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BULLETIN 192

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

(six papers)

A.E.H. Pedder, A.C. Lenz, D.E. Jackson, A.R. Ormiston, W.W. Nassichuk, T.P. Chamney

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CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

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PREFACE

Detailed studies of fossils are a vital part of the biostratigraphic correlation of sedimentary rocks. The six short papers that form this Bulletin describe different groups of fossils that are important to correlation in the sedimentary basins of northern and western Canada.

This Bulletin is the second of a series of annual paleontological volumes of short contributions from the Institute of Sedimentary and Petroleum Geology of the Geological Survey of Canada.

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

OTTAWA, June 4, 1969

BULLETIN 192 — BEITRÄGE ZUR KANADISCHEN PALÄONTOLOGIE

Monograptus des spätesten Silurs (Přidols) und des frühen Devons in Nordwestkanada
Von A. C. Lenz und D. E. Jackson

Trilobiten des Unterdevons aus der Michelle-Formation im Yukon-territorium
Von Allen R. Ormiston

Zwei neue aphroide Korallen aus der mitteldevonischen Hume-Formation Westkanadas
Von A. E. H.Pedder

Mitteldevonische Coelenterata aus der Nahanni-Formation von H. B., Amerada Camsell A-37 Well, Bezirk Mackenzie
Von A. E. H. Pedder

Helicoprion und *Physonemus,* Wirbeltiere des Perms aus der Assistance-Formation im Arktischen Archipel Kanadas
Von W. W. Nassichuk

Neue Foraminiferen-Arten aus dem Übergangsgebiet Jura/Kreide im arktischen Amerika
Von T. P. Chamney

БЮЛЛЕТЕНЬ 192 — МАТЕРИАЛЫ КАНАДСКОЙ ПАЛЕОНТОЛОГИИ

Поздне-сидурииские (пржидольские) и ранне-девонские граптолиты вида "монограптус", северо-западной Канады.
А. К. Ленц и Д. Е. Джаксон

Нижне-девонские трилобиты из свиты Мишель в Юконской Территории.
Аллен Р. Ормистон

Два новых афроидных коралла из средне-девонской свиты Хюм в западной Канаде.
А. Е. Х. Педдер

Средне-девонские беспозвоночные (*Coelenterata*) свиты Наханни из буровой скважины Амерада-Камзель А-37, в районе Макензи.
А. Е. Х. Педдер

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Т. П. Чамней

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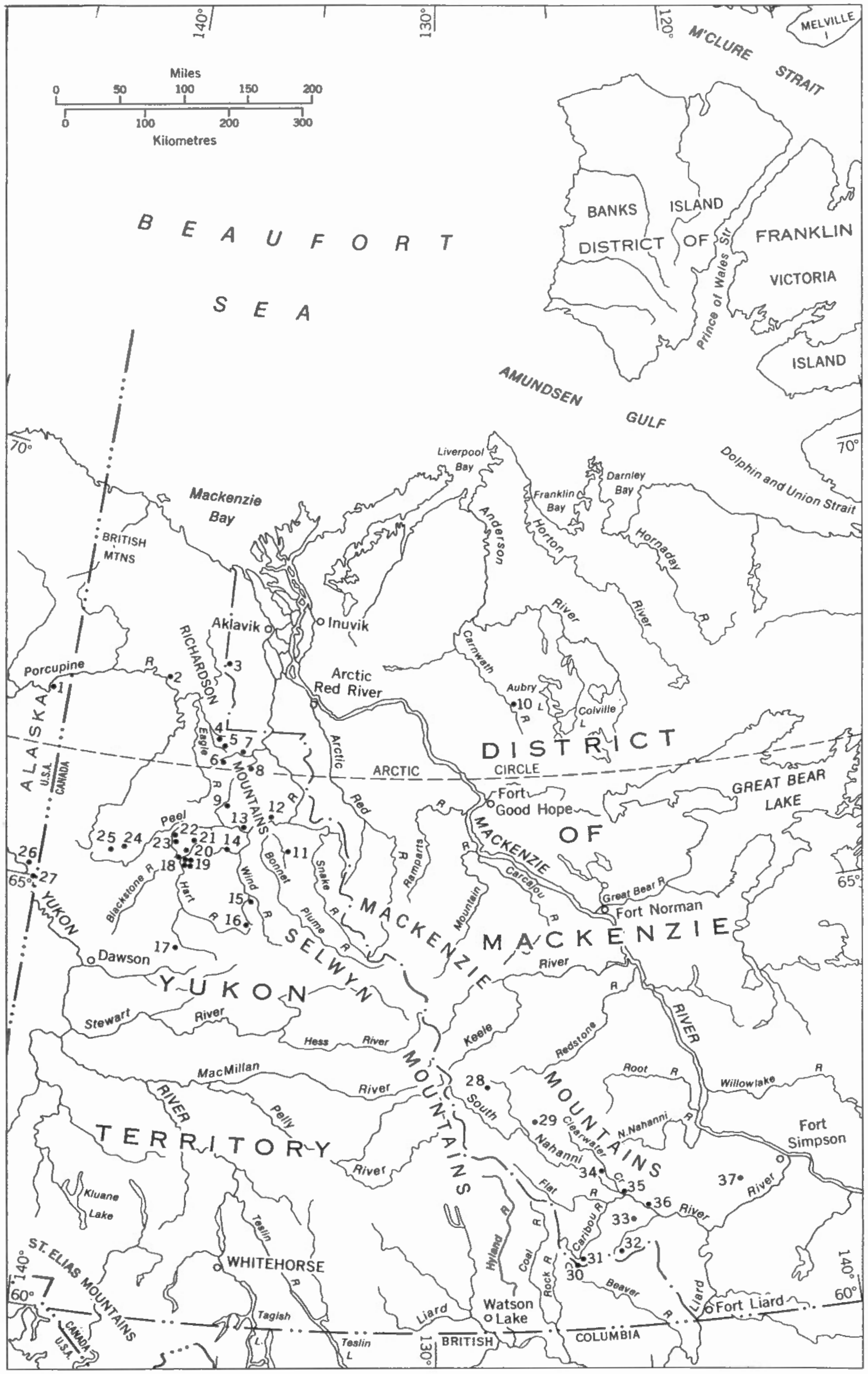

	Monograptus yukonensis	*M. telleri* new species	*M. thomasi*	*M. hercynicus*	*M.* cf. *M. uniformis*	*M. transgrediens praecipuus*	*M. chelmiensis* and *M. bugensis*	*M. norfordi* new species
Lenz and Jackson Localities								
1 Old Rampart, Porcupine River				?				
2 Lower Porcupine River	?						x	
3 McDougall Pass	?							
4 Tributary of Rock River	x							
5 Rock River	x	x					x	
6 Tributary of Eagle River	x							
7 Tetlit Creek	x	x						
8 Road River	x						x	
9 Canyon Creek	x	x						
11 Noisy Creek	x							
12 Lower Canyon, Peel River	x	x	x					
13 Upper Canyon, Peel River	x							
14 Prongs Creek	x	x		x		x	x	
15 Royal Creek	x	x	x					
16 Headwaters of Royal Creek	x	x						
18 Hart River							x	x
20 Hart River					x	x	x	x
22 Blackstone River	x							
26 Yukon River	x							
27 Yukon River	x							
28 Near O'Grady Lake	?							
29 Near South Nahanni River	?							
30 Headwaters of Beaver River	x							
31 Caribou River	x							
32 Headwaters of Meilleur River		x						
33 North of Meilleur River		x						
34 Clearwater Creek							?	
35 South Nahanni River		x						
36 South Nahanni River		x						

Ormiston Localities	Pedder Localities
17 Hart River	10 Carnwath River
19 Hart River	37 Camsell A-37 Well
21 Hart River	
23 Blackstone River	
24 Nahoni Range	
25 Nahoni Range	

TEXTFIGURE 1. Locality map for Lenz and Jackson, Ormiston, and Pedder papers.

LATEST SILURIAN (PŘIDOLIAN) AND EARLY DEVONIAN *MONOGRAPTUS* OF NORTHWESTERN CANADA

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

Abstract

Two new species and four species of *Monograptus* previously unknown in North America are described from Přidolian and Early Devonian strata in Yukon and southwest District of Mackenzie. They are *Monograptus telleri* n. sp., *M. norfordi* n. sp., *M. hercynicus* Perner, *M. thomasi* Jaeger, *M. transgrediens praecipuus* Přibyl, and *M.* cf. *M. uniformis* Přibyl. Also *M. yukonensis* Jackson and Lenz is redescribed. Recognition of these species permits the documentation of the zones of *M. transgrediens, M. uniformis,* and *M. hercynicus* for the first time in northwestern Canada.

Résumé

Les auteurs décrivent deux nouvelles espèces, et quatre espèces de *Monograptus* antérieurement inconnues en Amérique du Nord et provenant des couches pridoliennes et du début du Dévonien du Yukon et du sud-ouest du district de Mackenzie. Elles comprennent *Monograptus jaegeri* n.sp., *M. norfordi* n.sp., *M. hercynicus* Perner, *M. thomasi* Jaeger, *M. transgrediens praecipuus* Přibyl et *M.* cf. *M. uniformis* Přibyl. Les auteurs font une nouvelle description du *M. yukonensis* Jackson et Lenz. La découverte de ces espèces a permis pour la première fois de constituer la documentation des zones de *M. transgrediens, M. uniformis* et *M. hercynicus* du Nord-Ouest du Canada.

Introduction

Biostratigraphic studies on Upper Silurian and Lower Devonian graptolitic strata on the mainland of northwestern Canada have been in progress for a number of years (Jackson and Lenz, 1962; Lenz and Jackson, 1965; Lenz and Jackson, 1969). With the exception of two short publications, one on an Early Devonian *Monograptus* (Jackson and Lenz, 1963),

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[2]Department of Earth Sciences, The Open University, Bletchley, England.

and another on late Kopaninan and early Přidolian graptolites (Jackson and Lenz, 1969), very little work on the systematic descriptions of these faunas has been published. This paper brings together all available species of graptolites of that age from widely scattered localities, and describes and illustrates them.

Although this study is based on many graptolite collections in northern Yukon and southwestern Northwest Territories (Textfig. 1), the two key sections are those along Prongs Creek and Hart River. The Porcupine River section provides additional supplemental material. These sections are important because they have yielded species of graptolites not previously recognized in Canada and, equally important, because they are made up of a sequence of apparently continuously deposited graptolitic shales that represent a substantial part of Late Silurian and Early Devonian time. Stratigraphic and biostratigraphic studies of northern Yukon and northwestern District of Mackenzie which provide additional important regional as well as local information include those of Norford (1964) and Norris (1967; 1968a, 1968b).

Acknowledgments

The writers gratefully acknowledge the loan of graptolites from the Geological Survey of Canada, Chevron Standard Ltd., Pan American Petroleum Corp., Elf Oil Exploration and Production (Petropar), and Shell Canada Ltd. The assistance rendered to A. C. Lenz by Marathon Oil Company and British American Petroleum Company Ltd., and particularly by C. R. Swanson and David Capstick, respectively, is deeply appreciated. Financial assistance was provided by the National Research Council and to one of us (ACL) by Mobil Oil Canada Ltd. Photographs were prepared by F. Dimitrov of the University of Alberta. The manuscript has been critically read by R. Thorsteinsson of the Geological Survey of Canada. We also wish to acknowledge comments made by Hermann Jaeger, of the Humboldt Universität, Berlin, concerning the graptolite described herein as *Monograptus* cf. *M. uniformis*. Identification of fossils from Hart River, other than graptolites, are by B. S. Norford of the Geological Survey of Canada. Tentaculitid identifications from Royal Creek and the South Nahanni River region are by Bedrick Bouček, Czechoslovak Academy of Science, Prague. B. S. Norford identified and provided locations of *Monograptus yukonensis* from the Coal River and Nahanni River map-areas. These occurrences are included in the location map (Textfig. 1).

Biostratigraphy

The graptolite zones or units, their correlation with the Bohemian stages, and the faunal assemblages of the units are illustrated in Table 1.

Monograptus yukonensis Zone. This widely distributed zone is the latest Early Devonian graptolite zone recognized in northwestern Canada and has been collected from dozens of localities extending from Coal River area in the extreme southeast Yukon (Gabrielse, *pers. com.* 1968) to northern Yukon and westward into neighbouring Alaska (Churkin and Brabb, 1965). In northern Yukon, *M. yukonensis* is sometimes associated in the lower part of the

TABLE 1 | *Biostratigraphic intervals*

Series	Stage	Substage	Zone or interval	Fauna
Lower Devonian	Pragian		*M. yukonensis* Zone	*M. yukonensis*, *M. telleri* n. sp., *Nowakia acuaria*
			Beds with *M. thomasi*	*M. thomasi*
	Lochkovian		*M. hercynicus* Zone	*M. hercynicus*, *Toquimaella kayi*, *Spirigerina* cf. *S. supramarginalis*
			M. uniformis Zone	*M.* cf. *M. uniformis*, *M. angustidens-uniformis*, *Warburgella rugulosa canadensis*, *Icriodus woschmidti*
Upper Silurian	Přidolian	Upper	*M. transgrediens* Zone	*M. transgrediens praecipuus*
		Lower	*M. chelmiensis* Zone	*M. chelmiensis*, *M. bugensius*, *M. norfordi* n. sp., *M.* cf. *M. angustidens*, *M.* cf. *M. formosus*, *Linograptus posthumus tenuis*, *L.* cf. *L. posthumus posthumus*
			M. bugensius Zone	*M. bugensius*, *M.* aff. *M. kosoviensis*, *M.* cf. *M. formosus*, *L. posthumus tenuis*
	Kopaninan	Middle and Upper	*M.* aff. *M. formosus* Zone	*M. paraformosus*, *M.* aff. *M. kosoviensis*, ? *M. crinitus*, *L. posthumus tenuis*
			M. leintwardinensis primus Zone	*M. bohemicus tenuis*, *M. roemeri*, *M. leintwardinensis primus*, *M.* cf. *M. leintwardinensis leintwardinensis*, *M.* cf. *M. varians*, *M.* cf. *M. tumescens minor*, *M.* ex gr. *M. dubius*, *L. posthumus tenuis*
		Lower	*M. nilssoni* Zone	*M. nilssoni*, *M. bohemicus bohemicus*, *M. uncinatus orbatus*, *M. scanicus*, *M. crinitus*, *M. varians*, *M. colonus*, *M. vulgaris curtus*, *M. roemeri*, *M.* cf. *M. tumescens*, *M.* ex gr. *M. dubius*, *M. chimaera*, *M.* cf. *M. colonus compactus*

zone with *M. telleri* n. sp. The zone may attain a thickness of several hundred feet. The tentaculitid *Nowakia acuaria* (Richter) has been identified from the zone at Royal Creek and South Nahanni River region by Bedrick Bouček.

Beds with *Monograptus thomasi. Monograptus thomasi* Jaeger has been found near the mouth of Royal Creek in about 10 feet of strata immediately beneath the lowest recognized occurrence of *M. yukonensis.*

Monograptus hercynicus Zone is documented for the first time in northwestern Canada. To date the species is known only from the Prongs Creek section, where it occurs without association in a foot of shale. Where graptolites are absent, the interval can be recognized by the presence of *Toquimaella kayi* Johnson, *Spirigerina* cf. *S. supramarginalis* (Khalfin), or other representatives of the "*Spirigerina*-unit" of Lenz (1968).

Monograptus uniformis Zone. The presence of the index species of this zone in western Canada is documented for the first time. The existence of the zone is established on the basis of the zonal designate and *Warburgella rugulosa canadensis* Ormiston in the Hart River section, and on *Icriodus woschmidti* Ziegler and *Gypidula pelagica* (Barrande) at Royal Creek (Lenz, 1968).

Monograptus transgrediens Zone has not previously been recognized in North America. As now known the zone is typified by the subspecies *Monograptus transgrediens praecipuus*, which has been collected from Hart River and Prongs Creek. Direct comparison of the Yukon and Czechoslovakian material, and the occurrence of the subspecies a short distance below the Gedinnian trilobite *Warburgella rugulosa canadensis* Ormiston, suggest an age assignment to the latest Silurian (Late Přidolian).

Monograptus chelmiensis Zone is represented on Hart River, Prongs Creek, Porcupine River, and may be present in the Delorme Formation at the base of Cathedral Mountain, South Nahanni River. The zone, recognized by the association of *M. chelmiensis* (Teller) and *M. bugensius* (Teller), may be more than 50 feet thick.

Monograptus bugensius Zone. At all three of the Yukon occurrences of the *M. chelmiensis* Zone, *M. bugensius* appears somewhat earlier than, but considerably overlaps, the vertical range of *M. chelmiensis*, suggesting that it may represent merely a subzone within the *chelmiensis* Zone. Its association with *M.* cf. *M. formosus*, however, supports the separation of beds below the lowest occurrence of *M. chelmiensis* into a separate biostratigraphic unit. This interval may be more than 50 feet thick.

Monograptus aff. *M. formosus* Zone is recognized primarily on the basis of the index species *M. paraformosus* Jackson and Lenz, a species with a strong similarity to *M. formosus* Bouček. The zone is considered to represent the *formosus* Zone of latest Kopaninan (Late Ludlovian) age of Czechoslovakia. It is known on Porcupine River, Prongs Creek, and possibly Hart River.

Monograptus leintwardinensis primus Zone is particularly characterized by *M. leintwardinensis primus* Bouček, *M. leintwardinensis leintwardinensis* Hopkinson, *M. bohemicus tenuis* Bouček, and the first appearance of *Linograptus posthumus tenuis* Jaeger. Its distribution ranges from Clearwater Creek near South Nahanni River of southwest District of Mackenzie, to as far north as the central Richardson Mountains. The thickness of the zone is apparently extremely variable, but probably exceeds 250 feet. The zone may really be regarded as a catchall which, on the basis of faunal content and stratigraphic position, probably corresponds to the post-

scanicus to pre-*formosus* zones of Europe, that is to the Middle and most of the Upper Kopaninan. For this reason it should be emphasized that this zone is not synonymous with the more restricted zone of the same name of Münch (1952), and Bouček (1960); nor should it be confused with the Mid-Ludlovian *M. leintwardinensis leintwardinensis* Zone of the Welsh Borderland.

Monograptus nilssoni Zone, as pointed out by Lenz and Jackson (1969), is notable because of its extensive distribution through western District of Mackenzie and eastern and northern Yukon, the abundance and variety of species, and the thickness which may exceed 500 feet. The zone is readily recognized by *M. nilssoni* Barrande, *M. bohemicus* Barrande (*sensu stricto*), and *M. uncinatus orbatus* Wood, and is correlative with the Lower Ludlovian of Great Britain and the Lower Kopaninan of Bohemia.

Prongs Creek Collections (65°18′N, 135°40′W)

The section was collected by A. C. Lenz in 1968 and starts at shale and limestone outcrop that overlies the massive gate-forming Upper Ordovician limestones. The sequence includes Road River and Prongs Creek Formations in conformable contact. The base of the Prongs Creek Formation is drawn at the base of the first massive limestone beds that appear in the section some 510 feet stratigraphically above the Upper Ordovician limestones. This practice is in keeping with the procedure followed in Lenz (1967), that is, the Prongs Creek Formation in this region is recognized by being more calcareous as compared with the more argillaceous underlying Road River Formation. Norris (1967, sec. 10; 1968a, fig. 3, sec. 10) drew the boundary at 702 feet above the Upper Ordovician limestones, presumably corresponding approximately to the highest occurrence of graptolites. The writers' present collection of *M. yukonensis*, more than 600 feet stratigraphically above this level, indicates this is not a valid criterion. Section also corresponds to Section 7 of Norford (1964).

Footage above base of Section	Fauna
1,395–1,375	*Monograptus yukonensis* Jackson and Lenz
1,000	*Spirigerina, Toquimaella kayi* Johnson, *Plicoplasia*, and other brachiopods
925	*M. hercynicus* Perner
700	*M. transgrediens praecipuus* (Přibyl)
625	*Atrypella, Gracianella*
Top of Road River Formation and base of Prongs Creek Formation drawn at 510 feet.	
462	*M.* ex gr. *M. transgrediens* Perner, *Linograptus* ex gr. *L. posthumus* Richter
444	*M. bugensius* Teller, *M.* cf. *M. paraformosus* Jackson and Lenz, *M.* aff. *M. kosoviensis* Bouček, *L. posthumus tenuis* Jaeger
380	*M.* aff. *kosoviensis, M. paraformosus, L. posthumus tenuis*
374	M. aff. *kosoviensis*
343	*M. bohemicus* Barrande, *M.* sp.
326–309	*M. bohemicus* (abundant), *Linograptus* sp.
303	*M. bohemicus*
275	*M. bohemicus, M. roemeri* Barrande?, *M.* ex gr. *M. dubius* (Suess)
263	*M. bohemicus, M.* cf. *M. roemeri*
255–250	*Kirkidium*? cf. *K. alaskanese* (Kirk and Amsden), encrinurid trilobites

Hart River Collections (65°34′N, 136°55′W)

Section studied by W. S. MacKenzie (GSC) and Elf Canada, 1967. Section corresponds to Section 15 of Norris (1968a, Fig. 4)

GSC loc. No.	Footage above base of Road River Formation	Fauna
C-233	633	*Monograptus uniformis* Přibyl *M. angustidens-uniformis* transients sponge spicules
C-232	577	*Monograptus* cf. *M. angustidens-uniformis* transient straight cephalopod
C-231	542	*Warburgella rugulosa canadensis* Ormiston *Howellella* sp. ? *Mesodouvillina* sp. echinoderm fragments orthid and rhynchonellid brachiopods ostracods
C-230	507	*M. transgrediens praecipuus* Přibyl
C-229	420	*Monograptus norfordi* n. sp. *M. chelmiensis* Teller *Linograptus* sp.
C-228	259	*Monograptus* cf. *M. formosus* Bouček *M.* ex gr. *M. dubius* (Suess) brachiopods undet.
C-227	231	*Monograptus* ex gr. *M. dubius*
C-226*	175	*M. nilssoni* Barrande *M. bohemicus* Barrande ? *Linograptus* sp.
C-225*	140	*Monograptus* cf. *M. bohemicus*
C-224*	123	*Monograptus* spp. *M.* cf. *M. bohemicus*
C-223*	108	*Monograptus* spp.
C-222	66	*Monograptus* spp. *M.* aff. *M. flemingii* (Salter) *M.* cf. *M. testis* (Barrande)
C-221	24	*Monograptus* spp. *M.* aff. *M. spiralis* (Geinitz)

*Between C-223 and C-226 this interval has also yielded the following additional material collected by Pan American Petroleum Corporation: *M. nilssoni* Barrande, *M. bohemicus tenuis* Bouček, *M. scanicus* Tullberg, *M. leintwardinensis primus* Bouček, and *Linograptus posthumus tenuis* Jaeger.

Note: Identifications of collections C-231 and C-221 to C-223 inclusive are by B. S. Norford.

Systematic Paleontology

Prefix GSC refers to specimens in the type collection of the Geological Survey of Canada, Ottawa; UA to those of the Department of Geology, University of Alberta; and UWO to those housed in collections of the Department of Geology, University of Western Ontario.

Order GRAPTOLOIDEA
Family MONOGRAPTIDEA Lapworth, 1873
Genus *Monograptus* Geinitz, 1852

Monograptus hercynicus Perner, 1899

Plate 1, figures 1–6; Textfigure 2 A–F

Monograptus hercynicus Perner, 1899, pt. IIIb; pp. 19, 20, Textfig. 13. For complete synonymy *see* Jaeger, 1959, p. 87.

Material. Twenty-two specimens that show at least the proximal half of the rhabdosome preserved as silvery films on black, calcareous shale. Figured specimens comprise GSC hypotypes 21311 to 21316, Prongs Creek Formation, from Prongs Creek. Descriptions also based on hypotypes UWO 2622 to 2627 from the same location and beds.

Description. Rhabdosome medium sized, maximum length observed 32 mm, excluding virgula which is at least 7 mm long; weak dorsal curvature between th^1 and th^4, reversing to weak ventral curvature between th^7 and th^9, essentially straight distally. Width of rhabdosome, inclusive of thecal hood, increases fairly rapidly from about 0.9 mm ($\pm$ 0.2 mm) at th^1 to about 1.3 to 1.4 mm at th^{10}, and then widens gradually to a maximum of 1.3 to 1.6 mm between th^{10} and th^{15}.

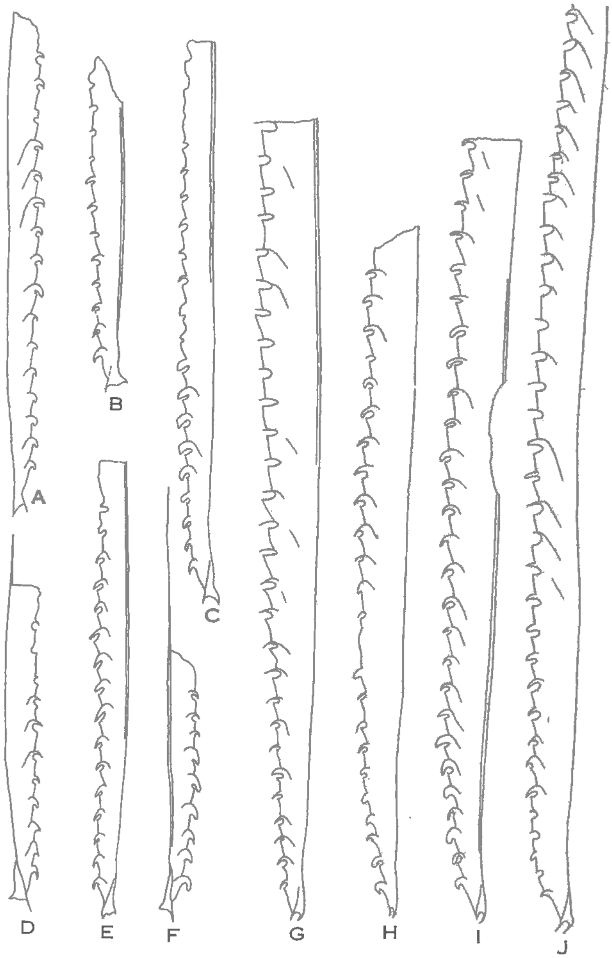
Thecae uniform, of *uncinatus* type, thecal hoods prominently hooked in proximal part of rhabdosome and usually cover thecal apertures, distally the hoods become progressively shorter and less down-curved leaving thecal apertures visible. Free ventral walls of thecae straight to slightly sinuous, inclined at 10 to 15 degrees to axis of rhabdosome. Thecae spaced at the rate of 5½ to 6 in 5 mm proximally and five in 5 mm distally. Interthecal septa, when seen, appear straight for proximal two thirds to three quarters of length, then curve to meet the free ventral wall at a steep angle and continue beyond as thecal hoods; beyond th^5 and th^6, thecae overlap moderately so that a cross-section through the rhabdosome would cut only the interthecal septum of the succeeding theca.

Sicula trumpet-shaped with flaring aperture, free dorsal side slightly sinuous with slight ventral curvature, apex extending to level between apertures of th^1 and th^2. Aperture up to 0.7 mm wide, with short virgella at least 0.6 mm long and a short postero-laterally projecting dorsal process.

Comparison and discussion. Monograptus hercynicus is an important early and middle Siegenian index species (Solle, 1963; Jaeger, 1965) which has a world-wide distribution. In addition to the localities in Europe reported by Jaeger (1959), the species is known in North Africa (Waterlot, 1945; Legrand, 1961; Hollard and Willefert, 1961; Willefert, 1962), and the Soviet Union (Obut, 1960; Koren, *pers. com.* 1968). The Prongs Creek occurrence represents the first discovery of the species in western Canada. Its occurrence 75 feet below carbonates containing the *Spirigerina* fauna (Lenz, 1967, 1968) provides important additional evidence of an early or middle Siegenian age for those beds in Yukon Territory.

Specimen No.	Rhabdosome length	Number thecae	Rhabdosome width Th¹	Th⁵	Th¹⁰	Maximum	Thecae in 5 mm Proximally	Distally
GSC 21311	17.5	17	0.8(0.7)[1]	1.1(0.9)	1.35(1.1)	1.4(th13)	5½	5
21312	12	12	0.9(0.65)	1.1(1.0)	1.2(1.0)	1.2(th10)	6	5?
21313	20.5	20	1.0(0.7)	1.25(0.9)	1.2(1.1)	1.4(th8)	6	5
21314	12	12	1.0(0.65)	1.3(1.05)	1.35(1.05)	1.35(th10)	5¾	5
21315	16.5	17	0.7(0.5)	1.1(0.8)	1.25(0.9)	1.3(th11)	6	5
21316	9	10	0.9(0.65)	1.2(1.0)	?	1.3(th9)	5½	?
UWO 2622	10	12	1.0(0.6)	1.2(0.9)	1.4(1.1)	1.4(th10)	6½	?
2623	23.5	26	1.0(0.8)	1.2(1.1)	1.6(1.3)	1.7(th13)	6½	6
2624	15	16	1.0(0.7)	1.4(1.2)	1.6(1.4)	1.6(th12)	6	5
2625	20	20	1.0(0.7)	1.25(1.0)	1.3(1.1)	1.4(th15)	5¾	5
2626	13.5	13	0.95(?)	1.2(1.0)	1.5(1.15)	1.6(th13)	6	5
2627	10	11	0.85(0.6)	1.15(0.9)	1.3(1.2)	1.3(th10)	6½	?

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



TEXTFIGURE 2

Monograptus hercynicus Perner

A-F. Drawings of hypotypes GSC 21311–21316 (see *also* Pl. 1, figs. 2, 6, 1, 4, 3, 5), 415 feet above base of Prongs Creek Formation, Prongs Creek; x5.6, x5.4, x5.3, x5.2, x5.4, x5.8.

Monograptus telleri new species

G. Drawing of holotype GSC 21317 (see *also* Pl. 1, fig. 15), distal portion omitted, Delorme Formation, South Nahanni River, 8 miles downstream from junction with Flat River, from small isolated outcrop; x5.2. H. Drawing of paratype GSC 21318 (see *also* Pl. 1, fig. 14), Prongs Creek Formation, Royal Creek, 1,025 feet above base of section; x5.2. I. Drawing of paratype GSC 21319, 570 feet below top of Road River Formation, tributary of Rock River; x5.4. J. Drawing of paratype GSC 21320 (see *also* Pl. 1, fig. 13), Delorme Formation, junction South Nahanni and Flat Rivers, 2,215 feet above base of section; x5.3.

Monograptus hercynicus is readily distinguished on the basis of its characteristic trumpet-shaped sicula. The Yukon species fits well within the range of variation of *M. hercynicus hercynicus* in length and width of rhabdosome and in the thecal spacing of 6½ to 5 in 5 mm (cf. dimensions of Sahara material in Willefert, 1962). *M. hercynicus nevadensis* described by Berry (1967) from Nevada differs in being distinctly broader (2.5 mm average) and usually possessing fewer thecae in 5 mm (5½ to 5 proximally, and 4¾ to 3½ distally).

Occurrence. Monograptus hercynicus has been collected only from the Prongs Creek Formation at Prongs Creek, where it was found on a single bedding plane 225 feet above an occurrence of *M. transgrediens praecipuus* of late Přidolian age and about 460 feet below beds containing *M. yukonensis.*

Monograptus telleri new species

Plate 1, figures 11–15; Textfigure 2 G–J

Monograptus cf. *hemiodon* Jaeger, Jackson and Lenz, 1963, p. 752.
Monograptus cf. *M. praehercynicus* Jaeger, Lenz and Jackson, 1965, p. 896.
Monograptus ramstalensis Jaeger?, Lenz and Jackson, 1965, p. 896.
Monograptus cf. *M. uniformis* Přibyl, Lenz and Jackson, 1965, p. 896.
Monograptus n. sp. A, Lenz, 1968, p. 593.
Monograptus n. sp. A, Lenz and Jackson, *in press.*

Material. Several hundred specimens from Royal Creek and a tributary of Rock River, Yukon, and at least 50 nearly complete specimens from southwest District of Mackenzie. Almost all specimens are preserved as silvery films on black shale.

Figured types comprise GSC holotype 21317, Delorme Formation, South Nahanni River, 8 miles downstream from junction with Flat River (61°31′N, 125°13′W); GSC paratypes 21318, 21339 and 21340, Prongs Creek Formation, Royal Creek (64°45′20″N, 135°10′W); GSC paratype 21319, Road River Formation, tributary of Rock River (66°48′N, 136°06′W); and GSC paratype 21320, Delorme Formation, junction of South Nahanni and Flat Rivers (61°34′N, 125°14′W).

Description. Rhabdosome of medium size, maximum length observed 44.5 mm. Proximal part between th^1 and th^5 with weak dorsal curvature, reversing to ventral curvature between th^6 and th^8, and straight thereafter. Ventral side of rhabdosome also displays weak dorsal curvature up to th^7 or th^8, the remaining distal part being straight. Rhabdosome widens fairly rapidly from about 1.0 mm across th^1, inclusive of thecal hood (about 0.5 mm exclusive of hood), to about 1.5 mm at th^5; thereafter width increases more gradually to an average of about 2.2 mm (maximum 2.5 mm) generally between th^{11} and th^{15}; beyond that width may remain constant or may diminish slightly. As a result of rapid initial widening, proximal part exhibits a somewhat pinched look. The pinched appearance, the weak dorsal curvature of the dorsal side of rhabdosome immediately above this level, and the fact that maximum width is most often attained not far beyond the level of ventral curvature, tend to accentuate the ventral curvature of the dorsal side of the rhabdosome.

Thecae in general of *uncinatus* type, thecal hoods strongly hooked and well developed proximally, occasionally obscuring thecal apertures; distally, hoods become proportionately shorter, narrower, less down-curved, and expose thecal apertures. Ratio of width of rhabdosome occupied by thecal hoods ranges from one third to one half proximally to about one fifth distally. Thecal apertures thickened, concave, often with slightly projecting outer lip. Free ventral wall usually straight, occasionally concave, almost invariably inclined at about 20 degrees to axis of rhabdosome. Interthecal septa straight, inclined at about 30 degrees to rhabdosome axis except near apertures where they curve to meet free ventral wall, only moderately imbricated so that a cross-section through the thecal hood of any distal theca will typically cut the septum of only the succeeding theca. Thecae 5½ in 5 mm proximally decreasing to 4¾ in 5 mm distally.

Sicula narrowly cone-shaped, dorsal side ventrally curved, apex extending to level of aperture of th^1. Dorsal process strongly ventrally deflected; virgella straight, at least 0.5 mm long, projecting postero-ventrally.

Specimen No.	Rhabdosome length	Number thecae	Rhabdosome width				Thecae in 5 mm	
			Th^1	Th^5	Th^{10}	Maximum	Proximally	Distally
UWO 2627	26	23	0.9(0.5)[1]	1.5(1.3)	2.1(1.7)	2.2(th^{17})	6	4½
GSC 21340	34	32?	1.0(0.5)	1.6(1.15)	2.3(1.8)	2.5(th^{11})	5	4½
GSC 21339	24	22	1.0(0.5)	1.5(1.15)	2.2(1.7)	2.4(th^{11})	5½	4?
UWO 2628	24.5	22	0.9(0.5)	1.5(1.3)	1.8(1.6)	1.9(th^{14})	6	4¾
UWO 2629	18	17	0.9(0.6)	1.7(1.3)	1.9(1.6)	2.05(th^{15})	5½	4¾
UWO 2630	10	10	1.1(0.7)	1.75(1.45)	1.8(1.6)	1.8(th^{10})	5½	?
UWO 2631	40.5	37	1.05(0.6)	1.5(1.3)	2.0(1.8)	2.5(th^{23})	5½	4¾
GSC 21319	24.5	24	1.0(0.5)	1.6(1.2)	2.05(1.7)	2.1(th^{11})	6	5½
UWO 2632	18.5	20	0.9(0.6)	1.55(1.05)	1.9(1.6)	2.05(th^{11})	6½	6
UWO 2633	32	30?	1.0(0.6)	1.5(1.4)	2.15(1.6)	2.2(th^{12})	6	5
UWO 2634	40.5	35	0.9(0.55)	1.55(1.2)	1.9(1.6)	2.0(th^{14})	5½	4½
UWO 2635	34.5	30	0.9(0.45)	1.5(1.2)	2.1(1.65)	2.1(th^{10})	5¼	4½
GSC 21320	35	31	1.0(0.6)	1.6(1.3)	1.8(1.6)	2.0(th^{11})	5½	4½
UWO 2636	25	23	1.0(0.6)	1.6(1.3)	1.85(1.55)	2.0(th^{11})	5½	5
UWO 2637	33.5	30	1.0(0.5)	1.5(1.15)	1.6(1.3)	1.9(th^{16})	5½	4¾
UWO 2638	33	30	1.0(0.6)	1.4(1.1)	1.8(1.6)	2.15(th^{12})	6	4¾
GSC 21317	44.5	40	0.9(0.5)	1.4(1.1)	1.95(1.5)	2.4(th^{20})	5½	4½

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

Comparison and discussion. Monograptus telleri is a common associate of *M. yukonensis* and the tentaculitid *Nowakia acuaria* (Richter) in northern Yukon, thereby confirming a correlation with the Pragian Stage (late Siegenian and/or early Emsian) of Czechoslovakia.

M. telleri bears some resemblance to *M. pacificus* Jaeger (*in* Churkin, Jaeger and Eberlein, 1970) in the general character of its rhabdosome. It differs, however, in being wider (average 2.2 mm vs. 1.5–1.8 mm for *M. pacificus*) and possessing more thecae (12–13 per cm proximally in *M. telleri* vs. 11 per cm proximally for *M. pacificus*).

Monograptus telleri is similar in many respects to *M. praehercynicus* Jaeger, and previously was tentatively identified as that species (Lenz and Jackson, 1965; 1969). It resembles *M. praehercynicus* in the thecal spacing, rhabdosome width, and overlap of interthecal septa. It differs, however, in the strongly ventrally curved dorsal tongue of the sicula, the much narrower interthecal widths between th^1 and th^3 which emphasize the pinched appearance of the proximal part of the rhabdosome, and in the rather consistent inclination of the free thecal walls to the axis of the rhabdosome.

Morphological variants of *Monograptus yukonensis* with relatively weakly dorsally curved proximal parts bear some resemblance to *M. telleri* but usually can be distinguished by their typical J-shape, more gradual widening of the proximal part of the rhabdosome up to the level of th^3 to th^4 which imparts a stretched look, and by their lesser width (average about 2.2 mm for *telleri* compared to about 1.7 mm for *yukonensis*).

This species is named in honour of Lech Teller, Geological Laboratory, Polish Academy of Sciences.

Occurrence. This species is common throughout northern Yukon, in relatively frequent association with *M. yukonensis;* typically, however, the first appearance of *M. telleri* is stratigraphically slightly above the first appearance of *M. yukonensis.* In northern Yukon, *M. telleri* has been collected from the Road River and Prongs Creek Formations of Royal Creek northwest of Royal Mountain (65°03′20″N, 135°09′10″W), where along with *M. yukonensis* it ranges through 160 feet of strata; Royal Creek headwaters (approximately 64°45′20″N, 135°10′W) at 821 feet of section 1 and 1,025 feet of section 2 of Lenz (1968, figs. 1 and 2); the tributary of Rock River (66°48′N, 136°06′W) where it more or less alternates with *M. yukonensis* through 230 feet of beds; Prongs Creek (65°04′40″N, 135°08′24″W) about 1,400 feet above base of the Road River Formation; the top of the section of the Lower Canyon of Peel River (65°55′30″N, 135°53′46″W); and Hart River (65°34′N, 136°55′W).

In southwest District of Mackenzie, *M. telleri* occurs alone or in association with *Nowakia acuaria* (Richter) in the Delorme Formation and has been collected from the junction of South Nahanni and Flat Rivers, north bank of South Nahanni River, north of Meilleur Creek, and on Meilleur Creek headwaters (localities 6, 8, 11, and 15, of Lenz and Jackson, 1965).

Monograptus norfordi new species

Plate 1, figures 7–10; Textfigure 3 E,F,J,L,K

Material. GSC holotype 21304 and GSC paratypes 21305 to 21310, preserved as silvery carbonaceous films on black shales, 420 feet above base of exposed Road River Formation, Hart River, GSC loc. C-229, collected by W. S. MacKenzie, 1967.

Description. Rhabdosome small, up to 9 mm long excluding virgula, dorsal edge dorsally curved throughout except for slight reversal at proximal end. Rhabdosome widens from 0.8 to 0.9 mm at aperture of th^1 to 0.8 to 1.0 mm across th^5, and a maximum width of about 1.0 mm is usually attained by th^5; interthecal widths are 0.5 to 0.6 mm above th^1 and 0.55 to 0.75 mm above th^5.

Sicula about 2.0 mm long, with curved axis, apex extends slightly above level of aperture of th^1; ventrally deflected aperture is 0.4 mm wide and furnished with a fine delicate virgella.

Thecae biform, at least first two proximal thecae exhibit a beak-like profile at ventral edge of thecal apertures. These apertures are probably formed by medial cleft as in some cyrtograptids rather than being truly hooked apertures. Such structure seems to be a common theme among late Silurian graptolites. Free ventral walls of more distal thecae dichograptid, slightly sigmoidal; interthecal septum not seen. There are 6½ to 7 thecae in 5 mm.

GSC No.	Rhabdosome length	Number thecae	Rhabdosome width		Thecae in 5 mm
			Th^1	Th^5	
21304	4.7	6	0.8(0.55)[1]	0.9(0.7)	—
21305	6.8	9	0.8(0.5)	1.0(0.75)	7
21306	5.0	6	0.85(0.5)	0.9(0.55)	—
21307	7.5	10	0.8(0.5)	1.0(0.7)	6½
21308	6.0	8	0.85(0.6)	0.85(0.55)	?7
21309	8.1	10	0.9(0.6)	1.0(0.65)	6½
21310	6.5	9	0.85(0.6)	0.8(0.6)	7

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

Comparison and discussion. The small size and dorsal curvature of the rhabdosome make this a very distinctive species among Přidolian faunas. It bears slight resemblance to *M. perneri* Bouček which has uniform, hooked thecae and to *M. fritschi* Perner which has wider and spinose thecae. This species is named in honour of B. S. Norford, Geological Survey of Canada.

Occurrence. The species is recorded from only two localities on the Hart River. At one of these localities (GSC loc. C-229) it occurs in the *chelmiensis* Zone associated with *M. chelmiensis* and *Linograptus* sp. indet. This occurrence is 161 feet above shales with *M.* cf. *M. formosus* and 87 feet below *M.* cf. *M. transgrediens praecipuus.* In the second locality about 5 miles upstream a single specimen occurs with *M. chelmiensis, M. bugensius,* and *Linograptus posthumus tenuis.*

TEXTFIGURE 3

Monograptus thomasi Jaeger

A, B, H, I. Drawings of hypotypes GSC 21321–21324, respectively, 160 to 170 feet above section base of Road River Formation, Royal Creek; x5, x5.2, x5.2, x5.5. Pl. 2, fig. 2 shows same specimen as 3–1.

Monograptus cf. *M. uniformis* Přibyl

C, G. Drawings of hypotypes GSC 21302 and 21303, from GSC loc. C-233, 633 feet above base of Road River Formation, Hart River; x5.0, x5.1.

Monograptus uniformis–angustidens transient (not described)

D. Drawing of hypotype GSC 27765, same horizon and locality as C and G; x5.1.

Monograptus norfordi new species

E, F, J, L. Drawings of paratypes GSC 21306, 21310, 21305, and 21307 respectively (see *also* Pl. 1, figs. 8, 7, 9; not 21305), from GSC loc. C-229, 420 feet above base of Road River Formation, Hart River; x5.0, 5.2, 5.1, 5.0. K. Drawing of holotype GSC 21304 (see *also* Pl. 1, fig. 10), same horizon and locality; x5.3.

Monograptus thomasi Jaeger, 1966

Plate 2, figures 1–4; Textfigure 3 A, B, H, I

Monograptus thomasi Jaeger, 1966, pp. 403–411, Pl. 41, figs. 3–5; Pl. 42, figs. 2–7; Pl. 43; Textfigs., 1a–c, o.

Material. The collection consists of about 100 specimens preserved as silvery films on black, calcareous shale; most of the specimens are rather poorly preserved. Figured types include GSC hypotypes 21321 to 21328, Road River Formation, Royal Creek immediately northwest of Royal Mountain (65°03′20″N, 135°09′10″W).

Description. Rhabdosome of medium size, maximum length observed 36 mm excluding virgula which attains a length of at least 4 mm. Dorsal edge of proximal part of rhabdosome generally with weak dorsal curvature between th^1 and th^5, reversing to ventral curvature between th^6 and th^8, and essentially straight or weakly ventrally curved thereafter. This reversal in curvature commonly results in the dorsal edge being hump-backed. A line joining tips of thecae on ventral side is more or less straight. Width of rhabdosome widens from about 0.9 mm at th^1 inclusive of thecal hood, to about 1.1 to 1.2 mm inclusive of thecal hood at th^5, then widening to a maximum width of 1.5 to 1.6 mm generally about th^{10} and th^{12}, and width remaining constant or, more commonly, decreasing slightly, thereafter.

Thecae uniform, of *uncinatus* type, strongly hooked thecal hoods well developed in proximal part of rhabdosome especially in vicinity of th^4 to th^6, obscuring thecal apertures; become progressively shorter, narrower, and less down-curved distally so that thecal hoods lie above thecal apertures leaving apertures visible. Free ventral walls of distal thecae parallel to inclined at about 10 degrees to rhabdosome axis. Interthecal septa straight for ⅔ to ¾ length then curve to meet ventral edge of rhabdosome. Thecal spacing remains essentially constant throughout entire length of rhabdosome and averages 5 to 5½ in 5 mm; because of this, and the delayed widening of the rhabdosome to the level of th^5 or th^6, the proximal part has a characteristic stretched look.

Sicula narrowly cone-shaped, up to 1.6 mm long, apex extending to level midway between th^1 and th^2, dorsal side ventrally curved; aperture 0.45 mm wide, furnished with a pronounced ventrally directed dorsal process, and straight virgella.

Specimen No.	Rhab-dosome length	Number thecae	Rhabdosome width Th^1	Th^5	Th^{10}	Maximum	Thecae in 5 mm Prox-imally	Distally
GSC 21321	22.5	23?	0.8(0.4)[1]	1.1(0.85)	1.5(1.3)	1.6(th^{13})	6	5¼
GSC 21322	16	17	0.8(0.6)	1.0(0.8)	1.3(1.15)	1.3(th^{10})	5½	5½
GSC 21323	12	13	0.9(0.5)	1.2(1.0)	1.5(1.3)	1.6(th^9)	6	?
GSC 21324	29	29	0.9(0.5)	1.0(0.75)	1.3(1.1)	1.5(th^{24})	5½	5
GSC 21326	25.5	26?	0.7(0.45)	1.1(0.9)	1.6(1.3)	1.6(th^{10})	6	5½?
UWO 2639	16.5	?	0.8(0.5)	1.2(0.85)	1.4(1.2)	1.4(th^{10})	5½	?
UWO 2640	32	?	0.9(0.6)	1.1(0.9)	1.5(1.2)	1.5(th^{10})	6	?
UWO 2641	15	16	?	1.1(0.9)	1.4(1.2)	1.45(th^{12})	5½	5½
GSC 21327	21	21	0.9(0.6)	1.2(0.8)	1.6(1.45)	1.6(th^{10})	5½	5½
GSC 21328	28	?	0.8(0.45)	1.1(0.95)	1.2(1.1)	1.6(th^{14})	5¾	?
UWO 2642	22	21	0.8(0.45)	1.2(0.9)	1.45(1.2)	1.5(th^{11})	5½	5¼
UWO 2643	20	21	0.85(0.5)	1.1(0.85)	1.3(1.15)	1.5(th^{12})	6	5½
GSC 21325	31	30	0.9(0.5)	1.1(0.8)	1.3(1.1)	1.5(th^{24})	5¾	5½

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

Comparison and discussion. Monograptus thomasi is recognized by the more or less constant number of thecae throughout its length, and by the stretched look of the proximal part. In the general character of the rhabdosome and of the sicula, *M. thomasi* bears a resemblance to *M. telleri* n. sp.; it differs, however, in being narrower, as well as in the more or less uniform spacing and frequency of thecae. The stretched look of the proximal part of *M. thomasi* resembles variants of *M. yukonensis* with mildly dorsally curved proximal ends. *Monograptus thomasi* can be distinguished from *yukonensis* in that it lacks the distinctive J-shape and has uniformly spaced thecae. *M. thomasi* nevertheless has affinities with *M. yukonensis* and *M. telleri* n. sp., and the fact that it lies stratigraphically immediately below these two species suggests that *M. thomasi* may be ancestral to both these species. The stratigraphic position of *M. thomasi* immediately below *M. yukonensis*, which we consider to be late Siegenian and/or early Emsian (Lenz, 1968), supports Jaeger's (1967) suggestion of an early Pragian age for *M. thomasi.*

Occurrence. This species occurs without association through 10 feet of shale near the mouth of Royal Creek, immediately below the lowest occurrence of *M. yukonensis.* It also occurs in the Lower Canyon of the Peel River, similarly below the lowest occurrence of *M. yukonensis.*

Monograptus transgrediens praecipuus (Přibyl, 1940)

Plate 2, figures 5–8; Textfigure 4 A–D

Monograptus (Pristiograptus) transgrediens var. *praecipuus* Přibyl, 1940, Textfigs. 1–5.
Pristiograptus transgrediens praecipuus Přibyl, Přibyl, 1943, Pl. III, figs. 2, 3; Textfigs. IIH and IIIE.

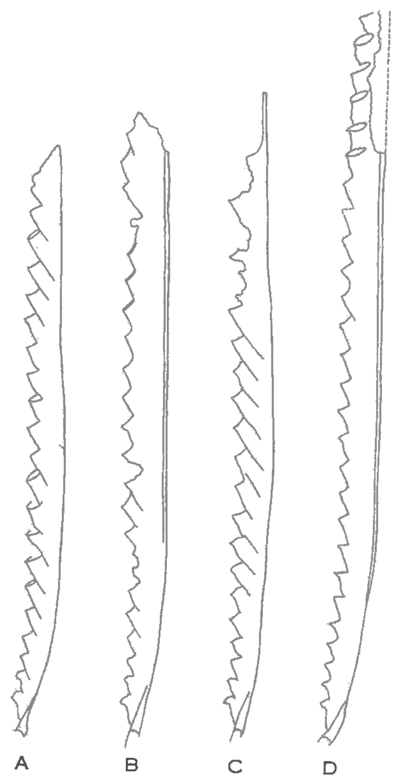
Material. Seven illustrated specimens and several fragments, all preserved as silvery films on black shale. GSC hypotypes 21295 and 21296, 507 feet above base of exposed Road River Formation, Hart River, GSC loc. C-230, collected by W. S. MacKenzie, 1967. GSC hypotypes 21297 to 21301, 190 feet above base of Prongs Creek Formation, Prongs Creek.

Description. Rhabdosome up to 34 mm long (20 mm common) with distinct ventral curvature between th^1 and th^{10}. Width across aperture of th^1 is 0.9 to 1.0 mm increasing to 1.2 to 1.3 mm at th^5 and attaining a maximum of 1.2 to 1.7 mm (1.4 to 1.6 mm common) about th^{10}. Interthecal widths at these intervals are 0.7 to 0.8 mm above th^1, 0.9 to 1.2 mm above th^5, and 1.0 to 1.4 mm above th^{10}.

Sicula in GSC 21300 is 2.0 mm long, apex extending to the level of aperture of th^2; aperture is 0.4 mm wide and furnished with a short virgella and a dorsal process which is ventrally deflected.

GSC No.	Rhab-dosome length	Number thecae	Rhabdosome width				Thecae in 5 mm	
			Th^1	Th^5	Th^{10}	Maximum	Prox-imally	Distally
21295	22	22	?0.9(0.6)[1]	1.3(1.0)	1.4(1.0)	$1.4th^7$	6	5
21296	22	21	?0.7(—)	1.2(0.9)	1.4(1.0)	$1.4th^7$	5½	5
21297	23	?22	1.0(0.8)	1.4(1.2)	1.7(1.4)	$1.8(1.4)th^{11}$	6	4½
21298	15	16	0.9(0.7)	1.2(0.9)	1.4(1.0)	$1.4(1.0)th^{10}$	6	5
21299	22	+22	1.0(0.7)	1.3(0.9)	1.5(1.1)	$1.6(1.2)th^{13}$	6	4¾
21300	28	27	1.0(0.7)	1.2(0.95)	1.4(1.2)	$1.6(1.1)th^{13}$	6	4¾
21301	22	21	?0.7(—)	1.2(0.9)	1.4(1.0)	$1.4(1.0)th^7$	5½	4¾

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



TEXTFIGURE 4

Monograptus transgrediens praecipuus Přibyl

A. Drawing of hypotype GSC 21295 from GSC loc. C-230, 507 feet above base of Road River Formation, Hart River; x5.2.
B, C, D. Drawings of hypotypes GSC 21297, 21299, 21300 respectively (*see also* Pl. 2, figs. 6, 5, 8), 190 feet above base of Prongs Creek Formation, Prongs Creek; x5.2.

Thecae biform, first two thecae exhibit a beak-like profile and the aperture may consist of a medial cleft. Beyond th^5, thecae are of dichograptid type, being long and straight with straight, free ventral wall. Interthecal septa in distal part of rhabdosome are straight and inclined at 35 ($\pm$5) degrees. Apertural margins are slightly concave. There are 5½ to 6 thecae per 5 mm proximally and 5 in 5 mm distally.

Comparison and discussion. This *Monograptus* has many similarities with *M. admirabilis* Teller, *M. graciosus* Přibyl, *M. spectatus* Přibyl, *M. transgrediens proximus* Přibyl, and *M. transgrediens praecipuus* Přibyl, all from strata of Přidolian age.

This form differs from *M. admirabilis* in having more ventral curvature; from *M. graciosus* by being shorter, slightly narrower, with more closely set thecae distally, and less ventral curvature; from *M. transgrediens transgrediens* (Perner) in being shorter, narrower and having slightly wider spaced thecae distally; and from *M. transgrediens proximus* in being shorter, narrower, with fewer thecae per cm and less ventral curvature. The Czechoslovak material of *Monograptus transgrediens praecipuus* resembles our specimens in length, maximum width, and thecal spacing, but has less pronounced ventral curvature.

Occurrence. The Prongs Creek material (GSC 21298–21301) was collected 225 feet below *M. hercynicus*-bearing beds and 256 feet above shales with *M. bugensius.* The Hart River specimens (GSC 21295–21297) occur 87 feet above *M. chelmiensis* and *M. norfordi* n. sp. and 35 feet below the Gedinnian trilobite *Warburgella rugulosa canadensis* Ormiston. The species is without association in both occurrences but a middle or late Přidolian age seems to be compatible with all the data.

Monograptus cf. *M. uniformis* Přibyl, 1940

Textfigure 3 C, G

cf. *Monograptus (Pomatograptus) uncinatus* Tullberg var. *uniformis*, Přibyl 1940, pp. 71–72, Pl. 1, fig. 1.
For complete synonymy *see* Jaeger, 1959, p. 94.

Material. GSC hypotypes 21302 and 21303 and several fragments are available for study. The hypotypes are incomplete distally and are preserved as pale buff or brass coloured films on black shale; 633 feet above base of measured section of Road River Formation on Hart River, GSC loc. C-233, collected by W. S. MacKenzie, 1967.

Description. Rhabdosome incomplete distally, exceeding 32 mm length. Dorsal edge exhibits dorsal curvature between th^4 and th^{10} becoming straight thereafter.

Sicula in GSC hypotype 21302 is about 1.9 mm long, aperture is 0.3 mm wide and furnished with a short delicate virgella and an incurved dorsal process.

Thecae essentially uniform, of *uncinatus* type, possessing strongly hooked, broad thecal hoods. These hoods are most pronounced proximally where they commonly obscure thecal apertures whereas distally they are shorter and less down-curved, often leaving apertures visible. Inclination of thecae decreases distally whereas amount of overlap increases. Interthecal septa at proximal end of GSC 21302 may be inclined at about 50 degrees in contrast to those between th^{12} and th^{14}, which are inclined at 30 to 40 degrees. Thecae are spaced at the rate of 6 to 6½ per mm proximally and 5 to 5½ per 5 mm distally.

GSC No.	Rhabdosome length	Number thecae	Rhabdosome width				Thecae in 5 mm	
			Th^1	Th^5	Th^{10}	Maximum	Proximally	Distally
21302	+20	+20	0.95(0.7)[1]	1.45(1.2)	1.8(1.5)	2.4(2.0)th^{20}	6	5
21303	+27	+29	0.7(—)	1.3(1.0)	2.0(—)	2.6(2.25)th^{24}	6½	5

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

Comparison and discussion. Jaeger (1968) has explored fully the relationship of *M. angustidens* and *M. uniformis* and finds that these species are alike in every respect except that the adult maximum width is greater in *M. uniformis*. However, Jaeger has stressed that there is some overlap in range of width measurements and that the maximum width is usually attained beyond th^{15} but in some specimens not before th^{30} thus making identifications on proximal ends and immature rhabdosomes very difficult. In that same paper, Jaeger opined that the aforementioned species grade into each other through a series of transients and regards the end members as merely subspecies of *M. uniformis*. Our findings of *M. angustidens-uniformis* transients on the same bedding plane as *M.* cf. *M. uniformis* (*sensu stricto*) seem to bear out that opinion.

The strong ventral curvature of the sicular dorsal process is a feature not typical of *M. uniformis*; however the deflection although probably real, seems excessively accentuated by tectonically induced flow cleavage.

Occurrence. The species is known only on Hart River where it occurs 213 feet above *M. chelmiensis*-bearing strata. It is associated with *M. angustidens–M. uniformis* transients and lies 91 feet above *Warburgella rugulosa canadensis* Ormiston of Gedinnian age.

Monograptus yukonensis Jackson and Lenz, 1963

Plate 2, figures 9–12; Textfigure 5 A–G

Monograptus sp. *E.* Jackson and Lenz, 1962, pp. 43, 44.
Monograptus yukonensis Jackson and Lenz, 1963, pp. 751–753, figs. 1a,b.
Monograptus yukonensis Jackson and Lenz, Jaeger (*in* Churkin *and others*) 1970, p. 191, fig. 7, D–F; fig. 8, A.
?*Monograptus craigensis* Jaeger (*in* Churkin *and others*), 1970, p. 198, fig. 7, B, C; fig. 8, B, C; fig. 9, A, F, K; fig. 6.

Material. Several hundred specimens from the Road River and Prongs Creek Formations, northern Yukon Territory, preserved for the most part as silvery films on dark shale. Description is based upon figured GSC hypotypes 21329–21338, plus type series UA 441–446, and UWO 2644–2651.

Description. Rhabdosome medium sized, maximum length observed is 42 mm, excluding a virgula at least 11 mm long. Proximal part moderately to strongly dorsally curved through 30 to 90 degrees, reversing to weak ventral curvature between th^5 and th^{10}, and essentially straight distally, resulting in a J-shape rhabdosome. Width increases from 0.7 to 0.9 mm across thecal hood of th^1 (about 0.5 mm between th^1 and th^2), to about 1.5 mm at th^{10} (1.0–1.3 mm between th^{10} to th^{11}) widening gradually to a maximum of about 1.7 mm between th^{11} and th^{15}, and thereafter maintaining constant width or, more commonly, decreasing slightly. The slender curved proximal part of the rhabdosome possesses a pinched and somewhat stretched look.

Thecae uniform, of *uncinatus* type, proximal thecae have strongly hooked, well-developed, broad thecal hoods which commonly obscure thecal apertures; distally, hoods become proportionately shorter, narrower, and only slightly down-curved, and project outwards approximately perpendicular to free ventral wall leaving thecal apertures exposed. Thecal apertures are weakly concave and have thickened rims. Free ventral walls of distal thecae straight or slightly sinuous, parallel or inclined at less than 10 degrees to rhabdosome axis. Interthecal septa usually appear straight, inclined at 25 to 35 degrees to axis of rhabdosome, overlapping one third proximally to one half distally. Paratype UA 445 (Textfig. 5B) preserved in partial relief shows septa between th^1 and th^{10} to be sigmoidal as in many of Jaeger's (1967) illustrations of *M. uncinatus* and *M. uniformis* from Australia, that is, each septum curves at its proximal extremity as it approaches the dorsal edge of the rhabdosome and its distal end curves in an opposite direction to meet the free ventral wall. Thecae number about 6 in 5 mm proximally and 5 in 5 mm distally, but in a few specimens, rate of thecae in proximal and distal portions is about the same.

Sicula narrowly cone-shaped, maximum 1.8 mm long and 0.5 mm wide, apex reaching to level of aperture of th^1. Dorsal process strongly deflected ventrally; virgella straight, up to 0.5 mm long projecting postero-ventrally.

Comparison and discussion. Since the original description by Jackson and Lenz (1963) the authors have acquired much more material from old and new localities and this has prompted further studies of the morphological variation, and a re-description of the species. The single most distinctive character of the species is the typical J-shape of the rhabdosome. However, the magnitude of the proximal dorsal curvature (excluding the effect of tectonic distortion) varies from specimen to specimen on the same bedding plane as well as from locality to locality. The curvature can range from as little as 25 degrees to as much as 110 degrees. Specimens with a large curvature are readily distinguished from all other species of monograptids, however, those with a low angle of curvature approach to some extent morphologic variations of *M. telleri* n. sp. *M. yukonensis* differs from that form in that its proximal part is thinner, more curved, and more stretched looking, also it is narrower in its distal part, and generally widens less rapidly up to th^{10}.

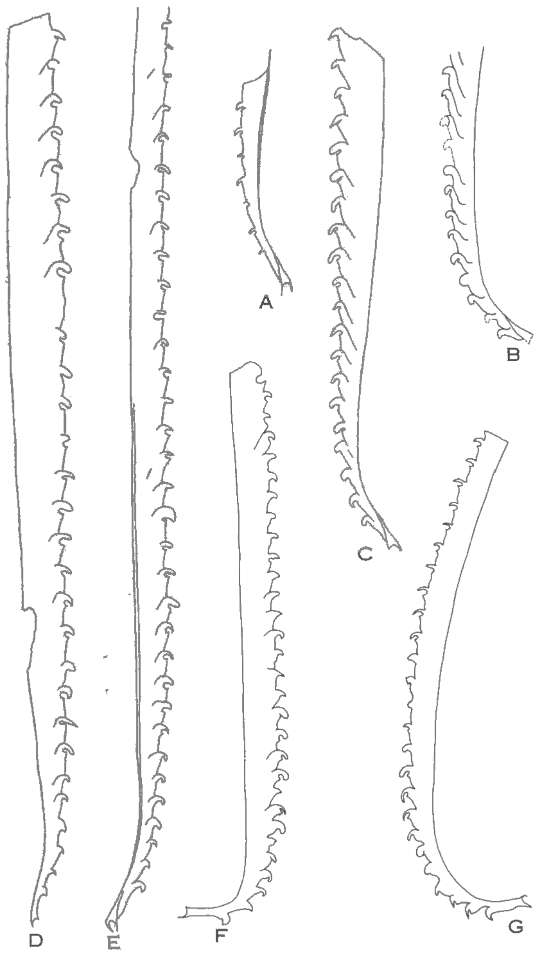
Specimen No.	Rhabdosome length	Number thecae	Rhabdosome width: Th^{1}	Rhabdosome width: Th^{5}	Rhabdosome width: Th^{10}	Rhabdosome width: Maximum	Thecae in 5 mm: Proximally	Thecae in 5 mm: Distally	θ[2]
GSC 21331	32.5	29	?	1.1(0.9)?	1.9(1.6)	2.4(th^{21})	5½	4	25
GSC 21332	42 (+11 mm virgella)	42	0.9(0.45)[1]	1.0(0.6)	1.3(1.0)	1.6(th^{14})	6¼	5	35
UWO 2644	17	17	0.85(0.5)	1.2(0.9)	1.5(1.2)	1.7(th^{13})	5¾	5½	55
UWO 2645	16.5	20	1.0(0.55)	1.1(0.8)	1.35(1.1)	1.4(th^{9})	6½	5¾	60
GSC 21335	26	24	0.9(0.5)	1.1(0.7)	1.45(1.0)	1.55(th^{17})	5½	4½	70
UWO 2646	13	15	0.9(0.5)	1.1(0.75)	1.2(0.9)	1.4(th^{12})	6½	5½	30
UWO 2647	16.5	19	0.85(0.55)	1.2(0.9)	1.4(1.1)	1.55(th^{11})	6¼	5½	50
UWO 2648	24.5	25	1.0(0.6)	1.3(1.0)	1.7(1.5)	1.75(th^{13})	5¾	5	45
UWO 2649	28	28?	0.8(0.5)	1.25(1.0)	1.7(1.5)	1.95(th^{15})	6	5	35
UWO 2650	25 (+11 mm virgella)	26	?	1.2(1.0)	1.6(1.3)	1.8(th^{21})	6	5¼	25
UWO 2651	28	27	0.6(0.4)	1.0(0.8)	1.4(1.1)	1.75(th^{15})	5½	5	55
GSC 21336	25	27	0.9(0.5)	1.05(0.6)	1.3(1.1)	1.8(th^{20})	6¼	5¼	55
GSC 21334	34	42	0.9(0.4)	1.3(0.85)	1.9(1.5)	2.05(th^{22})	5½	6?	75
UA 441 (holotype)	26	27	0.7(0.4)	1.0(0.7?)	1.3(1.0)	1.8(th^{24})	5½	9	70

Measurements in mm.
[1]Figures in brackets are interthecal widths measured immediately above aperture.
[2]Angle between proximal part (including long axis of sicula) and axis of main part of rhabdosome.

Monograptus yukonensis shows variation not only in the degree of curvature of its proximal end, but also in the delicate appearance and spacing of thecae in the proximal part of the rhabdosome. Forms with moderate curvature and very delicate looking proximal ends (*see* Textfig. 5) approach the morphologic characteristics of *M.* cf. *M. yukonensis* described by Bouček (1966) from the top of the Dvorce-Prokop Limestone (latest Early Emsian) of Bohemia. Forms of *M. yukonensis* with proximal thecae almost as widely spaced as distal thecae, however, approach *M. thomasi* in character. The typical dorsal curvature of *M. yukonensis*, as well as its generally greater width, set it apart from *M. thomasi.*

The apparent morphologic intergradation, and the close stratigraphic association of *thomasi*, *yukonensis*, and *telleri* are strong evidence that these three species are phylogenetically related.

In a recent study of Alaskan graptolites, Jaeger (*in* Churkin *and others*, 1970) erected a new species *Monograptus craigensis*. According to Jaeger, *M. craigensis* is distinguishable from *M. yukonensis* by its lesser curved and wider proximal portion, and by decreasing size of the distal thecae. Because of the variability of *M. yukonensis* in the dorsal curvature of its proximal portion, and of the variability of the rate of increase in the width of the thin, delicate proximal portion, even in specimens preserved on the same bedding plane, and of the variable nature of the size of the distal thecae of *M. yukonensis* from the Yukon, we feel the recognition of *M. craigensis* as anything more than a subspecies of *M. yukonensis* may be premature at this time. At best the separation of *M. yukonensis* (sensu Jaeger, 1970) and *M. craigensis* requires abundant, undeformed and well-preserved specimens.



TEXTFIGURE 5

Monograptus yukonensis Jackson and Lenz

A, C. Drawings of hypotypes GSC 21329, 21330 respectively from GSC loc. 51370, 2,876 feet above base of section, Road River Formation, Tetlit Creek; x5.6, x5.4. B. Drawing of paratype D, UA 445, preserved in partial relief, 196 feet below top of Road River Formation, Tetlit Creek; x5.6. Note imbricating thecae and sigmoidal nature of interthecal septa. D. Drawing of hypotype GSC 21331, Prongs Creek Formation, Royal Creek, same collection as GSC 21336; x5.4. E. Drawing of hypotype GSC 21332, 495 feet below top of Road River Formation, tributary of Rock River; x5.5. F, G. Drawings of hypotypes GSC 21333 and 21334 respectively, Road River Formation, Tetlit Creek, 6 feet below top; x5.0, x5.5.

Monograptus yukonensis has been observed to range through several hundred feet of strata, and an attempt was made to relate morphological variation to stratigraphic position, that is, to recognize an evolving lineage. Despite collecting hundreds of specimens from numerous horizons and localities, no distinct pattern has emerged.

Occurrence. *Monograptus yukonensis* has been collected by the authors from the upper Road River and Prongs Creek Formations in northern Yukon from the following localities: at the mountain front on Blackstone River (65°42′40″N, 137°26′24″W); at the mountain front on Prongs Creek (65°18′N, 135°40′W); Royal Creek northwest of Royal Mountain (65°03′20″N, 135°09′10″W) through some 245 feet of strata; Royal Creek headwaters (64°45′52″N, 135°10′W) through some 350 feet of strata; unnamed creek on west side of Richardson Mountains (66°34′N, 136°05′30″W); tributary of Rock River (66°48′N, 136°06′W) ranging through 380 feet of strata; top of formation of Road River at Tetlit Creek (66°44′N, 135°46′W) (Sec. 3 of Jackson and Lenz, 1962, fig. 2); at top of section, Peel River, Lower Canyon (65°55′30″N, 135°53′46″W); and at top of section, Peel River, Upper Canyon

(65°52′36″N, 135°42′40″W). In addition the following localities have been provided by B. S. Norford, Geological Survey of Canada: south side of Caribou River, GSC loc. 79155 (60°51′N, 126°35′W); near O'Grady Lake, GSC loc. 80914 (62°58′N, 128°49′W); and near headwaters of Beaver River, GSC loc. 81027 (60°48′N, 126°52′W). Alaskan localities are from Churkin and Brabb (1965).

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Plate 1

Monograptus hercynicus Perner (Page 7)

Figure 1. Hypotype GSC 21313 (*see also* Textfig. 2C), 415 feet above base of Prongs Creek Formation, Prongs Creek; x3.8.

Figure 2. Hypotype GSC 21311 (*see also* Textfig. 2A), same collection; x3.8.

Figure 3. Hypotype GSC 21315 (*see also* Textfig. 2E), same collection; x3.8.

Figure 4. Hypotype GSC 21314 (*see also* Textfig. 2D), same collection; x3.8.

Figure 5. Hypotype GSC 21316 (*see also* Textfig. 2F), same collection; x3.8.

Figure 6. Hypotype GSC 21312 (*see also* Textfig. 2B), same collection; x3.8.

Monograptus norfordi new species (Page 11)

Figure 7. Paratype GSC 21310 (*see also* Textfig. 3F), GSC loc. C-229, 420 feet above base of Road River Formation, Hart River; x3.7.

Figure 8. Paratype GSC 21306 (*see also* Textfig. 3E), same collection; x3.6.

Figure 9. Paratype GSC 21307 (*see also* Textfig. 3L), same collection; x3.5.

Figure 10. Holotype GSC 21304 (*see also* Textfig. 3K), same collection; x3.5.

Monograptus telleri new species (Page 9)

Figure 11. Paratype GSC 21339, Prongs Creek Formation, Royal Creek, 1,025 feet above base of section; x3.8.

Figure 12. Paratype GSC 21340, Prongs Creek Formation, Royal Creek, 1,025 feet above base of section; x3.8.

Figure 13. Paratype GSC 21320 (*see also* Textfig. 2J), Delorme Formation, junction of South Nahanni and Flat Rivers, 2,215 feet above of base section; x 3.8.

Figure 14. Paratype GSC 21318 (*see also* Textfig. 2H), Prongs Creek Formation, Royal Creek, 1,025 feet above base of section; x3.8.

Figure 15. Holotype GSC 21317 (*see also* Textfig. 2G), Delorme Formation, South Nahanni River, north bank, 8 miles downstream from junction with Flat River, from small, isolated outcrop; x3.5.

PLATE 1

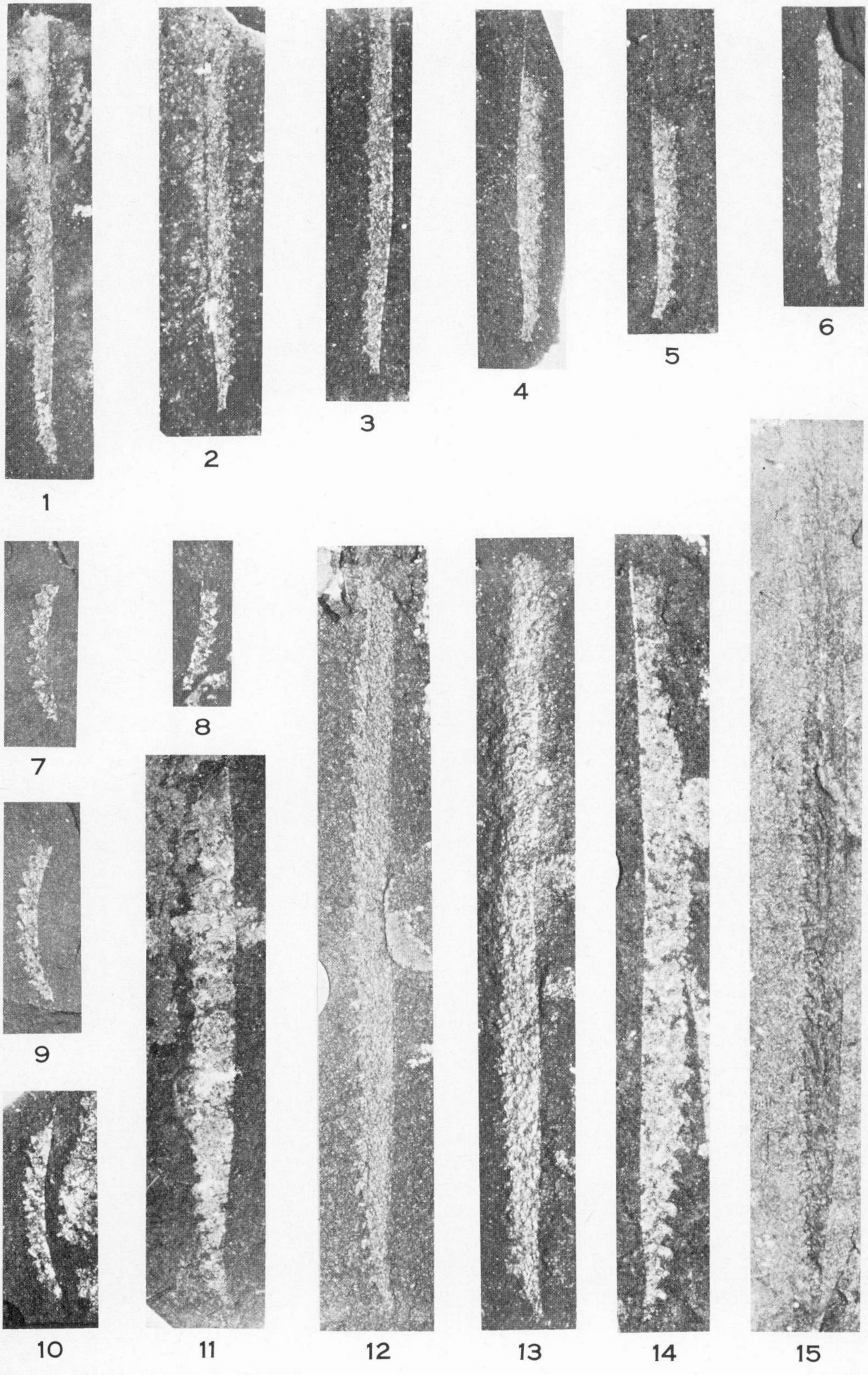


Plate 2

Monograptus thomasi Jaeger (Page 13)

Figure 1. Hypotype GSC 21325, Road River Formation, Royal Creek, 160 to 170 feet above base of section; x3.7.

Figure 2. Hypotype GSC 21324 (*see also* Textfig. 3I), same collection; x3.7.

Figure 3. Hypotypes GSC 21327 (left) and 21328 (right), same collection; x3.7.

Figure 4. Hypotype GSC 21326, same collection; x3.7.

Monograptus transgrediens praecipuus Přibyl (Page 14)

Figure 5. Hypotype GSC 21299 (*see also* Textfig. 4C), 190 feet above base of Prongs Creek Formation, Prongs Creek; x3.8.

Figure 6. Hypotype GSC 21297 (*see also* Textfig. 4B), same collection; x3.8.

Figure 7. Hypotype GSC 21298, same collection; x3.8.

Figure 8. Hypotype GSC 21300 (*see also* Textfig. 4D), same collection; x3.8.

Monograptus yukonensis Jackson and Lenz (Page 17)

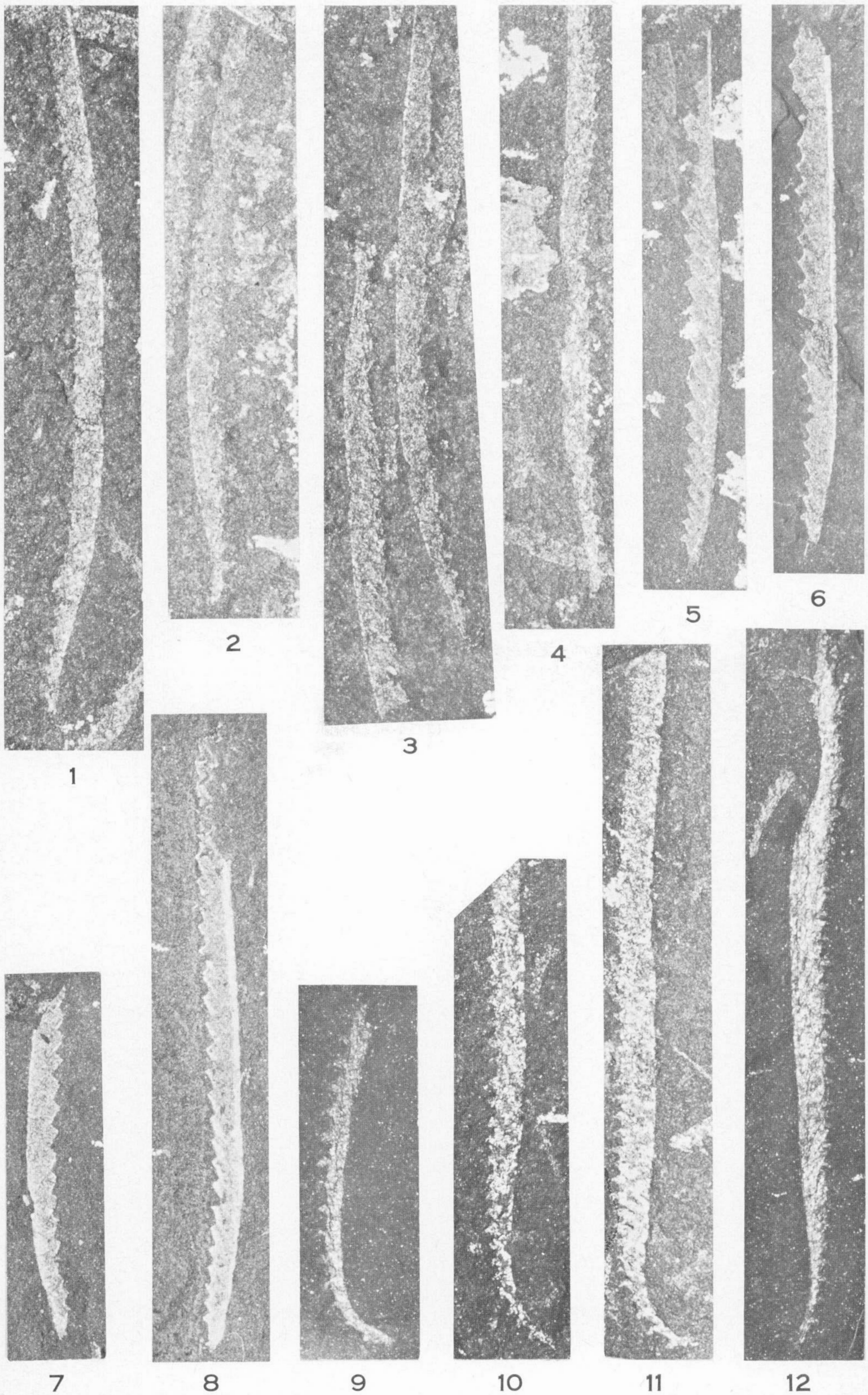
Figure 9. Hypotype GSC 21335, top of Road River Formation, Upper Canyon of Peel River; x3.7.

Figure 10. Hypotype GSC 21336, Prongs Creek Formation, Royal Creek, small outcrop 10 feet below top of ridge on southwest side of cirque; x3.7.

Figure 11. Hypotype GSC 21337, same collection as 21336; x3.7.

Figure 12. Hypotype GSC 21338, GSC loc. 51370, Road River Formation, Tetlit Creek, same collection as GSC 21329; x3.7.

PLATE 2



LOWER DEVONIAN TRILOBITES FROM THE MICHELLE FORMATION, YUKON TERRITORY

A. R. Ormiston[1]

Abstract

Trilobite collections from the Michelle Formation contain a distinctive Lower Devonian (Emsian) fauna. These trilobites appear to have affinity with Lower Devonian forms in the Canadian Arctic Islands and to a lesser extent with forms in the McCann Hill Chert of Alaska.

Résumé

Les groupes de trilobites de la formation de Michelle renferment une faune particulière au Dévonien inférieur (Emsien). Les trilobites s'apparentent aux formes du Dévonien inférieur de l'archipel Arctique canadien et, dans une moindre mesure, à celles du chert de McCann Hill en Alaska.

Introduction

The described trilobites were collected by A. W. Norris, D. J. McLaren, A. J. Jenik, and L. H. Green of the Geological Survey of Canada from the Ogilvie and Hart Rivers area, Yukon Territory (Textfig. 1, locs. 17, 19, 21, 23–25). Norris (1968a, p. 758; 1968b, pp. 16–18) has described the Michelle Formation and briefly discussed its fauna. Norris's stratigraphic cross-section (1968a, Fig. 5) shows the stratigraphic position within the Michelle Formation of most of the trilobite collections on which this paper is based.

The collections are indicated on Norris's Figure 5 by the letter D which stands for *Dechenellurus* sp. B (my identification), a synonym for *Lacunoporaspis norrisi* new species, the most common trilobite in the Michelle Formation. The locality register and faunal list (Textfig. 6) of the present paper is keyed to Norris's Figure 5.

Previous Work

Corgan (1963) gave faunal lists and a few illustrations of trilobites from the Yukon that he considered to be Lower Devonian. The trilobite assemblage he listed from a locality on the east bank of Blackstone River (65°42′N, 137°28′W) suggests to me that the collection is at least partly from the Michelle Formation. His (1963, p. 153, Textfig. 4) *Basidechenella*(?)

[1]Pan American Petroleum Corporation, Tulsa.

new species belongs to *Lacunoporaspis norrisi* new species. It is also possible that Corgan's (1963, p. 153) *Otarion* new species(?) and *Leonaspis* new species are the same as *Otarion* sp. and *Leonaspis* aff. *L. eremia* Ormiston, respectively, of this paper.

Trilobite Fauna and Correlation

Trilobites are sufficiently common in the Michelle Formation that one can reasonably expect to find specimens at most localities; eight trilobite taxa representing five families are described in the present paper. Of these only one, *Lacunoporaspis norrisi* new species can be considered abundant. It is present in most of the GSC samples examined (*see* Textfig. 6), commonly in great numbers. The remaining seven taxa are represented by many fewer specimens but are widely distributed.

GSC Locality Number	Michelle Formation (footage above base)	Geographic Position	Collector	Trilobite species										
				Lacunoporaspis sp.	*L. norrisi*	*Leonaspis* aff. *L. eremia*	*Reticuloharpes* sp.	*R.* cf. *R. reticulatus*	*Proetus* cf. *P. nerudai*	*Otarion* sp.	*Cornuproetus* cf. *C. haentzscheli*	? *Ceratarges* sp.	*Schizoproetoides* sp. A	proetid indet.
37055	No data	64°28'N, 137°02'W, Hart River	L.H. Green					×						
47314	10	65°23'N, 137°07'W, ridge east of Hart River, very near to Norris's Section 17 (see below) where Michelle is 375.5 feet thick	D.J. McLaren		×				×					
47326	No data				×									
47327	0-80				×				×					
47328	25			?										
47331	50				×	×			×			×		
47333	160				×									
47335	170-250				×									
47337	80			×		×		×						
50244	loose, 0-22	65°25'12"N, 137°06'W, ridge 1 mile east of Hart River; Section 17 of Norris (1967, pp. 126-130), Michelle is 375.5 feet thick	A.W. Norris											×
50251	loose, 62-92				×									
50252	loose, 93-106				×									
50255	119-127			×										
50274	loose, 137.5-179.5			?										
50277	loose, 119-127				cf.									
50288	24	65°27'30"N, 137°00'W, ridge about 1 mile east of Hart River; Section 16 of Norris (1967, pp. 113-118), Michelle is 380 feet thick	A.W. Norris		×	×				×	×			
50292	loose, 72.5-102.5				×	×								
50298	loose, 144.5			×						×				
50381	loose, from fm.	65°38'N, 136°45'36"W, ridge 1 mile west-northwest of Hart River; Section 14 of Norris (1968b, pp. 148-154), Michelle is 548.5 feet thick	A.W. Norris		×					×	×			
50385	loose, from fm.				×									
50394	loose, from fm.				×									
50405	154-162				×									
50674	29.5	65°42'N, 137°26'30"W, ridge east of Blackstone River; Section 19 of Norris (1967, pp. 137-142), Michelle is 613.5 feet thick	A.J. Jenik		×									
54589	136.5				×									
54592	85				×									
54086	200	65°33'N, 138°46'W, southeast flank of Nahoni Range; Section 21 of Norris (1967, pp. 169-175), Michelle is 278 feet thick	A.W. Norris				×							
54092	206												×	
54096	loose, 104-107							×						
54098	123-135				×			×						
54104	loose, 135-144				×			×						
54177	loose, 94	65°29'N, 139°09'W, southern end of Nahoni Range; Section 23 of Norris (1967, pp. 199-200) Michelle is 279 feet thick	A.W. Norris					×						
54178	loose, 27.5-38.5			×										

GSC

TEXTFIGURE 6. Distribution of trilobites in Michelle Formation.

All the trilobites in the Michelle Formation resemble Lower Devonian, and in particular Emsian, species from other areas. Although none of the Michelle forms is exactly conspecific with described Emsian species, the fact that each of the Michelle forms is most closely allied to an Emsian species is suggestive of Emsian age. This dating is supported by the presence in Emsian beds in the Eagle D-1 Quadrangle of Alaska (*see* Table 1 of Churkin and Brabb, 1968) of the Michelle form *Reticuloharpes* cf. *R. reticulatus* (Hawle and Corda) and of a *Lacunoporaspis* (listed as *Dechenellurus* sp.) close to *L. norrisi* new species of the Michelle. The Alaskan material is dated as Emsian on the basis of its trilobite fauna (my studies) and its conodont fauna (G. Klapper, 1967, *pers. com.*).

The presence of *Schizoproetoides* and ?*Ceratarges* sp. in the Michelle fauna suggests alliance with Lower Devonian trilobites (Ormiston, 1967) from the western Arctic Islands. Further evidence of this affinity is the possible presence of *Lacunoporaspis* in the Arctic Islands (this paper). Faunal similarity with nearby eastern Alaska is not surprising, but the relationship with Lower Devonian trilobites of the Arctic Islands, which were thought to be provincially distinctive (Ormiston, 1967), is less expectable.

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Morphological terms used in the systematic descriptions follow Ormiston (1967). Original sources for these terms are cited in that paper (p. 32). Prefix GSC refers to specimens in the type collection of the Geological Survey of Canada, Ottawa; USNM to specimens in the United States National Museum, Washington.

Family PROETIDAE Salter 1864

Genus *Proetus* Steininger 1831

Type species. *Calymene concinna* Dalman, 1827.
Diagnosis. See Přibyl, 1946, p. 4.

Proetus cf. *P. nerudai* Přibyl, 1964

Plate 4, figures 7–14

cf. *Proetus nerudai* Přibyl, 1964, p. 34, Textfig. 1, fig. 6.

Material. Hypotypes: GSC 24274, counterpart mould of part of cranidium from GSC loc. 47314; GSC 24275, counterpart mould of cranidium from GSC loc. 47345; GSC 24279, counterpart of posterior of cranidium from GSC loc. 47345; GSC 24278, counterpart mould of free cheek from GSC loc. 47345; GSC 24276 and 24277, two pygidia from GSC locs. 47327, 47345 respectively (*see* Textfig. 6 for details). Specimens from GSC loc. 47345 come, not from the Michelle Formation, but from the superjacent Ogilvie Formation (Norris, 1968b, pp. 28–32). The stratigraphic position of these specimens (collected by D. J. McLaren) is more than 725 feet above the base of the Michelle in the second section listed in Text-figure 6, where the Michelle is only $375\frac{1}{2}$ feet thick. The specimens are included in the present study because they are more nearly complete than those available from the Michelle and are important to the identification of the species.

Description. No complete cranidia are available for study, but several partial ones (Pl. 4, figs. 7, 8, 11, 14) allow interpretation of the entire cranidium. Glabella rapidly tapering with rounded anterior lobe; inflated in both longitudinal and transverse profiles. Axial furrow incised opposite palpebral lobes, shallows anteriorly but becomes incised again at anterior margin of glabella. Preglabellar field very short (*sag.*). Anterior border wide (*sag.*) and broadly convex. Fixed cheeks anterior to eye lobe are coarsely pitted as is genal field of free cheek. Palpebral lobes short (*exs.*), as wide as long and nearly horizontal in attitude. Three pairs of lateral glabellar furrows, all represented by smooth areas on the granulose glabella. 1p and 2p furrows extend from axial furrow backward and inward for only a short distance. 1p furrow is broad at axial furrow but rapidly tapers to a point. A small, separate anterior branch of 1p extends almost to midline. 3p furrow very faint, transverse, set well in from axial furrow. Occipital ring with median node and distinct, subtriangular occipital lobes which are incompletely separated from ring by weak branch furrows. Occipital furrow deep, forwardly deflected at lobe. Anterior ring with median node. Anterior branch of facial suture only slightly divergent from midline, smoothly rounded at beta angle (*see* Ormiston, 1967, p. 33). Cranidium finely granulose, except as noted above. Free cheek carries a small eye lobe. A broad, coarsely pitted genal field descends smoothly to broad lateral border. A short, acute genal spine is present.

Pygidial outline semicircular with truncated posterior margin. Axis high-standing with eight axial rings, second and third rings backwardly deflected sagittally. Axis reaches posterior border furrow. Pleurae evenly convex in transverse profile with five or six ribs. Pleural furrows deeper than interpleural. Broad, gently convex lateral border set off by furrow. Pygidial surface finely granulose.

Dimensions.

GSC 24276		GSC 24275	
Pygidial length	4.2 mm	Glabellar length	6.6+ mm
Pygidial width	8.0 mm	Glabellar width	6.0 mm

Comparison. This taxon is somewhat similar to *Proetus nerudai* Přibyl from the Lower Devonian (Siegenian or Emsian) Slivenece Limestone of Bohemia. It differs from that species in having a shorter (*exs.*) palpebral lobe, possibly a longer (*sag.*) occipital ring, and pitting of the preglabellar area of the cranidium. The pygidium of *P. nerudai* Přibyl has not been described.

Subfamily DECHENELLINAE Přibyl, 1946

Genus *Lacunoporaspis* Yolkin, 1966

Type species. *Lacunoporaspis contermina* Yolkin, 1966.

Diagnosis. Yolkin diagnosed the genus (1966, p. 26, writer's translation) as having: "Forwardly tapering glabella with three lateral furrows and very weak constriction opposite anterior extremity of palpebral lobe. Preglabellar field short. Occipital ring with occipital lobes and median tubercle. Pygidium of moderate convexity, rounded outline, having 9 to 12 axial segments and 5 to 8 pleurae." He considered *Lacunoporaspis* to be distinguished from *Dechenella* and *Basidechenella* by its less segmented pygidium and less constricted glabella.

As far as it goes, Yolkin's original diagnosis seems to provide valid generic differentiation, although the difference in glabellar outline from that in *Dechenella* is subtle. Further differences from *Dechenella* are the shallowness of the glabellar furrows and a smaller angle of divergence from the midline of the anterior branch of the facial suture (about 25° in *L. contermina* and 21° in *L. norrisi*). *Dechenellurus* Maximova (1960, p. 259) includes a variety of species difficult to accept as congeneric. The type species, *Dechenellurus ursus* Maximova (1960, p. 261, Pl. 54, fig. 7, Textfig. 41a) is easily distinguished from *Lacunoporaspis* by its subconical glabella without lateral constrictions which impinges on the anterior border, and (Maximova, 1968, Pl. 3, fig. 6) by its long, multisegmented pygidium.

Lacunoporaspis norrisi new species

Plate 3, figures 1–7, 9–15

Basidechenella(?) n. sp., Corgan, 1963, p. 153, fig. 4.
Dechenellurus sp. B, Ormiston *in* Norris, 1968a, p. 759.
Dechenellurus sp. B, Ormiston *in* Norris, 1968b, pp. 18, 47.

Diagnosis. Glabellar outline weakly constricted opposite 3p furrow. Lateral furrows shallow, barely reaching axial furrow. Eleven rings and eight ribs on pygidium. Cranidial and pygidial borders weakly convex.

Material. Holotype: GSC 24255, complete cranidium from GSC loc. 47331 (*see* Textfig. 6 for details). Paratypes: GSC 24256, partly exfoliated cranidium from GSC loc. 50288; GSC 24257, counterpart mould of pygidium, from GSC loc. 50394; GSC 24258, complete pygidium, from GSC loc. 50381; GSC 24259, incomplete thorax, from GSC loc. 47327; GSC 24261, complete pygidium from GSC loc. 50385; GSC 24263, free cheek from GSC loc. 47326 (*see* Textfig. 6 for details).

Other material. Numerous cranidia and pygidia from GSC locs. 47326, 50288, 50381, 50394, and 47331.

Description. Cranidium with anterior border only slightly convex in cross-section, no distinct border furrow. Length of preglabellar field one half of border width (*sag.*). Glabella straight-sided from base to midpoint of palpebral lobe, tapering rapidly thereafter. There is no deep constriction of the glabellar outline as in *Dechenella.* Faint constriction between 2p and 3p furrows commonly visible. In lateral profile glabella forms an evenly convex curve with high point opposite midpoint of palpebral lobes; moderately convex transversely.

Three pairs of shallow glabellar furrows which typically do not reach axial furrow. Furrows only moderately impressed, all trending inward and backward. lp furrow curvilinear and trends more strongly backward in its posterior part than do the weaker, rectilinear 2p and 3p furrows.

Occipital lobes distinct but not inflated, triangular in outline. Occipital ring as long (*sag.*) as anterior border (*sag.*), very convex in lateral profile. Occipital furrow backwardly convex medially, forwardly convex behind lp furrow, then branching around occipital lobes. Prominent median node on occipital ring. Palpebral lobes broad and lying in a horizontal plane. Anterior branch of facial suture moderately divergent, averaging 21 degrees from midline essentially straight between gamma and beta angles. Anterior border densely covered with fine, coalescent pustules; preglabellar field and anterior part of glabella with widely spaced, flat-topped pustules, posterior of glabella with larger pustules. Periphery of glabella pitted.

Thorax with apparently ten thoracic segments (Pl. 3, fig. 7). Axial rings divided into long (*sag.*) post-annulus and short pre-annulus (Richter and Richter, 1956, p. 346) by break in slope but no intra-annular furrow. Articulating furrow deep. Pleural furrow dies out distal to fulcrum. Posterior edge of rings with pustules.

Free cheek with eye lobe long extending from position opposite 3p furrow, to position opposite midlength of lp furrow, rests on a narrow (*trans.*) weakly convex eye socle (Ormiston, 1967, p. 33) which dies out rapidly both anteriorly and posteriorly. Under optical microscope, eye surface, as in many dechenellids, appears smooth. High magnification scanner electron photomicrographs show, however, a distinct lens-like (*see* Pl. 3, fig. 14) pattern. Genal field with tuberculate ridge at midwidth (*trans.*) which marks break in slope of field. Lateral border furrow very shallow, posterior border furrow incised. Lateral border with gently convex cross-section. Genal spine of length greater than eye lobe, sulcate cross-section for half its length. Lateral border and much of genal field with dense coalescent pustules as on anterior part of cranidium.

Pygidium with semielliptical outline. Axis evenly tapering, semicircular in transverse profile. Eleven axial rings, last two distinctly shorter than others. First ring furrow is deeper and broader than succeeding ones. In plan view, second through sixth axial rings are backwardly deflected medially. Axial terminus well rounded. Some specimens show a faint and short post-axial ridge. Axial furrow not deep. Typically eight pairs of "ribs" on the pleural fields (some large specimens show a faint ninth rib). Pleural furrows deeper than interpleural, both sets of furrows narrow. In transverse profile, pleural fields strongly convex and nearly vertical above border. No border furrow. Border steeply sloping and only faintly convex in cross-section. Border and lower half of pleural fields have dense, coalescent pustules; granules present on posterior half of axial rings.

Dimensions.

Holotype cranidium GSC 24255	
Glabellar length	4.3 mm
Glabellar width	4.1 mm
Cranidial length	6.4 mm

Paratype pygidium GSC 24261	
Pygidial width	6.4 mm
Pygidial length	4.0 mm

Comparison. Lacunoporaspis norrisi differs from *Khalfinella elegantula* Yolkin (1968a, Pl. 1, figs. 5, 6) from the Salairkinsk beds of western Siberia in having a more rapidly tapering and anteriorly attenuate glabella; a lower anterior border, a less sigmoidal lp glabellar furrow, and more axial segments in the pygidium. The same characters distinguish *L. norrisi* from *L. antiqua* Yolkin (1966, p. 26, figs. 6–9).

Dechenella spaekkassensis (Tolmachoff) from low in the Blue Fiord Formation on Ellesmere Island (Ormiston, 1967, p. 94, Pl. 12, figs. 9–17) has many similarities to *L. norrisi,* especially in pygidial structure. The cranidia are distinguished by the longer preglabellar field, less divergent facial suture, and shallower lp furrow of *L. norrisi.* The pygidium of *D. spaekkassensis* appears to have more axial segments (13 to 15) and coarser axial prosopon than that of *L. norrisi* but there is a strong basic resemblance. Although the glabella of *spaekkassensis* is *Dechenella*-like, the species approaches *Lacunoporaspis* in other features and could possibly belong in that genus.

Lacunoporaspis norrisi shows greatest similarity to the Siberian Eifelian species, *L. pulchella* (Khalfin) (Yolkin, 1968b, p. 17, Pl. 4, figs. 1–3, text-fig. 5) from which it differs in having a broader (*sag.*), less convex anterior border, a more distinct constriction in the glabellar outline, and a greater number of axial rings. The pattern of glabellar furrows is similar in the two species.

Although their cranidia are distinct, the pygidia of *L. norrisi* and of the type species, *L. contermina* Yolkin (1966, p. 28, figs. 4, 5; 1968b, Pl. 3, figs. 1–8), are much alike. Differences are hard to recognize without direct comparison of specimens, but the very faint post-axial ridge of *norrisi* (Pl. 3, fig. 4) is one possibility.

Yolkin (1966, p. 28) considered the source horizon of *L. contermina* to be of Eifelian age, but his later writings (1968a, p. 988) suggest that these are beds that might be assigned to the Emsian by European stratigraphers.

A species of *Lacunoporaspis* (Pl. 3, fig. 8) (identified as *Dechenellurus* sp. by Ormiston *in* Churkin and Brabb, 1968, table 1) very close to *L. norrisi* occurs in the McCann Hill Chert of East Central Alaska together with other trilobites suggesting an Emsian age.

A poorly preserved pygidium from Emsian beds on the Princess Royal Islands, western Canadian Arctic Islands identified by Ormiston (1967, p. 108, Pl. 17, fig. 10) as *Dechenella* sp. indet. may also be a *Lacunoporaspis*.

Genus *Schizoproetoides* Ormiston, 1967

Type species. *Cyrtosymbole richteri* (Tolmachoff, 1926).
Diagnosis. See Ormiston, 1967, p. 111.

Schizoproetoides sp. A

Plate 4, figure 15

cf. ?*Schizoproetoides* sp. indet., Ormiston, 1967, p. 117, Pl. 15, fig. 10.

Material. Hypotype: GSC 24280, internal mould of pygidium with first two axial rings broken, from GSC loc. 54092 (*see* Textfig. 6 for details).

Description. The single available pygidium apparently represents a new taxon close to *Schizoproetoides ellesmerensis* Ormiston (1967, p. 115, Pl. 15, fig. 7) from the Blue Fiord Formation of the Arctic Islands. Characters distinguishing it from *ellesmerensis* are: (1) broader pygidial border; (2) a faint post-axial ridge; (3) less convex lateral axial profile.

Discussion. This is the only specimen of *Schizoproetoides* in the collections from the Michelle Formation, but numerous cranidia and pygidia of the genus are present in collections from the overlying Ogilvie Formation (Norris, 1968a, 1968b). The *Schizoproetoides* in the Ogilvie is distinct from that in the Michelle, being very close to *S. richteri* (Tolmachoff) that is present in the Blue Fiord Formation (Ormiston, 1967, p. 111, Pl. 14, figs. 15–18; Pl. 15, figs. 1–6).

I suspect that the Michelle pygidium may belong with the cranidia described as ?*Schizoproetoides* sp. indet. (Ormiston, 1967, p. 117, Pl. 15, fig. 10) from the Lower Devonian beds near Drake Bay, Prince of Wales Island.

Subfamily CORNUPROETINAE Richter and Richter, 1956

Genus *Cornuproetus* Richter and Richter, 1919

Type species. *Gerastos cornutus* Goldfuss, 1843.
Diagnosis. See Přibyl, 1946, pp. 6,7.

Cornuproetus (Subgenus ?) cf. *C. haentzscheli* Alberti, 1967

Plate 3, figures 16–21

cf. *Cornuproetus* (*Lepidoproetus*?) *haentzscheli* Alberti, 1967, p. 487, Pl. 1, fig. 6.
Cornuproetus sp. Ormiston *in* Norris, 1968b, p. 47.

Material. Hypotype GSC 24268, entire cranidium with left side partly exfoliated, GSC loc. 50381; hypotype GSC 24267, incomplete cranidium and counterpart mould, GSC loc. 50288; hypotype GSC 24266, poorly preserved pygidium, GSC loc. 50288 (*see* Textfig. 6 for details).

Diagnosis. A *Cornuproetus* with a long (*sag.*) preglabellar region distinguished by a transversely oval prominence which intervenes between the glabella and anterior border.

Description. Anterior border broad (*exs.*) and moderately convex in profile, set off distally by distinct border furrow. Sagittally, border furrow disrupted by transversely oval, weak prominence bounded anteriorly and posteriorly by furrows. Prominence occupies most of posterior slope of anterior border at midline and "bridges" border furrow. Although conspicuous in plan view, prominence is weakly expressed in profile (Pl. 3, fig. 19). Posterior half of glabella essentially flat and anterior half gently descending in lateral profile. Posterior half of glabella distinctly broader (*trans.*) than anterior; anterior end broadly rounded. Dorsal and preglabellar furrows impressed. Three pairs of indistinct glabellar furrows represented by darkened, smooth areas. Glabellar furrows correspond in position and shape to those of *Cornuproetus* (*Lepidoproetus*?) *haentzscheli* Alberti (1967, Pl. 1, fig. 6). Occipital ring long (*sag.*) but shorter than preglabellar area. Median occipital node present. Palpebral lobes long (*exs.*) and relatively narrow. Anterior branch of facial suture a smooth, outwardly convex curve. Outer margin of palpebral lobe more distal than any part of anterior suture. Entire cranidium, excepting furrows, finely granulose. Three to four terrace lines on outer edge of anterior border.

Pygidial material poorly preserved, showing a long axis with five rings standing high above pleural fields. Anterior and posterior pleural bands of subequal size.

Dimensions.

Hypotype GSC 24268	
Cranidial length	7.0 mm
Beta-beta width	4.4 mm
Maximum glabellar width	4.2 mm

Discussion. The Michelle *Cornuproetus* probably represents a new and distinct taxon but a new species cannot be soundly based on the few fragmentary specimens now available. It shows several interesting points of comparison with *Cornuproetus* (*Lepidoproetus*?) *haentzscheli* Alberti (1967, p. 487, Pl. 1, fig. 6) from Lower Devonian beds of Morocco. Most conspicuous of these are the wide, relatively low anterior border and the sagittal-"bridging" of the border furrow, although the prominence in the Michelle species is distinctly longer (*sag.*). Other features in which these species correspond include the glabellar outline and pattern of glabellar furrows and the configuration of the occipital ring. They can be separated by the longer preglabellar prominence, narrower (*trans.*) palpebral lobes, and granulose (rather than ridge-like) prosopon of the Michelle species. Alberti provided no lateral view of *haentzscheli* and I have examined no specimens. Thus, there may be differences in the configuration of the anterior border other than those mentioned. Alberti assigned *haentzscheli* to the subgenus *Lepidoproetus* with question. The Michelle *Cornuproetus* is almost certainly not a member of that subgenus as it has a distinct border furrow. The other described subgenera (*see* Alberti, 1967) of *Cornuproetus* do not seem suitable for the Michelle species.

Cornuproetus tozeri Ormiston (1967, p. 64, Pl. 7, figs. 5–10) from the Lower Devonian of the Arctic Islands resembles the Michelle species in glabellar outline and sutural course, but lacks the distinctive preglabellar prominence and has a thorn-like spine on the posterior edge of the occipital ring.

Family Otarionidae Richter and Richter, 1926

Genus *Otarion* Zenker, 1833

Type species. *Otarion diffractum* Zenker, 1833.
Diagnosis. See Richter *in* Moore, 1959, p. 405.

Otarion sp.

Plate 4, figure 6

Material. Hypotypes: GSC 24273, cranidium with glabellar apex broken, from GSC loc. 50288; poorly preserved cranidium (not figured), from GSC loc. 50298 (*see* Textfig. 6 for details).

Description. All available material is poorly preserved, figured specimen lacks part of glabella and left anterolateral margin. Median glabellar lobe egg-shaped, but sides parallel opposite eye lobe. Strongly convex transversely, longitudinal profile not determinable because crest is broken. Basal glabellar lobes large, drop-shaped bodies. Occipital furrow relatively shallow for genus. Axial furrow deeply entrenched, shallowing anteriorly, with no preglabellar pit. Transverse eye ridges present. Preglabellar field longer (*sag.*) than occipital ring, broadly convex. Anterior border semicylindrical and with finer tubercles than those elsewhere on cranidium. Fixed cheeks steeply inward sloping. Curvature of anterior margin equal to the arc of a circle whose midpoint would be situated in the occipital furrow.

Discussion. Otarion sp. is most similar to *Otarion druida* Erben (1952, p. 242, Pl. 19, figs. 13, 14) from the Emsian Zorgensis Kalk of Germany from which it is distinguished by its shallower occipital furrow, finer tuberculation, and less perfectly egg-shaped glabella.

Family Odontopleuridae Burmeister, 1843

Genus *Leonaspis* Richter and Richter, 1917

Type species. *Odontopleura leonhardi* Barrande, 1846
Diagnosis. See Whittington, 1956, p. 206.

Leonaspis aff. *L. eremia* Ormiston, 1967

Plate 4, figures 16, 17

aff. *Leonaspis eremia* Ormiston, 1967, p. 56, Pl. 6, figs. 1, 2.

Material. Hypotypes: GSC 24281, well preserved cranidium from GSC loc. 50288; unfigured counterpart mould of cranidium, from GSC loc. 50292; unfigured partial cranidium, from GSC loc. 47331 (*see* Textfig. 6 for details).

Description. Assignment of the Michelle specimens to *L. eremia* Ormiston (1967, p. 56, Pl. 6, figs. 1, 2) is suggested by the inflated anterior glabellar lobe and the course of the eye ridge. The preserved occipital ring of the Michelle specimens shows a large, backwardly directed median node.

Discussion. The type specimen of *L. eremia* comes from more than 1,000 feet above the base of the Blue Fiord Formation on Ellesmere Island, a horizon considered to be of Eifelian age by Ormiston (1967). A poorly preserved cranidium of *Leonaspis* (*Leonaspis* sp. of Ormiston, 1967, p. 57) from 400 feet above the base of the Stuart Bay Formation, Bathurst Island (a horizon of Emsian age) resembles both the Michelle specimens and the type material of *L. eremia* (*see* Ormiston, 1967, p. 57).

Specimens from all three localities may represent the same species.

Family HARPIDAE Hawle and Corda, 1847

Genus *Reticuloharpes* Vaněk, 1963

Type species. *Harpes reticulatus* Hawle and Corda, 1847.
Diagnosis. See Vaněk, 1963, p. 229.

Assignment of the Michelle material to *Reticuloharpes* is indicated by the cephalic shape, coarseness and arrangement of pits on the fringe, carinate glabella, broad alae, large eye lobe consisting of two stemmata, and length of genal prolongations.

Reticuloharpes cf. *R. reticulatus* (Hawle and Corda, 1847)

Plate 4, figures 1, 2, 4, 5

Harpes cf. *H. reticulatus* Hawle and Corda, Ormiston *in* Norris, 1968a, p. 759.
Harpes cf. *H. reticulatus* Hawle and Corda, Ormiston *in* Norris, 1968b, pp. 18, 47.

Material. Hypotypes: GSC 24269, large crushed cephalon, from GSC loc. 37055; GSC 24270, counterpart mould of anterior end of cephalon, from GSC loc. 54096; GSC 24271 mould of ventral surface of fringe, from GSC loc. 54177; plus fragmentary material from several other localities (*see* Textfig. 6 for details).

Description. None of the available cephala is complete, and the glabella is especially poorly represented. The following features have been deduced from four fragmentary specimens. Cephalon U-shaped with long, acute genal prolongations which are not incurved at their tips, but are slightly convergent. Glabella carinate, surface is finely punctate (Pl. 4, fig. 2), glabellar furrows not preserved. Occipital ring not preserved. Alae broad (*trans.*) and well defined. Eye lobe of glabellar height, consists of two stemmata (Pl. 4, fig. 2). Brim long anteriorly (*sag.*) but rapidly narrows laterally to about half its anterior length. External rim of moderate height. Pitting of brim exceptionally coarse and permits easy recognition of even poorly preserved specimens of this taxon. Largest pits with diameter of 1.0 mm as compared with 0.4 mm for largest pits on superficially similar *H. macrocephalus* from early Middle Devonian of Canadian Arctic (Ormiston, 1967, p. 74, Pl. 4, figs. 4–7). As a consequence of their size the pits are fewer in number than in other harpid species. Brim steeply sloping in both lateral and anterior profiles. Cheek roll rises very steeply and is distinguished by having pits which are equal in size to those of brim. As in other harpids, pits on cephalon are coarsest adjacent to external rim and on either side of girder between brim and cheek roll.

Comparison. The Yukon taxon is distinguished from *H. macrocephalus* Goldfuss which occurs in the Eifelian Blue Fiord Formation of Bathurst Island (Ormiston, 1967, p. 74) by having: (1) coarser and fewer pits on the brim, (2) the brim narrowing markedly in its lateral part, (3) brim sloping steeply away from bell in all directions, and (4) genal tips not incurved.

The coarseness of the pitting on the brim, carinate glabella, lateral narrowing of the brim, and slope of the brim in cross-section are all features that suggest alliance with *Reticuloharpes reticulatus* (Hawle and Corda) from the Lower Devonian Vinarice Limestone (probably Emsian) of Bohemia (Prantl and Přibyl, 1954, p. 154, Pl. 1, figs. 4, 5; Pl. 2, figs. 5, 6, 9, 10; Pl. 8, fig. 6) and from the Emsian Zorgensis Limestone of Germany (Erben, 1952, p. 320). The Yukon specimens differ from *reticulatus* mainly in having pitting on the cheek roll that is as coarse as that on the brim. The Yukon specimens certainly belong in the same species group with the very distinctive *reticulatus* and are suggestive of an Emsian age.

Elsewhere this species occurs in the McCann Hill Chert of the Eagle Quadrangle, Alaska in collection USGS 6492-D (Ormiston *in* Churkin and Brabb, 1968, table 1) that includes *Lacunoporaspis* cf. *L. norrisi* new species. Its Emsian age seems therefore to be established.

Family Lichidae Hawle and Corda, 1847

Genus *Ceratarges* Gürich, 1901

Type species. *Arges armatus* Goldfuss, 1839
Diagnosis. See Tripp *in* Moore, 1959, p. 0501.

?*Ceratarges* sp.

Plate 4, figure 3

?*Ceratarges* sp. Ormiston, 1967, p. 127, Pl. 17, fig. 6.

Material. Hypotype GSC 24272, hypostome with prosopon preserved, from GSC loc. 47331 (*see* Textfig. 6 for details).

Description. Hypostomal length 3.7 mm, width at lateral shoulder 5.3 mm. No anterior border. Anterior wings not preserved. Middle body trapezoidal, short (*sag.*), twice as wide as long, low-lying in longitudinal profile, gently convex transversely. Middle furrows short, moderately deep, directed inward and slightly backward, forming anterior margin of independently convex macula at posterolateral corner of middle body. Lateral and posterior borders broad. Posterior border furrow deep. Median part of posterior border an inflated area of subcircular outline which is higher than middle body. Outline of posterior margin swings slightly forward on either side of midline, then backward again at posterolateral corner. Middle body coarsely tuberculate.

Comparison. This hypostome compares closely with one from 400 feet above the base of the Stuart Bay Formation, Bathurst Island (Ormiston, 1967, p. 127, Pl. 17, fig. 6), a horizon which has yielded conodonts suggesting an Emsian age (G. Klapper, *pers. com.* 1967).

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Plate 3

Lacunoporaspis norrisi new species (Page 31)

Figures 1, 3. Cranidium (holotype GSC 24255) from GSC loc. 47331, dorsal and left lateral views showing prosopon and relative shallowness of glabellar furrows; × 6.

Figures 2, 6. Cranidium (paratype GSC 24256) from GSC loc. 50288, dorsal and lateral views of partly exfoliated cranidium showing characteristic glabellar outline; × 5.

Figure 4. Pygidium (paratype GSC 24257) from GSC loc. 50394, latex cast showing prosopon, dorsal view; × 5.

Figure 5. Pygidium (paratype GSC 24258) from GSC loc. 50381, dorsal view; × 3.

Figure 7. Thorax (paratype GSC 24259) from GSC loc. 47327, dorsal view showing ten segments; × 3.

Figure 9. Slab (hypotype GSC 24260) with four pygidia and partial cranidium to illustrate local abundance of taxon, GSC loc. 54177; × 2.

Figures 10, 12. Pygidium (paratype GSC 24261) from GSC loc. 50385, dorsal and right lateral views; × 5.

Figure 11. Small cranidium (hypotype GSC 24262) for comparison with figure 8, GSC loc. 50288, dorsal view; × 5.

Figure 13. Free cheek (paratype GSC 24263) from GSC loc. 47326, dorsal view showing size of eye lobe and prosopon; × 3.

Figure 14. Electron scanner photomicrograph of eye surface (hypotype GSC 24264) to show fine lens-like structure, GSC loc. 47326; × 7,000.

Figure 15. Posterior view of incomplete cephalon (hypotype GSC 24265) to show eye lobe and eye socle GSC loc. 47326; × 3.

Lacunoporaspis cf. *L. norrisi* new species (Page 33)

Figure 8. Dorsal view of latex cast of cranidium (hypotype USNM 163591) from USGS collection 6492-SD, 135 feet above base of McCann Hill Chert, Eagle D-1 Quadrangle, east-central Alaska; × 6.

Cornuproetus (subgenus?) cf. *C. haentzscheli* Alberti, 1967 (Page 33)

Figure 17. Latex cast of damaged pygidium (hypotype GSC 24266) from GSC loc. 50288, dorsal view; × 6.

Figures 16, 19, 21. Entire cranidium with left side partly exfoliated (hypotype GSC 24268) from GSC loc. 50381, lateral, dorsal, and anterior views; × 5.

Figures 18, 20. Incomplete cranidium (hypotype GSC 24267) and latex cast (showing palpebral lobe) of counterpart, from GSC loc. 50288, dorsal views showing glabellar outline (left anterior part of cranidium thrust back over part of glabella) and furrows; × 5.

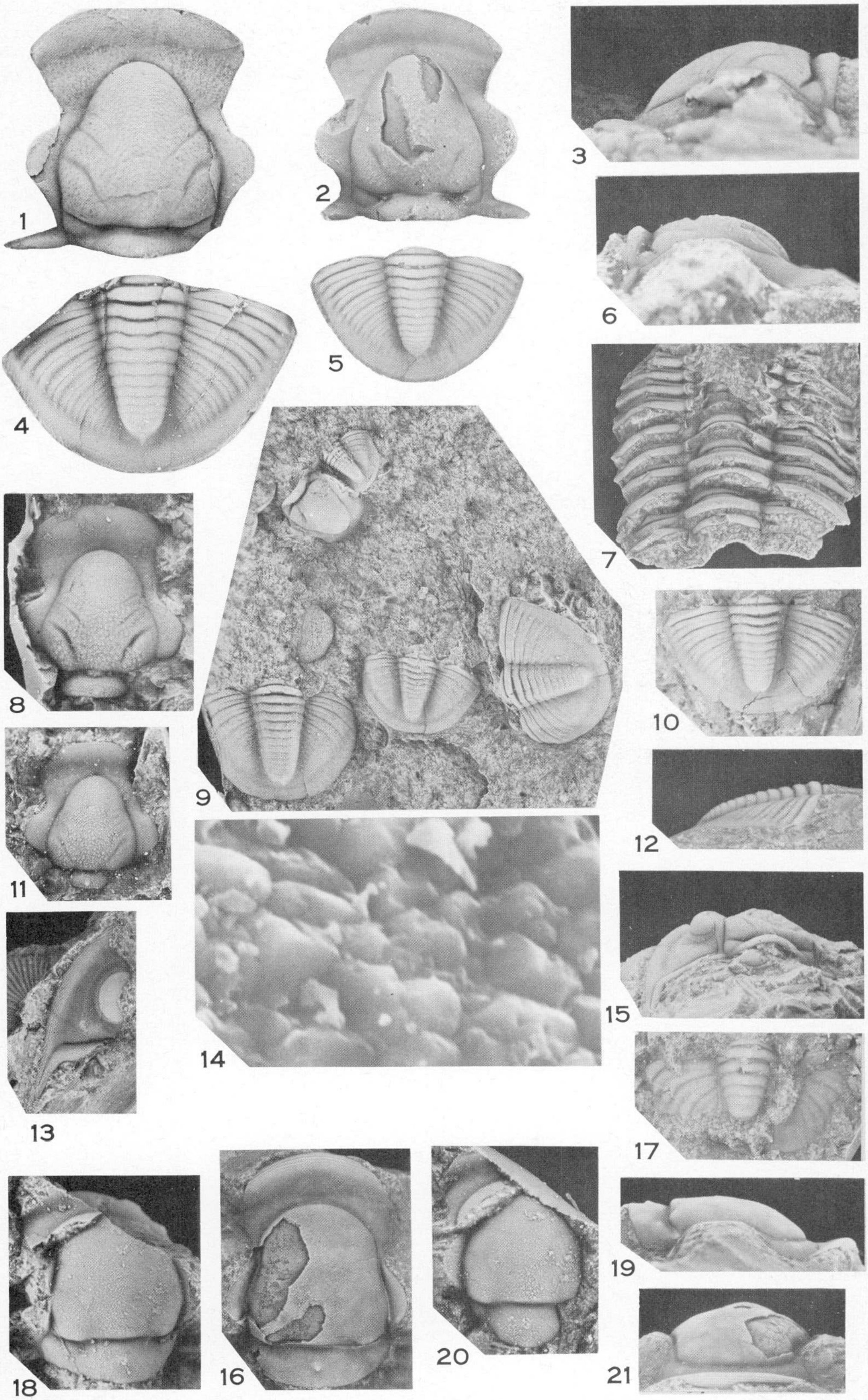
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Plate 4

Reticuloharpes cf. *R. reticulatus* (Hawle and Corda, 1847) (Page 36)

Figures 1, 5. Crushed cephalon (hypotype GSC 24269) with glabella largely destroyed but showing left ala and conspicuous coarse pitting of fringe, GSC loc. 37055, dorsal and oblique exterior views; × 2.

Figure 2. Latex cast of partial cephalon (hypotype GSC 24270) preserving anterior end of glabella and right eye. Rapid lateral narrowing of fringe is apparent, GSC loc. 54096, dorsal view; × 3.

Figure 4. Latex cast of mold (hypotype GSC 24271) of ventral surface showing (right side) short genal caeca on lower lamella of fringe, GSC loc. 54177; × 2.

? *Ceratarges* sp. (Page 37)

Figure 3. Hypostome (hypotype GSC 24272) with ornament well preserved, GSC loc. 47331, exterior view; × 8. Compare with Ormiston, 1967, Pl. 17, fig. 6.

Otarion sp. (Page 35)

Figure 6. Damaged cranidium (hypotype GSC 24273) from GSC loc. 50288, dorsal view; × 5.

Proetus cf. *P. nerudai* Přibyl, 1964 (Page 29)

Figure 7. Latex cast of partial cranidium (hypotype GSC 24274) from GSC loc. 47314, dorsal view showing preglabellar field; × 6.

Figures 8, 11. Latex cast of partial cranidium (hypotype GSC 24275) from GSC loc. 47345 (from Ogilvie Formation well above GSC loc. 47335), dorsal and anterior views showing glabellar furrows, convexity, and pitting of anterolateral fixed cheeks; × 6.

Figures 9, 10. Pygidium (hypotype GSC 24276) from GSC loc. 47327 dorsal and lateral views; × 6.

Figure 12. Pygidium (hypotype GSC 24277) from GSC loc. 47345 (from Ogilvie Formation as figs. 8, 11), dorsal view; × 3.

Figure 13. Free cheek (hypotype GSC 24278) from GSC loc. 47345 (from Ogilvie Formation as figs. 8, 11, 12), dorsal view showing pitted genal field and short genal spine; × 3.

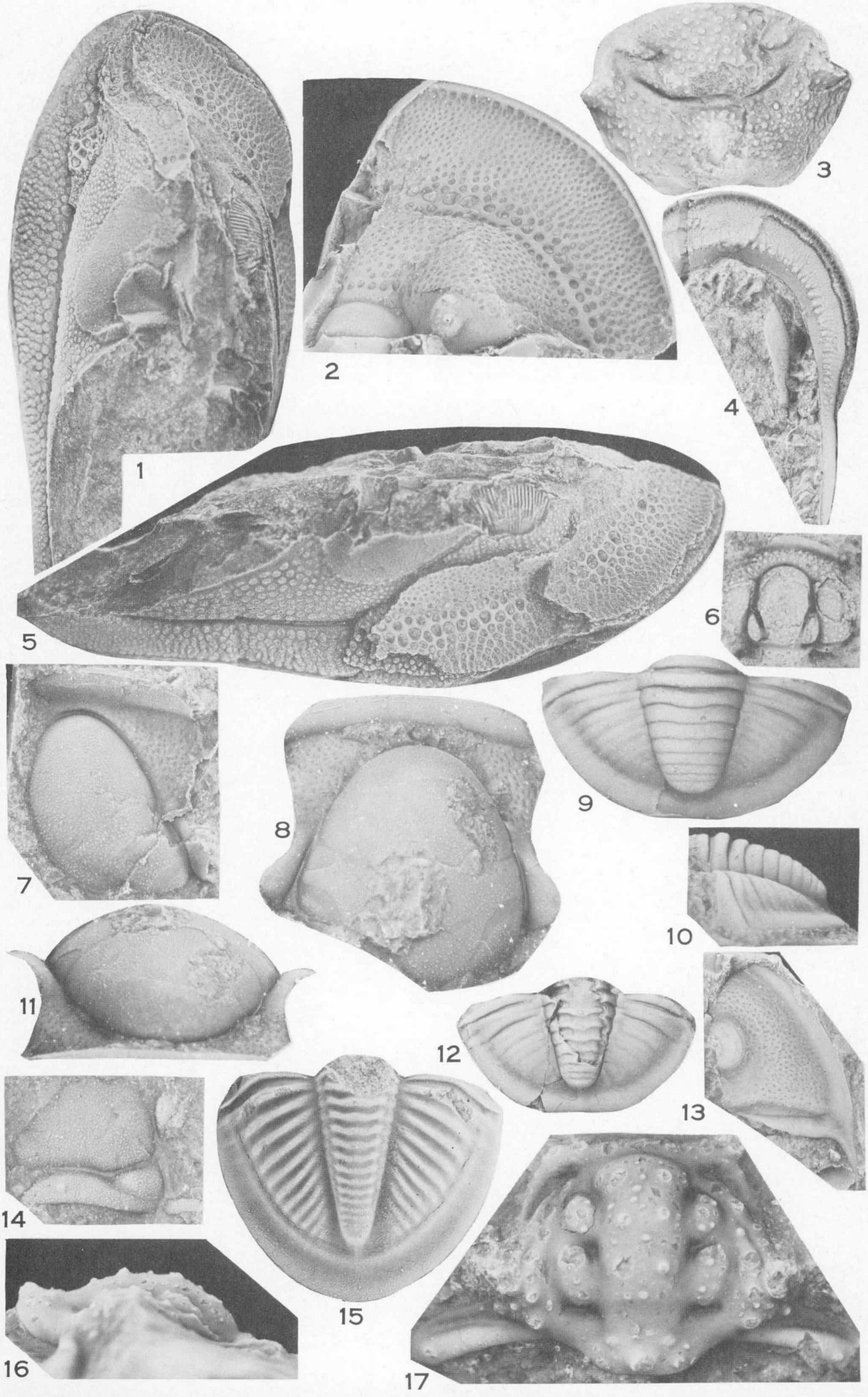
Figure 14. Latex cast of posterior part of cranidium (hypotype GSC 24279) from GSC loc. 47345 (from Ogilvie Formation as figs. 8, 11, 12, 13), dorsal view showing occipital ring; × 6.

Schizoproetoides sp. A (Page 33)

Figure 15. Internal mould of pygidium (hypotype GSC 24280) from GSC loc. 54092, dorsal view showing broad border; × 2.

Leonaspis aff. *L. eremia* Ormiston, 1967 (Page 35)

Figures 16, 17. Cranidium (hypotype GSC 24281), GSC loc. 50288, lateral and dorsal views; × 3.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TWO NEW APHROID CORALS FROM THE MIDDLE DEVONIAN HUME FORMATION OF WESTERN CANADA

A. E. H. Pedder

Abstract

Aphroidophyllum meeki new species and *Mackenziephyllum insolitum* new genus and species are described from an outcrop of late Eifelian or early Givetian Hume Formation on Carnwath River, District of Mackenzie. The type species of *Aphroidophyllum* is refigured and transferred from the Phillipsastraeidae to the Spongophyllidae. The new genus *Mackenziephyllum* is an aphroid member of the Cystiphyllidae.

Résumé

L'auteur décrit la nouvelle espèce *Aphroidophyllum meeki*, et le nouveau genre et la nouvelle espèce *Mackenziephyllum insolitum* provenant d'un affleurement de la fin de l'Eifélien ou du début du Givétien de la formation d'Hume, sur la rivière Carnwath, district de Mackenzie. Il propose une nouvelle représentation de l'espèce-type *Aphroidophyllum* et l'assigne aux Spongophyllidés plutôt qu'aux Phillipsastraeidés. Le nouveau genre *Mackenziephyllum* est un membre aphroïde des Cystiphyllidés.

Introduction

Corals described in this paper are part of a large fauna from the Hume Formation on the right bank of Carnwath River at 67°23′N; 127°44′W (Textfig. 1, loc. 10; GSC loc. C-2521, coll. A. E. H. Pedder, June 1968). About 40 feet of nodular weathered, brown, argillaceous limestone and calcareous shale is exposed at this locality. Although direct physical evidence of the position of the beds within the local sequence is lacking, the fauna, including *Taimyrophyllum stirps* (Crickmay), *Radiastraea tapetiformis* (Crickmay), *Desquamatia arctica* (Warren), and *Carinatina dysmorphostrota* (Crickmay), but not *Schuchertella adoceta* Crickmay, indicates that it is from the upper part of the formation (*see* Norris, 1968, p. 773).

In some places in the District of Mackenzie, the upper Hume fauna has been collected from less than 20 feet below occurrences of the Givetian goniatites *Agoniatites* sp. cf. *A. vanuxemi* (Hall), *Cabrieroceras karpinskyi* (Holzapfel), and *Tornoceras* (*T.*) sp. cf. *T. westfalicum* Holzapfel (House and Pedder, 1963). Elsewhere several hundred feet separates it from an underlying occurrence of the Eifelian goniatite *Anarcestes* (*Latanarcestes*) sp. cf. *A.*

praecursor Frech (*op. cit.*). In yet another locality it occurs well above the distinctive ostracod *Moelleritia canadensis* Copeland, which, on independent grounds, is regarded as Eifelian (Copeland, 1962, pp. 1, 2). It is thus reasonable to suppose that the upper Hume fauna is of early Givetian age; however, as absolutely diagnostic forms have not been found in it, the possibility of a late Eifelian age can not be entirely discounted.

Acknowledgments

The manuscript has been critically read by D. J. McLaren of the Geological Survey of Canada. The photographs were taken by D. Harvey.

Systematic Paleontology

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

Family Spongophyllidae Dybowski, 1873

Genus *Aphroidophyllum* Lenz, 1961

Type species. *Aphroidophyllum howelli* Lenz (1961, pp. 505, 506, Pl. 3, figs. 1, 2). Lenz stated that the species had been found only at two widely separated occurrences of the Hume Formation. This statement was not elaborated on, but the label accompanying the holotype reads: "Upper Hume Limestone Member Lac à Jacques; 66°05'N, 127°28'W."

Diagnosis. Corallum compound, mostly aphroid, but at some levels there are well-developed naotic septa of thamnasterioid arrangement. Septa with zigzag carinae in the vicinity of the inner margin of the dissepimentarium and commonly rotated at the axis. Tabulae incomplete, closely spaced, generally forming axially depressed tabularial surfaces.

Discussion. Lenz assigned *Aphroidophyllum* to the Phillipsastraeidae and commented that it "is probably fairly closely related to *Phillipsastrea*, but differs in lacking periaxially dilated septa and in the non-confluent nature of its corallites." The type species is one of the rarest Hume corals, and the present writer has examined only three specimens. As, however, all have axially rotated septa, clearly demarked tabularia composed of incomplete, adaxially sloping and closely spaced tabulae, there can be no doubt that the genus is more appropriately classed with the Spongophyllidae (= Ptenophyllidae).

It is most closely related to *Dohmophyllum* Wedekind, 1923 (*see* Birenheide, 1963, pp. 406–410), *Pseudochonophyllum* Soshkina, 1937 (*see* Strusz, 1966, pp. 563, 564), *Taimyrophyllum* Chernychev, 1941 (*see* Pedder, 1964, pp. 436, 437), and to corals that McLaren and Norris (1964, pp. 13–15) and Strusz (1966, pp. 586–588) have compared with *Australophyllum* (?) *thomasae* (Hill and Jones), but which may be species of *Kozlowiaphyllum* Rukhin, 1938. *Aphroidophyllum* is differentiated from all these genera, as a new figure (Pl. 9, fig. 1) of the type species supports, by its aphroid corallum and included layers of naotic and thamnasterioid septa.

"*Taimyrophyllum*" *carinatum* Bulvanker (1958, pp. 155, 156, Pl. 76, fig. 1; Pl. 77, fig. 1) from the Eifelian Shandin Beds of the Kuznetsk Basin shows all the diagnostic features of *Aphroidophyllum* and can be admitted unquestionably to the genus.

Aphroidophyllum meeki new species

Plate 5, figures 2, 3; Plate 6, figures 1–3; Plate 7, figures 1–3

Material. Holotype and thirteen paratypes, GSC Nos. 24643–24656. All from the Hume Formation on Carnwath River at GSC loc. C-2521.

Diagnosis. A large species of *Aphroidophyllum* in which axes of adjacent adult corallites are generally 25 to 50 mm apart and the tabularial diameters are 7.5 to 12.5 mm. Septal count 26 × 2 to 36 × 2 at maturity. Septa dilated, with strong zigzag carinae and vepreculae in the vicinity of the inner margin of the dissepimentarium. Minor septa weak, in places entirely suppressed. Dissepimentarium distinctly naotic at certain levels.

Description. The relatively flat colonial corallum is up to 20 cm or more in diameter and, although usually less, 10 cm high. In several specimens the patellate protocorallite has remained visible throughout subsequent development of the colony. Observed offsets are nonparricidal and originate well out from the axis of the parent corallite on a naotic dissepimentarial surface. Calices are shallow, locally almost flat, but in places may appear elevated due to erosion of the surrounding dissepiments to a stronger naotic level. Outer surfaces of the dissepimentarium may be flat or arched. A holotheca bearing fine growth ridges is preserved locally and possibly was once present over the entire under surface of the corallum. Axes of adjacent adult corallites are generally 25 to 50 mm apart. Diameters of adult calices normally fall within the range of 20 to 25 mm.

There are from 26 × 2 to 36 × 2 septa in fully grown corallites. At certain levels these are entirely lamellar, but peripherally withdrawn so that the corallum is clearly aphroid; at other levels they are highly naotic and appear thamnasterioid on a naturally weathered surface. At these levels different orders of septa are not usually distinguishable. The septa are lamellar in all levels in the region of the inner dissepimentarium, and in the vicinity of the tabularial margin are somewhat dilated and bear strong zigzag carinae and vepreculae. Minor septa project only slightly into the tabularium; between the naotic layers they are more withdrawn peripherally than the major septa and may be entirely suppressed. Major septa are well developed in the tabularium where most are long and markedly rotated about the axis.

There is considerable variation in the dissepimentarium. On the whole the inner dissepiments are smaller, more steeply inclined, and more uniformly inflated than the outer dissepiments, which vary greatly in size and curvature.

The tabularium is typically 7.5 to 10.0 mm in diameter, but may be as much as 12.5 mm in the adult part of the corallite, and has a clearly defined peripheral margin. The tabulae, which are invariably incomplete and closely spaced (2 to 4 per mm), tend to form concave tabularial surfaces.

Discussion. Aphroidophyllum howelli is a much smaller species and is unlikely to be confused with the new species. In it the axes of adjacent adult corallites are typically 15 to 30 mm apart (25 to 50 mm in *A. meeki*), the diameter of the tabularium is normally 4.5 to 5.5 mm (7.5 to 10.0 mm in *A. meeki*) and the septa number only 16 × 2 to 21 × 2 (26 × 2 to 36 × 2 in *A. meeki*). Moreover, in the new species calices are relatively shallower, and the septa are more dilated and vepreculate in the vicinity of the tabularial margin.

Aphroidophyllum carinatum is only slightly smaller (axes of adjacent corallites about 18 to 45 mm apart), but has fewer septa (21 × 2 to 25 × 2) which are not so long or axially rotated as those of *A. meeki.*

The species is named after the distinguished paleontologist F. B. Meek who, one hundred years ago, first described fossils from the Hume Formation.

Family Cystiphyllidae Milne Edwards and Haime, 1850

Genus *Mackenziephyllum* new

Type species. *Mackenziephyllum insolitum* new species.

Diagnosis. Corallum compound, aphroid. Septa undifferentiated, mostly represented by short, apparently structureless spines, which are periodically grouped to form low, wide-based septa on dissepimental surfaces at the margins of the tabularia. Dissepiments typically large, well inflated, forming arched dissepimentarial floors between the tabularia. Tabulae similar to the dissepiments but essentially flat lying.

Discussion. Mackenziephyllum resembles *Plasmophyllum* Dybowski, 1873 (*see* Birenheide, 1964) but that genus is rarely colonial and never aphroid. At present, the type is the only known species of *Mackenziephyllum.*

The name derives from the District of Mackenzie and the Greek, *phyllon* = leaf.

Mackenziephyllum insolitum new species

Plate 5, figure 1; Plate 8, figure 1; Plate 9, figures 2–4; Plate 10, figures 1,2

Material. Holotype and paratype, GSC Nos. 24657 and 24658. Both from the Hume Formation on Carnwath River at GSC loc. C-2521.

Diagnosis. A species of *Mackenziephyllum* in which the calices are usually 3.0 to 5.5 mm deep and 20 to 28 mm in diameter at the rim; the undifferentiated septa typically number 40 to 52 and are represented mostly by scattered spines.

Description. Both specimens are parts of large (at least 30 cm and probably more in diameter), more or less flat-topped, aphroid coralla. Before cutting, the height of the holotype was about 15 cm and that of the paratype 8 to 9 cm. The calices are typically 20 to 28 mm in diameter at the rim and are only 3.0 to 5.5 mm deep. They consist of a relatively deepened central area, 5 to 6 mm in diameter, corresponding to the tabularium, and an outer gently sloping area.

Although a proper intercorallite wall is lacking, small, upright, locally contiguous and superposed spines may be developed within planes that apparently separate neighbouring corallites. These are best seen in longitudinal section (e.g., right-hand side of fig. 3, Pl. 9). In adult corallites there are usually 40 to 52 undifferentiated septa which are mostly represented by isolated or rather crudely aligned spines. Sporadically more definite, although extremely broad and rather irregular septa are produced on dissepimentarial surfaces surrounding the tabularium by close packing of the spines and other septal material (*see* Pl. 10, fig. 1). Naturally weathered specimens are commonly eroded to the surfaces of these septa and at first glance give the impression of a strongly septate coral. The septal spines are short (predominantly less than 0.5 mm long) and mostly do not pierce overlying dissepiments; they are structureless when viewed through an optical microscope and may pass laterally imperceptibly into non-spinose stereome (*see* lower part of Pl. 10, fig. 2). The spines occurring in the intercorallite planes also lack visible internal structure.

Dissepiments are mostly large and well inflated; between the tabularia they form broadly to sharply elevated dissepimentarial surfaces. The tabulae are typically domed and resemble the dissepiments in size, but they are markedly more horizontal.

Discussion. Mackenziephyllum insolitum new species is such a distinct and unusual coral that no comparisons are necessary. It takes its trivial name from the Latin, *insolitus* = unusual or strange.

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Plate 5

Mackenziephyllum insolitum new species (Page 48)

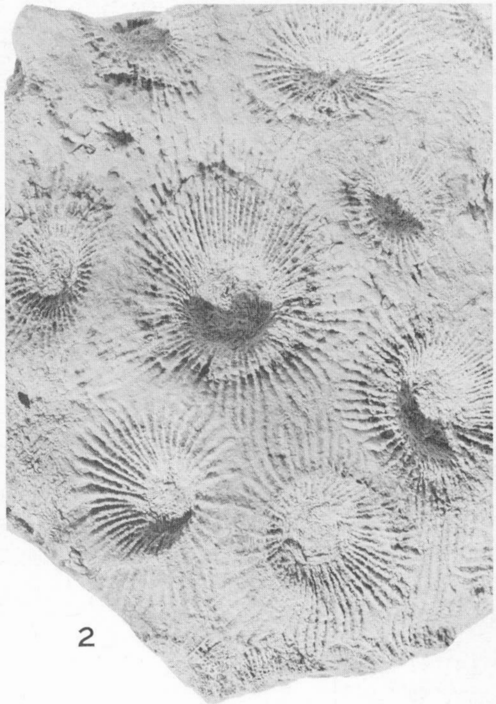
Figure 1. Exterior of the holotype (GSC 24657), GSC loc. C-2521; ×1.

Aphroidophyllum meeki new species (Page 47)

Figure 2. Exterior of paratype 5 (GSC 24648), same locality; ×1. The surface of the corallum is aphroid in the upper part of the figure, but in the lower part the septa are naotic and thamnasterioid.

Figure 3. Exterior of paratype 3 (GSC 24646), same locality; ×1. Naotic, thamnasterioid septa cover most of the surface of this specimen.

1



2

3

Plate 6

Aphroidophyllum meeki new species (Page 47)

Figure 1. Exterior of the upper surface of paratype 4 (GSC 24647), GSC loc. C-2521; ×1. An offset is visible on the right side of the figure.

Figure 2. Lateral view of paratype 4 (GSC 24647), same locality; ×1. The protocorallite and some of the holotheca are visible in the lower centre part of the figure.

Figure 3. Transverse section of paratype 1 (GSC 24644), same locality; ×2.

PLATE 6

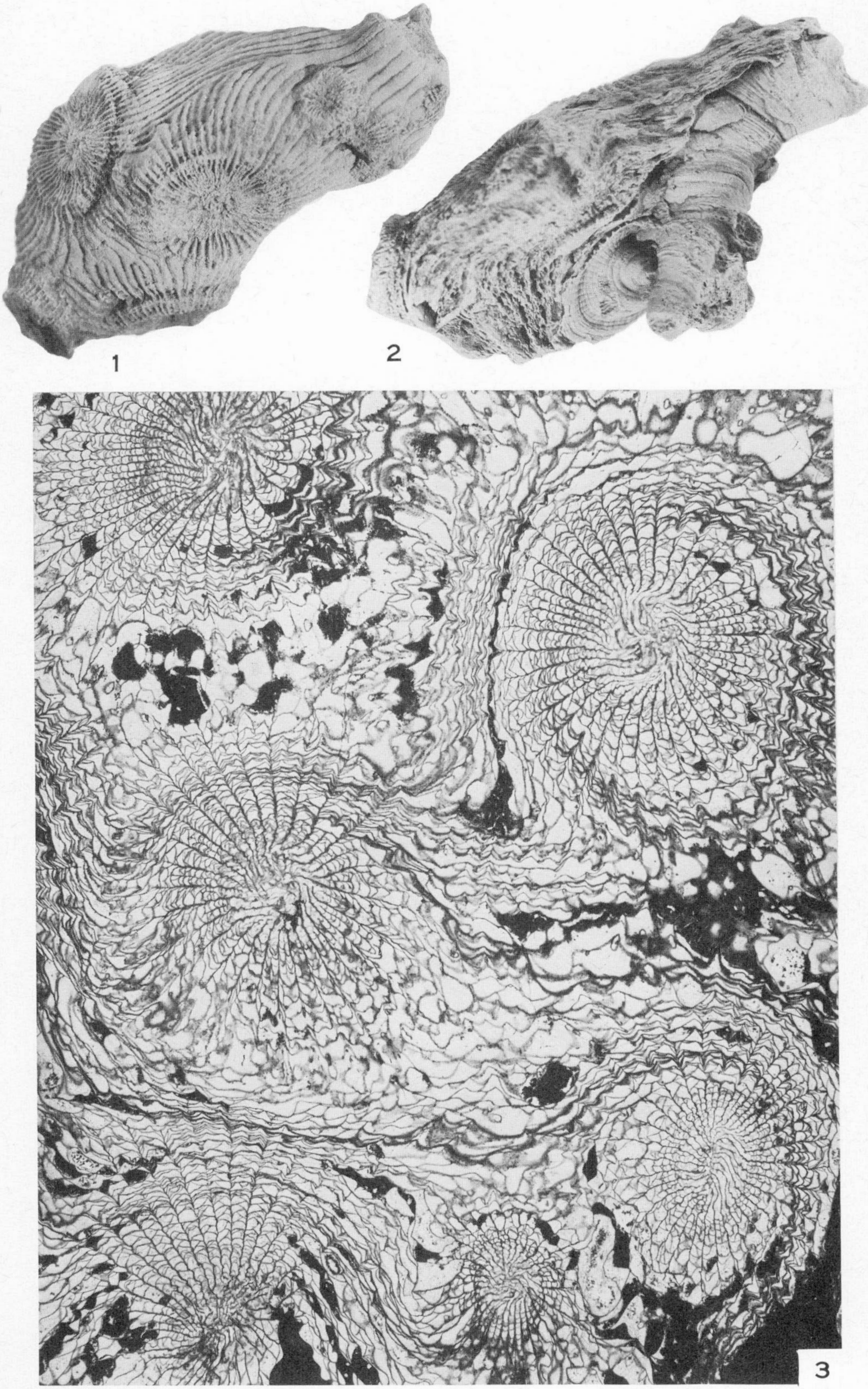


PLATE 7

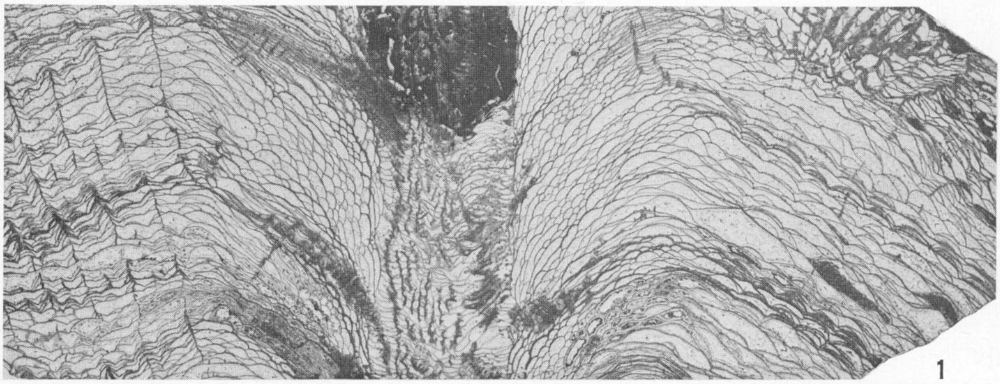
Aphroidophyllum meeki new species (Page 47)

Figure 1. Longitudinal section of the holotype (GSC 24643), GSC loc. C-2521; ×2. Shows periodic development of naotic septa.

Figure 2. Longitudinal section of paratype 2 (GSC 24645), same locality; ×2.

Figure 3. Transverse section of the holotype, which is also illustrated by figure 1; ×2.

PLATE 7



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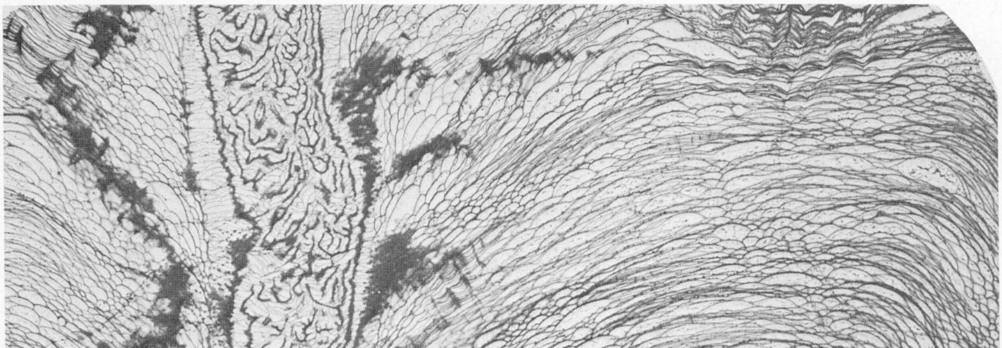

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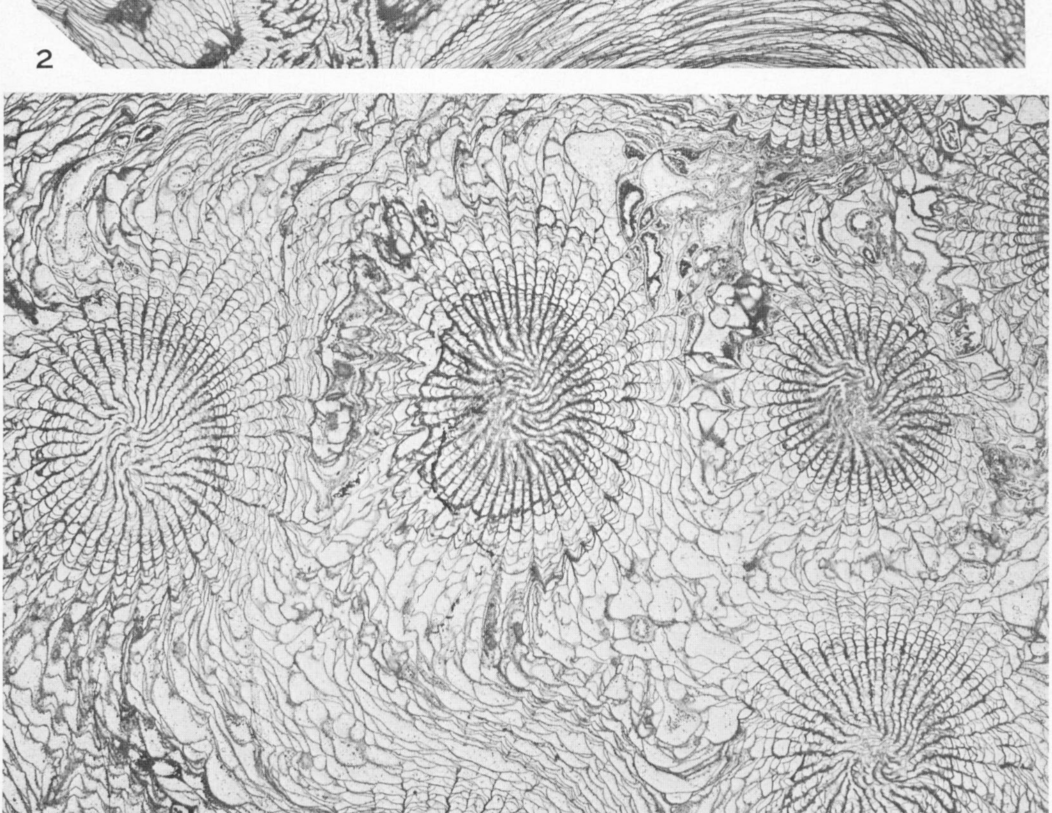
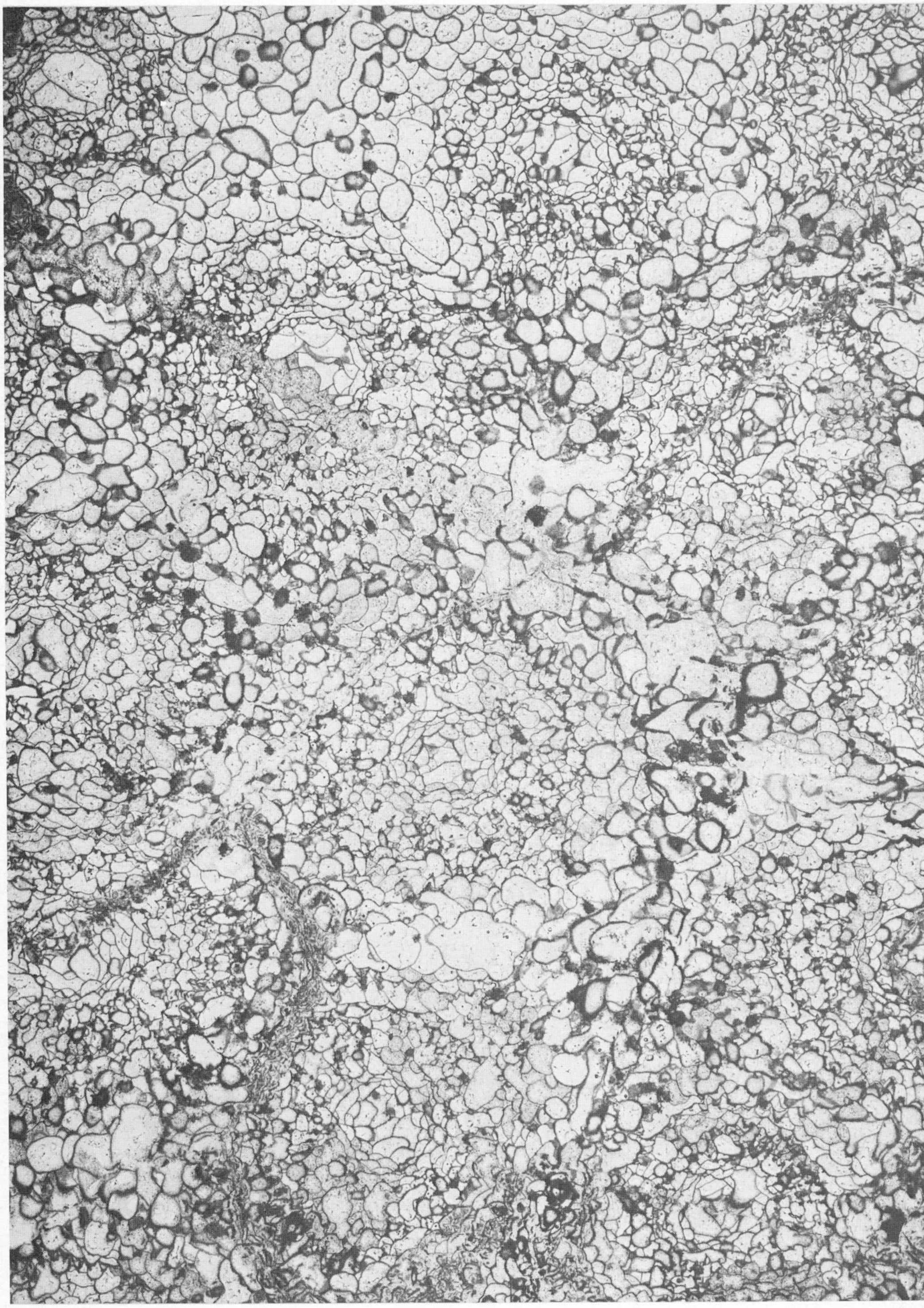


3

PLATE 8

Mackenziephyllum insolitum new species (Page 48)

Figure 1. Transverse section of the holotype (GSC 24657), GSC loc. C-2521; ×2.



1

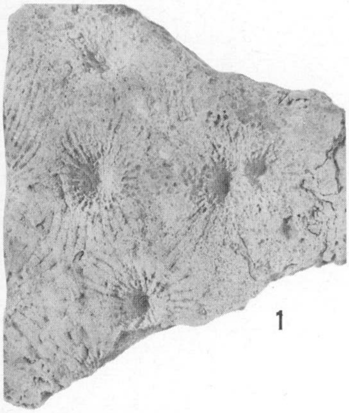
PLATE 9

Aphroidophyllum howelli Lenz (Page 47)

Figure 1. Exterior of the holotype, The California Standard Company No. S47-54; ×1. The septa are partly aphroid, partly naotic and thamnasterioid.

Mackenziephyllum insolitum new species (Page 48)

Figure 2. Longitudinal section of the paratype (GSC 24658), GSC loc. C-2521; ×2.
Figure 3. Longitudinal section of the paratype shown by figure 2; ×2.
Figure 4. Longitudinal section of the holotype (GSC 24657), same locality; ×2.



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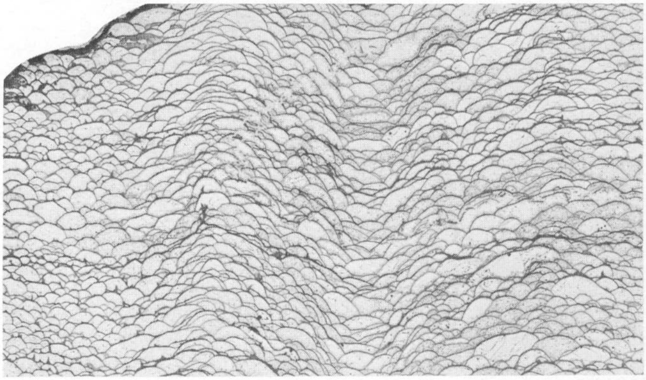

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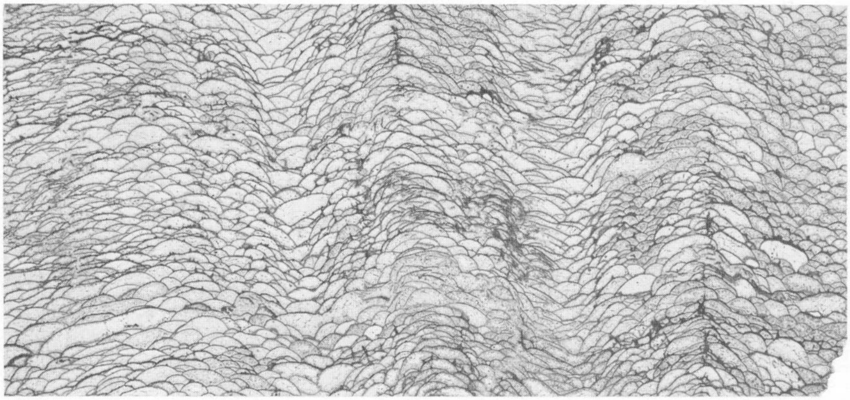

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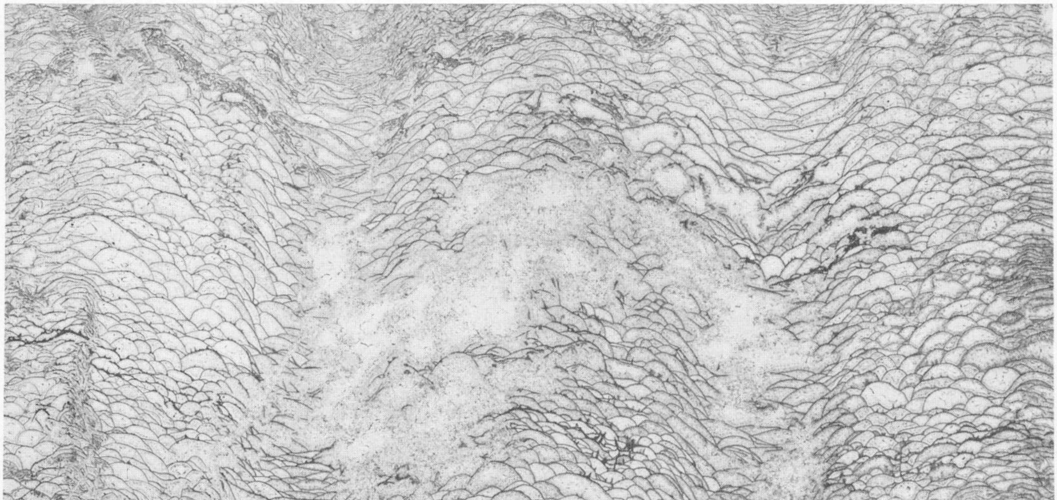


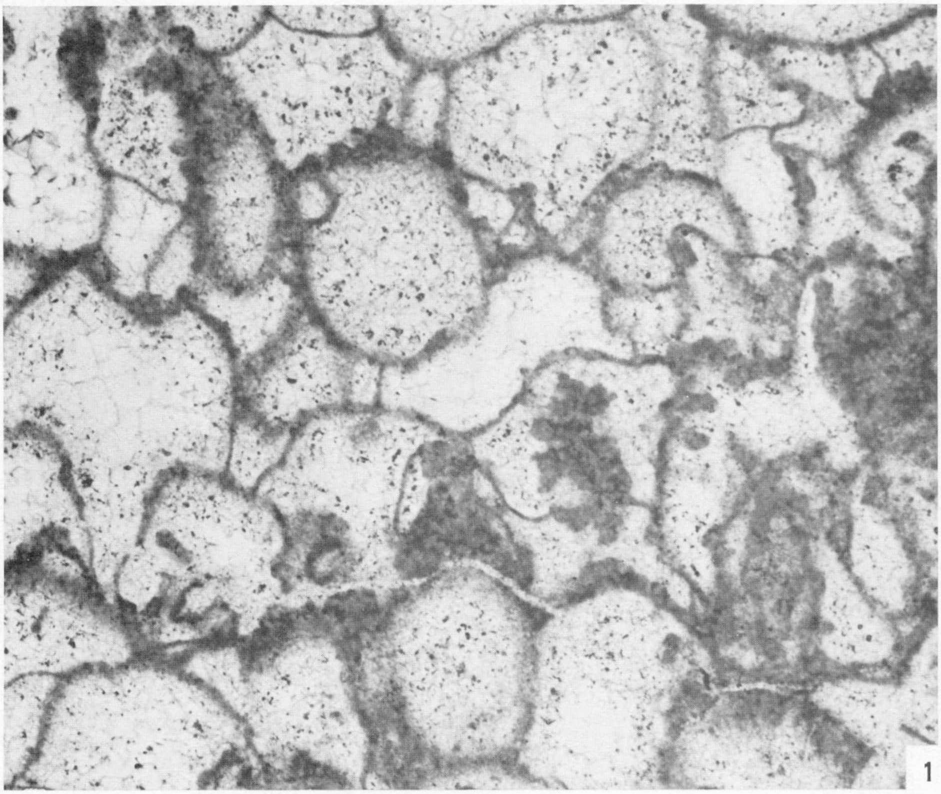
4

PLATE 10

Mackenziephyllum insolitum new species (Page 48)

Figure 1. Transverse section of the holotype (GSC 24657), GSC loc. C-2521; ×20. Shows crudely formed septa just exterior of a tabularium.

Figure 2. Longitudinal section of the paratype (GSC 24658), same locality; ×20.



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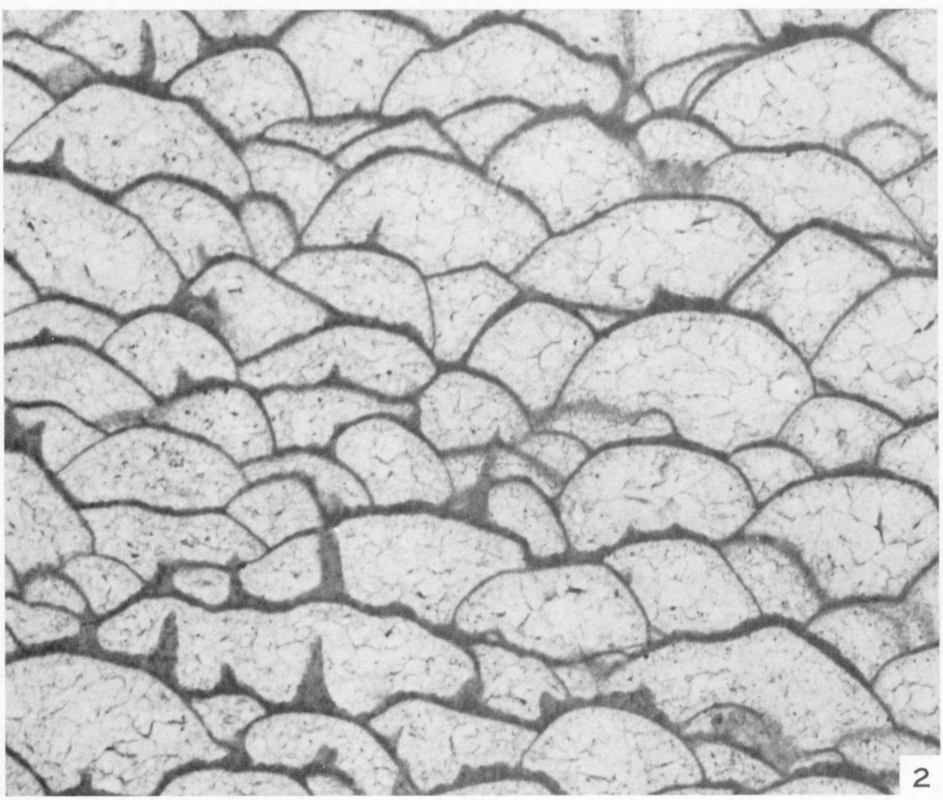

2

MIDDLE DEVONIAN COELENTERATES FROM THE NAHANNI FORMATION OF H.B., AMERADA CAMSELL A-37 WELL, DISTRICT OF MACKENZIE

A. E. H. Pedder

Abstract

A fauna consisting of *Cyclochaetetes* cf. *C. inflatus, Dendrostella trigemme, Kozlowiaphyllum* cf. *Australophyllum* (?) cf. *A.* (?) *thomasae* auct., *Grypophyllum* cf. *G. wedekindi* and *Sociophyllum glomerulatum* small var. is described from the Camsell A-37 well.

An early Givetian age is suggested by the fauna.

Résumé

L'auteur décrit les *Cyclochaetetes* cf. *C. inflatus, Dendrostella trigemme, Kozlowiaphyllum* cf. *Australophyllum* (?) cf. *A.* (?) *thomasae* auct., *Grypophyllum* cf. *G. wedekindi* et *Sociophyllum glomerulatum* (petite variété) provenant du puits Camsell A-37.

En raison de la faune il propose le début du Givétien.

Introduction

Correlation of Middle Devonian strata across the southern part of the District of Mackenzie from the Nahanni and other Cordilleran ranges eastwards to Great Slave Lake presents many problems. As difficulties arise principally from facies changes and lack of paleontological control in intervening subsurface sections, they should be alleviated by investigations of faunas obtained from cores; but unfortunately, most cores are either poorly fossiliferous or, because of the present state of knowledge, their faunas are not recognizably diagnostic. An exception to this is a 20-foot core taken from the upper Nahanni Formation (74 to 94 feet below top, 480 to 500 feet above base and 1,104 to 1,124 feet from surface) in Hudson's Bay, Amerada Camsell A-37 well (Textfig. 1, locality 37; 61°46′9″N; 122°35′55″W). The megafauna yielded, which is not only comparatively rich but also diagnostic, is the subject of this paper.

Lithology

The fauna occurs in a speckled grey to black, biogenic and very carbonaceous limestone. The darker variety is predominantly biomicritic with minor patches of biosparite, in contrast to the speckled type which is mostly biosparitic. Organic debris includes crinoid ossicles, usually with solution-affected margins, broken stromatoporoids, corals and rarer ostracods and gastropods; brachiopods have been recognized only in C-2551 and C-2553 (GSC locs., *see below*). Authigenic quartz amounts to 1 to 5 per cent of the rock volume in most slides, but in some it is much more and may constitute 20 per cent of the rock. Microstylolites, with carbonaceous material concentrated along their sutures, are present in several sections.

Fauna and Age

All collections are from core #1 (1,104 to 1,124 feet, 100 per cent recovery) of H.B., Amerada Camsell A-37 well. The core was sparingly collected by G. O. Raasch prior to slabbing (collections C-1748 to C-1751) and was later re-collected by the writer (collections C-2546 to C-2557).

The species of *Cyclochaetetes* present is closely related to *C. inflatus* and perhaps conspecific with that species, which is known only from a single specimen from the early Givetian of Belgium. The *Kozlowiaphyllum* is a new species close to a form occurring in the probable Givetian Horn Plateau Formation of the Great Slave Lake area, and also to a form occurring in the Givetian of northeastern British Columbia. *Grypophyllum wedekindi* occurs in the Givetian of England and Germany. *Dendrostella trigemme*, or closely comparable forms, are known from the Eifelian of Bashkirskaya, the Kuznetsk Basin, Yunnan and New South Wales and is even more widely distributed in Givetian strata. It is common in some surface outcrops of the Hume, Nahanni, and Headless Formations, and has been reported from about 80 feet below *Stringocephalus* sp. in Utah (Hose, 1966, p. B38). *Sociophyllum glomerulatum* is known only from western Canada, but is close to a form occurring in the early Givetian of Nepal. The age suggested by this fauna is early Givetian.

Acknowledgments

The manuscript has been critically read by D. J. McLaren of the Geological Survey of Canada. The Devonian stratigraphy of the well was studied by W. S. Mackenzie, also of the Survey, who provided the data on the upper and lower limits of the Nahanni Formation. The photographs were taken by D. Harvey.

Systematic Paleontology

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

Family Chaetetidae Milne Edwards and Haime, 1850

Genus *Cyclochaetetes* Sokolov, 1955

Type species. *Cyclochaetetes grandis* Sokolov, 1955.

Cyclochaetetes sp. cf. *C. inflatus* (Lecompte, 1939)

Plate 11, figures 1,2; Plate 14, figures 5,7

cf. *Chaetetes inflatus* Lecompte, 1939, pp. 164, 165; Pl. 22, fig. 1.

Material. Two figured hypotypes: GSC No. 24659, GSC loc. C-2554; GSC No. 24660, GSC loc. C-2557. Two other specimens: one from GSC loc. C-1750 and one from C-2555.

GSC locality	C-2546	C-2547	C-2548	C-2549	C-2550	C-2551	C-2552	C-2553	C-2554	C-2555	C-1748	C-1749	C-1750	C-2556	C-1751 C-2557
Well footage	·1104.5	1105.5	1106	1107	1107.5	1109	1112.5	1113	1114.5	1116.5	1118	1118.5	1120	1123	1124
Footage from top of Nahanni Formation	74.5	75.5	76	77	77.5	79	82.5	83	84.5	86.5	88	88.5	90	93	94
Footage from base of Nahanni Formation	499.5	498.5	498	497	496.5	495	491.5	491	489.5	487.5	486	485.5	484	481	480
Taxa															
Stromatopora sp. undet.				X											
Cyclochaetetes cf. *C. inflatus* (Lecompte)									X	X			X		X
Favosites sp. undet.													X		
Thamnopora sp. undet.		X	X	X			X						X		
auloporid fragments						X									
Dendrostella trigemme (Quenstedt)		X			X	X	X	X		X					
Kozlowiaphyllum cf. *Australophyllum* (?) cf. *A. thomasae* of McLaren, 1964										X	X	X		X	
Grypophyllum cf. *G. wedekindi* Middleton													X		
Sociophyllum glomeratum (Crickmay) small var.	X	X	X	X		X				X		X			X
Mesophyllum sp. indet.												X			
brachiopod indet., possibly a reticulariid								X							

GSC

TEXTFIGURE 7. Distribution of Middle Devonian coelenterates in Hudson Bay Amerada Camsel A-37 Well

Description. The lowest part of the core was taken entirely from within a specimen of this species, which is therefore assumed to have formed large colonies. The colony consists of a mass of contiguous tubular cells with completely amalgamated, non-perforate walls. Axes of adjacent cells are mainly 0.25 to 0.35 mm apart and the wall is normally 0.1 to 0.16 mm thick. As viewed in transverse section, the interiors of the tubes are rounded, but normally not circular. Short, blunt projections (pseudoseptal protuberances of Sokolov) are present in some tubes, absent in others; they leave the wall at an angle of about 45 degrees. Three to seven tabulae may be counted in 1.0 mm; they tend to occur at the same horizon in neighbouring cells and they may be periodically thickened by an investment of stereome on their upper surfaces.

Discussion. The unique specimen of *Cyclochaetetes inflatus*, which comes from the Lower Givetian (Gia) of the Dinant Basin, appears to have slightly thicker walls relative to the cell diameters. More specimens of it are needed to elucidate the relationship between the Canadian and Belgian forms.

Family STAURIIDAE Milne Edwards and Haime, 1850

Genus *Dendrostella* Glinski, 1957

Type species. *Cyathophyllum rhenanum* Frech, 1886.

Discussion. The genera *Soshkinella* Ivaniya, 1960, with type species *Columnaria vulgaris* Soshkina, 1936, and *Iteophyllum* Crickmay, 1962, based on *Iteophyllum virgatum* Crickmay, 1962, are synonymous with *Dendrostella.*

Dendrostella trigemme (Quenstedt, 1879)

Plate 12, figures 6–9

?*Cyathophyllum caespitosum*, Quenstedt, 1852 (in part), p. 664; Pl. 59, figs. 40a, b only.
?*Cyathophyllum caespitosum*, Quenstedt, 1867 (in part), p. 797; Pl. 76, figs. 40a, b only.
?*Cyathophyllum caespitosum*, Quenstedt, 1879, 1881 (in part), pp. 516–518 (1879); Pl. 162, figs. 1–4 (1881) only.
Cyathophyllum caespitosum trigemme Quenstedt, 1879, 1881, p. 518 (1879); Pl. 162, figs. 5–8 (1881).
Cyathophyllum caespitosum, Quenstedt, 1885 (in part), pp. 1023, 1024; Pl. 83, fig. 6 only.
Cyathophylloides rhenanum Frech, 1886, p. 207; Pl. 15, figs. 19, 19a.
Metriophyllum poshiense Mansuy, 1912, pp. 47, 48; Pl. 7, figs. 8a–d.
Columnaria (Pycnophyllum) rhenana Frech, Paeckelmann, 1922, pp. 74, 75.
Thamnophyllum murchisoni Penecke, Le Maître, 1937 (in part?), pp. 111–113; Pl. 7, figs. 3–5, 11, 12; Pl. 8, fig. 7.
Favistella rhenana (Frech), Hill, 1942a, p. 253; Pl. 9, figs. 2, 3.
cf. *Favistella* cf. *rhenana* (Frech), Hill, 1942b, p. 158; Pl. 4, fig. 13.
?*Columnaria* sp., Wang, 1948, p. 28; Pl. 4, fig. 23.
Columnaria vulgaris Soshkina, Soshkina, 1949, pp. 107, 108; Pl. 43, figs. 5, 6.
Columnaria vulgaris Soshkina, Soshkina (in part), 1952, p. 92; Pl. 26, fig. 102 only.
Columnaria rhenana Frech, Kraevskaya *in* Khalfin, 1955, pp. 216, 217; Pl. 41, figs. 2a, b.
Favistella (Dendrostella) rhenana (Frech), Glinski, 1957, pp. 88–90; textfigs. 1–4, 16.
Columnaria rhenana (Frech), Ivaniya, 1957, pp. 65, 66; Pl. 6, fig. 3 (not seen).
Favistella rhenana (Frech), Bulvanker, pp. 110–112; Pl. 42, figs. 3a–4; Pl. 43, figs. 2a, b.

Favistella (Dendrostella) rhenana (Frech), Flügel, 1959, pp. 49, 50.
Columnaria rhenana (Frech), Middleton, 1959, pp. 150–152; textfigs. 5f–h; Pl. 27, figs. 6a–7.
Favistella (Dendrostella) trigemme trigemme (Quenstedt), Flügel, 1959, pp. 113–117.
Soshkinella rhenana (Frech), Ivaniya *in* Khalfin, 1961, p. 372; Pl. D29, figs. 2a, b.
Dendrostella rhenana (Frech), Fontaine, 1961, pp. 156, 157; Pl. 28, figs. 6–8.
Columnaria rhenana (Frech) ?, Lenz, 1961, p. 506; Pl. 1, figs. 5–10.
Dendrostella rhenana (Frech), McLaren, Norris, and McGregor, 1962, Pl. 2, figs. 1, 2.
Iteophyllum virgatum Crickmay, 1962, pp. 1, 2; Pl. 1, figs. 3, 4; Pl. 2, figs. 1–3; Pl. 4, figs. 1–4.
Favistella rhenana (Frech), Ermakova, 1964, pp. 102, 103; Pl. 6, fig. 3; Pl. 8, figs. 5, 6.
Dendrostella trigemme (Quenstedt), Pedder, 1964, pp. 434–436; Pl. 62, figs. 1–11.
Soshkinella rhenana (Frech), Ivaniya, 1965, pp. 126–128; Pl. 43, figs. 199, 200; Pl. 45, figs. 206, 207.
Dendrostella trigemme (Quenstedt), Ferrari, 1968, pp. 561–565, textfigs. 11a, b; Pl. 50, figs. 1a–3.
not *Lithodendron caespitosum* Goldfuss, 1826, p. 44; Pl. 13, fig. 4 (= *Phacellophyllum caespitosum*).
not *Thamnophyllum murchisoni* Penecke, 1894, pp. 595, 596; Pl. 7, figs. 15–17 (= *Thamnophyllum* (?) *murchisoni*).
not *Disphyllum {Phacellophyllum} trigemme* (Quenstedt), Lang and Smith, 1935, pp. 575, 576; textfigs. 4, 5, 30, 31 (= *Thamnophyllum* (?) *germanicum*).
not *Columnaria vulgaris* Soshkina, 1936, pp. 22, 23; textfigs. 1–3 (= *Dendrostella vulgaris*).
not *Disphyllum (Phacellophyllum) trigemme* (Quenstedt) var., Weissermel, 1938, pp. 65–67; Pl. 2, figs. 1, 2 (=*Phacellophyllum* sp.).

Material. Three figured hypotypes: GSC 24661, GSC loc. C-2552; GSC 24662, 24663, both from GSC loc. C-2553. Five other specimens; one each from GSC loc. C-2547, C-2550, C-2551, C-2552, and C-2555.

Description. Due to pre-burial damage much of the material now consists only of solitary corallites; some specimens, however, are definitely branching and three thin sections show multiple non-parricidal budding. Two of these are precisely similar to German and Italian specimens illustrated by Glinski (1957, textfig. 3) and Ferrari (1968, textfig. 11a), in which three offsets are aligned normal to two prominent direction septa (Richtsepten of German authors) of the parent corallite.

Thickness of the wall is mainly 0.5 to 0.8 mm, but in one specimen from C-2550 is 1.0 to 1.8 mm. Where preservation is adequate the wall is seen to consist of prominantly dilated septal bases dissected longitudinally by a dark lamina, and lamellar tissue, although in places the septal bases are contiguous and there is very little of the lamellar tissue. Septa are smooth and number 16 × 2 or 17 × 2 in corallites of 5.0 to 7.0 mm diameter. The so-called direction septa generally terminate at or close to the axis, but other major septa may be only one half as long and may be pinnate in respect to one of the direction septa. Minor septa usually project about 0.5 mm into the tabularium.

There are no dissepiments. Many of the tabularia have been destroyed by recrystallization, where preserved they comprise widely spaced, broad to complete, flat to steeply sloping tabulae.

Discussion. Dendrostella trigemme is a widely distributed species. It occurs in the Eifelian of the Kuznetsk Basin and the southern Urals and perhaps also in Yunnan and northern New South Wales. In Givetian strata it has been described from Britain (south Devon), France (Deux Sèvres), Germany (Gladbach-Paffrather Mulde), Carnic Alps (Plöcken Pass and Monte Zermula), northern Urals, Altai-Sayan, Kuznetsk Basin, North Viêt-Nam (Ha Lang), and northern Queensland. In Canada occurrences have been documented in the Hume, Nahanni, and Headless Formations and in undifferentiated Middle Devonian in the Hart River area of the Yukon.

Family SPONGOPHYLLIDAE Dybowski, 1873

Genus *Kozlowiaphyllum* Rukhin, 1938

Type species. *Kozlowiaphyllum pentagonum* Rukhin, 1938.

Discussion. Five other genera of cerioid spongophyllids have been proposed: *Spongophyllum* Milne Edwards and Haime, 1851 (type species *S. sedgwicki* Milne Edwards and Haime), *Entelophylloides* Rukhin, 1938 (type species *Columnaria inequalis* Hall), *Xystriphyllum* Hill, 1939 (type species *Cyathophyllum dunstani* Etheridge), *Australophyllum* Stumm, 1949 (type species *Cyathophyllum cyathophylloides* Etheridge), and *Pseudospongophyllum* Zhmaev 1955 (type species *P. massivum* Zhmaev). Although several of these genera are certainly synonymous, the task of revising them is well beyond the scope of the present work: it is necessary only to note that *Kozlowiaphyllum* is distinguished from *Spongophyllum* by its wide dissepimentarium, commonly axially rotated and carinate septa and incomplete tabulae, and that it is distinguished from *Entelophylloides* by its lonsdaleoid dissepimentarium.

Kozlowiaphyllum cf. *Australophyllum* (?) cf. *A.* (?) *thomasae* of McLaren, 1964

Plate 12, figures 1–4

cf. *Australophyllum*? cf. *A.*? *thomasae* (Hill and Jones), McLaren and Norris, 1964, pp. 13–15; Pl. 4, fig. 3.

Material. Two figured hypotypes: GSC 24664, GSC loc. C-1748; GSC 24665, GSC loc. C-1749. Two other specimens, one each from GSC loc. C-2555 and C-2556.

Description. The four specimens are fragmentary cerioid coralla, in which the dissepimentaria have been crushed; despite this it is probably safe to say that the mean adult corallite diameters are mainly 18 to 30 mm. The intercorallite walls thicken and thin between 0.25 and 0.75 mm. Apart from the axial plate their fine structure is indistinct but the thicker parts do not appear to correspond with septal bases.

In adult corallites there are between 20 × 2 and 30 × 2 well differentiated and peripherally withdrawn septa. The major septa are of variable length in the tabularium, and may be either weakly rotated or somewhat pinnate. The minor septa may or may not just penetrate the tabularium; in exceptional cases they are almost entirely suppressed. Both orders of septa are flanged and vepreculate, locally strongly so, and are either thin or only slightly thickened in the vicinity of the boundary between the tabularium and dissepimentarium.

The dissepimentarium includes about 10 to 12 rows of large, commonly weakly inflated dissepiments. Those of the outer dissepimentarium are normally inosculating and inclined at about 45 degrees; adaxially they progressively steepen and tend to become a little smaller but relatively more inflated.

The tabulae, which are incomplete and closely spaced (up to 5 per mm), form slightly elevated tabularial floors in the axial region.

Discussion. The coral described by McLaren from the Horn Plateau Formation as *Australophyllum* ? cf. *A.* ? *thomasae* differs from the Nahanni specimens in having slightly larger corallites, more numerous septa and ribbed intercorallite walls. It is certainly closely related to the Nahanni specimens and may prove to be conspecific, but at the moment there is too little material on which to base an opinion. *Spongophylloides* (?) *thomasae* Hill and Jones is known from only one or two specimens from the Lower Devonian Garra Formation of New

South Wales (Strusz, 1966, p. 586; Pl. 94, fig. 1). Again there is too little material to be certain, but it appears to be a larger species with prominently sagging tabulae and may not be truly cerioid. A Givetian coral described by Firtion (1957, pp. 121, 122; Pl. 4, figs. 5, 6) from the Val de Bruche, France, as cf. *Spongophylloides tomasae* Etheridge (*sic*) is not closely related to either the Garra, Horn Plateau, or Nahanni forms. Irish (1964, p. 823) has recorded the occurrence of a coral identified by McLaren, as *Australophyllum* ? cf. *A. thomasae* (Hill and Jones) in the Givetian of northeast British Columbia. The material has not been examined by the writer, but the record is of interest in that it suggests that corals of this type may be of Givetian age in western Canada.

Genus *Grypophyllum* Wedekind, 1922

Type species. *Grypophyllum denckmanni* Wedekind, 1922. The subsequent designation of *Grypophyllum isactis* (Frech) by Wedekind in 1925 is invalid.

Discussion. *Hooeiphyllum* Taylor, 1950, with *Grypophyllum normale* Wedekind, 1925 as type species, is a synonymous genus.

Grypophyllum sp. cf. *G. wedekindi* Middleton, 1959

Plate 14, figures 4, 6

cf. *Grypophyllum gracile* Wedekind, 1925, p. 22; Pl. 5, figs. 28, 29.
cf. *Grypophyllum wedekindi* Middleton, 1959, p. 146.
not *Strephodes gracilis* McCoy, 1850, p. 378 (lectotype = *Grypophyllum gracile*).
not *Grypophyllum wedekindi* Ivaniya *in* Khalfin, 1961, p. 377; Pl. D-31, fig. 2 (unadjusted homonym).

Material. One figured hypotype: GSC 24666, GSC loc. C-1750.

Description. A fragmentary corallite, about 8 mm long and 9 to 10 mm in diameter, is all that is available. It has a well-developed wall, 0.5 to 1.3 mm thick, consisting of slender septal ends embedded in lamellar skeleton. The septa are smooth, strongly differentiated into two orders and weakly pinnate against the counter and alar septa. There are 21 major septa, some of which extend to the axial region, and slightly fewer minor septa. Neither major nor minor septa show any tendency to be withdrawn from the periphery.

There is a narrow dissepimentarium of one to four rows of relatively moderately sized and steeply inclined dissepiments, which may be invested by a thin layer of sclerenchyme. Suppression of the minor septa does not appear to result in the formation of a herringbone dissepimentarium.

The tabulae are broad, locally complete, and flat to weakly depressed in the axial region; they are not as densely spaced as in some species of the genus.

Discussion. The thick wall suggests a species of *Lyrielasma* Hill, 1939 (= *Salairophyllum* Besprozvannykh, 1968), but the smooth septa and weakly depressed tabularium are much more characteristic of *Grypophyllum.*

Apart from the wide wall and better developed minor septa the specimen closely resembles Wedekind's figures of *G. wedekindi*. It also resembles a small corallite identified as *G. tenue* by Middleton (1959, textfig. 2f), but adult specimens of that species are larger and have particularly well developed minor septa.

Family Stringophyllidae Wedekind, 1921

Genus *Sociophyllum* Birenheide, 1962

Type species. *Spongophyllum elongatum* Schlüter, 1881.

Sociophyllum glomerulatum (Crickmay, 1962) small var.

Plate 12, figure 5; Plate 13, figures 1,2; Plate 14, figures 1–3

Spongophyllum elongatum Schlüter, Lenz, 1961, pp. 506, 507; Pl. 1, figs. 19–22.
Stringophyllum (*Neospongophyllum*?) sp. J, McLaren, Norris, and McGregor, 1962, Pl. 1, figs. 7, 8.
Stringophyllum glomerulatum Crickmay, 1962, pp. 7, 8; Pl. 1, fig. 15; Pl. 2, figs. 6, 7; Pl. 4, figs. 8, 9.
Sociophyllum glomerulatum (Crickmay), Pedder, 1964, pp. 445, 446; Pl. 69, figs. 1–13; Pl. 70, figs. 1–12.
not *Spongophyllum elongatum* Schlüter, 1881, pp. 94, 95; Pl. 10, figs. 1–3 (= *Sociophyllum elongatum*).

Material. Four figured hypotypes: GSC 24667, GSC loc. C-1749; GSC 24668, GSC loc. C-2546; GSC 24669, GSC loc. C-2549; GSC 24670, GSC loc. C-2551. Six other specimens: one from GSC loc. C-1751, two from GSC loc. C-2547, two from GSC loc. C-2548 and one from GSC loc. C-2555.

Description. The corallum is fasciculate, in part phacelloid and at least 8 cm high and 10 cm in diameter. Adult corallites have mean diameters of 10 to 13.0 mm.

A wall, 0.3 to 0.8 mm thick, consisting primarily of lamellar tissue, is present around all corallites. The septa are smooth, mainly of one order, and extremely variable. Where well developed, they number up to 28 and most are embedded in the wall, but axially are slightly withdrawn and usually fragmented into discrete monacanths. Where poorly developed they are not only less numerous but, especially in the dissepimentarium, are largely represented solely by discrete monacanths. In extreme cases the septa are almost completely suppressed. The structure of the monacanths is typical of the family (*see* Engel and Schouppé, 1958, Pl. 8, fig. 4). Inclination of the monacanths varies from about 5 to 45 degrees with respect to the horizontal at the periphery, to more or less consistently 45 degrees in the axial region.

Variation within the dissepimentarium is considerable, even within a single corallite. There may be a single row of large lonsdaleoid dissepiments, or two, three, rarely four rows of generally smaller dissepiments. The smaller dissepiments mainly occur where the dissepimentarium is confined to interseptal loculi and is not lonsdaleoid.

The tabularium occupies one half or less of the total width of the corallite and consists of broad, commonly complete tabulae, of which there are 1 to 8 per 2 mm. Tabularial surfaces may be more or less flat, slightly concave, or slightly convex.

Discussion. The average size of the corallites and the number of septa are smaller in these specimens than in others previously made known from the Hume, Headless, and Nahanni Formations of the District of Mackenzie, and from an unnamed Middle Devonian unit in the Yukon, but in other respects there is no important difference. They appear to be close to forms from the early Givetian of Nepal identified questionably by Flügel (1966, p. 104, Pl. 1, figs. 3, 4) as *Stringophyllum* (*Sociophyllum*) *longiseptatum* (Bulvanker), although in the Nepalese specimens the septa number 29 to 33 and are better developed.

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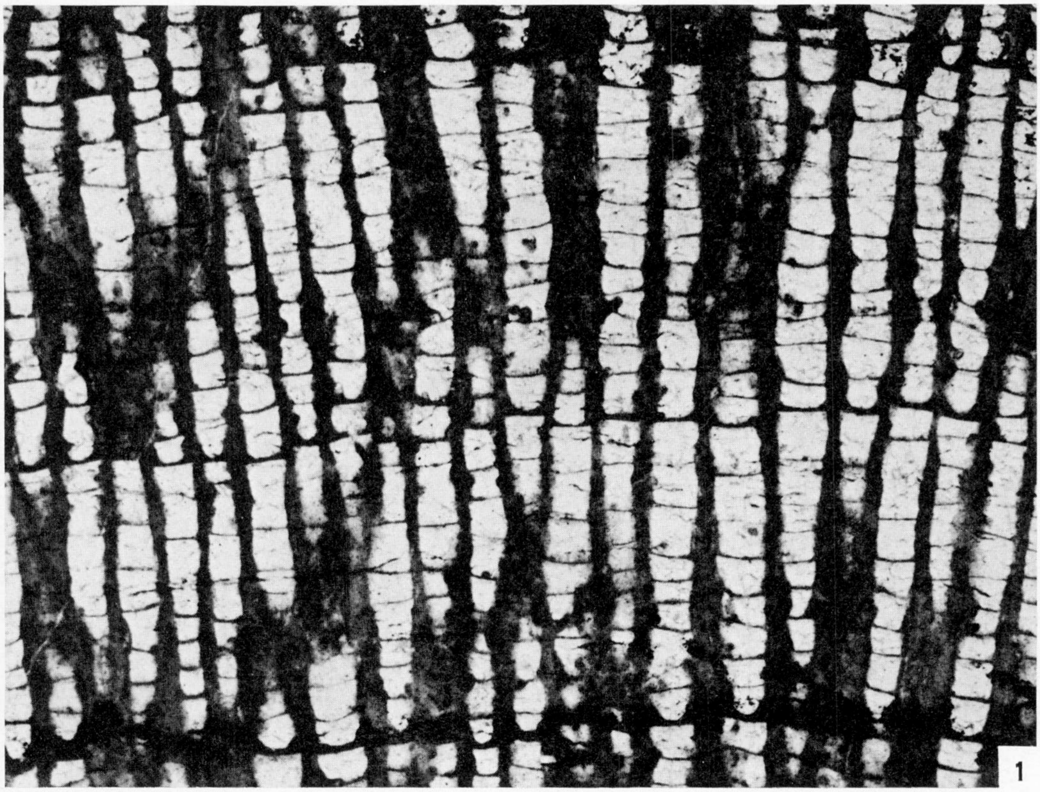
PLATE 11

Cyclochaetetes cf. *C. inflatus* (Lecompte, 1939) (Page 64)

Figures 1, 2. Longitudinal and transverse sections of hypotype (GSC 24660); GSC loc. C-2557, 94 feet below top and 480 feet above base of the Nahanni Formation; × 20. Pl. 14, fig. 5 shows another longitudinal section of this specimen.



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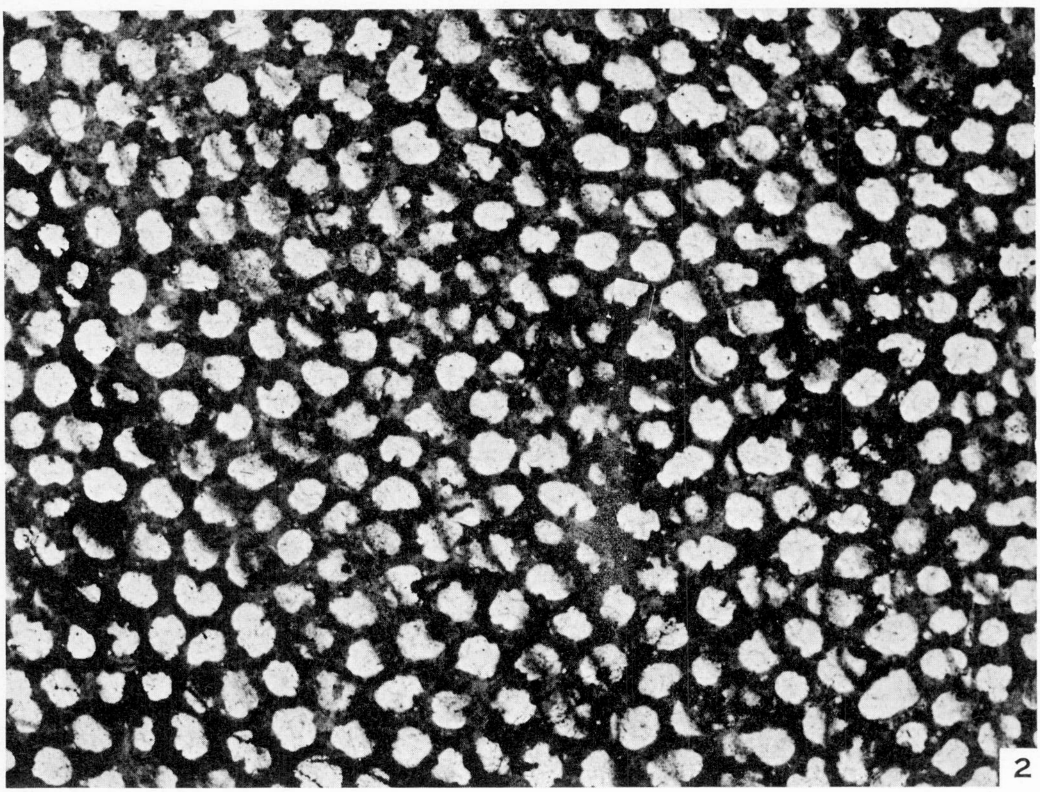

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Plate 12

Kozlowiaphyllum cf. *Australophyllum* (?) cf. *A.* (?) *thomasae* of McLaren, 1964 (Page 68)

Figures 1, 3, 4. Longitudinal (figs. 1 and 3) and transverse (fig. 4) sections of hypotype (GSC 24664); GSC loc. C-1748, 88 feet below top and 486 feet above base of the Nahanni Formation; × 2.

Figure 2. Longitudinal section of hypotype (GSC 24665); GSC loc. C-1749, 88½ feet below top and 485½ feet above base of the Nahanni Formation; × 2.

Sociophyllum glomerulatum (Crickmay, 1962) small var. (Page 70)

Figure 5. Transverse section of hypotype (GSC 24670); GSC loc. C-2551, 79 feet below top and 495 feet above base of the Nahanni Formation; × 3.

Dendrostella trigemme (Quenstedt, 1879) (Page 66)

Figure 6. Longitudinal section of hypotype (GSC 24662); GSC loc. C-2553, 83 feet below top and 491 feet above base of the Nahanni Formation; × 3.

Figures 7, 9. Longitudinal and transverse sections of hypotype (GSC 24661); GSC loc. C-2552, 82½ feet below top and 49½ feet above base of the Nahanni Formation; × 3.

Figure 8. Transverse section of hypotype (GSC 24663); GSC loc. C-2553, 83 feet below top and 491 feet above base of the Nahanni Formation; × 3.

PLATE 12

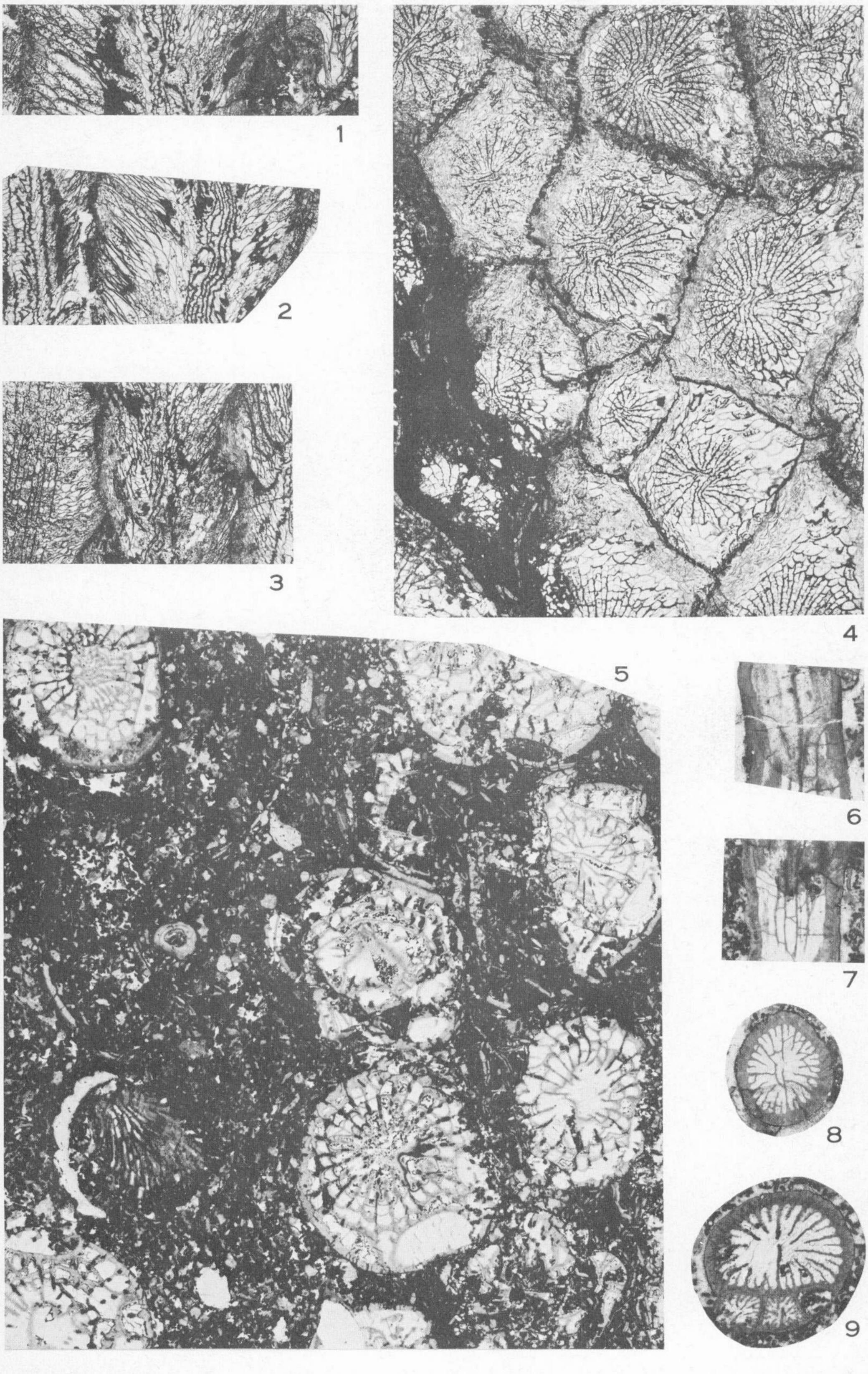
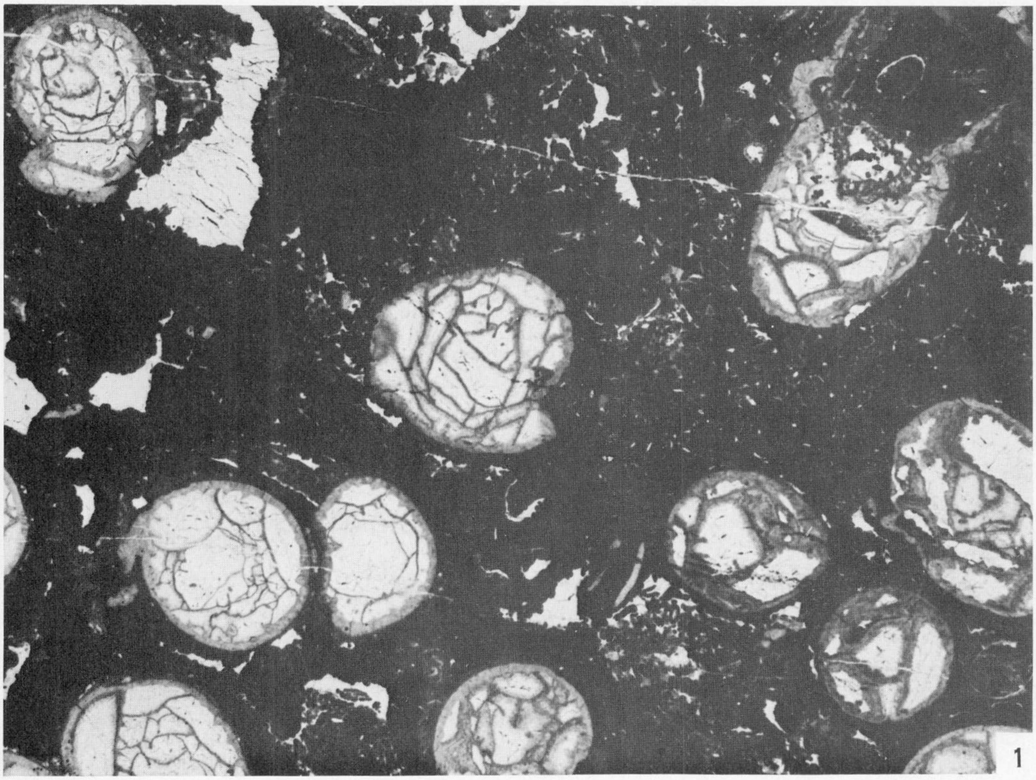


PLATE 13

Sociophyllum glomerulatum (Crickmay, 1962) small var. (Page 70)

Figure 1. Transverse section of hypotype (GSC 24669); GSC loc. C-2549, 77 feet below top and 497 feet above base of the Nahanni Formation; × 3. Pl. 14, fig. 2. shows a longitudinal section of this specimen.

Figure 2. Transverse section of hypotype (GSC 24668); GSC loc. C-2546, 74½ feet below top and 499½ feet above base of the Nahanni Formation; × 3. Pl. 14, fig. 3 shows a longitudinal section of this specimen.



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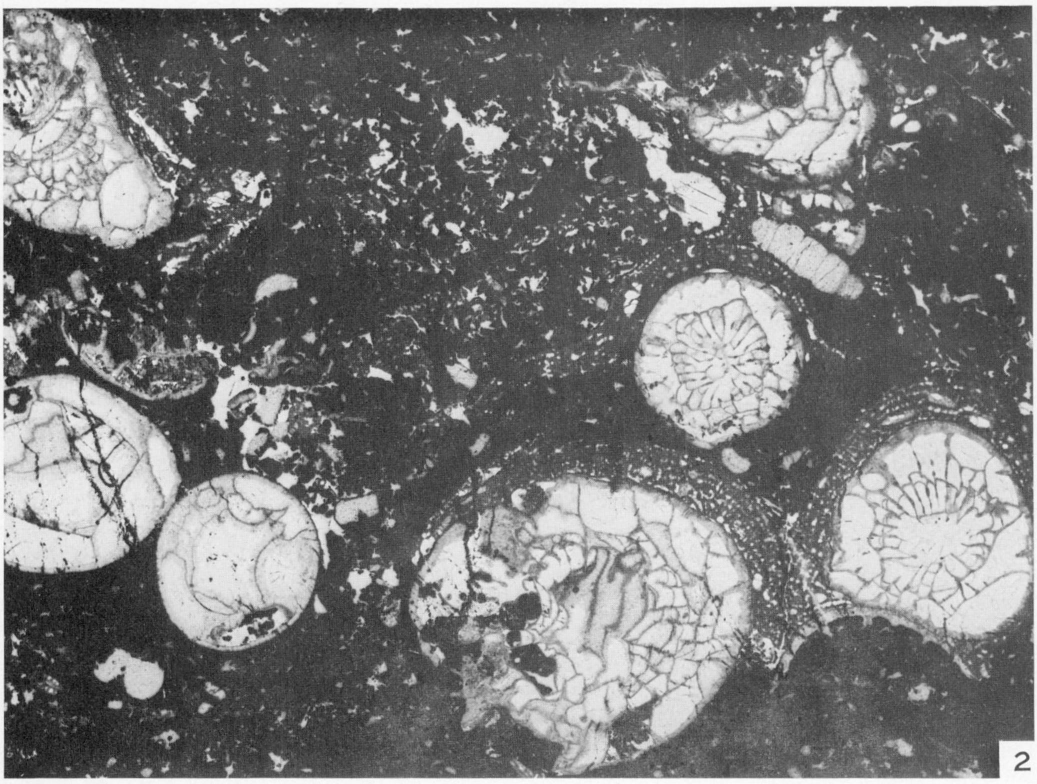

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Plate 14

Sociophyllum glomerulatum (Crickmay, 1962) small var. (Page 70)

Figure 1. Longitudinal section of hypotype (GSC 24667); GSC loc. C-1749, 88½ feet below top and 485½ feet above base of the Nahanni Formation; × 3.

Figure 2. Longitudinal section of hypotype (GSC 24669); GSC loc. C-2549, 77 feet below top and 497 feet above base of the Nahanni Formation; × 3. Pl. 13, fig. 1 shows a transverse section of this specimen.

Figure 3. Longitudinal section of hypotype (GSC 24668); GSC loc. C-2546, 74½ feet below top and 499½ feet above base of the Nahanni Formation; × 3. Pl. 13, fig. 2 shows a transverse section of this specimen.

Grypophyllum cf. *G. wedekindi* Middleton, 1959 (Page 69)

Figures 4, 6. Transverse and longitudinal sections of hypotype (GSC 24666); GSC loc. C-1750, 90 feet below top and 484 feet above base of the Nahanni Formation; × 3.

Cyclochaetetes cf. *C. inflatus* (Lecompte, 1939) (Page 64)

Figure 5. Longitudinal section of hypotype (GSC 24660); GSC loc. C-2557, 94 feet below top and 480 feet above base of the Nahanni Formation; × 20. Pl. 11, figs. 1, 2 show other sections of this specimen.

Figure 7. Transverse section of hypotype (GSC 24659); GSC loc. C-2554, 84½ feet below top and 489½ feet above base of the Nahanni Formation; × 20.

PLATE 14

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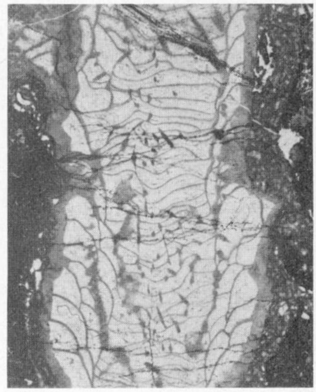

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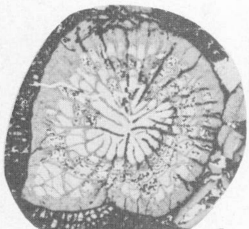

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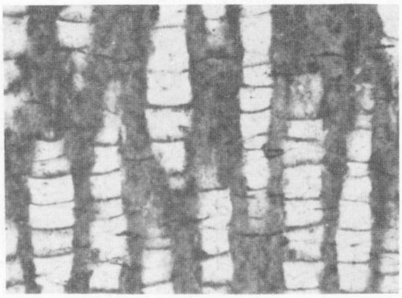

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HELICOPRION AND *PHYSONEMUS*, PERMIAN VERTEBRATES FROM THE ASSISTANCE FORMATION, CANADIAN ARCTIC ARCHIPELAGO

W. W. Nassichuk

Abstract

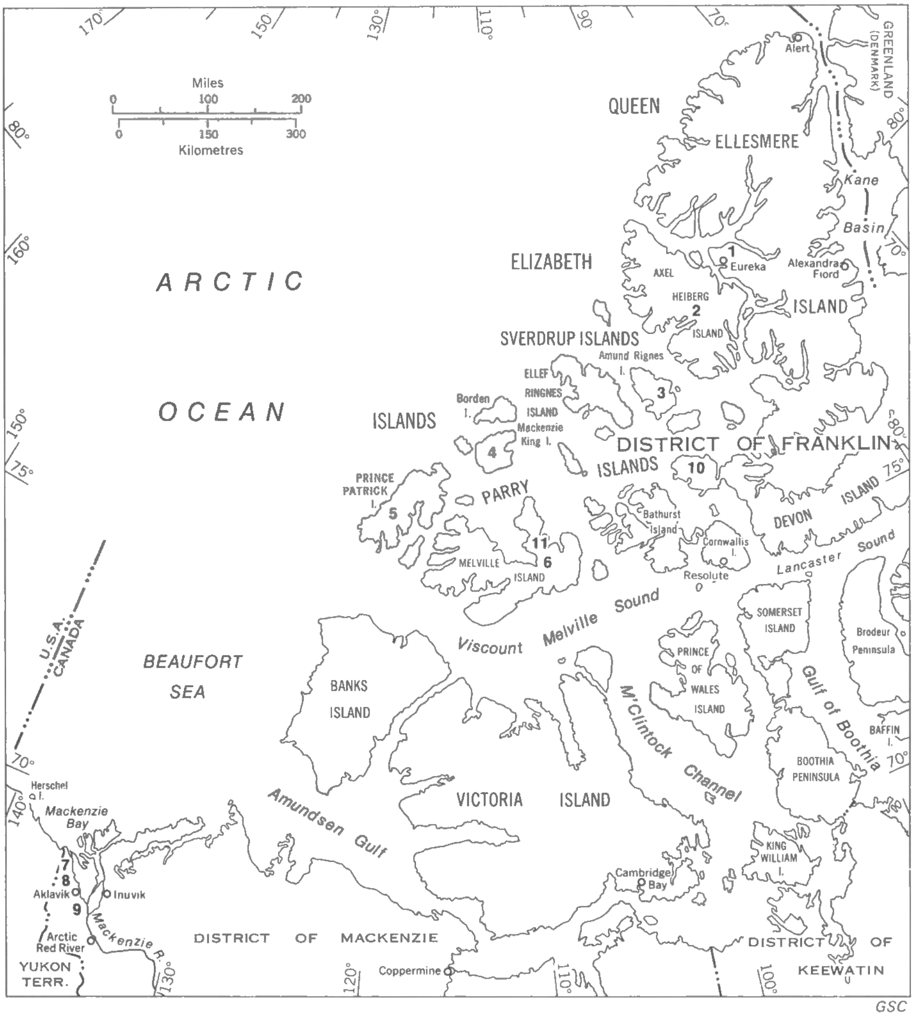
The first Permian vertebrates discovered in the Assistance Formation of the Sverdrup Basin, Canadian Arctic Archipelago are described. Remains of *Helicoprion* sp. and *Physonemus* sp., cartillaginous fish, were found directly associated with ammonoids which indicate a late Lower Permian age.

Résumé

L'auteur décrit les premiers vertébrés du Permien de la formation d'Assistance du bassin Sverdrup de l'archipel Arctique canadien. Les restes de l'*Helicoprion* et du *Physonemus*, deux poissons cartilagineux, étaient associés directement aux ammonoïdes et datent donc de la fin du Permien inférieur.

Introduction

Vertebrate fossils are rare in Permian rocks in the Arctic Archipelago and previously only one has been described (Nassichuk and Spinosa, 1970). During the course of stratigraphic studies, in 1964, the author discovered remains of cartillaginous fish at two localities in the Lower Permian Assistance Formation in the Parry Islands. The Assistance Formation extends as a discontinuous belt along the southern and eastern margins of the Sverdrup Basin and contains an abundant and varied fauna of marine invertebrates (*see* Harker and Thorsteinsson, 1960; Nassichuk, Furnish, and Glenister, 1965). A well-preserved representative of *Helicoprion* Karpinsky (subclass Elasmobranchii; Bendix-Almgreen, 1966, p. 50) was found on Sabine Peninsula, Melville Island (Textfig. 8, loc. 11) and a representative of the ichthyodorulite *Physonemus* McCoy (subclass Holocephali; Obruchev, 1964, p. 238) was found in the type Assistance Formation on Grinnell Peninsula, Devon Island (Textfig. 8, loc. 10). The only other known occurrence of vertebrate fossils in the Parry Islands is in a post-Assistance rock sequence designated 'Unit B' by Nassichuk (1965), north of the Raglan Range on northwestern Melville Island. A simple 'shark' tooth, about 1.5 cm long was recovered from a calcareous sandstone which also contained abundant brachiopods. 'Unit B' is considered to be of early Late Permian (Guadalupian) age on the basis of an examination



TEXTFIGURE 8. Locality map for Nassichuk and Chamney papers.

Locality No.

1. Mount Bridgeman, Ellesmere Island, 80°14′N, 84°50′W; British Petroleum Exploration (field No. CAI-E); 1961.
2. Buchanan Lake, Axel Heiberg Island, 79°13′N, 87°00′W; British Petroleum Exploration (field No. BP61-IVA); 1961.
3. Central Dome, Amund Ringnes Island, 78°22′N, 96°10′W; British Petroleum Exploration (field No. CAI-I); 1961.
4. Leffingwell Crags, Mackenzie King Island, 77°46′N, 112° – 112°30′W; Petropar Canada (field No. MAI-65); 1965.
5. Jameson Bay, Prince Patrick Island, 76°41′N, 116°10′ – 116°50′W; Petropar Canada (field No. PK III-65); 1965.
6. Sabine Peninsula, Melville Island, 76°03′N, 109°00′W; British Petroleum Exploration (field No. CAI-M); 1961.
7. Cache Creek, north flank, Richardson Mountains, 68°17′N, 135°45′W; Bullock and Gallup Consultants (field No. C Cr 1–65; 1965.
8. Martin Creek, northeastern flank, Richardson Mountains, 68°12′N, 135°25′ – 135°40′W; Chevron Standard Ltd., (field No. CB 1 to 231–66); 1966.

of the brachiopods by R. E. Grant (pers. com.). At both of the Assistance localities ammonoids are associated with the vertebrate fossils and largely for this reason *Helicoprion* sp. and *Physonemus* sp. can be accurately dated. Detailed systematics and comparative taxonomy are excluded from this report which serves to document the occurrence and age of two interesting and rare fossils.

Considerable discussion has been published on the problems of classification and taxonomy of *Helicoprion.* Bendix-Almgreen (1966) studied representatives of the genus from the Phosphoria Formation of Idaho and presented a comprehensive review of the problems; other pertinent data were provided by Teichert (1940) and by Obruchev (1964). Reference to earlier works on *Helicoprion* and related forms is cited in the above papers; statements pertaining to classification of *Physonemus* and its bibliography are provided by Obruchev (1964).

Localities

The Assistance Formation which yielded both *Physonemus* sp. and *Helicoprion* sp. comprises loosely consolidated grey-green glauconitic sandstone and minor dusky red siltstone bands and is fossiliferous throughout. At the type section, on the north side of Grinnell Peninsula, Devon Island, the formation is 200 feet thick and rests on fusulinid-bearing limestone of the Belcher Channel Formation. *Physonemus* sp. was found in association with ammonoids at GSC loc. 26406, about 170 feet above the base of the type Assistance (here 200 feet thick), on the west bank of Lyall River, 3 miles upstream from the mouth (76°57′30″N, 95°21′30″W; Textfig. 8, loc. 10)[1]. Ammonoids at this locality include species of *Daubichites* Popow, *Popanoceras* Hyatt and *Sverdrupites* Nassichuk.

Helicoprion sp., also found in association with representatives of *Daubichites* Popow and *Sverdrupites* Nassichuk (1970) was recovered from the Assistance Formation several hundred miles to the west of the type section, on Melville Island. It was found on western Sabine Peninsula in the St. Arnaud Hills, 20 feet below the top of the formation which is about 100 feet thick; GSC loc. C-1930 (75°49′N, 108°36′W; Textfig. 8, loc. 11). In this area the Assistance Formation rests conformably on non-marine sandstones of the lower Permian Sabine Bay Formation and is conformably overlain by thin fossiliferous limestone beds; 'Unit A' of Nassichuk (1965).

Nassichuk and Spinosa (1970) described *Helicoprion* sp. from black shales now known to be the Van Hauen Formation at Blind Fiord, Ellesmere Island. The Van Hauen Formation is the basinal equivalent of the Assistance Formation.

Age Relationships

The type Assistance Formation on Grinnell Peninsula is considered, on the basis of ammonoids, to be of late Early Permian age, equivalent to the basal limestone of the type Word Formation in the Glass Mountains of West Texas and to the Meade Peak Phosphate Member of the Phosphoria Formation of Idaho and Wyoming (Nassichuk, Furnish, and Glenister, 1965). Cooper and Grant (1966) raised the basal limestone of the Word Formation to forma-

[1]Fragments of *Helicoprion* sp. recently have been recognized by the author in this collection.

9. Treeless Creek, southeastern flank, Richardson Mountains, 67°52′N, 135°40′W; Operation Porcupine,[1] Geological Survey of Canada (field No. CR4–N62); 1962.
10. Grinnell Peninsula, Devon Island.
11. Western Sabine Peninsula, Melville Island.

[1]Operation Porcupine: a geological reconnaissance of northern Yukon and District of Mackenzie N lat. 65° and W long. 132°, by the Geological Survey of Canada.

tional status (Road Canyon Formation) and assigned it to the Leonard Series. At the time that Nassichuk, *et al.*, 1965 correlated the Assistance with the Word and Phosphoria Formations relationships between the Assistance and the type Lower Permian in the Soviet Union were not clear for only two ammonoid species were known from the Assistance, neither of which is represented in the Ural Mountains of the Soviet Union. Collections made by the author from the type Assistance on Grinnell Peninsula in recent years include ammonoids with Late Artinskian and older affinities; important among these are representatives of *Medlicottia* Waagen, *Synartinskia* Ruzhencev, and *Popanoceras* Hyatt (Nassichuk, 1970). Representatives of *Daubichites* Popow and *Sverdrupites* Nassichuk aie unknown from the type Permian in the Soviet Union, but close relatives of the Arctic species are known from the Lower Permian Meade Peak Member of the Phosphoria Formation in the Western United States.

Acknowledgments

The writer is grateful to Dr. Holmes A. Semken of the University of Iowa who critically read the manuscript and who assisted in describing the specimens. Dr. Richard E. Grant of the United States Geological Survey dated the brachiopods associated with the 'shark' tooth on Melville Island.

Descriptive Paleontology

All specimens bearing the prefix NMC are in the National Museum of Canada, Ottawa.

Genus *Helicoprion* Karpinsky, 1899

Lissoprion Hay 1907, 1909.

Type species. *Helicoprion bessonowi* Karpinsky, 1899; from Lower Permian (Artinskian) strata in the Ural Mountains, Soviet Union.

Helicoprion sp.

Plate 15, figures 1, 2

Material and occurrence. A single symphysial whorl referred to *Helicoprion* sp. (figured specimen NMC 12247) was found on western Sabine Peninsula, Melville Island, 20 feet below the top of the Assistance Formation, at GSC loc. C-1930 (Textfig. 8, loc. 11). A second figured specimen (NMC 12248) consisting of parts of four tooth-crowns and a compound root was found in association with and probably was a part of the above-mentioned symphysial whorl.

Description. Moulds and casts of the two available specimens are preserved in fine-grained, quartzose sandstone from a concretionary sandstone bed. The symphysial whorl (NMC 12247) has at least 2.5 volutions and more than 70 blade-like teeth in a single plane. The largest preserved volution is represented only by the compound root and bases of tooth-crowns. The maximum preserved diameter of the symphysial whorl from crown base to crown base is 11 cm. Individual tooth-crowns are pyritized and, on most, the enamel is preserved; both edges of all tooth-crowns are crenulated.

Remarks. Although the Melville Island discovery of *Helicoprion* sp. is one of the first records of the genus in Arctic Canada, a few localities have been recorded from high Lower Permian strata in the Rocky Mountain region of western Canada. Several specimens have been found in a phosphatic conglomerate at the base of the Ranger Canyon Formation, at Sundance Canyon, near Banff, Alberta; *see* Warren (1956); McGugan, *et al.* (1965); Norris (1965); Logan and McGugan (1968). Bamber, Taylor, and Procter (1968) reported five specimens of the genus from 81 feet below the top of the Fantasque Formation on Dunedin River, northeastern British Columbia. In addition to the type, which occurs in Lower Permian (Artinskian) strata in the Soviet Union, representatives of *Helicoprion* are known from high Lower Permian strata in: western United States (Hay 1907, 1909; Wheeler, 1939; Williams and Dunkle, 1948; Larson and Scott, 1951; Bendix-Almgreen, 1966); Japan (Yabe, 1903); Australia (Teichert, 1940); Spitzbergen (Siedlecki, 1970).

Genus *Physonemus* McCoy, 1848

Xystracanthus Leidy, 1859
Drepanacanthus Newberry and Worthen, 1866
Batacanthus St. John and Worthen, 1875

Type species. *Physonemus arcuatus* McCoy, 1848; from Lower Carboniferous strata in Ireland and England.

Physonemus sp.

Plate 16, figures 1–3

Material and occurrence. A single specimen of *Physonemus* sp. (figured specimen NMC 12249) was found 170 feet above the base of the type Assistance Formation, Grinnell Peninsula, Devon Island, at GSC loc. 26406 (Textfig. 8, loc. 10).

Description. The specimen is an incomplete, bilaterally symmetrical spine; the distal portion, about 180 mm above the base, and the posterior margin behind the anterior margin of the medullary cavity are absent. Maximum width of the specimen is 24 mm, measured on a transverse ridge that is 27 mm proximal to the lowest denticles. The anterior margin is concave in the proximal-distal plane and is covered with denticles of irregular shape. Denticles occur on the anterior margin 114 mm above the proximal end and extend transversely across the spine in poorly defined rows to a point 158 mm above the base of the specimen. Denticles decrease in size from a diameter of up to 5 mm along the anterior margin to a diameter of 0.7 mm at the posterior fracture. The denticles along the anterior margin are worn; intensity of wear decreases toward the posterior fracture.

Remarks. Representatives of *Physonemus* have not been recorded from elsewhere in Canada; however, the taxon, in the concept of Obruchev (1964) has a wide geographic distribution. According to Obruchev some 20 species are known from the Carboniferous of the British Isles and Belgium, Middle Carboniferous of the Russian Platform, Carboniferous of the United States of America, Lower Permian (Artinskian) of the Soviet Union and from the Upper Permian of Pakistan.

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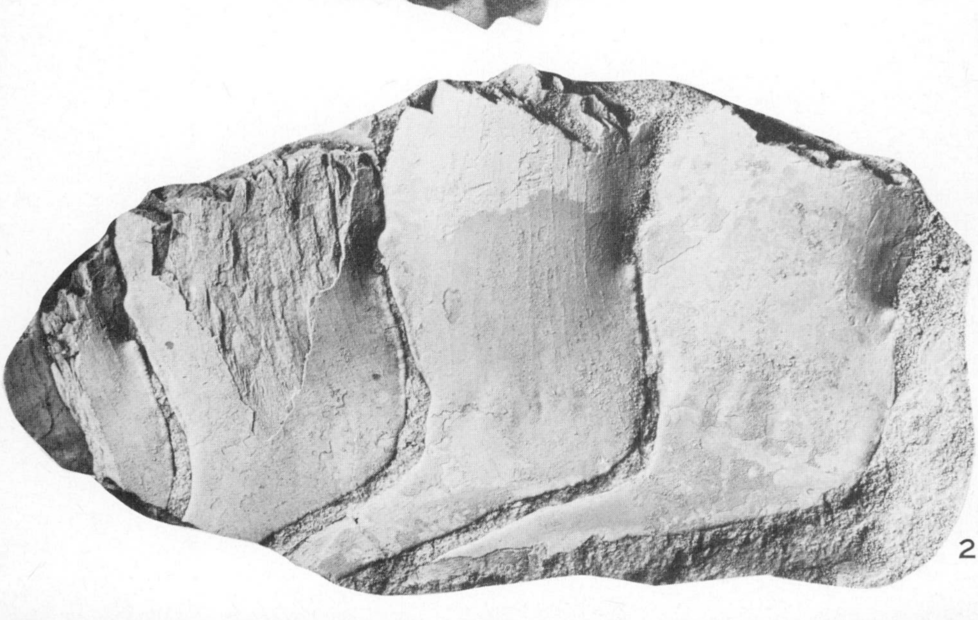
PLATE 15

Helicoprion sp. (Page 86)

Figure 1. Lateral view of specimen NMC 12247 from the Assistance Formation, Melville Island; × 1.

Figure 2. Lateral view of specimen NMC 12248 from same locality; × 2: This specimen was found directly associated with and probably is part of specimen NMC 12247.

1



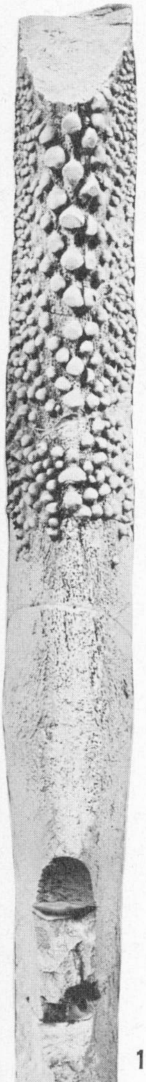
2

Plate 16

Physonemus sp. (Page 87)

Figures 1, 2. Anterior and lateral views of specimen NMC 12249 from the Assistance Formation, Devon Island; × 0.8.

Figure 3. Enlargement of same specimen showing surface details of denticles; × 3.



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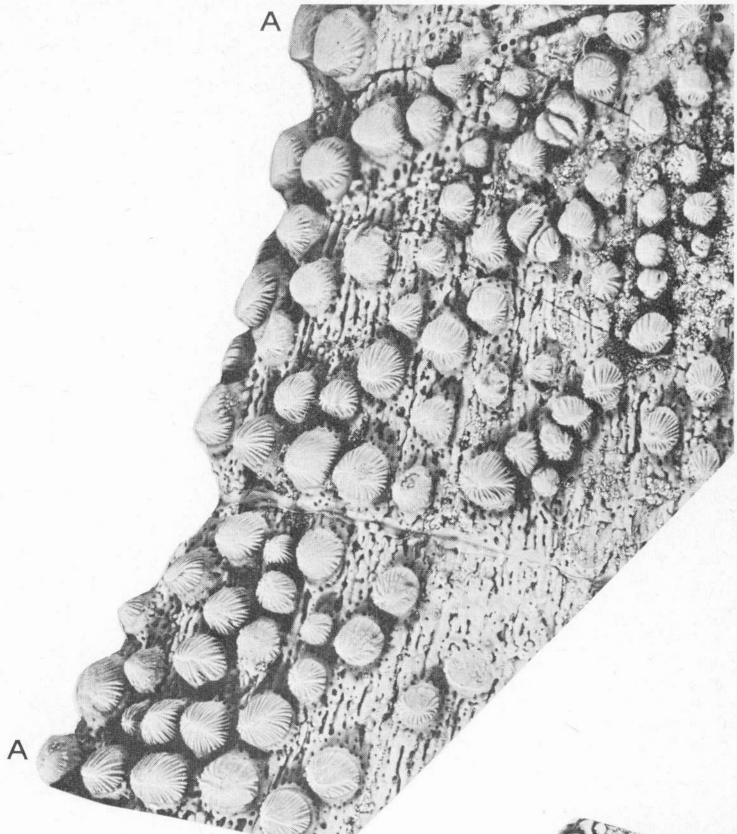


3

2

NEW SPECIES OF FORAMINIFERA, CRETACEOUS–JURASSIC BOUNDARY, ARCTIC AMERICA

T. P. Chamney

Abstract

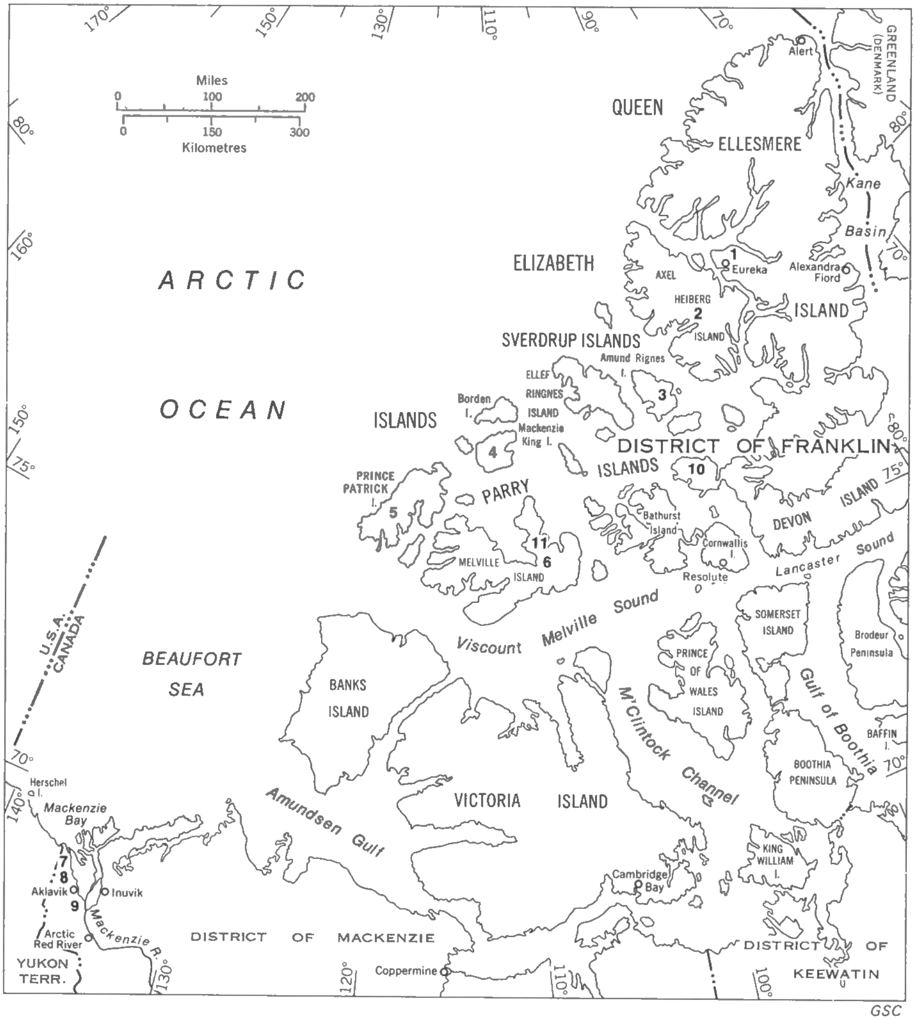
Seven species of the family Ammodiscinidae are described and include the new species *Lituotuba gallupi, Ammodiscus thomsi, Arenoturrispirillina waltoni, A. intermedia,* and *A. jeletzkyi.* The species are valuable biostratigraphic indicators and help to position the Cretaceous–Jurassic boundary in Arctic Canada where outcrops of Lower Cretaceous to Upper Jurassic strata extend from the Mackenzie Delta region of the mainland about 1,000 miles northeastward to Ellesmere Island.

Résumé

L'auteur décrit sept espèces de la famille des Ammodiscinidés y compris les nouvelles espèces *Lituotuba gallupi, Ammodiscus thomsi, Arenoturrispirillina waltoni, A. intermedia* et *A. jeletzkyi.* Indicateurs stratigraphiques utiles, ces espèces facilitent l'identification de la limite Jurassique-Crétacé de l'Arctique canadien où les affleurements datant du Crétacé inférieur au Jurassique supérieur s'étendent sur une distance d'environ 1,000 milles, de la région du delta du fleuve Mackenzie à l'île Ellesmere au nord-est.

Introduction

As part of programs of geological investigations in the Canadian Arctic, many stratigraphic sections have been sampled for microfossils; those providing the best specimens to represent the new species described in this report are listed in Textfigure 8. Samples were collected by officers of the Geological Survey of Canada and by geologists of the oil and gas industry. Abundant specimens of Foraminifera were obtained, but, because of the quantity, nature of preservation, and an element of endemic development in some taxa, description and illustration of the total microfauna will require considerable time. Generally, the results of foraminiferal studies of the Mesozoic succession in Arctic America have been most encouraging.



TEXTFIGURE 8. Locality map for Nassichuk and Chamney papers.

Locality No.

1. Mount Bridgeman, Ellesmere Island, 80°14′N, 84°50′W; British Petroleum Exploration (field No. CAI-E); 1961.
2. Buchanan Lake, Axel Heiberg Island, 79°13′N, 87°00′W; British Petroleum Exploration (field No. BP61-IVA); 1961.
3. Central Dome, Amund Ringnes Island, 78°22′N, 96°10′W; British Petroleum Exploration (field No. CAI-I); 1961.
4. Leffingwell Crags, Mackenzie King Island, 77°46′N, 112°–112°30′W; Petropar Canada (field No. MAI-65); 1965.
5. Jameson Bay, Prince Patrick Island, 76°41′N, 116°10′–116°50′W; Petropar Canada (field No. PK III-65); 1965.
6. Sabine Peninsula, Melville Island, 76°03′N, 109°00′W; British Petroleum Exploration (field No. CAI-M); 1961.
7. Cache Creek, north flank, Richardson Mountains, 68°17′N, 135°45′W; Bullock and Gallup Consultants (field No. C Cr 1–65; 1965.
8. Martin Creek, northeastern flank, Richardson Mountains, 68°12′N, 135°25′–135°40′W; Chevron Standard Ltd., (field No. CB 1 to 231–66); 1966.
9. Treeless Creek, southeastern flank, Richardson Mountains, 67°52′N, 135°40′W; Operation Porcupine,[1] Geological Survey of Canada (field No. CR4–N62); 1962.
10. Grinnell Peninsula, Devon Island.
11. Western Sabine Peninsula, Melville Island.

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[1]Operation Porcupine: a geological reconnaissance of northern Yukon and District of Mackenzie N lat. 65° and W long. 132°, by the Geological Survey of Canada.

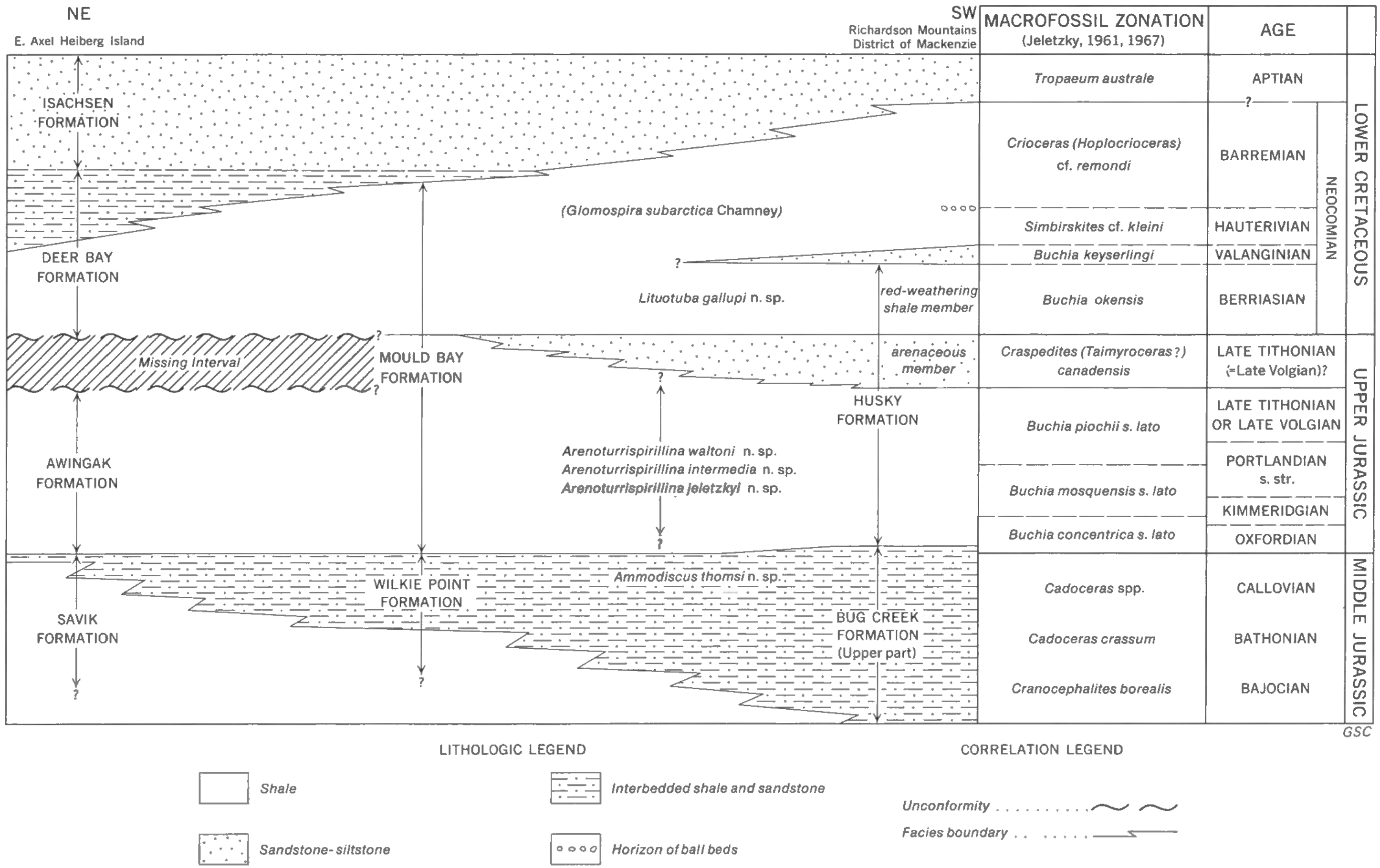
Several species that are an important aid in determining the boundary between the Cretaceous and Jurassic Systems are described here. The discussed region is represented by nine geological sections (*see* Textfig. 8); the total region is a belt of exposed strata trending southwest from locality 1 on the western part of Ellesmere Island to locality 9 in the mainland, west of the Mackenzie Delta.

One of the many challenging stratigraphic problems in northern North America has been the positioning of the Cretaceous–Jurassic boundary. For some years the boundary has been known to be within the relatively thick, more or less homogeneous marine shale lithofacies of the Deer Bay Formation and its lateral equivalents in Arctic America. This continuous marine environment of deposition from the Jurassic into the Cretaceous and its proximity to the boreal marine source has resulted in most favourable conditions amenable to the application of Foraminifera to stratigraphic studies. The homogeneity, however, makes it difficult to position the systemic boundary on the basis of physical stratigraphy. In sediments of equivalent age in the Canadian Western Interior to the south, the opposite stratigraphic relationships occur. There the rather rapid lithofacies changes, including considerable coarse clastics, favour selection of boundaries based on physical stratigraphic criteria. But the very restricted marine conditions indicated by the coarse clastic detritus does not favour recovery of Foraminifera, hence, only unprecise foraminiferal control has been obtained for positioning the Cretaceous–Jurassic boundary in that area. In addition to the rather distinctive, lithological rock-units of the Canadian Western Interior, the boundary is accentuated in many areas by a regional, pre-Albian unconformity.

Abundant foraminifers were recovered from most of the samples; varied taxa of both calcareous and agglutinated forms are present, but agglutinated foraminifers are more common. The new species described and illustrated have been selected on the basis of their very diagnostic features and their persistent occurrence within a limited stratigraphic range over an area of about 1,000 miles. They represent but a few species of the prolific foraminiferal population recoverable from the sediments of the reported depositional interval. The new species become more abundant upwards within the stratigraphic sequence; this may be due to marine conditions becoming more prevalent from Late Jurassic to Early Cretaceous time.

The genus *Arenoturrispirillina* is most distinctive with its chamber arrangement of the hollow, conical, coiled tube, and has never previously been reported from the Mesozoic of Canada. The new species of *Ammodiscus* is the largest of the genus known to the author; it is a giant form measuring 4.0 mm in diameter compared to the average foraminiferal population of 0.5 mm diameter for species of the stratigraphic interval. Although species of *Lituotuba* are fairly common throughout the Mesozoic, the acme of occurrence as revealed by this study has never been recorded previously from the Canadian Western Interior or Arctic America provinces.

The diagrammatic cross-section of Textfigure 9 is presented as a guide for relating the stratigraphic nomenclatures of the mainland and the Arctic Islands. The major references for biochronology and stratigraphy of the two areas are respectively Jeletzky (1961 and 1967) and Tozer (1960). The Cretaceous–Jurassic boundary is contained within, or slightly below, a sandstone unit (arenaceous member of the Husky Formation) in the southwest part of Textfigure 9, near the Mackenzie Delta; within a more or less homogeneous shale, silty shale, and concretion sequence (Mould Bay Formation) in the middle part; and within alternating shales, siltstones, and sandstones (Deer Bay Formation) in the extreme northeast. In the last two regions there are no persistent lithostratigraphic markers near the boundary. The three new species of *Arenoturrispirillina* are diagrammatically shown in the central part of



TEXTFIGURE 9. Diagrammatic cross-section from the mainland near the Mackenzie Delta to the northeastern Arctic Islands.

Textfigure 9 as representing biostratigraphic markers in ascending sequence of *A. jeletzkyi, A. intermedia*, and *A. waltoni.* The stratigraphic relationships of the three species are slightly more complex than is shown and are further discussed within the systematic descriptions. The vertical ranges of the species tend to overlap so that more than one new species may be present within a single sample. There is also evidence of some relationship between the species, which suggests a morphological sequence in the same ascending order and correlatable to the time interval from probable Oxfordian to Late Tithonian (marine equivalent of Purbeckian).

The remaining new species *Lituotuba gallupi* and *Ammodiscus thomsi* are biostratigraphic markers above and below the *Arenoturrispirillina* spp. horizons. Respectively, they also represent strata of the overlying early Lower Cretaceous and the underlying early Upper Jurassic Series. A pre-Albian unconformity exists east of Mackenzie River and southeastward into the Interior Plains region. Thus foraminiferal markers younger than the *Lituotuba gallupi* (Chamney, 1967) can be expected to overlie the *Arenoturrispirillina* spp. horizons.

When detailed studies of the numerous species of foraminifers associated with the new species are completed, some of these species will undoubtedly be related to forms present in the classical European stratigraphic sections and hence will allow correlation to the standard Jurassic and Cretaceous sequences. Such correlation is now achieved by means of macrofossil sequences (*see* Textfig. 9; Jeletzky, 1961 and 1967) which were established for the Canadian Arctic mainland west of the Mackenzie Delta. In the following taxonomic descriptions each species is referred to a distinctive stratigraphic marker; Jurassic species are referred to the base of the arenaceous member of the Husky Formation and Lower Cretaceous species to the base of the Isachsen Formation or its stratigraphic equivalent.

Acknowledgments

British Petroleum Exploration, Bullock and Gallup Consultants, Chevron Standard Limited, and Petropar Canada kindly made samples available for study. The manuscript has been critically read by F. C. Dilley of British Petroleum Company, Limited, and by B. S. Norford of the Geological Survey of Canada.

Systematic Descriptions

All described specimens are in the type collection of the Geological Survey of Canada, Ottawa.

Adequate photographic illustrations of the small agglutinated foraminifers are difficult to obtain, line drawings by the author of each illustrated specimen have therefore been included. Thus two versions of each of the two plates are presented; the formats of both versions are identical, but for each figure the suffix "A" refers to the photograph (which may be slightly retouched) and the suffix "B" refers to the corresponding line drawing.

Family AMMODISCIDAE Reuss, 1862
Subfamily TOLYPAMMINAE Cushman, 1928
Genus *Lituotuba* Rhumbler, 1895

Lituotuba gallupi new species

Plates 17A and 17B, figures 1a, b, 2

Types and occurrence. Holotype GSC 24190 was recovered from field sample 0 to 10 feet of the Cache (Canyon) Creek section, C Cr 1-65 (Textfig. 8, loc. 7) and was collected by

Bullock and Gallup consultants, 1965, from the north flank of the Richardson Mountains, District of Mackenzie, 68°17′N, 135°45′W. The section is within a rather complex structural area, and the age was determined by foraminiferal control (Chamney, unpubl. info.) and based on the occurrence of Barremian species in the interval 200 feet above the *Lituotuba gallupi* horizon. The highest occurrence of *L. gallupi* would thus be tentatively assigned to the Berriasian–Valanginian stages.

Paratype GSC 24191 was recovered at 1,145 feet of the Buchanan Lake section, BP61-IVA (Textfig. 8, loc. 2). The collection was made by British Petroleum Exploration Company from Axel Heiberg Island, 79°13′N, 87°00′W. The stratigraphic horizon is 515 feet below the base of the Isachsen Formation and is designated by British Petroleum Exploration as within the Deer Bay Formation.

Description. Test free, medium size, with a proloculus and long, undivided, tubular, second chamber with irregular constrictions, early stage irregularly coiled as in *Glomospira,* later stage uncoiling with a preferred terminal orientation and rectilinear arrangement in the direction of the long axis, rectilinear portion of the test easily broken; wall very finely arenaceous with much silica cement, surface finely roughened, pale brown; aperture at open end of the tube.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test			Chamber (tubular)			Average grain size	Number visible coils
				Coiled portion		Linear Extension	Diam. (visible)		Wall thickness		
				Length	Width		Final	Early			
17	1	Holotype	24190	0.600	0.400	0.230	0.170	0.065	0.022	0.010	4–6
17	2	Paratype	24191	.319	.260	.168	.143	.056	.020	.009	4–5

Discussion. The chamber arrangement of the early stage in *L. gallupi* is similar to that of *Glomospira* but the last coil of this bulbous part appears to maintain a planispiral plan about the early stage. This feature is the taxonomic criterion for *Glomospirella.* Thus there appears to be a relationship in the sequence of the chamber plan from the variable plane of coiling (*Glomospira*) to a loose, planispiral (*Glomospirella*) and finally a somewhat variable winding tube arrangement (*Lituotuba*). Incomplete stages of this sequence are present in younger strata of the Arctic province, thus *Glomospira subarctica* Chamney (1969) exhibits an aberrant chamber plan at the terminal portion of the ultimate coil. The direction of coiling changes abruptly at an obtuse angle away from the helical spire as if it might have continued the growth plan of *Glomospirella.*

The more rectilinear part of *L. gallupi* in the late stage of growth is somewhat loose and has not the support of the early coiled stage. It is easily broken and may be recovered from the rock samples as a simple, arenaceous, tubular form; if so it would be mistakenly identified as a fragment of *Bathysiphon.*

The species is named for W. B. Gallup, consulting geologist, who contributed some of the first rock sample material from Arctic America for this study.

Lituotuba sp.

Plates 17A and 17B, figures 3a, b, c

Type and occurrence. The hypotype GSC 24192 was recovered from field sample 780 to 790 feet of the Treeless Creek section, CR 4-N62 (Textfig. 8, loc. 9), collected by the author while participating on Operation Porcupine, 1962, on the southeastern flank of the Richardson Mountains, 67°52′N, 135°40′W. The stratigraphic position of the sample horizon is 38 feet above the top of the arenaceous member of the Husky Formation (Jeletzky, 1967) in the *Buchia okensis* Zone of Jeletzky, assigned an Early Cretaceous (Early Berriasian) age.

Description. Test free, small, with a proloculus followed by a long, undivided, tubular second chamber, early stage irregularly coiled as in *Glomospira,* later stage uncoiling with a zigzag arrangement over one surface of the early stage; wall very finely arenaceous with much silica cement, surface smooth, pale brown with translucent edges of freely exposed tube portions; aperture at open end of tube on opposite side to more bulbous early stage.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test			Chamber (tubular)			Average grain size	Number visible coils
							Diam. (visible)		Wall thickness		
				Length	Width	Thickness	Final	Early			
17	3	Fig. spec.	24192	0.358	0.238	0.126	0.066	0.045	0.020	0.010	3–4

Discussion. Lituotuba sp. is associated with *L. gallupi* but ranges higher stratigraphically into beds of Early Neocomian age. *Lituotuba* sp. differs from *L. gallupi* in being smaller in all measurements and by having a zigzag tubular arrangement without the linear apertural tube in the late stage of development. The zigzag tubular arrangement of the late stage is confined to one side which contributes a dorso-ventral orientation. The dorsal side exhibits a more bulbous, early, irregular coiled portion than the ventral side which has a flatter, zigzag tube bearing the aperture at the open end. There is no indication of a linear growth plan at the terminal part of the tube as exhibited by *L. gallupi.*

Subfamily Ammodiscinae Reuss, 1862

Genus *Ammodiscus* Reuss, 1862

Ammodiscus thomsi new species

Plates 17A and 17B, figures 4a, b, 5, 6a, b

Types and occurrence. Holotype GSC 24193, paratype GSC 24194, and paratype GSC 24195 were recovered from field sample 447 of the Mount Bridgeman section, CAI-E (Textfig. 8, loc. 1). The sample was collected by British Petroleum Exploration (Canada) in 1961, from Ellesmere Island, 80°14′N, 84°50′W. It was reported to be from the upper part of the Savik Formation which is assigned to Early Oxfordian or Late Callovian age (Tozer, 1960).

The very fragmented nature of *A. thomsi* new species as recovered from the sediments has precluded establishing additional paratypes. The following references to other occurrences are provided for biostratigraphic information. A second occurrence of *A. thomsi* is from the top beds of the Callovian, Savik Formation, Buchanan Lake section, BP61-IVA (Textfig. 8, loc. 2), samples 2,240 to 2,477 feet. These were collected by British Petroleum Exploration (Canada) from Axel Heiberg Island, 79°13′N, 87°00′W. The beds immediately overlying the sampled interval were designated as the Awingak Formation and provided specimens of *Ammodiscus cheradospira* Loeblich and Tappan, 1950, and associated microfauna of Oxfordian age.

Three occurrences of *A. thomsi* new species are recorded from the upper part of the Wilkie Point Formation. The uppermost part of the formation was dated as ? Oxfordian by Tozer (1960). Fragmented remains were recovered from field sample 61 of the Sabine Peninsula section, CAI-M, northeastern Melville Island, 76°03′N, 109°00′W (Textfig. 8, loc. 6, collected by British Petroleum Exploration (Canada)). The second recovery was from field samples 17 and 18 of the Central Dome section, CAI-I (Textfig. 8, loc. 3). The samples were collected by British Petroleum Exploration (Canada) from Amund Ringnes Island, 78°22′N, 96°10′W. The third section to provide *A. thomsi* new species control from the upper Wilkie Point Formation were samples 30276 and 30292 of the Leffingwell Crags section, MAI-65 (Textfig. 8, loc. 4.) These samples were collected by Petropar Canada from the top of the Wilkie Point Formation on Mackenzie King Island, 77°46′N, 112° to 112°30′W.

Description. Test free, very large, discoidal, biconcave, consisting of a proloculus and planispirally coiled tubular second chamber, completing as many as eleven volutions which up to the sixth volution increase in diameter slowly and regularly then rapidly; spiral suture fairly distinct within the broad clear bands representing combined wall thickness of the two tubular whorls in contact; wall very finely arenaceous with rare scattered fine quartz grains, cement very finely granular, very abundant, contributing a lustrous appearance to some specimens, aperture at open end of the tubular chamber.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test diameter		Chamber (tubular)				Average grain size	Number of whorls
						Diameter		Wall thickness			
				Max.	Min.	Final	Early	Final	Early		
17	4	Holotype	24193	3.900	—	0.500	0.083	0.083	0.016	0.016	11
17	5	Paratype	24194	3.750	—	.446	.050	.091	.016	.016	11
17	6	Paratype	24195	3.000	1.500	.300	.070	.083	.016	.016	10

Discussion. Specimens of this new species are so large and thin they were commonly broken or distorted during burial. More than 500 grams of sample was gently disintegrated to obtain only a few nearly complete specimens, but fragments of other tests were very abundant. For this reason fairly detailed measurements of the early and late growth parts are reported to assist in recognition of fragmentary remains. There are no published species of *Ammodiscus* comparable to *A. thomsi* new species in size and number of whorls. *A. silicea* Loeblich and Tappan, 1954, is 2.5 to 3.0 mm smaller in diameter and has three to four fewer whorls. Of interest to note is that the diameter of the initial tube wall approximates the average size of the very fine sand grains agglutinated together with silica cement to form the test. The final tube wall diameter is about a multiple of 5-grain diameters.

The new species is named for Mr. B. H. J. Thoms, Oil Conservation Engineer, Resources Management Division, Department of Indian Affairs and Northern Development.

Genus *Arenoturrispirillina* Tairov, 1955

The following descriptions were translated by Mrs. T. N. Roux from Tairov, 1955, pp. 113–116 and include both the genotype and the type species in order to provide a complete description of the form.

Diagnosis. "The shell is conical consisting of primordial and second tubelike chambers; the latter consists of 8 to 13 whorls of the conical spiral. The aperture is open at the end of the second tube-like chamber, it has the shape of the semicurved opening of the periphery of the shell. The walls are fine grained."

Discussion. "The shell of the described genus *Turrispirillina* Cushman, 1927, differs from *Arenoturrispirillina* mainly by its shell grain texture. In the same deposits, together with the shells of the new genus, are found large quantities of the species *Ammodiscus spirillinaformis*, a thin, tightly coiled shell with slowly enlarging spiral whorls. The shell of the genus *Arenoturrispirillina* differs from *A. spirillinaformis* only by its conical shape; all other peculiarities are similar. Apparently the representative of the genus *Arenoturrispirillina* is genetically related to the species *Ammodiscus spirillinaformis* from which it possibly originated as a result of the change in habits of existence (transition to the attached stage)."

Type species: *Arenoturrispirillina aptica* gen. and sp. n.

"Genotype No. 7-71 is in the collection at Az NII Lower Aptian, Southeastern Caucasus, Azarbaidjan, Southern Kobystan, Astrakkan."

Diagnosis. "The shell is conical in cross-section and rounded to oval in outline. The second tubular chamber completes 13 whorls of spiral. The sutures between the spiral whorls are simple, slightly depressed."

Description. "The shell is average in size, conical with rounded or oval contours, two chambers, of which the primordial is small, rounded, while the second is elongated, tubular. The second chamber consists of 13, gradually enlarging, spiral whorls. The sutures between the spiral whorls are simple, slightly depressed. The aperture semirounded, is at the opened edge of the last chamber at its periphery. The wall is fine grained."

Size. "The largest diameter is 0.36 mm; the smallest diameter is 0.30 mm; height is 0.1 mm. Variable peculiarities of the described species are: the size of shell, number of spiral whorls, the compression of shell from the side and also its profile.

"The largest diameter of the shell varies between 0.16 and 0.36 mm, the smallest diameter 0.10 and 0.33 mm, height 0.02 and 0.10 mm. The number of spiral whorls of the second chamber varies from 8 to 13.

"In fact the depression of the short cone at different stages changes and the shell exhibits various shapes such as a reverse cone, a truncated cone, or an asymmetric cone with compressed surface.

"Some forms have a cone with a blunt tip, depending on the degree of compression of the shell from the sides, it becomes oval or rounded in shape and sometimes even elongated, ellipsoidal."

Location, distribution, and age. "Astrakkan, lower Aptian. It is encountered in the lower Aptian of the same region in the cross-sections near the towns of Dibrar, Sarydash. Distribution in the lower Aptian in the area of Kishchai, Sitalchar-Iashma, Tegchai of the Pricaspian region."

Arenoturrispirillina waltoni new species

Plates 17A and 17B, figures 7a, b, c; Plates 18A and 18B, figures 1a, b, c

Types and occurrence. Holotype GSC 24196 and paratype GSC 24197 were recovered from field sample 42 of the Martin Creek section, CB-66 (Textfig. 8, loc. 8). The samples were collected by Chevron Standard Ltd., in 1966 from the northeastern Richardson Mountains, District of Mackenzie, 68°12′N, 135°25′W. The sample horizon is 570 feet above the creek level and its stratigraphic position is some 1,250 feet below the base of the massive sandstone beds of the arenaceous member of the Husky Formation (Jeletzky, 1967). Unfigured paratypes GSC 24198 and 24199 were recovered from field sample 62, some 600 feet above the holotype. This places the approximate uppermost range of the species about 600 feet below the base of the arenaceous member of the Husky Formation. Unfigured paratypes GSC 24200 and 24201 were recovered from field samples 250 and 270 feet respectively of the Treeless Creek section, CR 4-N62 (Textfig. 8, loc. 9). The samples were collected by the author in 1962 on the southeastern flank of the Richardson Mountains, District of Mackenzie, 67°52′N, 135°40′W. The sample horizons are about 445 feet below the base of the arenaceous member of the Husky Formation. The section is referable to Jeletzky's Treeless Creek section No. 72 (Jeletzky, 1967) and the comparable stratigraphic equivalent falls within the Portlandian, *Buchia mosquensis* Zone.

In the course of service determinations for the industry, several additional occurrences of *A. waltoni* are noteworthy from the Arctic Islands. Specimens were identified from field sample No. 30601 of the Jameson Bay section, PK III-65 (Textfig. 8, loc. 5), Prince Patrick Island, 76°41′N, 116°50′W. Petropar Canada reported the sample horizon to be from the upper member of the Mould Bay Formation and is estimated to be about 120 feet below the base of Isachsen Formation sandstones. *A. waltoni* was also identified from this company's section MAI-65 (Textfig. 8, loc. 4), field sample No. 30316, Leffingwell Crags, Mackenzie King Island, 77°46′N, 112°30′W. The sample horizon is 420 feet below the base of the Isachsen Formation sandstones within the middle member of the Mould Bay Formation. Field sample material contributed by British Petroleum Exploration Canada provided *A. waltoni* new species recovery from samples 1,058 to 1,088 feet of the Buchanan Lake section, BP61-IVA (Textfig. 8, loc. 2), Axel Heiberg Island, 79°13′N, 87°00′W. The sample horizon is within the Deer Bay Formation, 428 feet below the base of the Isachsen Formation sandstones.

Description. Test free, large, conical similar in plan to *Ammodiscus* but with regular trochospiral coil as in early stage of *Ammodiscoides,* periphery rounded; proloculus followed by a long tubular second chamber which increases gradually in diameter with growth, with some overlapping primarily caused by distortion, the first four whorls arranged in a moderately high cone, the final two to three whorls tending to irregular planispiral arrangement; spiral suture distinct, depressed; wall very fine to finely arenaceous with considerable amount of cement, rather smoothly finished texture with some scattered medium quartz grains; aperture at open end of the tube.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test (con cal)		Chamber (tubular)				Aver-age grain size	Num-ber of whorls
						Diameter		Wall thickness			
				Diam. (max.)	Height	Final	Early	Final	Early		
17	7	Holotype	24196	1.680	0.720	0.267	0.135	0.071	0.031	0.013	6–7
18	1	Paratype	24197	1.825	.937	.330	.090	.14	.035	.0168	6+

Discussion. The generic description of *Arenoturrispirillina* by Tairov (1955) explains the similarity of its initial trochospiral coiling to that of the early stage of *Ammodiscoides*, but the coiling in *Arenoturrispirillina* is not involute and close-coiled. He also states that the genotype is not highspired as in *Turritellella.* The genotype *A. aptica* is less than half the size of *A. waltoni* new species and has two or three more coils. There appears to be a tendency for more loose coiling in the larger species of this genus. *A. waltoni* new species becomes evolute in the later coiling of the planispiral part as evidenced by both overlapping and slight variability of the plane of coiling. These observed features could possibly be the result of distortion after burial due to the relative loosely coiled tubular plan.

The new species is named for Dr. Hughen Walton of Chevron Standard Limited, Calgary, Alberta, who collected the samples from the Martin Creek section.

Arenoturrispirillina intermedia new species

Plates 18A and 18B, figures 3a, b, c, 4a, b, 5a, b, c

Types and occurrence. Holotype GSC 24203 and paratype GSC 24204 were recovered from field sample 260 to 270 feet of the Treeless Creek section, CR4-N62 (Textfig. 8, loc. 9). The collection was made by the author on Operation Porcupine in 1962 on the southeastern flank of the Richardson Mountains, District of Mackenzie, 67°52′N, 135°40′W. The sample horizon is 453 feet below the base of the arenaceous member of the Husky Formation. The section is referable to Jeletzky's Treeless Creek section No. 72 (Jeletzky, 1967) and the beds with *A. intermedia* can be placed in the lower *Buchia mosquensis* Zone of late Kimmeridgian or Early Portlandian (*sensu stricto*) age.

Paratype GSC 24205 was recovered from field sample 60 of the Martin Creek section, CB-66 (Textfig. 8, loc. 8). The collection was made by Chevron Standard Ltd., in 1966 from the north-central Richardson Mountains, 68°12′N, 135°25′W, District of Mackenzie. The sample horizon is about 650 feet below the base of the arenaceous member of the Husky Formation. There is considerable scree cover and missing intervals within this stratigraphic interval and the true stratigraphic separation may be somewhat less than the estimated 650 feet. The time-stratigraphic assignment may thus be similar to the occurrence in the Treeless Creek section of Late Kimmeridgian to Early Portlandian (*sensu stricto*) age.

Unfigured paratype GSC 24206 was recovered from sample 1,414 feet of the Buchanan Lake section, BP61-IVA (Textfig. 8, loc. 2). The collection was made by British Petroleum Exploration Company (Canada) in 1961 from Axel Heiberg Island, 79°13′N, 87°00′W. The sample horizon is about 684 feet below the base of the Isachsen Formation sandstones, about 106 feet above the base of the Deer Bay Formation.

Description. Test free, medium, conical, similar in plan to *Ammodiscus* but with regular trochospiral coil as in early stage of *Ammodiscoides*, periphery rounded; proloculus followed by a long tubular second chamber which increases gradually in diameter with growth, with slight overlapping of the coils in the adult part; the first three whorls arranged in a moderately high cone, the final two tending to more planispiral, three or more whorls visible on ventral surface; spiral suture distinct, depressed; wall thin, very finely arenaceous with much silica cement, rather smoothly finished texture with slight transparency through the evolute part of the ultimate coil; aperture at open end of the tube.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test (conical)		Chamber (tubular)				Average grain size	Number of whorls
						Diameter		Wall thickness			
				Diam. (max.)	Height	Final	Early	Final	Early		
18	3	Holotype	24203	0.800	0.335	0.160	0.075	0.025	?	0.0136	5–6
18	4	Paratype	24204	.582	.308	.095	.036	.029	?0.014	.010	5–6
18	5	Paratype	24205	.697	.462	.103	.049	.024	.010	.010	5–6

Discussion. The taxonomic features of size and chamber arrangement of this species is intermediate between *A. waltoni* new species and *A. jeletzkyi* new species. It retains its conical test shape with a minimum of collapsing to the disc-like forms so common for *A. jeletzkyi.* Many specimens of *A. intermedia* exhibit secondary quartz addition over the apex of the prolocular area which masks the initial coiling and gives a very light colour or translucency to the early test portion.

Arenoturrispirillina jeletzkyi new species

Plates 18A and 18B, figures 6a, b, c, 7a, b, c, 8a, b, c, 9a, b

Types and occurrence. Holotype GSC 24207, paratype GSC 24208, and paratype GSC 24209 were recovered from field samples 1,354, 1,295, and 1,325 feet, respectively, of the Buchanan Lake section, BP61-IVA (Textfig. 8, loc. 2). The collection was made by British Petroleum Exploration Company (Canada) in 1961 on Axel Heiberg Island, 79°13′N, 87°00′W. The sample horizons are within the lowest third of the Deer Bay Formation, 724, 665, and 695 feet respectively, below the base of the Isachsen Formation sandstones.

Paratype GSC 24210 and two unfigured paratypes GSC 24211 and GSC 24212, were recovered from field samples 330 to 340 feet, 470 to 480 feet and 500 to 510 feet respectively, of the Treeless Creek section, CR4-N62 (Textfig. 8, loc. 9). The collection was made by the author on Operation Porcupine in 1962 from the southeastern flank of the Richardson Mountains, District of Mackenzie, 67°52′N, 135°40′W. The sample horizons are in the Husky Formation, 383, 243, and 200 feet, respectively, below the base of the arenaceous member, (Jeletzky, 1967). The sampled section is referable to Jeletzky's section No. 72 and the horizon of *A. jeletzkyi* new species falls within the late Kimmeridgian stage of the *Buchia mosquensis* (*sensu lato*) Zone and possibly into older sediments of the *Buchia concentrica* (*sensu lato*) Zone of Late Oxfordian age.

Unfigured paratypes GSC 24213 and GSC 24214 were recovered from field sample 75 of the Martin Creek section, CB-66 (Textfig. 8, loc. 8). The collection was made by Chevron Standard Ltd., in 1966 from the northeastern flank of the Richardson Mountains, District of Mackenzie, 68°12′N, 135°25′ to 135°40′W. The sample horizon is in the Husky Formation, 520 feet below the base of the arenaceous member.

Description. Test free, small, conical, similar in plan to *Ammodiscus* but with regular trochospiral coil as in early stage of *Ammodiscoides*, periphery rounded; proloculus followed by a long tubular second chamber which increases gradually in diameter with growth, six and one-half whorls arranged in a moderately high cone, nearly three coils visible on ventral surface; spiral suture distinct, depressed; wall thin, very finely arenaceous; aperture at open end of the tube.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test (conical)		Chamber (tubular)				Average grain size	Number of whorls
						Diameter		Wall thickness			
				Diam. (max.)	Height	Final	Early	Final	Early		
18	6	Holotype	24207	0.308	0.140	0.050	?0.025	0.014	?0.005	0.008	6½
18	7	Paratype	24208	.310	.092	.072	.030	.017	?0.004	.008	5
18	8	Paratype	24209	.220	.168	.075	.025	.020	?0.005	.007	5+
18	9	Paratype	24210	.340	.112	.056	.019	?	?	.008	4–5

Discussion. Arenoturrispirillina jeletzkyi new species is the most commonly recovered species of the genus in the Upper Jurassic of Arctic Canada. Because of its small size (average 0.3 mm) and relatively thin test wall it is prone to distortion. In the compressed state it is easily mistaken for minute species of *Ammodiscus* which are also present in the assemblage. The initial prolocular part is commonly of lighter colour than the remaining test and some specimens exhibit a translucent appearance in this part.

A. jeletzkyi has been recovered from older strata than the other reported species of *Arenoturrispirillina* and is commonly present in association with the others higher in the sequence of strata. This may indicate that *A. jeletzkyi* is the parent stock from which the younger, more robust species of *Arenoturrispirillina* were derived.

The new species is named for Dr. J. A. Jeletzky of the Geological Survey of Canada who contributed the first biochronological subdivisions of the low Lower Cretaceous and Jurassic sequence in the Richardson Mountains and adjacent areas.

Arenoturrispirillina sp.

Plates 18A and 18B, figures 2a, b, c

Types and occurrence. Hypotype GSC 24202 was recovered from field sample 430 to 440 feet of the Treeless Creek section, CR4-N62 (Textfig. 8, loc. 9). The collection was made by the author on Operation Porcupine, 1962, from the southeastern flank of the Richardson Mountains, District of Mackenzie, 67°52′N, 135°40′W. The sample horizon is within the

Husky Formation, 273 feet below the base of the arenaceous member and is referable to Jeletzky's Treeless Creek section No. 72 (Jeletzky, 1967) within the *Buchia mosquensis* Zone of the Early Portlandian (*sensu stricto*) age.

Description. Test free, medium-size, conical; regular trochospiral coil as in the early stage of *Ammodiscoides* but not as high spired as in *Turritellella*; periphery rounded; proloculus followed by a long tubular second chamber which increases rapidly in diameter with growth, with slight overlapping of the ultimate whorl, five whorls arranged in a moderately high cone, only two whorls visible from the ventral surface; spiral suture distinct, depressed; wall very fine to finely arenaceous with considerable amount of cement, slight scintillating lustre of larger quartz grains scattered throughout the test wall; aperture at open end of the tube.

Measurements (dimensions in mm).

Pl.	Fig.	Type	GSC No.	Test (conical)		Chamber (tubular)				Average grain size	Number of whorls
						Diameter		Wall thickness			
				Diam. (max.)	Height	Final	Early	Final	Early		
18	2	Fig. spec.	24202	0.935	0.925	0.500	0.055	?0.053	?0.012	0.013	5

Discussion. Specimens of this species exhibit rather extreme conical shapes and only two whorls are visible on the ventral surface. The generic placement in *Arenoturrispirillina* could be questioned but the numerous other species of the genus present in the same samples has deterred the author from erecting a new genus for this rather extreme conical form. Additional specimens are required for study as it appears to be related to *Arenoturrispirillina intermedia* new species except for the larger dimensions and the tighter and higher conical coiling. There is a slight overlapping of the ultimate coil which indicates a tendency towards a planispiral plan with continued growth stage; in this respect it would then approach the form of *A. waltoni* new species.

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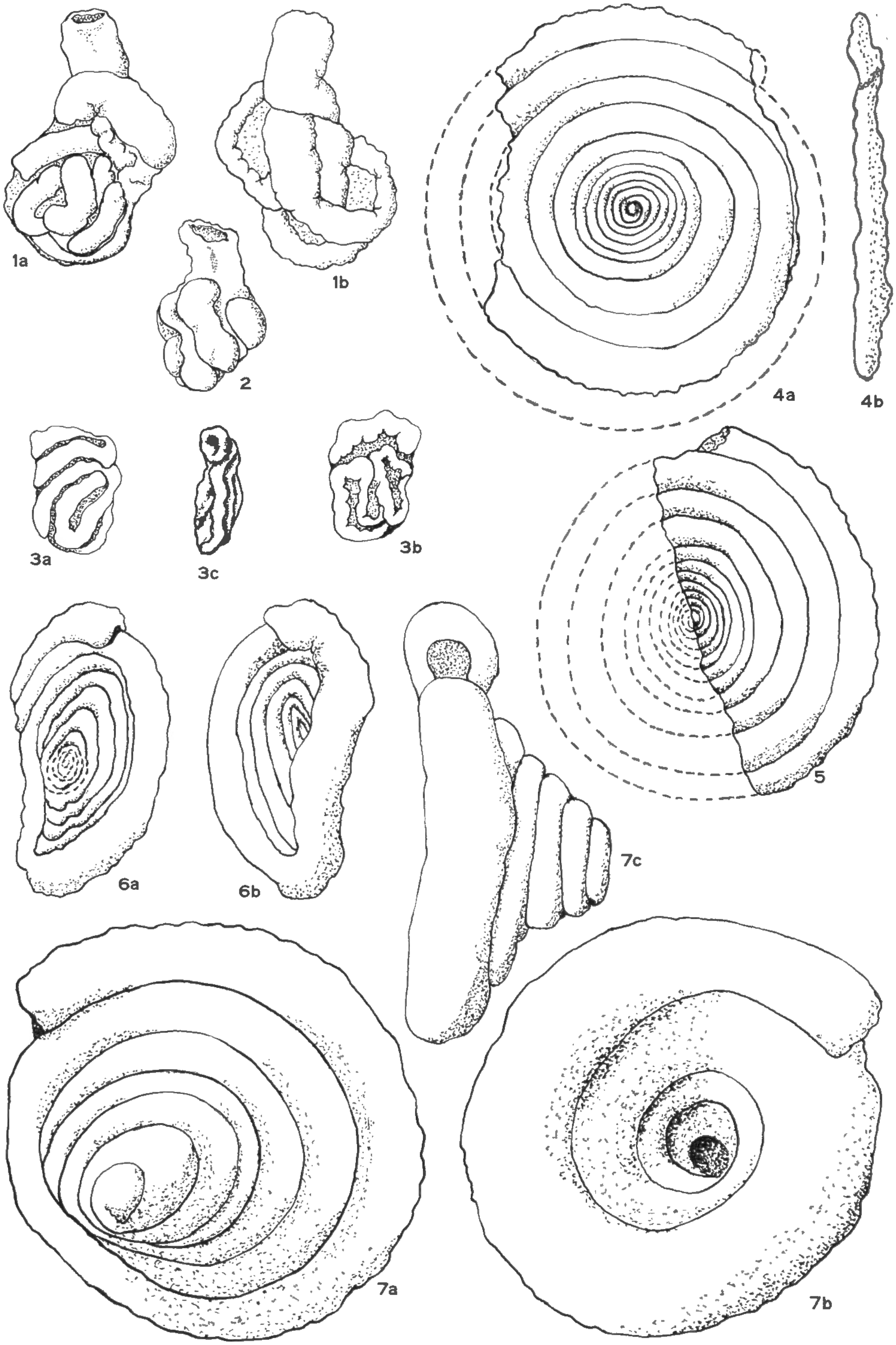
PLATE 17A

Lituotuba gallupi new species (Page 99)

Figures 1a, b. Views of opposite sides of holotype (GSC 24190); × 45.
Figure 2. Side view of paratype (GSC 24191); × 45.

Lituotuba sp. (Page 101)

Figures 3a, b, c. Opposite sides and edge views of hypotype (GSC 24192); × 45.



Ammodiscus thomsi new species (Page 101)

Figures 4a, b. Side and edge views of holotype (GSC 24193); × 14.
Figure 5. Side view of paratype (GSC 24194); × 14.
Figures 6a, b. Views of opposite sides of distorted paratype (GSC 24195); × 14.

Arenoturrispirillina waltoni new species (Page 104)

Figures 7a, b, c. Dorsal, ventral, and edge (apertural) views of holotype (GSC 24196); × 40.

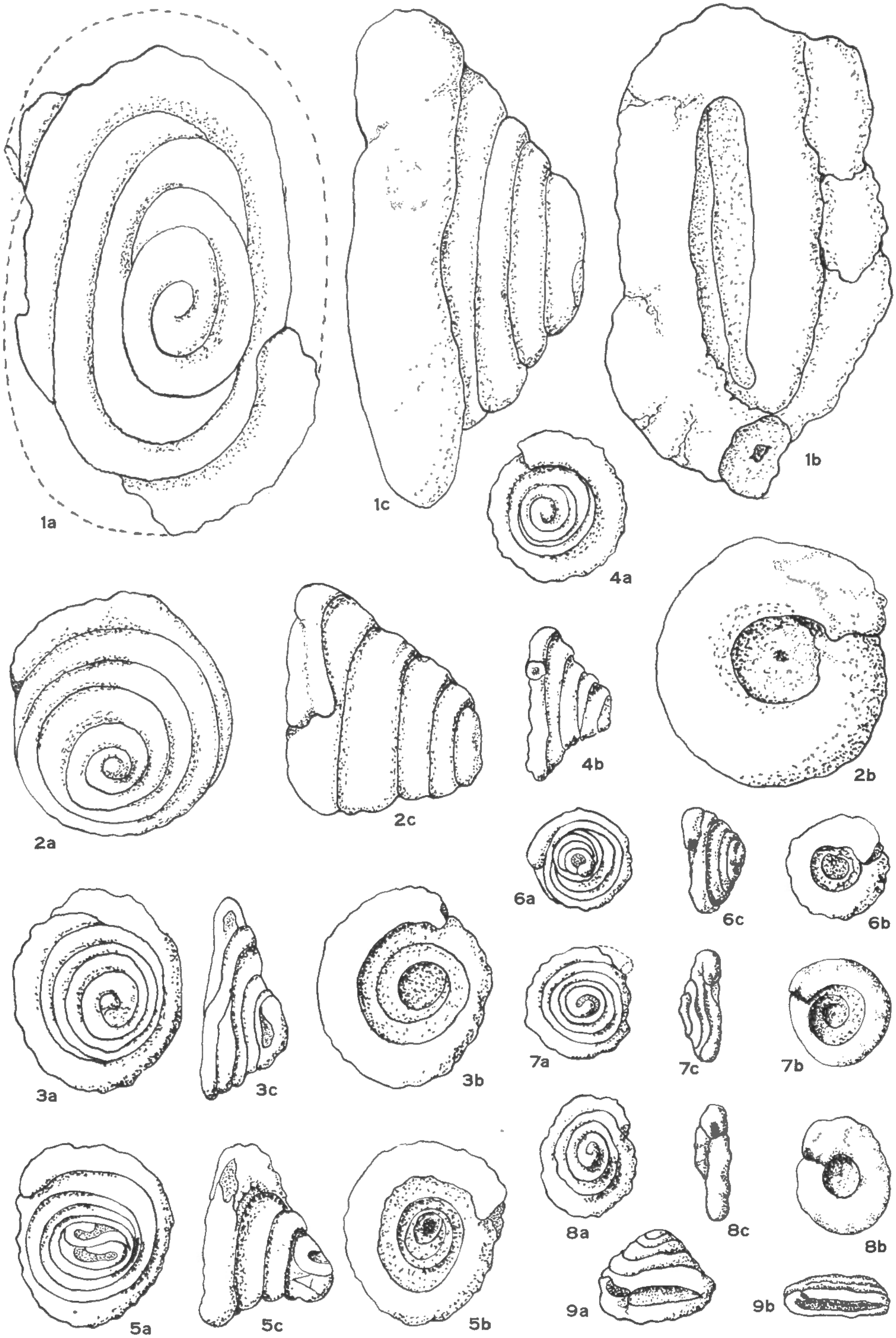
PLATE 18A

Arenoturrispirillina waltoni new species (Page 104)

Figures 1a, b, c. Dorsal, ventral, and edge views of paratype (GSC 24197); × 40.

Arenoturrispirillina sp. (Page 107)

Figures 2a, b, c. Dorsal, ventral, and edge view of hypotype (GSC 24202); × 40.



Arenoturrispirillina intermedia new species (Page 105)

Figures 3a, b, c. Dorsal, ventral, and edge (apertural) views of holotype (GSC 24203); × 40.
Figures 4a, b. Dorsal and edge (apertural) views of paratype (GSC 24204); × 40.
Figures 5a, b, c. Dorsal, ventral, and edge (apertural) views of paratype (GSC 24205); × 40.

Arenoturrispirillina jeletzkyi new species (Page 106)

Figures 6a, b, c. Dorsal, ventral, and edge views of holotype (GSC 24207); × 50.
Figures 7a, b, c. Dorsal, ventral, and edge views of paratype (GSC 24208); × 50.
Figures 8a, b, c. Dorsal, ventral, and edge view of paratype (GSC 24209); × 50.
Figures 9a, b. Side and dorsal views of paratype (GSC 24210); × 50.

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