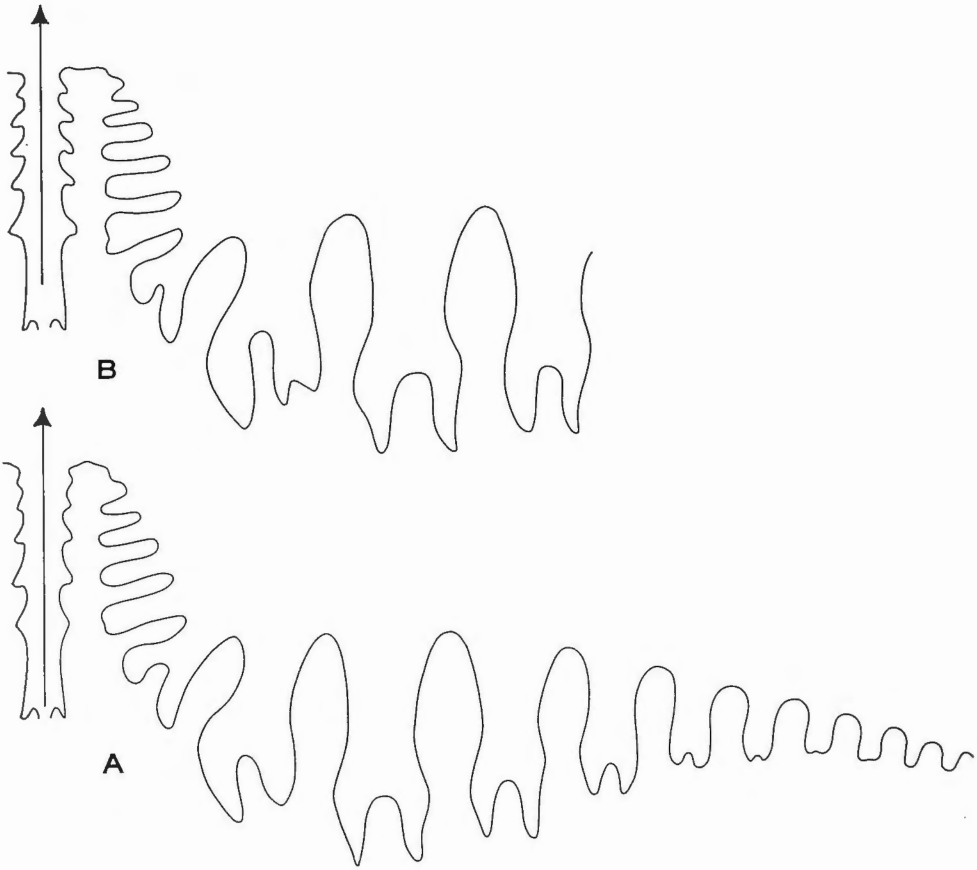

FIGURE 12. Diagrammatic representation of the external suture of *Medlicottia chozaensis* Plummer and Scott from the Leonardian Choza Formation, north-central Texas.

A. Based on type BEG 8918 (P 8918) figured by Plummer and Scott (1937, Pl. 6, fig. 6), at a diameter of about 55 mm and a whorl height of about 31 mm; x3.

B. Based on fragmentary figured specimen BEG 35506 (T 8922B) designated *M. "milleri"* by Plummer and Scott (1937, Pl. 6, fig. 1), at an estimated diameter of 60 mm; x3.

Description. Plummer and Scott (1937) based *M. chozaensis* on a number of syntypes from the upper Clear Fork Group. All the available type specimens are fragmentary moulds or casts in light grey dolomite and none has any shell preserved; hence details of ornament are unknown. The conch is sublenticular with a shallow concave venter, the width of which is greater than 25 per cent the corresponding width of the whorl. As none of the types are preserved entire, a presentation of conch dimensions and proportions is precluded. Septa are closely spaced, in part confluent (*see* influence of septal confluence on sutural pattern in Pl. 13, fig. 3).

The external suture which best characterizes the species is moderately well preserved only on a few specimens (Fig. 12). The first "lateral" lobe (U_1) is asymmetrically bifid and the ventrad prong of this element is slightly longer than the dorsad. A particularly unique feature of the species is that prongs of at least the first three bifid "lateral" lobes U_1, U^1, U^2 are separated by saddles, the sides of which are nearly parallel or slightly constricted. On each of these lobes the longitudinal axes of the prongs are nearly parallel.

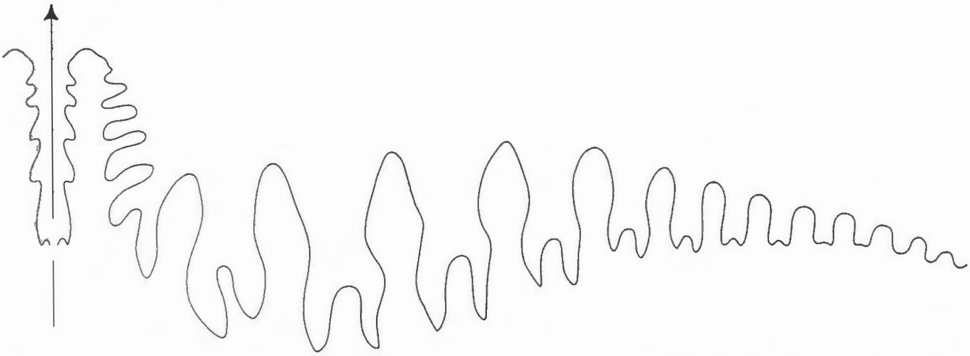

FIGURE 13. Diagrammatic representation of the external suture of *Medlicottia chozaensis* from the Belloy Formation, northeastern British Columbia. Suture is a composite from two specimens of comparable size. Ventral and first three "lateral" lobes are based on GSC hypotype 23605. Remainder of suture is based on GSC hypotype 23606 at a conch diameter of about 45 mm; x3.

The two specimens of *M. chozaensis* from the Belloy Formation are entirely septate; only one of them (GSC hypotype 23605) exhibits the ventral part of a mature suture. The fragile nature of the most nearly complete but partly crushed specimen (GSC hypotype 23606) does not allow extraction from the dolomite drill-core, therefore precise dimensions and proportions are not available. Nevertheless, the larger specimen is preserved intact to a diameter of about 45 mm and septal remains are present for another half volution beyond that size. The body chamber must have occupied at least an additional half volution and so, by reconstruction, the ultimate diameter was probably of the order of 90 mm. Most of the umbilical area is crushed but the umbilical shoulder is narrowly rounded. The venter is narrow, shallowly concave and is marked by sharply angular shoulders. No shell layer is preserved and the mould is smooth, showing no indication of ornament.

The external suture of the Canadian representatives of the species is drawn as a composite from the two specimens and is characterized by an asymmetrically bifid first "lateral" lobe, U_1 that is shallower than the second "lateral" lobe, U^1. Also, the prongs of U_1, of which the ventrad is slightly larger than the dorsad, are separated by a prominently constricted subsidiary saddle. Adventitious element l^1 is prominently divided and elongate.

Comparisons. Medlicottia chozaensis can be compared with other species only on the basis of the form of the external suture as specimens are fragmentary and shell ornament is absent. It closely resembles the Artinskian type species *M. orbignyana* in gross sutural form, but details of the shape and proportions of lateral elements of *M. chozaensis* differ and are unique to the species. In particular, the sides of each of the low saddles that separate the prongs of the first three "lateral" lobes are nearly parallel or slightly constricted in *M. chozaensis* but diverge apicad in *M. orbignayana.* Also, *M. chozaensis* differs from *M. costellifera* Miller and Furnish and *M. copei* White in possessing a more asymmetric first "lateral" lobe. The suture of *M. kingorum* Miller and Furnish resembles that of *M. chozaensis,* but the first lateral saddle of *M. kingorum* has a greater number of secondary or adventitious lobes.

The type specimens of *M. chozaensis* show considerable variation in sutural detail; some of the variation in the relative proportions and position of sutural elements may reflect distortion. The suture of the Canadian specimens cannot be precisely duplicated in the original types of *M. chozaensis* and differences in the relative proportions of sutural elements are apparent. For example, the first adventitious element (l^1) to form on the ventrolateral saddle is relatively longer on the Canadian specimens. Also, the first "lateral" lobe on the Canadian specimens is more nearly symmetrical. None of these differences is considered to be of specific importance and the Canadian specimens fall within the definition of the species.

Discussion. Böse (1919, p. 194) described but did not illustrate a small collection of poorly preserved ammonoids from the Choza Formation, north-central Texas. Representatives of *Medlicottia* in the collection were separated by Böse into two species: *Medlicottia* n. sp. I (two specimens) and *Medlicottia* n. sp. II ("more than a dozen specimens"). The distinction between the two species was based largely on minute sutural differences, particularly differences in the first "lateral" lobe. With respect to the suture of *Medlicottia* n. sp. I, Böse stated:

> The first lateral lobe is less deep than the second lateral one. It has an extremely characteristic form. A club-shaped, high, narrow secondary saddle, constricted near its base, divides it in two branches of which the one nearest to the venter is considerably longer and more strongly curved than the one nearer to the umbilicus; this latter one is again divided into two branches by a short, stout, triangular saddle, a complication which as yet has never been observed in another species of the genus.

Plummer and Scott (1937) based the two species *M. chozaensis* and *M. milleri* on Böse's material and concurred with Böse that the main difference between the two species is in the subdivision of the ventrad prong of the first "lateral" lobe, but made several mistakes in their assignment of synonyms. *M. milleri* was based on two specimens that showed such a trifurcate subdivision. Böse's *Medlicottia* n. sp. II was placed in synonymy with *M. milleri* despite the fact that Böse recognized trifurcation of the first "lateral" lobe only in his *M.* n. sp. I. Böse's *M.* n. sp. I was placed in synonymy with *M. chozaensis.* The illustrations of type representatives of *M. chozaensis* (Plummer and Scott, 1937, Pl. 6, figs. 4–6) show a small, fragmentary specimen (fig. 4) numbered P-1045 (BEG 1145) which possesses a bifid dorsad prong of the first "lateral" lobe, a feature which falls within the original concept of "*M. milleri.*" The sutural differences used to distinguish the two species are not considered to be of specific importance and *M. milleri* is considered, by the present author, to be a junior subjective synonym of *M. chozaensis* which has page priority. The largest of Plummer and Scott's figured syntypes of *M. chozaensis* (BEG 8917) is selected to serve as lectotype (*see* Plummer and Scott, 1937, Pl. 6, fig. 5).

Family PARAGASTRIOCERATIDAE Ruzhencev 1951

Genus *Daubichites* Popow 1963

Type species: *Daubichites orientalis* Popow 1963, from Permian strata in the Sikhote-Alin Range, Maritime Coast region (Primor-ye), Soviet Union.

?*Daubichites* sp.

Figure 14

Material and occurrence. Two fragments of immature specimens of ?*Daubichites* sp. (GSC hypotypes 23607, 23608) were found in association with *Medlicottia chozaensis* and *Daraelites* cf. *D. elegans* in the Belloy Formation, northeastern British Columbia. The specimens were recovered from drill-core from the Imperial Oil well, Sikanni Chief No. 1.

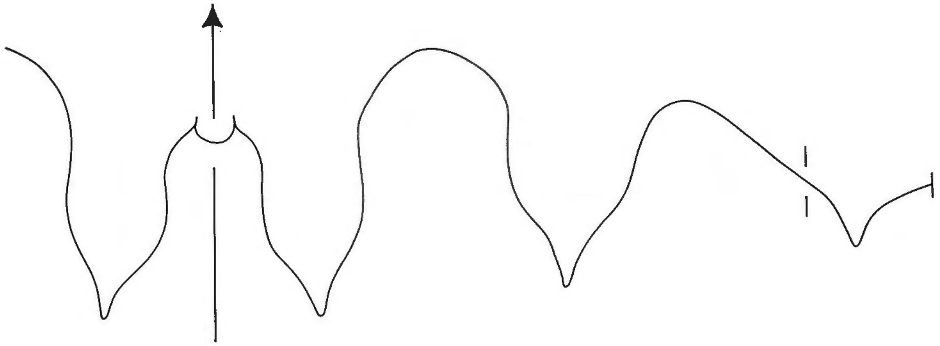

FIGURE 14. Diagrammatic representation of the external suture of ?*Daubichites* sp. from the Belloy Formation, northeastern British Columbia. Based on GSC hypotype 23607 at an estimated diameter of 15 mm and whorl width of 9 mm; x10.

Description. One specimen (GSC hypotype 23607) consists of three septa of a single whorl (whorl width 9 mm, whorl height 4.5 mm) and the external suture of this specimen is presented in Figure 14. The other specimen (GSC hypotype 23608) has an approximate whorl width of 6 mm and whorl height of 3 mm. By reconstruction the approximate diameter of the former specimen was 15 mm, and of the latter, 10 mm. At maximum size (10 mm) the smaller of the two specimens has a prominent constriction that forms a moderately deep dorsolateral sinus; however, near this constriction surface detail on the venter is not preserved.

Remarks. Assignment of the Belloy paragastrioceratids to ?*Daubichites* sp. is admittedly tentative due to the absence of external ornament and is based almost entirely on the form of the external suture. Mature representatives of *Daubichites* Popow differ from the closely related *Tumaroceras* Ruzhencev in that constrictions and growth lamellae form a sinus on the venter of the former but a salient on the venter of the latter. *Daubichites* is based on a single mature specimen (the holotype of the type species) and little is known of the early ontogenetic stages. Popow (1963) has briefly discussed the differences between *Daubichites* and other representatives of the Paragastrioceratidae.

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A LATE PENNSYLVANIAN AMMONOID FROM ELLESMERE ISLAND, CANADIAN ARCTIC ARCHIPELAGO

by W. W. Nassichuk

Abstract

Parashumardites sp. is the only late Pennsylvanian ammonoid known from Canada. It was discovered in the Hare Fiord Formation at Hare Fiord, northern Ellesmere Island and provides data for correlation with Missourian strata in the United States and Zhigulevian strata in the Soviet Union.

Résumé

L'espèce *Parashumardites* est le seul ammoïdés du Pennsylvanien récent connu au Canada. Elle a été découverte dans la formation Hare Fiord, située dans le fiord Hare (partie septentrionale de l'île Ellesmere) et fournit d'utiles renseignements en rapport avec les strates missouriennes des États-Unis et les couches du Zhigulévien de l'URSS.

Introduction

Many ammonoids have been collected from Lower and Middle Pennsylvanian rocks at several localities in central regions of the Sverdrup Basin in the Canadian Arctic Archipelago. They occur in limestones and calcareous siltstones and are generally well preserved. More than twenty genera are known and some provide new information on Palaeozoic ammonoid morphology. The ammonoids also provide data for correlation with deposits elsewhere in North America, Europe, and Asia.

In contrast, only one ammonoid specimen is known from Upper Pennsylvanian rocks in the arctic islands and the rest of Canada. The one specimen represents a mature individual and is described below as *Parashumardites* sp. The specimen comes from the Hare Fiord Formation at Hare Fiord, northern Ellesmere Island.

Lower Pennsylvanian (early Morrowan) ammonoids have been discovered in thin limestone and siltstone beds that are interbedded with anhydrite in evaporite piercement structures on northeastern Melville Island (Barrow Dome) and on western Axel Heiberg Island (South Fiord Dome). Included is the distinctive genus *Reticuloceras* Bisat which indicates correlation with the Hale Formation of Arkansas and with part of the Namurian sequence (Namurian B) of western Europe.

Early Middle Pennsylvanian, Atokan (Moscovian) ammonoids are abundant at Hare Fiord, Ellesmere Island, where they occur near the base of the Hare Fiord Formation, in a thick sequence of siltstone, argillaceous limestone, and bioclastic limestone (Nassichuk and Furnish, 1965; Nassichuk, 1967b). A monographic study of these and the Lower Pennsylvanian forms is currently in progress by the author. Elsewhere in Canada ammonoids of Middle Pennsylvanian age are known only by collections made by L. R. Laudon and some of his students from the Taku Group on Bove Island, Tagish Lake, in the south-central Yukon Territory.

The late Pennsylvanian (Missourian, Zhigulevian) ammonoid *Parashumardites* sp. was found in the Hare Fiord Formation at Hare Fiord, stratigraphically several hundred feet above strata that contain Atokan ammonoids. Poor preservation of the arctic specimen precludes derivation of additional taxonomic information but a record of the occurrence is of biostratigraphic and paleogeographic importance.

Acknowledgments

The author is indebted to W. M. Furnish and Brian F. Glenister of the University of Iowa for critically reading the manuscript and for providing comparative materials from the Iowa collections. B. S. Norford of the Geological Survey of Canada also criticized the manuscript.

Systematic Paleontology

The prefix "GSC" refers to specimens that are in the type collections of the Geological Survey of Canada, Ottawa. Similarly types that are lodged in the repository at the University of Iowa bear the prefix "SUI". Types dealt with in this report are a hypotype of the Canadian *Parashumardites* sp. (GSC 23603) and a topotype of *P. senex* (SUI 32366).

Order AMMONOIDEA Zittel 1884

Suborder GONIATITINA Hyatt 1884

Superfamily SHUMARDITACEAE Plummer and Scott 1937

Family SHUMARDITIDAE Plummer and Scott 1937

Genus *Parashumardites* Ruzhencev 1939

Type species: *Shumardites senex* Miller and Cline, 1934; from the Nellie Bly Formation, Oklahoma.

Parashumardites sp.

Figure 15B

1967b. *Parashumardites* Nassichuk, p. 11.

Material and occurrence. A single fragmentary and completely recrystallized phragmocone (GSC hypotype 23603) was recovered from light grey skeletal limestone some 400 feet above the base of the Hare Fiord Formation, at Hare Fiord. GSC locality 80159 (lat. 81°08′N, long. 84°06′W; Fig. 1, loc. 1) is on the north side of Hare Fiord, 18 miles northeast of Van Hauen Pass. None of the associated fossils, mainly brachiopods and gastropods, is well enough preserved for generic identification.

Description. The specimen cannot be extracted from the containing limestone and hence precise conch measurements and dimensions as well as details of shell ornament cannot be given. By reconstruction the specimen is moderately evolute and septate to a diameter of about 40 mm. At that size the general form of the external suture (Fig. 15B) is sufficiently well preserved to provide a distinct generic assignment but the lack of sutural and shell detail precludes all but general specific comparisons. The internal suture cannot be prepared.

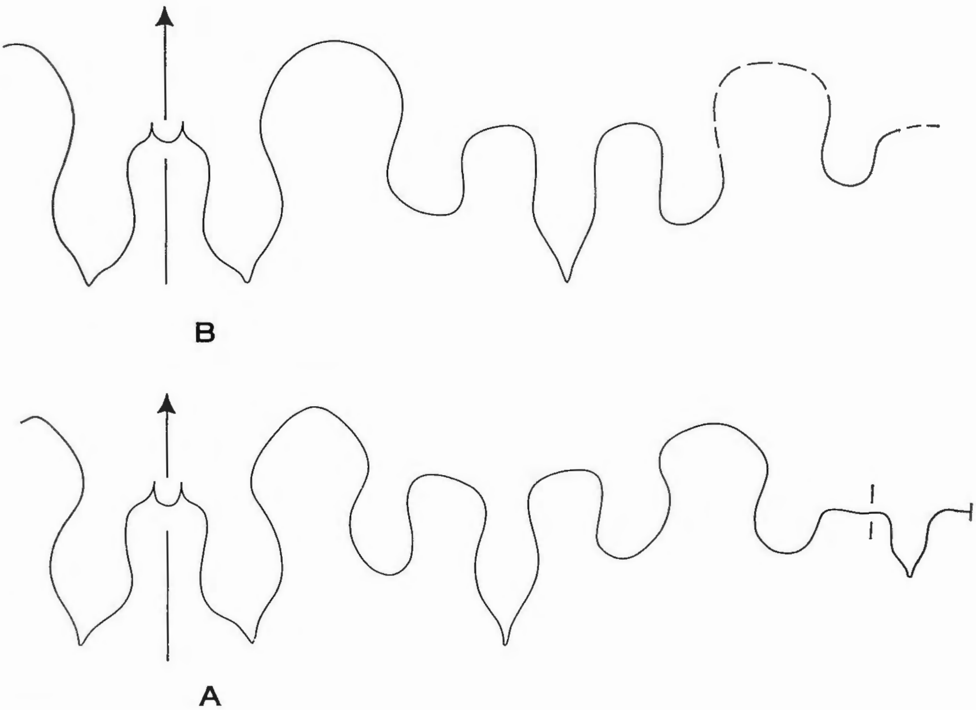

FIGURE 15. Diagrammatic representations of external sutures of *Parashumardites*.
A. *Parashumardites senex* (Miller and Cline) from the Missourian Nellie Bly Formation, Oklahoma; based on SUI topotype 32366, at a conch diameter of 41 mm; x4.
B. *Parashumardites* sp. from the Hare Fiord Formation at Hare Fiord, Ellesmere Island; based on GSC hypotype 23603, at a conch diameter of about 40 mm; x4.

Remarks. The type species of *Parashumardites, P. senex* (Miller and Cline), is from the Nellie Bly Formation, 6.5 miles west of Sand Springs, Oklahoma. W. M. Furnish (pers. com.) advises that the type locality is in a road-cut in the Nellie Bly Formation on U.S. highway 64 (Oklahoma highway 51), near the St. Louis–San Francisco railroad, Tulsa county.

Miller and Cline (1934, Pl. 28, figs. 31–36) illustrated both syntypes on which the species is based. Ruzhencev (1939) in establishing the genus did not designate a lectotype. The largest of the syntypes (Miller and Cline, 1934, Pl. 28, figs. 34, 35, 36) is herein selected to serve as lectotype.

The suture of SUI topotype 32366 is presented in Figure 15A. This specimen, devoid of shell ornament, is entirely septate to its maximum preserved diameter of 44 mm, and so the phragmocone is incomplete. At maximum diameter, whorl height is 13.5 mm, whorl width 24 mm, and umbilical diameter 16.2 mm.

Parashumardites and *Aktubites* Ruzhencev, both in the family Shumarditidae, exhibit external lateral, internal lateral, and dorsal lobes that are trifid; *Parashumardites* is slightly more advanced, however, and has an additional pair of umbilical lobes (Fig. 15A). *Proshumardites* Rauser-Tschernousova of Early and Middle Pennsylvanian age and a representative of the Agathiceratidae, also has a trifid external lateral lobe similar to *Parashumardites*. The internal lateral and dorsal lobes of *Proshumardites,* however, are simple and undivided.

Range of Parashumardites. Parashumardites senex is from the Nellie Bly Formation which is of Missourian age and which is a correlative of the Cherryvale Shale of Kansas (Moore, *et al.*, 1944). The Cherryvale can be correlated with the lower Kansas City Group.

Both of the other recorded North American species of *Parashumardites* are from Texas; *P. fornicatus* (Plummer and Scott), from the Missourian Graford Formation, north-central Texas and *P. sellardsi* (Plummer and Scott) from the Gaptank Formation in the Glass Mountains of west Texas. The arctic species and *P. fornicatus* and *P. senex* are similar in terms of evolutionary development but *P. sellardsi* is more advanced.

Two species are known from the Soviet Union: *P. mosquensis* Ruzhencev, 1939 from the Moscow Basin and *P. eurinus* Ruzhencev from the southern Ural Mountains. According to Ruzhencev (1950, 1962, 1965) the Soviet species are of Zhigulevian (Missourian) age. According to Ruzhencev (1962) and Naumova and Rauser-Tschernousova (1964), "Zhigulevian" as applied in the southern Urals is equivalent to the combined "Kasimovian" and "Gzhelian" stages as applied on the Russian Platform.

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UPPER PALEOZOIC FUSULINACEA: *EOWAERINGELLA* AND *WEDEKINDELLINA* FROM YUKON TERRITORY AND GIANT *PARAFUSULINA* FROM BRITISH COLUMBIA

by Charles A. Ross[1]

Abstract

Two new species of fusulinids are described: *Eowaeringella richardsonensis* from Middle Pennsylvanian (Desmoinesian) strata of the northern Yukon and *Parafusulina macdamensis* from Upper Permian (lower Guadalupian) strata of northern British Columbia. *Wedekindellina* cf. *W. cabezasensis* Ross and Sabins is documented from the Middle Pennsylvanian (Desmoinesian) of the northern Yukon.

Résumé

Description de deux nouvelles espèces de fusulinidés: *Eowaeringella richardsonensis* des strates du Pennsylvanien moyen (Desmoinésien) dans le Yukon septentrional, et *Parafusulina macdamensis* des strates du Permien supérieur (Guadalupéen inférieur) du nord de la Colombie-Britannique. La documentation relative au *Wedekindellina* cf. *W. cabezasensis* Ross et Sabine provient du Pennsylvanien moyen (Desmoinésien), dans le nord du Yukon.

Introduction

The fusulinids described in this report are from three geographically distinct areas (Fig. 1, locs. 6, 10, and 12). Two collections from the northern part of the Yukon Territory are of Middle Pennsylvanian (Desmoinesian) age and contain *Eowaeringella* and *Wedekindellina*; they supplement an earlier study of fusulinids from this general area (Ross, 1967). The discovery of a species of *Eowaeringella* Skinner and Wilde in the Richardson Mountains (Fig. 1, loc. 6) extends considerably northwards the geographic range of this genus, which has been known previously from the Midcontinent and Great Basin regions of the United States. Farther south, in the Ogilvie Mountains (Fig. 1, loc. 10), another collection contains the first species of *Wedekindellina* to be described from the Yukon. This species is more closely related to species of *Wedekindellina* from the Great Basin to the south than to other described species of this genus from the arctic.

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A collection from the Cassiar District of northern British Columbia (Fig. 1, loc. 12) contains a giant species of *Parafusulina* which shows great difference in size between its microspheric and megalospheric generations. The microspheric stages commonly reach 100 mm in length and form limestone coquinas. In many aspects this species is similar to other giant species of the genus from farther south in southern British Columbia, California, Mexico, and Texas. These species are characteristic of strata equivalent to the upper part of the Word Formation (lower Guadalupian).

Acknowledgments

It is a pleasure to acknowledge and thank B. S. Norford, J. A. Roddick, and W. J. Wolfe for collecting these interesting samples and R. Thorsteinsson for critically reading the manuscript.

Systematic Paleontology

Prefixes GSC refer to specimens in the type collection of the Geological Survey of Canada, Ottawa.

Order FORAMINIFERIDA

Family FUSULINIDAE

Genus *Eowaeringella* Skinner and Wilde 1967

Type species: *Wedekindellina ultimata* Newell and Keroher, 1937, from the Missourian Bethany Falls Member of the Swope Formation of Missouri.

Eowaeringella richardsonensis new species

Plate 14, figures 1–15

Material. Thirteen illustrated specimens, holotype GSC 23742, paratypes GSC 23743–23754, and several unillustrated poorly oriented specimens including one paratype, GSC 23755, that has three proloculi.

Occurrence. Fish Creek, northern Yukon, approximately 67°56′N latitude and 136°31′W longitude, 67 to 82 feet above the disconformable contact with Middle Devonian rocks; GSC loc. 53220 (Fig. 1, loc. 6); collected by B. S. Norford.

Description. Shells of this fusiform species commonly reach 6 mm in length and 1.5 mm in diameter in 7 or 7½ volutions. Proloculi in specimens examined range from 0.7 to 1.2 mm in outside diameter, the average being about 1.0 mm. The first volution is globose to subspherical (Pl. 14, figs. 2, 4) and succeeding volutions gradually increase proportionally more in length than height to attain form ratios of 2½ to 3½ by the sixth or seventh volution (Pl. 14, figs. 1, 5). Shape of the shell by the sixth volution is fusiform and the lateral slopes are straight to slightly concave and meet at sharply rounded poles. The spirotheca is composed of three well defined layers and a thin, commonly poorly defined lowest layer; these layers include a tectum, diaphanotheca, and lower and upper tectorial deposits (Pl. 14, figs. 2, 4). The thickness of the spirotheca increases gradually from about 0.015 mm in the proloculus to 0.07 mm in the sixth or seventh volution. Septa are nearly planar in the middle of the shell and become slightly undulatory near the poles (Pl. 14, figs. 8, 14). There are 10 to 12 septa in the first volution and this number gradually increases to 20 to 24 in the sixth or seventh volution.

The tunnel angle is nearly the same for all volutions ranging from about 28 degrees in early volutions to 36 degrees in later volutions. The tunnel follows a nearly regular path and is bordered by high, symmetrical chomata that extend to the roof of some chambers as thick accumulations on septa (Pl. 14, figs. 1, 5, 13, 15). Secondary deposits thicken the septa for about half the distance down the lateral slopes (Pl. 14, figs. 1, 5, 12) and line the floor of the tunnel in all but the last volution (Pl. 14, figs. 2, 4).

Remarks. Eowaeringella richardsonensis from the northern part of Yukon Territory is similar in general features to *E. alta* (Verville, Thompson, and Lokke) and *E. nevadensis* (Verville, Thompson, and Lokke) from Desmoinesian strata in the Ely Limestone, Cherry Creek Mountains, eastern Nevada. *E. richardsonensis* differs from these two species in being more elongate, having heavier secondary deposits coating the septa and a less well defined four-layered wall. *E. richardsonensis, E. alta,* and *E. nevadensis* fit well into a species complex within *Eowaeringella* described by Skinner and Wilde (1967), which they suggest may have given rise to the genus *Pseudofusulinella* Thompson. The occurrence of a species typical of this lineage complex in the arctic extends the biogeographic distribution and indicates species endemism during Middle Pennsylvanian time in a large north–south strip of central western North America. *E. richardsonensis* takes its name from the Richardson Mountains of the northern Yukon.

Age. Eowaeringella richardsonensis is Desmoinesian; probably from the middle part of this epoch.

Genus *Wedekindellina* Dunbar and Henbest 1933

Type species: *Fusulinella euthusepta* Henbest, 1928, from the Desmoinesian Stonefort Limestone Member of the Spoon Formation of Illinois.

Wedekindellina cf. *W. cabezasensis* Ross and Sabins 1965

Plate 15, figures 5–12

cf. *Wedekindellina cabezasensis* Ross and Sabins, 1965, p. 196, Pl. 26, figs. 14-18.

Material. Seven specimens, hypotypes GSC 23756–23762, these sections are not well oriented; additional fragments are present in several of the thin sections.

Occurrence. A talus block from a limestone bed at the approximate stratigraphic position of the "Lower Limestone Unit" of Nelson (1961), 64°47½'N latitude, 137°38½'W longitude, 7 miles northwest of Two Beaver Lake, Larsen Creek map-area, northern Yukon Territory, GSC loc. 47209 (Fig. 1, loc. 10); collected by J. A. Roddick.

Description. The large shells that characterize this species commonly reach 5 mm in length and 1.7 mm in diameter in 8 to 8½ volutions. In specimens measured, the proloculi are 0.10 to 0.12 mm in outside diameter and the first volution is subglobose (Pl. 15, fig. 8). Succeeding volutions are low and increase markedly in length to attain a form ratio of more than three by the eighth volution giving the shell a fusiform outline (Pl. 15, fig. 6). The spirotheca is four-layered (Pl. 15, fig. 8) and increases slightly in thickness from the proloculus (0.05 mm) to the eighth volution (0.08 mm). Septa are nearly planar from pole to pole (Pl. 15, fig. 9) and are closely spaced with about 40 septa in the tenth or eleventh volution (Pl. 15, fig. 10).

The tunnel follows an irregular path (Pl. 15, figs. 5, 6, 7, 8) and the tunnel angle decreases from about 35 degrees in the third volution to 25 to 30 degrees in the sixth or seventh volution. Chomata are high and secondary deposits thickly coat the septa giving the shell a dense appearance, particularly in the polar regions (Pl. 15, figs. 6, 7, 9).

Remarks. This species most closely resembles *Wedekindellina cabezasensis* from southeastern Arizona in size, shape, and rate of coiling. The Yukon specimens have more septa per volution and thicker secondary coatings. Other species reported from arctic North America include *W. dutkevitchi* Rauser-Chernousova and Beljaev from northeastern Greenland (Ross and Dunbar, 1962) and *W. lata* Thompson (1961) from Ward Hunt Island off the north coast of Ellesmere Island. Both these species are smaller, more elongate, and more tightly coiled than the Yukon specimens illustrated here.

Age. Wedekindellina cf. *W. cabezasensis* is a well developed species of the genus and is of Desmoinesian age, probably from near the middle of that epoch.

Genus ***Parafusulina*** Dunbar and Skinner 1931

Type species: *Parafusulina wordensis* Dunbar and Skinner, 1931, from the Guadalupian Word Formation of west Texas.

Parafusulina macdamensis new species

Plate 15, figures 1–4; Plate 16, figures 1–10

Material. Fourteen illustrated specimens, holotype GSC 23767 and paratypes GSC 23763–23766 and 23768–23777, and additional fragmentary specimens; all in strongly deformed limestone.

Occurrence. Unnamed Permian limestones (map-unit 5 of Wolfe, 1965, p. 5) McDame map-area, Cassiar District, British Columbia, 59°33′N latitude, 129°55′W longitude, about 2½ miles west of Blue River at an elevation of 5,250 feet; GSC loc. 51078 (Fig. 1, loc. 12); collected by W. J. Wolfe.

Description. Megalospheric shells of this large elongate species reach 24 mm in length and 3.5 mm in diameter in six to seven volutions. In megalospheric specimens measured, the proloculi range from 0.4 to 0.8 mm in outside diameter and have a prominent internal neck on the pore leading to the first chamber (Pl. 16, figs. 1, 3, 6). The first half volution is subglobose and succeeding volutions increase proportionately more in length than height to attain form ratios of 4 to 5 by the fourth or fifth volution and 6 to 7 in the sixth or sixth and one-half volution (Pl. 16, figs. 1–7). The shell shape is elongate and fusiform and the lateral slopes taper to sharply rounded poles. The thickness of the spirotheca is difficult to measure because of recrystallization, but it appears to increase gradually from the proloculus to the outer volution. Septa are folded from pole to pole (Pl. 16, figs. 1, 2, 10) into closely spaced, regular septal folds that tend to bulge above their attachment to the floor of the chambers. Septa increase gradually from 11 to 13 in the first volution to 28 to 34 in the fourth or fifth volution. Cuniculi are well developed (Pl. 15, figs. 2, 3; Pl. 16, fig. 10). The tunnel angle increases from about 30 degrees in the first volution to 45 degrees in the fourth or fifth volution. Chomata are lacking, other secondary deposits form light to medium axial deposits near the poles of many volutions.

Microspheric individuals are considerably larger; one broken specimen of about half its original size reaches 55 mm in length (the complete length would have been nearly 100 mm) and 10 mm in diameter. In comparison to the megalospheric form they have heavier axial deposits and thicker septa, and lack a tunnel (Pl. 15, fig. 1). I have not been able to obtain a complete microspheric specimen or a specimen showing the microspheric juvenarium of this generation; however, an indication of the size and some features are shown in Plate 15, figure 1.

Remarks. Parafusulina macdamensis is similar to other species of about the same age from the central western Cordillera of North America. Megalospheric shells of *Parafusulina californica* (Staff) from northern California (Thompson and Wheeler, 1946), and *P. thomassoni* Skinner and Wilde from the Cache Creek Group, northeast of Kamloops, British Columbia (Skinner and Wilde, 1966), are smaller per volution and their septal folds are less closely spaced than in *P. macdamensis. P. antimonioensis* Dunbar (1953) from El Antimonio, Sonora, Mexico (Dunbar, 1953); the Glass Mountains, West Texas (Ross, 1963); and Kettle Falls, Washington (Mills and Davis, 1962) is more elongate, has heavier secondary deposits, and lower, less crowded septal folds than *P. macdamensis. P. macdamensis* takes its name from the McDame map-area of the Cassiar District, British Columbia.

Age. Parafusulina macdamensis is similar in evolutionary development to species of this genus from the upper part of the Word Formation (lower part of the Guadalupian Series) of West Texas, and is of about the same age.

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AN UNDEFORMED SPECIMEN OF THE LOWER CRETACEOUS FORAMINIFER *HAPLOPHRAGMOIDES GIGAS* CUSHMAN, FROM ALBERTA

by R. T. D. Wickenden

Abstract

Previous studies of the species have been based on crushed specimens. The present specimen allows a more complete description than was previously possible. *Haplophragmoides gigas* Cushman is an important index fossil in the basal part of the Middle Albian Joli Fou Formation of Alberta, Saskatchewan, and Manitoba.

Résumé

Les études antérieures de cette espèce ayant été faites sur des spécimens écrasés; avec celui-ci il n'est maintenant pas impossible de donner une description plus complète de l'espèce. L'*Haplophragmoides gigas* Cushman constitue un important fossile-index de la basse partie de la formation Joli Fou (Albien moyen) de l'Alberta, de la Saskatchewan et du Manitoba.

Introduction

During burial in sediments, fossil arenaceous foraminifers commonly appear to have been crushed, or the walls of their chambers have collapsed. For some species, nearly all the available specimens appear to be so distorted. *Haplophragmoides gigas* Cushman is such a species, even the specimen selected as holotype is misshaped. All the material originally described by Cushman (1927, pp. 129, 130) has the chambers collapsed or crushed in the plane of coiling and perhaps more than ninety-nine per cent of the known specimens of the species are so flattened.

The discovery of a good specimen in an undeformed condition is worthy of illustration and warrants revision of the description of the species with special emphasis on the features by which it may be distinguished, whether or not specimens have been flattened in the plane of coiling. The sample that yielded the present specimen also contains typically crushed individuals and partly crushed specimens, leaving no doubt that the figured specimen is a true *Haplophragmoides gigas*.

The revised description is based on study of the undamaged specimen and of thin sections of typical distorted specimens.

Acknowledgments

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Systematic Paleontology

Prefix GSC refers to specimens in the type collection of the Geological Survey of Canada, Ottawa.

Order FORAMINIFERIDA

Family LITUOLIDAE de Blainville 1825

Genus *Haplophragmoides* Cushman 1910

Type species: *Nonionina canariensis* d'Orbigny 1839 from Recent rocks of the Philippines.

Haplophragmoides gigas Cushman 1927

Figure 16a, b

Haplophragmoides gigas Cushman 1927, pp. 129-130, Pl. 1, fig. 5.
Haplophragmoides gigas Cushman, Cushman 1946, p. 21, Pl. 3, fig. 2.
Haplophragmoides gigas Cushman, Nauss 1947, p. 338, Pl. 49, figs. 8a, 8b.
Haplophragmoides gigas Cushman, Stelck, Wall, Bahan, and Martin, 1956, p. 35, Pl. 5, fig. 1.
Haplophragmoides gigas Cushman, Guliov, 1967, pp. 23-24, Pl. 4, figs. 1a-1c.

Types and occurrence. Holotype GSC 9023 from the Lower Cretaceous Joli Fou Formation at 1,921–1,929 feet in the British Petroleum Number 3 Well, sec. 29, tp. 45, rge. 6, W. 4th mer., Alberta. Hypotype GSC 23730 from the Lower Cretaceous Joli Fou Formation at 1,850–1,860 feet in the Imperial Fabian Number 1 Well, lsd. 16, sec. 18, tp. 45, rge. 8, W. 4th mer., Alberta (Fig. 1, loc. 14); about 20 miles from the type locality.

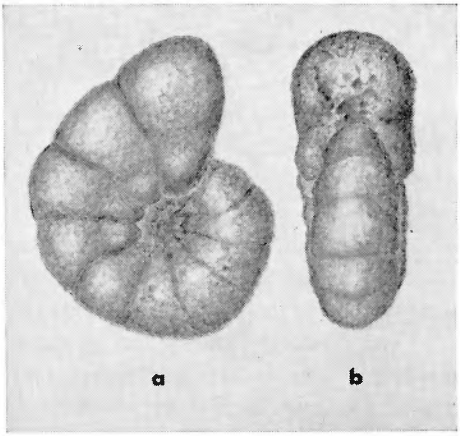

FIGURE 16. *Haplophragmoides gigas* Cushman, drawings of the dorsal (16a) and lateral (16b) views of the undeformed specimen (hypotype GSC 23730) from the Joli Fou Formation; x50.

Dimensions of hypotype GSC 23730. Diameter about 0.82 mm, maximum thickness 0.33 mm.

Description. Test free, planispiral, almost completely involute with the overlap of the last whorl less than those of early stages; biumbilicate; periphery rounded in un-crushed specimens; chambers usually ten in final whorl, as few as seven in initial whorl, somewhat U-shaped in cross-section with a slight re-entrant at sides, almost triangular from side view, somewhat umbonate near umbilicus; sutures depressed, sigmoidal, fairly wide, about 0.03 mm; wall arenaceous, glazed, with a fair amount of cement, fine grains closely packed, about 0.02–0.03 mm in diameter at periphery, larger near umbilicus, up to 0.06 mm; aperture a low arch at base of the face of the final chamber at the periphery of the previous whorl.

Remarks. The characteristic sigmoidal suture, the raised or umbonate inner end of the chamber near the umbilicus, and the usual ten chambers to the adult whorl are distinctive of both the crushed and undistorted specimens. The figured specimen is not so large as the holotype, but it developed as many whorls. It may not be as mature a specimen. Other specimens in the sample from the Fabian well are flattened and also larger, similar in size to the holotype.

Thin sections were made normal to and in the plane of coiling in an attempt to study the initial coil and the proloculum and also to observe any indication of space sufficient to form a living chamber. All specimens thus studied were so compressed that no indication was found of the proloculum, nor could the boundary between the coils be recognized. No attempt was made to section the undistorted specimen.

The species is a very useful horizon marker in the Lower Cretaceous (Middle Albian) Joli Fou Formation (Guliov, 1967, pp. 11–12). It can be recognized about 20 to 30 feet above the base of the formation at localities in wells and outcrops from west-central Manitoba to the Athabasca River sections in the plains of Alberta. It is probable that some specimens from other regions have been incorrectly identified as this species.

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PARAALNIPOLLENITES, A NEW FORM GENUS FROM UPPERMOST CRETACEOUS AND PALEOCENE ROCKS OF ARCTIC CANADA AND RUSSIA

by L. V. Hills[1] and Sandra Wallace[1]

Abstract

Paraalnipollenites a new form genus is described and illustrated from the Eureka Sound Formation of Bathurst Island, District of Franklin. The type species *P. confusus* (Zaklinskaia, 1963) was first described as *Triatriopollenites confusus* Zaklinskaia. In arctic Canada it occurs in the Eureka Sound Formation, Bathurst Island, and in the Reindeer Formation, District of Mackenzie. In the Eureka Sound Formation associated spores, pollen grains, and dinoflagellates indicate that the sediments are of Maestrichtian age, whereas in the Reindeer Formation a Paleocene age is indicated.

Résumé

Description et illustration du *Paraalnipollenites* nouveau genre de la formation Eureka Sound de l'île Bathurst, district de Franklin. À l'origine l'espèce type *P. confusus* (Zaklinskaia, 1963) a été décrite sous le nom de *Triatriopollenites confusus* Zaklinskaia. Dans l'Arctique canadien, on la trouve dans la formation Eureka Sound (île Bathurst) et dans la formation Reindeer, district de Mackenzie. La formation Eureka Sound produit un mélange de spores, de grains de pollen et de dinoflagellés et indique que les sédiments sont du Maestrichtien, alors que la formation Reindeer date du Paléocène.

Introduction

Pollen assigned to the form genus *Alnipollenites* or to the extant genus *Alnus* have been described from strata ranging in age from late Cretaceous (Srivastava, 1966; Stanley, 1965; Takahashi, 1965; Verbitskaya, 1958) through the Tertiary (Potonié, 1931; Wodehouse, 1935; Wilson and Webster, 1946; Rouse, 1962; Martin and Rouse, 1966, and others) to the Recent. Potonié (1931) created the form genus *Alnipollenites* to which he assigned Tertiary pollen of the *Alnus*-type. The essential characters of the genus are three to seven equatorially arranged aspidate pores that are interconnected by arcuate, internal thickenings (arci). The arci are present on both the proximal and distal surfaces of the pollen grain (Pl. 17, figs. 9–11).

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The number of pores has been used as a specific character. For example, Rouse (1962, p. 202) created two new fossil species of *Alnus* on the basis of pore number. One of these, *A. quadripollenites,* had four pores whereas the other, *A. quinquepollenites,* had five pores. Later Martin and Rouse (1966, p. 196) assigned both species to *A. verus* (R. Potonié) Martin and Rouse. Stanley (1965, p. 288) used pore number and the shape and width of the arci to differentiate species. Wodehouse (1935) and later workers have pointed out that pore number in Recent species is variable and therefore pore number alone cannot be considered diagnostic of a species. *Alnus rugosa* (Du Roi) K. Koch, for example, commonly has four or five pores but may have three or six. Erdtman (1936) attached diagnostic significance to the relative size of the aspids.

During a palynological study of about 100 feet of interbedded sandstones and shales assigned to the Eureka Sound Formation and exposed at the head of Freemans Cove (lat. 75°13′N, long, 98°3′W; Kerr and Temple, 1965, p. 8) Bathurst Island (Fig. 1, loc. 4), numerous pollen grains assignable to *Alnipollenites* or *Alnus* were encountered. Most of these grains exhibit well developed arci and three to seven pores. A few grains are atypical in that the arci are poorly or incompletely developed. The arci on these atypical grains commonly fuse to form the thickened annulus around a pore but in about a half of the fusions on a given grain no pore is developed. These atypical grains are characterized by three pores and three false pores which are situated on the amb or slightly offset onto one hemisphere and are midway between the pores. The combination of false pores and poor development of arci is significant and indicates a new genus. Zaklinskaia (1963) and Bratzeva (1967) illustrate a form from the Maestrichtian-Paleocene of the Soviet Union that shows the same characters.

In 1966, palynological samples were collected from shales exposed in the Caribou Hills area along the east side of Mackenzie River (lat. 68°47′N, long. 134°06′ W; Fig. 1, loc. 5). Mountjoy (1967, p. 10) assigned these strata to the Reindeer Formation. Samples from about 1,000 feet of section at this locality have yielded an abundance of grains of the same distinctive type as those found at Freemans Cove. The occurrence of this pollen type at two widely separated localities of approximately the same age suggests that it may be a useful stratigraphic marker.

Acknowledgments

The samples from Freemans Cove, Bathurst Island, were collected by Hills in August 1964 while associated with the Geological Survey of Canada. The authors thank Chevron Standard Limited for providing samples from the Caribou Hills for comparative purposes.

Miss B. Koch typed the manuscript and translated the generic diagnosis of *Alnipollenites*. The manuscript was criticized by D. C. McGregor of the Geological Survey of Canada. D. Harvey of the University of Calgary helped to prepare Plate 17. A National Research Council of Canada grant in aid of research is gratefully acknowledged. This grant provided a salary for one of the authors (S.W.) and purchased chemicals and photographic supplies.

Systematic Palynology

The Canadian hypotypes of *Paraalnipollenites confusus* are part of the type collection of the Geological Survey of Canada, Ottawa.

Anteturma POLLENITES R. Potonié, 1931

Turma POROSES (Porosa, Naumova, 1937, 1939) emend. Potonié, 1960

Subturma POLYPORINES (Polyporina, Naumova, 1937, 1939) emend. Potonié

Infraturma STEPHANOPORITI van der Hammen, 1954

Genus *Paraalnipollenites* new form genus

Diagnosis. Polyporate, commonly three pored, rarely four pored. Grains typically triangular to rounded-triangular with convex to straight sides. Arci poorly developed, frequently not extending from one pore to the next. Occasionally only one arcus is developed at each pore, the others being entirely absent or only rudimentarily present close to the pore. Midway between pores the arci characteristically arc out as if to form a pore, but instead either they fuse into a false pore or they swing back without fusing. Frequently the only development of the arci is in the vicinity of these false pores.

Type species: *Paraalnipollenites confusus* (Zaklinskaia, 1963) from Paleocene rocks of the Soviet Union.

Remarks. This genus can be differentiated from *Alnipollenites* and *Alnus* by the false pores and the poor development of the arci. *Paraalnipollenites* can be differentiated from *Triatriopollenites* Pflug (1953) and *Casuarinidites* Cookson and Pike (1954) by the absence of arci and false pores in the latter two genera.

The name *Paraalnipollenites* is in reference to the nearness (para) of this genus to *Alnipollenites*.

Paraalnipollenites confusus (Zaklinskaia, 1963)

Plate 17, figures 1–8

Triatriopollenites confusus Zaklinskaia, 1963, p. 232, Pl. 34, fig. 7.
Triatriopollenites confusus Zaklinskaia, Bratzeva, 1967, p. 125, Pl. 1, fig. F.

Diagnosis. As for genus except for the presence of a circular to oval thickening on one hemisphere of the grain. This thickening is best developed on grains with the least well developed arci. In some specimens it appears to replace the arci on one hemisphere. Both arci and well developed annular thickenings are present on some specimens and thus such thickenings are not entirely deformed arci. Exine psilate to faintly granular or scabrate. Size ranges from 22 to 32 microns (20 measured specimens) in specimens from arctic Canada and 30 to 40 microns in the specimens described from Russia.

Remarks. Although Zaklinskaia (1963, p. 2327) does not mention the presence of arci, false pores, and an annular thickening on one hemisphere these features can be seen on the illustration of the holotype of *Triatriopollenites confusus* (Pl. 34, fig. 7). Further, Bratzeva (1967, Pl. 1, fig. F) assigns a specimen to *T. confusus* which also has the above characters. Thompson and Pflug (1953) in their description of *Triatriopollenites* makes no mention of arci or false pores nor does Zaklinskaia (1963) modify the genus to include these features. The present writers believe that the arci and false pores are sufficient criteria for creating a new form genus, *Paraalnipollenites,* and that *Triatriopollenites confusus* belongs to that genus. The only difference between the specimens from Russia and those from the Canadian arctic is a slight difference in size range (22 to 32 microns, Canadian arctic; 30 to 40 microns, Russia). This slight size difference is not considered to be significant and hence the specimens from the two areas are considered to be conspecific.

The two paratypes illustrated by Zaklinskaia (1963, Pl. 34, figs. 6 and 8) do not appear to have either arci or false pores and hence cannot be reassigned to *Paraalnipollenites* at this time. They may well belong to *Triatriopollenites.*

Occurrence. Zaklinskaia (1963, p. 232) states that the holotype comes from the lower horizon of the Zhezdinsk suite, or Karakengirsk subsuite of K. V. Nikiforov, and is of Paleocene age. Bratzeva (1967) reports it from the Tsagaiansk deposits of the Zeya-Bureya depression of Maestrichtian age. In the Canadian arctic it is known to occur in the Eureka Sound Formation of Maestrichtian age and the Reindeer Formation of Paleocene age.

Types. Hypotype GSC 15722 (Pl. 17, figs. 1, 2), from GSC plant locality 7277, Eureka Sound Formation, Freemans Cove, Bathurst Island. Slide Freemans Cove No. 1-12, coordinates on University of Calgary Wild Research Microscope (Serial No. M20-56754): 17.7–73.2.

Hypotype GSC 15723 (Pl. 17, figs. 3–5), from same locality. Slide Freemans Cove No. 1–13, coordinates as above: 16.4–112.0.

Hypotype GSC 15724 (Pl. 17, figs. 6–8), from same locality. Slide Freemans Cove No. 1-1, coordinates as above: 11.0–99.5.

Description of hypotype GSC 15722. Triporate with three false pores. Shape rounded-triangular. Annular thickening present on one hemisphere but incompletely developed. Arci fully connected to only one pore. In one of the remaining pores only one arcus is connected, the other arcs out as if to join but does not fuse with the annular thickening surrounding the pore (upper left pore, Pl. 1, figs. 1, 2). The arci all appear to be present at the third pore (upper right) but they do not extend to adjacent false pores. Exine psilate to slightly scabrate. Size 31 microns.

Description of hypotype GSC 15723. Triporate with three false pores. Shape triangular. Annular thickening poorly defined, most easily distinguished under phase contrast (Pl. 17, fig. 4). Arci well developed, interconnecting all three pores and the intervening false pores. Arci fuse to thickening around pores but do not fuse at the false pores (Pl. 17, fig. 5). Exine appears to be psilate but is slightly corroded on the hemisphere with the annular thickening. Size 31 microns.

Description of hypotype GSC 15724. Triporate with three poorly defined false pores. Shape triangular with convex sides. Annular thickening (Pl. 17, fig. 8) well defined, oval in outline. Arci incomplete, not extending the entire distance from one pore to the next. False pores represented by a slight outward bulge of the arci. Exine psilate. Size 26 microns.

Geological range. At Freemans Cove, *Paraalnipollenites confusus* is associated with the following species that are illustrated by Plate 17, figures 9–19:

Orbiculapollis globosus Chlonova
Projectoporites magnus Mchedlishvili
Wodehouseia cf. *W. operculata* Chlonova
W. cf. *W. stanleyi* Srivastava
W. spinata Stanley
Alnipollenites spp.
Aquilapollenites granulatus Mchedlishvili
cf. *Aquilapollenites* sp.
Schizaea plectilis Stanley

Not illustrated but common in the assemblage from the locality:

Hystrichosphaeridium difficile Manum and Cookson
Odontochitina striatoperforata Cookson and Eisenack
Pityosporites spp.
Podocarpidites spp.
Sphagnum regium Drozhastichich
Translucentipollis sp.
Deflandrea scheii Manum
D. cf. *D. scheii* Manum
D. granulifera Manum
D. verrucosa Manum
Gymnodinium sp.

Chlonova (1962, p. 306) assigned such pollen grains as *Wodehouseia* to the morphological types "Oculata" characterized by apertures arranged in pairs along each of the long sides close to the narrow ends of the grains. This type of grain ranges from Maestrichtian to Danian and rarely into the Paleocene. *Wodehouseia stanleyi* is known only from the Maestrichtian of Alberta, *W. operculata* from the Maestrichtian of Siberia, and *W. spinata* from the Maestrichtian Hell Creek Formation of Montana (Norton and Hall, 1967, p. 107) and the late Upper Cretaceous Crow Butte section in South Dakota (Stanley, 1961, p. 106). *W. spinata* has been observed in the lower part of the Ravenscrag Formation in southern Saskatchewan by one of us (L.V.H.) indicating that it may range up into the Paleocene. *Orbiculapollis globosus* and *Aquilapollenites* spp. are assigned to the morphological group referred to as the "Unica"-type by Chlonova (1962). This group is characterized by asymmetric development of the poles and by peculiar pores. This type (Chlonova, 1962, p. 304) of pollen grain appears in the Senonian and reaches a peak in the Maestrichtian. Samoilovich (1967, p. 132) states that the Triprojectacites (*Projectoporites magnus,* etc.) are characteristic of the Late Senonian-Danian of the Middle Yenisey region of Asia. Species of *Aquilapollenites* survive until the Eocene (Funkhouser, 1961). *Schizaea plectilis* Stanley (1965, p. 261) is reported from the Hell Creek Formation (Maestrichtian) of South Dakota.

The dinoflagellates identified have been reported from the Hassel Formation (about mid-Cretaceous) of the arctic by Manum (1962) and by Manum and Cookson (1964).

From the foregoing discussion one can conclude that the strata at Freemans Cove, Bathurst Island, are of late Cretaceous age, probably Maestrichtian. The age of the Reindeer Formation is thought to be Paleocene.

Mountjoy (1967, p. 11) reports that palynological studies by Rouse had indicated an early Tertiary age (probably Paleocene or Eocene) for the unit but that a later re-examination by Rouse of all the samples suggested that the closest possible age assignment was Paleocene. The present writers are in agreement with the Paleocene age assignment. The plant fossils identified in association with *Paraalnipollenites confusus* in the Reindeer Formation are most similar to those reported by Rouse from 142 feet of beds within section 4 of Mountjoy (1967) and may therefore come from the same stratigraphic horizons as these plants.

On the basis of the evidence provided by the associated spores, pollen grains, and dinoflagellates the geological range of *P. confusus* is considered to be Maestrichtian to Paleocene. It is rare (about 1 in 500 grains) in the Freemans Cove samples and common in the Reindeer Formation where it is apparent even in quick scans of the material.

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