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BULLETIN 267

**CONTRIBUTIONS TO CANADIAN PALEONTOLOGY
(five papers)**

B.S. Norford and Reuben J. Ross, Jr.; T.T. Uyeno;
Charles A. Ross and E.W. Bamber; Charles A. Ross
and J.W.H. Monger; Charles A. Ross





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Preface

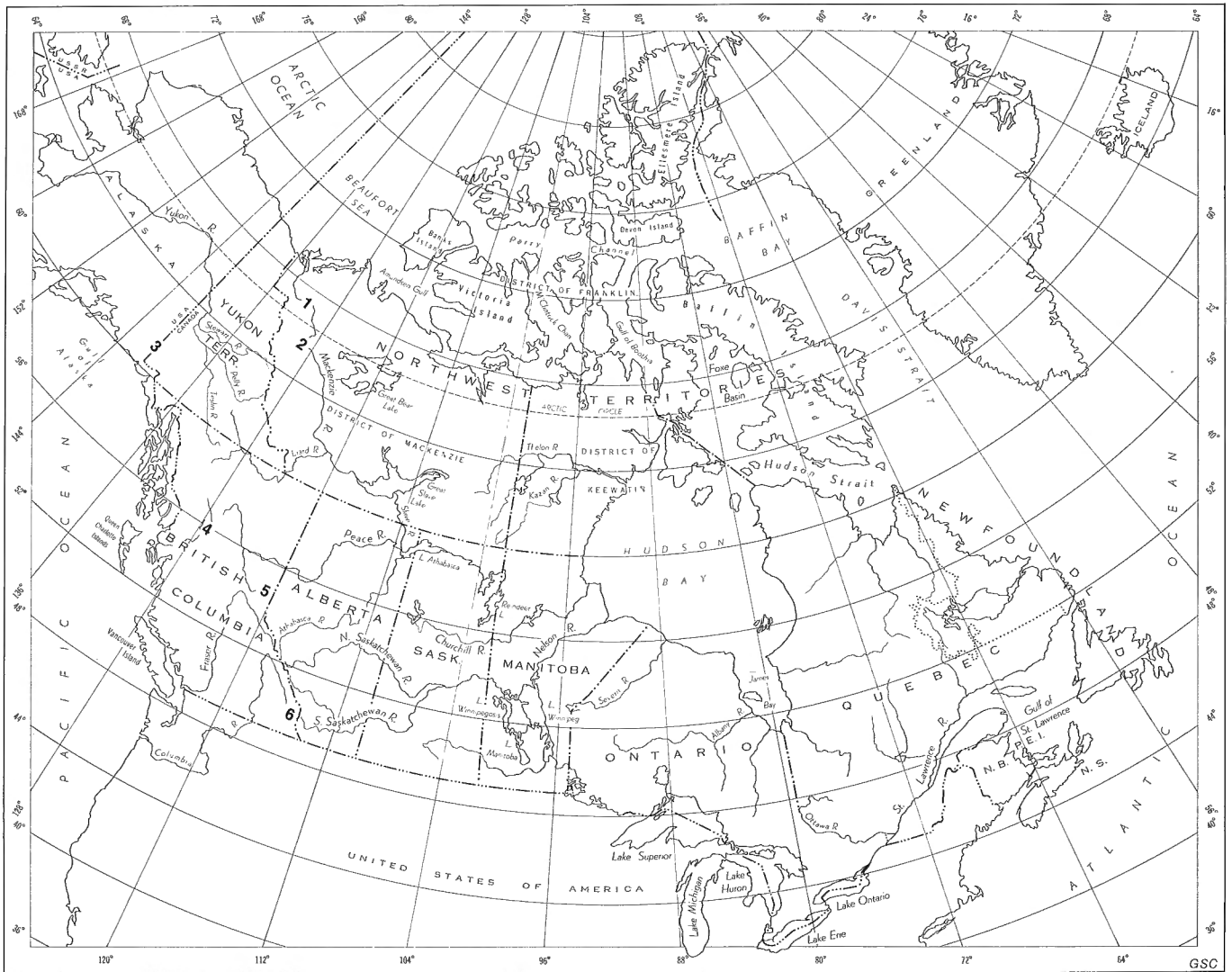
From time to time, it is appropriate to issue several papers on paleontological topics as a single volume under the general title *Contributions to Canadian Paleontology*. This bulletin contains five papers that present detailed descriptions of fusulinacean foraminifers, conodonts, trilobites and brachiopods. Such taxonomic studies provide the basis for precise paleontological determinations that are critical to accurate dating and to stratigraphic and economic analyses of the rocks forming the sedimentary basins of Canada.

Ottawa, 21 April 1977

D.J. McLaren
Director General
Geological Survey of Canada

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Textfigure 1. Locality map for all papers.

1. Charrue Lake and Gossage River, Mackenzie Valley (Uyeno)
2. Powell Creek section, Mackenzie Valley (Uyeno)
3. Kletsan Creek, St. Elias Mountains (Ross)
4. Omineca Mountains (Ross and Monger) (*see* Textfigs. 5 and 6 for more detail)
5. Monkman Pass (Ross and Bamber) (*see* Textfig. 3 for more detail)
6. North White River section (Norford and Ross)

CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

New Species of Brachiopods and Trilobites from the Middle Ordovician (Whiterock) of Southeastern British Columbia

B.S. Norford and Reuben J. Ross, Jr.

Abstract

Two small assemblages of brachiopods, trilobites and gastropods are described from the North White River section, which is transitional between the Ordovician carbonate and graptolite facies in southeastern British Columbia. The brachiopods, *Hesperomena canadensis* new species and an indeterminate leptaenid, and the gastropods are from beds of the Skoki Formation within the *Anomalorthis* Zone. The trilobites are from the Glenogle Shales within the *Isograptus caduceus* Zone and also within the *Orthidiella* Zone. They include *Globampyx sinalae* new species, *Peraspis kolouros* new species, and a generically indeterminate asaphacean pygidium. The gastropods are not well preserved but represent four different genera.

Résumé

On décrit ici deux modestes assemblages de brachiopodes, trilobites et gastropodes, rencontrés dans la section de la rivière North White, qui dans le sud-est de la Colombie-Britannique est transitionnelle entre les faciès calcaire et graptolithique de l'Ordovicien. Les brachiopodes (qui comprennent une nouvelle espèce nommée *Hesperomena canadensis* et un leptaenidé indéterminé) et les gastropodes proviennent de lits de la formation de Skoki qui sont situées dans la zone à *Anomalorthis*. Les trilobites proviennent des argiles litées de la formation de Glenogle à l'intérieur de la zone à *Isograptus caduceus* et de la zone à *Orthidiella*. Parmi ceux-ci, on rencontre les nouvelles espèces *Globampyx sinalae* et *Peraspis kolouros*, ainsi qu'un pygidium d'un asaphacé non identifié. Les gastropodes sont mal conservés, mais représentent quatre genres différents.

Introduction

The North White River section of southeastern British Columbia is transitional between the lower Middle Ordovician carbonate and graptolitic facies (McKee *et al.*, 1972). Both graptolite faunas and shelly faunas (primarily brachiopods and trilobites) are present within the stratigraphic section.

The fossils described in this paper are from the Skoki Formation (GSC loc. 64561) and from the Glenogle Shales (GSC loc. 64579). Textfigure 2 shows their positions within the stratigraphic section (after McKee *et al.*, 1972, p. C151, C152). Faunal lists from the two collections are:

GSC loc. 64561, Skoki Formation,
47–50 m (156–164 ft) above base;
635–638 m (2084–2092 ft) above base of Glenogle Shales

sponges
echinoderm and trilobite fragments
undetermined gastropods spp.*
Maclurites sp.*
indeterminate leptaenid brachiopod*
Hesperomena canadensis new species*

GSC loc. 64579, Glenogle Shales,
229–233 m (750–763 ft) above base

undetermined orthoconic cephalopod
undetermined inarticulate brachiopod
indeterminate asaphacean trilobite*
Peraspis kolouros new species*
Globampyx sinalae new species*
cf. *Primitiella* sp.
dichograptid fragments
Isograptus caduceus divergens Harris
Isograptus forcipiformis Ruedemann

The upper collection overlies beds dated as *Anomalorthis* Zone and its own fauna indicates the same zone. Leptaenid brachiopods are not known prior to the Middle Ordovician. *Hesperomena leptellinoidea* Cooper, the only other described species of the genus, is known only from high in the *Anomalorthis* Zone (*Rhysostrophia* Subzone) of Nevada (Ross, 1970, p. 21, 23, 49, 51, 64).

The lower collection is well dated by enclosing graptolitic horizons to be within the *Isograptus caduceus* Zone (Textfig. 2). The other described species of *Peraspis* are known from the *Orthidiella* Zone at Ikes Canyon, Nevada (Ross, 1970); from the middle Table Head Formation of Newfoundland, which is thought to be coeval with part of the *Orthidiella* Zone (Whittington, 1965; Barnes *et al.*, 1976); from unnamed lower

*Illustrated taxa.

Llanvirn rocks in the Yukon (Dean, 1973); and from parts of the Valhallfonna Formation (Profilbekken and high Olenid-letta members) of Spitsbergen that are late Arenig and early Llanvirn (Fortey, 1975, p. 10). The acme of the genotype of *Globampyx* is in the lower 75 m (246 ft) of the Profilbekken Member of the Valhallfonna Formation, which Fortey (*ibid.*) correlates as Whiterock (restricted *Orthidiella* Zone and "pre-*Orthidiella*" Zone). An *Orthidiella* Zone (*sensu lato*) correlation can be suggested for the lower collection in the North White River section.

Acknowledgments

All determinations of graptolites and resulting correlations are by D.E. Jackson of the Open University; identifications of ostracodes are by M.J. Copeland of the Geological Survey of Canada. G.A. Cooper of the Smithsonian Institution, W.T. Dean of the Geological Survey of Canada, and C.P. Hughes and H.B. Whittington of Cambridge University kindly critically reviewed the manuscript. The photographs are by D.G. Lawrence and L. Wilson.

Systematic Paleontology

Prefix GSC refers to the type specimens and the other illustrated material, all stored in the type collections of the Geological Survey of Canada, Ottawa.

Phylum Brachiopoda
Superfamily Strophomenacea King, 1846
Family Leptaenidae Hall and Clarke, 1894
Genus indeterminate
Plate 3, figures 17, 20

Material. A single, silicified, apparently juvenile pedicle valve (hypotype GSC 42595) from GSC loc. 64561.

Description. Valve semielliptical in outline, about 16 mm wide at hinge and 7.5 mm long. Genuiculate at right angles at midlength of 5 mm. Disc and trail strongly rugose concentrically; no apparent radial ornamentation.

No muscle scars imprinted on interior. Roughly concentric flange raised above floor at midlength of 4.5 mm forms edge of visceral disc. No hinge teeth and no deltidial structures preserved. No indication that dental plates were present.

Discussion. No generic identity can be attempted.

Superfamily Plectambonitacea Jones, 1928
Family Leptestiidae Öpik, 1933
Genus *Hesperomena* Cooper, 1956

Hesperomena Cooper, 1956, p. 744, 745

Type species. *Hesperomena leptellinoidea* Cooper, 1956, from the Middle Ordovician Antelope Valley Limestone, Toquima Range, Nevada

Hesperomena canadensis new species
Plate 1, figures 1–12; Plate 2, figures 7, 8, 11–17

Material. About 16 specimens (including holotype GSC 42596 and paratypes GSC 42597–42603) all from GSC loc. 64561,

Skoki Formation, Llanvirn; mostly damaged or fragmentary so that proportions of shells must be estimated.

Description. Length of shell about three fifths of its width; widest at hinge line. Outline broadly semielliptical. Surface marked by costellae of two sizes; width of each large costella about a third to half of space between each pair of costellae. Within 5 mm of umbo, up to 4 evenly spaced multicostellae between each pair of costellae; distally and medially these multicostellae become very faint.

Pedicle valve in lateral profile most convex at midlength where profile obtusely genuiculate. Resulting trail more convex than posterior half of valve (Pl. 2, fig. 11). Between umbo and middle of valve, narrow fold corresponds to sulcus in brachial valve. Cardinal area short, apsacline. Convex pseudodeltidium with small elongate apical perforation for pedicle foramen. Hinge teeth barely supported by downward-diverging receding lamellae. Muscle scars indistinct in available specimens but limited to posterior portion of valve.

Brachial valve about twice as wide as long, exclusive of cardinal process. Shallow median sulcus extending as far forward as genuiculation of trail. Interior of valve bears distinctly elevated margin (Pl. 1, fig. 9; Pl. 2, fig. 15) around visceral disc, but without any overhang. Cardinal process and a pair of subsidiary ridges form a projecting platform supported laterally by a pair of posteriorly converging plates (Pl. 1, figs. 9, 11; Pl. 2, figs. 14–17) above notothyrial platform, producing a subconical chamber between platform and underside of cardinal process. Bachiophores divergent forward, posteriorly fused with the pair of plates whose bases project a short distance forward, jointly forming a broad median callosity, from which a sharp but low median septum continues forward and dies out a short distance in front of visceral disc (Pl. 2, fig. 15).

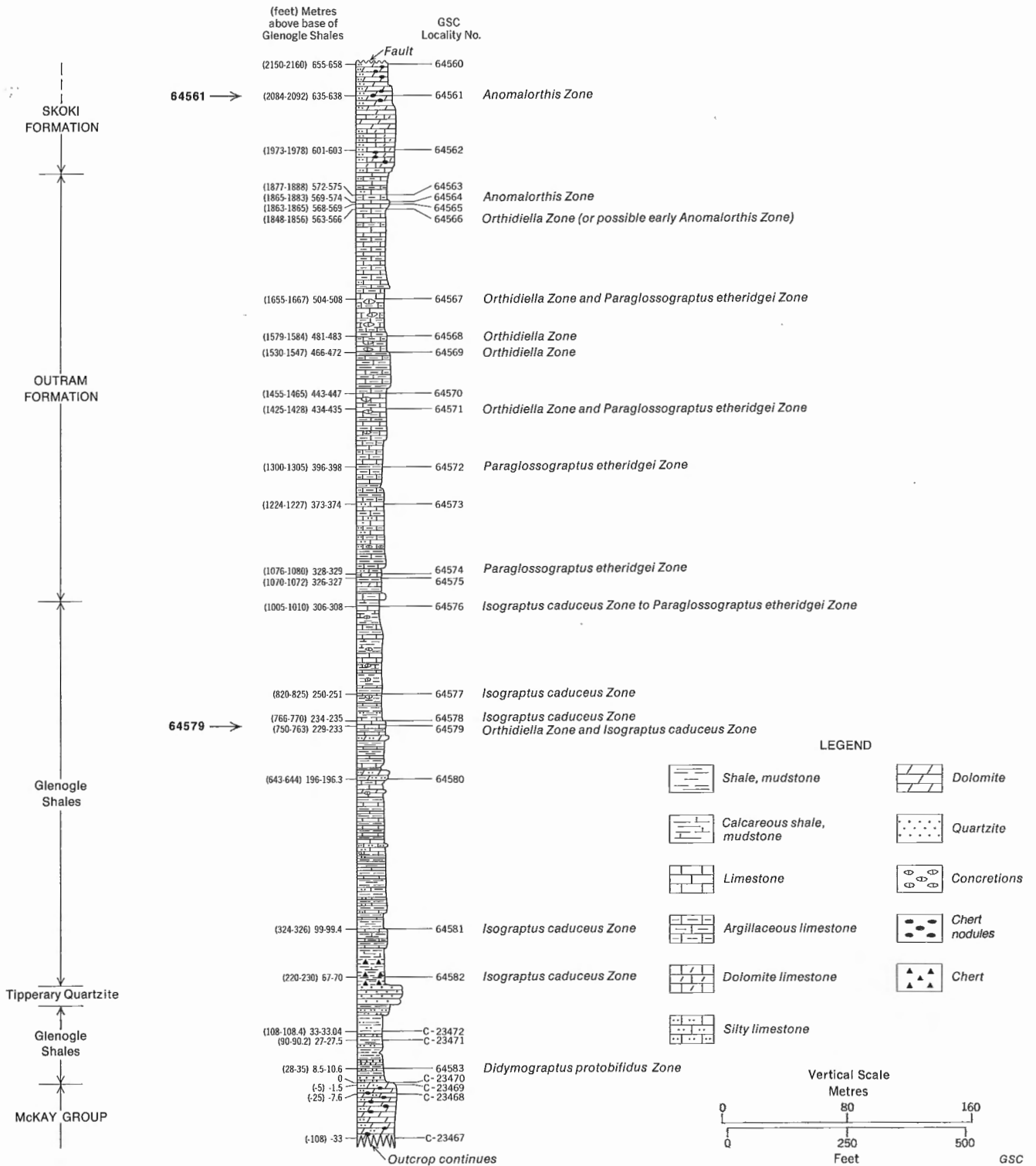
Measurements

GSC specimen	Valve	Length	Hinge width	Mid-width	Costellae in 5 mm	
					at 5 mm	at 10 mm
paratypes						
42602	both	8.5+	(13+)	(10)	—	—
42598	both	11.2	(16+)	(14.5)	12	—
42603	both	10+	21	(15)	—	—
42597	pedicle	12.5	18	(16.5)	11	8
42599	brachial	(8.5)	(17+)	—	—	—
holotype						
42596	brachial	(12)	26	20	—	—

() Estimate

Discussion. The species differs from *Hesperomena leptellinoidea* in outline, being widest at the hingeline. In the type species, the greatest width is opposite the midlength of the shell. The cardinal area of the pedicle valve is longer in *H. canadensis* than in *H. leptellinoidea*, giving a proportionately longer and more acute delthyrium. In *H. canadensis*, the peculiar notothyrial 'chamber' of the brachial valve also is larger and deeper because the lateral plates beneath the cardinal process are larger; compare this feature in *H. leptellinoidea* (Ross, 1970, Pl. 10, fig. 1) and in *H. canadensis* (Pl. 1, fig. 11; Pl. 2, figs. 14–17). Genuiculation of the pedicle valve is more pronounced in the holotype of *H. leptellinoidea*.

The name is from the occurrence of the genus in Canada.



Textfigure 2. North White River section, southeastern British Columbia (lat. 50°19'N, long. 115°15'W). Fossils from GSC locs. 64561 and 64579 (indicated) are described in this paper

Phylum Arthropoda
 Class Trilobita
 Family Nileidae Angelin, 1854
 Genus *Peraspis* Whittington, 1965

Peraspis Whittington, 1965, p. 363

Type species. *Peraspis lineolata* (Raymond, 1925) from the middle Table Head Formation, western Newfoundland

Peraspis kolouros new species
 Plate 2, figures 1–3, 5, 6, 9

Material. Holotype GSC 42604, one nearly complete exoskeleton, two pairs of linked free cheeks (paratypes GSC 42605, 42606), one separate pygidium (paratype GSC 42607) and one hypostome (paratype GSC 42608) possibly assignable to this species; all from GSC loc. 64579, Glenogle Shales, Llanvirn.

Description. Holotype exoskeleton 11.6 mm long, of low convexity. Oval in outline, cephalon wider than pygidium. Axial lobe well defined on thorax and pygidium.

Cephalon, including genal spines, almost semicircular in outline. Genal spines extend backward at least to fifth thoracic segment on the complete specimen. Border concave to flattened, of uniform width from genal angles forward but seemingly very narrow or absent in front of glabella.

Glabella of low convexity; preglabellar field imperfectly preserved. Axial furrows shallow, converging between anterior and posterior ends of eyes; width (trans.) of glabella between eye centres a little over 0.7 of its length (sag.); its width between ends of eyes, 0.6 of its length (sag.). Fine terrace lines on anterior part of glabella (Pl. 2, fig. 2). Palpebral lobes flat, crescentic, and widest (trans.) opposite a point a third of cranial length (sag.) from rear. Cranial width (trans.) at that point equals its length (sag.).

Free cheeks yoked by doublure that is wider (sag.) than border. Genal spines stout. Eyes large; their length (exsag.) over 0.7 that of cranium (sag.).

Associated hypostome with outline similar to that of *Peraspis lineolata* (Whittington, 1965, Pl. 35, figs. 6, 8) but differing in several details. Outline more strongly pointed sagittally. Greatest width (trans.) at anterior wings. Length (sag.) equals 0.7 of greatest width and 0.85 of width on line through maculae. Border obtusely pointed sagittally, bears paired posterolateral spines and rounded anterolateral shoulder. Border furrow wide, shallow, ill defined, bounding flattened border. Width (sag.) of border somewhat less than a quarter of length (sag.) of pygidium.

Thorax of 7 segments. Each pleura bears diagonal furrow in its proximal half, distal half smooth; doublure sheathes ventral surface of distal half.

Pygidium semicircular in outline. Length (sag.) of axis slightly more than half that of pygidium. Axis tapers slightly to bluntly rounded terminus. One anterior axial ring is only evidence of segmentation on undeformed pygidium. Anterior width (trans.) of axis is about a third of greatest width of pygidium. Border furrow wide, shallow, ill defined, bounding flattened border. Width (sag.) of border somewhat less than a quarter of length (sag.) of pygidium.

Discussion. Four species of *Peraspis* have been described previously. The present species differs from *Peraspis lineolata*

(Raymond) (Whittington, 1965, p. 364–366), from *P. erugata* Ross, from *P. yukonensis* Dean, and from *Peraspis omega* Fortey in the short pygidial axis and in the virtual lack of segmentation of the pygidium. Like *P. erugata* Ross, it has a very narrow (sag.) border in front of the glabella. The associated hypostome is probably juvenile; it differs from that of *P. lineolata* in possessing small but distinct maculae and paired posterolateral spines on the border. As noted by Dean (1973, p. 21), the hypostome illustrated by Ross (1970, Pl. 15, fig. 5) probably does not belong to *P. erugata*.

The species is named *kolouros* from the Greek word meaning stumpled.

Family Raphiophoridae Angelin, 1854
 Genus *Globampyx* Fortey, 1975

Globampyx Fortey, 1975, p. 76

Type species. *Globampyx trinucleoides* Fortey, 1975, from the lower Middle Ordovician and uppermost Lower Ordovician parts of the Valhallfonna Formation, Spitsbergen

Globampyx sinalae new species

Plate 2, figure 4; Plate 3, figures 1, 2, 5, 6, 9, 15, 19, 22, 23, 25

Material. Holotype GSC 42609, a damaged but nearly complete exoskeleton, a cranium with four partial thoracic segments (paratype GSC 42610), two separate cranidia (paratypes GSC 42611, 42612), a pair of free cheeks, yoked (paratype GSC 42613), and two separate pygidia (paratypes GSC 42614, 42615); all from GSC loc. 64579, Glenogle Shales, Llanvirn.

Description. Exoskeleton, excluding free cheeks, broadly oval in outline. Associated pair of free cheeks preserved together (Pl. 2, fig. 4) indicates that genal spines extended backward considerably past back of pygidium; their length (exsag.) probably equals 1.5 times combined length (sag.) of thorax and pygidium.

Cranidium strongly convex. Surface of convex fixed cheeks marked by raised anastomosing ridges that distally roughly parallel border. Proximally on each cheek, ridges form a more even network so that the surface appears pitted.

Glabella subovoid, expanding forward, overhanging anterior margin of cephalon. Lateral glabellar furrow *lp* represented by pair of shallow crescentic pits constricting posterior sides of glabella approximately 0.3 of glabellar length from the rear. Pits curve from axial furrow upward and backward without reaching occipital furrow. These pits correspond to blunt appendifers on ventral side. Fossula well developed at position three quarters of glabellar length from rear. Occipital ring narrow (sag.), its width (sag.) barely exceeding 0.1 of total glabellar length (sag.); ring continuous with posterior cephalic border. Fixed cheeks convex, sloping increasingly steeply distally. No alae (bacculae of Fortey, 1975, p. 14, 15) present. Facial suture runs forward from genal angle in a somewhat sinuous curve to cross border furrow into border beneath glabella; right and left sutures are confluent within border. Free cheeks known only from ventral side of specimen (Pl. 2, fig. 4).

Thorax composed of 5 short (sag.) segments. Axial ring

narrowly convex; each pleura flat, bearing transverse furrow, and tipped by vertical facet.

Pygidium semielliptical, length (sag.) about 0.3 of width (trans.). Axis narrow, semiconical, composed of 2 anterior rings and very faintly segmented posterior portion; anterior width (trans.) of axis about 0.3 of pygidial width (trans.). Two raised pleurae on each pleural platform terminate at narrow border. Border bounded by steep, nearly vertical face.

Discussion. The new species resembles the genotype *Globam-pyx trinucleoides* Fortey in the general features of the cephalon, thorax and pygidium and in the lack of alae (bacculae) and of a median spine to the glabella. Its glabella is more inflated forward and the distinctive ornament of raised anastomosing ridges on the fixed cheeks is very different from the densely punctate ornament in *G. trinucleoides*. The ornament of the fixed cheeks of *G. sinalae* is similar to that developed in some species of *Raymondella* (Whittington, 1950, p. 559; 1959, p. 488).

The species is named *sinalae* from the lack of alae (from Latin *sine*, without).

Superfamily Asaphacea Burmeister, 1843

Genus indeterminate

Plate 2, figure 10

A single pygidium (hypotype GSC 42616) is illustrated as a matter of record, but is considered generically indeterminate without cephalic parts; GSC loc. 64579.

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1965: Trilobites of the Ordovician Table Head Formation, western Newfoundland; *Harvard Univ., Mus. Comp. Zool., Bull.*, v. 132, p. 275–442, Pls. 1–68.

Phylum Mollusca

Class Gastropoda

Maclurites sp.

Plate 3, figures 24, 26

Material. Several fragments of a hyperstrophic shell (including hypotype GSC 42617) from GSC loc. 64561, Skoki Formation, Llanvirn.

Discussion. The material is inadequate for comparison with established species of *Maclurites*. Early representatives of the genus are known from the Whiterock part of the Skoki Formation in Alberta and from similar horizons in the Antelope Valley Limestone in Nevada.

undetermined gastropods

Plate 3, figures 3, 4, 7, 8, 10–14, 16, 18, 21

Material. Small gastropods are abundant in the etched material from GSC loc. 64561 and are illustrated for record. At least three different species are present, including a probable muchisoniid (Pl. 3, figs. 7, 8), a pleurotomariid (Pl. 3, figs. 10, 13, 14, 16), and a small orthostrophic shell in which the spire is only very slightly elevated (Pl. 3, figs. 8, 21). The silicification is too coarse to adequately reproduce the ornament. Two fragmentary opercula were recovered (Pl. 3, figs. 3, 4, 11, 12); either, neither or both may belong to *Maclurites* sp.

Plate 1

Hesperomena canadensis new species

(page 2)

All from GSC loc. 64561

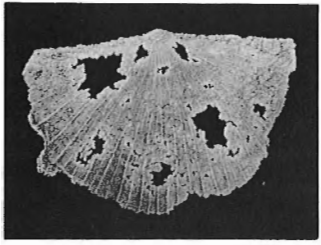
Figures 1, 3, 5. Exterior, interior and posterior views of pedicle valve, paratype GSC 42597; stereophotographs, $\times 2$.

Figures 2, 4, 6. Dorsal, ventral and posterior views of complete shell, paratype GSC 42598, partly damaged around border; stereophotographs, $\times 2$.

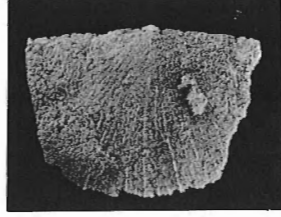
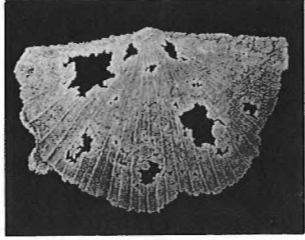
Figures 7, 9. Exterior and interior of brachial valve, paratype GSC 42599; stereophotographs, $\times 3$. Pl. 2, fig. 12 gives posterior view.

Figures 8, 10. Dorsal and ventral views of a juvenile shell, paratype GSC 42600 with damaged borders; stereophotographs, $\times 3$.

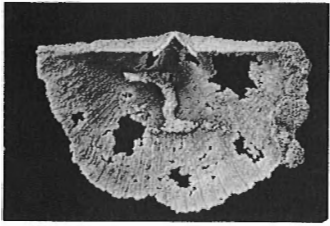
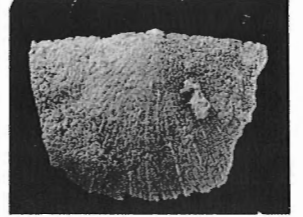
Figures 11, 12. Anterior and posterior views of a fragment of shell, paratype GSC 42601, showing structure of cardinal process and hinge structures of both valves; stereophotographs, $\times 4$.



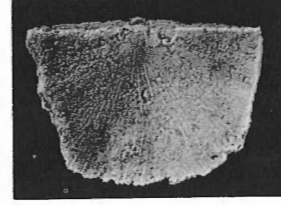
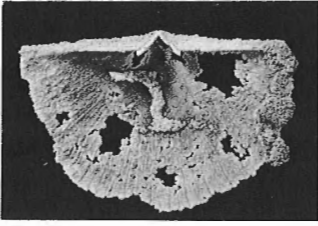
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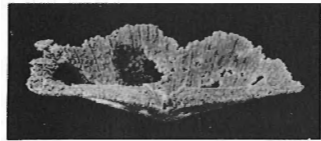
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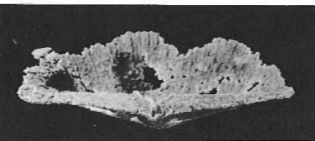
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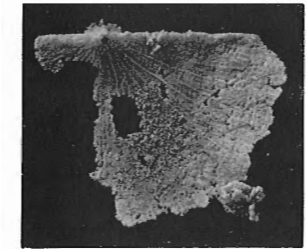
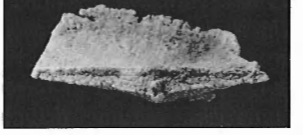
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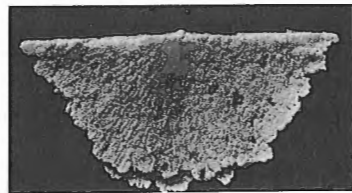
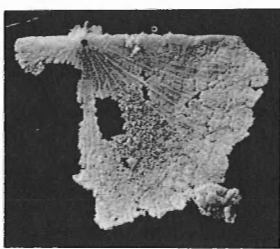
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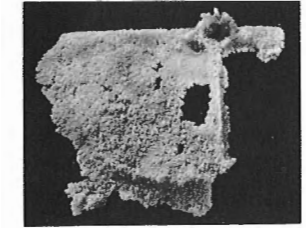
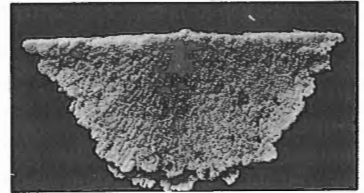
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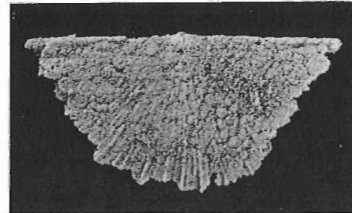
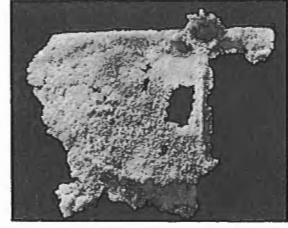
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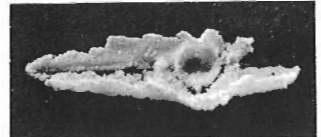
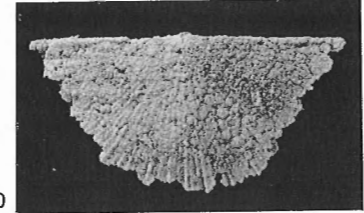
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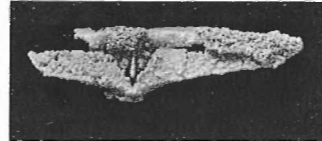
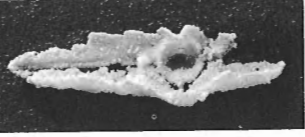
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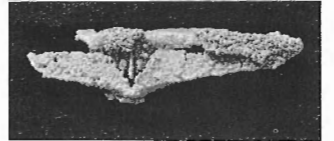


Plate 2

Peraspis kolouros new species (page 4)

All from GSC loc. 64579

Figure 1. Dorsal view of yoked free cheeks, paratype GSC 42606, showing broad doublure and stout genal spines, $\times 3$. Two pygidia of *Globampyx sinalae* are on the same slab (see Pl. 3, figs. 13, 14).

Figure 2. Enlarged view of part of figure 1, showing detail of ornament on glabella near anterior margin, $\times 6$.

Figure 3. Dorsal view of yoked free cheeks, paratype GSC 42605, $\times 3$.

Figure 5. Dorsal view of pygidium, paratype GSC 42607; stereophotographs, $\times 5$.

Figure 6. Dorsal view of carapace, holotype GSC 42604; stereophotographs, $\times 3$.

Figure 9. Ventral view of juvenile (?) hypostome, paratype GSC 42608, probably assignable to this species; stereophotographs, $\times 7$.

Globampyx sinalae new species (page 4)

Figure 4. Ventral view of free cheeks, paratype GSC 42613, that still are connected together, GSC loc. 64579; $\times 5$.

Hesperomena canadensis new species (page 2)

All from GSC loc. 64561

Figures 7, 8, 11. Ventral, dorsal and lateral views of a complete shell, paratype GSC 42603, $\times 2$.

Figure 12. Posterior view of brachial valve, paratype GSC 42599; stereophotographs, $\times 3$ (see also Pl. 1, figs. 7, 9).

Figure 13. Ventral view of a complete shell, paratype GSC 42602, $\times 2$.

Figures 14, 16, 17. Posterior, anterior and tilted posterior views of cardinal structures of brachial valve, holotype GSC 42596, $\times 9$.

Figure 15. Interior view of same brachial valve, holotype GSC 42596, $\times 3$.

asaphacean, genus indeterminate (page 5)

Figure 10. Dorsal view of juvenile (?) pygidium, hypotype GSC 42616; stereophotographs; GSC loc. 64579; $\times 7$.

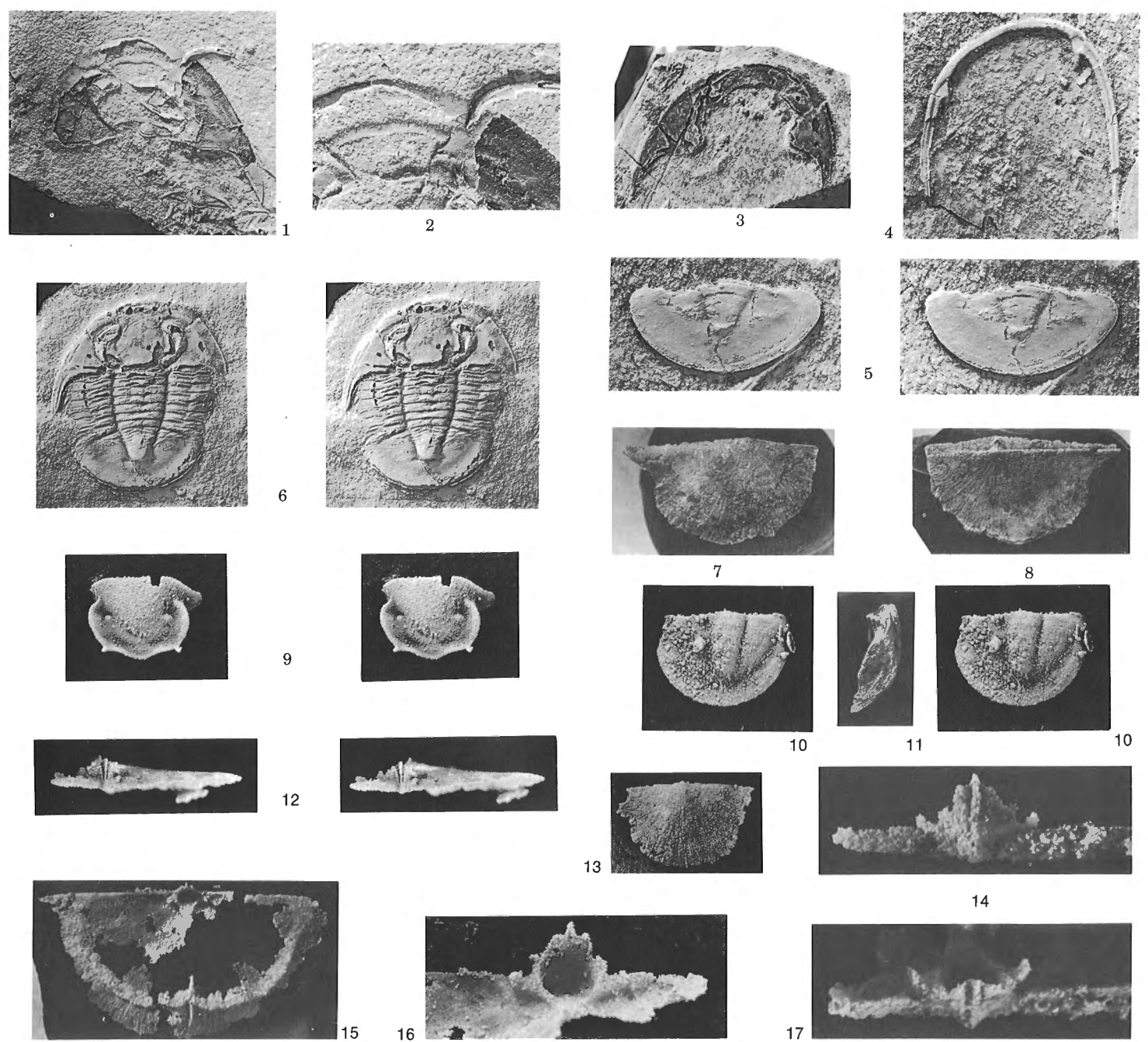


Plate 3

Globampyx sinalae new species (page 4)

All from GSC loc. 64579

Figures 1, 5, 9. Dorsal, anterior, and left lateral views of damaged cranidium, paratype GSC 42611; stereophotographs, $\times 6$. This is the largest available cranidium and has lateral glabellar furrow *lp* better developed than in other specimens.

Figure 2. Dorsal view of cranidium, paratype GSC 42610, to which four thoracic segments still are attached; stereophotographs, $\times 6$.

Figures 6, 15, 19. Dorsal, lateral and left anterior views of small cranidium, paratype GSC 42612; stereophotographs, $\times 7$. This specimen may have suffered some lateral compression.

Figure 22. Dorsal view of nearly complete carapace, holotype 42609; stereophotographs, $\times 6$. The specimen has been partly dismembered accidentally since it was photographed.

Figures 23, 25. Dorsal view of pygidia, paratypes GSC 42615, 42614, somewhat crushed; stereophotographs, $\times 6$ (see also Pl. 2, fig. 1).

gastropod, undetermined species (page 5)

All from GSC loc. 64561

Figures 3, 4, 11, 12. Views of two fragments, hypotypes GSC 42620, 42619, of opercula, $\times 2$.

Figures 7, 8. Views of a fragment of a small murchisoniid shell, hypotype GSC 42611, $\times 3$.

Figures 10, 13, 14, 16. Abapertural and apertural views of two pleurotomariid shells, hypotypes GSC 42622, 42633, $\times 3$.

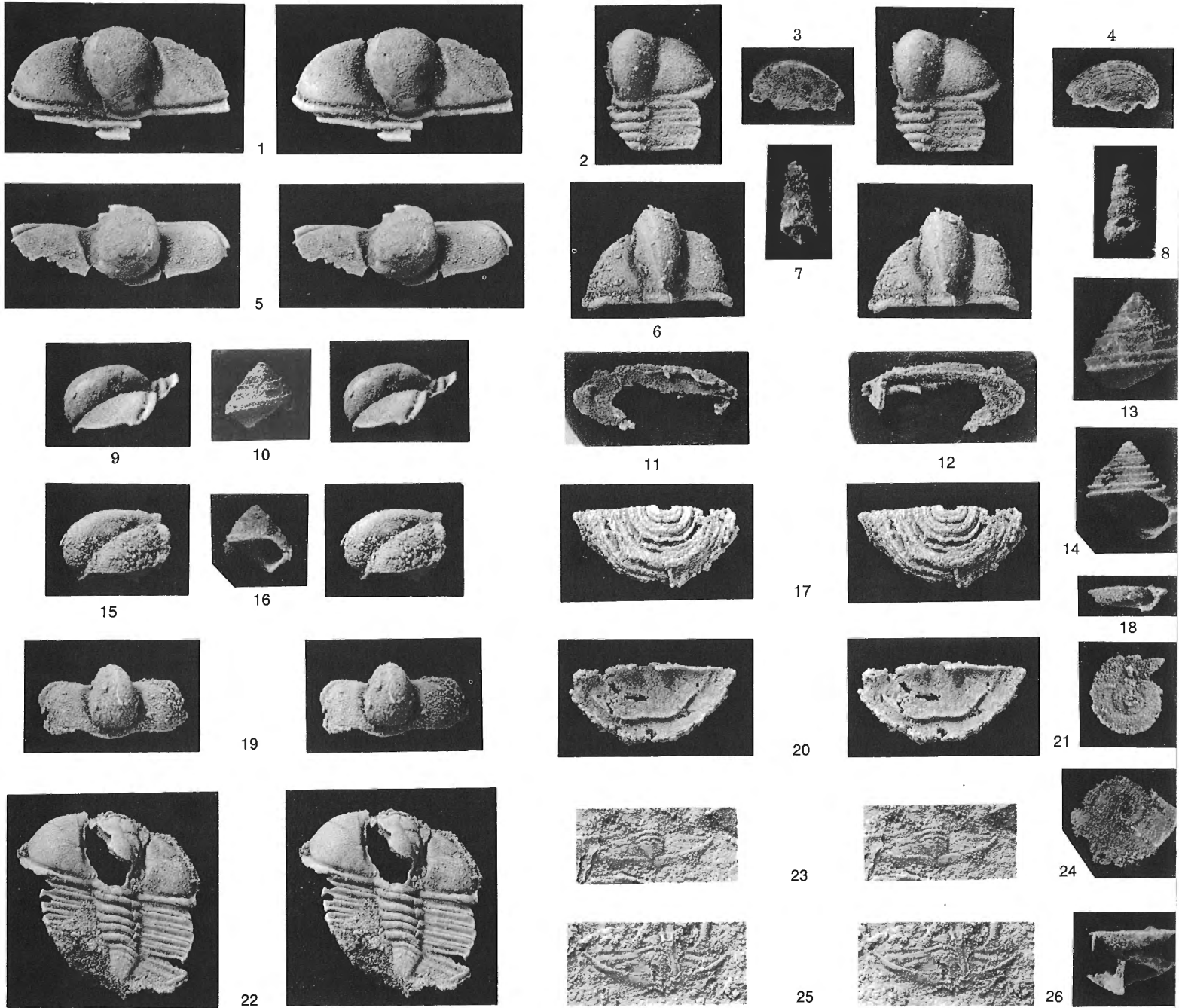
Figures 18, 21. Apertural and apical views of a small orthostrophic shell, hypotype GSC 42618, with a very low spire, $\times 3$.

leptaenid, genus indeterminate (page 2)

Figures 17, 20. Exterior and interior views of pedicle valve, hypotype GSC 42595; stereophotographs; GSC loc. 64561; $\times 2$.

Maclurites sp. (page 5)

Figures 24, 26. Apical and apertural views of the early part of a large hyperstrophic shell, hypotype GSC 42617; GSC loc. 64561; $\times 3$.



Some Late Middle Devonian (*Polygnathus varcus* Zone) Conodonts from Central Mackenzie Valley, District of Mackenzie

T.T. Uyeno

Abstract

Conodonts assignable to the *Polygnathus varcus* Zone (late Middle Devonian age) are described from central Mackenzie Valley. Evidence presented by conodonts suggests correlation of the unnamed D₄ unit of Cook and Aitken (1975) with parts of the Hare Indian and Ramparts formations, and that the arenaceous sediments of the D₄ unit are situated below a regional Middle/Upper Devonian disconformity.

Three new species are introduced: *Polygnathus? geniculatus*, *Pelekysgnathus bidentatus* and *P. mackenziensis*.

Résumé

On décrit ici des conodontes appartenant à la zone à *Polygnathus varcus* (fin du Dévonien moyen) de la partie centrale de la vallée du Mackenzie. La présence de ces conodontes nous permet probablement d'établir une corrélation entre l'unité D₄ de Cook et Aitken (1975), que l'on n'a pas encore désignée, et certaines parties des formations de Hare Indian et de Ramparts; elle semble indiquer aussi que les sédiments arénacés de l'unité D₄ sont situés au-dessous d'une discordance régionale entre le Dévonien moyen et supérieur.

On signale trois nouvelles espèces: *Polygnathus? geniculatus*, *Pelekysgnathus bidentatus* et *P. mackenziensis*.

Introduction

The geology and age of the arenaceous sediments between limestones of the Middle Devonian Ramparts Formation, and their equivalents, and shales of the Upper Devonian Canol Formation have recently been reviewed and discussed by MacKenzie *et al.* (1975). These sediments were discussed further and mapped over three map-sheets (106J, O and P) by Cook and Aitken (1975), with appendixes faunal determinations made by Uyeno and Pedder (*in MacKenzie et al.*, 1975). Neither of these studies formally named this sandstone unit, although Cook and Aitken (1975) referred to it as "map-unit D₄". MacKenzie *et al.* (1975) regarded this unit as a part correlative of the full Ramparts Formation, predating the regional Middle/Upper Devonian disconformity.

This paper formally describes the conodont faunas listed by MacKenzie *et al.* (1975, p. 552) and Cook and Aitken (1975, p. 37, 38). The conodonts are from the D₄ unit and the underlying beds, collected at two localities (both shown by loc. 1, Textfig. 1) separated by 45 km (28 mi). The more northerly section (loc. 1a) is located along a small creek, 2.5 km (1.5 mi) south of Charrue Lake (lat. 67°30'45"N, long. 130°09'15"W; NTS 106-O; section figured by MacKenzie *et al.*, 1975, p. 548, Fig. 3), and the second locality (loc. 1b) is exposed along the northern bank of Gossage River, 7.2 km (4.5 mi) directly southwest of its confluence with the Mackenzie River (lat. 66°57'15"N, long. 130°19'00"W; NTS 106J).

The thickest outcrop section known of the D₄ unit is at the Charrue Lake locality; 13.7 m (45 ft) of the arenaceous beds are exposed, underlain by 0.6 m (2 ft) of limestone of the Ramparts Formation, and overlain disconformably by the Canol Formation. Conodonts were obtained from fossiliferous

calcareous beds within the sandy unit, at 8.5 to 8.8 m (GSC loc. C-19855), 9.27 to 9.33 m (GSC loc. C-19856), and 9.57 to 9.75 m (GSC loc. C-19857) (28–29 ft, 30.4–30.6 ft, and 31.4–32 ft) above the base of the unit, and top 0.6 m (2 ft) of the Ramparts Formation (GSC loc. C-19853). At locality 1b (Gossage River), the following sequence is exposed (in ascending order): Hare Indian Formation, 20.4 m (67 ft); Ramparts Formation, 3.4 m (11 ft); D₄ unit, 9.4 m (31 ft); and the Canol Formation, 9.1 m (30 ft). Conodonts were obtained from limestone lenses within the Hare Indian Formation at 9.8 (GSC loc. C-19867) and 6.4 m (GSC loc. C-19868) (32 and 21 ft) below the top of the formation, and from the upper 3.1 m (10 ft) of the Ramparts Formation (GSC loc. C-19872).

The samples were collected by the writer in 1972, in collaboration with W.S. MacKenzie and A.E.H. Pedder.

Acknowledgments

Comments and suggestions made by G. Klapper, University of Iowa, P. Bultynck, Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussels, and A.W. Norris, Geological Survey of Canada, are gratefully acknowledged.

Conodont fauna and its biostratigraphic significance

Of the eleven samples processed, seven yielded a collection of 874 conodont specimens. The average weight of the samples was 4 kg. The distribution of conodonts is shown in Table 1.

The conodonts from the D₄ unit at Charrue Lake, and from the upper part of the Hare Indian Formation at Gossage River, are assignable to the *Polygnathus varcus* Zone, of late Middle Devonian (Givetian) age. The principal constituents are *Icriodus brevis*, *Polygnathus xylus*, *P. decorosus* *sensu lato*,

and *P. linguiformis linguiformis*. New species include *Polygnathus? geniculatus*, *Pelekysgnathus bidentatus* and *P. mackenziensis*. *Icriodus brevis* has been reported to be restricted to the *varcus* Zone (Klapper in Klapper *et al.*, 1975, p. 89) but may extend downward (see discussion under *I. brevis* in the Systematics). *Polygnathus decorosus* sensu lato is being named by G. Klapper and W. Ziegler in a manuscript now in preparation and, according to Klapper (*pers. com.*, Oct. 1975), its range is about mid-*varcus* Zone through *Schmidtognathus hermanni*-*Polygnathus cristatus* Zone. *Polygnathus xylus* ranges from the *varcus* Zone to lower Upper Devonian, at least as high as the *Icriodus angustulus* horizon of Seddon (1970), which was correlated by position with the Upper *Mesotaxis asymmetrica* Zone (Klapper in Klapper *et al.*, 1973, p. 396).

Based on the conodont evidence, then, parts of the D₄ unit at locality 1a, and the upper Hare Indian Formation at locality 1b, represent time equivalents. In turn, they may be correlated with the Powell Creek section (loc. 2 of Textfig. 1), 201 km (125 mi) south-southeast of locality 1b (Uyeno in Lenz and Pedder, 1972, p. 35, 36). The correlations are with the upper part of the Hare Indian Formation (130.4–159.1 m, or 428–522 ft, above the base of the formation; 11.3–39.9 m, or 37–131 ft, below the top); and with the lower Ramparts Formation (0.6–9.4 m, or 2–31 ft, above the base of the formation; 21.0–29.9 m, or 69–98 ft, below the top). In Manitoba, an almost identical conodont fauna was recovered from the Dawson Bay Formation (Uyeno in Norris and Uyeno, 1972). Elsewhere, conodonts of the *varcus* Zone are known from the Hamilton Formation of southern Ontario (Uyeno in Winder *et al.*, 1975, and MS. in prep.; Winder, 1968), parts of the Traverse Group of Michigan (Orr, 1971), the upper part of the Hamilton Group and the Tully Formation of New York (Klapper and Ziegler, 1967; Huddle in Klapper *et al.*, 1971; Orr, 1971), the lower part of the Cedar Valley Limestone of Iowa and Illinois (Klapper and Collinson in Klapper *et al.*, 1971), the upper part of the Ogilvie Formation in northern Yukon Territory (Klapper in Perry *et al.*, 1974, p. 1065), and in flanking beds of reefs of the Horn Plateau Formation in the Great Slave Lake area, southern District of Mackenzie (Pollock in Fuller and Pollock, 1972, p. 151, Fig. 5).

In the type area of Givet in northern France, the *varcus* Zone has a range within the Givet Group, from the Mont d'Haus Formation (Gid) through the lower part of the Lower Member of the Fromelennes Formation (F1a) (Bultynck, 1975, Figs. 2, 5). The Lower Member is considered by some as lower Frasnian, but is actually a part of the Givetian in its original sense (Bultynck, 1972, p. 71, 72). At the Martenberg section in Germany, the highest occurrence of the *varcus* Zone is slightly above the level of *Maenioceras terebratum* (Kullmann and Ziegler, 1970, Fig. 1). In New York, the upper part of the *varcus* Zone occurs in the Tully Formation with *Pharciceras*-type goniatites (House, 1968, p. 1065; 1973, p. 8; Klapper and Ziegler, 1967, p. 79, Fig. 1; Huddle in Klapper *et al.*, 1971, p. 297, Fig. 3).

Megafossils associated with the conodonts

Megafossils collected at the Charrue Lake locality from the D₄ unit were assigned to the *Stringocephalus aleskanus* Zone (Givetian) and the *Leiorhynchus hippocastanea* Zone. The

latter zone at Powell Creek is associated with conodonts of the Upper *hermanni-cristatus* Zone, which, in North America, generally is regarded as late Middle Devonian in age (Uyeno in Lenz and Pedder, 1972, p. 36; Klapper *et al.*, 1971, p. 299). Those from the underlying Ramparts Formation at the same locality were assigned to the Givetian *Ectorensselandia laevis* Zone (Cook and Aitken, 1975). Collections from the Gossage River locality, from the Hare Indian and Ramparts formations, were assigned a Givetian age, of probable lower *E. laevis* Zone, and the D₄ unit a late Givetian age (Pedder in Cook and Aitken, 1975, p. 35).

Paleoecological interpretations of the conodonts

The *Polygnathus-Icriodus-Pelekysgnathus* conodont fauna described herein was deposited in two different environments. At the Charrue Lake locality, the fauna occurs in the sandstones of the D₄ unit. This unit, the provenance of which was to the east, was deposited in shallow, moderately turbulent water (MacKenzie in MacKenzie *et al.*, 1975, p. 548, 550). Megafossils from the D₄ unit at this locality include colonial corals, bryozoans, brachiopods, trilobites, ostracodes, tentaculitids and styliolinids (Pedder in MacKenzie *et al.*, 1975, p. 550). The shelly fossils were interpreted as having undergone little or no postdepositional movement, as they display only minor abrasion. The conodonts, on the other hand, are only poorly preserved and, furthermore, probably suffered some postdepositional sorting, as suggested by varying and disproportionate numbers of constituent elements; *Icriodus brevis*, for example, has a ratio of 163 I elements: 26 S₂ elements in one sample, and 58 I : 2 S₂ ratio in another.

The same conodont fauna is found in limestone lenses within shales of the Hare Indian Formation, at the Gossage River locality. This site was farther seaward than the Charrue Lake locality (MacKenzie *et al.*, 1975, p. 550) and, therefore, presumably in deeper waters. Megafossils associated with the conodonts include brachiopods, trilobites and dacryoconarid tentaculites (Pedder in Cook and Aitken, 1975, p. 35).

The fact that these two different environments carry the same conodont fauna leads to a suggestion that the conodontophorids that produced this particular population were pelagic, living in the upper photic zone. This conclusion matches that of Seddon and Sweet (1971, p. 871–874), who termed such a population “*Icriodus* biofacies”, which resulted from an “*Icriodus-Polygnathus* group” living in the near-surface waters. Druce’s (1973, p. 210) interpretation is a slight modification of the Seddon-Sweet model of simple vertical stratification, and the D₄-Hare Indian conodont fauna fits into his “Biofacies II”.

The shallow-water, pelagic mode of living of some conodontophorids is further substantiated by thin-shelled tentaculites. The arenaceous clastics of the D₄ unit yielded tentaculitids and styliolinids, whereas limestone lenses within the shales of the Hare Indian Formation carry dacryoconarid tentaculites. Berger (1974) suggested a benthic mode of life for tentaculitid tentaculites. According to Ludvigsen (1972, p. 304), “Tentaculitid tentaculites occur mainly in sparites and calcarenites, rich in fossil debris, that are interpreted as being of shallow-water, high energy origin, whereas dacryoconarid tentaculites typically occur in shales and argillaceous micrites of deeper-water, low energy origin.” It would appear, then,

that the conodontophorids of the *Icriodus-Polygnathus* group or Biofacies II inhabited a niche similar to that of the dacryoconarid tentaculites, at least in open waters. That the niche was not identical is testified by the absence of dacryoconarids in the sandy D₄ unit.

Systematic paleontology

The discussed conodonts are assignable to families Polygnathidae and Icriodontidae, of late Middle Devonian (Givetian) age. Simple cones are identified to elemental level only. The distribution of conodonts is shown on Table 1.

Symbols for the skeletal elements used herein are those proposed by Klapper and Philip (1971, 1972). The familial classification follows that reintroduced by Klapper and Philip (1972).

Following the models proposed by Klapper and Philip, every attempt was made to reconstruct apparatuses from their disjunct skeletal elements. Owing to the clastic nature of some of the enclosing rocks, however, such an attempt proved to be extremely difficult, for two reasons: possible postdepositional sorting of conodonts, leading to disproportionate numbers of some elements over others, and their poor state of preservation. The following reconstructions, therefore, may be modified in future.

All types and figured specimens are stored with the Geological Survey of Canada (GSC), Ottawa.

Conodonta

Family Polygnathidae Bassler, 1925

Type genus. *Polygnathus* Hinde, 1879

Genus *Polygnathus* Hinde, 1879

Type species. *Polygnathus dubius* Hinde, 1879

Polygnathus decorosus Stauffer sensu lato of Ziegler, 1966

Plate 4, figures 15–17, 53, 54

Polygnathus decorosus Stauffer sensu lato, Ziegler, 1966, p. 672, 673, Pl. 6, figs. 7, 8, 13, 14 only (P element); Uyeno in Norris and Uyeno, 1972, p. 215, Pl. 3, fig. 6 (P element)

Polygnathus dubius Hinde, Bultynck, 1975, p. 22, 23, Pl. 5, figs. 2, 3 (P element) (not Pl. 1, fig. 4 = *P. dubius*)

Remarks. As already noted by Ziegler (1966, p. 672, 673) and Huddle (1970, p. 1036), during or near the critical Middle/Upper Devonian boundary interval *Polygnathus decorosus* sensu lato formed the root stock from which evolved other species of *Polygnathus*, as well as other genera. As such a root stock, Ziegler (1966) illustrated forms transitional to *Schmidtnathus hermanni* Ziegler, *P. dubius* Hinde, and *P. pennatus* Hinde. The present form appears to be closest to those considered as transitional to *Polygnathus dubius* (Ziegler, 1966, Pl. 6, figs. 7, 8, 13, 14).

The P element of *P. decorosus* sensu stricto (discussed by Klapper *et al.*, 1970, p. 652–654) has a narrow, lanceolate platform, which is not constricted anteriorly, and is nodose only at the margin. The pit of *P. decorosus* is of similar size, but is located more anteriorly than that of *P. decorosus* sensu lato. The P element of *Polygnathus dubius* Hinde has a short free blade (about one third of unit length), which is higher anteriorly, whereas in *P. decorosus* sensu lato the free blade is about the same length as the platform and is of more uniform height throughout. The adcarinal grooves tend to be deeper in

P. dubius. The platform of *P. dubius* is narrower and is constricted anteriorly.

The P element of *Polygnathus pseudofoliatus* Wittekindt is similar to the same element of *P. decorosus* sensu lato in its relative free blade length and platform surface ornamentation (noded in *P. decorosus* sensu lato, may be noded in *P. pseudofoliatus*). The former displays a more conspicuous anterior platform constriction, which is due to its greater asymmetric flaring of the platform on the outer side, posterior to the constriction.

Bultynck (1975, p. 22, Pl. 5, figs. 2, 3) illustrated specimens from the Lower Member of the Fromelennes Formation (Fla) at Fromelennes, which appear to be identical to the present individuals.

As noted elsewhere in this paper, this species is being named by G. Klapper and W. Ziegler in a manuscript now in preparation.

The other elements of the apparatus of *P. decorosus* sensu lato are as yet unknown. That the apparatus probably consisted of 'normal' *Polygnathus* elements is suggested by a reconstruction of the apparatus of *P. dubius* (Klapper and Philip, 1971, Fig. 12), the P element of which is morphologically similar to that of *P. decorosus* sensu lato. Another clue is obtained from examining lists of the form-taxa associated with the polygnathan elements somewhat similar to the P element of *P. decorosus* sensu lato. One such reference is Seddon's (1969, p. 27, Pl. 1, figs. 1–3, Table 1) account of *Polygnathus pennatus* Hinde sensu lato, a general form that is common at or near the Middle/Upper Devonian boundary.

Occurrence. Ziegler (1966, Pl. 6, figs. 7, 8, 13, 14, Table 2) recorded the transitional form to *Polygnathus dubius* from Giebringhausen 13. The conodonts of this locality are assignable to the Upper *hermanni-cristatus* Zone. Uyeno (*in* Norris and Uyeno, 1972, p. 215) recorded this species from the Dawson Bay Formation of Manitoba, associated with conodonts assignable to the *varcus* Zone. G. Klapper (*pers. com.*, Oct. 1975) notes the range of this species as about mid-*varcus* Zone through the *hermanni-cristatus* Zone.

Figured specimens. GSC 35327 and 35328, from GSC locs. C-19853 and C-19868, respectively.

Polygnathus? geniculatus new species

Plate 4, figures 55–64

Diagnosis. A species questionably assigned to *Polygnathus*, the P element of which exhibits a sharp inward bend in posterior quarter of unit. The O₁ element is nothognathellan, N is neopriodontan, and A₁ is transitional between hindeodellan and ligonodinian. Irregular denticulation, with random interspersions of slender and stout denticles, characterize these elements. The remaining constituent elements are yet unknown.

Description. Representative P elements have a platform three quarters of unit length. In upper view, unit straight with posterior quarter slightly to sharply bent inward. Latter feature best exhibited by carina at all growth stages but especially in large specimens. In larger specimens, inner margin of platform straight, whereas outer margin uniformly and broadly convex. Platform slightly constricted at point of

Table 1. Distribution of conodonts in the unnamed D₄ unit and the Hare Indian and Ramparts formations (figures indicate number of identifiable specimens recovered)

FORMATION Data above base for Charrue Lake and below top for Gossage River		CHARRUE LAKE				GOSSAGE RIVER		
		Ramparts	D4	D4	D4	Hare Indian	Hare Indian	Ramparts
		0-2 ft	28-29 ft	30.4-30.6 ft	31.4-32.0 ft	32 ft	21 ft	0-10 ft
		0-0.6 m	8.5-8.8 m	9.27-9.33 m	9.57-9.75 m	9.8 m	6.4 m	0-3.1 m
GSC Locality Numbers		C-19853	C-19855	C-19856	C-19857	C-19867	C-19868	C-19872
Sample Weight (kg)		8.3	4.1	4.1	4.2	0.9	4.1	4.1
<i>Polygnathus decorosus</i> s.l.	P	1					7	
<i>Polygnathus ? geniculatus</i>	P						39	
	O ₁						5	
	N						6	
	A ₁						1	
<i>Polygnathus linguiformis linguiformis</i>	P				2		11	
<i>Polygnathus xylus</i>	P	2	39	31	8	1	9	3?
	O ₁	1	8	1				
	N		10	4			4	
	A ₁		8				2	
	A ₂		2	5			2	
	A ₃		3	1			2	
<i>Icriodus brevis</i>	I		163	58	13		41	
	S _{2a}		7	2				
	S _{2b}		12				4	
	S _{2c}		7					
<i>Pelekysgnathus bidentatus</i>	I			3				
	S ₂	1	23	6				
	M _{2a}	1	147	25				
	M _{2b}		5	2				
<i>Pelekysgnathus mackenziensis</i>	I						18	
	S ₂						20	
	M ₂						69	
Unassigned elements	acodinan		6					
	belodellan				2			
	bryantodinan			1	2			
	drepanodontan		4					
	ligonodinan		3	3				
	ozarkodinan		1				3	
	plectospathodontan		3					
	trichonodellan		1					

GSC

Note: A pyritized charophyte specimen, *Moellerina?* sp., was recovered from GSC locality C-19872

Note: The following samples were etched but yielded no conodonts. Weights given in kilograms (footage in brackets)

Charrue Lake section, D4 unit, 11.3 to 11.6 m (37-38 ft) above base, 2.1 to 2.4 m (7-8 ft) below top, GSC locality C-19860, 4.0 kg

Gossage River section, Ramparts Fm., 0.3 to 0.6 m (1-2 ft) above base, 2.7 to 3.0 m (9-10 ft) below top, GSC locality C-19870, 4.0 kg

Charrue Lake section, D4 unit, 13.66 to 13.72 m (44.8-45 ft) above base, 0 to 0.06 m (0-0.2 ft) below top, GSC locality C-19866, 4.0 kg

Gossage River section, Ramparts Fm., 1.5 to 1.8 m (5-6 ft) above base, 1.5 to 1.8 m (5-6 ft) below top, GSC locality C-19871, 4.0 kg

geniculation and considerably narrower posteriorly, forming a 'tongue' (see Bultynck, 1970, p. 126; Klapper, 1971, p. 62). In a smaller specimen (Pl. 4, figs. 55–57), platform is terminated at point of geniculation. Anterior third of platform with irregular transverse ridges, replaced posteriorly by randomly arranged nodes; carina separated from both features by shallow grooves. In small specimens, carina consists of distinct denticles but partly fused in large individuals. Anterior margin of platform narrow and rounded in smaller specimens, but wide and more square in larger ones.

In lateral view, unit slightly arched under platform. Geniculation points (of Klapper *et al.*, 1970, p. 652) slightly offset, with short anterior trough margin. Free blade short, about one quarter of unit length, and highest at midlength.

Lower surface of P element with an inverted basal cavity, and a small distinctly rimmed pit is located about midway between midlength and anterior margin of platform. Distinct keel, which runs the entire unit length, is grooved anterior of pit.

O₁ element is nothognathellan (Pl. 4, figs. 63, 64). Unit strongly arched, and only very slightly bowed laterally, with apical denticle about the same size as remaining denticles. Smaller denticles occur posteriorly to apical denticle. All denticles stout and discrete except at their bases. Inner and outer lateral platforms about equal size, with small nodes on upper surface, especially along margins. Lower surface of figured specimen covered with a basal plate, but other specimens suggest a small pit surrounded by a large, inverted basal cavity.

N element is neoprioniodontan (Pl. 4, fig. 61). Its discrete denticles irregular with interspersed of stout and smaller slender ones. A small pit, surrounded by a large inverted cavity, is followed posteriorly by a shallow groove extending along the entire lower surface of the posterior process.

A₁ element is a transitional form between hindeodellan and ligonodinan (Pl. 4, fig. 62). Denticles highly irregular, but mostly stout, interspersed with smaller slender ones. A small pit at junction between posterior and anterolateral processes, with an inverted basal cavity extending a short distance along lower surfaces of both processes.

O₁, N and A₁ elements exhibit similarly stout denticles, randomly interspersed with more slender ones; both types are relatively free of each other and touch only at their bases. All four elements have a similarly sized pit, surrounded by an inverted basal cavity.

Remarks. Juvenile specimens of the P element superficially resemble its counterpart in *Parapolygnathus angusticostatus* (Wittekindt), with a carina extending beyond the platform. The latter, however, has a carina that is either straight or broadly curving (Wittekindt, 1966, p. 631; Klapper, 1971, p. 65).

Three additional different polygnathan elements are found in the same sample as *P.?* *geniculatus* (GSC loc. C-19868): *P. linguiformis linguiformis*, *P. decorosus sensu lato* and *P. xylus*. The accompanying elements of *P. linguiformis linguiformis* were illustrated by Klapper and Philip (1971, p. 432, 449, Fig. 2) in a fauna from the Dundee Formation at St. Marys, Ontario. As stated in its description, the apparatus of *P. decorosus sensu lato* is yet unknown, but is likely to be that of a 'normal' species of *Polygnathus*.

After eliminating, as far as possible, the apparatuses of *P. linguiformis linguiformis*, *P. decorosus sensu lato* and *P. xylus* from the sample, a tentative reconstruction of the apparatus of *P.?* *geniculatus* was made. Owing to the fragmentary nature of most of the conodonts in this sample, it was not possible to select the remaining constituents of this apparatus.

Schumacher (1971, p. 66, 99, Pl. 10, figs. 3, 4) illustrated a polygnathan element from the Lindwurm Member, Milwaukee Formation of eastern Wisconsin, which he referred to *Polygnathus pennatus* Hinde. Unlike the present specimens it has a platform that is narrower anteriorly. Those P elements of *P. pennatus* illustrated by Huddle (1970) exhibit a carina that is straight or broadly curving, and the upper surface of the platform ornamented with distinct transverse ridges the entire platform length, thereby differing from the Milwaukee specimen. Schumacher (1971) assigned conodonts of the Lindwurm Member to the Upper *hermanni-cristatus* Zone.

Polygnathus? *geniculatus* is only questionably assigned to *Polygnathus* for the following reasons: (i) Klapper and Philip (1972, p. 99) assigned a nothognathellan as the O₁ element to *Mesotaxis* and *Palmatodella*, and an ozarkodinian to *Polygnathus*; (ii) the A₁ element is a form transitional between hindeodellan (A₁) and ligonodinan (B₁), which suggests that the species perhaps may be assigned more correctly to *Parapolygnathus*.

Derivation of name. Latin, *geniculatus*, knee, referring to the sharp inward bend of posterior quarter of the P element.

Type series. Holotype GSC 35322 (the specimen illustrated on Pl. 4, figs. 58–60); paratypes GSC 35323 to 35326; all from GSC loc. C-19868.

Locus typicus and stratum typicum. Gossage River section, Hare Indian Formation, 6.4 m (21 ft) below top of formation (base not exposed), GSC loc. C-19868.

Polygnathus xylus Stauffer Plate 4, figures 1–4

Polygnathus xylus Stauffer, 1940, p. 430, 431, Pl. 60, figs. 54, 66, 72–74 (only) (P element); Klapper, Philip and Jackson, 1970, p. 659, 660, 662, 664, 666, Pl. 1, figs. 4–6, 11, Pl. 2, figs. 4, 5, 7–12, 16–18 (P element) (includes synonymy); Uyeno in Norris and Uyeno, 1972, p. 215, Pl. 3, fig. 8 (P element); Klapper in Klapper *et al.*, 1973, p. 395, 396, Pl. 2, fig. 6 (P element); Bultynck, 1975, p. 24, Pl. 5, fig. 5 (P element)
Spathognathodus planus Bischoff and Ziegler, 1957, p. 117, Pl. 19, figs. 34, 35 (O₁ element); Wittekindt, 1966, p. 643, 644, Pl. 3, fig. 30 (O₁ element); Bultynck, 1975, p. 25, Pl. 5, figs. 8, 9 (O₁ element) (includes synonymy)

Remarks. As noted by Klapper *et al.* (1970, p. 664), the P element of *Polygnathus xylus* is distinguished from its counterpart of *P. varcus* by its larger platform and the pit that is located more posteriorly.

The O₁ element is referable to form-species "*Spathognathodus*" *planus* Bischoff and Ziegler. It is characterized by its low arch, uniform denticulation, and a shallow pit. The identity of the O₁ element has been verified by G. Klapper (*pers. com.*, Oct. 1975) with his collections from Nevada.

The N element is synprioniodinan, A₁ is hindeodellan, A₂ is angulodontan, and A₃ is hibbardellan. Because the conodonts were extracted from coarsely bioclastic rocks, the specimens are fragmented and the ratios of constituent elements are offset. As a result of this, also, the present

reconstruction may be altered if better preserved faunas are found in the future.

Range. According to Klapper (*in Klapper et al.*, 1973, p. 396), *P. xylus* ranges from the *varcus* Zone to lower Upper Devonian, at least as high as the *Icriodus angustulus* horizon of Seddon (1970), which was correlated by position with the Upper *Mesotaxis asymmetrica* Zone.

Figured specimens. GSC 35329 to 35335 from GSC loc. C-19855, and GSC 35336 from GSC loc. C-19857.

Family Icriodontidae Müller and Müller, 1957

Type genus. *Icriodus* Branson and Mehl, 1938

Genus *Icriodus* Branson and Mehl, 1938

Type species. *Icriodus expansus* Branson and Mehl, 1938

Remarks. In the original of Klapper and Philip (1971, 1972), the *Icriodus* apparatus was shown to consist of two elements, I and S₂, but subsequently Klapper and Ziegler (*in Klapper et al.*, 1975, p. 67) suggested that the genus might contain a third element, M₂.

In the unnamed D₄ unit, three distinct conelike elements are present in the same sample containing *Icriodus brevis* Stauffer. These three forms are perhaps variants of the S₂ element. One of these is similar to the form-species "*Acodina lanceolata*" Stauffer.

Icriodus brevis Stauffer

Plate 4, figures 28–44

Icriodus brevis Stauffer, 1940, p. 424, Pl. 60, figs. 36, 43, 44, 52 (I element); Klapper *in Klapper et al.*, 1975, p. 89, 90, Pl. *Icriodus*-3, figs. 1–3 (I element) (includes synonymy)

Remarks. The specimens illustrated on Plate 4, figures 28–30 and 36–41 demonstrate three growth stages of the I element of *Icriodus brevis*. The posterior rim in the smaller forms is pointed, and in the larger forms, straight to rounded. There may be a slight development of a spoon on the inner side of the unit. One of the acodinan elements (S_{2a}; Pl. 4, figs. 31, 32) is characterized by anterior and posterior keels, and an asymmetrical basal cavity that is compressed both anteriorly and posteriorly. It exhibits a weakly developed outer lateral keel, which extends from the base to about midlength of the cusp.

The second acodinan element (S_{2b}; Pl. 4, figs. 33, 34) is similar to form-species "*Acodina lanceolata*" Stauffer. The third acodinan (S_{2c}; Pl. 4, fig. 35) consists of a simple cone with minute denticles attached near the base, posteriorly and anteriorly of the main cusp. Similar acodinans, including those without additional denticulation, were found by Lange (1968, p. 42, Pl. 6) in clusters associated with icriodontans.

After examining several hundreds of Middle Devonian samples from the Ardennes, Bultynck (1972, p. 72) concluded that many apparatuses, including that of *Icriodus brevis*, consist of an icriodontan element only. Similar results were obtained with early Late Devonian faunas from the Waterways Formation of Alberta (Uyeno, 1967, 1974), but the acodinans may have been lost in the laboratory washing procedure. Sieves of 120 mesh per inch (125-micron opening) were used in washing of the Waterways samples, compared with sieves of 200 mesh per inch (75 microns) for the present samples.

Klapper (*in Klapper et al.*, 1975, p. 89) considered *Icriodus eslaensis* van Adrichem Boogaert as synonymous with *I. brevis*. The stratum typicum—7 m (23 ft) above the base of La Portilla Formation, Cantabrian Mountains, Río Esla area, Spain—contains *Eognathodus bipennatus* (Bischoff and Ziegler) (van Adrichem Boogaert, 1967, Encl. 1). Bultynck (1975, p. 12) observed *E. bipennatus* in the Ardennes in the Trois-Fontaines Formation and the basal part of the Mont d'Haurs Formation. This suggests that the range may extend below the *varcus* Zone. Struve and Mohanti (1970) and Mohanti (1972) discussed the brachiopods of La Portilla Formation and assigned them a late Eifelian-Givetian age.

Range. Klapper (*in Klapper et al.*, 1975, p. 89) noted the range of *I. brevis* as within the *varcus* Zone. The range may extend below that zone (*see discussion above*).

Figured specimens. GSC 35337 to 35343, from GSC loc. C-19855; GSC 35344 from GSC loc. C-19868.

Genus *Pelekysgnathus* Thomas, 1949

Type species. *Pelekysgnathus inclinatus* Thomas, 1949

Remarks. Klapper and Philip (1972, p. 101) noted the genus *Pelekysgnathus* in the Dawson Bay Formation (*varcus* Zone; Uyeno *in* Norris and Uyeno, 1972) of Manitoba. This aided in closing the apparent Middle Devonian gap in the range of this genus. Another Middle Devonian occurrence was noted recently by Uyeno and Mason (1975) in strata of Eifelian age in the western District of Mackenzie. Here two species are described from the unnamed D₄ unit and the Hare Indian Formation, helping to close this gap still further.

Pelekysgnathus bidentatus new species

Plate 4, figures 18–27

Diagnosis. A species of *Pelekysgnathus*, the I element of which is characterized by a large cusp and a smaller anterior denticle. Of the M₂ elements, one (M_{2b}) is a transitional form between a simple unornamented cone (M_{2a}) and an acodinan (S₂).

Description. I element only slightly bowed laterally, with lower margin straight to slightly concave in lateral view. A large reclined cusp has concave posterior margin outline. Secondary denticle anterior of cusp. Both cusp and denticle laterally compressed. In lower view, basal cavity widest just posterior of midlength, tapering only gradually to rounded posterior and anterior terminals. Outer lateral margin of basal cavity convex whereas inner lateral margin straight to only slightly convex. Outer lateral side of unit flat whereas that of inner side convex.

Basal cavity outline of S₂ element vaguely similar to that of I element; i.e., widest about midlength and tapering to a narrow terminal anteriorly, but posteriorly slightly expanded with a narrowly rounded terminal. Cusp may be laterally twisted and basal part of unit sharply bent inward. Cusp with sharp posterior and anterior edges, and equiconvex on its lateral sides.

Two M₂ elements represented, one a transitional form between a 'typical' M₂ and an S₂ form. Transitional form (M_{2b}; Pl. 4, fig. 20) has a cusp only slightly laterally twisted, with

sharp posterior and anterior edges. Outer lateral side only slightly convex whereas inner side much more rounded. Basal cavity biconvex in outline, with a small central pit. Two shallow furrows run from the indentations on lower margin to point of maximum curvature of cusp. More 'typical' M_2 form (M_{2a} ; Pl. 4, figs. 21, 26) with an unornamented cusp that is keeled on its anterior margin. Basal cavity outline circular with a small central pit.

Remarks. The M_{2a} element is considered more 'typical' than the other by comparison with previously described apparatuses. Most M_2 elements are unornamented cones (e.g., those of *Pelekysgnathus inclinatus* Thomas and *P. glenisteri* Klapper), although some (e.g., that of *P. furnishi* Klapper) may possess a faint anterior keel (Klapper and Philip, 1972, p. 102).

Derivation of name. From the two denticles of the pelekysgnathan skeletal element.

Locus typicus and stratum typicum. Charrue Lake section, the unnamed D_4 unit, 8.5 to 8.8 m (28–29 ft) above base of unit, 4.9 to 5.2 m (16–17 ft) below top.

Type series. Holotype GSC 35345 (the specimen illustrated on Pl. 4, figs. 18, 19); paratypes GSC 35346 to 35348; all from GSC loc. C-19856.

Figured specimens. GSC 35349 to 35351, from GSC loc. C-19855.

Pelekysgnathus mackenziensis new species

Plate 4, figures 45–49

Diagnosis. A species of *Pelekysgnathus*, the I element of which is characterized by an extremely large cusp, preceded anterior-

ly by 5 to 6 irregularly shaped, partly fused denticles.

Description. I element slightly bowed laterally; lower margin straight in lateral view, whereas upper marginal outline semicircular. Upper surface with 5 to 6 denticles of irregular sizes, fused almost to their apices; these followed posteriorly by a large reclined cusp with a convex posterior margin outline. All denticles, including cusp, laterally compressed. In lower view, basal cavity widest posteriorly, almost uniform width to about midlength of unit, and narrows gradually anteriorly.

Inner lateral face of S_2 element rounded, whereas outer lateral face only slightly convex with low ridge extending from base to about midheight of unit. This ridge runs parallel and close to anterior margin of cusp.

Basal cavity outline of M_2 element circular with a small pit within an inverted basal cavity. Cone basically unornamented, with only a slight low ridge on its anterior margin.

Remarks. The I element *Pelekysgnathus serratus*, unlike that of *P. mackenziensis*, generally bears 7 or more denticles (Carls and Gandl, 1969, p. 191–193; Klapper, 1969, p. 12, 13). *Pelekysgnathus serratus elatus* Carls and Gandl, which has 6 to 7 denticles, is an exception to this, but this subspecies may be distinguished by its smaller, often double, cusps.

Derivation of name. From Mackenzie River, close to the type locality.

Locus typicus and stratum typicum. Gossage River section, Hare Indian Formation, 6.4 m (21 ft) below top of formation (base not exposed), GSC loc. C-19868.

Type series. Holotype GSC 35352 (the specimen illustrated on Pl. 4, figs. 45–47); paratypes GSC 35353 and 35354; all from GSC loc. C-19868.

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Plate 4

(all figures $\times 28$, unless otherwise noted)*Polygnathus xylus* Stauffer (page 17)

All except GSC 35336 from GSC loc. C-19855

Figures 1–3, 9–14. P element: (1, 9) inner lateral, (2, 10) upper, (3, 11) lower views, GSC 35329 and 35330, respectively; (12) outer lateral, (13) upper, (14) lower views, GSC 35336; GSC loc. C-19857.

Figure 4. O_1 element, inner lateral view, GSC 35331.Figure 5. A_1 element, inner lateral view, GSC 35333.Figure 6. A_2 element, inner lateral view, GSC 35334.

Figure 7. N element, inner lateral view, GSC 35332.

Figure 8. A_3 element, posterior view, GSC 35335.*Polygnathus decorosus* Stauffer sensu lato of Ziegler, 1966 (page 15)

Figures 15–17. P element: (15) inner lateral, (16) upper, (17) lower views, GSC 35327; GSC loc. C-19853.

Figures 53, 54. P element: (53) upper, (54) lower views, GSC 35328; GSC loc. C-19868.

Pelekysgnathus bidentatus new species (page 18)
(all $\times 40$)

Figures 18, 19. I element: (18) outer lateral, (19) inner lateral views, holotype GSC 35345; GSC loc. C-19856.

Figure 20. M_{2b} element, inner lateral view ('transitional' form), GSC 35348; GSC loc. C-19856.

Figure 21. M_{2a} element, lateral view, GSC 35347; GSC loc. C-19856.

Figure 22. S_2 element, inner lateral view, GSC 35346; GSC loc. C-19856.

Figures 23–25, 27. S_2 element: (23) outer lateral, (24) inner lateral, (25) anterior views, GSC 35349; (27) inner lateral view, GSC 35350; GSC loc. C-19855.

Figure 26. M_{2a} element, lateral view, GSC 35351; GSC loc. C-19855.

Icriodus brevis Stauffer (page 18)

All except GSC 35344 from GSC loc. C-19855
(all $\times 40$)

Figures 28–30, 36–41. I element: (28, 36, 39) outer lateral, (29, 37, 40) upper, (30, 38, 41) lower views, GSC 35343, 35341 and 35342, respectively (Figs. 28–30 of same specimen as figured by Uyeno in MacKenzie *et al.*, 1975, Figs. 19–21).

Figures 31, 32. S_{2a} element: (31) inner lateral, (32) outer lateral views, GSC 35340.

Figures 33, 34. S_{2b} element, lateral views, GSC 35338 and 35339.

Figures 35. S_{2c} element, inner lateral view, GSC 35337.

Figures 42–44. I element: (42) outer lateral, (43) upper, (44) lower views, GSC 35344; GSC loc. C-19868.

Pelekysgnathus mackenziensis new species (page 19)

All from GSC loc. C-19868
(all $\times 40$)

Figures 45–47. I element: (45) outer lateral, (46) upper, (47) inner lateral views, holotype GSC 35352.

Figure 48. S_2 element, inner lateral view, GSC 35353.

Figure 49. M_2 element, lateral view, GSC 35354.

Polygnathus linguiformis linguiformis Hinde (page 17)

Figures 50–52. P element: (50) inner lateral, (51) lower, (52) upper views, GSC 35355; GSC loc. C-19868.

Polygnathus? geniculatus new species (page 15)

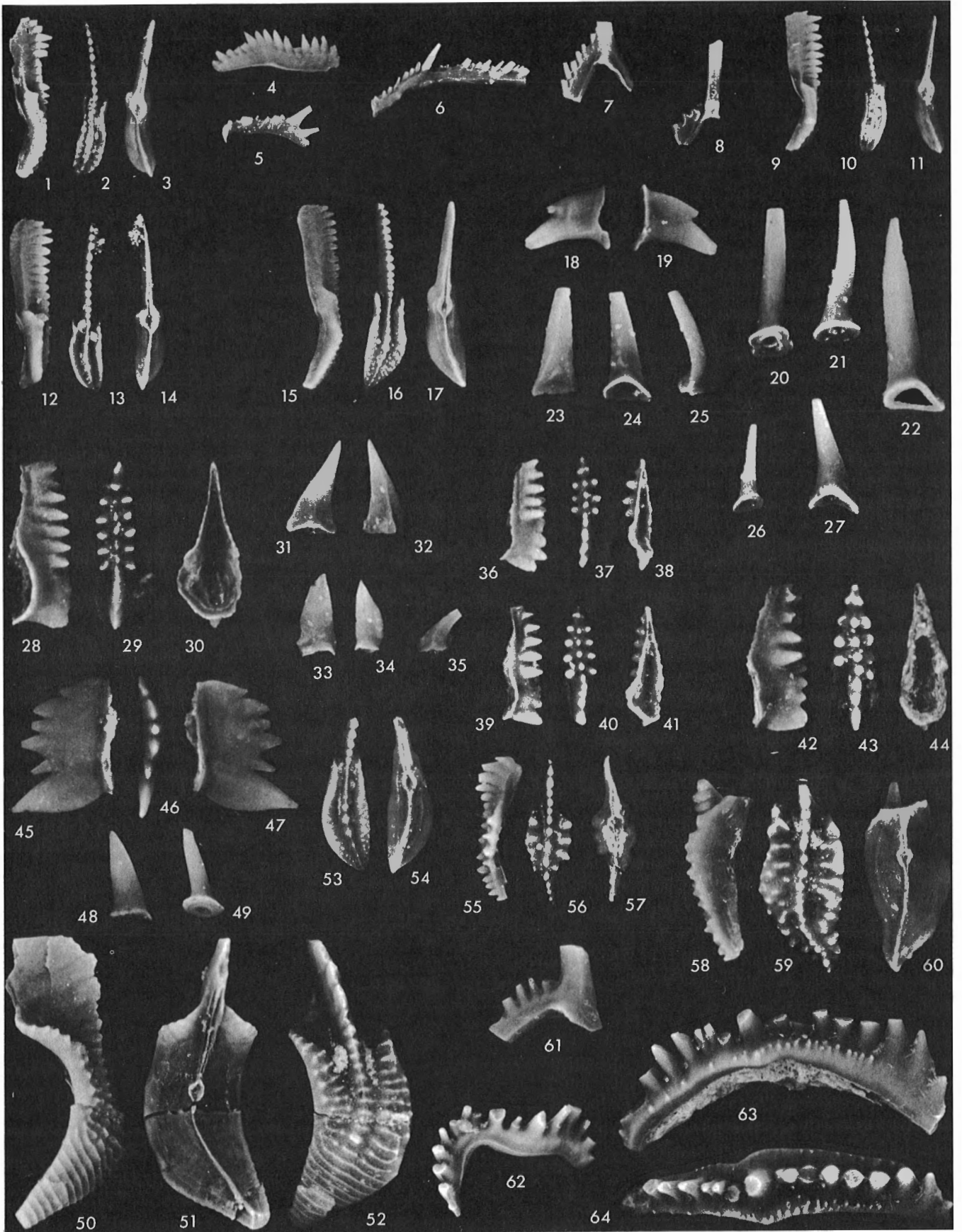
All from GSC loc. C-19868

Figures 55–60. P element: (55, 58) inner lateral, (56, 59) upper, (57, 60) lower views, GSC 35323 and holotype 35322, respectively.

Figure 61. N element, inner lateral view, GSC 35325.

Figure 62. A_1 element, inner lateral view, GSC 35324.

Figures 63, 64. O_1 element: (63) inner lateral, (64) upper views, GSC 35326.



Middle Carboniferous and Early Permian Fusulinaceans from the Monkman Pass Area, Northeastern British Columbia

Charles A. Ross and E.W. Bamber

Abstract

Sixteen species of fusulinaceans are described and illustrated, from five stratigraphic sections through the Belcourt Formation (Lower Permian) and an underlying, unnamed lower Moscovian (Carboniferous) formation of northeastern British Columbia. New species are *Pseudofusulina (Daixina) proluxa* Ross and *Eoschubertella rotunlata* Ross. The age relations of the collections and facies distribution data indicate an Early Permian transgression toward the east over an unconformable surface that formed on a limestone terrain composed of lower Moscovian and older rocks.

Résumé

Dans le présent rapport, on présente des descriptions et des illustrations de seize espèces de fusulinacés provenant de cinq coupes stratigraphiques traversant la formation de Belcourt (Permien inférieur) et une formation sous-jacente Moscovienne (Carbonifère) à laquelle on n'a pas donné de nom, au nord-est de la Colombie-Britannique. Les nouvelles espèces décrites sont *Pseudofusulina (Daixina) proluxa* Ross, et *Eoschubertella rotunlata* Ross. Les corrélations d'âge entre les assemblages et la répartition des faciès indiquent qu'une transgression a eu lieu au Permien inférieur vers l'est, au-dessus d'une surface de discordance constituée sur un terrain calcaire composé de roches du Moscovien inférieur, et encore plus anciennes.

Introduction

Fusulinaceans first were reported from northeastern British Columbia by Forbes and McGugan (1959), who illustrated and described *Schwagerina emaciata* (Beede) from Lower Permian silicified, sandy dolomite and limestone near Wapiti Lake (Textfig. 3, loc. 3). Those authors outlined the Permian stratigraphic succession of the area and showed that fusulinacean-bearing beds are present for approximately 65 km (40 mi) between the Wapiti Lake area and Narraway River to the south. Subsequently *Pseudofusulinella* sp. and additional species of *Schwagerina* were reported from the Permian rocks of this area by McGugan and Rapson (1963), who divided the succession, in ascending order, into the Belcourt Formation (cherty carbonate, siltstone, sandstone, basal conglomerate), Ranger Canyon Formation (phosphatic chert, siltstone, sandstone, silicified carbonate) and Mowitch Formation (sandstone and silicified carbonate). Fusulinaceans, accompanied by corals, brachiopods and other fossils, have since been reported from the Belcourt Formation to the south toward Jasper, Alberta (McGugan *et al.*, 1964, p. 106, 108) and to the north in the northern Monkman Pass area (Bamber and Macqueen, 1971).

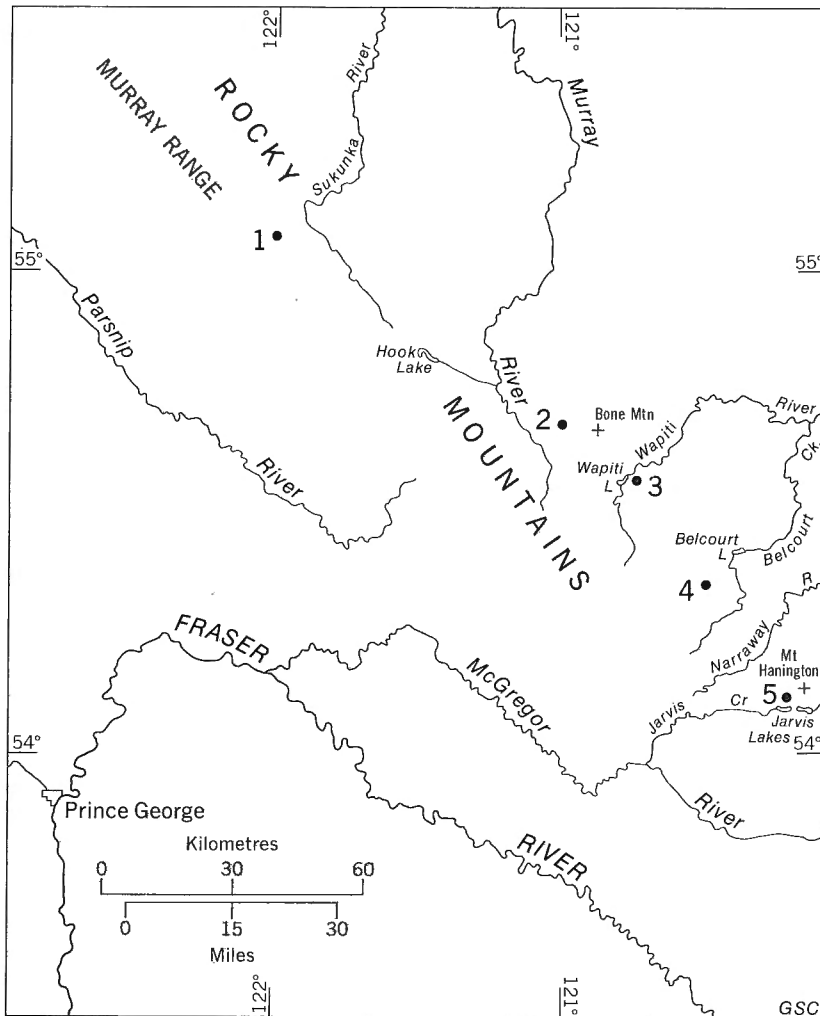
In the present paper, sixteen species of fusulinaceans from eleven sample localities (Textfig. 4; Tables 2 and 3) are described. They were collected by E.W. Bamber and R.W. Macqueen from several levels in the Lower Permian (Wolfcampian to lower Leonardian) Belcourt Formation (GSC locs. C-7328, C-7329, C-7385, C-7387, C-7388, C-7393, C-7415, C-7426) and also from an underlying unnamed lower Mos-

covian carbonate unit (GSC locs. C-7416, C-7417, C-4576) presently being described by Bamber and Macqueen (*in prep.*).

Two distinct limestone facies are present at the lower Moscovian localities. One facies, at GSC locs. C-7416 and C-7417 on the ridge west of Mount Hanington (Textfig. 3, loc. 5; Table 3), has abundant specimens of *Pseudoeendothya* cf. *P. bradyi* (von Möller), *Profusulinella* cf. *P. walnutensis* Ross and Sabins, and *Eoschubertella rotunlata* new species, in a fine-grained, partly recrystallized matrix containing small, well sorted shell fragments including numerous non-fusulinacean Foraminifera. The other limestone facies, from GSC loc. C-4576 on the east side of the Murray Range approximately 154 km (96 mi) to the northwest (Textfig. 3, loc. 1), has abundant specimens of *Profusulinella copiosa* Thompson and fewer specimens of *Profusulinella* sp. A in a fine-grained, slightly recrystallized matrix containing relatively few fossils other than fusulinaceans.

Samples from the remaining localities, all within the Belcourt Formation, are Early Permian in age and contain species most similar to those described from the Russian Platform. These species appear to be progressively younger from northwest to southeast (Textfig. 4; Table 3). The oldest samples are from the Fellers Creek section northeast of Bone Mountain (Textfig. 3, loc. 2), 6 m (20 ft) (GSC loc. C-7329) and 7.5 m (25 ft) (GSC loc. C-7328) above the top of the basal conglomerate. They contain *Pseudofusulina (Daixina) proluxa* new species, of early to middle Asselian (early to middle Wolfcampian) age, in oolitic limestone representing a shallow-water marine environment. The next youngest species, *Schwagerina emaciata* (Beede), from the Wapiti Lake section (Textfig. 3, loc. 3; GSC loc. C-7426), 9.9 m (33 ft) above the top of the basal conglomerate, is of middle to late Asselian (middle to late Wolfcampian) age. These specimens are in

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Textfigure 3. Map showing location of stratigraphic sections bearing fusulinaceans in northern British Columbia.

1. West Sukunka section
2. Fellers Creek section
3. Wapiti Lake section
4. Belcourt Creek section
5. Mount Hanington section

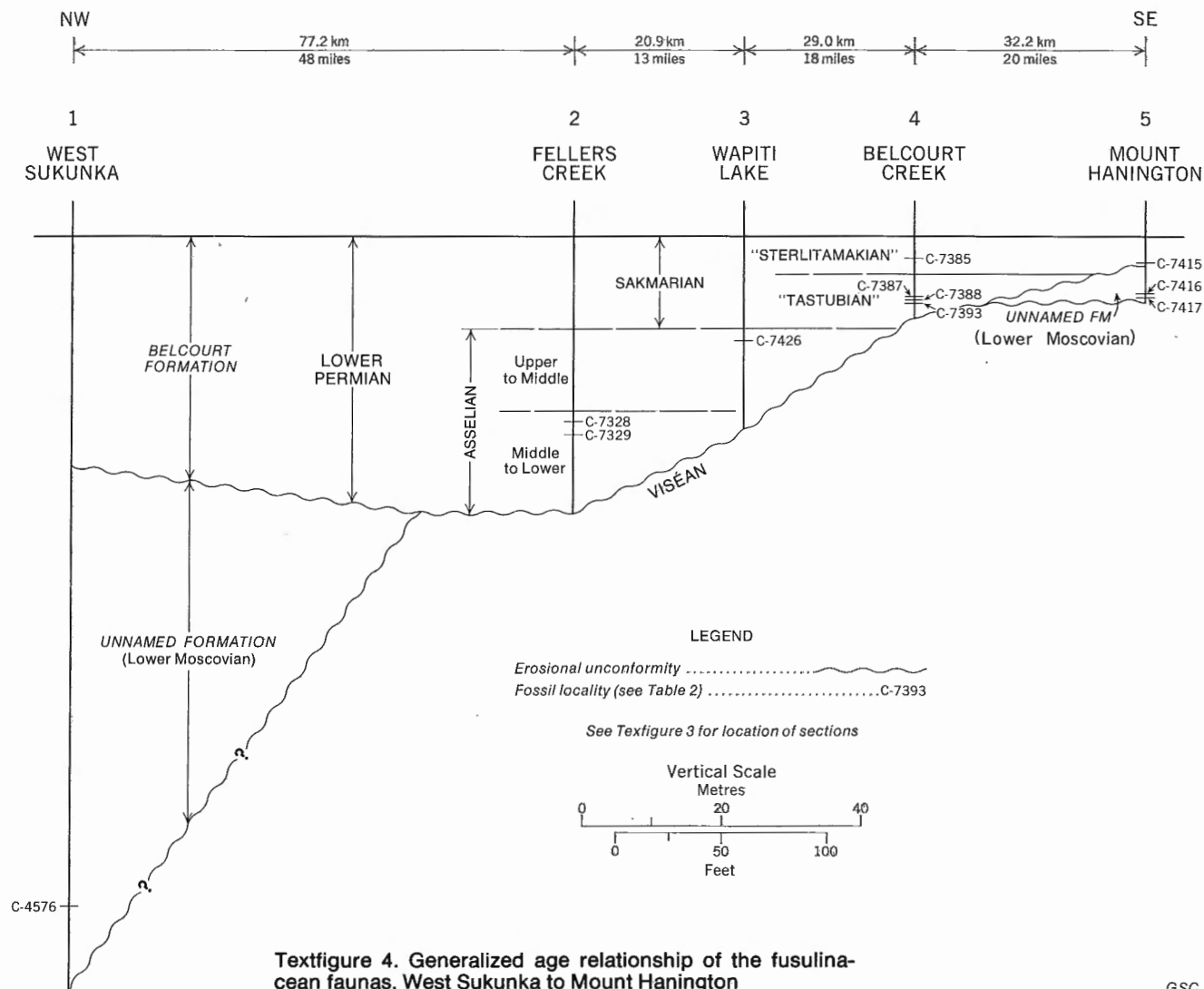
secondary chert that contains ghost outlines of other fossils, including fenestrate bryozoans, echinoderm columnals and algae. The next younger collections, from locality 4, the Belcourt Creek section (GSC locs. C-7387, C-7388 and C-7393), 4.05 m (13.5 ft), 2.85 m (9.5 ft), and 2.55 m (8.5 ft), respectively, above the top of the basal conglomerate, include *Schwagerina rapsonae* McGugan, *S. cf. S. dispansa* Ross, and *S. cf. S. sulcata* (Korzhenevskii), which are of early Sakmarian (late Wolfcampian) age. These are all in secondary chert with ghost outlines of a number of other fossils, including echinoderm columnals and algae. The youngest collections are from the upper part of the Belcourt Formation, 8.25 m (27.5 ft) above the top of the basal conglomerate (GSC loc. C-7385) at the Belcourt Creek section (loc. 4), and from the basal conglomerate (GSC loc. C-7415) in the Mount Hanington section (loc. 5). These contain *Schwagerina plicatissima* (Rauzer-Chernousova) and *Schwagerina* sp., indicating a late Sakmarian age (Sterlitamak beds; late Wolfcampian or early Leonardian).

The ages of the above collections indicate the general relationships shown in Textfigure 4. An erosional unconformity separates the lower Moscovian unit from the overlying

Lower Permian Belcourt Formation. The progressive decrease in age of the Permian beds from northwest to southeast, combined with regional facies considerations and the presence of a widespread basal conglomerate (Bamber and Macqueen, *in prep.*), indicates shoreline transgression in an easterly direction. The fusulinaceans, which were associated predominantly with shallow-water marine environments (middle and upper part of photic zone), are common near the shoreline in this transgressive succession.

Fusulinacean faunas of the same age as the early Moscovian species from the West Sukunka section (loc. 1) and the Mount Hanington section (loc. 5) occur in the Kananaskis Formation at Tunnel Mountain, near Banff, Alberta. This fauna, which contains *Profusulinella*, *Pseudostaffella*, and other foraminifers, was considered early Moscovian in age (Ross *in* McGugan *et al.*, 1968) and at the time of that report all of the early Moscovian was correlated with the lower part of the North American Atokan.

Fusulinaceans of early Sakmarian age have been reported also by McGugan (1963) from the lower part of the Ishbel Group (Johnston Canyon Formation) at Crossing Creek in southern British Columbia. This fauna is the same age as the



Textfigure 4. Generalized age relationship of the fusulinaean faunas, West Sukunka to Mount Hanington

GSC

Schwagerina species (including *S. rapsonae* McGugan) from GSC locs. C-7387, C-7388 and C-7393 at the Belcourt Creek section (loc. 4).

Acknowledgments

It is a pleasure to acknowledge and thank R.W. Macqueen for his part in collecting this material and for his discussion of the stratigraphic and environmental aspects of the report. The manuscript was critically read by R.W. Macqueen and B.S. Norford.

Systematic Paleontology

by Charles A. Ross

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

Order Foraminiferida
 Superfamily Fusulinacea von Möller, 1878
 Family Staffellidae Miklukho-Maklay, 1949
 Genus *Staffella* Ozawa, 1925
Staffella(?) species
 Plate 5, figures 23, 31, 44

Material. Specimens in random orientation, GSC 42653, 42654 and 42655 with recrystallized walls and indistinct structures.

Occurrence. Dolomitic limestone, GSC loc. C-7415, 0.15 to 0.45 m (0.5–1.5 ft) above base of Belcourt Formation, ridge west of Mount Hanington.

Discussion. This small species has recrystallized walls and was not apparent in the rock until thin sections were studied in transmitted light. Assignment of these specimens to *Staffella* is

Table 2. Distribution of fusulinacean species in collections studied from northeastern British Columbia

GSC LOCALITIES	FUSULINACEAN SPECIES															
	<i>Schwagerina plicatissima</i> (Rauzer-Ch.)	<i>S. emaciata</i> (Beede)	<i>S. cf. S. dispansa</i> Ross	<i>S. rapsonae</i> McGugan	<i>S. cf. S. sulcata</i> (Korzhenevskii)	<i>Schwagerina</i> sp.	<i>Pseudofusulina</i> (<i>Daixina</i>) <i>prolix</i> n. sp.	<i>Profusulinella copiosa</i> Thompson	<i>P. cf. P. walnutensis</i> Ross and Sabins	<i>Profusulinella</i> sp. A	<i>Eoschubertella rotundata</i> n. sp.	<i>Schubertella</i> (?) sp.	<i>Pseudoendothyra cf. P. bradyi</i> (von Möller)	<i>Staffella</i> (?) sp.	<i>Pseudofusulinella</i> sp. A	<i>Pseudofusulinella</i> sp. B
C-7328	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
C-7329	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
C-7385	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
C-7387	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
C-7388	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
C-7393	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-
C-7415	X	-	-	-	-	-	-	-	-	-	X	-	X	-	-	X
C-7416	-	-	-	-	-	-	-	X	-	X	-	X	-	-	-	-
C-7417	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-
C-7426	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C-4576	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-

GSC

based on the discoidal shape of the early volutions which become progressively more rounded in later volutions. The gentle forward arch of the septa (Pl. 5, fig. 44) is typical of the Staffellidae in general.

Age. *Staffella*(?) sp. occurs with *Schwagerina plicatissima* Rauzer-Chernousova, *Pseudofusulinella* and *Schubertella*(?) sp. and is late Sakmarian (Sterlitamak) (Early Permian).

Genus *Pseudoendothyra* Mikhailov, 1939
Pseudoendothyra cf. *P. bradyi* (von Möller)

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Plate 5, figures 16-21

cf. *Fusulinella bradyi* von Möller, 1878, p. 111, Pl. 5, figs. 5a-d, Pl. 15, figs. 2a, b
 cf. *Parastaffella bradyi* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, p. 148, Pl. 12, figs. 10, 11
 cf. *Pseudoendothyra bradyi* Rozovskaya, 1963, p. 30

Material. Four thin sections, GSC 42636 to 42639, and two thin sections assigned questionably, GSC 42640 and 42641, of recrystallized specimens.

Occurrence. Limestone, GSC loc. C-7417, 1.05 m (3.5 ft), and C-7416, 1.8 m (6 ft) above base of unnamed formation, ridge west of Mount Hanington.

Description. This small lenticular species reaches 1.4 mm diameter and 0.6 mm length in 6 to 7 volutions. In specimens examined, proloculi are small, 0.05 mm outside diameter, and the volutions are low and increase in height only slightly in successive volutions. The periphery of the shell has gently convex lateral slopes and a rounded equatorial region in early volutions (Pl. 5, figs. 18, 19) that becomes more sharply rounded in later volutions (Pl. 5, figs. 20, 21). The spiral wall is recrystallized to very coarse granular calcite. Septa are

Table 3. Localities and stratigraphic data for samples studied from north-central British Columbia

GSC LOCALITIES	FORMATION	STRATIGRAPHIC POSITION		Locality	Location
		Above base of formation	Above top of basal conglomerate		
C-4576	Unnamed (Moscovian)	12.3 m (41 ft)		1 - West Sukunka	55°05'N, 122°00'W
C-7328	BELCOURT	13.2 m (44 ft)	7.5 m (25 ft)	2 - Fellers Creek	54°42.5'N, 120°58'W
C-7329	BELCOURT	11.7 m (39 ft)	6 m (20 ft)	2 - Fellers Creek	54°42.5'N, 120°58'W
C-7385	BELCOURT	8.7 m (29 ft)	8.25 m (27.5 ft)	4 - Belcourt Creek	54°22'N, 120°29.5'W
C-7387	BELCOURT	4.5 m (15 ft)	4.05 m (13.5 ft)	4 - Belcourt Creek	54°22'N, 120°29.5'W
C-7388	BELCOURT	3.3 m (11 ft)	2.85 m (9.5 ft)	4 - Belcourt Creek	54°22'N, 120°29.5'W
C-7393	BELCOURT (rubble)	3 m (10 ft)	2.55 m (8.5 ft)	4 - Belcourt Creek	54°22'N, 120°29.5'W
C-7415	BELCOURT	0.15-0.45 m (0.5-1.5 ft)	in basal conglomerate	5 - Mt Hanington	54°07'N, 120°12'W
C-7416	Unnamed (Moscovian)	1.8 m (6 ft)		5 - Mt Hanington	54°07'N, 120°12'W
C-7417	Unnamed (Moscovian)	1.05 m (3.5 ft)		5 - Mt Hanington	54°07'N, 120°12'W
C-7426	BELCOURT (rubble)	13.5 m (45 ft)	9.9 m (33 ft)	3 - Wapiti Lake	54°34'N, 120°45'W

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GSC

planar and their bases slope forward toward the growing margin.

A poorly defined tunnel is present. Low chomata extend along the lateral slopes nearly to the poles. Other secondary features are not apparent.

Remarks. *Pseudoendothyra* cf. *P. bradyi* is a large species that appears most closely related to *P. bradyi* of the Russian Platform. It also shows general similarities in size and outline to specimens from Texas identified as *Nankinella* sp. by Thompson (1948, Pl. 25, figs. 13–16). *Pseudoendothyra* cf. *P. bradyi* has lower volutions than *P. depressa* (Thompson) or *P. powwowensis* (Thompson) from Texas. Specimens from GSC loc. C-7416 (Pl. 5, figs. 16, 17) are small and are probably immature.

Age. The associated faunas in GSC locs. C-7416 and C-7417 indicate an early Moscovian age for this species.

Family Fusulinidae von Möller, 1878

Genus *Eoschubertella* Thompson, 1937 329

Eoschubertella rotunlata new species

Plate 5, figures 1–5, 9, 10

Material. Specimens include one deep tangential section, paratype GSC 42628, four axial sections, paratypes GSC 42624, 42625, 42626 and holotype 42629, two sagittal sections, paratypes GSC 42627 and 42630, and about six sections in various orientations, not illustrated.

Occurrence. Limestone, GSC loc. C-7416, 1.8 m (6 ft) above base of unnamed formation, ridge west of Mount Hanington.

Description. This small subglobose species reaches 0.3 mm length and 0.3 mm diameter in 2½ to 3 volutions. In specimens measured, proloculi range from 0.06 to 0.08 mm outside diameter and are irregular in shape (Pl. 5, figs. 4, 10). First volution is low and does not completely cover proloculus. Succeeding volutions close at poles and may be coiled at a high angle to first volution. Spiral wall is very thin and composed of a tectum and diaphanotheca. Septa are planar.

A tunnel is present and is bordered by low, narrow chomata. Other secondary deposits are lacking.

Remarks. *Eoschubertella rotunlata* is similar to a group of species of the *E. obscura* (Lee and Chen) complex, but it has a broadly rounded outline and less well developed chomata. Other species of *Eoschubertella* are larger and are more elongate in outline. *Eoschubertella rotunlata* takes its name from the Latin and refers to its rounded outline in thin sections.

Age. Species of this general group are reported from upper Morrowan, Atokan, and Desmoinesian strata or equivalent units in the Russian Platform. *Eoschubertella rotunlata* occurs with *Profusulinella* cf. *P. walnutensis* Ross and Sabins and probably of early Moscovian age.

Genus *Schubertella* Staff and Wedekind, 1919

Schubertella(?) species 330

Plate 5, figure 8

Material. Thin section of one specimen, GSC 42718, and two randomly cut specimens not illustrated.

Occurrence. Dolomitic limestone, GSC loc. C-7415, 0.15 to 0.45 m (0.5–1.5 ft) above base of Belcourt Formation, ridge west of Mount Hanington.

Discussion. This is a rare species in the collection and none of the specimens has more than 3 or 4 volutions. The proloculus is 0.07 mm in outside diameter (Pl. 5, fig. 8), and the first volutions are low and subspherical, and coiled at a high angle to the coiling axis of the latest volution. The spiral wall is thin and granular (partly recrystallized?) and does not appear to have a keriotheca. These features indicate that the specimens are immature members of the genus *Schubertella*.

Age. The occurrence of *Schubertella*(?) sp. with *Schwagerina plicatissima* Rauzer-Chernousova, *Pseudofusulinella* sp. B, and *Staffella*(?) sp. indicates a late Wolfcampian to early Leonardian (Early Permian) age.

Genus *Profusulinella* Rauzer-Chernousova and Belyaev, 1936

Profusulinella copiosa Thompson 331
Plate 5, figures 24–29, 32, 37

Profusulinella copiosa Thompson, 1948, p. 80, Pl. 27, figs. 1–3, Pl. 28, figs. 14–32; Slade, 1961, p. 60, Pl. 7, figs. 5, 6; Ross and Sabins, 1965, p. 185, Pl. 21, fig. 14

Material. Specimens include one sagittal section, GSC 42645, seven axial sections, GSC 42646 to 42652, and several dozen other sections in various orientations, not illustrated.

Occurrence. Limestone, GSC loc. C-4576, 12.3 m (41 ft) above base of unnamed formation, east side of Murray Range (West Sukunka section).

Description. This small, subglobose to thickly fusiform species reaches 1.10 mm length, 0.65 mm diameter, and a form ratio of 1.7 in 3½ to 4 volutions. In eight specimens measured, proloculi range from 0.06 to 0.20 mm outside diameter. First volution is low (Pl. 5, fig. 24) and coiled at a small angle to later volutions (Pl. 5, fig. 25). After the second volution, chamber height increases appreciably and shell shows only slight change in form ratio in later volutions. Lateral slopes are strongly convex. Thin spiral wall is composed of a tectum and thin, inconspicuous diaphanotheca. Septa are planar except near the poles, where they are slightly folded (Pl. 5, figs. 25–29, 32, 37).

Tunnel is well developed, commonly reaches 0.12 mm width by the fourth volution, and is bordered by low prominent chomata, which extend along the basal edge of septa about halfway to the poles. Other secondary deposits are lacking.

Remarks. *Profusulinella copiosa* from GSC loc. C-4576 is similar in all features to the type specimens from West Texas. This species is similar in shape to *P. prisca* (Deprat), *P. paratimanic* Rauzer-Chernousova, and *P. chernovi* Rauzer-Chernousova from the Russian Platform but differs in internal details, most notably by having a large proloculus and small chomata that are nearly pseudochomata between septa.

Age. In North America, *Profusulinella copiosa* marks a stratigraphic position at the base of the zone of *Profusulinella* and in many sections on the cratonic shelves lies immediately below a prominent unconformity. This physical unconformity marks the base of the Derryan Series (Thompson, 1948) of

New Mexico. Thompson (*ibid.*) correlated the Derryan with the Atokan Series. Therefore, the range of *P. copiosa* and the base of the zone of *Profusulinella* in North America may be pre-Atokan. In terms of the Russian Platform, this is stratigraphically equivalent to the lower Moscovian.

Profusulinella cf. *P. walnutensis* Ross and Sabins 332
Plate 5, figures 6, 7, 11–13

cf. *Profusulinella walnutensis* Ross and Sabins, 1965, p. 185, Pl. 21, figs. 9–13

Material. Specimens include two slightly oblique axial sections, GSC 42634 and 42635, three sagittal sections, GSC 42631 to 42633, and about six random oblique sections, not illustrated.

Occurrence. Limestone, GSC locs. C-7416 and C-7417, 1.8 and 1.05 m (6 and 3.5 ft), respectively, above base of unnamed formation, ridge west of Mount Hanington.

Description. This small, thickly fusiform species reaches 0.75 mm length and 0.45 mm diameter in 4 to 4½ volutions. In specimens measured, proloculi range from 0.05 to 0.12 mm outside diameter. First volution is low (Pl. 5, figs. 6, 12) and coiled at an angle to later volutions (Pl. 5, figs. 7, 13). Second and third volutions increase markedly in height. Spiral wall is composed of a tectum, diaphanotheca, and thin outer tectorial layer. Septa are planar.

Tunnel is narrow and is bordered by prominent, low, broad chomata (Pl. 5, fig. 11) that extend nearly to the poles in early volutions.

Remarks. The specimens from GSC locs. C-7416 and C-7417 are similar in size, shape and several internal features to the type specimens from Arizona, but have slightly less inflated volutions. They are smaller and have less highly inflated volutions compared with *P. copiosa* Thompson and *Profusulinella* sp. A from GSC loc. C-4576. Of the several species of *Profusulinella* described from the Russian Platform, *P. polansensis* Safonova has about the same size and shape but has smaller and lower inner volutions. Some of the species of *Schubertella* described from the Russian Platform, such as *S. acuta* Rauzer-Chernousova and *S. gracilis* Rauzer-Chernousova, are also similar, but they lack well developed chomata.

Age. Lower part of the zone of *Profusulinella* in North America, equivalent to lower Moscovian of the Russian Platform.

Profusulinella species A 333
Plate 5, figures 14, 15, 22

Material. Specimens include one axial section, GSC 42642, one sagittal section GSC 42643, one oblique sagittal section, GSC 42644, and about six random sections, not illustrated.

Occurrence. Limestone, GSC loc. C-4576, 12.3 m (41 ft) above base of unnamed formation, east side of Murray Range (West Sukunka section).

Description. The medium to large, subglobose species reaches 2.5 mm length, 1.5 mm diameter, and form ratio of 1.67 in 5½ volutions. In three specimens measured, proloculi range from 0.10 to 0.19 mm outside diameter. First volution is low, 0.07

mm, and succeeding volutions increase markedly in height, to reach 0.4 mm by the fourth or fifth volution. The outline of the shell is slightly irregular because the spiral wall arches between septa (Pl. 5, figs. 15, 22) and the axial section (Pl. 5, fig. 14) cuts across several septa. Spiral wall is composed of a tectum and a thick diaphanotheca that has prominent pores passing through it. Outer tectorial deposits are thin and irregularly distributed in the early volutions. Septa are gently and irregularly folded and folding becomes more pronounced near the poles.

A tunnel (Pl. 5, fig. 14) is present and appears to be irregular in width and position. Chomata border the tunnel in all but the last volution, but these become pseudochomata in some volutions (Pl. 5, fig. 14), where they mainly thicken the edges of septa adjacent to the tunnel. Other secondary deposits are lacking.

Remarks. This species is characterized by its high arched chambers, thick spiral wall and relatively large size. Although rare in the collection studied, this species has distinctive features of size, shape and internal characters that are not found in other described species of *Profusulinella*.

Age. This species occurs with *Profusulinella copiosa* Thompson in GSC loc. C-4576 and probably is early Moscovian in age.

Genus *Pseudofusulinella* Thompson, 1951

Type species. *Neofusulina occidentalis* Thompson and Wheeler, 1946, from the McCloud Limestone, northern California (middle Wolfcampian part)

Discussion. *Pseudofusulinella* was established to include elongate to thickly fusiform shells with small proloculi, dense high chomata, and a spiral wall composed of a tectum, diaphanotheca and tectorial deposits. Septa are gently to moderately folded near the poles. This genus is one of the later genera of the Fusulinidae and apparently is derived from the Middle Carboniferous genus *Fusulinella* von Möller. Rozovskaya (1958) considered *Pseudofusulinella* as a synonym of *Fusulinella* and Rauzer-Chernousova (1965) considered it as a subgenus of *Fusulinella*. Although the general features of *Pseudofusulinella* show that it is derived from *Fusulinella* and therefore closely related, several features have been useful in recognizing species of *Pseudofusulinella*. The chomata in *Pseudofusulinella* are high at the septa and commonly form a marked thickening of the septa above the tunnel. Between septa, the chomata are commonly lower and broader and may extend farther toward the poles than at the septa. The spiral wall also shows distinctive features in mature later volutions. The outer tectorial deposits (i.e., the deposits at the bottom of the chamber that lie on the tectum of the previous volution) are thin on the lateral slopes of the chambers. The inner tectorial deposits (i.e., the deposits at the top of a chamber on the diaphanotheca of the spiral wall of a chamber) are also thin relative to the thickness of the diaphanotheca. Generally the diaphanotheca appears to be more translucent in *Pseudofusulinella* than in *Fusulinella* but the tectorial deposits in *Pseudofusulinella* may be darker, possibly because of more organic material, so that there is an illusion that the diaphanotheca is clearer.

Ozawa (1967) and Wilde (1971) have examined the described species of *Pseudofusulinella*, their phylogeny, and their

stratigraphic positions. Ozawa (1967) distinguished two subgenera: *P. (Pseudofusulinella)* with *P. occidentalis* (Thompson and Wheeler) as type species, and *P. (Kanmeraia)* Ozawa with *P. utahensis* Thompson and Bissel as type species. *Pseudofusulinella (Kanmeraia)* has a more elongate shape with form ratios in the sixth or later volutions exceeding 2.2, only 6 to 9 volutions in mature shells, wide tunnel angles (20 to 25 degrees) in comparison with *P. (Pseudofusulinella)*, which has mature form ratios less than 2.2, 7 to 12 volutions, and tunnel angles of 11 to 22 degrees. *Pseudofusulinella (Kanmeraia)* is older and its species range from Missourian to middle Wolfcampian whereas *P. (Pseudofusulinella)* ranges from early Wolfcampian to near the end of Leonardian.

Pseudofusulinella species A 334
Plate 5, figures 30, 35, 36

Material. Silicified specimens consisting of one axial section, GSC 42711, one sagittal section, GSC 42712, and three unoriented oblique sections, not illustrated.

Occurrence. Chert, GSC loc. C-7393, 3 m (10 ft) above base of Belcourt Formation, Belcourt Creek section (loc. 3 of Bamber and Macqueen, 1971); collected from rubble.

Description. This small species reaches 1.5 mm length and a form ratio of about 2.0 in about 4 volutions. In specimens measured (Pl. 5, figs. 30, 35, 36), the proloculi are about 0.06 mm diameter, first volution is 0.05 mm, second 0.06 mm, third 0.08 mm and fourth 0.10 mm high. The shell has convex lateral slopes and lacks a thickening of the equatorial region, at least in the outermost volution observed (fourth volution). Septa are nearly planar except near the poles, where they are gently folded.

Secondary features of the shell include a tunnel that is 0.1 mm wide in the fourth volution and is bordered by chomata that are tabular near the septa and broader and lower between septa (Pl. 5, figs. 30, 36). Tectorial deposits and spiral wall structure are indistinctly preserved in these silicified specimens.

Remarks. The specimens are not well preserved and silicification has destroyed many of their features including some of the outer volutions; it is not possible to assign them to a species.

Age. Species of *Pseudofusulinella* having form ratios similar to these specimens are usually from strata that are Wolfcampian or younger.

Pseudofusulinella species B 335
Plate 5, figures 33, 34, 38-43

Material. Specimens consist of four axial sections, GSC 42713 to 42716, one sagittal section, GSC 42717, and four unoriented oblique sections not illustrated.

Occurrence. Dolomitized limestone, GSC loc. C-7415, 0.15 to 0.45 m (0.5–1.5 ft) above base of Belcourt Formation, on ridge west of Mount Hanington.

Description. This small species reaches 1.1 mm length, 0.7 mm diameter and a form ratio of 1.5 to 1.6 in 4 to 5 volutions. In specimens measured, proloculi are 0.06 to 0.07 mm diameter

and first volutions are low (0.02 to 0.04 mm). After the shell reaches about 0.4 mm diameter, chamber height reaches about 0.1 mm. The shell has convex to straight lateral slopes (Pl. 5, figs. 33, 40, 42) and in specimens observed, which are incomplete and lack mature volutions, there is little tendency to form an equatorial bulge. Septa are nearly planar.

Secondary shell features show a narrow and irregular tunnel that is 0.07 mm wide in the third or fourth volution. Chomata are half to two-thirds chamber height, and are steep toward the tunnel and taper toward the lateral slopes (Pl. 5, figs. 33, 40, 42).

Remarks. Diagenesis in this limestone has resulted in sufficient recrystallization of the specimens that the wall structure is difficult to study and photograph. The wall is well enough preserved to place the specimens in *Pseudofusulinella*.

Age. The shape of these shells, their form ratio of 1.5 to 1.6, and tunnel angle suggest that this is a late Wolfcampian or early Leonardian species of *Pseudofusulinella*. It occurs with *Schwagerina plicatissima* (Rauzer-Chernousova), *Schubertella*(?) sp. and *Staffella*(?) sp., which indicate a Sakmarian age.

Family Schwagerinidae Dunbar and Henbest, 1930

Genus *Pseudofusulina* Dunbar and Skinner, 1931

Type species. *Pseudofusulina huecoensis* Dunbar and Skinner, 1931, p. 257, Pl. 1, figs. 3–6b; emend. Skinner and Wilde, 1965, p. 56, Pl. 13, figs. 4, 5; 1966, p. 1, Pls. 1 and 2

Discussion. Skinner and Wilde (1965, 1966) have discussed at length the history of the various nomenclatural problems involving *Pseudofusulina* and similar genera, which became compounded by a series of misidentifications and usage. There is a large number of species that occur near the Carboniferous-Permian boundary that have most of the general features of *Pseudofusulina huecoensis*, such as an elongate shape, irregular outline of the spirotheca (rugosity), low chomata or pseudochomata in the early several volutions, false walls (phrenotheca) in the chambers, and septal folds that are fairly regular but not crowded together as closely spaced high folds. Enough of these species have been described to see an evolutionary diversity from a species group within *Triticites* into *Pseudofusulina* and finally into *Schwagerina*. Several lineages and species have been selected from this array of species and used to form the basis for at least two new generic concepts but, because of the gradational changes in morphological features between many of these species, these generic concepts generally have not been adopted. *Daixina* Rozovskaya, 1949, with *D. ruzhencevi* as the type species, has a more extended development of chomata and pseudochomata into later volutions than *Pseudofusulina huecoensis*. Stratigraphically and morphologically, *Daixina* is an intermediary between *Triticites (Rauserites)* Rozovskaya, 1948 and *Pseudofusulina*. *Schwagerina*, with *Borelis princeps* Ehrenberg as the type species, is a more thickly fusiform to subglobose lineage that has more closely spaced and higher septal folds and is gradational with *Paraschwagerina* Dunbar and Skinner in most internal features and shape. *Rugosofusulina* Rauzer-Chernousova, 1937, with *Fusulina prisca* Ehrenberg (as identified by von Möller, 1878) as the type species, is similar to *Pseudofusulina huecoensis* but has finely wrinkled (rugose)

spirotheca, which may either be a surface feature or involve the entire spirotheca. As Skinner and Wilde (1965, 1966) have illustrated, the spirotheca in *Pseudofusulina huecoensis* at irregularly spaced places along its surface has wrinkled areas which are not as well developed but do involve the upper and possibly the lower surface. Thus *Rugosofusulina* is considered by Skinner and Wilde to be a junior synonym of *Pseudofusulina* although most species assigned to *Rugosofusulina* have much more strongly wrinkled (rugose) surfaces and commonly include the entire spirotheca.

Because these various taxonomic subdivisions are based on distinctive features that tend to have a broad range of development or expression, they are characteristic of several of the important lineages that existed in the latest Carboniferous and Early Permian. At present, three subgenera of *Pseudofusulina* seem to be recognizable: *Daixina*, *Rugosofusulina*, and *Pseudofusulina*.

Subgenus *Daixina* Rozovskaya, 1949

Pseudofusulina (*Daixina*) *prolixa* new species 336

Plate 6, figures 1–3, 6, 8, 9, 11, 13, 14, 16, 17, 19–22, 24–26

Material. Specimens consist of twelve axial sections, holotype GSC 42656, paratypes 42657 to 42662 and 42664 to 42668; three sagittal sections, paratypes 42663, 42669, 42670; and fourteen additional axial, sagittal and tangential sections not illustrated.

Occurrence. Oolitic limestone, GSC locs. C-7328 and C-7329, 13.2 and 11.7 m (44 and 39 ft), respectively, above the base of Belcourt Formation, Fellers Creek (loc. 1-west of Bamber and Macqueen, 1971).

Description. This elongate species reaches 11 mm length, 2.3 mm diameter and has a form ratio of 4.75 in 5½ to 6 volutions. In specimens measured, proloculi range between 0.12 to 0.24 mm diameter in megalospheric individuals and 0.024 mm in a single microspheric individual (Pl. 6, figs. 2, 24). The first volutions (Pl. 6, figs. 25, 26) are subspherical and thin-walled, with low chomata. The succeeding volutions are low relative to shell length and the spiral wall thickens from about 0.001 or 0.002 mm in the first volution to 0.01 mm in the fourth or fifth volution (Pl. 6, figs. 1, 6, 8, 9, 11, 13, 14, 16, 17, 21, 22). Keriotheca has 5 to 7 alveoli per 0.1 mm. Shell shape becomes increasingly elongate with successive volutions, the shell outline is irregular, and the spiral wall is strongly deflected at the septa (Pl. 6, figs. 19, 20) and locally irregular (Pl. 6, figs. 16, 17, 22).

Secondary features include a tunnel (Pl. 6, figs. 3, 19, 20) that reaches 0.4 to 0.7 mm width by the third or fourth volution. Chomata are poorly developed in the first one or two volutions (Pl. 6, figs. 24–26) and become pseudo-chomata in later volutions where secondary deposits are thickest at the septa and are thin or lacking between septa. In these later volutions, the pseudo-chomata are heaviest at septal folds.

Remarks. *Pseudofusulina* (*Daixina*) *prolixa* is more elongate than most species of this subgenus. It has lower chamber height than *P. (D.) amdрупensis* Ross and Dunbar from northeastern Greenland, and *P. (D.) grinnelli* Thorsteinsson from Grinnell Peninsula. *Pseudofusulina huecoensis* Dunbar and Skinner from the Hueco Limestone, West Texas, is less

elongate, and has more regularly folded septa and less well developed pseudo-chomata; *Pseudofusulina laxissima* (Dunbar and Skinner) from Texas and Utah, *P. robleda* Thompson from the Hueco Limestone, New Mexico and Texas, and *P. providens* Thompson and Hazzard from California and Arizona, are larger. *Pseudofusulina attenuata* Skinner and Wilde from the lower part of the McCloud Limestone, California, is smaller at corresponding volutions. *Pseudofusulina longisimoidea* (Beede) from Kansas, and *P. campensis* Thompson from north-central Texas are larger and less elongate. Specimens identified as *Schwagerina emaciata* (Beede) from Wapiti Lake, British Columbia, are less elongate than *P. (D.) prolixa*.

Age. In the Urals species of this general level of evolutionary development are common in the uppermost Carboniferous (Orenburgian) and lowermost Permian (Asselian), and in North America they occur in the lower part of the Wolfcampian Series (Early Permian).

Genus *Schwagerina* von Möller, 1877

Schwagerina cf. *S. sulcata* (Korzhenevskii) 337

Plate 7, figures 2, 5–7, 9, 10, 27

cf. *Pseudofusulina sulcata* Korzhenevskii, 1940, p. 4, Pl. 1, figs. 1–13

Material. Silicified specimens consist of three axial sections, GSC 42677 to 42679, two sagittal sections, GSC 42675 and 42676, two tangential sections, GSC 42673 and 42674, and about a dozen obliquely oriented specimens.

Occurrence. Chert, GSC loc. C-7387, 4.5 m (15 ft) above base of Belcourt Formation, Belcourt Creek section (loc. 3 of Bamber and Macqueen, 1971).

Description. This species reaches more than 8 mm length and 2.5 mm diameter in 5½ to 6 volutions. In specimens measured, proloculi range from 0.18 to 0.32 mm outside diameter. The first volution is low (Pl. 7, figs. 5, 6) and subglobose in outline and succeeding volutions become progressively more elongate. The poles are bluntly rounded in later volutions (Pl. 7, figs. 7, 9, 10). Septa are folded into regular narrow, rounded, low folds that decrease in magnitude toward the top of the chambers (Pl. 7, figs. 2, 9, 27). The spiral wall has a well developed keriotheca with 6 to 7 alveoli per 0.1 mm in the fifth or sixth volution. Secondary features include a tunnel that reaches 0.8 mm width by the fifth or sixth volutions (Pl. 7, figs. 2, 10). Secondary deposits appear to be minor or lacking, although the preservation is poor and they would be difficult to observe. Cuniculi are lacking.

Remarks. *Schwagerina* cf. *S. sulcata* differs from *Schwagerina* sp. and *S. rapsonae* McGugan in having less strongly folded septa. *Schwagerina rapsonae* has more secondary deposits in early volutions. *Schwagerina callosa* (Rauzer-Chernousova) from the Urals and Alaska has heavier axial deposits and a more rounded outline, and *S. moffiti* Petocz and *S. rapsonae* McGugan have lower inner volutions and heavier axial deposits. Specimens described as *Schwagerina emaciata* (Beede) from Wapiti Lake (Forbes and McGugan, 1959) are less elongate than *S. cf. S. sulcata*.

Age. The present taxon represents the stage of evolution of *S. sulcata* found in the Sakmarian Series of the Urals and of species of *Schwagerina* from the late Wolfcampian and early Leonardian series of the North American reference sections.

Schwagerina rapsonae McGugan nom. correct. 338

Plate 7, figures 12, 13, 15, 17, 21

Schwagerina rapsoni McGugan, 1963, p. 625, Pl. 78, figs. 1-18

Material. Specimens consist of five axial sections, GSC 42680 to 42684, and one tangential section and four oblique axial sections, not illustrated.

Occurrence. Chert, 3.3 m (11 ft) above base of Belcourt Formation, GSC loc. C-7388, Belcourt Creek section (loc. 3 of Bamber and Macqueen, 1971).

Description. This fusiform species reaches 11 mm length and 2.5 mm diameter in 6 to 7 volutions. In specimens examined, the proloculi ranged from 14 to 20 mm outside diameter. First 2 to 2½ volutions are low and appear dense (Pl. 7, figs. 12, 13, 15, 17, 21). Chamber height increases markedly after the third volution and shell appears to be more open. Poles become less sharply rounded after 2 to 3 volutions and axis of coiling may not be regular (Pl. 7, figs. 12, 17, 21). Spiral wall has well developed keriotheca with 6 to 7 alveoli per 0.1 mm. Septa are strongly folded into high, regular, closely spaced folds in early volutions. Septal folds become more widely spaced in later volutions (Pl. 7, figs. 12, 13).

Secondary features include a regular tunnel which is 0.7 mm wide by the seventh volution. Secondary deposits coat the closely folded septa in the first 3 to 5 volutions but do not completely infill the chambers. Cuniculi were not observed.

Remarks. Specimens of *Schwagerina rapsonae* from GSC loc. C-7388 agree closely in size, shape, axial deposits, septal folds, and low early volutions to the type specimens from further south in British Columbia at Crossing Creek Ridge (McGugan, 1963). The low, elongate early volutions and secondary septal coatings of *S. rapsonae* distinguish it from *S. sulcata* (Korzhënevskii) and *S. plicatissima* (Rauzer-Chernousova) from the Urals and *S. emaciata* (Beede) from Wapiti Lake, British Columbia and the North American Midcontinent area. *Schwagerina rapsonae* is similar to *Schwagerina* sp. B of Petocz (1970) from the east-central Alaska Range but has a more elongate shape. *Schwagerina demissa* Skinner and Wilde from the McCloud Limestone, California, has less strongly folded septa and more loosely coiled early volutions.

Age. Late Wolfcampian to early Leonardian of North America and Sakmarian of the Ural Mountains.

Schwagerina emaciata (Beede) 339

Plate 7, figures 19, 22, 23

Fusulina emaciata Beede, 1916, p. 14; Dunbar and Condra, 1927, p. 116, Pl. 10, figs. 1-3

Schwagerina emaciata (Beede), Dunbar and Skinner, 1937, p. 633, Pl. 56, figs. 1-12; Thompson, 1954, p. 55, Pl. 25, figs. 14-20, Pl. 30, figs. 10-22; Forbes and McGugan, 1959, p. 40-42, Pl. 1, figs. 1-7; Ross, 1963, p. 126, Pl. 9, figs. 6-9; Sabins and Ross, 1963, p. 349, Pl. 37, figs. 11-19

Material. Specimens consist of two axial sections, GSC 42685 and 42686, one tangential section, GSC 42687, and one small axial and two tangential sections not illustrated.

Occurrence. Chert rubble, GSC loc. C-7426, 13.5 m (45 ft) above base of Belcourt Formation, Wapiti Lake section.

Description. This elongate fusiform species reaches 9 mm length, 2.5 mm diameter and a form ratio of 3 to 4 in 5 to 5½

volutions. In two specimens measured, proloculi are 0.12 and 0.22 mm outside diameter. First volution is low and subglobose and succeeding volutions gradually increase proportionally more in length than height. Lateral slopes are nearly regular, gently convex, and taper to small, bluntly rounded poles. Spiral wall has a well developed keriotheca with 5 to 6 alveoli per 0.1 mm. Septa are closely spaced and folded into high, septal folds with nearly parallel sides and flattened crests (Pl. 7, figs. 19, 22, 23).

Secondary features include a narrow, irregular tunnel that reaches 0.3 mm width in the fifth volution. Secondary deposits coat the septal folds in the polar regions of the early volutions. Cuniculi are apparently lacking (Pl. 7, fig. 23).

Remarks. The specimens of *Schwagerina emaciata* studied have been distorted by diagenetic changes and one (Pl. 7, fig. 23) is slightly compressed perpendicular to the axis of coiling. The Wapiti Lake specimens studied here are similar to the specimens described by Forbes and McGugan (1959) from the same area. This is a species that is widely distributed along the western margin of the late Paleozoic North American craton. *Schwagerina emaciata* is similar to *S. pseudokaragasensis* Petocz from east-central Alaska Range, but that species has heavier axial deposits.

Age. Middle to late Wolfcampian.

Schwagerina cf. *S. dispansa* Ross 340

Plate 7, figures 3, 8, 11, 14, 16, 18, 20, 24, 25, 26(?), 28, 29

cf. *Schwagerina dispansa* Ross, 1963, p. 121, Pl. 1, figs. 5-10

Material. Silicified specimens consist of six axial sections, GSC 42691 to 42696, three sagittal sections, GSC 42697 to 42699, three tangential sections, GSC 42688 to 42690, and about six unoriented sections not illustrated.

Occurrence. Chert, GSC loc. C-7393, 3 m (10 ft) above base of Belcourt Formation, Belcourt Creek section (loc. 3 of Bamber and Macqueen, 1971); collected from rubble.

Description. This species reaches 5.5 mm length, 2 mm diameter and a form ratio of 2.75 in 5 volutions. In 6 specimens measured, proloculi range from 0.12 to 0.20 mm diameter. The early volutions are subspherical and gradually become proportionally longer as chamber height increases more near the poles than at the equator. In fifth or sixth volution, the lateral slopes become straight to slightly concave (Pl. 7, figs. 11, 18, 25). Spiral wall (Pl. 7, figs. 20, 28) has keriotheca with 7 to 9 alveoli per 0.1 mm. Septa are highly and regularly folded. Septal folds increase slightly in intensity away from the equatorial region and have narrow crests (Pl. 7, figs. 11, 18, 25, 26, 29).

Secondary features include a tunnel, which is difficult to trace in the silicified specimens but appears to reach 0.25 mm by the fourth or fifth volution. Chomata appear to be lacking (Pl. 7, figs. 3, 14, 16, 24); however, secondary deposits coat the septal folds of the early volutions, particularly near the tunnel (Pl. 7, figs. 8, 14, 18).

Remarks. *Schwagerina* cf. *S. dispansa* compares closely in size, shape, septal folding and other internal features to *S. dispansa* from the Lenox Hills Formation (upper Wolfcampian) of West Texas, and differs mainly in less strongly developed

axial deposits on the septal folds. *Schwagerina* cf. *S. dispansa* is similar to *S. firma* (Shamov) from the upper part of the Asselian of the Urals. *Schwagerina* cf. *S. dispansa* occurs with *Pseudofusulinella* sp. A.

Schwagerina plicatissima (Rauzer-Chernousova) 341
Plate 6, figures 4, 5, 7, 10, 12, 15, 18, 23, 27–29

Pseudofusulina plicatissima Rauzer-Chernousova, 1940, p. 87, Pl. 4, figs. 5, 6, Pl. 5, figs. 1–3; 1965, p. 72, Pl. 6, fig. 9; Grozdilova and Lebedeva, 1961, p. 239, Pl. 19, fig. 3

Material. Specimens consist of eight axial sections, GSC 42700 to 42707, one sagittal section, GSC 42708, one tangential section, GSC 42709, about a dozen unoriented sections, not illustrated, and one small axial section, GSC 42710.

Occurrence. Dolomitized limestone, GSC loc. C-7415, 0.15 to 0.45 m (0.5–1.5 ft) above base of Belcourt Formation, on ridge west of Mount Hanington.

Description. Shells reach 5 mm length, 1.8 mm diameter and form ratios of about 2.8 in 5 to 6 volutions. In 6 specimens measured, proloculi range from 0.1 to 0.2 mm diameter and the first 1 to 3 volutions are low, followed by a significant increase in chamber height beyond shell diameters of 0.7 to 0.9 mm (Pl. 6, figs. 4, 5, 7, 10, 12, 15, 18, 23, 27, 29). The lateral slopes are gently convex and the form ratios increase gradually in successive volutions.

The spiral wall has a well defined keriotheca with 7 to 8 alveoli per 0.1 mm and reaches a thickness of 0.06 mm by the fourth or fifth volution. Septa are regularly and highly folded with the flattened crests of the folds reaching to the top of the chambers (Pl. 6, figs. 7, 10, 15). Cuniculi are not present in the first five volutions (Pl. 6, fig. 28) and were not observed in random sections of the limestone.

Secondary features include a regular, narrow tunnel, 0.16 to 0.19 mm wide by the fifth volution, and marked secondary

coatings that line the septa and floor of the chambers (Pl. 6, figs. 10, 15), giving the shell a dense appearance.

Remarks. *Schwagerina plicatissima* is similar to *S. urdalensis* var. *abnormis* Rauzer-Chernousova in having similar secondary coatings on the high rectangularly shaped septal folds, but is less elongate than that species. *Schwagerina callosa* (Rauzer-Chernousova) has less highly folded septa, *S. rowetti* Petocz has more irregularly folded septa, and *S. munda* Skinner and Wilde has more rounded septal folds and less dense secondary coatings on the septa than *S. plicatissima*. Specimens identified as *S. emaciata* (Beede) (Forbes and McGugan, 1959) from Wapiti Lake, British Columbia, have less regularly folded septa and less dense axial deposits.

Age. In the southern Ural Mountains and in Timan, *S. plicatissima* is a zonal index for the Sterlitamak beds at the top of the Sakmarian Series, Lower Permian.

Schwagerina species 342
Plate 7, figures 1, 4

Material. Four obliquely oriented silicified specimens in chert; GSC 42671 and 42672, are illustrated.

Occurrence. Chert, GSC loc. C-7385, 8.7 m (29 ft) above base of Belcourt Formation, Belcourt Creek section (loc. 3 of Bamber and Macqueen, 1971).

Discussion. Although these few specimens are poorly preserved and not oriented, several features indicate they are a distinct species from others in this study. The diameter of 4.5 mm, the uniformity of its strongly folded septa and lack of cuniculi and secondary deposits suggest that this is a large and advanced species of the genus.

Age. Based on general stage of evolution, *Schwagerina* sp. is late Wolfcampian to Leonardian (Early Permian).

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Plate 5

(all figures $\times 40$, unless otherwise noted)

Eoschubertella rotunlata new species 329 (page 29)
All from GSC loc. C-7416

Figures 1–3. Axial or near-axial sections, paratypes GSC 42624, 42625 and 42626.

Figure 4. Sagittal section, paratype GSC 42627.

Figure 5. Tangential section, paratype GSC 42628.

Figure 9. Axial section, holotype GSC 42629.

Figure 10. Sagittal section, paratype GSC 42630.

Profusulinella cf. *P. walnutensis* Ross and Sabins 332 (page 30)

Figures 6, 7, 13. Sagittal sections, GSC 42631, 42632 and 42633; GSC loc. C-7416.

Figures 11, 12. Axial sections, GSC 42634 and 42635; GSC loc. C-7417.

Schubertella(?) species 330 (page 29)

Figure 8. Axial section of immature specimen, GSC 42718; GSC loc. C-7415.

Profusulinella species A 333 (page 30)
All from GSC loc. C-4576

Figure 14. Axial section, GSC 42642.

Figures 15, 22. Sagittal and oblique sagittal sections, GSC 42643 and 42644.

Pseudoendothyra cf. *P. bradyi* (von Möller) 328 (page 28)

Figure 16. Sagittal section, GSC 42641; GSC loc. C-7416.

Figure 17. Axial section, GSC 42640; same locality.

Figures 18, 19, 21. Axial or near-axial sections, GSC 42636, 42637 and 42638; GSC loc. C-7417.

Figure 20. Olique section of large specimen, GSC 42639; same locality.

Staffella(?) species 346 (page 27)
All from GSC loc. C-7415

Figures 23. Oblique tangential section approximately parallel to axis, GSC 42653.

Figure 31. Sagittal section, GSC 42654.

Figure 44. Oblique tangential section approximately perpendicular to axis, GSC 42655.

Profusulinella copiosa Thompson 331 (page 29)
All from GSC loc. C-4576

Figure 24. Sagittal section, GSC 42645.

Figures 25–29, 32, 37. Axial sections, GSC 42646, 42648, 42649, 42650, 42647, 42651 and 42652.

Pseudofusulinella species A 334 (page 31)

Figure 30. Sagittal section, GSC 42712; GSC loc. C-7393.

Figures 35, 36. Axial section, GSC 42711, $\times 10$ and $\times 40$; same locality.

Pseudofusulinella species B 335 (page 31)
All from GSC loc. C-7415

Figures 33, 34, 40–43. Axial sections, GSC 42713, $\times 10$ and $\times 40$, 42714 $\times 10$ and $\times 40$, 42715 and 42716.

Figures 38, 39. Sagittal section, GSC 42717, $\times 10$ and $\times 40$.

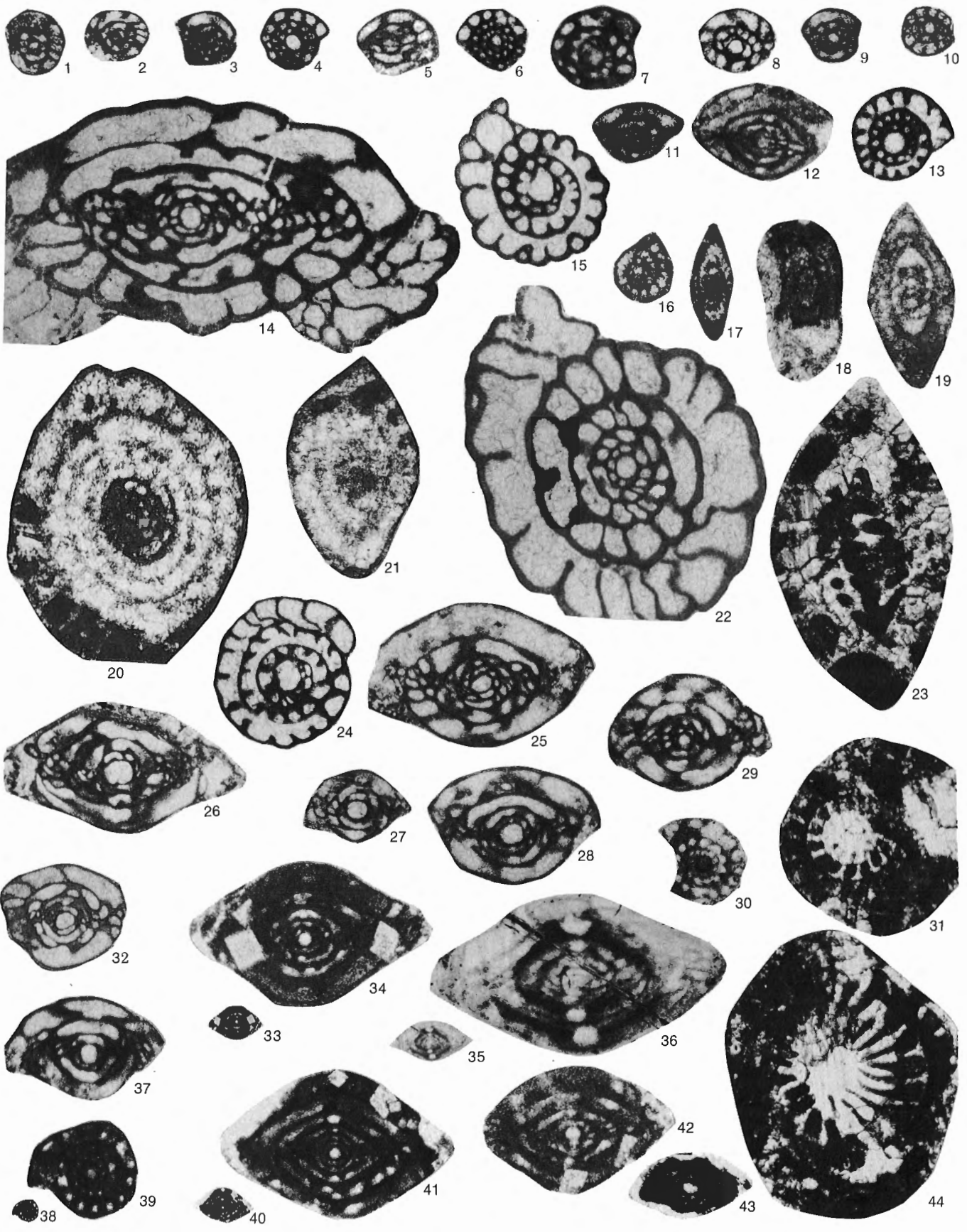


Plate 6

(all figures $\times 10$, unless otherwise noted)

Pseudofusulina (Daixina) proluxa n. sp. 336 (page 32)

Figures 1, 2, 6, 8, 9, 11, 13. Axial sections, holotype GSC 42656 and paratypes 42657, 42658, 42659, 42660, 42661 and 42662; GSC loc. C-7328.

Figure 3. Sagittal section, paratype GSC 42663; same locality.

all paratypes
c holotype
Figures 14, 16, 17, 21, 22. Axial sections, GSC 42664, 42665, 42666, 42667 and 42668; GSC loc. C-7329.

Figures 19, 20. Sagittal sections, GSC 42669 and 42670; same locality.

Figures 24-26. Enlarged views, $\times 40$, of portions of figures 2, 8 and 11.

Schwagerina plicatissima Rauzer-Chernousova 341 (page 34)

All from GSC loc. C-7415

Figure 4. Sagittal section, GSC 42708.

Figures 5, 7, 10, 12, 15, 18, 23, 27. Axial sections GSC 42700, 42701, 42705, 42702, 42706, 42704, 42703 and 42707.

Figure 28. Tangential section, GSC 42709.

Figure 29. Axial section of immature specimen, GSC 42710, $\times 40$.

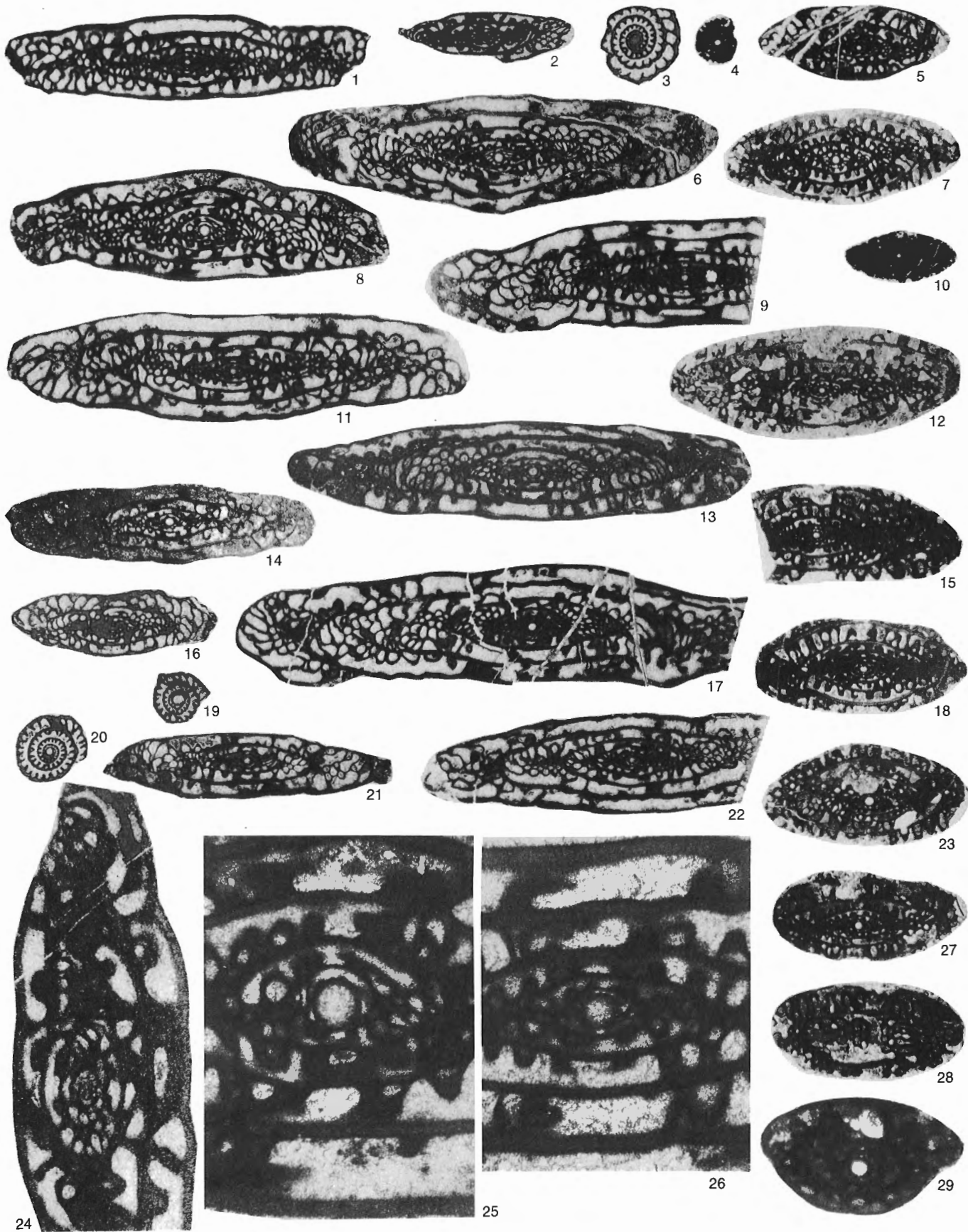


Plate 7

(all figures $\times 10$, unless otherwise noted)

Schwagerina species 342 (page 34)

Figure 1. Oblique sagittal section, GSC 42671; GSC loc. C-7385.

Figure 4. Sagittal section, GSC 42672; same locality.

Schwagerina cf. *S. sulcata* (Korzhenevskii) 317 (page 32)

All from GSC loc. C-7387

Figures 2, 27. Tangential sections. GSC 42673 and 42674.

Figures 5, 6. Sagittal sections, GSC 42675 and 42676.

Figures 7, 9, 10. Axial sections, GSC 42679, 42678 and 42677.

Schwagerina cf. *S. dispansa* Ross 340 (page 33)

All from GSC loc. C-7393

Figures 3, 14, 16. Tangential sections, GSC 42689, 42688 and 42690.

Figures 8, 11, 18, 25, 26, 29. Axial sections, GSC 42693, 42691, 42694, 42692, 42696 and 42695. (GSC 42696, figure 26, is questionably assigned.)

Figures 20, 24, 28. Sagittal sections, GSC 42697, 42699 and 42698, all $\times 40$.

Schwagerina rapsonae McGugan 338 (page 33)

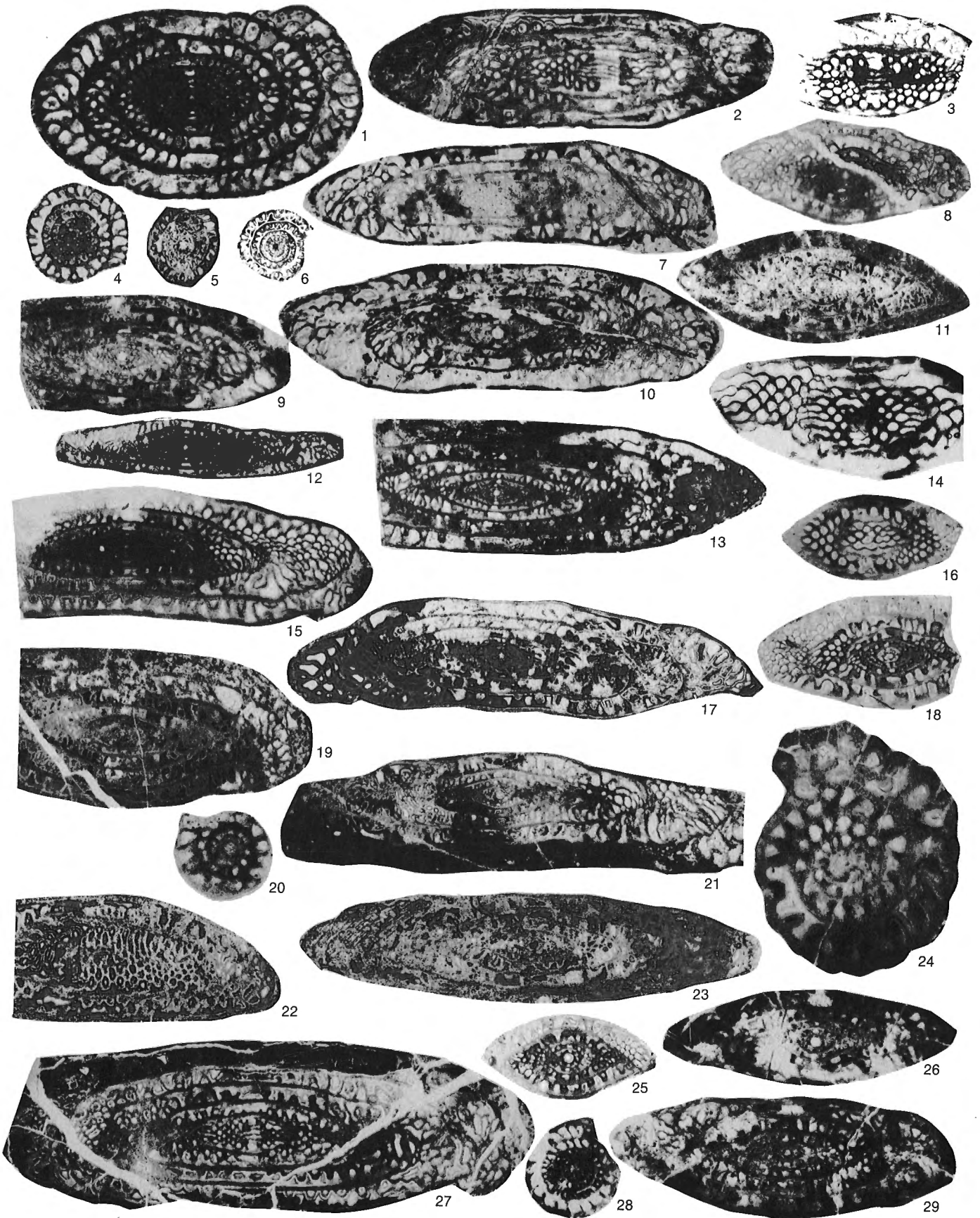
Figures 12, 13, 15, 17, 21. Axial sections, GSC 42682, 42681, 42680, 42683 and 42684; GSC loc. C-7388.

Schwagerina emaciata (Beede) 339 (page 33)

All from GSC loc. C-7426

Figures 19, 23. Axial sections, GSC 42685 and 42686.

Figure 22. Tangential section, GSC 42687.



Carboniferous and Permian Fusulinaceans from the Omineca Mountains, British Columbia

Charles A. Ross and J.W.H. Monger

Abstract

Known fusulinacean faunas from the Omineca Mountains are of six different ages: early Moscovian, late Moscovian, latest Carboniferous or earliest Permian, Asselian, early Sakmarian, and late Early or early Late Permian. Nineteen species are recognized from 20 localities including the new species *Fusulinella decora*, *F. concava*, *F. (?) densa*, and *Schwagerina sustutensis*. The faunas show affinities to faunas of the Russian Platform and the Ural Mountains.

Résumé

Les faunes connues de fusulinacés provenant des monts Omineca appartiennent à six époques différentes: le Moscovien inférieur, le Moscovien supérieur, la toute fin du Carbonifère ou le tout début du Permien, l'Assélien, le Sakmarien inférieur, et la fin du Permien, inférieur ou le début du Permien supérieur. On a identifié dix-neuf espèces provenant de 20 localités, y compris les nouvelles espèces *Fusulinella decora*, *F. concava*, *F. (?) densa*, et *Schwagerina sustutensis*. Ces faunes présentent des affinités avec celles de la plate-forme russe, et des monts Oural.

Introduction

Fusulinacean fossils were collected from the central Omineca Mountains during stratigraphic and structural studies by J.W.H. Monger in 1972 and by Monger and I.A. Paterson in 1973. Although the Omineca Mountains are relatively small in geographic extent, they contain three different upper Paleozoic volcanic and sedimentary rock assemblages. Some of the fusulinacean faunas are from Middle Carboniferous to Permian carbonates of the Lay Range lithic assemblage in the eastern part, shown on Textfigure 5; others are from Permian metasediments of the Cache Creek and Asitka groups in the western part. Previously, Monger and Ross (1971) thought that faunas in the Asitka Group belonged with those in the Lay Range assemblage in an eastern belt of fusulinaceans and that those in the Cache Creek Group were part of a central belt. Recent work (Richards, 1976) shows that the Asitka Group is overthrust from the east by the Cache Creek Group. Therefore, the Asitka Group originally lay west of the Cache Creek Group and probably has affinities with upper Paleozoic rocks in the Stikine area that Monger and Ross (1971) included in their western belt.

Lay Range

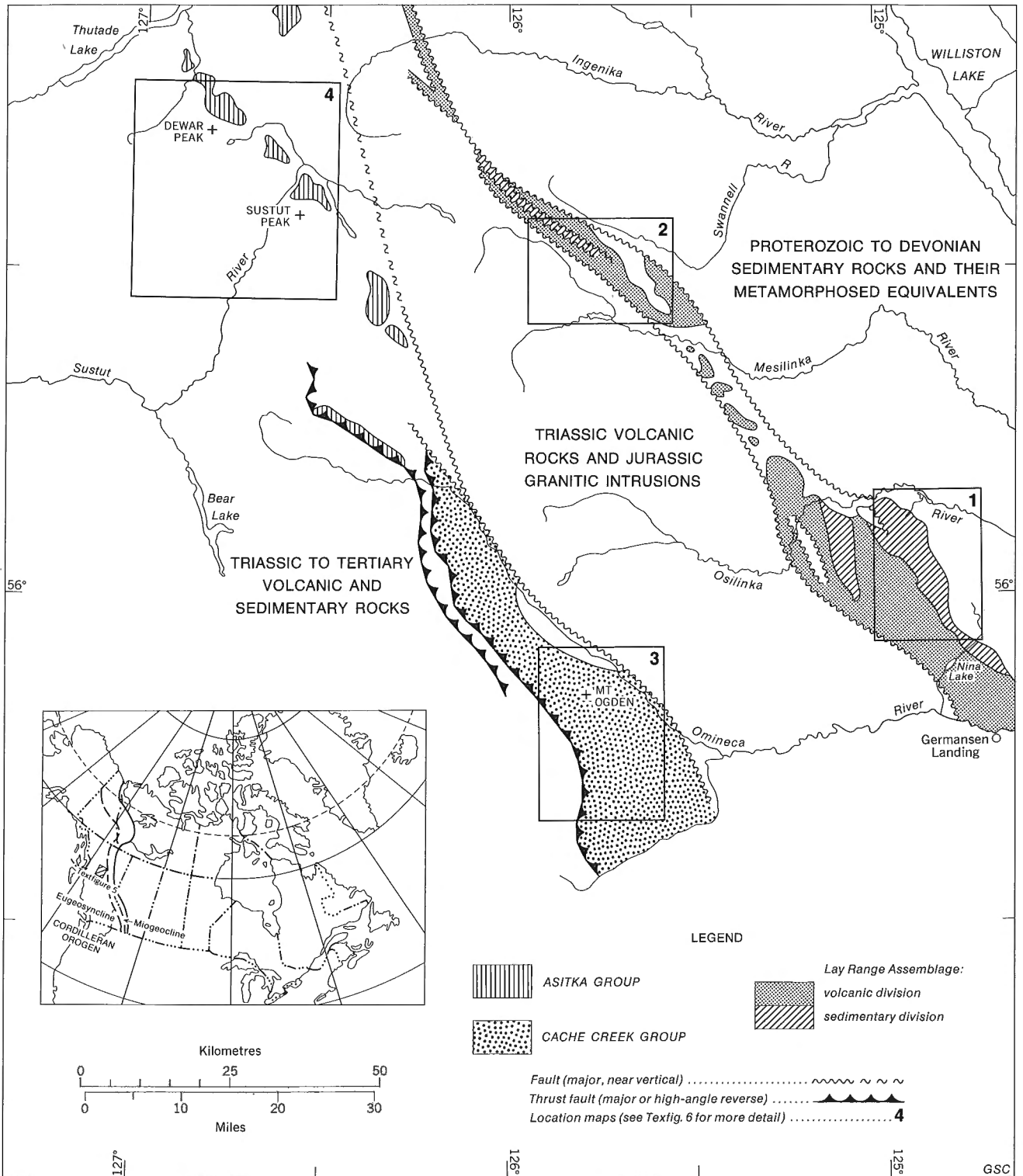
The Lay Range lithic assemblage is the easternmost 'eugeosynclinal' stratigraphic facies in the Cordillera at this latitude. South of the Osilinka River, these rocks lie in apparently normal stratigraphic sequence on a succession of Middle Devonian to upper Proterozoic sedimentary and metasedimentary, miogeosynclinal strata (Monger, 1973; Monger and Paterson, 1974). North of the Osilinka River, in the Lay

Range, these rocks are exposed as a series of narrow, imbricated fault slices that lie between Proterozoic metasedimentary rocks to the east and Upper Triassic volcanic rocks to the west (Roots, 1954). The lower part of this eugeosynclinal facies is mainly cherty argillite, chert and slate, with local conglomerate and quartzite, and minor amounts of acid tuff and fusulinacean-bearing carbonate strata. The upper part is basalt and interbedded volcanoclastics (Nina Creek greenstone of Armstrong, 1949), lies conformably on the lower part and has yielded a conodont fauna of Permian, possibly Leonardian, age from one locality (GSC loc. 86400, B.E.B. Cameron, *pers. com.*).

The fusulinacean faunas from south of the Osilinka River are in argillaceous limestone beds in about the middle part of the section (Textfig. 6). The collections from 3 km (2 mi) northwest of End Lake on the Osilinka River, GSC locs. C-37899 and C-37917, contain broken and fragmentary fusulinaceans that probably include *Pseudofusulinella(?)* species, *Schwagerina(?)* species, *Schubertella(?)* species and *Triticites* species. These forms indicate Early Permian but the two collections possibly may be of slightly different age. The fauna from 10 km (6 mi) north of Nina Lake, GSC loc. C-37898, has *Pseudofusulinella (Kanmeria) meeki* Skinner and Wilde and *Triticites* species that indicate a stratigraphic position close to the Carboniferous-Permian boundary.

The fusulinacean faunas in the Lay Range are from a series of aligned, locally extremely foliated, carbonate pods in a fault slice of the lower division that forms the crest of the range (Textfig. 6). Previously crinoids, corals, bryozoans and brachiopods of "Mississippian to possibly Permian" age were collected from these carbonates by Roots (1954, p. 118, 119) and Pennsylvanian fusulinids by J.K. Rigby (*pers. com.*). Specimens collected in 1972 from GSC localities C-37879 to C-37889 represent strata of two ages. Six localities, C-37879,

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Textfigure 5. Distribution of upper Paleozoic rocks in the central Omineca Mountains, British Columbia. Location of more detailed maps showing sample localities (see also Textfig. 6)

C-37882, C-37884, C-37886, C-37888 and C-37889, contain *Profusulinella prisca* (Deprat). This widely distributed species is associated at one or more of these localities with *P. arta* Leontovich, *P. ovata* Rauzer-Chernousova, *Profusulinella* species, *Fusulinella*(?) *densa* new species and *Pseudoendothyra* species (Table 4). This assemblage is a late early Moscovian fauna characteristic of the Kashirian Stage (Textfig. 7). Two localities, C-37883 and C-37887, contain *Pseudoendothyra timanica* Rauzer-Chernousova and either *Pseudostaffella gorskyi* (Dutkevich) or *Pseudostaffella paracompressa* Safonova, *Millerella* species and *Eostaffella* species; these are early Moscovian, probably also Kashirian, in age. Four localities, C-37880, C-37881, C-37885, and C-37920, contain *Fusulinella decora* new species, *F. concava* new species, *Wedekindellina* cf. *W. uralica* (Dutkevich), or a combination of these species and form a distinctive late Moscovian (Myachkovian) fauna (Textfig. 7).

Cache Creek Group

At this latitude, at the northern end of the Stuart Lake belt of Armstrong (1949, p. 32), the Cache Creek Group is highly deformed and metamorphosed, typically in the lower greenschist facies but, locally, transitional to blueschist facies (Paterson, 1974). It is an entirely fault-bounded terrane, lying between the Pinchi Fault to the east and a series of east-dipping thrusts or reverse faults that bring the Cache Creek Group over metamorphosed Upper Triassic and underlying Permian rocks of the Asitka Group to the west (Paterson, *ibid.*; Richards, 1976). The rocks comprise chert, phyllite, greywacke, metabasalt and bodies of commonly recrystallized carbonate and associated alpine ultramafic rock; these bodies range in size up to 10 km (6 mi) long and 5 km (3 mi) wide.

The fusulinaceans in this report were collected from massive carbonates on Mount Ogden, where they occur together with crinoids, horn corals and bryozoans (Textfig. 6). Fossils collected earlier by Armstrong (1949, p. 45-47) from less metamorphosed rocks farther south in the Stuart Lake belt include a similar variety and are of Late Pennsylvanian, Early Permian and Late Permian ages. Fusulinaceans of Pennsylvanian and Early Permian ages were described by Thompson *et al.* (1953) and Thompson (1965). The fossils from Mount Ogden are recrystallized 'ghosts' of *Neoschwagerina*(?) or *Yabeina* of Middle to Late Permian age.

Asitka Group

Field work in 1975 showed that the Asitka Group lies disconformably below Upper Triassic rocks that in turn are overthrust from the east by strata of the Cache Creek Group (Richards, 1976). Near Dewar Peak, the Asitka Group can be subdivided into three parts. The lowest is composed of basalt, argillite, chert, tuffaceous carbonate and carbonate, and contains a fauna of fusulinaceans, corals, bryozoans, brachiopods and echinoderms of Early Permian age (Lord, 1948). Above this is a volcanic division that ranges from basalt to rhyolite and that probably was extruded subaerially. The uppermost part comprises basalt and tuffaceous carbonate with a fauna of sponges, corals, bryozoans, brachiopods and echinoderms. Rigby (1973) recently has studied sponges from

this unit and suggests that they are of Permian, probably Early Permian, age.

The fusulinaceans in this study, collected on Sustut, Dewar and Niven peaks, are from foliated, tuffaceous limestone of the lowest division (Textfig. 6). Strata of the Asitka Group at these eight localities (Table 4) are of nearly the same age, middle and late Asselian to possibly early Sakmarian.

Acknowledgments

It is a pleasure to acknowledge and thank I.A. Paterson for collecting some of the material and for his discussion of the stratigraphic significance of this interesting fauna, and also B.S. Norford for critically reading the manuscript.

Systematic Paleontology

by Charles A. Ross

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

Order Foraminiferida

Family Ozawainellidae Thompson and Foster, 1937

Genus *Millerella* Thompson, 1942

Millerella species

Plate 11, figure 12

Material and occurrence. One axial section, GSC 44544, and about six randomly oriented sections, from GSC loc. C-37887.

Discussion. This small species becomes progressively more evolute in later volutions (Pl. 11, fig. 12) and reaches 0.6 mm diameter in 4 to 4½ volutions. Chomata are well displayed. The volutions in *Millerella* sp. are more regularly coiled than in *M. marblensis* Thompson from south-central British Columbia and Washington.

Age. The associated fauna includes fragments of a species of *Profusulinella* and *Pseudostaffella paracompressa* Safonova and indicates an early Moscovian age.

Genus *Eostaffella* Rauzer-Chernousova, 1948

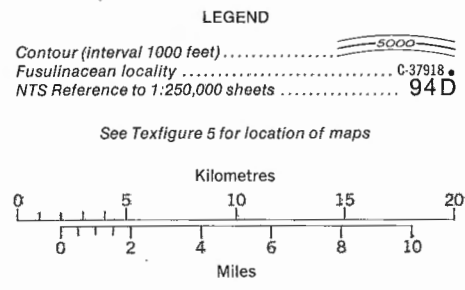
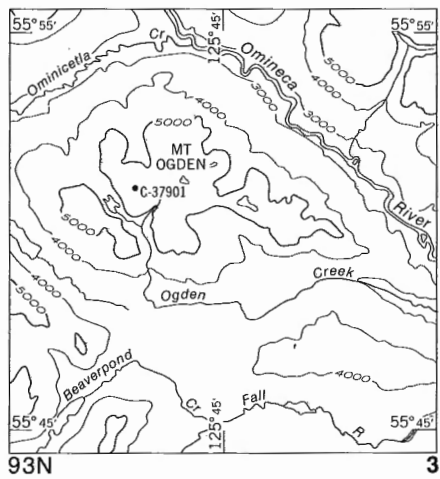
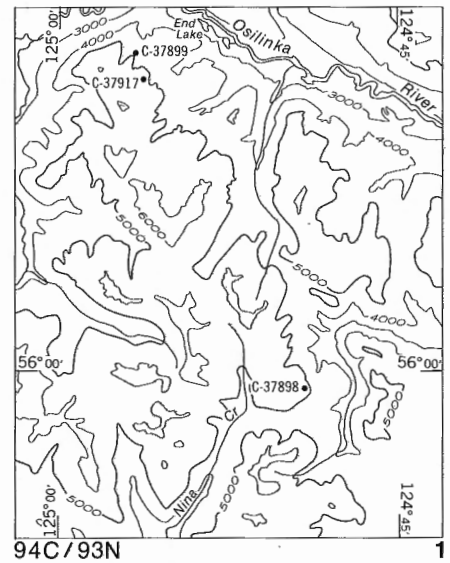
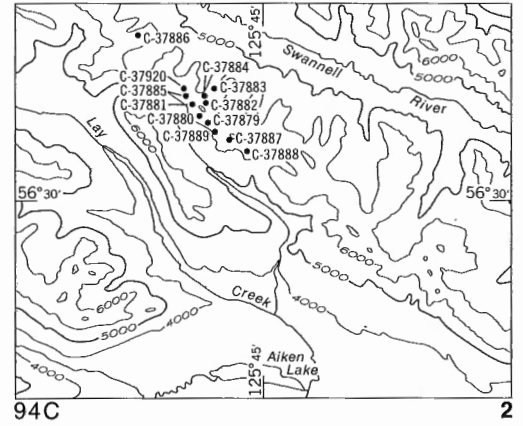
Eostaffella species

Plate 10, figure 32

Material and occurrence. One axial section, GSC 44545, and some randomly oriented thin sections, from GSC loc. C-37887.

Discussion. This thickly lenticular, involute species has slightly dimpled poles and low inconspicuous chomata, and reaches 0.6 mm diameter in 5 to 6 volutions. The outer chambers of this species are more inflated and the specimens are smaller than *Eostaffella columbiana* Sada and Danner and *E. kanmerai* (Igo) from south-central British Columbia and *E. britishensis* (Ross) from northern Yukon Territory.

Age. The associated fauna includes fragments of a species of *Profusulinella* and *Pseudostaffella paracompressa* Safonova and indicates an early Moscovian age.



Textfigure 6. Location of fusulinacean localities in the Omineca Mountains (see index, opposite page)

Locality index, Textfigure 6

GSC loc.	Area	Map reference	GSC loc.	Area	Map reference
	Osilinka River (map 1) <i>Fort Grahame map-area (94C)</i>		C-37888	Carbonate, southeast end of knoll of C-37887	10V CT 329990 6267420
C-37889	Carbonate bed in predominant cherty argillite, on ridge about 3 km (2 mi) west-southwest of End Lake, Osilinka River	10V CT 379250 6222450	C-37889	Carbonate, southwest side of main ridge of Lay Range	10V CT 328800 6267820
C-37917	Carbonate bed in calcareous argillite, on slope 4 km (2.25 mi) southwest of End Lake, Osilinka River	10V CT 379600 6221000	C-37920	Carbonate, lip of northeast-facing cirque, on main ridge of Lay Range	10V CT 326750 6270530
	<i>Manson River map-area (93N)</i>			Mount Ogden (map 3) <i>Manson River map-area (93N)</i>	
C-37898	Brown carbonate bed in argillite and siliceous argillite, on ridge 10 km (6 mi) north of Nina Lake	10U CT 386620 6206550	C-37901	Black calcareous siltstone	10U CS 323550 6192900
	Lay Range (map 2) <i>Fort Grahame map-area (94C)</i>			Sustut River (map 4) <i>McConnell Creek map-area (94D)</i>	
C-37879	Carbonate, southwest side of ridge, near top	10V CT 328450 6268750	C-37891	Tuffaceous carbonate, just above contact with Triassic argillite, on northeast spur of Sustut Peak, 1.6 km (1 mi) from summit	9V XN 649370 6275700
C-37880	Carbonate, southwest side of ridge, near summit	10V CT 327500 6269750	C-37892	Brown tuffaceous carbonate, above C-37891, same locality data	
C-37881	Carbonate, southwest side of ridge, just below and west of high point	10V CT 327250 6270100	C-37893	Calcareous tuffs, ridge northeast of Dewar Peak, 2 km (1.25 mi) from summit, at elevation 1737 m (5700 ft)	9V XN 635800 6291000
C-37882	Carbonate, on northeast-trending spur, northeast side of ridge just below summit	10V CT 328230 6269750	C-37897	Carbonate, on ridge northeast of Niven Peak, 2.5 km (1.5 mi) from summit	9V XN 632300 6294300
C-37883	Carbonate, north end of northeast spur above Swannell River, on northeast side of main ridge of Lay Range	10V CT 328620 6270370	C-37918	Tuffaceous carbonate, top of ridge, 1.6 km (1 mi) northwest of Niven Peak, at elevation 1981 m (6500 ft)	9V XN 631600 6294500
C-37884	North side of same carbonate body as C-37882	10V CT 328200 6270100	C-37999a	Sample marked loc. 5 with samples marked Lord's fossil locality 7, GSC Mem. 251, Map 962A, same or similar locality to C-37892	
C-37885	Carbonate, near top of southwest side of slope	10V CT 327100 6270470	C-37999	Lord's locality 7, GSC Mem. 251, Map 962A, same or similar locality to C-37892	
C-37886	Carbonate, north side of Lay Range, above Swannell River	10V CT 325300 6273120	C-38000	Lord's locality 5, GSC Mem. 251, Map 962A, approximately 3.2 km (2 mi) southeast of C-37892	
C-37887	Carbonate, forms large knoll on high point of main ridge of Lay Range	10V CT 329250 6268010			

Family Staffellidae Miklukho-Maklay, 1949

Genus *Pseudoendothyra* Mikhailov, 1939

Pseudoendothyra timanica (Rauzer-Chernousova)

Plate 11, figures 8, 10, 13, 19, 23, 28, 30, 32–42

Parastaffella timanica Rauzer-Chernousova in Rauzer-Chernousova et al., 1951, p. 148, Pl. 12, figs. 12, 13

Material and occurrence. Specimens include fifteen axial sections, GSC 44547 to 44561, and three sagittal sections, GSC 44562 to 44564, from GSC loc. C-37883; also present at C-37887.

Description. This small, thickly lenticular species commonly reaches 0.5 mm in length, 1 mm diameter and a form ratio of 0.5 in 5 to 6 volutions. In specimens measured, proloculi range from 0.03 to 0.05 mm outside diameter. The axis of coiling of the first one or two volutions is parallel to that of later volutions and the coiling is evolute. Succeeding volutions increase gradually in height (Pl. 11, figs. 23, 38, 39) and the shell has a broadly rounded periphery (Pl. 11, figs. 8, 10, 13, 19, 30, 32–37, 40–42). In some specimens, the lateral slopes are slightly flattened (Pl. 11, figs. 13, 37) in the later volutions and this gives the shells a more angular outline; however, this flattening is apparently the result of diagenetic alteration. The spiral wall is recrystallized but appears to have been originally composed of a tectum, protheca and minor secondary layers. As seen in sagittal section (Pl. 11, figs. 23, 38, 39), the septa appear relatively thick but are clearer, except at their bases, than the spiral wall. Septa are planar across the face of the shell.

The tunnel is poorly defined because of the extensive recrystallization of the shell walls. Chomata, where they are well preserved, outline the tunnel (Pl. 11, figs. 19, 42) and show that it follows a regular path and gradually increases in width.

Remarks. The species has a less sharply rounded periphery than *P. bradyi* (von Möller) and lacks the strongly indented poles of *P. umbonata* Rauzer-Chernousova. *Pseudoendothyra depressa* (Thompson) from southwestern United States has higher chambers, and *P. powwowensis* (Thompson) is more globose in outline.

Age. In the U.S.S.R. *Pseudoendothyra timanica* occurs in the Bashkirian and lower and middle Moscovian (Vereian to Podol'ian) of the Russian Platform and Ural Mountains. Because it occurs with an unidentified species of *Profusulinella*(?) in GSC loc. C-37883, the age of the present material is probably early Moscovian.

Pseudoendothyra species

Plate 11, figure 2

Material and occurrence. One axial specimen, GSC 44546, and two randomly oriented thin sections from GSC loc. C-37882.

Discussion. This small species has a sharply rounded outline and reaches 0.3 mm diameter in three volutions. The specimen measured (Pl. 11, fig. 2) is probably immature but indicates the overlap of successive half-volutions at the poles. The spiral wall is partly recrystallized and small low chomata are present. In general outline the shell is similar to *Pseudoendothyra umbonata* Rauzer-Chernousova or *P. preobrajenskyi* (Dutkevich) from the Russian Platform, but is smaller.

Age. The taxon is associated with *Profusulinella prisca* (Deprat) in GSC loc. C-37882 and is of early Moscovian (Kashirian) age.

Family Fusulinidae von Möller, 1878

Genus *Profusulinella* Rauzer-Chernousova and Belyaev, 1936

Profusulinella prisca (Deprat)

Plate 8, figures 9–25, 27–30, 38, 41–43, 46, 47(?)

Schwagerina prisca Deprat, 1912, p. 41, Pl. 4, figs. 10–14

Profusulinella prisca (Deprat), Rauzer-Chernousova, Belyaev and Reitlinger, 1936, p. 176, Pl. 1, fig. 1; Grozdilova and Lebedeva, 1960, p. 144, Pl. 19, fig. 6

Material and occurrence. Specimens include eleven axial sections, GSC 44458 to 44468, from GSC loc. C-37879; eight axial sections, GSC 44449 to 44456, and one oblique sagittal section, GSC 44457, from GSC loc. C-37882; one axial section, GSC 44469, and one oblique sagittal section, GSC 44470, from GSC loc. C-37884; two axial sections, GSC 44471 and 44472, from GSC loc. C-37888; one axial section, GSC 44473, from GSC loc. C-37889; one axial section, GSC 44474, from GSC loc. C-37886; and one axial section, GSC 44475 assigned with question from GSC loc. C-37885.

Description. This small subglobose species reaches 2.5 mm length and 1.2 mm diameter in 6 to 7 volutions. In specimens measured, proloculi range from 0.03 to 0.12 mm outside diameter. In specimens with smaller proloculi, the first volution commonly is coiled at a high angle to later volutions (Pl. 8, figs. 18, 21–25, 27–30, 38). In succeeding volutions, the chamber height increases markedly and the shell maintains a globose to subglobose shape (Pl. 8, figs. 9–25, 27–30, 38, 43, 46). The lateral slopes are convex and the poles are bluntly rounded. Septa are nearly planar and are only gently warped near the poles. The spiral wall has a tectum, protheca and irregularly distributed outer tectorial deposits. Tunnel is well developed, follows a nearly regular path and is bordered by massive asymmetrical chomata, which reach to the top of the tunnel at the septa and are low and broad between septa. Other secondary deposits are lacking.

Remarks. The species is more globose than *P. regia* Thompson, from West Texas and Utah, and *P. decora* Thompson and *P. munda* Thompson, from West Texas. *Profusulinella copiosa* Thompson is smaller and has less well developed chomata. Several subspecies of *P. prisca* have been described from the Russian Platform and the specimens from the Omineca Mountains are most similar in size to *P. prisca timanica* Kireeva but lack the thick outer tectorium apparently present in that subspecies. *Profusulinella priscoidea* Rauzer-Chernousova from the Russian Platform and Greenland has more massive chomata.

Age. Now reported from western Canada, *Profusulinella prisca* is a widely distributed species in strata of late early Moscovian (Kashirian) age in eastern Europe and southeastern Asia.

Profusulinella ovata Rauzer-Chernousova

Plate 8, figures 26, 31–34, 36, 37, 39, 40;

Plate 10, figures 1–3, 5, 6, 8–11

Profusulinella ovata Rauzer-Chernousova, 1938, p. 101, Pl. 1, figs. 14–16

Material and occurrence. Specimens include seven axial sections, GSC 44476 to 44482, and one sagittal section, GSC

Table 4. Distribution of fusulinacean species in collections studied from Omineca Mountains

		FUSULINACEAN SPECIES																							
ASITKA GROUP	LAY RANGE	GSC LOCALITY	<i>Millerella</i> species	<i>Eostaffella</i> species	<i>Pseudoendothyra timanica</i> Rauzer-Chernousova	<i>Pseudoendothyra</i> species	<i>Pseudostaffella gorskyi</i> Grozdilova and Lebedeva	<i>P. paracompressa</i> Safonova	<i>Profusulinella prisca</i> (Deprat)	<i>P. arta</i> Leontovich	<i>P. ovata</i> Rauzer-Chernousova	<i>Profusulinella</i> species	<i>Fusulinella decora</i> new species	<i>F. concava</i> new species	<i>F. (?) densa</i> new species	<i>Wedekindellina</i> cf. <i>W. uralica</i> (Dutkevich)	<i>Pseudofusulinella (Kanmeria) meeki</i> (Skinner and Wilde)	<i>Pseudofusulinella (Kanmeria)</i> species	<i>Triticites</i> species	<i>Pseudofusulina (?)</i> species	<i>Schwagerina sustutensis</i> new species	<i>Schwagerina</i> species	<i>Pseudoschwagerina</i> cf. <i>P. moelleri</i> Rauzer-Chernousova	<i>Eoparafusulina</i> species	
				C-37879							X						X								
		C-37880											X												
		C-37881											X			X									
		C-37882				X			X			X			X										
		C-37883			X		X																		
		C-37884							X		X														
		C-37885							X				X	X		X									
		C-37886							X																
		C-37887	X	X	X			X																	
		C-37888							X	X	X														
		C-37889							X		X														
		C-37920											X	X											
		C-37891																				X			
		C-37892																				X			
		C-37893																							
		C-37897																X							
		C-37918																	X						
		C-37999																					X		
		C-37999a																					X		
		C-38000																					X		
		C-37898															X		X						
		C-37899	recrystallized fragments of <i>Pseudofusulinella(?)</i> and <i>Schwagerina(?)</i>																						
		C-37901	recrystallized <i>Neoschwagerina(?)</i> or <i>Yabeina(?)</i>																						
		C-37917	recrystallized <i>Triticites(?)</i> , <i>Pseudofusulinella(?)</i> and <i>Schubertella(?)</i>																						

GSC

		RUSSIAN PLATFORM AND URAL MTS	NORTH AMERICAN REFERENCE	
PERMIAN	EARLY PERMIAN	Artinskian	Leonardian	
		Sakmarian	Wolfcampian	
		Sterlitamakian		
		Tastubian		
	Asselian			
	CARBONIFEROUS	MIDDLE CARBONIFEROUS	LATE CARBONIFEROUS	
			LATE PENNSYLVANIAN	
			Myachkovian	Desmoinesian
Podol'ian				
Kashirian			Atokan	
Vereian				

GSC

Textfigure 7. Correlation of part of Russian Platform and Ural Mountains stratigraphic units with those of North America

44483, from GSC loc. C-37884; one axial section, GSC 44484, from GSC loc. C-37888; and nine axial sections, GSC 44485 to 44493, from GSC loc. C-37889.

Description. This small species is thickly fusiform and reaches 2.5 mm length, 1.2 mm diameter and a form ratio of about 2.1 in 5½ to 6 volutions. In specimens measured, proloculi range from 0.05 to 0.11 mm outside diameter. The first volution is coiled at a high angle to the later volutions and is low and subglobose (Pl. 10, figs. 1, 9). Succeeding volutions gradually increase in height and length to give the shell a thickly fusiform outline (Pl. 8, fig. 31; Pl. 10, figs. 1, 2, 3, 8, 9). Lateral slopes are convex and taper to small rounded poles (Pl. 8, fig. 39; Pl. 10, fig. 1). The spiral wall is composed of a tectum, protheca and irregularly distributed outer tectorial layers. Septa are nearly planar and only near the poles are they gently curved.

The tunnel is well displayed and follows a regular path; it increases markedly in width in the fifth or sixth volution (Pl. 8, fig. 39; Pl. 10, figs. 1, 9) and is bordered by prominent chomata. Chomata are higher than the tunnel and are massive and asymmetrical (Pl. 10, figs. 1, 9). Axial deposits are minor but may be present in the axial region of mature specimens (Pl. 10, figs. 1, 2).

Remarks. In having a more elongate shape *Profusulinella ovata* differs from *P. prisca* (Deprat), and in its less subcylindrical outline, from *P. constans* Safonova. *Profusulinella burrensis*

Thompson and Shaver from the Illinois Basin is similar in shape but has wider, more asymmetrical chomata, and *P. kentuckyensis* Thompson and Riggs is more elongate.

Age. The species *Profusulinella ovata* occurs in the late early Moscovian (Kashirian) of the Russian Platform in beds associated with *P. prisca* (Deprat).

Profusulinella arta Leontovich

Plate 8, figures 35, 44, 45; Plate 10, figure 4

Profusulinella arta Leontovich in Rauzer-Chernousova et al., 1951, p. 180, Pl. 19, figs. 4-6

Material and occurrence. Three axial sections, GSC 44494 to 44496, and one sagittal section, GSC 44497, from GSC loc. C-37888.

Description. This elongate fusiform to subcylindrical species reaches 2.5 mm length, 1.1 mm diameter and a form ratio of about 2.3 in 5 to 6 volutions. In the three specimens measured (Pl. 8, figs. 35, 44, 45) proloculi range from 0.04 to 0.10 mm outside diameter. Specimens having a small proloculus have a first volution that is coiled at a high angle to later volutions (Pl. 8, figs. 44, 45). The succeeding volutions increase regularly in height (Pl. 10, fig. 4) and length to give the shell an elongate fusiform (Pl. 8, fig. 35) or subcylindrical (Pl. 8, fig. 44) outline at maturity. Lateral slopes are regularly to slightly irregularly convex and pass into rounded poles. The thin spiral wall is composed of a tectum and protheca and irregularly distributed outer tectorial deposits. Septa are thin and nearly planar near the poles, where they are gently folded.

The tunnel is well displayed and increases markedly in width in later volutions (Pl. 8, figs. 35, 44, 45). Chomata line the tunnel and are low, massive and asymmetrical. Axial deposits are minor.

Remarks. The species *Profusulinella arta* is more elongate than *P. prisca* (Deprat), *P. ovata* Rauzer-Chernousova and *P. constans* Safonova. In general size, shape and most internal features, it compares closely with *P. kentuckyensis* Thompson and Riggs but is more regular in outline.

Age. In the U.S.S.R. *Profusulinella arta* occurs in the early Moscovian (Vereian and Kashirian) of the Russian Platform.

Profusulinella(?) species

Plate 10, figure 7

Material and occurrence. One axial section, GSC 44498, from GSC loc. C-37882.

Discussion. This specimen reaches 3 mm length and 1.8 mm diameter in 5 to 5½ volutions. The proloculus is large, 0.16 mm outside diameter, and the first volutions are high and globose. Height and length increase gradually and the lateral slopes are nearly straight and taper to broadly rounded poles (Pl. 10, fig. 7). The spiral wall is thick and is composed of a tectum and a protheca. The slide with the specimen is thick and septa intersecting the plane of the slide give the shell a dark appearance. The tunnel and chomata are shown well.

This may be a specimen of *Profusulinella prisca* (Deprat); however, this specimen has a larger proloculus, more strongly developed chomata and is slightly larger than most of the specimens assigned to *P. prisca* in the same collection.

Age. Moscovian, probably Kashirian.

Genus *Fusulinella* von Möller, 1877*Fusulinella*(?) *densa* new species

Plate 8, figures 1–8

Material and occurrence. Specimens include four axial sections, paratype GSC 44441, holotype 44442 and paratypes GSC 44443 and 44444, and one sagittal section, paratype GSC 44448, all from GSC loc. C-37879; and three axial sections, paratypes GSC 44445 to 44447, from GSC loc. C-37882.

Description. This elongate fusiform species reaches 2.7 mm length and 1.2 mm diameter in 6 to 6½ volutions. In specimens measured, proloculi range from 0.05 to 0.10 mm outside diameter. The first volutions are subglobose and succeeding volutions become progressively elongate to reach a form ratio of about 2.2 by the sixth volution (Pl. 8, figs. 1–7). The lateral slopes of the later volutions commonly are slightly concave (Pl. 8, figs. 1, 2, 5) and the poles are narrowly to sharply rounded. The chambers are of nearly constant height from the equatorial region to near the poles. The spiral wall is composed of a tectum and protheca or diaphanotheca, and has thin inner and heavy outer tectorial deposits. Septa are nearly planar from pole to pole (Pl. 8, figs. 1, 2, 4).

Other internal features of the shell include a narrow, well developed tunnel that follows a nearly regular path (Pl. 8, figs. 2, 5). Well developed and asymmetrical chomata are high at the septa, reaching to the top of the tunnel. The chomata merge with thick outer tectorial deposits to form extensive axial deposits (Pl. 8, figs. 1, 2, 5–7).

Remarks. In *Fusulinella*(?) *densa* new species the fusulinellid wall is poorly developed with only a thin and generally discontinuous inner tectorial layer. The prothecal or diaphanothecal layer is not as clear as the normal fusulinid wall. The heavy, low, broad chomata are similar to those seen in some species of *Profusulinella*, such as *Profusulinella pararhomboides* Rauzer-Chernousova and Belyaev and *P. pseudorhomboides* Putrja, from the Russian Platform, but those species apparently have a protheca rather than a diaphanotheca and an inner tectorial layer. *Profusulinella burrensis* Thompson and Shaver has strongly developed chomata but has higher volutions. *Wedekindellina matura* Thompson, from the Desmoinesian Series in Utah, Arizona and Colorado, is similar but more elongate and has higher, less massive chomata. *Fusulinella keatingensis* Ross and Sabins from Arizona has a well developed fusulinellid wall.

Age. The association of *Fusulinella*(?) *densa* with *Profusulinella prisca* (Deprat) in GSC locs. C-37879 and C-37882 indicates a late early Moscovian (Kashirian) age.

Fusulinella concava new species

Plate 9, figures 1, 3, 5, 13, 14, 18

Material and occurrence. Specimens include three axial sections, holotype GSC 44499 and paratypes GSC 44500 and 44501, from GSC loc. C-37885; and three axial sections, paratypes GSC 44502 to 44504, from GSC loc. C-37920.

Description. This thickly fusiform species reaches 4 mm length, 2.4 mm diameter and a form ratio of 1.7 in 6½ to 7 volutions. In specimens measured, proloculi range from 0.03 to 0.07 mm outside diameter. The first one or two volutions are low and coiled at a high angle to later volutions. Succeeding volutions

gradually increase in height and length and form a distinctive thick equatorial region. Lateral slopes are concave in mature volutions and meet at rounded poles. The spiral wall is composed of a tectum, diaphanotheca and inner and outer tectorial deposits (Pl. 9, figs. 1, 3). Septa are gently folded near the poles and nearly planar across the equatorial region.

The tunnel is clearly defined, follows a regular path and gradually widens. Chomata are massive, asymmetrical to tabular and reach above the top of the tunnel at the septa (Pl. 9, figs. 1–3, 18). In the first four or five volutions, the chomata merge with thick tectorial deposits on the floor of the chambers.

Remarks. In general stage of evolutionary development *Fusulinella concava* compares with *F. pulchra* Rauzer-Chernousova and Belyaev and *F. eopulchra* Rauzer-Chernousova from the Russian Platform and Ural Mountains but is less elongate than those two species. *Fusulinella concava* is not closely similar to described species of *Fusulinella* from southwestern Canada or the southwestern part of the North American craton. *Fusulinella concava* takes its name from the Latin *concavus* in allusion to the outline of its lateral slopes.

Age. Late Moscovian (Myachkovian).

Fusulinella decora new species

Plate 9, figures 2, 4, 6–12, 15–17, 19;

Plate 10, figures 12–15, 17–19, 21, 22

Material and occurrence. Specimens include eight axial sections, holotype GSC 44505 and paratypes GSC 44506 to 44512, and one tangential section, paratype GSC 44513, from GSC loc. C-37885; two near axial sections, paratypes GSC 44514 and 44515, from GSC loc. C-37920; four axial sections, paratypes GSC 44516 to 44519, two oblique sagittal sections, paratypes GSC 44520 and 44521, and one tangential section, paratype GSC 44522, from GSC loc. C-37881; and four axial sections, paratypes GSC 44523 to 44526, from GSC loc. C-37880.

Description. This elongate fusiform species reaches 5.5 mm length, 2.2 mm diameter and a form ratio of 2.5 in 7 to 8 volutions. In specimens measured, proloculi are small, ranging from 0.02 to 0.06 mm outside diameter. The early one to three volutions are low and coiled at a high angle to later volutions (Pl. 9, figs. 2, 4, 6, 7, 9, 11). Succeeding volutions increase proportionally more in length than height to make the shell elongate. Lateral slopes are slightly convex to slightly concave (Pl. 9, figs. 2, 4, 6–12, 15–17, 19; Pl. 10, figs. 12, 13, 15, 17–19, 21, 22). Septa are gently folded (Pl. 10, fig. 14) near the poles and across the equatorial region. The poles are acutely rounded (Pl. 9, figs. 2, 4, 6). The spiral wall is composed of a tectum, diaphanotheca and well developed inner and outer tectorial deposits (Pl. 9, fig. 5).

The tunnel follows a slightly irregular path and gradually increases in width. High, massive, asymmetrical to nearly symmetrical chomata border the tunnel and extend over the tunnel at the septa. The septa (Pl. 9, figs. 6, 15; Pl. 10, fig. 14) appear to be heavily coated with extension of the secondary deposits that form the chomata. These deposits give the shells a dense or dark appearance in many thin sections (Pl. 9, figs. 10, 12; Pl. 10, figs. 18, 19, 21, 22).

Remarks. Although *Fusulinella decora* is more elongate than *F. eopulchra* Rauzer-Chernousova and *F. pulchra* Rauzer-Chernousova and Belyaev, it has similarly constructed chomata and represents a similar stage of evolutionary development. *Fusulinella decora* differs from *F. concava* new species in being more elongate. It is not closely similar to other species of *Fusulinella* described from western Canada or the southwestern part of the North American craton. *Fusulinella decora* takes its name from the Latin *decorus* in reference to its inner beauty as seen in thin sections.

Age. Late Moscovian (Myachkovian). *Fusulinella decora* occurs with *F. concava*.

Genus *Wedekindellina* Dunbar and Henbest, 1933

Wedekindellina cf. *W. uralica* (Dutkevich)

Plate 10, figures 16, 20, 23–25

cf. *Fusulinella uralica* Dutkevich, 1934, p. 47, 84, Pl. 5, figs. 7, 11–16
cf. *Wedekindellina uralica* (Dutkevich), Rauzer-Chernousova and Belyaev in Rauzer-Chernousova, Belyaev and Reitlinger, 1936, p. 183, Pl. 2, figs. 5–7; Rauzer-Chernousova and Safonova in Rauzer-Chernousova *et al.*, 1951, p. 237, Pl. 36, figs. 1, 2; Grozdilova and Lebedeva, 1960, p. 158, Pl. 26, fig. 1

Material and occurrence. One partial axial section, GSC 44527, and an oblique sagittal section, GSC 44528, from GSC locality C-37881; three axial or oblique axial sections, GSC 44529 to 44531, from GSC locality C-37885.

Discussion. This elongate ellipsoidal species reaches 3 mm length and 0.8 mm diameter in 7 volutions. The proloculi are small, about 0.06 mm outside diameter, and the first volution is commonly coiled at a high angle to later volutions (Pl. 10, figs. 16, 25). In succeeding volutions, length increases proportionally more than height and the shell becomes markedly elongate. The spiral wall is thin and slightly recrystallized in specimens examined but seems to be composed of a tectum and thin diaphanotheca and thick tectorial deposits. Septa are planar except close to the poles. The narrow tunnel follows a nearly regular path. Chomata are well developed and merge with thick tectorial deposits on the floor and sides of the chambers, giving the shell a dense dark appearance in thin sections.

The specimens from the Omineca Mountains compare closely in morphological features with *Wedekindellina uralica* from the Russian Platform and Ural Mountains but are smaller. *Wedekindellina dutkevichi* Rauzer-Chernousova and Belyaev from the Russian Platform, the Ural Mountains and Greenland is more elongate and less ellipsoidal in shape.

Age. Late Moscovian (Myachkovian).

Subgenus *Pseudofusulinella* (*Kanmeraia*) Ozawa, 1967

Pseudofusulinella (*Kanmeraia*) *meeki* Skinner and Wilde

Plate 11, figures 4, 21, 24; Plate 12, figure 16

Pseudofusulinella meeki Skinner and Wilde, 1965, p. 28, Pl. 8, figs. 13–17

Material and occurrence. Specimens include two axial sections, GSC 44577 and 44578, one tangential section, GSC 44576, and about 24 randomly oriented fragments (not illustrated), all from GSC loc. C-37898.

Description. This large species reaches 7 mm length, 2.5 mm diameter and a form ratio of 2.8 in 8 to 9 volutions. Proloculi

are about 0.08 mm outside diameter and early volutions are low and subglobose. Volutions gradually increase in length and lateral slopes may be concave in fifth and later volutions. Poles are narrow and sharply rounded (Pl. 11, figs. 4, 21, 24). Spiral wall is composed of a tectum, diaphanotheca and tectorial deposits (Pl. 12, fig. 16). Septa are nearly planar except in the polar region, where they are slightly folded.

Tunnel is well defined and follows a nearly regular path between high, massive, tabular chomata (Pl. 12, fig. 16). Tectorial deposits are well developed above and near tunnel and on floor of chambers. Minor secondary deposits appear in axial region of early volutions.

Remarks. Based on size and form ratio, *Pseudofusulinella meeki* is an early member of the genus and belongs to *P. (Kanmeraia)* Ozawa, which ranges from Missourian to middle Wolfcampian (*note* Ross and Bamber, this bulletin, p. 30, 31). The species is similar to other species of *Pseudofusulinella* such as *P. prima* Skinner and Wilde, *P. ventricosus* Skinner and Wilde, and *P. thompsoni* Skinner and Wilde from the lower part of the McCloud Limestone, but differs from those in the amount of septal folding, size, height and shape of the chomata, size of the equatorial bulge, and in amount of secondary deposits on septa.

Age. The species was described from the lowest zone of the McCloud Limestone of California, which Wilde (1971) correlates with beds that have been variously assigned a Late Pennsylvanian or Early Permian age in the Glass Mountains of West Texas.

Pseudofusulinella (*Kanmeraia*) species

Plate 11, figures 18, 26

Material and occurrence. Two recrystallized axial sections, GSC 44579 and 44580, and one oblique section, not illustrated, from GSC loc. C-37897; also present at C-37893, C-37918, C-37999 and C-37999a.

Discussion. Enough details can be seen in these specimens to identify this as a species of *Pseudofusulinella* of the *P. (Kanmeraia)* type having a form ratio of about 2.5. The shape of the shell with its concave lateral slopes, relict outline of volutions, high, narrow chomata, and narrowly rounded poles are distinctive features found in few, if any, other fusulinacean genera.

Age. The subgenus *Pseudofusulinella* (*Kanmeraia*) Ozawa has a range from Missourian to middle Wolfcampian.

Genus *Pseudostaffella* Thompson, 1942

Pseudostaffella gorskyi Grozdilova and Lebedeva

Plate 10, figures 26–29, 37

Pseudostaffella gorskyi Grozdilova and Lebedeva, 1950, p. 37, Pl. 4, figs. 5–7; Rauzer-Chernousova, 1951, p. 108, Pl. 6, figs. 6–9; Grozdilova and Lebedeva, 1960, p. 128, Pl. 15, figs. 9, 10

Nomenclature note. Grozdilova and Lebedeva, 1950, p. 37 and Pl. 4, figs. 5–7, designated this species as "*Pseudostaffella gorskyi* (Dutkevitsch) sp. n.", which appears to include a *lapsus calami*. They list no synonymy showing a previous reference or description and designate their specimen shown in Pl. 4, fig. 5 as the typical specimen. Rauzer-Chernousova,

1951, illustrated additional specimens as "*Pseudostaffella gorskyi* (Dutkevich)". The footnote attributes that particular description of the species to D. M. Rauzer-Chernousova. Her synonymy lists "1934, *Staffella sphaeroidea* var. *gorskyi* Dutkevich, *Materialy k poznaniyu mikrofauny srednego i nizhnego karbona Kizelovskogo ugol'nogo basseina na zapadnom sklone Urala*. p. 119–132, pl. II, fig. 16, 17" as well as Grozdilova and Lebedeva, 1950. Although two published references are listed in Rauzer-Chernousova's bibliography for Dutkevich for 1934, neither have that title nor the correct pagination or plate and figure numbers. An additional Dutkevich 1934 publication also has another title and pagination. Kahler and Kahler, 1966–1967, in their *Fossilium Catalogus of Fusulinida* used the first reference of those listed by Rauzer-Chernousova (1959), i.e., Dutkevich, 1934 (*Tr. Neft. Geol. razv. Inst.*, ser. A. vol. 36), which has insufficient pages (1–98) and insufficient figures on Plate 2 to be the correct reference. However, this *Fossilium Catalogus* listing has since been cited in several later descriptions as the original reference. Elsewhere in Rauzer-Chernousova and others (1951) descriptions of a few other species are attributed to "... (Dutkevich), mscr." with the actual description written by another fusulinacean specialist. At this point it appears probable that the name *gorskyi* was first used by Dutkevich in an unpublished manuscript having the title listed by Rauzer-Chernousova (1951, p. 108) in her synonymy of *Pseudostaffella gorskyi*. The first valid published description of this name and species appears to be that of Grozdilova and Lebedeva (1950).

Material and occurrence. Specimens include four axial sections, GSC 44532 to 44535, and one sagittal section, GSC 44536, from GSC loc. C-37883. The specimens have been distorted in shape and proportion.

Description. This subglobose species commonly reaches 1 mm length, 1.4 mm diameter and a form ratio of 0.7 in 6 volutions. In the five specimens measured, proloculi range from 0.05 to 0.09 mm outside diameter. The first 1 to 2 volutions are coiled at a high angle to later volutions. Succeeding volutions increase gradually in height and have gently rounded outline in thin section (Pl. 10, figs. 26–28, 37). Small dimples are present at the poles (Pl. 10, figs. 27, 37). The spiral wall is composed of a tectum, protheca and outer tectorial deposit (Pl. 10, figs. 29, 37). Septa are planar and commonly are coated with secondary deposits.

The tunnel follows a slightly irregular path and is bordered by low, wide massive chomata that extend to the lateral shoulders.

Remarks. Differing from earlier species of the genus, such as *P. antiqua* (Dutkevich) and *P. praegorskyi* Rauzer-Chernousova, *Pseudostaffella gorskyi* is larger and has low chomata that extend to the lateral shoulders. It differs from later species, such as *P. sphaeroidea* (Ehrenberg), *P. paradoxa* (Dutkevich) and *P. rostovezi* Rauzer-Chernousova, in being smaller and having chomata that do not extend to the poles. *Pseudostaffella ettrainensis* Ross from northern Yukon Territory is large and square in outline.

Age. This is a common middle Moscovian (Kashirian and Podol'ian) species. Based on the size and extent of the chomata, the specimens illustrated from GSC loc. C-37883 are probably Kashirian.

Pseudostaffella paracompressa Safonova

Plate 10, figures 30, 31, 33–36, 38

Pseudostaffella paracompressa Safonova in Rauzer-Chernousova et al., 1951, p. 100, Pl. 5, figs. 12, 13

Material and occurrence. Specimens include six axial sections, GSC 44538 to 44543, and one oblique sagittal section, GSC 44537, from GSC loc. C-37887. The specimens have been slightly distorted in shape and proportion by metamorphism.

Description. This globose species reaches 0.7 mm length, 0.9 mm diameter and a form ratio of 0.8 in 5 to 6 volutions. The proloculi range from 0.05 to 0.07 mm outside diameter in six measured specimens. The first 2 to 3 volutions are low and involute and coiled at a high angle to the rest of the shell (Pl. 10, figs. 30, 31, 33, 35, 36, 38). The succeeding volutions increase in height and length to give the shell a globose outline. The poles are slightly dimpled and the lateral slopes are rounded. The spiral wall is composed of a tectum, protheca and thin outer tectorial deposits that are irregularly distributed (Pl. 10, figs. 34, 35). Septa are planar.

The tunnel follows a slightly irregular path and is well defined in the middle portion of the shell, but commonly is difficult to trace in the outer volution. Chomata are small and crescentic in cross-section (Pl. 10, figs. 31, 35). Secondary deposits are minor features in these shells and the chambers generally appear open (Pl. 10, figs. 31, 34, 35). In thick sections (Pl. 10, figs. 30, 38) the specimens appear darker.

Remarks. The specimens from the Omineca Mountains assigned to *Pseudostaffella paracompressa* are closely similar to the type specimens from the Russian Platform in size, shape, spiral wall thickness and development of chomata. This species is smaller than *P. gorskyi* Grozdilova and Lebedeva, and has smaller chomata and fewer secondary deposits. *Pseudostaffella ettrainensis* Ross from northern Yukon Territory is larger and has a more advanced set of early volutions, and *P. sandersoni* Thompson from the Fort St. James area, British Columbia, is smaller and has lower volutions.

Age. In the lower part of the Moscovian (Vereian) on the Russian Platform, *Pseudostaffella paracompressa* is a distinctive zonal fossil.

Family Schwagerinidae Dunbar and Henbest, 1930

Genus *Triticites* Girty, 1904

Triticites species

Plate 11, figure 20

Material and occurrence. One oblique axial section, GSC 44575, and one tangential section, not illustrated, from GSC loc. C-37898.

Discussion. The one specimen indicates that this sample is from the zone of *Triticites* and is either late Carboniferous (i.e., Late Pennsylvanian) or earliest Permian (i.e., Wolfcampian). Proloculus is small, 0.12 mm outside diameter, and the early volutions are low and thin-walled. The keriothecal wall thickens only gradually and the chomata are low, broad and massive. The oblique section suggests the shell is elongate with a form ratio of 3.0 or greater by the fourth volution.

Age. The general features of *Triticites* sp. suggest a stage of

evolution equivalent to Virgilian to early Wolfcampian species of *Triticites*.

Genus *Pseudofusulina* Dunbar and Skinner, 1931

Pseudofusulina (?) species

Plate 11, figures 7, 22, 25, 27, 29, 31

Material and occurrence. Specimens include three axial, or oblique axial, sections, GSC 44584 to 44586, three sagittal sections, GSC 44581 to 44583, and about two dozen tangential, sagittal, axial and randomly oriented thin sections (not illustrated), from GSC loc. C-37897.

Discussion. The elongate specimens have bluntly rounded poles (Pl. 11, figs. 27, 29, 31) and a form ratio from about 4 to 5 and lengths of 8 mm, or commonly more. More than one species may be present because of the different rate of change in volution height as seen in sagittal sections (Pl. 11, figs. 7, 22, 25). Also, one tangential section indicates septal folding restricted to near the base of the septa with upper portions nearly planar. Other tangential sections indicate strongly folded septa for the entire height of the chambers. Neither cuniculi nor chomata are apparent and probably are absent. The proloculi are 0.14 to 0.25 mm outside diameter. Considering all these features, the specimens appear to be Early Permian in age, probably middle to late Wolfcampian.

Genus *Schwagerina* von Möller, 1877

Schwagerina sustutensis new species

Plate 11, figures 1, 3, 5, 6, 9, 11, 14-17

Material and occurrence. Specimens include six axial sections, paratypes GSC 44565, 44567 to 44570, holotype GSC 44566, one sagittal section, paratype GSC 44571, one tangential section, paratype GSC 44572, all from GSC loc. C-37891; two

axial sections, paratypes GSC 44573 and 44574, from GSC loc. C-37892; and six additional thin sections, not illustrated, from the two localities. Specimens have been deformed and recrystallized by metamorphism.

Description. This elongate fusiform species reaches 11 mm length, 2.5 to 2.9 mm diameter and a form ratio of 3.5 to 4.0 in 5 to 5½ volutions. In specimens measured, proloculi range from 0.15 mm to 0.45 mm outside diameter. First 1 to 3 volutions are low and elongate. Succeeding volutions increase markedly in height and length (Pl. 11, figs. 1, 5, 6, 9, 11, 15). Spiral wall is composed of a tectum and keriotheca and increases from 0.015 to more than 0.14 mm thickness from first to fifth volutions. Septa are strongly folded across chambers and septal folds are regularly spaced, reaching to top of chambers (Pl. 11, figs. 5, 6, 14-17).

Secondary features include a tunnel which may reach 0.8 mm width by the fifth volution. Cuniculi are lacking. Secondary deposits are thin and coat the crests of septa folds, particularly near the tunnel.

Remarks. These specimens are from a metamorphosed limestone and all are distorted. *Schwagerina sustutensis* is similar to *S. juresanensis* (Rauzer-Chernousova) from the lower part of the Artinskian Series in the southern Ural Mountains but has less strongly folded septa and more tapered lateral slopes than that species. *Schwagerina jenkinsi* Thorsteinsson and *S. hyperborea* (Salter) from the Canadian Arctic Islands are more elongate and larger, and have more strongly folded septa. *Schwagerina rapsonae* McGugan from the southern British Columbia Rocky Mountains is about the same size but has more strongly folded septa, lower early volutions and heavier secondary coatings on septal folds in the early volutions.

Age. An Early Permian species, *Schwagerina sustutensis* is probably of late Sakmarian or early Artinskian age.

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Plate 8

(all figures $\times 20$)*Fusulinella(?) densa* new species (page 51)

Figures 1–4. Axial sections, paratype GSC 44441, holotype GSC 44442 and paratypes GSC 44443 and 44444; GSC loc. C-37879.

Figures 5–7. Axial sections, paratypes GSC 44445, 44446 and 44447; GSC loc. C-37882.

Figure 8. Sagittal section, paratype GSC 44448; GSC loc. C-37879.

Profusulinella prisca (Deprat) (page 48)

Figures 9–13, 15, 16, 19. Axial sections, GSC 44449, 44450, 44453, 44451, 44452, 44454 to 44456; GSC loc. C-37882.

Figures 14, 43. Axial sections, GSC 44472 and 44471; GSC loc. C-37888.

Figure 17. Axial section, GSC 44474; GSC loc. C-37886.

Figures 18, 21–25, 27–30, 38. Axial sections, GSC 44458, 44460 to 44463, 44459, 44466, 44467, 44464, 44465 and 44468; GSC loc. C-37879.

Figure 20. Oblique sagittal section, GSC 44457; GSC loc. C-37882.

Figure 41. Axial section, GSC 44469; GSC loc. C-37884.

Figure 42. Oblique sagittal section, GSC 44470; same locality.

Figure 46. Axial section, GSC 44473; GSC loc. C-37889.

Figure 47. Axial section, GSC 44475; GSC loc. C-37885; assigned to this species with question.

Profusulinella ovata Rauzer-Chernousova (page 48)

Figures 26, 31–34, 37. Axial sections, GSC 44477, 44479, 44480, 44478, 44476, 44481; GSC loc. C-37884.

Figure 36. Sagittal section, GSC 44483; same locality.

Figure 39. Axial section, GSC 44482; GSC loc. C-37884.

Figure 40. Axial section, GSC 44484; GSC loc. C-37888.

Profusulinella arta Leontovich (page 50)

Figures 35, 44, 45. Axial and oblique axial sections, GSC 44494 to 44496; GSC loc. C-37888.

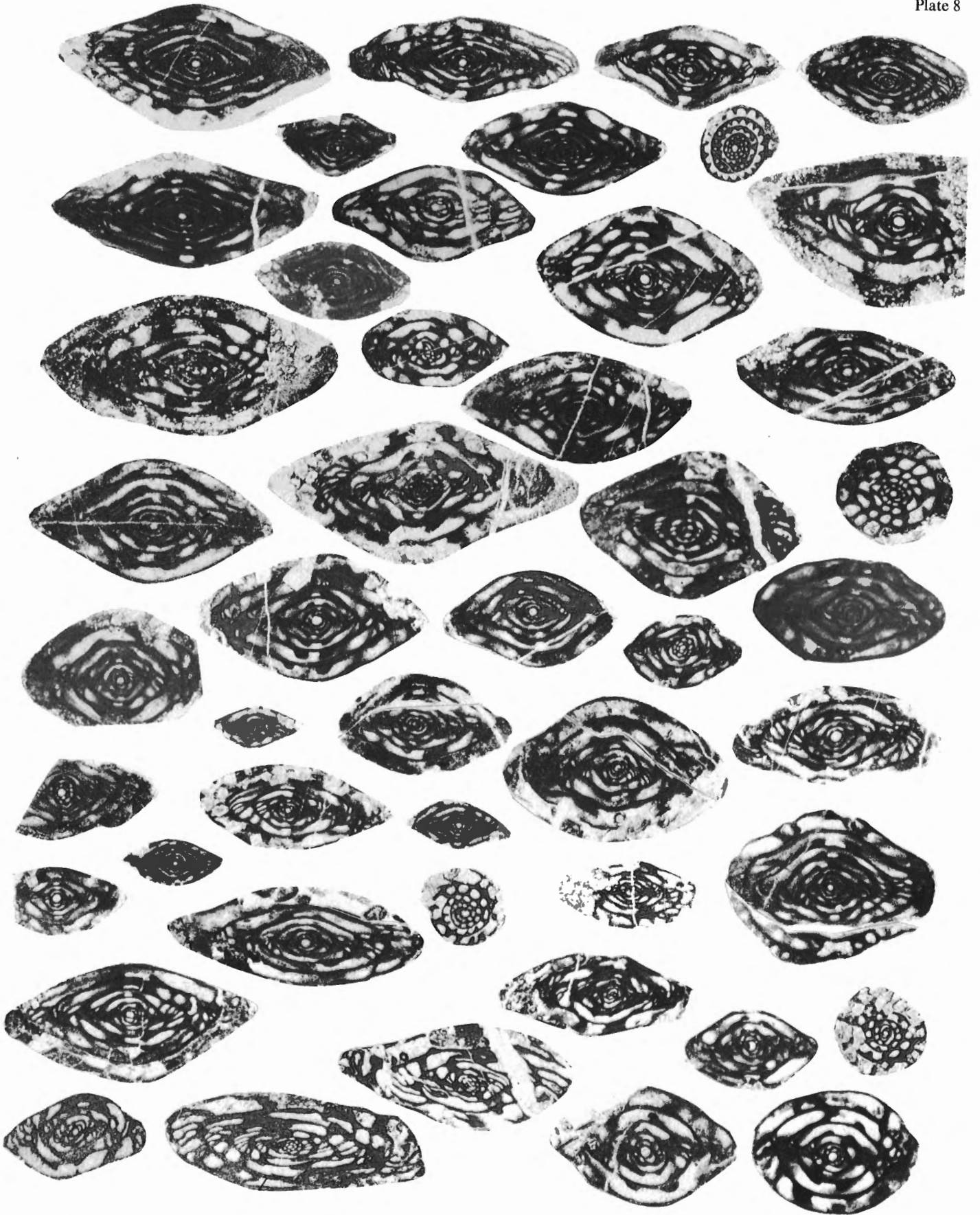


Plate 9

(all figures $\times 20$)

Fusulinella concava new species (page 51)

Figures 1, 3, 5. Axial sections, holotype GSC 44499 and paratypes GSC 44500 and 44501; GSC loc. C-37885.

Figures 13, 14, 18. Axial sections, paratypes GSC 44502, 44503 and 44504; GSC loc. C-37920.

Fusulinella decora new species (page 51)

Figures 2, 4, 6, 8–12. Axial sections, holotype GSC 44505 and paratypes GSC 44506–44512; GSC loc. C-37885.

Figure 7. Tangential section, paratype GSC 44513; same locality.

Figures 15, 19. Axial sections, paratypes GSC 44514 and 44515; GSC loc. C-37920.

Figures 16, 17. Axial sections, paratypes GSC 44517 and 44516; GSC loc. C-37881.

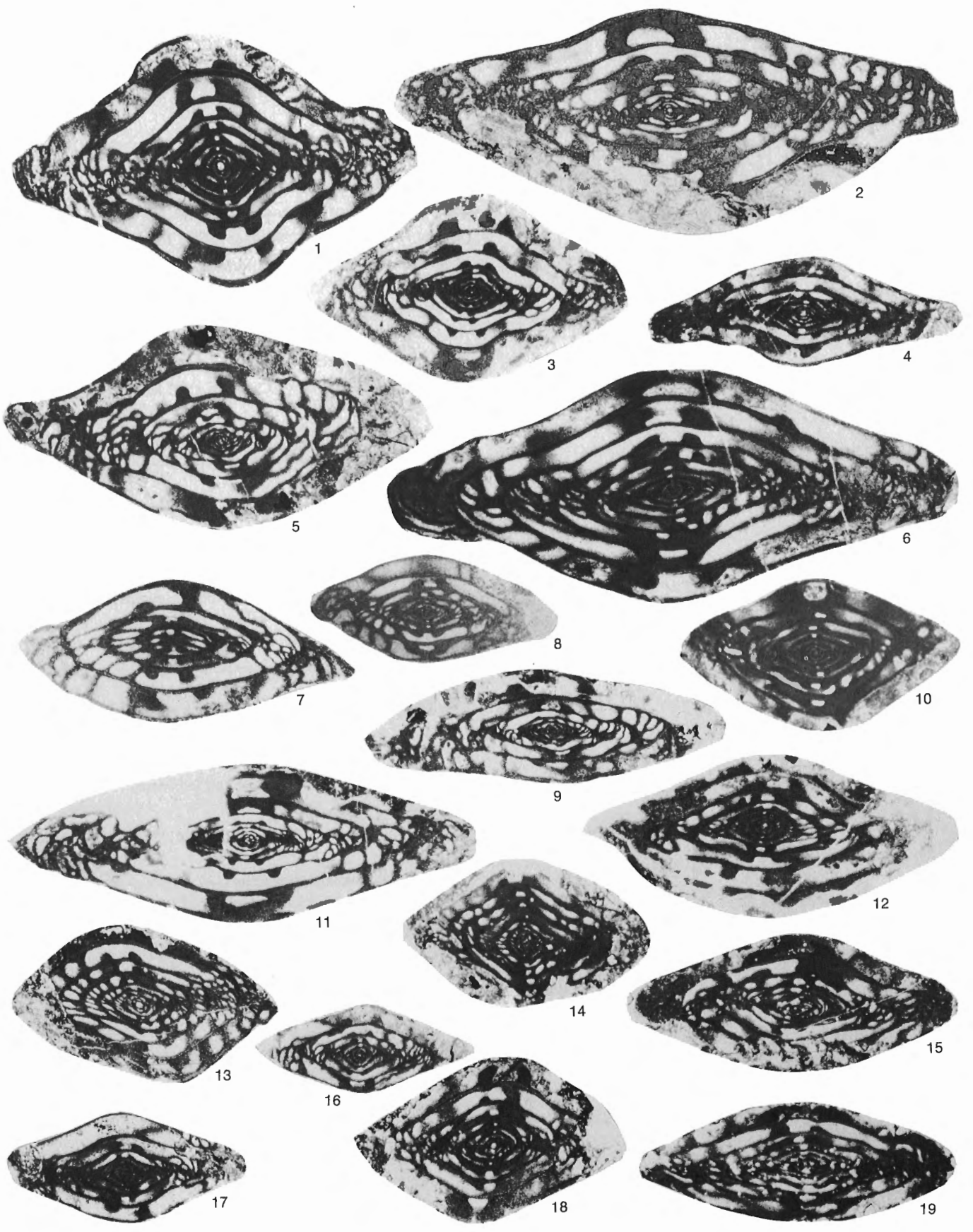


Plate 10

(figures 1–11, ×20; figures 12–25, ×15; figures 26–38, ×40)

Profusulinella ovata Rauzer-Chernousova (page 48)

Figure 1. Axial section, GSC 44487; GSC loc. C-37889.

Figures 2, 3, 5, 6, 8–11. Axial sections, GSC 44485, 44486, 44488 to 44493; GSC loc. C-37889.

Profusulinella arta Leontovich (page 50)

Figure 4. Sagittal section, GSC 44497; GSC loc. C-37888.

Profusulinella(?) species (page 50)

Figure 7. Axial section, GSC 44498; GSC loc. C-37882; a thick thin-section.

Fusulinella decora new species (page 51)

Figures 12, 15. Axial sections, paratypes GSC 44518 and 44519; GSC loc. C-37881.

Figures 13, 17. Sagittal sections, paratypes GSC 44521 and 44520; same locality.

Figures 14. Tangential section, paratype GSC 44522; same locality.

Figures 18, 19, 21, 22. Axial sections, paratypes GSC 44524, 44525, 44523 and 44526; GSC loc. C-37880.

Wedekindellina cf. *W. uralica* (Dutkevich) (page 52)

Figure 16. Oblique sagittal section, GSC 44528; GSC loc. C-37881.

Figure 20. Partial axial section, GSC 44527; same locality.

Figures 23–25. Oblique axial sections, GSC 44529, 44530 and 44531; GSC loc. C-37885.

Pseudostaffella gorskyi Grozdilova and Lebedeva (page 52)

All from GSC loc. C-37883

Figures 26–28, 37. Axial sections, GSC 44532, 44533, 44534 and 44535.

Figure 29. Oblique sagittal section, GSC 44536.

Pseudostaffella paracompressa Safonova (page 53)

All from GSC loc. C-37887

Figure 34. Sagittal section, GSC 44537.

Figures 30, 31, 33, 35, 36, 38. Axial sections, GSC 44541, 44539, 44540, 44538, 44543 and 44542.

Eostaffella species (page 45)

Figure 32. Axial section, GSC 44545; GSC loc. C-37887.

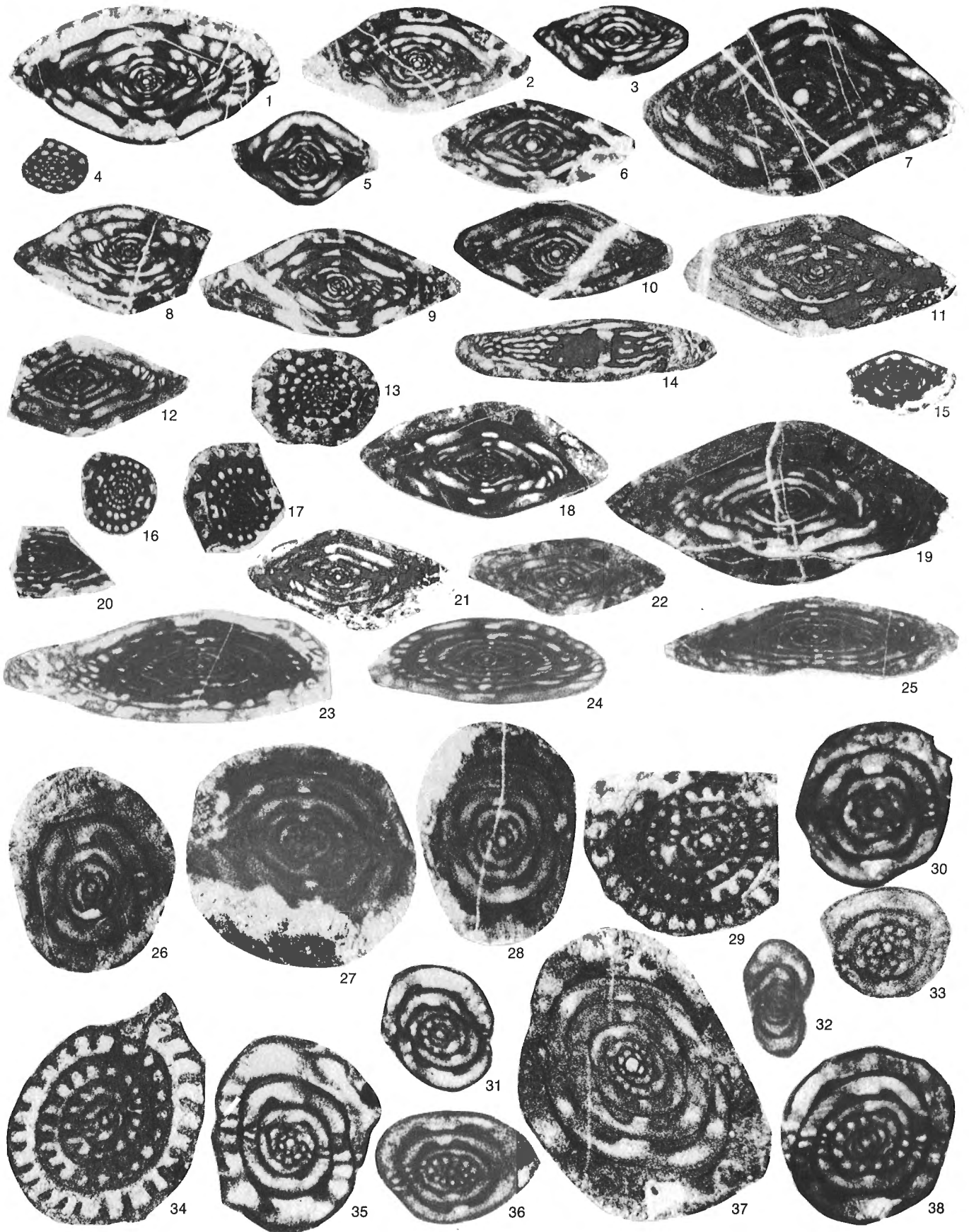


Plate 11

(all figures $\times 10$, unless otherwise noted)

Schwagerina sustutensis new species (page 54)

Figures 1, 5, 6, 9, 11, 15. Axial sections, paratype GSC 44565, holotype GSC 44566 and paratypes GSC 44567 to 44570; GSC C-37891.

Figure 3. Oblique sagittal section, paratype GSC 44571; same locality.

Figure 17. Deep tangential section, paratype GSC 44572; same locality.

Figures 14, 16. Oblique axial section and axial section, paratypes GSC 44573 and 44574; GSC loc. C-37892.

Pseudoendothyra species (page 48)

Figure 2. Axial section, GSC 44546, $\times 40$; GSC loc. C-37882.

Pseudofusulinella (Kanmeraia) meeki (Skinner and Wilde) (page 52)

All from GSC loc. C-37898

Figures 4, 24. Axial sections, GSC 44578 and 44577.

Figure 21. Deep tangential section, GSC 44576.

Pseudofusulina(?) species (page 54)

All from GSC loc. C-37897

Figures 7, 22, 25. Sagittal sections, GSC 44582, 44583 and 44581.

Figures 27, 29, 31. Axial sections GSC 44586, 44584 and 44585.

Pseudoendothyra timanica (Rauzer-Chernousova) (page 48)

All from GSC loc. C-37883

Figures 8, 10, 13, 19, 28, 30, 32–37, 40–42. Axial sections, GSC 44550, 44549, 44555, 44560, 44561, 44547, 44553, 45554, 45552, 44548, 45551, 45556, 45557, 45558, 45559, $\times 40$.

Figures 23, 38, 39. Sagittal sections, GSC 44562, 44563 and 44564, $\times 40$.

Millerella species (page 45)

Figure 12. Axial section, GSC 44544, $\times 40$; GSC loc. C-37887.

Pseudofusulinella (Kanmeraia) species (page 52)

Figures 18, 26. Axial sections, GSC 44580 and 44579; GSC loc. C-37897.

Triticites species (page 53)

Figures 20. Partial oblique axial section, GSC 44575; GSC loc. C-37898.



Permian Fusulinaceans from the St. Elias Mountains, Yukon Territory

Charles A. Ross

Abstract

Fusulinaceans from a massive, shallow-water Permian limestone unit near the Yukon-Alaska Border are grouped into four biostratigraphic assemblages of early to early middle Leonardian age. In ascending order, these are characterized by: *Schwagerina kletsanensis* new species, *Schwagerina parvagrandsis* new species, *Parafusulina*(?) (*Skinnerella*) *megagrandsis* new species, and *Schwagerina jenkinsi* Thorsteinsson.

Résumé

On a groupé des fusulinacés provenant d'une unité calcaire massive formée au Permien en eau peu profonde, et située près de la frontière entre le Yukon et l'Alaska, en quatre assemblages biostratigraphiques dont l'âge s'échelonne entre le Léonardien inférieur et le début du Léonardien moyen. De bas en haut, ces assemblages sont caractérisés par: une nouvelle espèce, *Schwagerina kletsanensis*, une nouvelle espèce *Schwagerina parvagrandsis*, une nouvelle espèce *Parafusulina*(?) (*Skinnerella*) *megagrandsis*, et *Schwagerina jenkinsi* Thorsteinsson.

Introduction

During Operation Saint Elias, J.W.H. Monger collected a series of fossil-bearing samples from a thick limestone succession of Permian age exposed in a cliff along Kletsan Creek near the Alaska-Yukon Border (lat. 61°36'N, long. 141°00'W, UTM 7V EU 00082820; Textfig. 1, loc. 3). The samples were collected from horizons at approximately 15 m (50 ft) intervals in the upper 152 m (500 ft) of the limestone unit that is overlain by Triassic argillites and basic igneous rocks (Read and Monger, 1975, p. 57); its base is not exposed. To the southeast, in the Steele Creek and Hoge Creek areas, the Permian sedimentary interval changes facies into crossbedded calcareous sandstone, sandy limestone, chert pebble conglomerate, siltstone and argillite, but is not known to contain fossil fusulinaceans. To the northwest in Alaska, this Permian limestone sequence is thought to be traceable into the Mankomen Formation (Berg *et al.*, 1972; Bond, 1973) of the eastern Alaska Range.

Acknowledgments

It is a pleasure to acknowledge and thank J.W.H. Monger for help in collecting this material and for discussion of the stratigraphic significance of the fauna. Thanks also are extended to Monger and B.S. Norford for critically reading the manuscript and to E.W. Bamber, who identified the corals and the brachiopod cited in the paper.

Fusulinacean zonation

Four fusulinacean species dominate the assemblages (Table 5) and each seems characteristic of certain parts of the limestone succession. The lowest assemblage (GSC loc. C-37588) is

characterized by *Schwagerina kletsanensis* n. sp. and has the fewest specimens.

The same collection contains *Fomichevella* sp. and a cyathopsid coral. The succeeding two collections (GSC locs. C-37587 and C-37586) lack fusulinaceans but do include other fossils. The second fusulinacean assemblage (GSC loc. C-37585) contains *Schwagerina parvagrandsis* n. sp. as a distinctive and abundant species. Above this, the third fusulinacean assemblage (GSC locs. C-37584, C-37583 and C-37582) has a large and distinctive species, *Parafusulina*(?) (*Skinnerella*) *megagrandsis* n. sp., and less abundant, small, and partly recrystallized species of *Boultonia*(?) and *Endothyra*, neither of which are particularly diagnostic. The next higher collection (GSC loc. C-37581) contains a probable richthofenid brachiopod but no fusulinaceans. The highest assemblage (GSC locs. C-37580, C-37579 and C-37578) is dominated by *Schwagerina jenkinsi* Thorsteinsson, which appears to be a widely distributed species in the Yukon Territory (Ross, 1967) and the Arctic Islands (Thorsteinsson *in* Harker and Thorsteinsson, 1960). *Pseudofusulinella* sp. is a rare member of this highest assemblage.

The species of these four fusulinacean assemblages are most similar to taxa reported elsewhere from early and middle Leonardian or to late Sakmarian and early Artinskian faunas. Petocz (1970) described fusulinaceans from the Mankomen Formation from the Delta River area, east-central Alaska Range, and described eighteen species which he assigned to six zones. The uppermost of Petocz's zones (Assemblage Zone F) is characterized by *Schwagerina rainyensis* Petocz, *S. mankomenensis* Petocz and *S. hyperborea* (Salter) and can be correlated with the assemblage containing *Schwagerina jenkinsi* in the upper part of the Permian limestone of the Kletsan Creek section. *Schwagerina mankomenensis* is similar to *S. jenkinsi* and further study may determine that they are the same species. *Schwagerina rainyensis* is similar to *S. hyperborea* and these two may be synonymous. *Schwagerina jenkinsi*

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Table 5. Distribution of fusulinacean species in collections from Kletsan Creek section (note Read and Monger, 1975, p. 57). The uppermost limit of the stratigraphic section is a contact with Triassic igneous rocks; the base of the Permian limestones is not exposed

GSC LOCALITY	BELOW TOP OF LIMESTONE UNIT metres (feet)	FUSULINACEAN SPECIES						
		<i>Schwagerina kletsanensis</i> n. sp.	<i>S. parvagrands</i> n. sp.	<i>S. jenkinsi</i> Thorsteinsson	<i>Paratusulina</i> (?) (<i>Skinnerella</i>) <i>megagrands</i> n. sp.	<i>Pseudofusulinella</i> sp.	<i>Boultonia</i> (?) sp.	<i>Endothyra</i> sp.
C-37578	Top			A		R		
C-37579	15 (50)			A				
C-37580	30 (100)			A		R		
C-37581	46 (150)	crinoidal limestone						
C-37582	61 (200)				A			
C-37583	76 (250)				A		C	R
C-37584	91 (300)				A			
C-37585	107 (350)		A					
C-37586	122 (400)	bryozoan-crinoidal limestone						
C-37587	137 (450)	bryozoan-molluscan limestone						
C-37588	152 (500)	C						

GSC

Rare R Common C Abundant A

is similar in most features to *Schwagerina juresanensis* Rauzer-Chernousova from the western slope of the Ural Mountains and indicates a correlation with the lower part of the Artinskian Series of the Permian type region. In terms of the West Texas succession, fusulinids with this stage of evolution occur in the lower and middle parts of the Leonardian Series (Skinner Ranch Formation and lower part of Cathedral Mountain Formation). Consideration of the stage of evolution and of the elongate shape of *Schwagerina kletsanensis* n. sp. suggests probably a lower Leonardian correlation of its assemblage. Similar lower Leonardian correlation is indicated for the *parvagrands* and *megagrands* assemblages.

These fusulinacean faunas from the Kletsan Creek section are of particular interest. They are from limestones deposited in shallow water as massive units, possibly as reefs or carbonate banks, and are associated with many other fossil forms. The faunal association is with the Permian non-Tethyan realm, mainly with the eastern belt of the North American Cordilleran or with the Canadian Arctic and the northern and central Uralian Geosyncline (see also discussion of coral distribution by Moffit, 1954; Wilson and Langenheim, 1962; Rowett, 1969). To the southwest in the Anchorage area, Douglass (*pers. com.*) has identified *Cancellina*, a typical Tethyan genus which would be approximately the same age as the fusulinaceans studied for this report. To the southeast, Monger and Ross (1971) reported the distribution of Tethyan and non-Tethyan fusulinids in three broadly defined belts in British Columbia. The fusulinaceans from the Kletsan Creek

section appear to represent a northwestward continuation of their western belt of non-Tethyan related genera and species.

Systematic paleontology

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

Order Foraminiferida

Family Fusulinidae von Möller, 1878

Subfamily Fusulininae von Möller, 1878

Genus *Pseudofusulinella* Thompson, 1951

Pseudofusulinella species

Plate 12, figures 9-11

Material and occurrence. Three specimens, an axial section, GSC 42722, a sagittal section, GSC 44416, and an oblique axial section, GSC 42723, from GSC locs. C-37578 and C-37580.

Discussion. The small specimens probably are incomplete and represent only the early volutions of a species of *Pseudofusulinella* (note Ross and Bamber, this bulletin, p. 30, 31). The axial section (Pl. 12, fig. 9) consists of five volutions, is 0.9 mm in length, and has a form ratio of about 1.3. Chomata are relatively low and reach to about one-third chamber height. The poles are sharply rounded and lateral slopes are nearly straight.

The stratigraphic position of these specimens high in the limestone unit and the associated species of morphologically advanced *Schwagerina* indicate that this species is a very late representative of the genus.

Age. Late Wolfcampian to Leonardian.

Subfamily Schwagerininae Dunbar and Henbest, 1930

Genus *Schwagerina* von Möller, 1877

Schwagerina kletsanensis new species

Plate 12, figures 2, 7, 12

Material and occurrence. Specimens include two axial sections, holotype GSC 42719 and paratype GSC 42720, one tangential section, paratype GSC 42721, and six obliquely oriented and broken specimens, not illustrated, all from GSC loc. C-37588.

Description. This elongate species reaches 13 mm length, 3 mm diameter, and a form ratio of 4.3 to 4.7 in 7 to 8 volutions. In the two specimens measured, proloculi were 0.10 to 0.15 mm outside diameter. First 3 to 5 volutions are low and relatively elongate. Succeeding volutions increase in height slowly and increase proportionally much more in length to reach an elongate outline. A slight constriction is common in later volutions in the equatorial region. Spiral wall is composed of a tectum and keriotheca and is thin, 0.015 mm thick in the first 1 or 2 volutions and gradually increases to 0.09 to 0.11 mm thick in seventh or eighth volution. Septa are strongly folded into high, regularly but widely spaced septal folds that have flattened crests and nearly straight sides reaching to the top of the chambers (Pl. 12, figs. 7, 12).

Secondary features include a tunnel that is about half the height of the chambers and reaches 0.9 mm wide in the fifth or sixth volution. Secondary deposits either heavily coat the septal folds, particularly the crests of the folds (Pl. 12, fig. 7),

or infill nearly completely septal folds of the earlier volutions (Pl. 12, fig. 12). Cuniculi are lacking (Pl. 12, fig. 2).

Remarks. None of the species described by Petocz (1970) from the east-central Alaska Range is closely similar to *Schwagerina kletsanensis*. Of the other described fusulinacean faunas of the North American Cordillera, *S. juncea* Skinner and Wilde (1965) from Zone G in the upper part of the McCloud Limestone has a similar shape and axial deposits but lacks the septal fold pattern of *S. kletsanensis*. The species takes its name from Kletsan Creek along which the specimens were collected.

Age. Based on the stage of evolution, *Schwagerina kletsanensis* is late Wolfcampian to early Leonardian in age. As most late Wolfcampian species of this genus have a less elongate shape, *S. kletsanensis* is probably early Leonardian.

Schwagerina parvagrandsis new species

Plate 12, figures 1, 3–6, 8, 14

Material and occurrence. Specimens include seven axial sections, holotype GSC 44400, paratypes GSC 44401 to 44406, and numerous tangential and oblique sections of fragmental specimens, not illustrated, all from GSC loc. C-37585.

Description. This large fusiform species reaches 15 mm length, 3.5 mm diameter and a form ratio of 4.3 in 6 to 7 volutions. In specimens measured, proloculi range from 0.22 to 0.45 mm outside diameter. First 1 to 3 volutions are low and succeeding volutions gradually increase in length and height to give the shell a fusiform outline and broadly rounded poles. Spiral wall is thin, 0.02 mm thick in first 1 or 2 volutions and increases gradually to 0.12 mm thick in sixth or seventh volution. It is composed of a thin tectum and a keriotheca having 5 to 7 alveoli per 0.1 mm. Septa are strongly folded into high regular folds across chambers (Pl. 12, figs. 1, 5, 6).

Secondary features include a low, broad tunnel that reaches 0.8 to 0.9 mm width in sixth or seventh volution. Chomata are lacking. Secondary deposits coat and infill the septal folds in the axial region of early chambers and along the lateral slopes of some later chambers (Pl. 12, figs. 1, 3–6, 8, 14). Secondary deposits commonly coat the crests of most septal folds in all but the last volution.

Remarks. Although in general features *Schwagerina parvagrandsis* is similar to *S. megagrandsis* new species, which appears 15 m (49 ft) or more higher in the section, *S. parvagrandsis* is smaller at corresponding volutions, is more elongate and is probably an ancestral species in the same lineage. None of the species described by Petocz (1970) from the Mankomen Formation in the east-central Alaska Range is closely similar to *S. parvagrandsis*. *Schwagerina amoena* Skinner and Wilde (1965) from Zone G of the McCloud Limestone, California, and *S. dugoutensis* Ross (1963) from the lower part (Skinner Ranch Formation) of the Leonardian Series, West Texas, are similar to *S. parvagrandsis* in general shape, size, and amount of axial deposits but differ from it in shape of septal folds. The species takes its name from Latin for its relatively large size, although it is smaller than *Parafusulina*(?) (*Skinnerella*) *megagrandsis* new species, which appears higher in the succession.

Age. Early Leonardian.

Schwagerina jenkinsi Thorsteinsson

Plate 13, figures 2, 3, 6; Plate 14, figures 1–21

Schwagerina jenkinsi Thorsteinsson in Harker and Thorsteinsson, 1960, p. 25, Pl. 4, figs. 9–12, Pl. 5, figs. 1–4; Ross, 1967, p. 722, Pl. 85, figs. 11–17, Pl. 86, figs. 1–7

Material and occurrence. Specimens include sixteen axial sections, GSC 44417 to 44425 and 44427 to 44433, one tangential section, GSC 44426, seven sagittal sections, GSC 44434 to 44440, and about two dozen axial, sagittal, tangential and oblique sections, not illustrated, from GSC locs. C-37578 to C-37580.

Description. This large elongate fusiform species commonly reaches 13 mm length, 3 mm diameter and a form ratio of 4.3 in 7 volutions. In specimens illustrated, proloculi range from 0.10 to 0.30 mm outside diameter. First volution is low and subglobose and succeeding volutions are generally low (Pl. 13, figs. 2, 3, 6; Pl. 14, figs. 6–9) and become increasingly elongate. Lateral slopes are convex and taper to narrowly rounded poles (Pl. 14, figs. 2, 12). Spiral wall is composed of a tectum and a keriotheca with 6 to 7 alveoli per 0.1 mm. Septa are regularly folded across the entire chamber (Pl. 14, figs. 17, 20). Septal folds are high, reach to the top of chambers, and have rounded crests (Pl. 14, figs. 1–5, 10–21).

Well developed tunnel follows a regular path and is 0.6 to 0.7 mm wide by the sixth or seventh volution. Secondary deposits coat the septal edge near the tunnel, along the axial part of the earlier volutions (Pl. 14, figs. 4, 5, 12, 18), and the crests of septal folds of all but the outermost volution.

Remarks. Careful searching of all the tangential sections and continual observation during the grinding of the thin sections revealed that one specimen showed a small pore through a septum that might be a small cuniculus. Based on this, *Schwagerina jenkinsi* cannot be considered a *Parafusulina* although it is obviously an advanced species of *Schwagerina*. *Schwagerina jenkinsi* is similar to *S. mankomenensis* Petocz (1970) from the upper part of the Mankomen Formation in the east-central Alaska Range but has slightly heavier axial deposits. *Schwagerina jenkinsi* is similar to several species that are transitional between *Schwagerina* and *Parafusulina*. *Parafusulina leonardensis* Ross, from the Skinner Ranch Formation (Leonardian Series), West Texas, and *P. lutugini* (Schellwien) from the lower part of the Artinskian Series, Ural Mountains, resemble *S. jenkinsi* in shape and size, but have low, poorly developed cuniculi in their outer one or two volutions. *Schwagerina juresanensis* (Rauzer-Chernousova) from the lower part of the Artinskian Series is similar but has less strongly developed axial deposits.

Age. Early to middle Leonardian, equivalent to the Skinner Ranch Formation or lower part of Cathedral Mountain Formation, West Texas.

Genus *Parafusulina* Dunbar and Skinner, 1931

Subgenus *Skinnerella* Coogan, 1960; emend. Skinner, 1971

Parafusulina(?) (*Skinnerella*) *megagrandsis* new species

Plate 12, figures 13, 15; Plate 13, figures 1, 4, 5, 7–10

Material and occurrence. Specimens include nine axial sections, holotype GSC 44409 and paratypes GSC 44407, 44408, 44410 and 44411, from GSC loc. C-37582; paratypes 44412 to

44414, from GSC loc. C-37583; paratype GSC 44415, from GSC loc. C-37584; and six tangential or recrystallized sections, not illustrated, from the three localities.

Description. This very large, thickly fusiform species commonly reaches 16 to 18 mm length, 5.5 to 6 mm diameter and form ratios of 3.0 in 7 to 10 volutions. In specimens illustrated, proloculi range from 0.16 to 0.45 mm outside diameter and are spherical. First 1 to 3 volutions in specimens having smaller proloculi are low and thin-walled until they reach a diameter of about 0.5 mm, where the chamber height and spiral wall thickness appear to increase significantly. Later volutions are high and the highest part of the volution is generally along the lateral slopes, giving the specimen a constricted equatorial region (Pl. 13, figs. 1, 4, 5). The outer part of the lateral slopes converge as nearly straight walls toward the rounded poles (Pl. 12, fig. 15; Pl. 13, figs. 1, 4, 5, 7-9). The spiral wall is composed of a tectum and keriotheca having 6 to 7 alveoli per 0.1 mm. Septa are strongly folded from the base to the top of chambers into regularly and closely spaced folds with flat sides and subangular crests (Pl. 13, figs. 1, 4, 5, 7, 8).

Secondary features include regular, nearly straight tunnel,

which is 0.7 to 0.8 mm wide by the seventh volution. Cuniculi, if present, are confined to outer one or two volutions and are low and difficult to locate. Secondary deposits heavily coat the septal folds, particularly in the inner volutions and in the shoulders of the lateral slopes in later volutions (Pl. 12, figs. 13, 15; Pl. 13, figs. 1, 4, 5, 7-10).

Remarks. The new species does not closely resemble other described species. It is larger than *Schwagerina parvagrands* new species which appears lower in the same section. None of the species described from the Mankomen Formation, east-central Alaska Range (Petocz, 1970) is similar. One specimen from the Cache Creek Group, Stikine River area, Cassiar District, British Columbia, illustrated as "*Parafusulina* sp. C" by Pitcher (1960) may be related to *P. (?) (S.) megagrands*. Although differing in some internal details, *P. (?) (S.) megagrands* is similar in stage of evolution and size to *Parafusulina (Skinnerella) tenuis* Skinner (1971) from the Leonardian of West Texas.

The species takes its name from Latin and refers to its large size.

Age. Early Leonardian.

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Plates 12 to 14

Plate 12

(all figures $\times 10$, unless otherwise noted)

Schwagerina parvagrandsis new species (page 67)

Figures 1, 3–6, 8, 14. Axial sections, holotype GSC 44400 and paratypes GSC 44402, 44406, 44405, 44404, 44403 and 44401; GSC loc. C-37585.

Schwagerina kletsanensis new species (page 66)

Figure 2. Tangential section showing septal folds of adjacent septa touching but not forming cuniculi, paratype GSC 42721; GSC loc. C-37588.

Figures 7, 12. Axial sections, holotype GSC 42719 and paratype GSC 42720; same locality.

Pseudofusulinella species (page 66)

Figures 9, 11. Slightly oblique axial sections, GSC 42722 and 42723, $\times 40$, GSC loc. C-37578.

Figure 10. Sagittal section, GSC 44416, $\times 40$, GSC loc. C-37580.

Parafusulina(?) (Skinnerella) megagrandsis new species (page 67)

Figure 13. Axial section, paratype GSC 44413; GSC loc. C-37583.

Figure 15. Axial section, paratype GSC 44415; GSC loc. C-37584.

Pseudofusulinella (Kanmeraia) meeki (Skinner and Wilde) (page 52)

Figure 16. Axial section, GSC 44578, $\times 40$; GSC loc. C-37898; enlarged view of part of figure 4 of Plate 11.

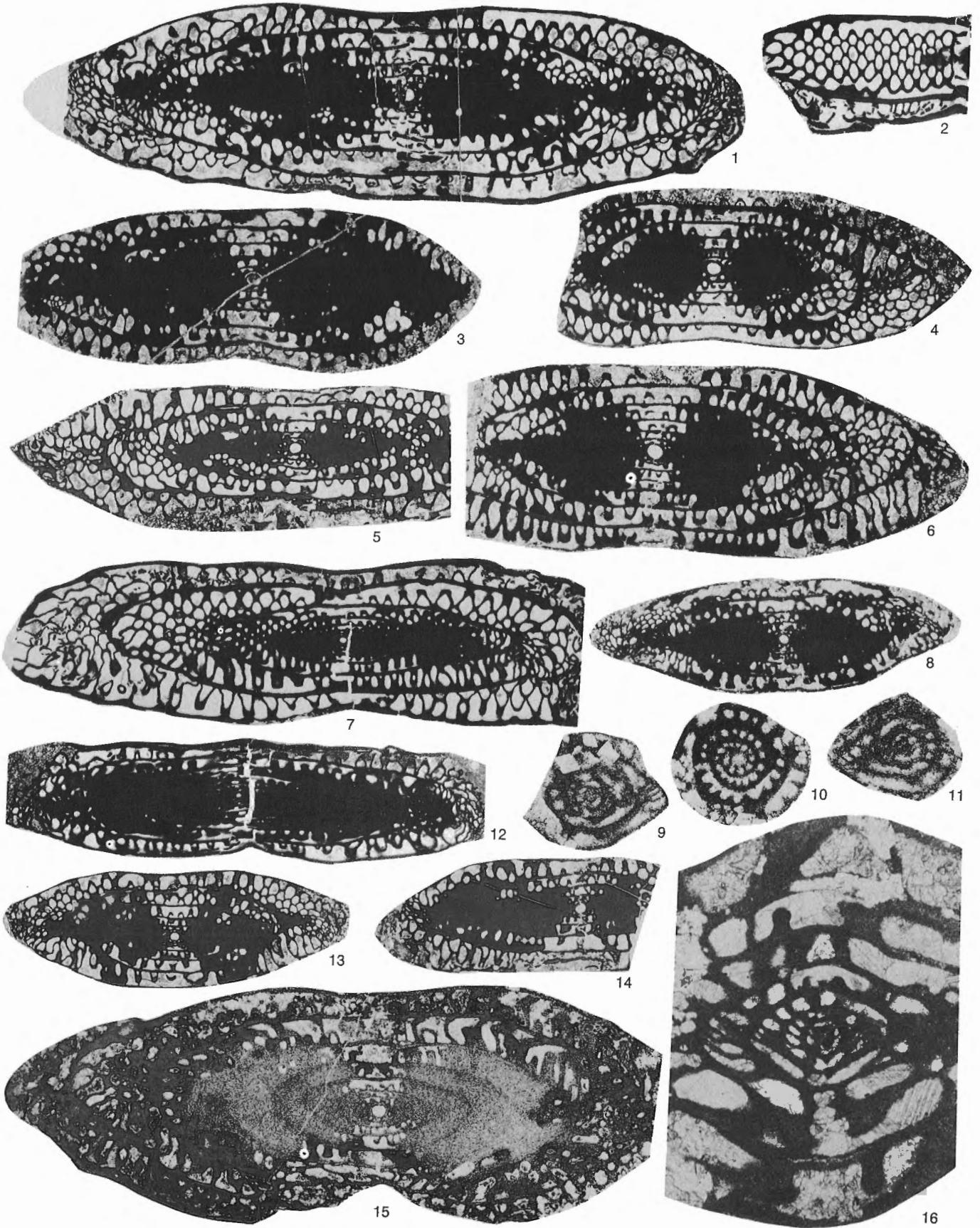


Plate 13

(all figures $\times 10$)

Parafusulina(?) (Skinnerella) megagrandis new species (page 67)

Figures 1, 4, 5, 7, 8. Axial sections, paratype GSC 44411, holotype GSC 44409 and paratypes GSC 44408, 44407 and 44410; GSC loc. C-37582.

Figures 9, 10. Axial sections, paratypes GSC 44412 and 44414; GSC loc. C-37583.

Schwagerina jenkinsi Thorsteinsson (page 67)

Figures 2, 3, 6. Sagittal sections, GSC 44434, 44435 and 44436; GSC loc. C-37580.

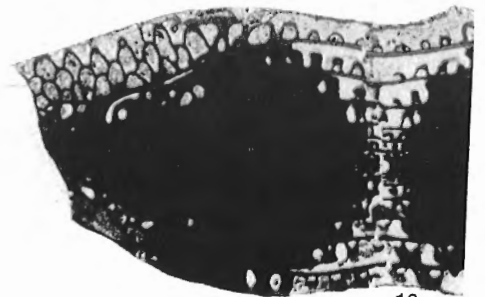
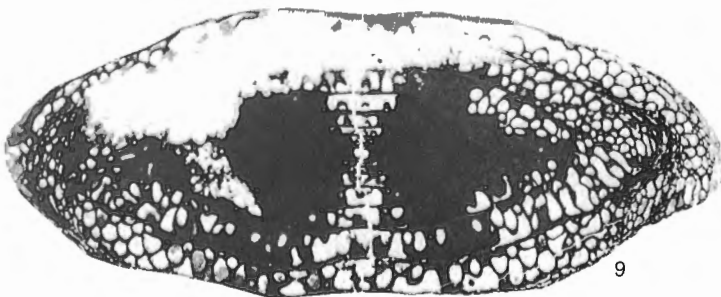
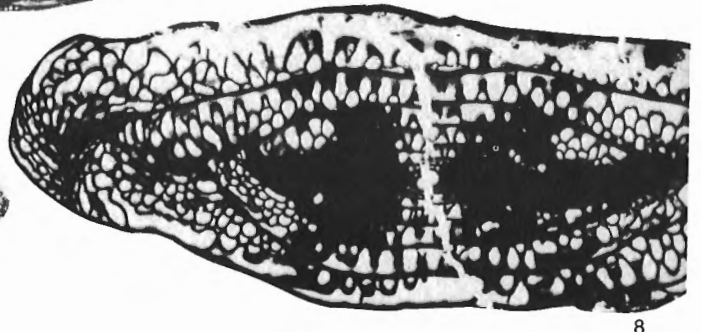
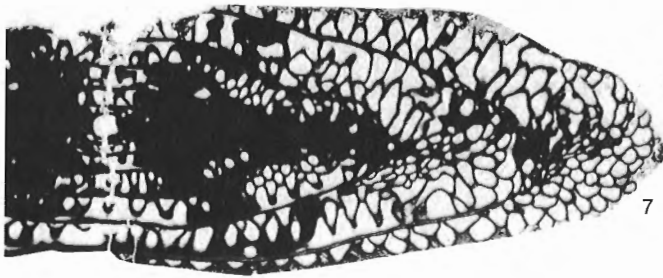
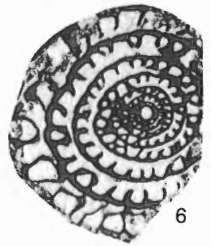
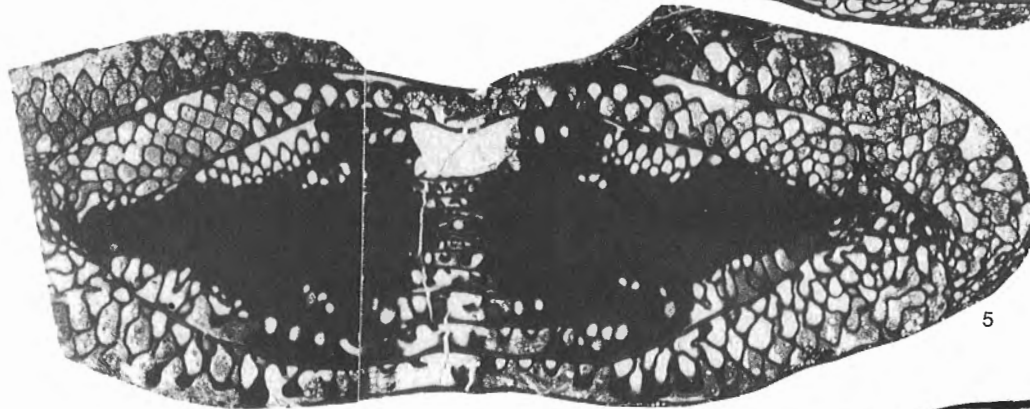
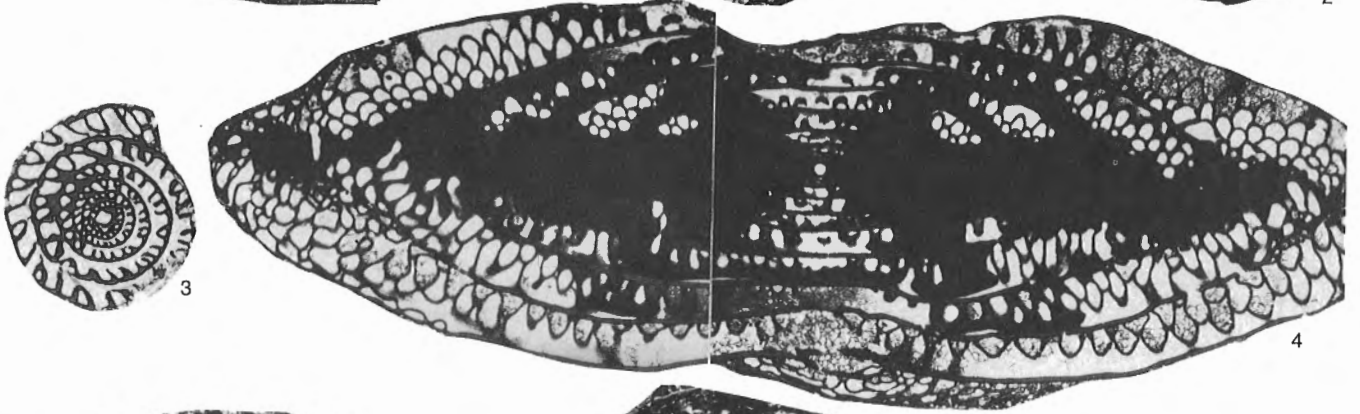
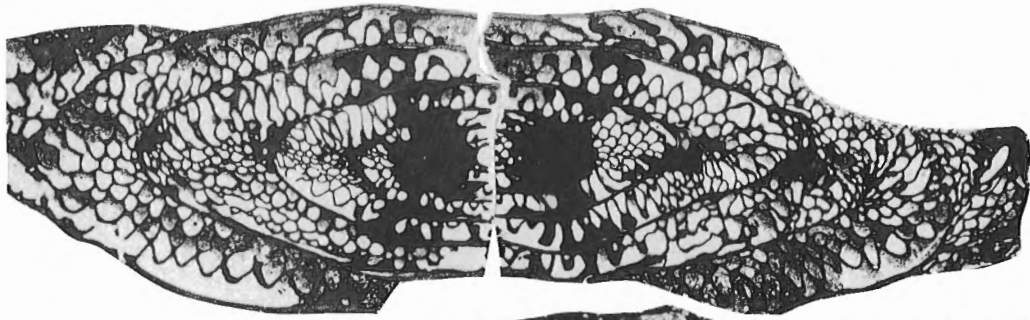


Plate 14

(all figures $\times 10$)

Schwagerina jenkinsi Thorsteinsson (page 67)

Figures 1, 2, 4, 20. Axial sections, GSC 44422, 44425, 44423 and 44424; GSC loc. C-37578.

Figures 3, 5, 16, 21. Axial sections, GSC 44428, 44427, 44429 and 44430; GSC loc. C-37579.

Figures 6, 7. Sagittal sections, GSC 44437 and 44438; GSC loc. C-37578.

Figures 8, 9. Sagittal sections, GSC 44440 and 44439; GSC loc. C-37579.

Figures 10–15, 17, 18. Axial sections, GSC 44417, 44419, 44431, 44421, 44433, 44420, 44432 and 44418; GSC loc. C-37580.

Figure 19. Tangential section, GSC 44426; GSC loc. C-37578.

