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CARBONIFEROUS AMMONOIDS AND STRATIGRAPHY IN THE CANADIAN ARCTIC ARCHIPELAGO

W. W. Nassichuk

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By
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PREFACE

The first Carboniferous ammonoid to be discovered in Sverdrup Basin was from a piercement structure on northern Amund Ringnes Island in 1955 during reconnaissance explorations by members of the Geological Survey's first major Arctic helicopter-supported project, "Operation Franklin." Since then, work by Geological Survey parties, by geologists attached to petroleum exploration companies, and by members of university geology departments has resulted in numerous ammonoid collections from northern Ellesmere Island and Axel Heiberg Island. Many of these were made available to Dr. Nassichuk, and, together with his own extensive collections, were the basis for the present study.

Although ammonites make up a very small component of the faunas of the Arctic Carboniferous, they are of great significance as they offer a method, not only of correlation within the various basins of deposition, but perhaps even more important a precise means of dating the sedimentary events within the world time scale.

To meet one of its objectives, the estimation of the potential abundance and probable distribution of the mineral and fuel resources available to Canada, the Geological Survey requires extensive stratigraphic and paleontological data. This report presents information and interpretations that will be of considerable assistance in better understanding the geology of an important part of the Canadian Arctic.

D. J. MCLAREN,
Director, Geological Survey of Canada

OTTAWA, December 5, 1973

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CARBONIFEROUS AMMONOIDS AND STRATIGRAPHY IN THE CANADIAN ARCTIC ARCHIPELAGO

Abstract

Forty-six species of Carboniferous ammonoids are known from the Sverdrup Basin in northern regions of the Canadian Arctic Archipelago; these are represented by several thousand specimens from 60 localities. All species are described and their biochronologic significance assessed in the present study. The oldest known marine fossils in the Sverdrup Basin are ammonoids, brachiopods, and calcareous foraminifers of early Namurian (Chesteran) age; *Cravenoceras tozeri* n. sp. from the Otto Fiord Formation on Melville Island closely resembles species that occur in the E_2 Zone in Morocco, Algeria, and the Soviet Union. Late Namurian R_2 and G_1 (Halian) ammonoids also occur in the Otto Fiord Formation on Melville and Axel Heiberg Islands. These include:

Bilinguites canadensis n. sp.
Bilinguites heibergensis n. sp.
Bilinguites sp.
Bisatoceras hoeni n. sp.

The following early Westphalian (Kayalian) ammonoids also occur in the upper part of the Otto Fiord Formation:

Branneroceras branneri (Smith)
Branneroceras nicholasi n. sp.
Branneroceras hillsi n. sp.
Branneroceras sp.
Bisatoceras renni n. sp.
Gastrioceras melvillensis n. sp.
Gastrioceras liratum n. sp.
Gastrioceras sp.
Syngastrioceras oblatum (Miller and Moore)
Melvilloceras sabinensis n. gen., n. sp.

The base of Westphalian-A in Western Europe and the base of the Kayalian in Eastern Europe approximate the base of the Bloydian Stage in the Morrowan Series in the North American Midcontinent. The Otto Fiord Formation shows marked diachroneity. In parts of northern Ellesmere Island, early Moscovian foraminifers occur in the upper part of the formation but in other parts, the youngest fossils in the Otto Fiord Formation are of Kayalian age.

An abundant early Moscovian (Middle Pennsylvanian, Atokan) ammonoid fauna occurs in the Hare Fiord and Nansen Formations on Ellesmere and Axel Heiberg Islands including:

Boesites gracilis n. sp.
Stenopronorites sersoni n. sp.

Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Maximites alexanderi n. sp.
Neodimorphoceras sverdrupi n. sp.
Goniolobocerratoides curvatus n. gen., n. sp.
Proshumardites aequalis n. sp.
Syngastrioceras smithwickense (Plummer and Scott)
Syngastrioceras orientale (Yin)
Syngastrioceras constrictum n. sp.
Clistoceras globosum Nassichuk
Clistoceras sp.
Bisatoceras kotti n. sp.
Neogastrioceras arcticum n. gen., n. sp.
Neoglaphyrites bisulcatus n. sp.
Neoicoceras martini n. sp.
Phaneroceras lenticulare Plummer and Scott
Phaneroceras compressum (Hyatt)
Trettinoceras ellesmerensis n. gen., n. sp.
Somoholites merriami (Miller and Furnish)
Gastrioceras glenisteri n. sp.
Diaboloceras neumeieri Quinn and Carr
Diaboloceras involutum n. sp.
Winslowoceras greelyi n. sp.
Christioceras trifurcatum Nassichuk and Furnish

Of the above species, *Diaboloceras involutum* and *Gastrioceras glenisteri* are associated also with upper Moscovian (Podolian); that is early Desmoinesian fusulinaceans and smaller calcareous foraminifers near the top of the "Tellevak Limestone" member of the Hare Fiord Formation in the Krieger Mountains, northern Ellesmere Island. In addition, several other Desmoinesian ammonoids are known from the Canyon Fiord Formation on Ellesmere Island, including:

Boesites sp.
Metapronorites pseudotimorensis (Miller)
Bisatoceras sp.
Somoholites bamberi n. sp.

Similarly, the Desmoinesian *Bisatoceras* cf. *B. greenei* is known from the Nansen Formation on Axel Heiberg Island.

A single Zhigulevian (Missourian) ammonoid *Parashumardites* sp. is described from the Nansen Formation on Ellesmere Island.

Résumé

Quarante-six espèces d'ammonoïdes du Carbonifère ont été trouvées dans le bassin Sverdrup situé dans les régions nordiques de l'Archipel arctique canadien; elles sont représentées par plusieurs milliers de spécimens provenant de 60 localités. L'auteur décrit ici toutes les espèces et évalue leur signification biochronologique. Les plus anciens fossiles connus du bassin Sverdrup sont des ammonoïdés, des brachiopodes et des foraminifères calcaires du début du Namurien (Chestérien); *Cravenoceras tozeri*, nouvelle espèces de la formation Otto Fiord dans l'île Melville, ressemble beaucoup aux espèces qu'on retrouve dans la zone E_2 au Maroc, en Algérie et en Union soviétique. On retrouve aussi des ammonoïdés R_2 et G_1 du Namurien supérieur (Halien) dans la formation Otto Fiord dans les îles Melville et Axel Heiberg. Ce sont:

Bilinguites canadensis, nouvelle espèce
Bilinguites heibergensis, nouvelle espèce

Bilinguites, espèce
Bisatoceras hoeni, nouvelle espèce

On retrouve aussi des ammonoïdés du Wesphalien inférieur (Kayalien) à la partie supérieure de la formation Otto Fiord:

Branneroceras branneri (Smith)
Branneroceras nicholasi, nouvelle espèce
Branneroceras hillsi, nouvelle espèce
Branneroceras, espèce
Bisatoceras renni, nouvelle espèce
Gastrioceras melvillensis, nouvelle espèce
Gastrioceras liratum, nouvelle espèce
Gastrioceras, espèce
Syngastrioceras oblatum (Miller et Moore)
Melvilloceras sabinensis, nouveau genre, nouvelle espèce

La base du Westphalien-A en Europe de l'ouest et la base du Kayalien en Europe de l'est ressemble à la base de l'étage du Bloydien de la série morrovienne au centre du continent nord-américain. La formation Otto Fiord porte les marques d'une forte évolution dans le temps. Dans certaines parties au nord de l'île Ellesmere des foraminifères du Moscovien inférieur se présentent à la partie supérieure de la formation mais, ailleurs, les fossiles récents de la formation Otto Fiord proviennent du Kayalien.

Une faune abondante d'ammonoïdés du Moscovien inférieur (Pennsylvanien moyen, Atokien) se présente dans les formations Hare Fiord et de Nansen dans les îles Ellesmere et Axel, comprenant:

Boesites gracilis, nouvelle espèce
Stenopronorites sersoni, nouvelle espèce
Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis, nouvelle espèce
Maximites alexanderi, nouvelle espèce
Neodimorphoceras sverdrupi, nouvelle espèce
Gonioloboceratoïdes curvatus, nouveau genre, nouvelle espèce
Proshumardites aequalis, nouvelle espèce
Syngastrioceras smithwickense (Plummer et Scott)
Syngastrioceras orientale (Yin)
Syngastrioceras constrictum, nouvelle espèce
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Diaboloceras neumeieri Quinn et Carr
Diaboloceras involutum, nouvelle espèce
Winslowoceras greelyi, nouvelle espèce
Christioceras trifurcatum Nassichuk et Furnish

Parmi les espèces sus-mentionnées, la *Diaboloceras involutum* et la *Gastrioceras glenisteri* proviennent aussi du Moscovien supérieur (Podolien); ce sont des fusilinacéens et des foraminifères calcaires plus petits du Desmoinésien inférieur que l'on trouve au sommet du niveau "Tellevak Limestone" de la formation Hare Fiord dans les monts Krieger, au nord de l'île Ellesmere, comprenant:

Boesites, espèce
Metapronorites pseudotimorensis (Miller)
Bisatoceras, espèce
Somoholites bamberi, nouvelle espèce

Pareillement, l'espèce *Bisatoceras* cf. *B. greenei* du Desmoinésien provient de la formation de Nansen dans l'île Axel Heiberg.

L'auteur ne décrit qu'une seule espèce d'ammonoïdés, la *Parashumardites* du Zhigulevien (Missourien) provenant de la formation de Nansen dans l'île Ellesmere.

INTRODUCTION

Scope of Report

Carboniferous ammonoid cephalopods have been recovered from 60 localities on Ellesmere, Axel Heiberg, Ellef Ringnes, Amund Ringnes, and Melville Islands, where they occur in the Otto Fiord, Hare Fiord, Nansen, and Canyon Fiord Formations. All of the known collections have been examined for this report. Included are ammonoid faunas of Namurian (Chesteran, Morrowan), Kayalian (Morrowan), Moscovian (Atokan, Desmoinesian), and Zhigulevian (Missourian) ages. Whereas some faunal groups occur more or less continuously throughout the above formations, ammonoids are common only at specific levels where they may be the dominant fauna. Despite apparent relative paucity, the ammonoids assume a disproportionate significance for basinal as well as for intercontinental correlation. Thus, in addition to discussing local correlation, special emphasis is placed on correlating ammonoid-bearing formations in the Sverdrup Basin with strata in Europe as well as with those in other places in North America. In addition to the general review of Carboniferous stratigraphy in the Sverdrup Basin provided here, a more comprehensive treatment of the subject will be presented in other papers currently being prepared by the writer.

Regional Setting

Carboniferous rocks in the Canadian Arctic Archipelago are confined to the Sverdrup Basin, and their deposition represents an important sequence of events in the history of the basin. The Sverdrup Basin, which is generally considered a successor basin superposed on block-faulted terrain underlain by the Franklinian Geosyncline, was defined by Fortier (1957) as a regional depression occupying a large part of the northwestern Queen Elizabeth Islands and containing an essentially conformable sequence of strata ranging from Lower Carboniferous (Viséan) to lower Tertiary (Eocene). According to Trettin *et al.* (1972), the basic tectonic framework of the generally unstable Sverdrup Basin was inherited from early Paleozoic events while the configuration of the basin varied periodically during its history; that is, its boundaries shifted. Indeed, during the early history of the basin, during Early Carboniferous and into Late Carboniferous time, deposition appears to have occurred in a number of smaller, interconnected or even disconnected basins separated from each other by topographic basement highs. The southern and eastern edges of the basin are defined approximately on Melville, Cameron, Helena, Devon, and Ellesmere Islands where upper Paleozoic or Mesozoic rocks of the Sverdrup Basin succession rest unconformably on lower and middle Paleozoic rocks of the Franklinian Geosyncline. The northern edge of the basin, however, is less clearly defined and some evidence suggests that, during at least part of the Carboniferous, the basin extended a considerable distance northwest of Ellesmere Island.

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Details concerning the distribution of Carboniferous facies belts in the Sverdrup Basin and a review of ammonoid-bearing formations within those belts are given in another part of this report; additionally, for completeness, a brief review of the depositional sequence of events during the Carboniferous is appropriate here.

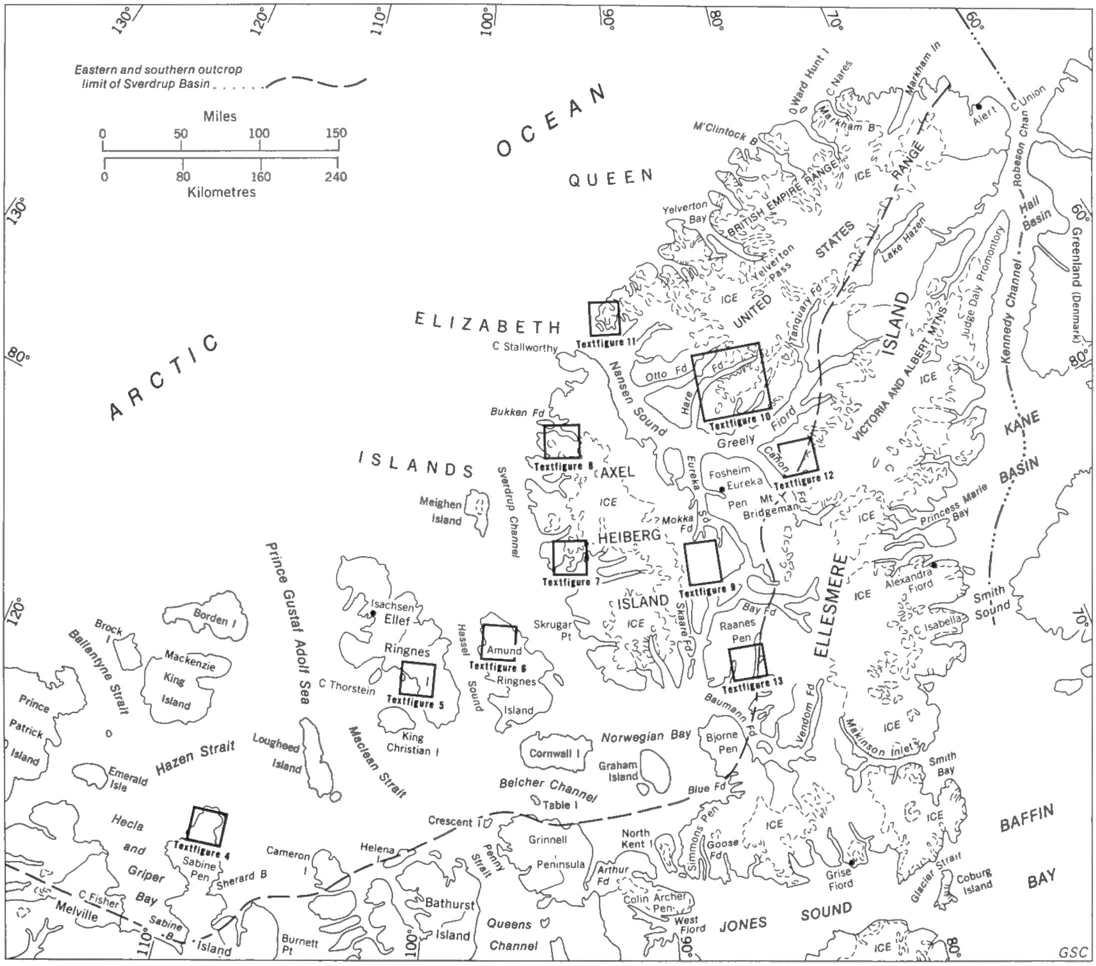
The oldest rocks in the Sverdrup Basin belong to the Lower Carboniferous (Viséan) Emma Fiord Formation; they were deposited following a prolonged period of deformation and subsidence of the Franklinian Geosyncline that took place during Late Devonian and earliest Carboniferous (Tournaisian) time. The Emma Fiord Formation consists of nonmarine deltaic and lacustrine siltstone, sandstone with minor amounts of shale and coaly beds. The formation occurs mainly in a narrow, discontinuous 'belt' extending nearly 100 miles from the northern tip of Axel Heiberg Island to northeastern Ellesmere Island but Kerr (pers. com., 1973) has identified Emma Fiord rocks within a synclinal depression on northern Grinnell Peninsula, Devon Island.

During the Late Carboniferous, sedimentation occurred throughout the basin with a resultant cumulative thickness of some 5,000 feet. A comprehensive study of the stratigraphy of those beds was completed by Thorsteinsson (1974) and many of the local stratigraphic relationships discussed in this report are derived from that source. Whereas sedimentation appears to have been continuous through the Late Carboniferous in some eastern regions of the Sverdrup Basin, the same may not be true in the west. Some microfaunal evidence now available from northwestern and eastern Axel Heiberg Island and the van Hauen Pass region of western Ellesmere Island suggest that a major disconformity occurs between Middle Pennsylvanian (Moscovian) and Lower Permian (Asselian) strata (Textfig. 2). A comparable disconformity was documented for the upper Paleozoic sequence in the Richardson Mountains in northern Yukon by Bamber and Waterhouse (1971).

The Borup Fiord Formation, deposited during early Namurian (Late Mississippian, Chesteran) time, marks the first widespread marine transgression in the Sverdrup Basin. The Borup Fiord consists of red- and green-weathering conglomerate, sandstone, and shale with minor lenses of bioclastic and stromatolitic, dolomitic limestone. It is confined generally to interior regions of the Sverdrup Basin where it overlies either the Emma Fiord Formation or deformed older Paleozoic rocks. The upper part of the Borup Fiord Formation probably is continuous with basal beds of the lithologically similar, basin-marginal Canyon Fiord Formation. In addition, in the type area on northern Ellesmere Island, the upper beds in the Borup Fiord are transitional with the overlying Nansen Formation, which is discussed in a following paragraph. Locally, the upper Borup Fiord interfingers with the lower part of the Nansen and Otto Fiord Formations. In parts of northwestern Ellesmere Island, a thick sequence of volcanic rocks, the Audhild Formation, is intercalated between the Borup Fiord and overlying Nansen Formation.

Following the shallow-marine deposition of the Borup Fiord Formation in interior regions of the basin, the Otto Fiord Formation, comprising mainly anhydrite, shale, and limestone, and the lower part of the Nansen Formation, comprising sandy, skeletal limestone, were deposited simultaneously. Both the latter units also appear to have been deposited in a shallow-marine environment.

The Otto Fiord Formation is overlain typically by the Hare Fiord Formation, a dark grey weathering unit of thin-bedded cherty limestone, siltstone, and shale with thick local accumulations of fenestrate bryozoan mounds near the base. These mounds, which contain most of the Middle Pennsylvanian (Atokan and Desmoinesian) ammonoids described in this report, developed either near shore or on topographic highs within a deep, starved shale basin. Bonham-Carter (1966) informally designated strata within mounds at the base of the



TEXTFIGURE 1. Index map of Carboniferous ammonoid occurrences, Arctic Islands. Ammonoid localities are precisely shown on inset maps.

Hare Fiord as the "Tellevak Limestone." Deposition of the Hare Fiord and its lateral equivalent, the Nansen Formation, continued into the Early Permian.

The only other Carboniferous formation in the basin is the Antoinette Formation, which ranges in age from Moscovian to Orenburgian. It interfingers with and, locally, overlies the Canyon Fiord and equivalent strata near the eastern edge of the basin in the vicinity of Cañon Fiord and Antoinette Bay on western Ellesmere Island. The Antoinette contains mainly limestone and is overlain by evaporites and limestone of the Lower Permian (Asselian) Mount Bayley Formation.

The Lower and Upper Carboniferous succession on northern Axel Heiberg Island and northwestern Ellesmere Island is remarkably similar to that in Spitzbergen. In the latter area, a Lower Carboniferous nonmarine sequence of shale and sandstone, designated as the Culm beds (Lyutkevich, 1937; Orvin, 1940; Gee, Harland, and McWhae, 1953), corresponds to the Emma Fiord Formation in Arctic Canada; not only the lithologies but also the thicknesses of the units in both areas are comparable. Similarly, greenish conglomerates near the top of the Culm in Spitzbergen may correspond with the Borup Fiord Formation which overlies the Emma Fiord Formation in Canada. The Lower Gypsiferous Series and the overlying Passage Beds of Vestspitzbergen are practically identical with the Otto Fiord and Hare Fiord Formations, respectively, on Ellesmere Island. A particularly striking comparison can be drawn between the Ebbadalen Formation of Vestspitzbergen and the Otto Fiord Formation of Ellesmere Island. The Ebbadalen, which was differentiated from the Lower Gypsiferous Series by Cutbill and Challinor (1965) and comprehensively described by Holliday and Cutbill (1972), is almost identical with the Otto Fiord Formation on a bed-by-bed basis in terms of lithology, thickness, and age.

Carboniferous Faunas in the Sverdrup Basin

Since Carboniferous faunas from the Sverdrup Basin are generally poorly known and only a few species of fusulinids, spores, and brachiopods have been described in the literature, the following brief résumé is presented to outline the occurrence of major fossil groups in various formations and the paleontologists currently involved in research on these groups. The physical stratigraphy and age relationships of the formations are discussed later under the following headings.

The Emma Fiord Formation has yielded only plant remains and spores. The late Walter Bell described a single plant species *Cardiopteris abbensis* Read from the type section in an unpublished report for the Geological Survey of Canada and considered a Viséan age most likely. Spores from this unit were described by Playford and Barss (1963), who also suggested a Viséan age.

The Borup Fiord Formation is unfossiliferous except in the upper third of the formation, where dolomitic limestone lenses have yielded brachiopods (being studied by J. L. Carter), calcareous foraminifers, and spongiostromid stromatolitic algae.

The Otto Fiord Formation contains an abundant fauna in practically all limestone beds. It contains a wide variety of brachiopods (*see* identifications by Carter in Appendix), conodonts (*see* identifications by Bender in Appendix), solitary corals (*see* identifications by Bamber in Appendix), fusulinaceans (*see* identifications by Ross in Appendix), and other calcareous foraminifers and algae (*see* identifications by Mamet in Appendix), as well as crinoids, trilobites, gastropods, ostracodes, bryozoans, and ammonoids (this report). Practically all macrofauna has been bored by algae or other organisms, probably indicating shallow-water (photic zone) deposition.

The Hare Fiord Formation has yielded a great variety of fossils, including most of the ammonoids described in this report. Although fossils are scattered throughout the formation, they are particularly abundant in bedded limestones and carbonate mounds that occur in the lower part. In addition to ammonoids, the following are abundant and diversified: brachiopods (being studied by J. L. Carter), conodonts (*see* identifications by Bender in Appendix), corals (being studied by E. W. Bamber), fusulinaceans (*see* identifications by Ross in Appendix), and other calcareous foraminifers and algae (*see* identifications by Mamet in Appendix), crinoids (*see* identifications by Strimple in Appendix), blastoids (*see* identifications by Macurda in Appendix), trilobites (being studied by K. Chamberlain), gastropods, pelecypods, and spores.

The Nansen Formation has yielded ammonoids (this report), brachiopods, conodonts (being studied by P. K. Bender), fusulinaceans (Thompson, 1961; Thorsteinsson, 1974), and other calcareous foraminifers (*see* identifications by Mamet in Appendix).

The Canyon Fiord Formation has yielded ammonoids (this report), brachiopods (Whitfield, 1908), corals (*see* identifications by Bamber in Appendix), fusulinaceans (Troelson, 1950; Thorsteinsson, 1974), and other calcareous foraminifers (*see* identifications by Mamet in Appendix), crinoids (*see* identifications by Strimple in Appendix), and calcareous algae (Mamet and Rudloff, 1972, Pl. 5).

The Antoinette Formation has yielded brachiopods, corals (being studied by E. W. Bamber), and fusulinaceans (Thorsteinsson, 1974).

History of Discoveries of Carboniferous Ammonoids in the Sverdrup Basin

The first Carboniferous ammonoid to be discovered in the Sverdrup Basin was a single specimen recovered by A. W. Norris from an evaporite piercement structure on northern Amund Ringnes Island in 1955; Norris was attached to "Operation Franklin," a Geological Survey of Canada party engaged in mapping large parts of Ellesmere, Axel Heiberg, and adjacent islands. Norris' specimen was also the first Carboniferous ammonoid from the basin to be documented in the literature; Harker (*in* Norris, 1963) included it in a fossil list as *Gastrioceras* sp. The specimen is included in the present report as *Branneroceras branneri.* In 1972, H. Balkwill of the Geological Survey of Canada discovered specimens of the same species at a nearby locality in the same dome. A single specimen of *B. branneri* was collected from Malloch Dome on Ellef Ringnes Island by W. S. Warden of Mobil Oil Company, Calgary, in 1965.

Ammonoids were discovered first on Melville Island by J. C. Sproule and Associates, Calgary, who recovered specimens of *Branneroceras branneri* and *Branneroceras nicholasi* n. sp. from Barrow Dome on northern Sabine Peninsula in 1961. Additional large collections from Barrow Dome were assembled by geologists with BP Exploration Canada Limited in 1965 and by the author in 1967.

A few ammonoids were discovered on western Axel Heiberg Island in 1960 by E. Hoen, geologist to the "Jacobsen McGill Arctic Research Expedition, 1959-1962." These were correctly dated as Early Pennsylvanian by W. M. Furnish and Brian F. Glenister (*in* Hoen, 1964).

In 1956 and 1957, Thorsteinsson and Tozer extended the work they had begun on upper Paleozoic and Mesozoic rocks while attached to "Operation Franklin" in 1955, and in the early spring of both years undertook extensive trips from Eureka, Ellesmere Island, using dog teams. In 1957, they studied Carboniferous rocks in the Otto Fiord and Hare Fiord Formations east of van Hauen Pass, on Hare Fiord, northern Ellesmere Island, and discovered Middle Pennsylvanian ammonoids near the base of a sequence of limestone and shale that Thorsteinsson (1970) subsequently designated as the type section of the Hare Fiord Formation.

Thorsteinsson extended his work on Carboniferous and Permian stratigraphy on Ellesmere and Axel Heiberg Islands in 1961 and 1962 when he led "Operation Eureka," an airborne geological operation designed to refine and extend the mapping and stratigraphic studies of Axel Heiberg and Ellesmere Islands that had begun with "Operation Franklin." In 1961, Thorsteinsson made additional collections of Middle Pennsylvanian ammonoids from the Hare Fiord Formation at Hare Fiord, near Stepanow Creek, and also from the same formation on eastern Axel Heiberg Island near Whitsunday Bay. That same year Thorsteinsson discovered Middle Pennsylvanian ammonoids near the base of the Canyon Fiord Formation north of Cañon Fiord, on the west side of the Victoria and Albert Mountains. In 1963, Thorsteinsson, accompanied on northern Ellesmere Island by P. Harker, completed his field studies in the basin; during that year, Harker collected Middle Pennsylvanian ammonoids with G. Bonham-Carter who was engaged in studying Hare Fiord carbonates in the Blue Mountains of northern Ellesmere Island as the subject of a Ph.D. thesis at the University of Toronto. Also during 1963, the writer, in the company of R. L. Christie, assembled large collections of Middle Pennsylvanian ammonoids from the Hare Fiord Formation on Hare Fiord; these ammonoids served as a basis for a Ph.D. thesis completed by the writer at the University of Iowa in 1965. F. Stehli of Western Reserve University, Cleveland, found a few Middle Pennsylvanian specimens in the Hare Fiord Formation near Buchanan Lake, eastern Axel Heiberg Island in 1964. The writer subsequently collected Middle Pennsylvanian ammonoids from the Hare Fiord Formation at Hare Fiord and in the Blue Mountains, as well as in the Krieger Mountains in 1969 with C. S. Spinosa of Boise State College, Idaho, and in 1971 with colleagues G. R. Davies and K. Roy. Also in 1971, a collection from the Krieger Mountains was assembled by Dario Sedero of Cities Service Canada Ltd. The writer and Davies discovered Early Pennsylvanian ammonoids in 1971 in the Otto Fiord Formation on Ellesmere Island. In the same year, the writer and E. W. Bamber collected early Middle Pennsylvanian specimens from the Hare Fiord Formation near Buchanan Lake, eastern Axel Heiberg Island and late Middle Pennsylvanian ammonoids from the Canyon Fiord Formation at Raanes Peninsula, Ellesmere Island. In 1972, the writer and G. R. Davies assembled collections from Middle Pennsylvanian strata in the Nansen Formation at Hare Fiord and the Hare Fiord Formation in the Krieger Mountains, Ellesmere Island. Also in 1972, Dario Sedero of Cities Service Canada Ltd. discovered Middle Pennsylvanian specimens in the Nansen Formation of northwestern Axel Heiberg Island.

Acknowledgments

The writer is pleased to express his gratitude to colleagues with the Geological Survey of Canada and to scientists attached to other institutions who have assisted in various phases of this project. Special thanks are due R. Thorsteinsson who initiated the project and who generously provided his own field and research data on the physical stratigraphy and biostratigraphy of Carboniferous rocks in the Sverdrup Basin. Also, some of the most important collections used in this study were discovered by Thorsteinsson. Special thanks are due also to W. M. Furnish and Brian F. Glenister of the University of Iowa who guided the author through preparation of a Ph.D. dissertation on Carboniferous ammonoids from Arctic Canada in 1965, and who have maintained a close contact with the writer and the subject of this study.

E. W. Bamber, H. R. Balkwill, R. L. Christie, G. R. Davies, P. Harker, A. W. Norris, K. Roy, and E. T. Tozer, of the Geological Survey of Canada, and Claude Spinosa of Boise State College, Idaho, collected ammonoids in the Sverdrup Basin; Bamber identified corals, and Christie, Davies, and Roy provided important stratigraphic data for the present study. Collections also have been turned over to the writer by F. Stehli of Western Reserve University, Cleveland, R. DeCaan, formerly of BP Exploration Canada Ltd., Calgary, and Dario Sedero of Cities Service Canada Ltd., Calgary. Additional collections were provided through the co-operation of J. C. Sproule and Associates, Calgary, and Mobil Oil Canada, Calgary.

P. K. Bender, while a post-doctoral fellow with the Geological Survey of Canada, identified conodonts; J. L. Carter, Carnegie Museum, Pittsburgh identified brachiopods; D. B. Macurda, University of Wisconsin identified blastoids; B. L. Mamet, University of Montreal identified calcareous foraminifers and algae; Charles A. Ross, Western Washington State College identified fusulinids; and H. L. Strimple, University of Iowa identified crinoids.

Able assistance in the field on various phases of Carboniferous stratigraphy was given by R. Woodsworth in 1966, E. Thorsteinsson in 1968, and K. Britton in 1971; all of whom demonstrated special abilities in stratigraphy and fossil collecting.

Logistic assistance was provided by Panarctic Oils Ltd., Calgary (1969), Atlantic Richfield Co. Ltd., Dallas (1971), and Cities Service Canada Ltd., Calgary (1972).

PHYSICAL STRATIGRAPHY

General Review

Important contributions to the understanding of the rather complex stratigraphy of Carboniferous rocks in the Sverdrup Basin have been made by Troelson (1950, 1952, 1954), Kerr and Trettin (1962), Thorsteinsson (1970), Thorsteinsson and Tozer (1960, 1963), Tozer and Thorsteinsson (1964), Christie (1964), Nassichuk and Christie (1969), Trettin (1969), and Trettin *et al.* (1972). Thorsteinsson is responsible for establishing a generally accepted model for the deposition of Carboniferous rocks over much of the basin and has recently completed an excellent comprehensive report on Carboniferous and Permian stratigraphy on Axel Heiberg Island and much of Ellesmere Island (Thorsteinsson, 1974). Thorsteinsson's (ibid.) general stratigraphic scheme is subscribed to by the present writer with few modifications. It is inevitable when dealing with a subject of this magnitude that refinement of terminology and correlation will develop as new data are assembled. Undoubtedly such refinements will be assisted by detailed studies of ammonoids and other fossil groups.

A complete summary of Carboniferous stratigraphy in the Sverdrup Basin is beyond the scope of this paper, and only the formations that have yielded Carboniferous ammonoids are reviewed; that is, the Otto Fiord, Hare Fiord, Nansen, and Canyon Fiord Formations. For information concerning the following Carboniferous units in the Sverdrup Basin, the reader is referred to Thorsteinsson (1970, 1974): Emma Fiord Formation, Borup Fiord Formation, Audhild Formation, Antoinette Formation. For information on the enigmatic and possibly Carboniferous Sail Harbour and Guide Hill Groups of northeastern Ellesmere Island, reference is made to Blackadar (1954), Christie (1964), and Trettin (1969).

Thorsteinsson (1970, 1974) recognized that Upper Carboniferous and Lower Permian (Namurian–Artinskian) rocks in the Sverdrup Basin demonstrate marked differences in lithologic character between the basin edge and the basin interior, and identified a series of facies belts that accommodate various formations. The most significant formations for ammonoid occurrences are the Otto Fiord Formation (anhydrite, limestone, and shale) and the Hare Fiord Formation (limestone and shale). Both of these formations occur in the Basinal Clastic and Evaporitic Belt (Thorsteinsson, 1974) which extends, in central regions of the basin, from near the head of Hare Fiord on Ellesmere Island southwesterly to at least northern Melville Island. Near the northern and northwestern edges of this belt, both the Otto Fiord and Hare Fiord Formations interfinger with and grade into a thick sequence of shelf carbonates, the Nansen Formation, which is the principal formation in the Northwestern Carbonate Belt (Thorsteinsson, 1970). Thorsteinsson, Tozer, and Kerr (1972) and Thorsteinsson (1974) indicated that the Nansen Formation is also the principal formation in the Southeastern Carbonate Belt on the southeastern side of the Basinal Clastic and Evaporitic Belt. Ammonoids have been recovered from a sequence of interbedded limestone and sandstone mapped as the Nansen Formation by Thorsteinsson *et al.* (1972) between Blind Fiord and Trold Fiord on Raanes Peninsula, western Ellesmere Island (Textfig. 13). In the writer's opinion, the occurrence of the Nansen Formation on Raanes Peninsula is open to question on a lithological basis. Thorsteinsson clearly recognized the problem and succinctly stated that the sequence of rocks between the Blind Fiord Thrust and Trold Fiord Thrust (*see* GSC Map 1300A, *Eureka Sound South*, by Thorsteinsson, Tozer, and Kerr, 1972) is intermediate in lithological character between the typical Nansen Formation and a combination of the Canyon Fiord and Belcher Channel Formations. Whereas Thorsteinsson (ibid.) preferred to refer those rocks to the Nansen Formation, the author suggests that both the Canyon Fiord and Belcher Channel Formations can be identified in the area. Resolution of this problem in terminology must await more detailed mapping and stratigraphic studies. For purposes of this paper, ammonoids collected from Raanes Peninsula, in strata mapped by Thorsteinsson, Tozer, and Kerr (1972) as Nansen Formation, are considered to be from the Canyon Fiord Formation. Elsewhere in the basin, the Canyon Fiord Formation occurs in two distinct facies belts (Thorsteinsson, 1974): the Marginal Clastic Belt, near the eastern edge of the basin between Cañon Fiord and Bay Fiord on western Ellesmere Island, where the formation includes mainly sandstone and conglomerate; and the Marginal Clastic and Carbonate Belt, along the eastern and southern edges of the basin, where the formation contains limestone beds and occurs beneath either the Belcher Channel Formation or the Antoinette Formation. The latter formation is confined to western Ellesmere Island, between Tanquary Fiord and the northern part of the "Sawtooth Range" where it underlies the Lower Permian (Asselian) evaporite unit, the Mount Bayley Formation.

Stratigraphy of Ammonoid-Bearing Formations

Otto Fiord Formation

The designation "Otto Fiord Formation" was used informally by Thorsteinsson (1970) for a sequence of interbedded anhydrite, shale, and limestone that occurs in axial regions of the Sverdrup Basin in the Basinal Clastic and Evaporitic Belt (Thorsteinsson, 1974). The type section faces Hare Fiord a few miles east of van Hauen Pass on northern Ellesmere Island (Textfig. 10) and was identified on a geological map (GSC Map 1309A, *Otto Fiord*) by Thorsteinsson, Tozer, and Trettin (1972). It has been described in detail by Thorsteinsson (1974).

In the type area, the Otto Fiord Formation attains a thickness of about 1,300 feet and is of Kayalian (Westphalian-A) and possibly early Moscovian age. The base of the type section is marked by a thrust fault but, in a relatively undisturbed section some 14 miles to the east, along Hare Fiord near Stepanow Creek, the formation rests conformably on red-weathering sandstone and conglomerate of the lower Namurian (Upper Mississippian) Borup Fiord Formation; in the latter area, the Otto Fiord has a thickness of only about 800 feet.

The Otto Fiord is overlain typically by the Hare Fiord Formation which consists of limestone and shale and which also is confined to the Basinal Clastic and Evaporitic Belt. Near the head of Hare Fiord, which is near the northern edge of the Basinal Clastic and Evaporitic Belt, both the Otto Fiord and Hare Fiord Formations interfinger with and, northward, grade into shelf carbonates of the Nansen Formation. The Nansen may have served as a barrier to open-marine conditions allowing periodic deposition of evaporites in a moderately restricted basin. The interbedded arrangement of anhydrite, shale, and limestone in the Otto Fiord appears to reflect a number of minor transgressions and regressions.

Near the eastern edge of the Basinal Clastic and Evaporitic Belt, in the Krieger Mountains some 15 miles southeast of van Hauen Pass (Textfig. 10), the upper part of the Otto Fiord

Formation shows a slight diachroneity for it contains slightly younger Middle Pennsylvanian (Moscovian Zone 22) fossils than at van Hauen Pass where the formation is of Kayalian and possibly early Moscovian (Zone 20 and ?21) age. In the Krieger Mountains the upper beds in the Otto Fiord appear to interfinger with the lower beds in the Hare Fiord Formation. Thus, while basal Hare Fiord rocks were being deposited near the western edge of the Basinal Clastic and Evaporitic Belt at Hare Fiord, evaporites of the Otto Fiord Formation were being deposited in the Krieger Mountains. Between the Krieger Mountains and the Blue Mountains to the southwest (Textfigs. 2, 10), the Otto Fiord Formation contains several hundred feet of pink-weathering, ripple-marked, and crossbedded sandstone which is interbedded with anhydrite beds and which appears to have been derived from a southerly source. Although the regional implication of this sandstone is uncertain, it is possible that it represents a basinward extension of the Canyon Fiord Formation.

Whereas the Otto Fiord Formation outcrops in bedded sequences showing little disturbance between Hare Fiord and Whitsunday Bay on eastern Axel Heiburg Island, it is clear that the distribution of the formation is far more extensive, for it is the source of evaporites in all of the more than one hundred evaporitic piercement structures that occur on Axel Heiberg, Ellef Ringnes, Amund Ringnes, and Melville Islands. A number of these piercement structures have yielded ammonoids that form an important part of this study. For a review of piercement structures within the basin, reference is made to Thorsteinsson and Tozer (1970) who have categorized occurrences in a variety of structural settings.

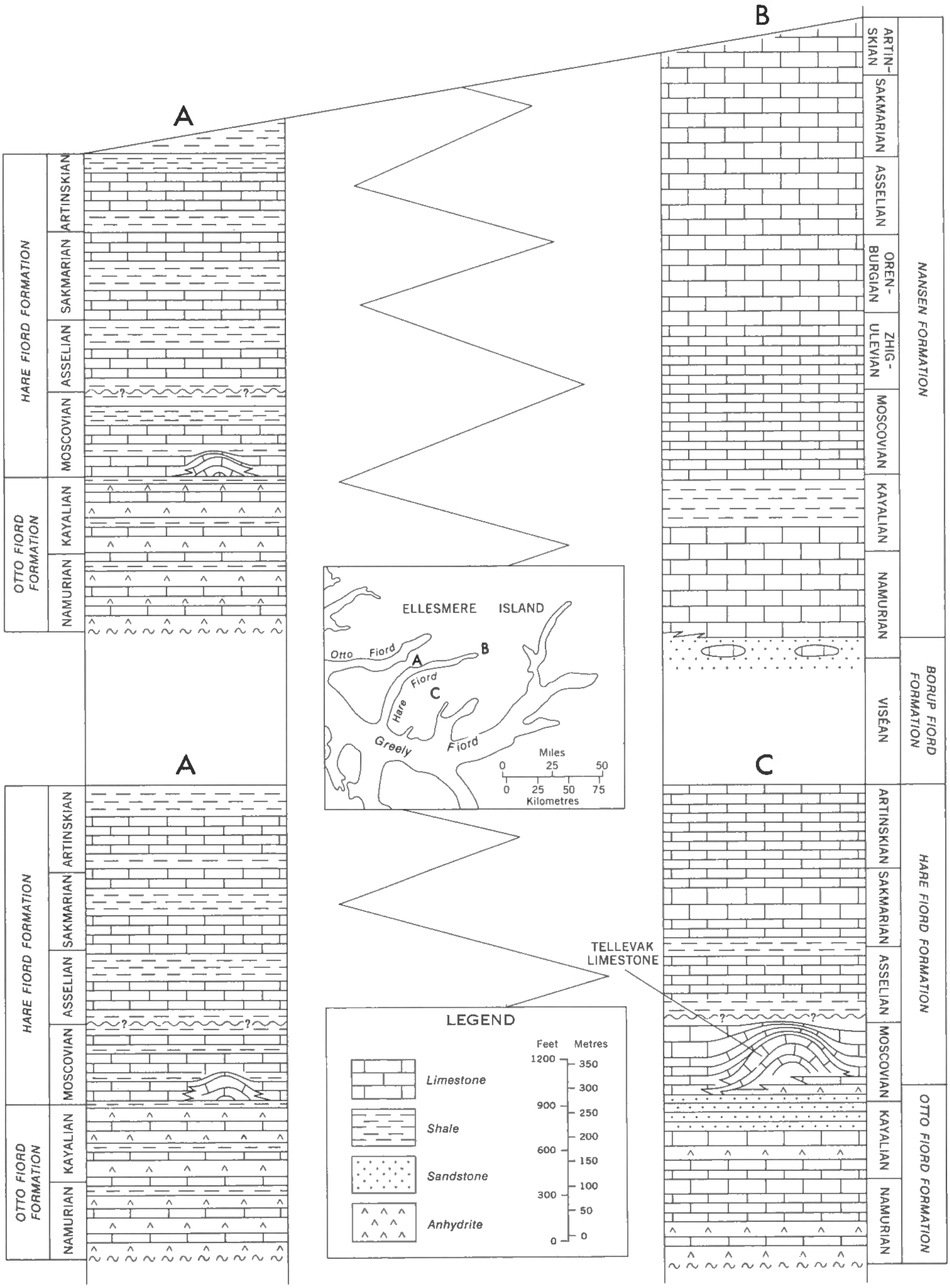
Hare Fiord Formation

The Hare Fiord Formation was described in general, informal terms by Thorsteinsson (1970), and a type section was designated on a geological map (GSC Map 1309A, *Otto Fiord*) by Thorsteinsson, Tozer, and Trettin (1972). The type section is on Hare Fiord, Ellesmere Island, a few miles east of van Hauen Pass (Textfig. 10) and was described in detail by Thorsteinsson (1974). The type section overlies typical Otto Fiord strata; both formations are confined to the Basinal Clastic and Evaporitic Belt of Thorsteinsson (1974).

In the type area, the Hare Fiord Formation includes up to 2,400 feet of thinly bedded limestone, siltstone, and shale. Some small biogenic carbonate mounds occur near the base. The formation is overlain conformably by the van Hauen Formation (2,000 feet thick), which includes noncalcareous dark grey shale, siltstone, and bedded black chert of late Early Permian (Artinskian–Roadian) age.

The Hare Fiord Formation outcrops discontinuously in two narrow bands on either side of the Basinal Clastic and Evaporitic Belt on northern Ellesmere Island. One band extends from about 25 miles east of the head of Hare Fiord southwesterly along the north side of Hare Fiord to the vicinity of van Hauen Pass, and the other band, some 15 miles southeast of the first, extends for about 30 miles from Ricker Glacier in the Van Royen Ridges (Textfig. 10) southwesterly through the Blue Mountains. The Hare Fiord Formation also outcrops on eastern Axel Heiberg Island between Buchanan Lake in the north and Whitsunday Bay in the south (Textfig. 9). Although these outcrop patterns are readily visible on GSC Map 1309A, *Otto Fiord* by Thorsteinsson *et al.* (1972) and GSC Map 1311A, *Greely Fiord West* by Thorsteinsson and Tozer (1971), they are cited here for purposes of discussion.

The Hare Fiord Formation on eastern Axel Heiberg Island and north of Hare Fiord grades into limestone of the Nansen Formation to the west and northwest, respectively. Thorsteinsson (1974) documented a sharply defined facies change between the Hare Fiord Formation and the Nansen Formation near Stepanow Creek on the north side of Hare Fiord (Textfig. 10). Gradation of the lower half of the Hare Fiord Formation into the Nansen



TEXTFIGURE 2. Schematic diagram showing stratigraphic relationships of the Otto Fiord, Hare Fiord, and Nansen Formations on northern Ellesmere Island.

Formation is rather more gradual, in terms of lithological change, than that of the upper half. The thin-bedded character of the limestone in the lower part of the Hare Fiord is retained, but with considerably less shale in the Nansen Formation. The upper part of the Hare Fiord, on the other hand, contains considerable shale and dark grey, thin-bedded limestone, whereas equivalent strata in the Nansen Formation comprise limestone that is thick bedded or massive and includes widespread biogenic mounds.

In much of its outcrop between the Blue Mountains and the Van Royen Ridges (Textfig. 10), the Hare Fiord Formation contains two distinctive "members." The lower part of the formation includes thick mounds of biogenic limestone containing a rich and varied fauna of bryozoans, brachiopods, ammonoids, and other fossil groups. This limestone ranges in thickness from 800 feet to about 1,000 feet and was designated informally the "Tellevak Limestone" by Bonham-Carter (1966). The Tellevak Limestone in this region overlies a thick sequence of sandstone in the upper part of the Otto Fiord Formation. Above the Tellevak Limestone, strata within the Hare Fiord Formation resemble those in the type area; that is, they include uniform beds of limestone, siltstone, and dark grey shale.

East of the easternmost occurrence of the Tellevak Limestone on the west side of Wood Glacier (Textfig. 10), the Hare Fiord Formation assumes the same general lithologic character that it displays in the type area. One exception, however, occurs in the vicinity of Wood Glacier, where some faunal evidence is available to suggest that the lower beds of the Hare Fiord Formation interfinger with the upper beds of the underlying Otto Fiord Formation. Mamet (*see* Appendix) and Ross (*see* Appendix) identified early Moscovian foraminifers including fusulinaceans from limestone interbedded with anhydrite near the top of the Otto Fiord. In all other areas, including the type area, the youngest fossils identified from the Otto Fiord are either of an earlier Moscovian or a Kayalian age; thus, the upper boundary of the Otto Fiord appears to be diachronous northeast of the type area.

Thorsteinsson and Tozer (1972, GSC Map 1311A, *Greely Fiord West*) showed that the Hare Fiord Formation grades into the Nansen Formation north of the head of Oobloyah Bay (Textfig. 10). The lithological character of the Nansen Formation near the Hare Fiord transition in this area is unlike that of the typical Nansen Formation. Whereas the Nansen in the type area consists mainly of limestone, north of Oobloyah Bay the formation is lithologically atypical and contains abundant thick dolomite beds.

Nansen Formation

The type section of the Nansen Formation was designated on a geological map by Thorsteinsson, Tozer, and Trettin (1972, GSC Map 1309A, *Otto Fiord*); it is on Girty Creek, near the head of Hare Fiord, northern Ellesmere Island (Textfig. 10). The formation was discussed briefly by Thorsteinsson (1970) and the type section, as well as the regional distribution of the formation, has been described in considerable detail by Thorsteinsson (1974). The present author has examined only a few sections of Nansen rocks in the basin and has little to add to the comprehensive work of Thorsteinsson (ibid.) concerning the regional distribution and relationships of this complex formation. A few field observations appear pertinent to this study, however, and are discussed here.

The type section of the Nansen Formation occurs in the Northwestern Carbonate Belt adjacent to the northern edge of the Basinal Clastic and Evaporitic Belt and contains about 7,000 feet of limestone and lesser amounts of shale. Laterally in the type area, the Nansen Formation interfingers with and grades into the upper part of the Borup Fiord Formation and the entire Otto Fiord and Hare Fiord Formations.

In the facies scheme devised by Thorsteinsson (1970, 1974), the Nansen Formation is the principal unit in both the Northwestern Carbonate Belt, which occurs north of the

Basinal Clastic and Evaporitic Belt, and the Southeastern Carbonate Belt, which occurs adjacent to the eastern side of the Basinal Clastic and Evaporitic Belt. According to Thorsteinsson (1974), the Nansen Formation within the Northwestern Carbonate Belt can be recognized in surface exposures from northwestern Axel Heiberg Island northward at least to the head of Hare Fiord on northern Ellesmere Island. Nassichuk and Christie (1969) recognized the Nansen Formation as far north as Yelverton Pass on northern Ellesmere Island. Thorsteinsson (ibid.) also considered that the Northwestern Carbonate Belt merges with the Southeastern Carbonate Belt near the head of Hare Fiord, and that the Nansen Formation extends southward from the head of Hare Fiord, mainly in the subsurface, to Raanes Peninsula on western Ellesmere Island (Textfig. 1). It is clear that the Nansen Formation demonstrates considerable change in lithology within the Northwestern Carbonate Belt, where local developments of sandstone and biogenic carbonate mounds have been identified. Even greater changes are apparent between the Nansen Formation in the Northwestern Carbonate Belt and the rocks referred by Thorsteinsson (1974) to the Nansen Formation in the Southeastern Carbonate Belt. For example, rocks that have been mapped as Nansen Formation in northern reaches of the Southeastern Carbonate Belt in the Krieger Mountains, unlike the type section, include considerable primary dolomite. Furthermore, as discussed under a previous heading, rocks that have been mapped as Nansen Formation on Raanes Peninsula contain conglomerate and sandstone interbedded with limestone that might better be referred to the Canyon Fiord Formation. The latter procedure is adopted in this report.

Canyon Fiord Formation

The name Canyon Fiord Formation was assigned by Troelson (1950; *see also* 1952, 1954) to about 400 feet of limestone near Caledonian Bay in Cañon Fiord, western Ellesmere Island. Additional information on Canyon Fiord rocks in the type area and elsewhere was presented by Thorsteinsson (1970), Thorsteinsson and Tozer (1963), and Tozer and Thorsteinsson (1964). Thorsteinsson (1974) extensively reviewed the Canyon Fiord Formation in the type area and documented several emendations of the type section by identifying new reference sections in the type area. According to Thorsteinsson (ibid.), the Canyon Fiord Formation in the vicinity of Cañon Fiord contains about 5,500 feet of strata, mainly red-weathering quartzose sandstone with lesser amounts of conglomerate and limestone.

The Canyon Fiord Formation has been recognized in discontinuous surface outcrops along the entire eastern and southern margins of the Sverdrup Basin. On Feilden Peninsula, northeastern Ellesmere Island, it was referred to the Guide Hill Group by Blackadar (1954). Elsewhere on northeastern Ellesmere Island, a thick section (2,000 ft.) was measured by the author beneath the Belcher Channel Formation north of Lake Hazen, near Henrietta Nesmith Glacier (Textfig. 1). Nassichuk and Christie (1969) also described the formation near the head of Tanquary Fiord on northern Ellesmere Island (Textfig. 1). All other occurrences of the formation on western Ellesmere, Devon, and Melville Islands have been documented in the above-cited papers by Thorsteinsson.

In the area between Cañon Fiord and Bay Fiord, adjacent to the eastern edge of the Sverdrup Basin on western Ellesmere Island (Textfig. 1), Thorsteinsson (1974) delineated the Marginal Clastic Belt, which is occupied by only the Canyon Fiord Formation. Within this belt, the formation consists almost entirely of sandstone and conglomerate. Elsewhere the formation contains a greater proportion of limestone beds and occupies a position in Thorsteinsson's (ibid.) Marginal Clastic and Carbonate Belt. Within the latter belt, the Canyon Fiord Formation commonly is overlain by limestone of the Belcher Channel Formation (Upper Pennsylvanian to Lower Permian). In some parts of the belt on western Ellesmere Island, between the mouth of Tanquary Fiord in the north and Mount Bridgeman near Cañon Fiord in the south (Textfig. 1), the Canyon Fiord Formation either is thinly developed and overlain by Upper Pennsylvanian limestones of the Antoinette Formation, or is absent and represented by equivalent Middle Pennsylvanian to Lower Permian strata of the Antoinette, Mount Bayley (Asselian), and Tanquary (Asselian–Sakmarian) Formations.

The lower part of the Canyon Fiord Formation probably is continuous with red-weathering sandstone, conglomerate, and shale of the Borup Fiord Formation which is present nearer the interior of the basin. Whereas the youngest strata in the Borup Fiord Formation are of Late Mississippian (Chesteran) age, the oldest known strata within the Canyon Fiord Formation are of Early Pennsylvanian (Morrowan) age.

CHRONOSTRATIGRAPHY

General Remarks

Considerable progress has been made in recent years in correlating Carboniferous strata on a worldwide basis but, to this date, no universally accepted scale for subdividing the entire Carboniferous System has been developed. Numerous fossil groups have been employed by various scientists to establish local correlations and a variety of national stratigraphic schemes are in the literature. Quite naturally, those fossil groups that appear to offer significant rewards in terms of intercontinental correlation are nektonic groups including ammonoids, conodonts, and some foraminifers which display a rapidly evolving phylogenesis. It is undoubtedly a mistake, however, to underestimate the chronostratigraphic value of fossil groups that are confined to the benthos for much or all of their life, such as corals, brachiopods, crinoids, and trilobites and, in this report, chronostratigraphic conclusions are drawn from data supplied by all groups.

The stratigraphic importance of calcareous foraminifers, particularly in the Lower Carboniferous, was emphasized first by Rauser-Tschernoussova (1948) and a great number of subsequent papers, including important works by Mamet (1962, 1965), Mamet and Skipp (1970), and Mamet and Armstrong (1972) have further demonstrated the value of this group. The value of calcareous foraminifers is by no means limited to the Lower Carboniferous. They have proven to be exceedingly useful in establishing Upper Carboniferous correlations in the Canadian Arctic Islands (*see* Appendix for fossil identifications by Mamet). Similarly, the chronostratigraphic importance of Carboniferous fusulinaceans for intercontinental correlation has long been recognized (Thompson, 1948, 1964; Rauser-Tschernoussova and Fursenko, 1959). Ross (1967b) used fusulinids to discriminate distinctive Carboniferous faunal realms on a worldwide scale.

Considerable attention has been given to the stratigraphic relationships between Carboniferous ammonoids of Europe and North America, particularly during the past decade (Elias, 1952, 1970; Ruzhencev, 1965; Gordon, 1970; Furnish and Saunders, 1971; Quinn, 1971; Ruzhencev and Bogoslovskaya, 1971b; Drahovzal, 1972). Since the role of Carboniferous ammonoids in intercontinental correlation is a particularly involved subject, only points relevant to a discussion of Arctic ammonoids and their relationships are reviewed here. It is important to point out, however, that a significant reason for some discrepancies in correlation between Europe and North America is the apparent endemism or at least restricted distribution of certain important ammonoid groups. Many genera which are important for intracontinental correlation lack the cosmopolitan distribution necessary for ideal worldwide index genera. For example, much of the Namurian and lower Westphalian of Western Europe is subdivided into zones on the basis of variations in *Reticuloceras* and *Gastrioceras* sensu lato. Although these genera also occur in North America, they cannot be placed in evolutionary sequences within given stratigraphic successions as precisely as in Europe. Conversely, Carboniferous strata in North America have been identified successfully on the basis of representatives of the Schistoceratidae, for example *Brannero-*

ceras, *Diaboloceras*, and *Paralegoceras*, but these genera are particularly rare in Europe, especially in regions accommodating Coal Measures where standard successions have been developed.

Problems in Intercontinental Correlation

The ages of Carboniferous formations in the Canadian Arctic are presented in terms of American and European Stages and are compared with formations of comparable age elsewhere in North America and in Spitzbergen. Since correlations between standard American successions and European stages are refined only moderately, particularly in the Namurian–Westphalian interval, which includes most of the ammonoids described here, some pertinent problems are reviewed.

In Western Europe, where the type Carboniferous is defined, the System is separated into two series. The Lower Carboniferous (Dinantian) includes widespread 'shelf' carbonates and 'basinal' shales and contains the "Strunian," Tournaisian, and Viséan Stages. The Upper Carboniferous (Silesian) includes extensive coal measures as well as marine limestones, shales and sandstones, and contains the Namurian, Westphalian, and Stephanian Stages. Dinantian, Namurian, and Westphalian stratigraphy in Great Britain have been reviewed recently by George (1969), Ramsbottom (1969b), and Calver (1969), respectively. In Eastern Europe (Soviet Union), marine strata are generally more prevalent than in Western Europe, and the Carboniferous is divided into three series: the lower contains the Tournaisian, Viséan, and Namurian Stages; the middle, the Bashkirian (or Kayalian), and Moscovian Stages; and, the upper, the Zhigulevian (or Gzhelian), and Orenburgian Stages. Eastern European stages have been reviewed by Ruzhencev (1950) and Ruzhencev and Bogoslovskaya (1971b).

In North America, the Carboniferous is represented by the Mississippian and Pennsylvanian Systems which, in their respective type areas, are separated from each other by a regional unconformity. The Lower Mississippian is divided into two provincial series: the Kinderhookian and Osagian, while the Upper Mississippian is divided into the Meramecian and Chesteran Series. The Pennsylvanian is divided into three series: the Lower Pennsylvanian contains a single provincial series, the Morrowan; the Middle Pennsylvanian contains two provincial series, the Atokan and Desmoinesian; and the Upper Pennsylvanian is divided into the Missourian and Virgilian. A review of the Carboniferous of North America and a generalized correlation between North America and Europe was presented recently by Wanless (1969). More detailed correlations over specific intervals of the Carboniferous have been made by Lane (1967), Mamet and Skipp (1970), and Furnish and Saunders (1971).

As has been pointed out already, correlation between the standard successions of Europe and North America is not yet firmly established, particularly in the Namurian–Westphalian interval. Furthermore, there is little general agreement among Europeans concerning the relationships of stage boundaries between the Western European and Soviet schemes. For purposes of this report, ammonoids are discussed generally in terms of American Stages and counterparts in the Ural Mountains and Moscow Basin. Less well known but more complete marine Carboniferous sequences, however, may occur in other parts of the Soviet Union and eventually may serve as satisfactory references—for example, the sequences in the Donetz Basin of the Ukraine and the Sette Daban region in Verkhoyan, in the Soviet Arctic.

Since the oldest rocks in the Sverdrup Basin are Viséan nonmarine, deltaic, and lacustrine sequences and hence are devoid of ammonoids, they are not of concern in terms of international correlation in the present study. Ammonoids of Namurian and Westphalian ages are common in the basin, whereas only a single ammonoid of Stephanian (Missourian) age is known (Textfig. 3a).

During the Heerlen Carboniferous Congresses of 1927 and 1935, the Namurian was divided into three parts (A, B, C) and the Westphalian into four parts (A, B, C, D). The lower boundary of the Namurian was selected to coincide with the base of the *Eumorphoceras pseudobilingue* species zone (E_1b). At the fourth Heerlen Congress in 1958, the boundary was placed slightly lower to include the species zone of *Cravenoceras leion* (E_1a). Ruzhencev and Bogoslovskaya (1971b) indicated that *Eumorphoceras* was generally unacceptable for purposes of determining the base of the Namurian because of its absence in many parts of the globe, particularly in the Ural and Mediterranean basins. The latter Soviet authors (ibid.) considered the more cosmopolitan *Cravenoceras leion* to be a more acceptable index than *Eumorphoceras pseudobilingue* to mark the boundary, but proposed to lower the base of the Namurian even further to include the P_2 beds of the Viséan which coincide with the initial emergence of the Cravenoceratidae and hence the superfamily Neoglyphioceratacea. Ruzhencev and Bogoslovskaya's proposal would necessitate transferring their genozone *Hypergoniatites–Ferganoceras* from the Viséan to the Namurian.

The top of the Namurian in Western Europe is drawn at the base of the marine band containing *Gastrioceras subcrenatum* (Frech), which is within genozone G or the Halifaxian beds of Bisat (1928). According to Hodson (1957), and Ramsbottom (1969b), genozone G has been subdivided subsequently into a lower zone, G_1 (Namurian-C), and a higher zone, G_2 (Westphalian-A). Zone G_1 includes the species zones G_1a—*Gastrioceras cancellatum* Bisat and G_1b—*Gastrioceras cumbriense* Bisat, whereas G_2 includes the species zones G_2a—*Gastrioceras subcrenatum* (Frech) and G_2b—*Gastrioceras listeri* (Sowerby).

In Eastern Europe, the Namurian Stage is succeeded by the Bashkirian, which is defined at a stratotype in the southern Urals. The base of the Bashkirian coincides with the base of Namurian-C according to some Soviet authors, and with the base of Namurian-B according to others, whereas the top of the Bashkirian coincides with the top of Westphalian-A. Ruzhencev and Bogoslovskaya (1969b, 1971b) abandoned the Bashkirian in favour of the Kayalian Stage, which was defined by Rotai (1957) and is based on a stratotype in the Donetz Basin in the Ukraine. According to these authors, the base of the Kayalian coincides with the top of Namurian-C and extends up to the base of the Moscovian; that is, it includes Westphalian-A and -B. In a subsequent part of this report it will be seen that some European authors consider part of Westphalian-A as well as Westphalian-B to be equivalent to Moscovian. The opinion that the Bashkirian should be either abandoned or redefined was expressed also by Ektova (1969) who studied fusulinids in the interval between the Namurian and Moscovian in Tien Shan, Central Asia. On the basis of these studies, Ektova (ibid.) suggested that a prominent hiatus is apparent in the upper part of the type Bashkirian. According to Mamet and Armstrong (1972), a single foraminiferal zone (Zone 20), characterized by the appearance of the *Lipinella–Millerella* sensu stricto assemblage, occurs in the type Bashkirian (Textfig. 3). It is not yet precisely clear, however, whether Zone 20 occurs in upper Namurian or lower Westphalian strata in Western Europe.

It is generally agreed that the base of the Moscovian is equivalent to the base of the Atokan in North America (Ruzhencev and Bogoslovskaya, 1971b; Thompson, 1964) but the position of the base of the Moscovian in terms of Western European stratigraphy appears somewhat more conjectural. According to Aisenverg *et al.* (1960) and Stepanov *et al.* (1962), Moscovian strata in the Soviet Union contain the equivalents of Westphalian-C and -D in Western Europe. A completely different point of view has been expressed recently by Moore *et al.* (1971) who reported a Westphalian-B spore flora associated with an upper lower Moscovian (Kashirian) foraminiferal assemblage in Spain and suggested that the base of the Moscovian probably extends downward to the upper part of Westphalian-A or basal Westphalian-B. Similar correlations were expressed earlier by Winkler-Prins (1968). If this contention is correct, then the Kayalian Stage has little basis for recognition. The question of the correlation of the Moscovian in the Soviet Union with Western Europe and North America is complicated by the fact that in the type area, within the Moscow Basin, a single type section has not been designated formally to serve as a standard reference.

According to Mamet (pers. com.), foraminiferal Zone 21 (Mamet and Armstrong, 1972) occurs near the base of the type Atokan in Oklahoma and slightly above the base of the Moscovian in the Moscow Basin. Foraminiferal Zone 22 occurs near the top of the Atokan (Textfig. 3). Brazhnikova *et al.* (1967) studied foraminifers in the Dnieper–Donetz region in the Ukraine and included foraminiferal assemblages that characterize Zones 21 and 22 within the Bashkirian. This interpretation would elevate the base of the Moscovian and hence place the entire Atokan series within the Kayalian (or Bashkirian) Stage. This viewpoint is unacceptable considering not only the above interpretation of Mamet, but also the fact that *Fusulinella*, generally considered a Moscovian index, is known from Atokan strata in Arkansas where it is associated with the ammonoid index *Winslowoceras* (Henbest, pers. com. in 1968). It is hoped that this fusulinacean eventually will be described and compared with species in the Moscow Basin.

In the genozone scheme introduced by Ruzhencev and Bogoslovskaya (1969b, 1971b), the British superzones R_2 and G_1, which occur in Namurian-B and -C respectively, are combined into a single genozone *Bilinguites–Cancelloceras*, the youngest Namurian genozone. In Britain, typical *Bilinguites superbilingue* occurs in R_2c, G_1a, and G_1b beds, whereas *Cancelloceras* (type, *Gastrioceras cancellatum*) is confined to G_1b beds.

Many of the Morrowan, Atokan, and Desmoinesian ammonoids, as well as the single Missourian species known from the Canadian Arctic, can be identified closely with species that occur in the Midcontinent region of Arkansas and Oklahoma or in West Texas. The oldest ammonoid from the area, however, *Cravenoceras tozeri* n. sp., bears only a superficial resemblance to American species. It more closely resembles *Cravenoceras beleutense evolutum* Ruzhencev and Bogoslovskaya (1971b) from lower Namurian Nm_1b_2 (E_2) strata in the southern Urals, and *Cravenoceras africanum* Delépine from E_2 strata in Algeria and Morocco.

Throughout the American Midcontinent a prominent hiatus occurs between Mississippian and Pennsylvanian strata, and it is thought generally that much of Bisat's (1924) original *Homoceras* Zone H (Chokerian H_1 and Alportion H_2 stages of Hodson, 1957) is absent because of it. Furnish and Saunders (1971), however, implied that lower Chokerian ammonoids may occur near the top of the Imo Formation in Arkansas, which is mainly E_2 in age. *Homoceras* is not known from North America despite the contentions of Elias (1970), who identified a probable cravenoceratid from the Goddard Formation in Oklahoma as "*Homoceras*" sp. G. According to Mamet *et al.* (1971), foraminiferal Zone 19, which is characterized by *Eosigmoilina*? and which represents the time equivalent of *Homoceras* Zone H, occurs in the Surrett Canyon Formation in south–central Idaho. According to Mamet and Armstrong (1972), Zone 19 has been identified also in the Indian Springs Formation in Nevada, and from localities in the Saddlerochit Mountains in Alaska. Mamet has also recognized Zone 19 fossils in the Nansen Formation on Ellesmere Island (*see* Mamet in Appendix).

Ammonoids from the Otto Fiord Formation in Arctic Canada resemble species that have been described from the Hale and Bloyd Formations in the Morrowan Series of Arkansas. Furnish and Saunders (1971) designated the Halian and Bloydian Stages for the latter formations. According to Furnish and Saunders (ibid.), the Halian equivalents in Europe are the Kinderscoutian (R_1) and Marsdenian (R_2) Stages, and the Bloydian is equivalent to the Yeadonian (G_1) Stage. Ruzhencev and Bogoslovskaya (1971b) summarized published data on ammonoids from both the Hale and Bloyd Formations and concluded that the Hale contains equivalents of R_1c, R_2 and G_1 Zones and that the Bloyd is equivalent to G_2 (Westphalian-A) in Western Europe and the Kayalian in Eastern Europe. The base of the Kayalian is marked by the *Branneroceras–Gastrioceras* genozone of these authors.

A completely different and, in the writer's opinion, incorrect point of view was expressed by Gordon (1970), who correlated the Hale Formation with the R_1 and H Zones in Europe, and the lower part of the Bloyd Formation (which contains *Branneroceras branneri*) with the R_2 Zone. Gordon (ibid.) included *Branneroceras branneri* in the R_2 Zone because of the presence of "*Branneroceras*" *branneroides* and other early *Gastrioceras* species in R_2 strata in England. Clearly Gordon does not recognize either *Retites* McCaleb, which characterizes the Halian, or *Cancelloceras* Ruzhencev and Bogoslovskaya, which typically occurs in G_1 strata in England, for he places the former in synonymy with *Branneroceras* and considers the latter to be an early *Gastrioceras*. Both *Retites* and *Cancelloceras* are discussed in the taxonomic part of this report relative to discussions of *Gastrioceras* and *Branneroceras*.

In general, disagreement concerning correlation between Namurian strata in Western Europe and Morrowan strata in North America results from the fact that the sequence of *Gastrioceras* zones recognized in Western Europe has not been recognized in North America. Whereas a number of *Gastrioceras* species are known to occur in sequences in the southern American Midcontinent, these have not yet been seriously analyzed. It seems clear that minimal paleontological effort has been expended toward recovery of Carboniferous fossils from coal basins in the eastern United States, but in recent years some important discoveries have been made. Furnish and Knapp (1966) briefly summarized age relationships between the Eastern Interior and the Midcontinent and suggested that *Gastrioceras occidentale*, which they described from Pottsvillian coal measures in Eastern Kentucky (Breathitt Formation), "fall in the group of *G. subcrenatum*" which defines the base of Westphalian-A. Eager (1970) illustrated *Gastrioceras* aff. *G. subcrenatum*, identical to *G. occidentale*, from coal measures in southeastern Kentucky and similarly applied a Westphalian-A age to strata containing it in the Hance Formation.

New and important data concerning the problem of correlation between the American Midcontinent and Europe were provided by Moore *et al.* (1971), who reported the occurrence of both *Retites semiretia* and *Branneroceras branneri* from northwestern Spain; both species are associated with miospores. They also indicated that spores in the *Retites semiretia* band indicate an upper Namurian-B, Marsdenian (R_2) age and those associated with *Branneroceras branneri* a basal Westphalian-A age. The procedure in this report follows that employed by Moore *et al.* (ibid.) and by Ruzhencev and Bogoslovskaya (1971b); that is, *Branneroceras branneri* is used to indicate the base of Westphalian-A (G_2) and the base of Kayalian.

According to Rotai (1957), the upper boundary of the Kayalian extends up to the base of the Moscovian; that is, to the base of Westphalian-C. Ruzhencev and Bogoslovskaya (1971b) included the *Diaboloceras–Winslowoceras* genozone in the upper part of the Kayalian. *Winslowoceras*, which is absent from the Soviet Union, occurs typically in the "Winslow" Formation in Arkansas where it is directly associated with *Fusulinella*. Ruzhencev and Bogoslovskaya's opinion that *Winslowoceras* belongs in the Kayalian appears to stem from McCaleb's (1968) contentions that the "Winslow" is equivalent to Westphalian-B strata in Europe. McCaleb (ibid.), however, did not express any reasons for this correlation. There is little doubt that the Winslow Formation is in the main equivalent to the Atokan, but it is entirely possible that the lower part of the Winslow, that is, the succession below *Fusulinella* and *Winslowoceras*, predates the Atokan. An excellent summary of Atokan relationships in North America was presented by Strimple and Watkins (1969) who supported the contention that the "Winslow" is entirely equivalent to the Atokan. It is clear that additional research is required to answer perplexing questions concerning relationships of the "Winslow" Formation but, for purposes of this report, *Winslowoceras* is considered to represent an Atokan (Moscovian) age.

Previous Studies of Carboniferous Chronostratigraphy in the Sverdrup Basin

The study of upper Paleozoic rocks and fossils in the Canadian Arctic Archipelago dates back at least to 1852, to collections assembled by members of British expeditions sent in search of Captain Sir John Franklin, lost with all hands between 1846 and 1848. Of particular significance are the geological observations and collections made by parties of Captain Sir Edward Belcher on Grinnell Peninsula, Devon Island, and of Commander Leopold M'Clintock on Melville Island. Excellent documentations of the geological achievements of Belcher and M'Clintock have been entered into the literature by Harker and Thorsteinsson (1960), Thorsteinsson (1963), and Tozer and Thorsteinsson (1964). Fossils collected by Belcher from near Lyall River on Grinnell Peninsula were described by J. W. Salter in an appendix to Belcher's report (Belcher, 1855, p. 377); he considered them to be of Carboniferous age. Harker and Thorsteinsson (1960) re-examined some of Salter's materials in the course of describing their own collections from the Belcher Channel and Assistance Formations on Grinnell Peninsula and found them to be Permian. In a similar manner, Haughton (1857, 1859), utilizing reports and specimens of M'Clintock, recorded the occurrence of "Carboniferous Limestones" and "Lower Carboniferous Sandstones" on Melville Island. Tozer and Thorsteinsson (1964) indicated that Haughton's "Lower Carboniferous Sandstone" is now known to be Devonian and his "Carboniferous Limestone" to be of Permian age.

Additional references to Carboniferous strata in the Arctic Archipelago have been made by several authors based on collections assembled from northeastern Ellesmere Island by members of Feilden's 1875 expedition and Peary's 1905–1906 expedition. Most Carboniferous citations have been proven to be Permian by subsequent workers. Some doubt still exists amongst specialists, however, as to whether certain of the early collections, which include mainly brachiopods and corals, are indicative of a Late Carboniferous or an Early Permian age.

Feilden and De Rance (1878) applied the name Dana Bay to a group of rocks on Feilden Peninsula on the north coast of Ellesmere Island. From these rocks Feilden had earlier (in 1875) collected fossils that were identified as Devonian by Etheridge (1878). Holtedahl (1924), on the other hand, indicated that the collection was of Carboniferous age. Similarly, Weller *et al.* (1948) suggested that some of the fossils listed by Feilden and De Rance (ibid.) may be Mississippian. Marine uppermost Mississippian rocks are known elsewhere in axial regions of the basin but they have never been recognized adjacent to the basin edge as at Feilden Peninsula. Fossils collected from the Dana Bay beds by Blackadar in 1953 were examined by Harker (*in* Blackadar, 1954), who favoured a Permian age but did not discount fully the possibility of a Late Carboniferous age. Blackadar (1954) described the Guide Hill and the Feilden Groups for conglomerates and limestones, respectively, in the vicinity of Feilden Peninsula. In all probability, the Guide Hill Group is equivalent to the Canyon Fiord Formation (Troelson, 1950) and the Feilden Group to the Belcher Channel Formation (Harker and Thorsteinsson, 1960).

Fossils collected by Feilden from the Feilden Group were identified as Carboniferous by Etheridge (1878), Tschernyschew (1902), and Grönwall (1917). Holtedahl (1924) and Harker (*in* Blackadar, 1954) indicated a probable Permian age for these fossils. Whitfield (1908) examined collections purported to have been collected from Cape Sheridan, east of Feilden

Peninsula, by members of Peary's 1905–1906 expedition, and reported a Late Carboniferous age. According to Whitfield (ibid.), the Cape Sheridan fossils are similar to specimens collected by Feilden from the Feilden Group on Feilden Peninsula. The precise locality of Peary's collection is uncertain, for Blackadar (1954) visited Cape Sheridan on several occasions but was unable to locate upper Paleozoic rocks of any description. A similar investigation with comparable results was carried out in 1965 by Christie (pers. com. in 1972). Whitfield's fossil plates have been examined recently by Carter, who suggests that the brachiopods are of either very Late Carboniferous or Early Permian age (Carter, pers. com. in 1971).

Nearly a century after the upper Paleozoic discoveries of Belcher and M'Clintock, the first unequivocal documentation of Carboniferous rocks from the Arctic Archipelago appeared in the literature. Troelson (1950) correlated the Canyon Fiord Formation on Cañon Fiord, Ellesmere Island with the Upper Carboniferous Moscovian Series (Middle Pennsylvanian) on the basis of fusulinaceans that he had collected while serving as geologist to the Danish Thule and Ellesmerelands Expedition, 1939 to 1941. Whereas Troelson is generally credited for the first recognition of Late Carboniferous fossils, the first authentic documentation of Lower Carboniferous rocks in the Archipelago was by Kerr and Trettin (1962). Those authors reported the occurrence of Mississippian spores from nonmarine shales, now included in the Emma Fiord Formation, on Axel Heiberg Island. The spores were identified for Kerr and Trettin in an unpublished Geological Survey of Canada report by Playford, Hueber, and Barss in 1962. The composition and age of the flora were subsequently published by Playford and Barss (1963).

In 1956, Christie collected fossils from a sequence of limestone, equivalent to the Nansen Formation, on Ward Hunt Island, just off the north coast of Ellesmere Island between Cape Nares and M'Clintock Inlet. In these collections, Harker (*in* Christie, 1957, 1964) identified Late Carboniferous brachiopods ("*Choristites fritschi* fauna") and suggested a correlation with the Lower Marine Group (of Grönwall, 1917) of northeastern Greenland and with part of the *Cyathophyllum* Limestone of Spitzbergen. Ross and Dunbar (1962) described 15 Moscovian (Middle Pennsylvanian) fusulinacean species from the Lower Marine Group in Greenland. Similarly, Moscovian and younger Carboniferous strata are known to occur in the *Cyathophyllum* Limestone. Thompson (1961) identified Carboniferous fusulinaceans from probable Nansen strata on Ward Hunt Island and suggested a correlation with the middle part of the Desmoinesian Series (Middle Pennsylvanian) in the American Midcontinent. One year earlier, Thorsteinsson and Tozer (1960) documented the occurrence of the Middle Pennsylvanian fusulinacean *Profusulinella* in strata on Axel Heiberg Island that Thorsteinsson later (1970) referred to the Hare Fiord Formation.

In 1957 and 1961, Thorsteinsson discovered ammonoids in the Hare Fiord Formation of Ellesmere and Axel Heiberg Islands and these were identified by W. M. Furnish and Brian F. Glenister, at the University of Iowa in 1962, as species that range through both the Lower and Middle Pennsylvanian. Also in 1961, Thorsteinsson discovered Moscovian fusulinaceans in the Blue Mountains of northern Ellesmere Island within a reefoid member of the Hare Fiord Formation. This member was designated informally the "Tellevak Limestone" by Bonham-Carter, who studied it as the subject of a Ph.D. dissertation in 1963 (Bonham-Carter, 1966, 1967). During 1963, Bonham-Carter discovered additional Moscovian fusulinaceans as well as ammonoids in the Tellvak Limestone. The fusulinaceans were identified for him by Thorsteinsson and the ammonoids by the present writer. Additional documentation of Moscovian ammonoids in the Hare Fiord Formation of Ellesmere Island was provided by Nassichuk (1965, 1967a) and by Nassichuk and Furnish (1965). A Late Pennsylvanian ammonoid was described from the Nansen Formation on Ellesmere Island by Nassichuk (1969).

Tozer and Thorsteinsson (1964) recorded lower and upper Moscovian strata (Atokan and Desmoinesian) in the Canyon Fiord Formation of Melville Island. According to these authors, Atokan strata on Melville Island are characterized by the fusulinacean *Profusulinella* and the brachiopod *Choristites*, and Desmoinesian strata by *Fusulina* and *Fusulinella*.

Hoen (1964) reported the discovery of a number of brachiopods and ammonoids in a limestone inclusion within "South Fiord Dome", an evaporite piercement structure, on western Axel Heiberg Island. The ammonoids were identified for Hoen by Furnish and Glenister, who provided a middle Namurian (Early Pennsylvanian) age. The present writer (1968) reported additional Early Pennsylvanian (middle Namurian and Bashkirian) ammonoids from Barrow Dome on Sabine Peninsula, Melville Island.

Trettin (1969) designated a sequence of Carboniferous rocks at M'Clintock Inlet, northern Ellesmere Island as "Map-unit 10." From this unit, fossils were identified in unpublished Geological Survey of Canada reports for Trettin as follows: plants by the late W. A. Bell as "Pennsylvanian (Westphalian);" spores by Barss as "Pennsylvanian;" ostracodes by Copeland as "Middle Pennsylvanian (Westphalian-C and-D);" fusulinaceans by Thorsteinsson as "Middle Pennsylvanian (Moscovian);" and other calcareous foraminifers by Mamet as "Middle Pennsylvanian (Moscovian)."

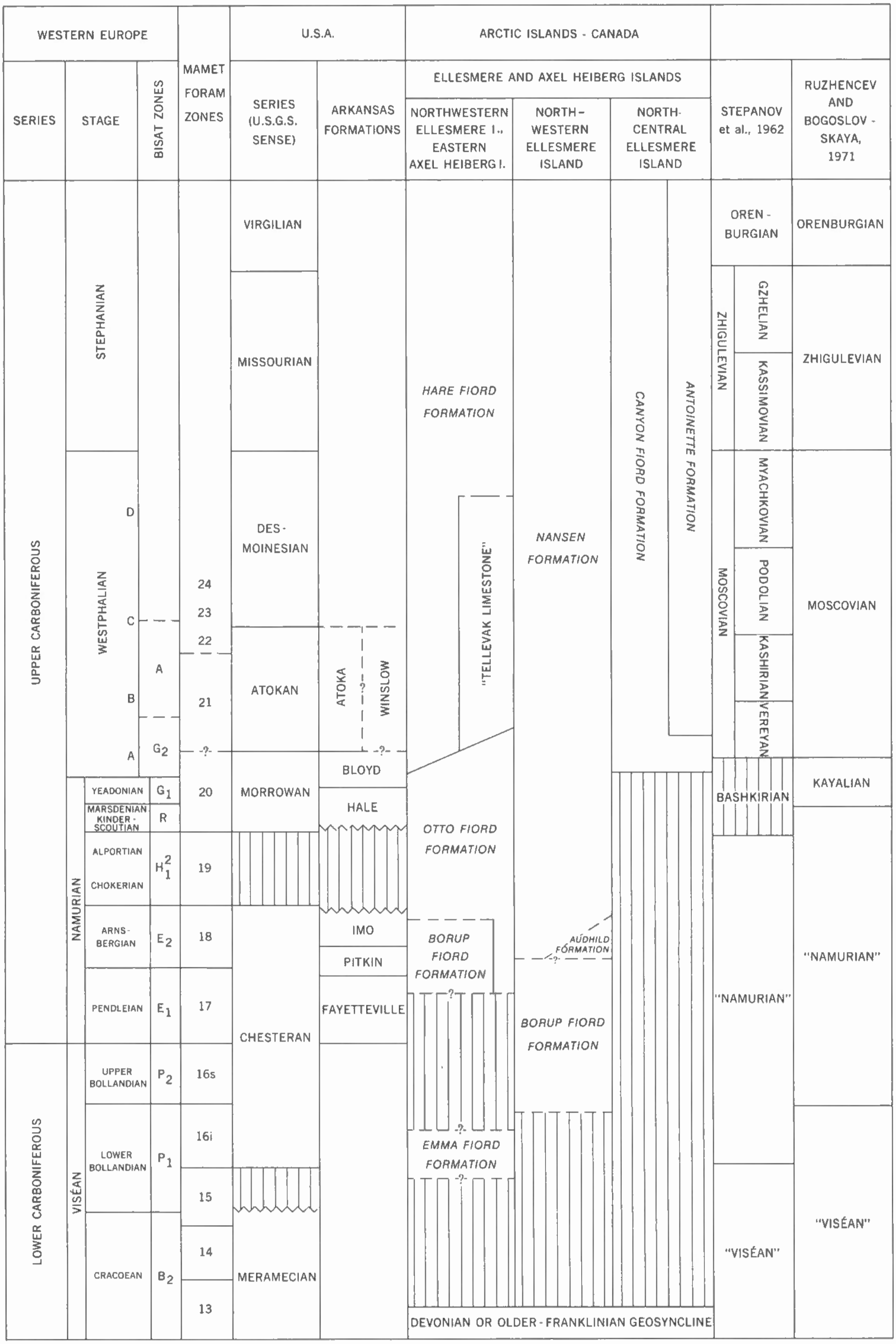
By far the most intensive Carboniferous studies in the Sverdrup Basin have been completed by Thorsteinsson, who has established an important stratigraphic and sedimentological framework of Carboniferous strata. Some of the key fusulinaceans which identify specific Carboniferous zones in the basin were listed by Thorsteinsson (1970, p. 569) but a far more comprehensive review of Carboniferous biostratigraphy has subsequently been prepared by him (Thorsteinsson, 1974). Incorporated in the latter report are important identifications of calcareous foraminifers by Mamet, who recognized lower Namurian (Upper Mississippian) marine strata in the Borup Fiord Formation. Recently Mamet (*see* Appendix) has identified an identical fauna from the base of the type Nansen Formation on Ellesmere Island.

Ages and Correlation of Arctic Carboniferous Formations

Particular attention is given in this report to the age relationships of four formations that have yielded Carboniferous ammonoids in the Sverdrup Basin—the Otto Fiord, Hare Fiord, Nansen, and Canyon Fiord Formations. For completeness, however, a brief summary of the age of the remaining Carboniferous formations in the basin is provided: that is, the Emma Fiord, Borup Fiord, Audhild, and Antoinette Formations (Textfig. 3). The Hare Fiord, Nansen, and, in some places, the Canyon Fiord Formations contain Lower Permian as well as Carboniferous strata. Much of the Permian age data on these formations was derived from Thorsteinsson (1970, 1974), who examined fusulinaceans from these units while studying the stratigraphy of Carboniferous and Permian formations on much of Ellesmere and Axel Heiberg Islands.

Emma Fiord Formation

Playford and Barss (1963) identified 19 spore species from a single sample in the formation from the Svartevaeg Cliffs on northern Axel Heiberg Island and commented: "the microfloral evidence clearly suggests that Arctic Canada formed part of an extensive floral province which also embraced Spitzbergen and the Soviet Union during Viséan times." The late Walter Bell reported the identification of the plant *Cardiopteris abbensis* Read in an



TEXTFIGURE 3. Correlation chart showing relationships between Carboniferous formations in the Arctic Islands and standard successions in the Midcontinent and Europe.

unpublished Geological Survey of Canada report and also suggested a Viséan age. As stated previously, the Emma Fiord Formation appears equivalent to the Culm beds in Spitzbergen, which consist mainly of nonmarine shale and sandstone. Additionally, the Emma Fiord can be correlated with the Kayak Formation in the Brooks Range in Alaska (Bowsher and Dutro, 1957) and in northern Yukon (Bamber and Waterhouse, 1971). Viséan strata are known also from the Calico Bluff Formation and the Alapah Limestone in the Brooks Range in Alaska, from the Alapah Limestone and the Hart River Formation as well as "Unit 1" (Bamber and Waterhouse, 1971) in the Yukon Territory, and from the Prophet, Mattson, Debolt, and Rundle Formations in northeastern British Columbia.

Borup Fiord Formation

The lower part of the Borup Fiord Formation is devoid of fossils and its age is unknown. Limestone recovered from near the top of the formation in the type area, however, contains an abundant fauna of calcareous foraminifers. The fauna was dated as early Namurian (Upper Mississippian Zone 18) by Mamet (*in* Thorsteinsson, *in press*). Zone 18, which has been defined by Mamet and Skipp (1971) and by Mamet and Armstrong (1972), is equivalent to the upper *Eumorphoceras* Zone in Britain. Comparable Zone 18 faunas have been identified by Mamet (*see* Appendix) from the base of the type section of the Nansen Formation east of the head of Hare Fiord, and from the base of the Otto Fiord Formation in the same general area. Green-weathering conglomerate and sandstone near the top of the Culm beds in Spitzbergen have not been dated precisely but probably are equivalent to part of the Borup Fiord Formation. Mamet and Armstrong (1972) reported Zone 18 foraminifers from the Kogruk Formation and Alapah Limestone in the Lisburne Group in northern Alaska. Mamet (*in* Bamber and Waterhouse, 1971) documented the occurrence of similar faunas in the Alapah Limestone and Ettrain Formation in northern Yukon Territory.

Audhild Formation

This formation consists of volcanic rocks and is intercalated between the Borup Fiord and Nansen Formations on Kleybolte Peninsula, northwestern Ellesmere Island. Because of its stratigraphic position it is thought to be of either Namurian or Kayalian age.

Otto Fiord Formation

In the type area, the formation is mainly of Morrowan, that is Kayalian (Zone 20) age but slightly younger Atokan, that is Moscovian (Zone 21) strata may also be present. Elsewhere it is known to contain strata as old as early Namurian [lower *Eumorphoceras* Zone (E_1)], and as young as lower Moscovian (Zone 22). The only ammonoids known from the type section of the Otto Fiord Formation are *Branneroceras branneri* (Smith) and *Gastrioceras* sp. and both indicate an upper Morrowan (Bloydian), that is, Kayalian age. Mamet (*see* Appendix) has identified calcareous foraminifers and algae from the type area that are mainly Morrowan (Zone 20) but also possibly as young as early Atokan (Zone 21). Similarly conodonts identified by Bender (*see* Appendix) indicate a Morrowan (Bloydian) age.

The oldest fossils known from the Otto Fiord Formation occur in limestone and shale blocks enveloped in anhydrite at Barrow Dome on Melville Island. Carter (*see* Appendix) identified early Namurian [lower *Eumorphoceras* Zone (E_1)] brachiopods from these blocks which he considered to be equivalent to the Fayetteville Formation in Arkansas. Thus, the oldest fossils known from the Otto Fiord Formation occur near the southern limit of the Basinal Clastic and Evaporitic Belt. The youngest fossils from the formation occur on the eastern side of the belt near Wood Glacier, in the Krieger Mountains on northern Ellesmere Island. Early Moscovian (Atokan) fusulinaceans and other calcareous foraminifers have been recovered from limestone interbedded with anhydrite near the top of the formation in this area. Ross (*see* Appendix) identified *Pseudostaffella gorskyi* (Dutkevich) and *Eostaffella kashira* var. *rhomboides* Rauser and assigned an early Moscovian (Kashirian) age. Mamet (*see* Appendix) identified a variety of calcareous foraminifers and algae from the same general horizon which he placed in his Zone 22 (Atokan). The Bloydian (Kayalian) ammonoid *Branneroceras branneri* occurs several hundred feet below this Moscovian calcareous foraminiferal horizon.

It is clear from these data that the Otto Fiord Formation shows a diachroneity from the type area on the western side of the Basinal Clastic and Evaporitic Belt to the Krieger Mountains near the eastern edge of the belt. Otto Fiord evaporites still were being deposited in some regions in the Krieger Mountains while Hare Fiord siltstones were being deposited in the west. A comparable diachroneity across the Basinal Clastic and Evaporitic Belt also is apparent in the younger Hare Fiord Formation.

The Otto Fiord Formation grades laterally into the Nansen Formation but, also, the base of the Otto Fiord interfingers locally with the upper part of the Borup Fiord Formation. Equivalents of the lower part of the Otto Fiord Formation, that is, Zone 18 (E_2), occur in the Lisburne Group in Alaska and the Yukon Territory and in the Ettrain Formation in northern Yukon. Similarly, fusulinaceans and smaller foraminifers in the upper part of the Otto Fiord, that is those representing Zones 20, 21, 22 ("Bashkirian"–Moscovian), have been identified in the Lisburne Group in both Alaska and the Yukon Territory and in the Hart River Formation in the Yukon (Bamber and Waterhouse, 1971).

The Ebbadalen Formation, formerly part of the Lower Gypsiferous Series in Spitzbergen, is equivalent to the Otto Fiord Formation. According to Holliday and Cutbill (1972), the Ebbadalen Formation has yielded the fusulinaceans *Pseudostaffella sphaeroidea* (Ehrenburg), *Pseudostaffella antiqua* Dutkevich and *Profusulinella* cf. *P. prisca* (Deprat) and a variety of smaller calcareous foraminifers, including representatives of *Eostaffella*, *Millerella*, *Ozawainella*, and *Pseudoendothyra*. The formation is thought to range in age from Namurian to "Bashkirian."

Hare Fiord Formation

Ammonoids provide a definite early Moscovian (Atokan) age for strata about 90 feet above the base of the Hare Fiord Formation in the type section and 50 feet above the base along strike to the northeast near Stepanow Creek (Textfig. 10). The age of the lower 50 feet of strata can be expressed with less certainty; these strata comprise mainly siltstone and silty cherty limestone, which are sparsely fossiliferous. Bender (*see* Appendix) discovered the following conodonts 5 feet above the base of the type section:

Gnathodus ouachitensis (Harlton)
Idiognathodus cf. *I. claviformis* Gunnell
Hindeodella sp.
Metalonchodina bidentata (Gunnell)
Ligonodina sp.

According to Bender (ibid.), the fauna is practically identical with a late Morrowan (Bloydian) fauna from near the top of the underlying Otto Fiord Formation. One important difference, however, is the presence of *Idiognathodus* cf. *I. claviformis* in the basal Hare Fiord. This species is known to extend into Atokan strata elsewhere in North America. Thus, it appears that sedimentation in the transitional beds between Otto Fiord and Hare Fiord strata in the type area was continuous, and that the Morrowan–Atokan contact probably occurs in the basal beds; that is, the lower 10 or 20 feet of the type Hare Fiord Formation.

Stages and Provincial Series			Ammonoid Species	Formations and Occurrences
ZHIGULEVIAN	MISSOURIAN		*Parashumardites* sp.	NANSEN FORMATION (Ellesmere Island)
MOSCOVIAN	DESMOINESIAN		*Boesites* sp., *Metapronorites pseudotimorensis* (Miller), *Bisatoceras* sp., *Somoholites bamberi* n. sp.	CANYON FIORD FORMATION (Ellesmere Island)
MOSCOVIAN	DESMOINESIAN		*Gastrioceras glenisteri* n. sp., *Diaboloceras involutum* n. sp., *Bisatoceras* cf. *B. greenei* Miller and Owen	HARE FIORD FORMATION, NANSEN FORMATION (Ellesmere and Axel Heiberg Islands)
MOSCOVIAN	ATOKAN		*Boesites gracilis* n. sp., *Pseudopronorites arkansiensis* (Smith), *Metapronorites ellesmerensis* n. sp., *Maximites alexanderi* n. sp., *Neodimorphoceras sverdrupi* n. sp., *Gonioloboceratoides curvatus* n. gen., n. sp., *Proshumardites aequalis* n. sp., *Syngastrioceras smithwickense* (Plummer and Scott), *Syngastrioceras constrictum* n. sp., *Syngastrioceras orientale* (Yin), *Clistoceras globosum* Nassichuk, *Clistoceras* sp., *Neoglaphyrites bisulcatus* n. sp., *Neogastrioceras arcticum* n. gen., n. sp., *Bisatoceras kotti* n. sp., *Neoicoceras martini* n. sp., *Somoholites merriami* (Miller and Furnish), *Phaneroceras lenticulare* Plummer and Scott *Phaneroceras compressum* (Hyatt), *Diaboloceras neumeieri* Quinn and Carr *Diaboloceras involutum* n.sp., *Trettinoceras ellesmerensis* n.gen., n.sp., *Winslowoceras greelyi* n. sp., *Christioceras trifurcatum* Nassichuk and Furnish, *Stenopronorites sersoni* n. sp.	HARE FIORD FORMATION, NANSEN FORMATION (Ellesmere and Axel Heiberg Islands): CANYON FIORD FORMATION (Ellesmere Island)
KAYALIAN	MORROWAN	BLOYDIAN	*Branneroceras branneri* (Smith), *Branneroceras nicholasi* n. sp., *Branneroceras hillsi* n. sp., *Branneroceras* sp., *Bisatoceras renni* n. sp., *Gastrioceras melvillensis* n. sp., *Gastrioceras liratum* n. sp., *Gastrioceras* sp., *Melvilloceras sabinensis* n. gen., n. sp., *Syngastrioceras oblatum* (Miller and Moore)	OTTO FIORD FORMATION (Melville, Amund Ringnes, Ellef Ringnes, Ellesmere Islands)
NAMURIAN	MORROWAN	HALIAN	*Bilinguites canadensis* n. sp., *Bilinguites heibergensis* n. sp., *Bilinguites* sp., *Bisatoceras hoeni* n. sp.	OTTO FIORD FORMATION (Melville, Axel Heiberg Islands)
NAMURIAN / VISÉAN	CHESTERAN		*Cravenoceras tozeri* n. sp.	OTTO FIORD FORMATION (Melville Island)

TEXTFIGURE 3a. Stratigraphic distribution of Carboniferous ammonoid species in Arctic Canada.

Ammonoids recovered from 90 feet above the base of the type section of the Hare Fiord Formation at GSC locality 47867 include:

Metapronorites ellesmerensis n. sp.
Phaneroceras lenticulare Plummer and Scott
Syngastrioceras smithwickense (Plummer and Scott)
Diaboloceras involutum n. sp.

Typical representatives of *Phaneroceras lenticulare* and *Syngastrioceras smithwickense* occur in Atokan strata in north-central and West Texas, respectively, and also are known from Atokan strata in Arkansas and Oklahoma. Fifteen ammonoid species, from a comparable stratigraphic position about 100 feet above the base of the formation, were recovered from a bryozoan mound about 12 miles along strike to the east of the type section (GSC loc. 56430). Several species, including *Maximites alexanderi* n. sp., *Neodimorphoceras sverdrupi* n. sp., and *Gonioloboceratoides curvatus* n. gen., n. sp., indicate close affinities with younger (Desmoinesian) species in the American Midcontinent, but association of these species on Ellesmere Island with *Winslowoceras greelyi* n. sp. supports an Atokan age. From a collection made only a few feet stratigraphically above the latter collection, Mamet (pers. com. in 1973) identified the following calcareous foraminifers and assigned an early Moscovian age:

Ammovertella sp.
apterrinellids
Biseriella sp.
Beresella? sp.
Bradyina sp.
Calcitornella sp.
Endothyra sp.
Eotuberitina sp.
Tuberitina sp.
Volvotextularia sp.
Asteroarchaediscus sp.
Earlandia sp.
Eolasiodiscus sp.
Palaeotextularia sp.
Planoendothyra sp.
Planospirodiscus sp.
Tetrataxis of the group *T. angusta* Vissarionova

Late Pennsylvanian fossils have never been recovered from the type area of the Hare Fiord Formation. Less than 400 feet above the Moscovian ammonoids recovered from the type section, Ross (pers. com. in 1973) identified a variety of Early Permian (Asselian) fusulinaceans. Thus it appears that, if Upper Pennsylvanian (post-Moscovian) strata are present, they are disproportionately thin. Since there is no obvious evidence for subaerial erosion in the section, it is conceivable that the apparent hiatus may have been caused by lack of deposition in a starved basin. The youngest fossils known from the Hare Fiord Formation are ammonoids of early Artinskian age (Spinosa and Nassichuk, 1971).

Most of the Atokan ammonoid species that occur near the base of the Hare Fiord Formation on the west side of the Basinal Clastic and Evaporitic Belt, that is, on eastern Axel Heiberg Island (Textfig. 9) and in the vicinity of Hare Fiord on Ellesmere Island, occur also near the top of the Tellevak Limestone member of the Hare Fiord Formation on the east side of the Basinal Clastic and Evaporitic Belt in the southern Blue Mountains of northern Ellesmere Island (Textfig. 10). In the latter area, the ammonoid fauna is dominated by *Phanero-*

ceras lenticulare, *Diaboloceras involutum* n. sp., and *Stenopronorites sersoni*, and is considered to be either of an early Atokan age like those in the vicinity of Hare Fiord, or of slightly younger Atokan age. Mamet (pers. com. in 1973) identified the following fauna associated with *Diaboloceras involutum* n. sp. in the upper part of the Tellevak Limestone in the southern Blue Mountains and suggested an early Moscovian age:

apterrinellids
Asteroarchaediscus sp.
Calcitornella sp.
Diplosphaerina sp.
Endothyra sp.
Eolasiodiscus sp.
Eotuberitina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Neoarchaediscus sp.
Palaeonubecularia sp.
Planoendothyra sp.
primitive *Profusulinella* sp.
cf. *Sphaeroporella?* sp.
Tetrataxis sp.

Whereas the bryozoan mound which contains ammonoids at Hare Fiord has a maximum thickness of about 100 feet, contemporaneous bryozoan mounds in the southern Blue Mountains have a thickness of about 900 feet. Thus, geological conditions on the eastern side of the Basinal Clastic and Evaporitic Belt were more amenable to rapid carbonate deposition than on the western side.

Although the ammonoids and conodonts in the type section and those that occur near the top of the Tellevak Limestone in the southern Blue Mountains indicate an Atokan age, some peculiar differences in age are apparent for strata near the top of the Tellevak Limestone farther north in the Krieger Mountains (Textfig. 10). It was shown previously that, in the latter area, the Otto Fiord Formation underlying the Tellevak Limestone member of the Hare Fiord Formation is considerably younger than it is in the type area and was deposited contemporaneously with lower Moscovian (Atokan) strata in the type section of the Hare Fiord Formation. Not surprisingly, then, a comparable diachroneity is apparent also in the Hare Fiord Formation in the Krieger Mountains area. Whereas 12 Atokan ammonoid species were recovered from near the top of the Tellevak Limestone in the southern Blue Mountains, only two of these species were found in the Krieger Mountains where the Tellevak Limestone is about 900 feet thick. *Gastrioceras glenisteri* n. sp. and *Diaboloceras involutum* n. sp. were found 240 feet below the top of the "member" (GSC loc. C21750). The following fauna, which is associated with ammonoids at the latter locality, was identified by Mamet (pers. com. in 1973) as of Middle Moscovian (Desmoinesian) age:

Eotuberitina sp.
Climacammina sp.
Earlandia sp.
Endothyra sp.
cf. *Eoschubertella* sp.
Globivalvulina of the group *G. bulloides* (Brady)
Ozawainella sp.
Profusulinella sp.
staffellids

Ross (pers. com. in 1973) identified fusulinids from a lower locality in the same section and also suggested a Moscovian (Desmoinesian) age.

In conclusion, ammonoids that occur near the base of the Hare Fiord Formation in the type area, including *Winslowoceras greelyi* and *Christioceras trifurcatum*, are considered to be of early Atokan age. Those in the Tellevak Limestone in the southern Blue Mountains, on the other hand, including *Christioceras trifurcatum*, *Diaboloceras neumeieri*, *Diaboloceras involutum*, and *Neodimorphoceras sverdrupi*, are probably of slightly later Atokan age; *Winslowoceras* is absent from the southern Blue Mountains. *Gastrioceras glenisteri*, in association with *Diaboloceras involutum*, occurs farther north in the Krieger Mountains and is of early Desmoinesian age.

The Hare Fiord Formation grades laterally into the Nansen Formation on Ellesmere and Axel Heiberg Islands. Locally, in the Krieger Mountains on Ellesmere Island, the basal Hare Fiord Formation interfingers with the upper part of the Otto Fiord Formation.

The Hare Fiord Formation is equivalent to the Upper Carboniferous Passage Beds in Vestspitzbergen which lie between the Lower Gypsiferous Series below and the *Cyathophyllum* Limestone above. The Hare Fiord is equivalent also to the Wahoo Limestone in the Lisburne Group of Alaska and the northern Yukon, and to the upper part of the Hart River Formation, as well as the Ettrain Formation in the northern Yukon (Bamber and Waterhouse, 1971). Part of the Taku Group in the southern Yukon, containing undescribed species of *Neodimorphoceras*, *Phaneroceras*, and *Proshumardites* also is correlative with the Hare Fiord Formation.

Nansen Formation

The type section of the Nansen Formation contains 7,000 feet of limestone with small amounts of shale and rests on the Borup Fiord Formation. The formation ranges in age from early Late Carboniferous (early Namurian) to Early Permian. The lower 250 feet of the formation contains calcareous foraminifers identified by Mamet (*see* Appendix) as belonging to his Zone 18 (lower Namurian = upper Chesteran). Some 22 miles along strike to the west of the type section, Mamet (*in* Thorsteinsson, 1974) identified an identical Zone 18 fauna near the top of the Borup Fiord Formation. An identical fauna also occurs near the base of the Otto Fiord Formation 7 miles east of Girty Creek (Textfig. 10). It has long been recognized that the Otto Fiord Formation interfingers with the lower Nansen Formation in the type area (Thorsteinsson, 1970), but it has not been demonstrated previously that upper beds of the Borup Fiord Formation also interfinger locally with the basal Nansen. This phenomenon occurs rather subtly only a few miles west of Girty Creek.

Mamet (*see* Appendix) recognized a distinctive foraminiferal fauna (Zone 19) between 268 and 283 feet above the base of the type Nansen. According to Mamet (ibid.), Zone 19 is the equivalent of the *Homoceras* Zone (H_1) in Great Britain, which is generally absent on the American Midcontinent where a hiatus occurs between Chesteran and Morrowan strata.

The early Moscovian (Atokan) ammonoids *Phaneroceras* cf. *P. compressum* and *Somoholites merriami* occur 1,530 feet above the base of the type section. Strata immediately above this level in the type section have not yet been examined by the author for microfauna and so the presence or absence of Desmoinesian strata in the type Nansen must await additional research.

Missourian (Zhigulevian) and Virgilian (Orenburgian) strata have not yet been recognized in the type section of the Nansen Formation. However, the ammonoid *Parashumardites* sp. of Missourian age has been described from the Nansen Formation east of Stepanow Creek (Textfig. 10), about 20 miles west of the type section (Nassichuk, 1969).

The upper part of the type section of the Nansen Formation includes an abundance of the probable hydrozoan *Palaeoaplysina*, which forms extensive mounds. Elsewhere in the

Sverdrup Basin, *Palaeoaplysina* generally is confined to Lower Permian (Asselian) strata (Davies and Nassichuk, 1973) and presumably the same relationship applies in the Nansen Formation. The youngest fossils known from the Nansen Formation are fusulinaceans of early Artinskian age recovered from near the top of the formation west of Tanquary Fiord, northern Ellesmere Island (Thorsteinsson, pers. com., 1972).

Canyon Fiord Formation

Maximum thickness of the Canyon Fiord Formation is in the type area on Cañon Fiord where, according to Thorsteinsson (pers. com., 1972), a composite section approximately 5,500 feet thick occurs. Fossils within the formation, particularly fusulinaceans and other calcareous foraminifers, show a maximum age range in the type area also—Bashkirian (Zone 20 of Mamet) to Sakmarian (Thorsteinsson, 1974).

According to Thorsteinsson (1974):

> Fusulinaceans that indicate correlation with the Moscovian Series constitute some of the most abundant and widespread fossils in the formation and include such characteristic genera as *Profusulinella*, *Palaeofusulina*, and *Fusulina*.

The ammonoid *Phaneroceras compressum* (Hyatt), of early Moscovian (Atokan) age, occurs 150 feet above the base of the Canyon Fiord Formation north of Cañon Fiord on Hamilton Peninsula. Mamet (*in* Thorsteinsson, 1974) has identified Bashkirian (Zone 20) calcareous foraminifers 115 feet stratigraphically below *Phaneroceras compressum* in the same section. Fossils of a comparable early Moscovian (Atokan) age have been identified by Mamet (*see* Appendix) from localities in the Canyon Fiord Formation east of Blind Fiord on Raanes Peninsula, Ellesmere Island and northwest of M'Clintock Inlet, Melville Island.

The late Moscovian (Desmoinesian) ammonoids *Boesites* sp., *Metapronorites pseudotimorensis* (Miller), *Bisatoceras* sp., and *Somoholites bamberi* n. sp. have been recovered from a locality east of Blind Fiord, Ellesmere Island, 1,145 feet above the base of the Canyon Fiord Formation (mapped as Nansen Formation on GSC Map 1300A, *Eureka Sound South*, by Thorsteinsson, Kerr, and Tozer, 1972). Mamet (*see* Appendix) has identified a variety of calcareous foraminifers of Moscovian age directly associated with ammonoids at this locality. *Somoholites bamberi* is similar to *S. sagittarius* Saunders from Alleghenian strata in Ohio and equivalent (Desmoinesian) strata in Oklahoma.

Thorsteinsson (1974) documented the occurrence of Late Carboniferous (Zhigulevian) and Early Permian (Asselian or Sakmarian) fusulinaceans from the Canyon Fiord Formation but, to date, Orenburgian fossils are unknown from the formation.

Antoinette Formation

The present writer has no new data concerning the age of the Antoinette Formation. According to Thorsteinsson (1974) the Antoinette, which is the lateral equivalent of the Canyon Fiord Formation, contains a variety of fusulinaceans indicating the presence of Moscovian, Zhigulevian and/or Orenburgian, and possible Asselian strata.

CARBONIFEROUS AMMONOID LOCALITIES AND AGES

Carboniferous ammonoids described in this report are from Melville, Amund Ringnes, Ellef Ringnes, Axel Heiberg, and Ellesmere Islands. All occurrences on the first two islands and one of those on western Axel Heiberg Island are within evaporitic piercement structures in which Upper Mississippian and Lower Pennsylvanian strata occur as evaporite-enveloped blocks that were derived from the Otto Fiord Formation. Piercement structures that have yielded ammonoids on these islands have penetrated Jurassic and Cretaceous strata; thus, Carboniferous and Mesozoic rocks, normally separated by at least 10,000 feet of strata in axial regions of the basin, are in juxtaposition.

All ammonoid occurrences on eastern and northwestern Axel Heiberg Island and on Ellesmere Island are in normal stratigraphic successions. On eastern Axel Heiberg Island, Middle Pennsylvanian (Atokan) ammonoids occur in the Hare Fiord Formation whereas, on northwestern Axel Heiberg, species of the same age have been recovered from the Nansen Formation. By far the most numerous and taxonomically most diversified Carboniferous ammonoids in the Sverdrup Basin have been found on Ellesmere Island. Early Pennsylvanian (Morrowan) species have been recovered from the Otto Fiord Formation, early Middle Pennsylvanian (Atokan) species from the Hare Fiord, Nansen, and Canyon Fiord Formations, late Middle Pennsylvanian (Desmoinesian) species from the Hare Fiord and Canyon Fiord Formations and Late Pennsylvanian (Missourian) species from the Nansen Formation.

Melville Island

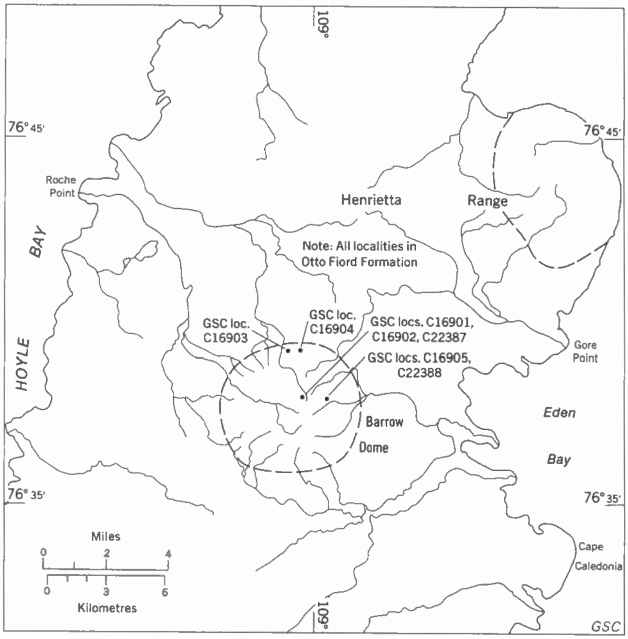
(Textfig. 4)

All Carboniferous ammonoid occurrences on Melville Island are from Barrow Dome, an evaporite piercement structure on northern Sabine Peninsula on the northeastern part of the island. Barrow Dome has an approximate diameter of 4 miles and an elevation of about 1,000 feet; relief is generally less than 200 feet. The dome is transected by numerous streams which form a radial drainage pattern. Within the dome numerous large "blocks" of strata, essentially comprising interbedded limestone, shale, and anhydrite, are separated from each other by contorted anhydrite. Some blocks of strata are nearly 500 feet thick and are laterally continuous for up to half a mile.

1. *GSC locality C16904* is on the northern rim of the dome 2.0 miles (brg. 07°) north of the centre of the dome (76°39′15″N, 109°02′30″W). The locality is 100 feet above the base of a sequence of interbedded black shale, black, thin-bedded limestone and anhydrite. The collection was assembled by the author in 1967.

Ammonoids at this locality include:

Cravenoceras tozeri n. sp.
age: Chesteran (early Namurian, E_2)



TEXTFIGURE 4

Ammonoid localities on northern Sabine Peninsula, Melville Island.

2. *GSC locality C16901* is 0.6 mile (brg. 45°) northeast of the centre of Barrow Dome (76° 38'N, 109°01'30''W). The locality occurs in a 15-foot sequence of thin-bedded, shale-like, dark grey limestone which is underlain by about 10 feet of anhydrite and is overlain by 60 feet of light grey shale interbedded with calcareous sandstone. The collection was assembled by the author in 1967.

Ammonoids at this locality include:

Bilinguites canadensis n. sp.
Bisatoceras hoeni n. sp.
age: Halian (late Namurian, R_2 or G_1)

3. *GSC locality C22386* is in the same stratigraphic horizon as the previous locality (GSC loc. C16901), but is approximately 300 feet farther east. The collection was assembled by geologists of BP Exploration Canada Limited in 1965.

Ammonoids at this locality include:

Bilinguites canadensis n. sp.
Bisatoceras hoeni n. sp.
age: Halian (late Namurian, R_2 or G_1)

4. *GSC locality C16902* is in the same location as, but 60 feet stratigraphically above, the Halian collection at GSC locality C16901. It occurs in light grey weathering interbeds of shale and calcareous sandstone. The collection was assembled by the author in 1967.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
Branneroceras nicholasi n. sp.
age: Bloydian (Westphalian-A = Kayalian)

5. *GSC locality C22387* is in the same stratigraphic horizon as GSC locality C16902, but approximately 500 feet along strike. The collection was assembled by J. C. Sproule and Associates of Calgary in 1961.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
Branneroceras nicholasi n. sp.
age: Bloydian (Westphalian-A = Kayalian)

6. *GSC locality C16903* is near the northern edge of Barrow Dome, 2 miles due north of the centre of the dome (76°39′15″N, 109°03′W). It occurs in thin-bedded, dark grey shaly limestone near the top of a 200-foot section of interbedded shale, limestone, and anhydrite. The collection as assembled by the author in 1967.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
Branneroceras hillsi n. sp.
Branneroceras sp.
Bisatoceras renni n. sp.
Gastrioceras melvillensis n. sp.
Gastrioceras liratum n. sp.
Gastrioceras sp.
Syngastrioceras oblatum (Miller and Moore)
age: Bloydian (Westphalian-A = Kayalian)

7. *GSC locality C16905* is 1.3 miles (brg. 71°) northeast of the centre of the dome (76°38′N 108°58′30″W). It occurs in shaly argillaceous limestone that is underlain by a sequence, about 200 feet thick, of interbedded shale, limestone, and anhydrite. The collection was assembled by the author in 1967.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
Branneroceras nicholasi n. sp.
Melvilloceras sabinensis n. gen., n. sp.
age: Bloydian (Westphalian-A = Kayalian)

8. *GSC locality C22388* is immediately adjacent to GSC locality C16905 and is in the same stratigraphic horizon. The collection was assembled by geologists of BP Exploration Canada Limited in 1965.

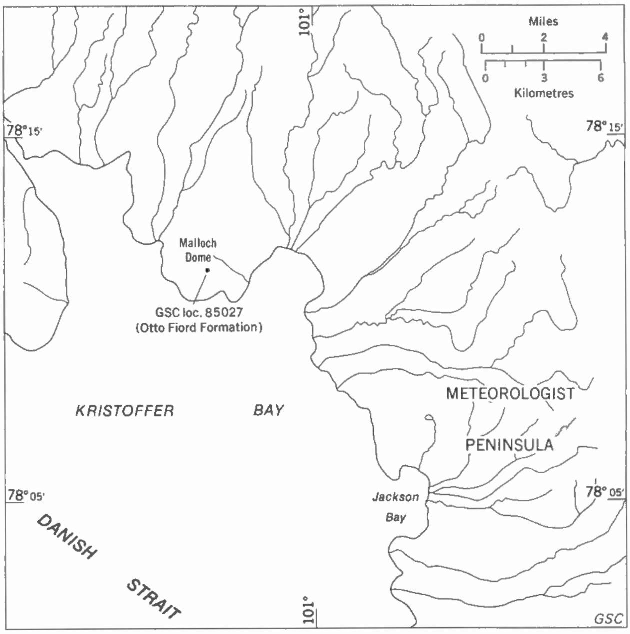
Ammonoids at this locality include:

Branneroceras branneri (Smith)
Branneroceras nicholasi n. sp.
Melvilloceras sabinensis n. gen., n. sp.
age: Bloydian (Westphalian-A = Kayalian)

Ellef Ringnes Island

(Textfig. 5)

One Carboniferous ammonoid locality is known on Ellef Ringnes Island. It occurs in the core of Malloch Dome situated on a short peninsula projecting into Kristoffer Bay on the southwest side of the island. Only the northern part of Malloch Dome is exposed; the remainder is probably under the sea. The dome has a maximum exposed diameter of 4 miles and a maximum elevation of about 400 feet. To the north, the core of the dome is in steeply dipping fault contact with the Lower Cretaceous Isachsen Formation. Greiner (1963) recognized a variety of inclusions within evaporites in the core of the dome. One large inclusion apparently contains some 300 feet of well-bedded siltstone, dolomitic siltstone, dolo-



TEXTFIGURE 5

Ammonoid locality on southern Ellef Ringnes Island.

mite, and limestone whereas another contains more than 100 feet of light red to pale pink sandstone.

1. *GSC locality 85027* cannot be more precisely identified than "Malloch Dome, 78°11'N, 101°15'W." The collection was assembled by A. S. Warden of Mobil Oil Co. in 1965.

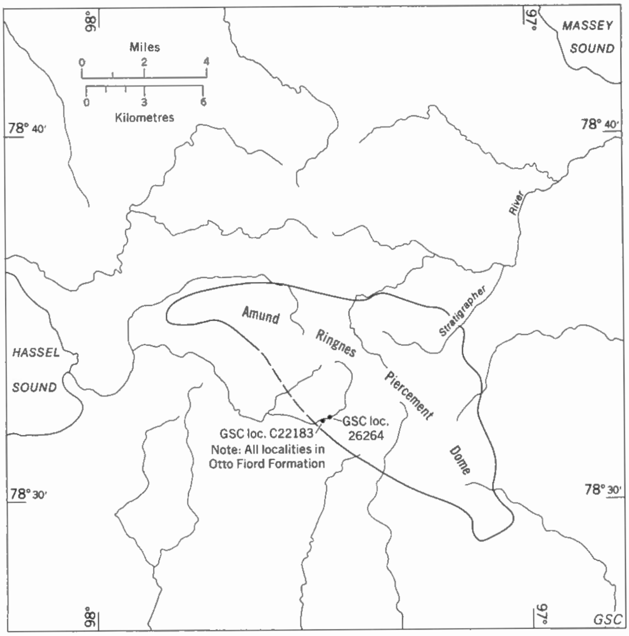
Ammonoids at this locality include:

Branneroceras branneri (Smith)
age: Bloydian (Westphalian-A = Kayalian)

Amund Ringnes Island

(Textfig. 6)

Carboniferous ammonoids are known from 2 localities on Amund Ringnes Island. Both occur in limestone blocks in a large, unnamed evaporite piercement dome in the central northwestern part of the island. This dome, which has been referred to variously as "Amund Ringnes piercement dome" (Norris, 1963) and "North Cornwall Dome" (Gould and De-Mille, 1964), has an exposed length of about 17 miles and a maximum width of 8 miles. The maximum elevation of the dome is close to 900 feet and the maximum relief is about 200 feet. In most places, the dome is surrounded by rather gently dipping Jurassic and Lower Cretaceous shale belonging to the Deer Bay Formation but, near the south end of the dome, Balkwill (pers. com., 1972) recognized sandstones that probably belong to the Upper Triassic–?Lower Jurassic Heiberg Formation. The Heiberg is in fault contact with limestone and limestone collapse breccia having a total thickness of about 500 feet and extending for about a mile along strike. The limestone probably was derived from the Otto Fiord Formation. Another fairly continuous limestone sequence, which was mapped by Norris (1963) and is about 100 feet thick, occurs on the western edge of the dome. At various other places within the dome, isolated blocks of limestone are enclosed in anhydrite and gypsum but, unlike the succession at Barrow Dome, shale and sandstone have not been reported.



TEXTFIGURE 6

Ammonoid localities on northern Amund Ringnes Island.

1. *GSC locality 26264* is ½ mile east of the western edge of the Amund Ringnes piercement dome, more or less opposite the headwaters of Stratigrapher River, which flows down the eastern side of the dome. According to Norris (1963), the locality is "in a six-foot bed of limestone interbedded with isoclinally folded gypsum." The collection was assembled by A. W. Norris in 1955.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
age: Bloydian (Westphalian-A = Kayalian)

2. *GSC locality C22183* is less than 1,000 feet east of the western edge of the Amund Ringnes piercement dome and occurs in a block of limestone that is about 75 feet thick (78°32′N, 97°27′W). The collection was assembled by H. R. Balkwill in 1972.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
age: Bloydian (Westphalian-A = Kayalian)

Axel Heiberg Island

(Textfigs. 7, 8, 9)

Carboniferous ammonoids have been found on both the western and eastern sides of Axel Heiberg Island. Lower Pennsylvanian species have been found within a large evaporite piercement structure ("South Fiord Dome") near Strand Fiord on western Axel Heiberg Island, but younger, Middle Pennsylvanian forms have been found in normal stratigraphic successions on both the northwestern and eastern sides of the island. On the northwestern side of Axel Heiberg Island, near Bunde Fiord, ammonoids occur in the Nansen Formation and on the west side of the island, near Whitsunday Bay and Buchanan Lake, they occur in contemporaneous strata in the Hare Fiord Formation.

"South Fiord Dome," situated near the head of South Fiord on west-central Axel Heiberg Island, is one of the largest diapiric structures on the island. It is ovoid in plan, with a maximum north-south diameter of about 5 miles and a maximum east-west diameter of about 4 miles. The dome is surrounded by Jurassic-Cretaceous rocks. As in previously discussed domes on Melville, Amund Ringnes, and Ellef Ringnes Islands, numerous limestone inclusions enveloped in contorted anhydrite and gypsum occur in "South Fiord Dome." One of these inclusions has yielded an important Early Pennsylvanian ammonoid fauna.

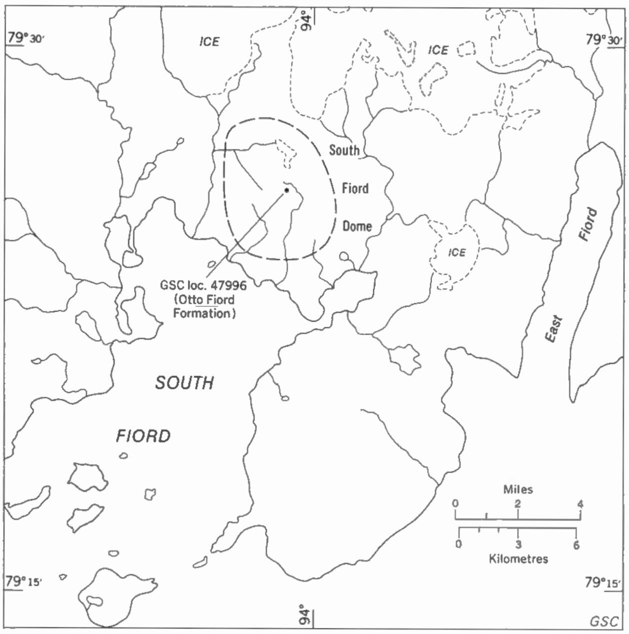
On northwestern Axel Heiberg Island, Carboniferous and Permian strata were mapped as an undivided unit "CpN" (*see* GSC Map 1310A, *Bukken Fiord*, Thorsteinsson and Trettin, 1972). Thorsteinsson and Trettin (ibid.) recognized five formations within this map-unit in the area: Borup Fiord, Otto Fiord, Nansen, van Hauen, and Degerböls. Thick and extensive carbonates, which have yielded ammonoids south of Bunde Fiord near Griesbach Creek, clearly belong to the Nansen Formation, which is invariably faulted at the base in this area and is variously overlain by rocks of the van Hauen or Degerböls Formations.

On eastern Axel Heiberg Island, between Whitsunday Bay in the south and Buchanan Lake in the north, a narrow belt of upper Paleozoic rocks has been mapped consisting of, in ascending order, the Otto Fiord, Hare Fiord, and van Hauen Formations. The van Hauen Formation is overlain by the Lower Triassic Blind Fiord Formation. In this region, Carboniferous ammonoids have been recovered from several localities near the base of the Hare Fiord Formation.

"South Fiord Dome"

(Textfig. 7)

1. *GSC locality 47996*. According to Hoen (1964), this locality is in a "large inclusion in the centre of South Fiord Diapir." Presumably Hoen's reference is to a large block of limestone adjacent to the southeast edge of a small ice cap (Central Ice Cap) which occurs in about the middle of the dome. The collection was assembled by Hoen in 1960.



TEXTFIGURE 7

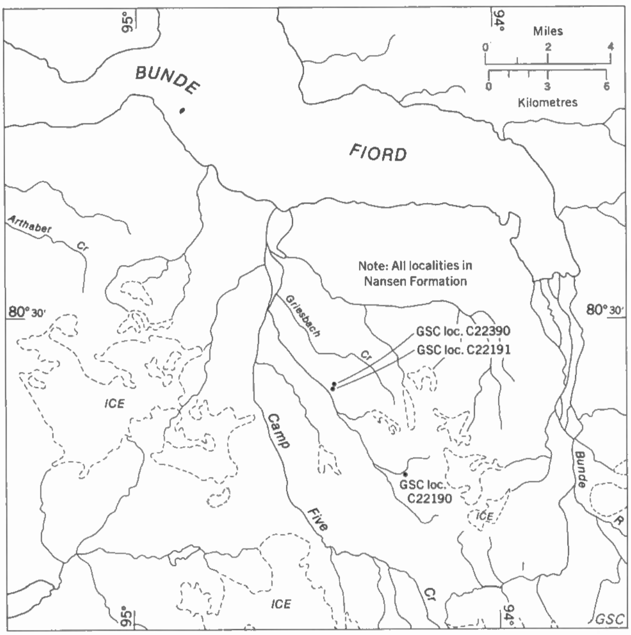
Ammonoid locality on west-central Axel Heiberg Island, "South Fiord Dome."

Ammonoids at this locality include:

Bisatoceras hoeni n. sp.
Bilinguites heibergensis n. sp.
Bilinguites sp.
age: Halian (late Namurian, R_2 or G_1)

Northwestern Axel Heiberg Island
(Textfig. 8)

1. *GSC locality C22190* is 8.4 miles south of Bunde Fiord and 5.4 miles west of Bunde River, in light grey skeletal limestone of the Nansen Formation. It occurs 360 feet above the base of the section, which is marked by a prominent thrust fault (Griesbach Creek Thrust). The collection was assembled by Dario Sedero of Cities Service Canada Ltd. in 1972.



TEXTFIGURE 8
Ammonoid localities on northwestern Axel Heiberg Island.

Ammonoids at this locality include:

Phaneroceras lenticulare Plummer and Scott
Syngastrioceras sp. indet.
age: early Atokan (early Moscovian)

2. *GSC locality C22390* is about 4 miles northwest of the previous locality (GSC loc. C22190). It occurs in talus at the base of the Nansen Formation beside an unnamed stream 6 miles south of Bunde Fiord and 3.2 miles southeast of the confluence of Camp Five Creek and Griesbach Creek (80°28′10″N, 94°28′30″W). A single specimen was found by the writer in 1972.

Ammonoids at this locality include:

?*Phaneroceras lenticulare* Plummer and Scott
age: early Atokan (early Moscovian)

3. *GSC locality C22191* is adjacent to the previous locality, 6.0 miles south of Bunde Fiord, 3.2 miles southeast of the confluence of Camp Five Creek and Griesbach Creek. The locality is 727 feet above the lowest exposure in the Nansen Formation; the base of the section is marked by a prominent fault (Griesbach Creek Thrust). The collection was assembled by Dario Sedero of Cities Service Canada Ltd. in 1972.

Ammonoids at this locality include:

Bisatoceras cf. *B. greenei* Miller and Owen
age: Desmoinesian (late Moscovian)

Eastern Axel Heiberg Island
(Textfig. 9)

1. *GSC locality C4010* is 6.8 miles north of the head of Whitsunday Bay on eastern Axel Heiberg Island. It is adjacent to a small stream flowing into a rather wide north–south trending valley north of Whitsunday Bay (87°12′N, 79°27′W). The collection is from a talus slope at the base of the Hare Fiord Formation and was assembled by the author in 1969.

Ammonoids at this locality include:

Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Syngastrioceras constrictum n. sp.
Bisatoceras kotti n. sp.
?*Neogastrioceras arcticum* n. sp.
Phaneroceras lenticulare Plummer and Scott
Gastrioceras cf. *G. glenisteri* n. sp.
Diaboloceras involutum n. sp.
age: early Atokan (early Moscovian)

2. *GSC locality C4011* is 6.8 miles north of the head of Whitsunday Bay, in the same section and above locality C4010. Locality C4011 is 170 feet above the base of the Hare Fiord Formation. The collection was assembled by the author in 1969.

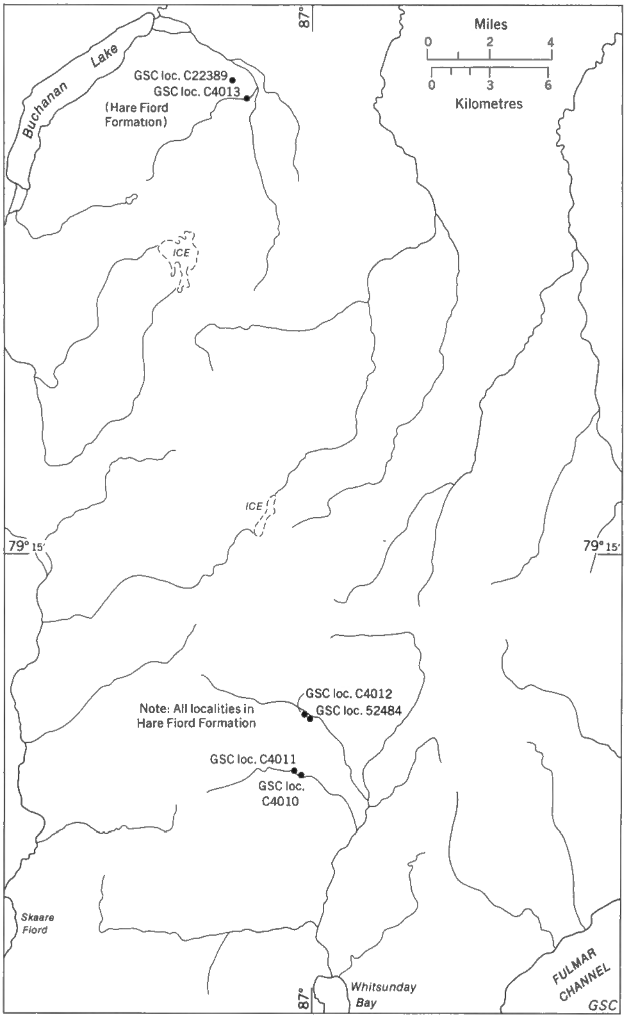
Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
Clistoceras globosum Nassichuk
Syngastrioceras constrictum n. sp.
Phaneroceras lenticulare Plummer and Scott
Diaboloceras involutum n. sp.
age: early Atokan (early Moscovian)

3. *GSC locality C4012* is 8.6 miles north of the head of Whitsunday Bay, near the southwest edge of the Whitsunday Bay Diapir (87°01′N, 79°11′W). The locality is 150 feet above the base of the Hare Fiord Formation. The collection was assembled by the author in 1969.

Ammonoids at this locality include:

Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Proshumardites aequalis n. sp.
Syngastrioceras sp.
Diaboloceras neumeieri Quinn and Carr
age: early Atokan (early Moscovian)



TEXTFIGURE 9

Ammonoid localities on eastern Axel Heiberg Island.

4. *GSC locality 52484* is in the same geographic position as locality C4012 (87°01′N, 79°11′W) but is slightly lower in the section. The collection was assembled from the lower 100 feet of the Hare Fiord Formation by Thorsteinsson in 1961.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
?*Neogastrioceras arcticum* n. sp.
age: early Atokan (early Moscovian)

5. *GSC locality C4013* is 4 miles southeast of the northern end of Buchanan Lake on eastern Axel Heiberg Island. The locality is adjacent to a small unnamed, easterly flowing stream, the headwaters of which are almost directly opposite the headwaters of Savik Creek, which flows in the opposite direction. The locality is at the base of the Hare Fiord section which is marked by a prominent thrust fault (Stolz Thrust). The collection was assembled by the author in 1969.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
Syngastrioceras constrictum n. sp.
Neogastrioceras cf. *N. arcticum* n. sp.
Bisatoceras kotti n. sp.
Phaneroceras lenticulare Plummer and Scott
age: early Atokan (early Moscovian)

6. *GSC locality C22389* is 3.4 miles southeast of the northern end of Buchanan Lake, ½ mile along strike to the northwest of the previous locality. The collection is at the base of the Hare Fiord section which is marked by the Stolz Thrust. It was assembled by F. G. Stehli of Western Reserve University, Cleveland, in 1964.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
age: early Atokan (early Moscovian)

Ellesmere Island

(Textfigs. 10, 11, 12, 13)

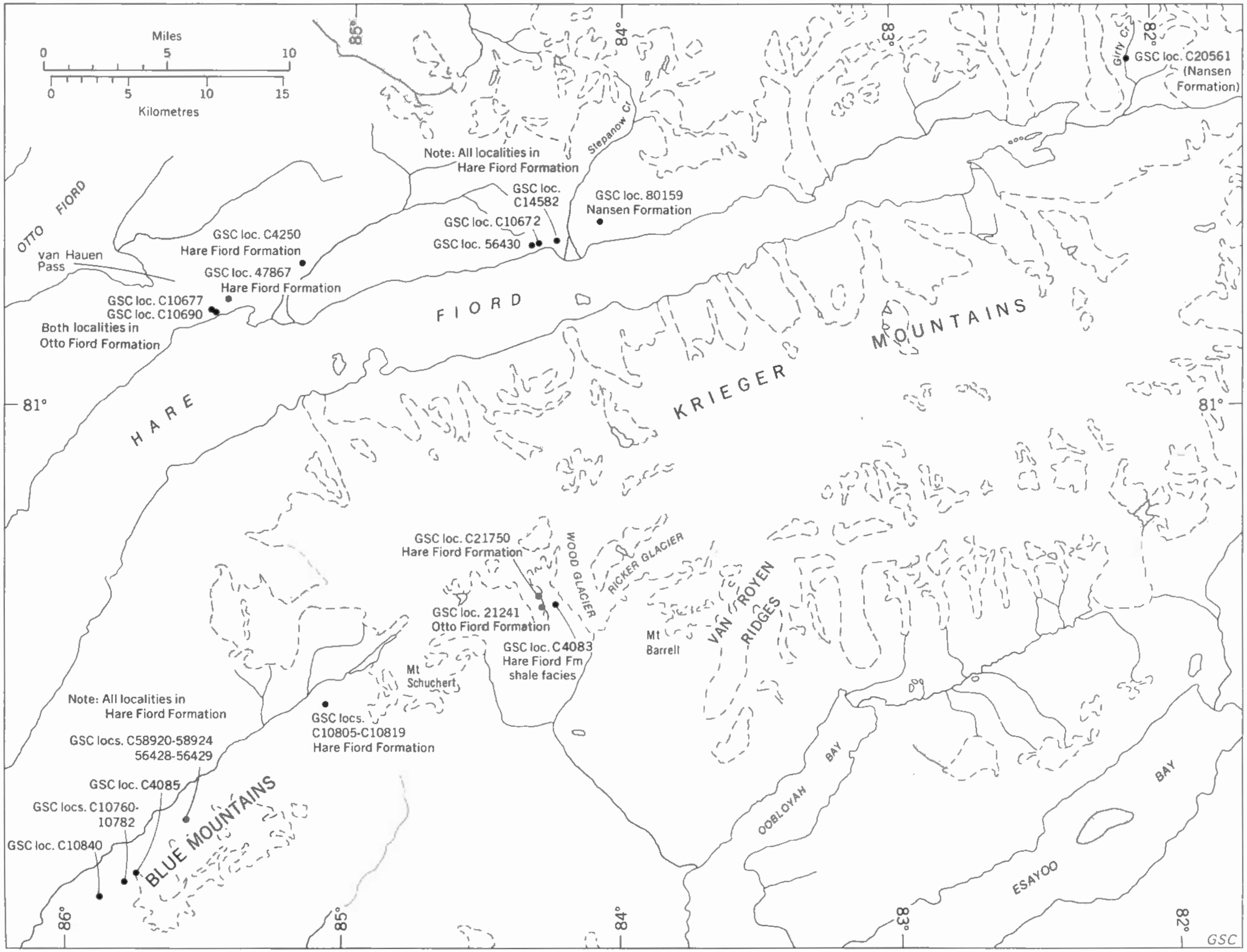
In contrast to previously discussed islands, evaporitic diapirs are relatively rare on Ellesmere Island, and all known occurrences of Carboniferous ammonoids are in normal stratigraphic successions. Ammonoids are particularly common in the Basinal Clastic and Evaporitic Belt in the general vicinity of Hare Fiord and slightly farther to the east, in the Blue Mountains. In those areas, Early Pennsylvanian (Bloydian) species occur in shale and limestone that are interbedded with anhydrite in the Otto Fiord Formation, and Middle Pennsylvanian (Atokan) species occur in bedded limestone as well as in bryozoan carbonate mounds in the lower part of the Hare Fiord Formation. West and north of Hare Fiord, basinal shale and limestone of the Hare Fiord Formation grade laterally into shelf-edge carbonates of the Nansen Formation which characterize the Northwestern Carbonate Belt. The latter formation has yielded both Middle Pennsylvanian (Atokan) and Late Pennsylvanian (Missourian) ammonoids.

Near the eastern edge of the basin, in the Marginal Clastic Belt, the Canyon Fiord Formation essentially comprises conglomerate and sandstone. Slightly basinward, in the Marginal Clastic and Carbonate Belt, limestone is commonly associated with sandstone in the Canyon Fiord Formation. In the latter facies belt, Middle Pennsylvanian (Atokan) ammonoids have been found northeast of Cañon Fiord in the vicinity of Victoria and Albert Mountains, and slightly younger Middle Pennsylvanian (Desmoinesian) ammonoids occur east of Raanes Peninsula, between Blind Fiord and Trold Fiord.

Hare Fiord

(Textfig. 10)

1. *GSC locality C10677* occurs 576 feet above the base of the Otto Fiord Formation, ½ mile along strike to the southwest of the type section in the vicinity of van Hauen Pass. The locality is in a deeply incised stream cut one-tenth of a mile north of Hare Fiord and 1.6 miles northeast of the point of maximum incursion of Hare Fiord into van Hauen Pass (81°03′30″N, 85°32′W). At this locality, the Otto Fiord section has a thrust fault at its base and a total thickness of 1,340 feet. The collection was assembled by the author and G. R. Davies in 1971.



TEXTFIGURE 10. Ammonoid localities on Hare Fiord, in the Blue Mountains and the Krieger Mountains, northern Ellesmere Island.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
age: Bloydian (Westphalian-A = Kayalian)

2. *GSC locality C10690* occurs 1,163 feet above the base of the Otto Fiord Formation in the same section as, but above, the previous locality C10677. The collection was assembled by the author and G. R. Davies in 1971.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
Gastrioceras sp. indet.
age: Bloydian (Westphalian-A = Kayalian)

3. *GSC locality 56430* is near the top of a small biogenic (bryozoan) mound about 100 feet above the base of the Hare Fiord Formation. The locality is less than 1,000 feet north of Hare Fiord and 2 miles west of the midpoint of the delta formed by Stepanow Creek (81°07′30″N, 84°20′W). The locality was discovered by the writer and R. L. Christie in 1963. Subsequent collections were assembled from this locality by the writer accompanied by C. Spinosa (Boise State College) in 1969 and by colleagues G. R. Davies and K. Roy in 1971.

Ammonoids at this locality include:

Boesites gracilis n. sp.
Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Maximites alexanderi n. sp.
Neodimorphoceras sverdrupi n. sp.
Gonioloboceratoides curvatus n. gen., n. sp.
Proshumardites aequalis n. sp.
Syngastrioceras smithwickense (Plummer and Scott)
Clistoceras globosum Nassichuk
Neogastrioceras arcticum n. gen., n. sp.
Bisatoceras kotti n. sp.
Neoicoceras martini n. sp.
Trettinoceras ellesmerensis n. gen., n. sp.
Winslowoceras greelyi n. sp.
Christioceras trifurcatum Nassichuk and Furnish
age: early Atokan (early Moscovian)

4. *GSC locality C10672* is located 1.8 miles to the west of the midpoint of the delta that is formed by Stepanow Creek (81°07′30″N, 84°19′W), less than ¼ mile along strike to the east of the previous locality. It occurs between 36 and 46 feet above the base of the Hare Fiord Formation. The locality was discovered by the writer and G. R. Davies in 1971.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
Christioceras trifurcatum Nassichuk and Furnish
age: early Atokan (early Moscovian)

5. *GSC locality C14582* is at the base of the Hare Fiord Formation ¼ mile north of Hare Fiord and a mile west of Stepanow Creek (81°07′N, 84°16′W). The ammonoids were collected from talus but are known to have originated in the lower 120 feet of the formation at this locality. The locality was discovered by R. Thorsteinsson in 1957. A subsequent collection was assembled by the writer and R. L. Christie in 1963.

Ammonoids at this locality include:

Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Syngastrioceras smithwickense (Plummer and Scott)
age: early Atokan (early Moscovian)

6. *GSC locality 47867* occurs 90 feet above the base of the type section of the Hare Fiord Formation north of Hare Fiord near van Hauen Pass. The locality is 0.1 mile north of Hare Fiord and 2.2 miles northeast of the point of maximum incursion of Hare Fiord into van Hauen Pass (81°03′30″N, 85°29′W). It was discovered by R. Thorsteinsson in 1957.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
Phaneroceras lenticulare Plummer and Scott
Syngastrioceras smithwickense (Plummer and Scott)
Diaboloceras involutum n. sp.
age: early Atokan (early Moscovian)

7. *GSC locality C4250* occurs 75 feet above the base of the Hare Fiord Formation, 2 miles northwest of Hare Fiord and 5.8 miles northeast of the point of maximum incursion of Hare Fiord into van Hauen Pass (81°05′N, 85°13′W). The locality is 3.6 miles along strike to the northeast of the type section of the Hare Fiord Formation and was discovered by the writer in 1966.

Ammonoids at this locality include:

Metapronorites ellesmerensis n. sp.
Neodimorphoceras sverdrupi n. sp.
Neogastrioceras arcticum n. sp.
Phaneroceras lenticulare Plummer and Scott
Diaboloceras involutum n. sp.
age: early Atokan (early Moscovian)

8. *GSC locality C20561* occurs 1,530 feet above the base of the type section of the Nansen Formation, 2.6 miles northeast of the head of Hare Fiord, near the creek bottom on the east side of Girty Creek (81°12′N, 82°06′W). The locality was discovered by the writer and G. R. Davies in 1972.

Ammonoids at this locality include:

Phaneroceras cf. *P. compressum* (Hyatt)
Somoholites merriami (Miller and Furnish)
age: Atokan (lower Moscovian)

9. *GSC locality 80159* is 1.2 miles east of Stepanow Creek and 1.4 miles north of Hare Fiord (81°07′N, 84°06′W). Nassichuk (1969, p. 125) indicated that the locality occurs in a massive skeletal limestone, 400 feet above the base of the Hare Fiord Formation, but recent investigations have shown that a major fault occurs in the section and so the thickness of strata that separates this locality from the bottom of the formation is unknown. Furthermore, in the immediate vicinity of this locality, the Hare Fiord Formation interfingers with the Nansen Formation and, for mapping purposes, all strata have been incorporated in the Nansen Formation (*see* GSC Map 1309A, *Otto Fiord* by Thorsteinsson, Tozer, and Trettin, 1972). The locality was discovered by the writer in 1966.

Ammonoids at this locality include:

Parashumardites sp.
age: Missourian (Zhigulevian)

Blue Mountains

(Textfig. 10)

1. *GSC locality C4085* occurs in light grey skeletal limestone in the upper 10 feet of the Tellevak Limestone of the Hare Fiord Formation. It is on the southwestern side of the Blue Mountains, 3.6 miles northeast of the northern tip of Hare Fiord Diapir (80°44′N, 85°40′54″ W). The locality is in a creek bottom near the terminus of the southernmost large westerly directed glacial tongue that is derived from a small icefield in the southern Blue Mountains. This locality was discovered by the writer and C. Spinosa (Boise State College) in 1969. Subsequent collections were assembled by the writer and G. R. Davies in 1971.

Ammonoids at this locality include:

Stenopronorites sersoni n. sp.
Pseudopronorites arkansiensis (Smith)
Neodimorphoceras sverdrupi n. sp.
Syngastrioceras smithwickense (Plummer and Scott)
Syngastrioceras constrictum n. sp.
Clistoceras globosum Nassichuk
Clistoceras sp.
Bisatoceras kotti n. sp.
Neoglaphyrites bisulcatus n. sp.
Phaneroceras lenticulare Plummer and Scott
Gastrioceras glenisteri n. sp.
Diaboloceras involutum n. sp.
Christioceras trifurcatum Nassichuk and Furnish
age: late Atokan (early Moscovian)

2. *GSC locality C10840* is the most southerly locality in the Blue Mountains, 1.8 miles along strike to the southwest of the previous locality (C4085) and 2 miles northeast of the northern edge of Hare Fiord Diapir (80°42′41″N, 85°52′05″W). It occurs in red-weathering silty limestones, 40 feet above the Tellevak Limestone. The locality was discovered by the author and G. R. Davies in 1971.

Ammonoids at this locality include:

Pseudopronorites arkansiensis (Smith)
Metapronorites ellesmerensis n. sp.
Syngastrioceras sp. indet.
Phaneroceras lenticulare Plummer and Scott
Diaboloceras neumeieri Quinn and Carr
Diaboloceras involutum n. sp.
age: early Atokan (early Moscovian)

3. "Southern Blue Mountains Section"—*GSC localities C10760, C10767, C10772, C10775, C10781, C10782* are all from different levels in a section of the Tellevak Limestone measured less than ¼ mile along strike from locality C4085 (80°43′33″N, 85°42′25″W). The locality is 3.4 miles northeast of the northern edge of Hare Fiord Diapir. The Tellevak Limestone is 845 feet thick at this locality and is underlain by the Otto Fiord Formation. The section was measured and ammonoids collected by the writer and G. R. Davies in 1971. The stratigraphic position within the Tellevak Limestone of each locality and ammonoids collected at each are:

i. GSC locality C10760—25 feet below top:

Syngastrioceras constrictum n. sp.

ii. GSC locality C10767—70 feet below top:

Syngastrioceras constrictum n. sp.
Phaneroceras lenticulare Plummer and Scott

iii. GSC locality C10772—169 feet below top:

Syngastrioceras constrictum n. sp.
Phaneroceras lenticulare Plummer and Scott

iv. GSC locality C10775–190 feet below top:

Diaboloceras involutum n. sp.

v. GSC locality C10781—392 feet below top:

Syngastrioceras sp. indet.

vi. GSC locality C10782—403 feet below top:

Syngastrioceras sp. indet.

age: late Atokan (early Moscovian)

4. "Glacier Lake Section"—*GSC localities C10805, C10807, C10808, C10810, C10811, C10812, C10819* are all from different levels in a section of the Tellevak Limestone member of the Hare Fiord Formation measured on the west side of the Blue Mountains, west of Mount Schuchert. The section is 1.6 miles southeast of the southern tip of an elongate northeast-trending glacial lake, a few miles northwest of Mount Schuchert (80°50′N, 85° 04′W). The stratigraphic position of each locality and ammonoids collected are:

i. GSC locality C10819—Talus collection from base of lowest exposure:

Stenopronorites sersoni n. sp.
Syngastrioceras orientale (Yin)
Neoglaphyrites bisulcatus n. sp.
?*Neoicoceras* sp. indet.

ii. GSC locality C10805—311 feet above base of lowest exposure:

Boesites sp. indet.

iii. GSC locality C10807—393 feet above base of lowest exposure:

?*Syngastrioceras constrictum* n. sp.

iv. GSC locality C10808—433 feet above base of lowest exposure:

Neogastrioceras sp. indet.
Diaboloceras sp. indet.

v. GSC locality C10810–670 feet above base of lowest exposure:

Syngastrioceras sp. indet.
?*Neogastrioceras* sp. indet.

vi. GSC locality C10811—730 feet above base of lowest exposure (talus):

Stenopronorites sersoni n. sp.

vii. GSC locality C10812—788 feet above base of lowest exposure:

Syngastrioceras constrictum n. sp.
?*Neogastrioceras* sp. indet.
Phaneroceras lenticulare Plummer and Scott

age: late Atokan (early Moscovian)

5. Individual localities in the southwestern Blue Mountains were discovered in 1963 by G. Bonham-Carter—*GSC localities 58920, 58921, 58922, 58923, 58924*, and P. Harker—

GSC localities 56428, 56429. Although precise co-ordinates of the above localities have never been determined, all are rather closely spaced near the top of a thick exposure of the Tellevak Limestone about 6.5 miles northeast of the Hare Fiord Diapir (80°46′N, 85°32′W).

i. GSC locality 58920 is in the uppermost beds of the Tellevak Limestone:

Stenopronorites sersoni n. sp.
Syngastrioceras constrictum n. sp.
Clistoceras globosum Nassichuk
Neogastrioceras sp.
Bisatoceras kotti n. sp.
Phaneroceras lenticulare Plummer and Scott

ii. GSC locality 58921 is in red beds overlying the Tellevak Limestone:

Metapronorites ellesmerensis n. sp.
Clistoceras globosum Nassichuk
Bisatoceras kotti n. sp.

iii. GSC locality 58922 is in red beds overlying the Tellevak Limestone:

Metapronorites ellesmerensis n. sp.
Neogastrioceras sp. indet.
Phaneroceras lenticulare Plummer and Scott
Diaboloceras sp.
Bisatoceras kotti n. sp.

iv. GSC locality 58923 is in the uppermost beds of the Tellevak Limestone:

Stenopronorites sersoni n. sp.

v. GSC locality 58924 is in the upper 50 feet of the Tellevak Limestone:

Gastrioceras glenisteri n. sp.

vi. GSC locality 56428 is near the top of the Tellevak Limestone:

Stenopronorites sersoni n. sp.
Syngastrioceras orientale (Yin)
Syngastrioceras constrictum n. sp.
Phaneroceras lenticulare Plummer and Scott

vii. GSC locality 56429 is in red beds overlying the Tellevak Limestone:

Metapronorites ellesmerensis n. sp.

age: late Atokan (early Moscovian)

Krieger Mountains, midway between Mount Schuchert and Mount Barrell (Textfig. 10)

1. *GSC locality C21241* is in dark grey shaly limestone, about 300 feet above the base of the Otto Fiord Formation on the east side of the first unnamed glacier west of Wood Glacier (80°54′30″N, 84°15′W). A single specimen was recovered by the writer and G. R. Davies in 1972.

Ammonoids at this locality include:

Branneroceras branneri (Smith)
age: Bloydian (Westphalian-A = Kayalian)

2. *GSC locality C21750* is stratigraphically above the previous locality, on the east side of the first unnamed glacier west of Wood Glacier (80°54′30″N, 84°15′W). The locality is in

dark grey limestone, 240 feet below the top of the Tellevak Limestone. It was discovered by the writer and G. R. Davies in 1972.

Ammonoids at this locality include:

Gastrioceras glenisteri n. sp.
Diaboloceras involutum n. sp.
age: Desmoinesian (late Moscovian)

3. *GSC locality C4083* is in the saddle of a northeast–southwest trending ridge about 5 miles northwest of Mount Barrell and immediately west of Wood Glacier (80°54′N, 84°11′W). The locality is in thin-bedded, dark grey limestone, about 150 feet above the base of the Hare Fiord Formation. It was discovered originally by the writer and C. Spinosa (Boise State College) in 1969; a subsequent collection was made from the locality by Dario Sedero of Cities Service Canada in 1971.

Ammonoids at this locality include:

Pseudopronorites cf. *P. arkansiensis* (Smith)
Metapronorites ellesmerensis n. sp.
Syngastrioceras smithwickense (Plummer and Scott)
Syngastrioceras sp. indet.
?*Clistoceras globosum* Nassichuk
Bisatoceras kotti n. sp.
Neoglaphyrites bisulcatus n. sp.
Phaneroceras lenticulare Plummer and Scott
Somoholites merriami (Miller and Furnish)
Gastrioceras cf. *G. glenisteri* n. sp.
Diaboloceras involutum n. sp.
Christioceras trifurcatum Nassichuk and Furnish
age: early Atokan (early Moscovian)

Kleybolte Peninsula, Northwestern Ellesmere Island
(Textfig. 11)

1. *GSC locality 57698* is near the southern end of Kleybolte Peninsula which juts into Nansen Sound between Audhild Bay and Bjare Strait, northwestern Ellesmere Island. The locality is 3.2 miles northeast of the most southerly tip of the peninsula (81°31′30″N, 91°15′W). It is in a carbonate mound which is 1,250 feet above the base of the Nansen Formation which, in turn, rests on volcanic rocks of the Audhild Formation overlying the Borup Fiord Formation. The locality was discovered by R. Thorsteinsson in 1963.

Ammonoids at this locality include:

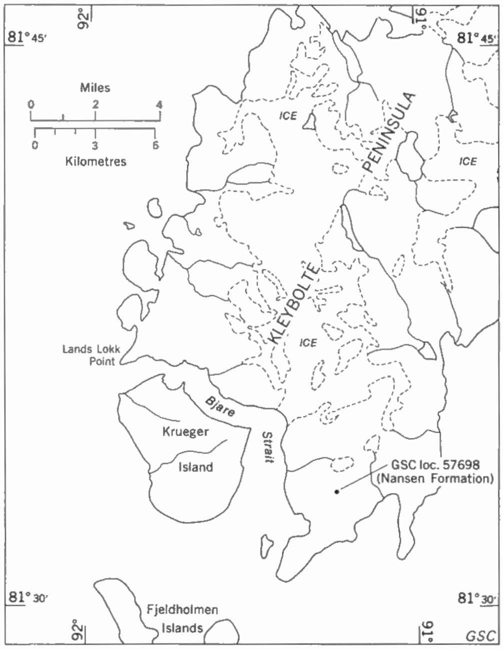
Neoglaphyrites bisulcatus n. sp.
age: late Atokan (early Moscovian)

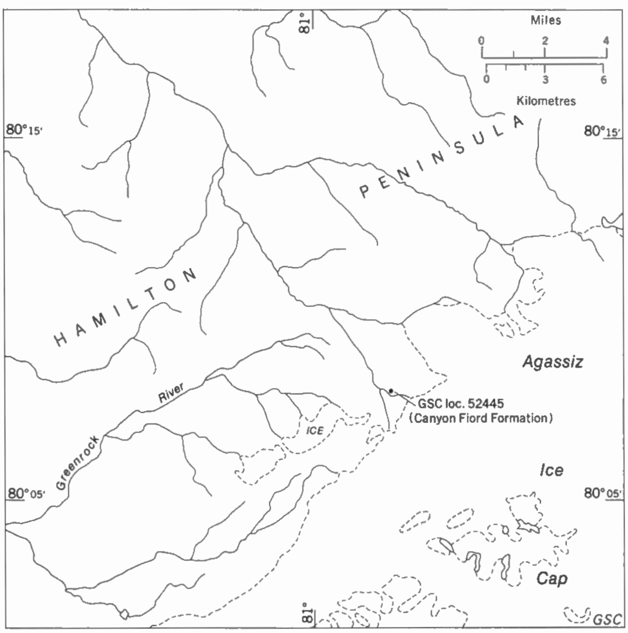
Hamilton Peninsula, North of Cañon Fiord
(Textfig. 12)

1. *GSC locality 52445* is on eastern Hamilton Peninsula, less than a mile west of the western edge of the Agassiz Ice Cap in the Victoria and Albert Mountains. The locality is 19 miles northeast of East Cape and 1.4 miles south of a broad tongue-shaped glacier that extends west-northwesterly from the Agassiz Ice Cap (80°08′N, 80°48′W). The collection was assembled from a red weathering calcareous siltstone bed, 150 feet above the base of the Canyon Fiord Formation; the lower 110 feet of the formation consist of conglomerate at this locality.

TEXTFIGURE 11

Ammonoid locality on Kleybolte Peninsula, northwestern Ellesmere Island.





TEXTFIGURE 12

Ammonoid locality on Hamilton Peninsula, west-central Ellesmere Island.

The locality was discovered by R. Thorsteinsson in 1963.

Ammonoids at this locality include:

Phaneroceras compressum (Hyatt)
age: early Atokan (early Moscovian)

Raanes Peninsula, Western Ellesmere Island
(Textfig. 13)

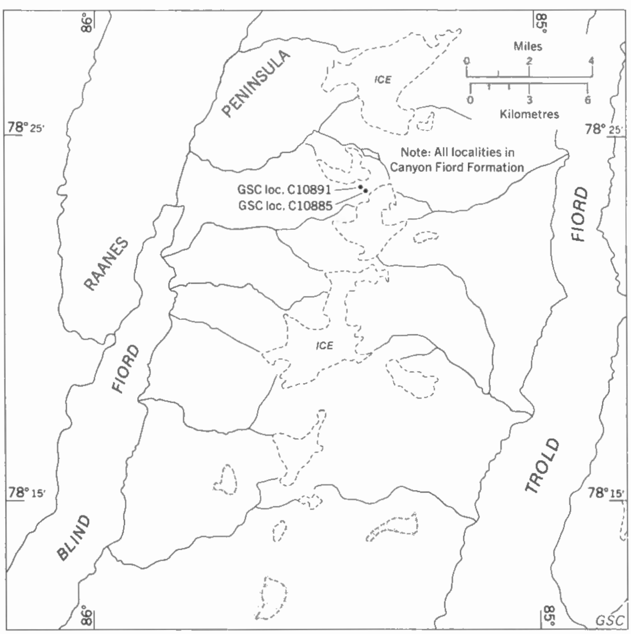
1. *GSC localities C10885 and C10891* are in the Canyon Fiord Formation on eastern Raanes Peninsula between Blind Fiord and Trold Fiord. The base of the section is 6 miles east of the head of Blind Fiord (78°23′30″N, 85°23′W). GSC localities C10885 and C10891 occur 1,145 and 1,462 feet, respectively, above the base of the Canyon Fiord Formation. Both localities were discovered by the author and E. W. Bamber in 1971.

Ammonoids at GSC locality C10885 include:

Boesites sp.
Metapronorites pseudotimorensis (Miller)
Bisatoceras sp.
Somoholites bamberi n. sp.
age: Desmoinesian (late Moscovian)

Ammonoids at GSC locality C10891 include:

Metapronorites pseudotimorensis (Miller)
Somoholites bamberi n. sp.
age: Desmoinesian (late Moscovian)



TEXTFIGURE 13
Ammonoid localities on Raanes Peninsula, Ellesmere Island.

SYSTEMATIC PALEONTOLOGY

The prefix "GSC" refers to specimens that are in the type collections of the Geological Survey of Canada. Types lodged in the repository at the University of Iowa bear the prefix "SUI" and those in the Yale Peabody Museum of Natural History bear the prefix "YPM."

Order **AGONIATITIDA** Ruzhencev, 1967
Superfamily PROLECANITACEAE Hyatt, 1884
Family DARAELITIDAE Tchernow, 1907

Genus ***Boesites*** Miller and Furnish, 1940

Type species. *Daraelites texanus* Böse, 1919; from Virgilian strata in the Gaptank Formation, West Texas.

Diagnosis. The conch of *Boesites* is discoidal to subdiscoidal and is moderately evolute; the umbilicus of typical representatives is at least 25 per cent of the conch diameter at maturity. Whorls have a rounded venter, rounded or slightly flattened lateral flanks, and a moderately impressed dorsum. The shell possesses delicate, sinuous growth lamellae, which form ventral and dorsolateral sinuses and a ventrolateral salient.

The external suture has a broad, trifid, constricted ventral lobe which is typically denticulate, a broad denticulate first lateral lobe and several additional lateral elements, of which the second also may be denticulate. The bifid dorsal lobe is slightly inflated.

Sutural formula is $(V_2V_1V_2)LU^1U^2U^3U^4U^6{:}U^5I(D_1D_1)$.

Discussion. Boesites was reviewed by Miller and Furnish (1940a) and additional information was provided by Ruzhencev (1950). A comprehensive treatment of the Daraelitidae forms an important part of a Ph.D. thesis prepared by K. A. Hodgkinson (1965) at the University of Iowa. The author joined Hodgkinson in study of the early ontogenetic stages of the Arctic species *B. gracilis* as well as those of typical representatives of *B. scotti* Miller and Furnish and other representatives of *Boesites* in the University of Iowa collections.

Boesites is intermediate between *Epicanites* Schindewolf, which ranges in age from late Viséan to early Namurian, and *Daraelites* Gemmellaro, which ranges from Asselian to early Guadalupian. *Epicanites* (=*Praedaraelites* Schindewolf) is distinguished from *Boesites* on the basis of a simpler suture with fewer elements. Denticulation in the lobes may be preserved in *Epicanites*; this feature is particularly well demonstrated by Miller and Furnish (1940b) and by Ruzhencev and Bogoslovskaya (1971b). The suture of *Daraelites* has more elements and a greater degree of denticulation than *Boesites*, but *Daraelites* is distinguished further from *Boesites* in that the former has a proportionately broader, unconstricted ventral lobe, and a relatively narrower first lateral lobe. The first lateral saddle of *Daraelites* diverges orad but on *Boesites* it is nearly parallel with the axis of the ventral lobe.

According to Ruzhencev (1960b), *Boesites* and other daraelitids are distinguished from the Prolecanitidae, the probable ancestral group of the daraelitids, by the possession of a rounded trifid ventral lobe and, to a lesser degree, by more denticulation of ventral and lateral lobes. On the basis of sutural ontogenies of representatives of the Prolecanitidae (Karpinsky, 1896; Schindewolf, 1922, 1926, 1951; Schmidt, 1951), it is apparent that lateral sutural elements are derived by a subdivision of the umbilical saddle and that 'L,' by definition, is not present. Ruzhencev (1950, p. 54) considered the suture of *Boesites* to be $VLUU^1U^2U^3U^5{:}U^4ID$. Ruzhencev (1951), however, prepared sutures of *Daraelites elegans* and 'L' was omitted from the sutural formula. A sutural ontogeny of *D. elegans* by Bogoslovskaya (1962, p. 31) and study of early stages of the Arctic *B. gracilis* indicate that Ruzhencev's earlier (1950) description was correct and 'L' is indeed present in the sutural development.

Species composition and distribution.

Boesites eotexanus Wagner-Gentis, 1971; from upper Westphalian (Upper Moscovian) strata in northern Spain.

B. girtyi (Plummer and Scott, 1937); from the Desmoinesian (Moscovian) Wewoka Formation in Oklahoma (Plummer and Scott, 1937) and possibly from the Atoka Formation in Oklahoma (Unklesbay, 1962).

B. gracilis n. sp.; from Atokan (Moscovian) strata in the Hare Fiord Formation, Ellesmere Island. Quinn and Carr (1963) and McCaleb (1968) recorded *B. scotti* from Morrowan strata in Arkansas and Oklahoma but the Arkansas species more closely resembles *B. gracilis* than *B. scotti.*

B. primoris Ruzhencev, 1950; from Orenburgian strata in the southern Urals.

B. scotti (Miller and Furnish, 1940); from Atokan strata in the Smithwick Shale near Rochelle, McCulloch County, central Texas.

B. serotinus Ruzhencev, 1951; from Sakmarian strata in the southern Urals.

B. texanus (Böse, 1917); from Virgilian (Orenburgian) strata in the Gaptank Formation, West Texas and the Graham Formation in north-central Texas and from Missourian (Zhigulevian) strata in the Nellie Bly Formation, Oklahoma (Böse, 1917; Smith, 1929; Miller, 1930; Miller and Cline, 1934).

B. sp. Ruzhencev, 1951; from Asselian strata in the southern Urals.

B. sp. indet. Nishida, 1971; from Atokan strata in the Akiyoshi Limestone Group, Japan.

B. sp.; from Desmoinesian or Missourian strata on Ellesmere Island, Arctic Canada.

Boesites gracilis Nassichuk, n. sp.

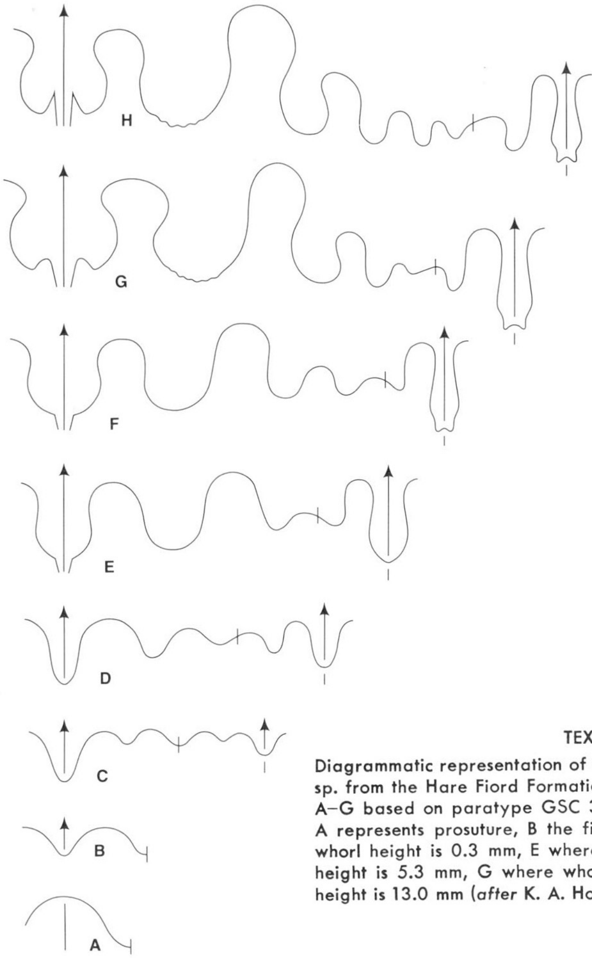
Plate 1, figures 1, 3, 5, 6; Textfigures 14, 15

Boesites scotti Miller and Furnish QUINN and CARR, 1963, p. 117; McCALEB, 1964, p. 147, 1968, p. 75.

Description. More than 100 well-preserved specimens of *Boesites gracilis* were recovered from Ellesmere Island. Most specimens have shell material preserved and retain a living chamber that occupies about half a volution. The conch is markedly evolute throughout ontogeny and the umbilicus of the largest specimen closely approximates one-third the conch diameter. Whorls are slightly depressed in the inner volutions but become nearly circular in section at about 5 mm diameter, and slightly compressed at maturity.

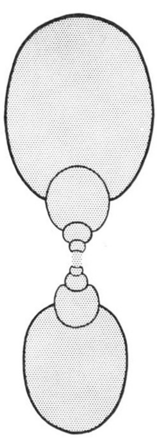
Shell ornament is preserved only faintly on a few specimens; ornament consists of fine growth lamellae which form a shallow ventral sinus, a deep sinus on the umbilical wall, and a low ventrolateral salient.

The external suture has a low, broad trifid ventral lobe at maturity and five pairs of rounded lateral lobes. The ventral lobe is about the same width as the serrate first lateral lobe and about three-quarters the height of the first lateral saddle. The denticulate first lateral lobe is about the same width as the ventral lobe and is constricted only slightly.



TEXTFIGURE 14

Diagrammatic representation of the sutural ontogeny of *Boesites gracilis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A–G based on paratype GSC 31919, H based on holotype GSC 31913. A represents prosuture, B the first suture, C the second suture, D where whorl height is 0.3 mm, E where whorl height is 0.7 mm, F where whorl height is 5.3 mm, G where whorl height is 7.0 mm, and H where whorl height is 13.0 mm (*after* K. A. Hodgkinson, University of Iowa, 1965).



TEXTFIGURE 15

Diagrammatic cross-section of *Boesites gracilis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 31915 at a conch diameter of 15.7 mm.

TABLE 1. Dimensions (in mm) and proportions of *Boesites gracilis* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 31913	20.1	9.0	7.9	6.3	0.45	0.39	0.31
Paratype GSC 31914	17.4	8.1	6.7	5.7	.46	.39	.32
Paratype GSC 31939	16.0	6.9	5.9	5.1	.43	.37	.32
Paratype GSC 31915	15.6	6.8	5.8	5.0	.43	.37	.32
Paratype GSC 31916	11.5	4.5	4.3	4.0	.39	.37	.35

Comparisons. Boesites gracilis closely resembles *B. scotti* from the Smithwick Shale in central Texas. It differs from *B. scotti,* however, in suture details. Both species have 5 external lateral lobes, only the first of which is denticulate. The ventral lobe of *B. gracilis,* however, is proportionately broader and shorter than that of *B. scotti.* Also the whorls of *B. scotti* consistently are more depressed than those of *B. gracilis* and the walls of the former appear to be relatively flatter.

Boesites girtyi (Plummer and Scott) is based on a single specimen from the Desmoinesian (Moscovian) Wewoka Formation in Oklahoma; the specimen was described first by Girty (1915b) as *Pronorites*?? sp. It is clear from Girty's description and illustration (Girty, 1915b, p. 247–248, Pl. 34, figs. 5–5c) that the holotype must be worn and the suture may be absent across the venter; thus, comparison with established species must await discovery of additional material from the type locality. Unklesbay (1962) referred a worn specimen from the Atoka Formation on Barnett Hill, near Clarita, Oklahoma to *B. girtyi.* Although Unklesbay's account of the Atokan occurrence is important, reference to *B. girtyi* must remain open to question until other material can be assembled from Oklahoma.

The younger Pennsylvanian forms, *B. texanus* and *B. primoris,* and the Permian *B. serotinus* have a considerably more advanced suture with more elements and a greater degree of lobal denticulation.

Ruzhencev (1951, p. 61) presented two sutural drawings of *Boesites* sp. from basal Asselian strata in the southern Urals, and suggested that this species may prove to be conspecific with *B. primoris.* Ruzhencev's (ibid.) specimens are obviously immature and sutures drawn at conch widths of about 3.5 mm indicate a *B. scotti* or *B. gracilis* stage of development.

Occurrence. The type locality of *B. gracilis* is near the base of the Hare Fiord Formation on the north side of Hare Fiord, Ellesmere Island (GSC loc. 56430; Textfig. 10). Other forms tentatively referred to the species occur in the upper Morrowan Trace Creek Shale Member of the Bloyd Formation, Arkansas and in the Morrowan Wapanucka Formation, Oklahoma.

Age. Atokan (Moscovian).

Boesites sp.

Description. One fragmentary specimen of *Boesites* sp. was found in the Canyon Fiord Formation of southern Ellesmere Island. Inner whorls are preserved entire up to a diameter of 5.5 mm. Only parts of septa of two additional whorls are visible; by reconstruction, the conch appears to have attained an approximate diameter of 15 mm. At a size of 5.5 mm, whorl height is 2.2 mm, whorl width 2 mm, and the umbilical diameter 2 mm. Shell ornament is absent. At a size of 5 mm the external suture includes a broad inflated ventral lobe and 4 lateral lobes; the first lateral lobe is as broad as the ventral lobe and is slightly narrower than the first lateral saddle.

Occurrence. Boesites sp. was found 1,145 feet above the base of the Canyon Fiord Formation on Raanes Peninsula, southern Ellesmere Island (GSC loc. C10885; Textfig. 13), 6 miles east of the head of Blind Fiord (85°23′N, 78°23′30″W).

Age. Desmoinesian (Moscovian).

Superfamily MEDLICOTTIACEAE Karpinsky, 1889

Family PRONORITIDAE Frech, 1901

Genus ***Stenopronorites*** Schindewolf, 1934

Pronorites KARPINSKY, 1889 (part), 1891 (part); YANISHEVSKY, 1900, 1910; YIN, 1935; TCHERNOW, 1907; SCHMIDT, 1925, 1929, 1955; RAUSER-TSCHERNOUSSOVA, 1928; KULLMANN *in* STEVANOVIC and KULLMANN, 1962 (part); KULLMANN, 1963 (part).
Stenopronorites SCHINDEWOLF, 1934 (part); LIBROVITCH, 1938; DELÉPINE, 1941; RUZHENCEV, 1949 (part).
Megapronorites KULLMANN, 1962.

Type species. *Pronorites cyclolobus* var. *uralensis* Karpinsky, 1889; from Namurian limestones along the Shartymka River in the Ural Mountains.

Diagnosis. Stenopronorites is extremely involute and characteristically has flattened sides and a rounded venter. In early growth stages, the ratio of whorl height to whorl width approximates unity but at maturity the whorl height is twice the whorl width. The shell is smooth but faint ribs may be present on the venter and ventrolateral flanks.

The suture has 6 or 7 lobes between the ventral lobe and the umbilical seam and 2 to 4 internal lobes in addition to the dorsal lobe for a total complement of 18 to 24 lobes. The first lateral lobe is divided into two more or less equal subdivisions by a moderately high saddle with diverging flanks.

Discussion. Stenopronorites includes the type species *S. uralensis* (Karpinsky) as well as *S. ferganensis* (Rauser), *S. occidentalis* (Kullmann), *S. omolonicus* Ruzhencev and Ganelin, *S. sersoni* n. sp., and possibly forms referred to *S. karpinskii* Librovitch by Popow, 1970. The following species have all been included in the genus by various authors: "*S.*" *arkansiensis* (Smith), "*S.*" *llanoensis* (Plummer and Scott), "*S.*" *kansasensis* (Newell), and "*S.*" *karpinskii* Librovitch. These are assigned to the new genus *Pseudopronorites* (type species *Pronorites cyclolobus* var. *arkansiensis* Smith). The taxonomic approach followed in this scheme is a modification of Ruzhencev's (1949) separation of the genus into "groups" which that author suggested might be recognized eventually as subgenera of *Stenopronorites. Stenopronorites* is distinguished from *Pseudopronorites* on the basis of sutural differences. *Stenopronorites* has from 18 to 24 lobes, whereas *Pseudopronorites* has from 22 to 26 lobes. The major distinction between the two genera is in the form of the first lateral lobe. In *Stenopronorites*, the saddle which divides the first lateral lobe is less than half the height of the first lateral saddle and has diverging flanks. In *Pseudopronorites*, however, the saddle which divides the first lateral lobe is at least two-thirds the height of the first lateral saddle, is slightly constricted at midpoint, and has nearly parallel flanks.

Stenopronorites is distinguished from the Viséan *Pronorites* Mojsisovics in that the former has a relatively higher saddle dividing the first lateral lobe; additionally *Pronorites* has fewer lobes (14) than *Stenopronorites.* Ruzhencev (1949) indicated that the first internal lateral lobe of *Pronorites* is connected with the fourth external lateral lobe, whereas in *Stenopronorites* the first internal lateral lobe is connected with the third external lateral lobe. Miller and Owen (1944) suggested that *Stenopronorites* sensu lato can be distinguished from *Pronorites* on the basis that the former possesses ventral ribs and the latter does not. Even though the species Miller and Owen (ibid.) described as '*Pronorites*' *arkansiensis* possesses faint ventral ribs, it was considered by those authors to be transitional between *Pronorites* and *Stenopronorites;* '*P.*' *arkansiensis* is the basis for the new genus *Pseudopronorites*. The presence or absence of ventral ribs appears to be an unreliable criterion to distinguish pronoritid genera as ribs may not be apparent until full maturity. Additionally, ribs may be present or entirely absent from conspecific individuals of equal size. Gordon (1964) has shown that ribs may be present on true representatives of *Pronorites*.

Kullmann (1963) suggested that a simple lobe count was insufficient to distinguish pronoritid genera and placed both *Stenopronorites* and the Namurian *Uralopronorites* (Librovitch) in synonymy with *Pronorites*. Librovitch (1947) recognized a basic similarity between *Stenopronorites* and *Uralopronorites* but pointed out that the two genera can be distinguished from one another on the basis of conch form and sutural detail. *Uralopronorites* has a flattened or concave venter and a shallow groove on the ventrolateral flanks. Ruzhencev (1949) and Ruzhencev and Bogoslovskaya (1971b) have shown that the saddle which divides the first lateral saddle on *Uralopronorites* is relatively shallow, broad, and asymmetric, whereas on *Stenopronorites* it is proportionately higher, narrower, and more nearly symmetrical. Only a few species of *Uralopronorites* have been described in the literature and the range of variation in the suture pattern is little known.

Ruzhencev (1949) suggested that the Namurian *Megapronorites* Ruzhencev can be distinguished from *Stenopronorites* on the basis that the former is more evolute during early ontogeny and that the two genera show different relationships between external and internal lobes. In *Megapronorites*, the first internal lateral lobe is connected with the fourth external lateral lobe whereas in *Stenopronorites* the first internal lateral lobe is connected with the third external lateral lobe. Furthermore, the first lateral lobe of *Stenopronorites* is divided into two branches by a relatively higher, more symmetrical saddle than that which separates the two branches of the first lateral lobe of *Megapronorites*. According to Kullmann (1963), the fundamental difference between *Stenopronorites* and *Megapronorites* was not so much the number or nature of lobes but rather the degree to which lobes are subdivided or modified in the umbilical region. For instance, Ruzhencev (1949) demonstrated that some sutures of the type species of *Megapronorites*, *M. sakmarensis*, have a bifid lobe on the umbilical wall. Kullmann (1963) assigned "*S.*" *occidentalis* from the Namurian of Spain to *Megapronorites* on the basis of a comparable bifid lobe in the umbilical region on one side of the conch, even though the conch form as well as the general sutural plan, particularly the narrowly divided first lateral lobe of the Spanish species, necessitates reference to *Stenopronorites*. Use of such a criterion for generic distinction is an unrealistic approach to taxonomy since the feature occurs erratically and may occur only on one side of the conch of mature specimens. A comparable bifid element near the umbilical shoulder occurs erratically on *Metapronorites stelcki* Nassichuk, 1971. Despite this, the fundamental differences between *Stenopronorites* and *Metapronorites* are, firstly, in the form of the first lateral lobe and, secondly, in the total number of lobes; the former has from 18 to 24 lobes and the latter 26 to 32 lobes.

Species composition and distribution.

Stenopronorites uralensis (Karpinsky, 1889); from Namurian strata in the Ural Mountains (Karpinsky, 1889, 1891; Yanishevsky, 1900, 1910; Tchernow, 1907; Ruzhencev, 1949; Ruzhencev and Bogoslovskaya, 1971b), Novaya Zemlya (Librovitch, 1938), Spain (Schmidt, 1929; Kullmann, 1962, 1963) and Morocco (Delépine, 1941).

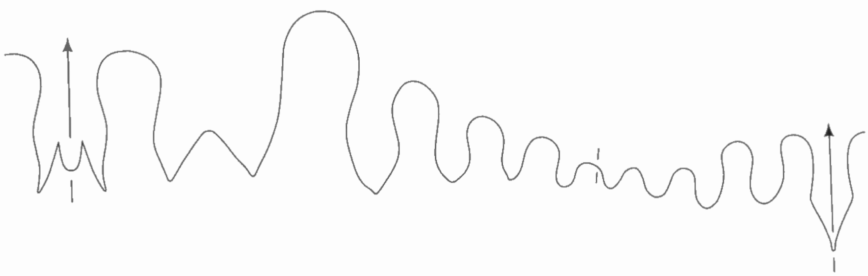
S. ferganensis (Rauser-Tschernoussova, 1928); from Namurian strata in Fergana.
S. omolonicus Ruzhencev and Ganelin, 1971; from Kayalian strata in Eastern Siberia.
S. shuichengensis (Yin, 1935); from Morrowan (Bloydian) strata in China.
S. occidentalis (Kullmann, 1962); from Namurian strata in Spain.
S. leonensis (Kullmann, 1963); from Namurian strata in Spain.
S. sersoni n. sp.; from Atokan strata on Ellesmere Island, Canada.

Several species in the literature are either inadequately preserved or poorly illustrated and, although some bear a close resemblance to *Stenopronorites*, reference to the genus must await further study; included are species described by Popow (1970) as *Stenopronorites karpinskii* and by Schmidt (1955) as *Pronorites arkansiensis*. The latter species is from Namurian strata in Spain and the former from Middle Carboniferous (C_2–C_3) strata in Southern Verkhoyan. Additionally, Thomas (1928) described *Pronorites*? *peruvianus* from Peru but preservation of Thomas' material precludes more than familial assignment; the Peruvian species undoubtedly will prove to be either *Stenopronorites* or *Pseudopronorites*.

Stenopronorites sersoni Nassichuk, n. sp.

Plate 4, figures 1, 3, 4, 5, 8, 9; Textfigure 16

Description. During early ontogeny, the conch of *S. sersoni* is moderately evolute but it becomes increasingly more involute during development. At a diameter of 20 mm, U/D equals 30 per cent but at 40 mm diameter, U/D equals 15 per cent. The venter is broadly rounded and the lateral flanks flat. The umbilical shoulder is narrowly rounded and the umbilical wall steep.



TEXTFIGURE 16. Diagrammatic representation of the suture of *Stenopronorites sersoni* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on paratype GSC 31926 at a conch diameter of 45 mm.

The shell is smooth except for extremely fine and nearly straight growth lines on the lateral flanks. At full maturity, faint ribs are visible across the venter of some specimens. A fine longitudinal groove is impressed along the middle of the venter.

The suture has a full complement of 20 lobes; 5 pairs of lobes on the ventrolateral and lateral flanks, one pair on the umbilical wall, and 3 pairs in an internal lateral position. The first lateral lobe is divided into two more or less equal parts by a low saddle with diverging flanks; this saddle is slightly less than half the height of the first lateral saddle. The first internal lateral lobe is connected to the third external lateral lobe.

Comparisons. Minor sutural differences distinguish *S. sersoni* from the type species. The latter has a relatively narrower first lateral lobe that is subdivided into two equal parts by a slightly narrower saddle. *Stenopronorites sersoni* differs from *S. occidentalis* in having a broader conch and a shorter but broader first lateral lobe. The suture of *S. sersoni* is closely comparable to that of Rauser's species *S. ferganensis* but the latter has a considerably narrower conch. Similarly, the suture of *S. leonensis* resembles that of *S. sersoni* but the former has a wider umbilicus. Whereas the conch of *S. sersoni* is practically identical with that of *S. omolonicus*, the sutures are different. *Stenopronorites omolonicus* has 15 external lobes (outside the umbilical seam) while *S. sersoni* has only 13.

TABLE 2. Dimensions (in mm) and proportions of *Stenopronorites sersoni* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 31921	39.5	20.5	13.3	5.0	0.52	0.34	0.13
Paratype GSC 31922	29.3	14.4	10.5	6.4	.49	.36	.22
Paratype GSC 31923	25.2	12.4	9.0	6.5	.49	.36	.29
Paratype GSC 31924	20.1	8.1	7.0	6.1	.40	.35	.33

Occurrence. The type locality of *S. sersoni* is GSC locality C4085 near the top of the "Tellevak Limestone" in the Blue Mountains, northern Ellesmere Island (Textfig. 10).

Age. Atokan (Moscovian).

Genus ***Pseudopronorites*** n. gen.

Pronorites SMITH, 1896, p. 267–270; 1903, p. 43–47; 1913, p. 633; 1914, Pl. 12, figs. 11, 12; ?THOMAS, 1928, p. 291; NEWELL, 1936, p. 488, 489; PLUMMER and SCOTT, 1937, p. 56–59 (part); MILLER and MOORE, 1938, p. 345; MILLER and OWEN, 1944, p. 420; SHIMER and SHROCK, 1944, p. 567; MILLER, FURNISH and SCHINDEWOLF, 1957, p. L72, Fig. 117; UNKLESBAY, 1962, p. 119; McCALEB, 1968, p. 75; NISHIDA, 1971, p. 19.
Goniatites WILLIAMS, 1900, p. 359.
Stenopronorites SCHINDEWOLF, 1934, p. 170; LIBROVITCH, 1939, p. 140; RUZHENCEV, 1949, p. 66; 1962, p. 350; McCALEB, 1963, p. 878; GORDON, 1964, p. A23; 1965, p. 288; 1968, p. A17; 1969, p. C10; NASSICHUK and FURNISH, 1965, p. 724; 1970, p. 399; POPOW, 1970, p. 115.

Type species. *Pronorites cyclolobus* var. *arkansiensis* Smith, 1896, p. 267–270, Pl. 24, figs. 1–4; from the Lower Coal Measures on Pilot Mountain, Boone County, Arkansas. Miller and Moore (1938) indicated that the holotype was from the Hale Formation, the upper part of which is considered by Gordon (1965) to be equivalent to the basal part of the Witts Springs Formation. In all probability, the ammonoid horizon is equivalent to the Brentwood Member of the Bloyd Formation (McCaleb, 1968).

Diagnosis. The conch of *Pseudopronorites* is discoidal and highly involute; U/D is less than 15 per cent at maturity. Lateral flanks are flat and the venter is evenly rounded.

Shell is smooth during early ontogeny, but at maturity ribs cross the venter and extend onto the ventrolateral flanks to about the position of the first lateral lobe.

The mature suture has from 22 to 26 lobes; 7 or 8 pairs of lobes are situated externally between the ventral lobe and the umbilical seam and 3 or 4 pairs of lobes occur internally on either side of the simple dorsal lobe. A high constricted saddle separates the first lateral lobe into two more or less equal parts; this saddle is at least two-thirds the height of the first lateral saddle.

Discussion. Pseudopronorites is readily distinguished from all other pronoritids on the basis of the external suture. In particular, the first lateral lobe is separated into two more or less equal parts by a narrow, constricted saddle that approaches the height of the first lateral saddle. The genus originated during the Namurian as an offshoot from a major pronoritid lineage which includes *Pronorites* (Viséan), *Stenopronorites* (Namurian–Moscovian), and *Metapronorites* (Moscovian–Sakmarian). It maintained a remarkable stability to the end of its range in the Missourian (Zhigulevian).

Pseudopronorites is widespread in North America where it has been reported from strata ranging from lower Morrowan to Missourian (Namurian to Zhigulevian) but it is rare elsewhere in the world. Librovitch (1939) erected *Stenopronorites karpinskii* from Middle Carboniferous strata in the southern Urals. He suggested that his species differed from typical *Stenopronorites* in possessing more lobes of comparable size and a higher saddle between the subdivisions of the first lateral lobe. Librovitch's (ibid., Textfig. 35, Pl. 34, figs. 11a, 11b) suture drawing and illustration of the species confirm reference to *Pseudopronorites*. The only other authentic occurrence outside of North America is in Japan where Nishida (1971) described *Pronorites arkansasensis* (*Pseudopronorites arkansiensis*) from probable Atokan strata in the Akiyoshi Limestone Group (*Profusulinella beppensis* Zone).

Species composition and distribution.

- *Pseudopronorites arkansiensis* (Smith) (=*Pronorites siebenthali* Smith, 1903), from the lower Morrowan (Namurian) Hale Formation, Arkansas and comparable strata (Witts Springs Formation) in Oklahoma; from the Morrowan Bloyd Formation and Johns Valley shale in Arkansas and the Union Valley Formation, Oklahoma; from the Atokan Winslow Formation in Arkansas; from the Atoka Formation as well as the Atokan Buckhorn Asphalt, Oklahoma and the Atokan "Smithwick Shale horizon" in the Magdalena Formation, West Texas. Beghtel (1962) recognized the species in the Desmoinesian (Moscovian) Wewoka Formation, Oklahoma. Similarly, Nishida (1971) reported *P. arkansiensis* from Atokan strata in the Akiyoshi Limestone Group, Japan. In Arctic Canada it occurs in the Hare Fiord Formation on Ellesmere Island.
- *P. kansasensis* (Newell, 1936); from Missourian (Zhigulevian) strata in the Argentine limestone, Kansas.
- *P. llanoensis* (Plummer and Scott, 1937); from the Atokan Marble Falls limestone, central Texas.
- *P. karpinskii* (Librovitch, 1939); from Middle Carboniferous (?Moscovian) strata in the southern Ural Mountains.
- *P. quinni* (Gordon, 1968); from lower Morrowan strata in Arkansas.

In addition to the above-listed occurrences, *Pseudopronorites* has been reported from probable Atokan strata in the Tihvipah Limestone in the Panamint Range, Inyo County, California ("*Stenopronorites*" sp. of Gordon, 1964). Gordon (1965) described "*Stenopronorites*" sp. A from two limonitic casts in the Atoka Formation, Arkansas, and suggested that it could be distinguished from "*S.*" *arkansiensis* on the basis of a broader venter and weak ventral ribs that form a shallow ventral sinus. Furthermore, Gordon (1969) recognized immature representatives of *Pseudopronorites* in probable Morrowan strata in the Tippipah Limestone and the Bird Spring Formation, Nevada.

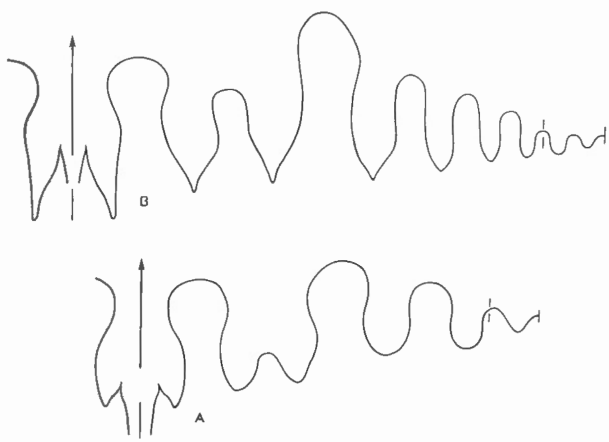
Several species in the literature require additional study before a certain generic assignment can be made. Thomas (1928) described *Pronorites*? *peruvianus* from the Amotape Mountains, Peru; the critical first lateral lobe is not preserved on Thomas' species which belongs either in *Stenopronorites* or *Pseudopronorites*. Schmidt (1955) described *Pronorites* *arkansasensis* from Namurian strata in Spain; the first lateral lobe of the Spanish species is separated into two parts by a low lobe which suggests that assignment should be made either to *Stenopronorites* or to *Metapronorites.*

Pseudopronorites arkansiensis (Smith), 1896

Plate 3, figure 3; Textfigures 17, 18

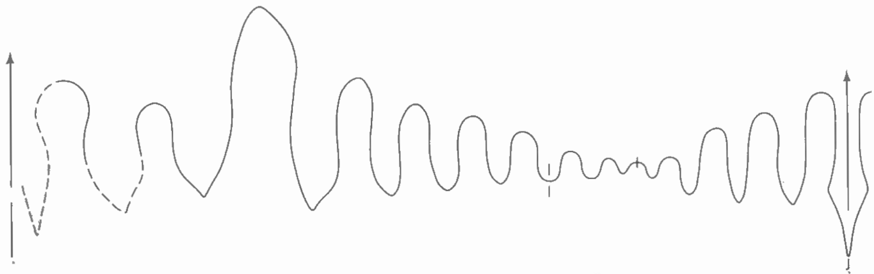
Goniatites cyclolobus WILLIAMS (*not* PHILLIPS), 1900, p. 359.
Pronorites cyclolobus var. *arkansiensis* SMITH, 1896, p. 267–270, Pl. 24, figs. 1–4; 1897, p. 57–60, Pl. 24, figs. 1–4.
Pronorites sp. indet, SMITH, 1896, p. 60, Pl. 20, fig. 2.
Pronorites cyclolobus var. *arkansasensis* SMITH, 1903, p. 43, Pl. 12, figs. 12–15; 1914, Pl. 12, figs. 11, 12.
Pronorites siebenthali SMITH, 1903, p. 47, Pl. 11, figs. 5–7.
Pronorites arkansasensis SMITH, 1913, p. 633, Textfig. 1183; PLUMMER and SCOTT, 1937, p. 57–59, Pl. 2, figs. 1–4; MILLER and MOORE, 1938, p. 345–346, Pl. 43, figs. 8, 9; MILLER and OWEN, 1944, p. 420, Pl. 63, figs. 3, 4; SHIMER and SHROCK, 1944, p. 567, Pl. 232. figs. 1, 2; UNKLESBAY, 1962, p. 119–121, Pl. 19, figs. 1–4; NISHIDA, 1971, p. 19, Pl. 7, figs. 1–4.
Pronorites arkansiensis (Smith) McCALEB, 1968, Pl. 2, figs. 20, 21; Pl. 12, figs. 1–3.
Stenopronorites arkansasensis (Smith) RUZHENCEV, 1949, p. 66, 67; McCALEB, 1963; Pl. 112, figs. 3, 4; Pl. 113, figs. 6–8.
Stenopronorites arkansiensis (Smith) GORDON, 1965, Pl. 23, figs. 26–29, 32, 33, 38–41.

Description. Four specimens of *P. arkansiensis* with diameters greater than 60 mm and three smaller specimens are available from Arctic Canada. During ontogeny, the conch experienced considerable change in proportions. At 6 mm diameter the shell is evolute and whorl width exceeds whorl height by the ratio 8:5; at 13 mm diameter the ratio W/H approximates unity; and at maturity the whorl is twice as high as it is wide and the shell is markedly involute and discoidal.



TEXTFIGURE 17

Diagrammatic representation of immature and mature sutures of *Pseudopronorites arkansiensis* (Smith) from the Hare Fiord Formation on Ellesmere Island; based on hypotype GSC 31931 from GSC loc. 56430 at a diameter of 6 mm and hypotype GSC 31929 from GSC loc. 58920 at a diameter of 35 mm.



TEXTFIGURE 18. Diagrammatic representation of the suture of *Pseudopronorites arkansiensis* (Smith) from the Hare Fiord Formation on Ellesmere Island (GSC loc. 58920); based on hypotype GSC 31930 at a conch diameter of about 68 mm.

During early ontogeny, fine transverse growth lines occur in the umbilical area and, at a diameter of about 30 mm, low, broad ribs appear which form a shallow ventral sinus and a low ventrolateral salient. The mature suture is characterized by a strongly bifid first 'lateral' lobe; the two subdivisions are markedly attenuate and are separated by a high, symmetrical constricted saddle. During ontogeny, elements are added to the suture by subdivision in the umbilical area. At a diameter of 60 mm, 6 pairs of 'lateral,' 2 pairs of umbilical, and 4 pairs of internal lateral lobes occur between the ventral and dorsal lobes. The only significant change in the suture between 30 mm and 80 mm diameter is an increase in the attenuation of 'lateral' lobes.

TABLE 3. Dimensions (in mm) and proportions of *Pseudopronorites arkansiensis* (Smith)

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 31928	88.3	50.0	23.5	11.7	0.57	0.27	0.13
Hypotype GSC 31929	49.8	25.7	16.8	7.1	.52	.34	.14
Hypotype GSC 31931	11.3	3.7	4.5	5.0	.32	.40	.44

Comparisons. The single specimen on which *Pseudopronorites arkansiensis* is based (the holotype; Smith, 1896, Pl. 24, figs. 1–4) is small for the genus (diameter 34 mm) and has a smooth surface. Thus, comparison with the holotype must be made on a size-for-size basis. Ribs are absent from the holotype but, in general, ribs appear on other representatives of the species only at full maturity. Arctic specimens of *P. arkansiensis* are slightly broader than the holotype and conspecific forms from the Morrowan Union Valley Sandstone, Oklahoma and the Hale Formation of Arkansas but, considering the general variation exhibited by the genus, there seems little reason to distinguish species on this basis.

Distinction between *P. arkansiensis* and *P. llanoensis* (Plummer and Scott) and *P. kansasensis* (Newell) is rather obscure since the materials on which the two last species are based are fragmentary and worn. Both may prove to be conspecific with *P. arkansiensis* when better preserved topotypes are recovered. As is typical of *P. arkansiensis*, the holotype of *P. karpinskii* (Librovitch) is small but the conch appears slightly wider than that of *P. arkansiensis.*

Occurrence. Pseudopronorites arkansiensis is known from three localities on Ellesmere Island. It was found in talus near the base of the Hare Fiord Formation, on the north side of Hare Fiord, one mile west of Stepanow Creek at GSC locality C14582 (Textfig. 10). It was found also in a small carbonate mound near the base of the Hare Fiord Formation, at GSC locality 56430. Additionally it occurs near the top of the "Tellevak Limestone" in the Blue Mountains, at GSC locality 58920.

Age. Atokan (Moscovian).

Genus *Metapronorites* Librovitch, 1938

Type species. *Pronorites timorensis* Haniel, 1915; from the Lower Permian (Sakmarian) Somohole beds, Timor.

Diagnosis. Metapronorites is discoidal and has flattened flanks and either a broadly rounded or a flattened venter. The umbilicus is open and is typically about 10 per cent of the conch diameter. The shell surface is typically smooth but some species possess faint growth lines on the ventrolateral flanks. The first lateral lobe is broad and bifid; the saddle separating the two asymmetric divisions of this lobe is low, unconstricted, and has sharply diverging flanks. The first lateral lobe may be denticulate on one or the other subdivision; similarly, the second lateral lobe may be denticulate. The number of lobes is variable; the type species has 32 lobes but other species have as few as 26.

Discussion. A fundamental problem in dealing with the taxonomy of the pronoritids is the treatment of forms that display a broad spectrum of sutural variation. Several genera are based on peculiarities of the suture line such as the number of lobes in the suture or the degree to which lateral lobes are serrate. It is rather apparent that these criteria are subject to extreme variation on a single specimen and that gradations may exist between established genera. Some species that are described in the literature as *Metapronorites* resemble, in a gross sense, *Neopronorites* Ruzhencev, 1936; Miller and Furnish (1940a) considered *Metapronorites* to be a synonym of *Neopronorites*. There exists, however, a fundamental distinction between the type species of both genera. Thus, the writer favours retention of both genera since appropriate criteria are evident to distinguish them.

Ruzhencev (1949, 1950, 1962) and Bogoslovskaya (1962) indicated that an important criterion distinguishing *Neopronorites* from *Metapronorites* was a bidentate dorsal lobe on the former and a simple undivided dorsal lobe on the latter. Haniel (1915, p. 26) and Smith (1927, Pl. 10) showed the dorsal lobe of the type species of *Metapronorites* to be undivided; a similar observation was made by the author on topotype materials collected by S. Martodjojo in the University of Iowa collections. A single fragmentary specimen in the latter collection has a sutural complement of 18 lobes at a diameter of about 10 mm, but at a size of about 25 mm (whorl height 11 mm) it has 28. Another large fragmentary topotype with a whorl height of 30 mm and an estimated diameter of about 60 mm has 32 lobes. Similar observations were recorded by Haniel (1915, p. 26, Fig. 2b), who figured a suture with 30 lobes on a fully mature specimen of the type species. Smith (1927, Pl. 10) showed the suture of a large specimen to have 28 lobes at a diameter of 40 mm and showed sutures from specimens at diameters of 5½ mm, 8 mm, and 10½ mm to have 12, 16, and 18 lobes, respectively. Thus, lobe counts by Haniel (ibid.), Smith (ibid.), and the present author are consistent on a size-for-size basis. None of the 3 topotypes of *Metapronorites timorensis* that were examined by the present author or specimens figured by Smith (1927) shows denticulation of lateral lobes. However, one specimen illustrated by Haniel (1915, Pl. 46, fig. 3) shows denticulation on the ventral subdivision of the first lateral lobe.

Ruzhencev (1956) and Bogoslovskaya (1962) presented sutural ontogenies of the type species of *Neopronorites*, *N. permicus*. Both typical *Neopronorites* and typical *Metapronorites* have comparable numbers of lobes. The main distinction between the type species of these genera is that, on the former, denticulation occurs on both subdivisions of the first lateral lobe and on the second lateral lobe at least from a diameter of about 15 mm. Despite this distinction, Ruzhencev has included several species with a *Metapronorites*-like suture in *Neopronorites* because of a divided dorsal lobe. Included are: *N. prior* Ruzhencev, *N. rotundus* (Maximova), and *N. schucherti* (Ruzhencev). The phylogenetic significance of a divided dorsal lobe is difficult to assess; however, the dorsal lobe of the Permian *Sakmarites* Ruzhencev, a probable successor to *Neopronorites*, has a comparable division. All Arctic representatives of *Metapronorites* have a simple dorsal lobe.

The Viséan *Pronorites* Mojsisovics is distinguished readily from *Metapronorites* on the basis of a relatively simple suture; that is, *Pronorites* has a sutural complement of 14 lobes at maturity whereas *Metapronorites* has at least 26. Furthermore, the first 'lateral' lobe of *Pronorites* is shallowly bifid whereas in *Metapronorites* it is relatively deeply bifid and may have denticulation on either subdivision.

Metapronorites has considerably more lobes than either the Namurian *Uralopronorites* Librovitch or the Namurian–Moscovian *Stenopronorites* Schindewolf. In addition, the saddle separating the two subdivisions of the first lateral lobe of *Metapronorites* is higher and narrower than that of *Uralopronorites*. Also, the second and third 'lateral' lobes of *Uralopronorites* have a higher degree of symmetry than do comparable lobes in *Metapronorites*.

Species composition and distribution.

Metapronorites cuneilobatus Ruzhencev, 1949; from Zhigulevian (Missourian) strata in the southern Urals.

M. ellesmerensis n. sp.; from Atokan strata on Ellesmere and Axel Heiberg Islands, Arctic Canada and possibly from the Winslow Formation of comparable age in Arkansas.

M. pseudotimorensis (Miller, 1930); from Missourian (Zhigulevian) and Virgilian strata in the Gaptank Formation, West Texas. The species also occurs in Moscovian strata in the Canyon Fiord Formation on Ellesmere Island.

M. stelcki Nassichuk, 1971; from Missourian (Zhigulevian) strata in the Yukon Territory, Canada.

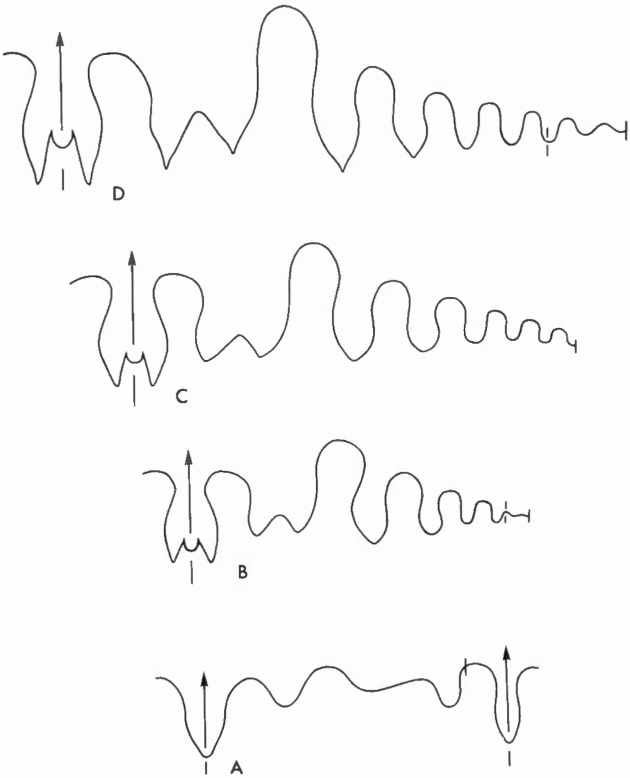
M. timorensis (Haniel, 1915); from Sakmarian and Artinskian strata in Timor.

NOTE: As was indicated by Nassichuk (1971), immature representatives of an undescribed species in the University of Iowa collections have been recovered from probable Virgilian strata in the Gaptank Formation, West Texas.

Metapronorites ellesmerensis Nassichuk, n. sp.

Plate 1, figures 2, 9, 10; Plate 3, figures 1, 2, 4, 5, 6;
Plate 4, figure 6; Textfigures 19, 20, 21

Description. During early ontogeny, at a diameter of less than 5 mm, the conch of *M. ellesmerensis* is evolute and the umbilical diameter is at least 30 per cent of the conch diameter; at that size the ratio of whorl height to whorl width approximates unity. During ontogeny, whorl height increases at a much faster rate than does whorl width and, in mature specimens, the whorl height is twice the whorl width. At maturity the shell is highly involute, the venter is gently rounded and the walls are flat to slightly convex.

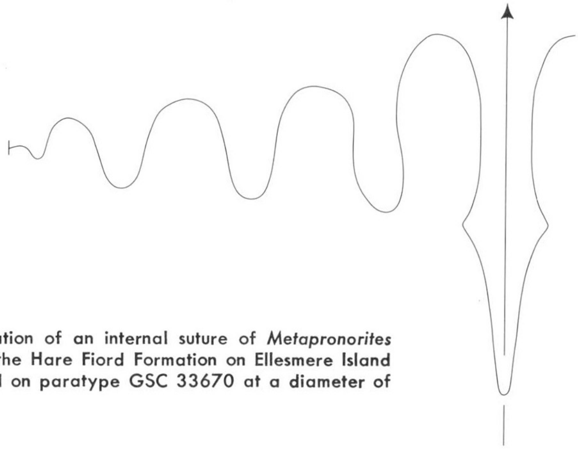


TEXTFIGURE 19

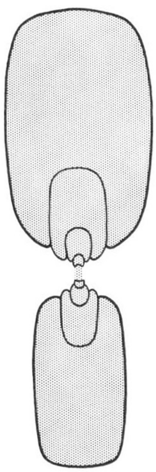
Diagrammatic representation of the sutural ontogeny of *Metapronorites ellesmerensis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A based on paratype GSC 31935 at a diameter of 2.5 mm, B based on paratype GSC 31936 at a diameter of 10.5 mm, C based on paratype GSC 31934 at a diameter of 20 mm, and D based on paratype GSC 31937 at a diameter of about 45 mm.

At a diameter of 30 mm, the shell is nearly smooth except for a fine ventral groove and delicate growth lamellae that form a salient on the ventrolateral flanks. At full maturity, broad but subdued ribs cross the venter and form a shallow ventral sinus and a low ventrolateral salient. At a diameter of 60 mm, ribs are about 3 mm wide and 4 mm apart on the venter.

The mature suture is characterized by a trifid, inflated ventral lobe and a broad bifid first 'lateral' lobe. The sixth 'lateral' lobe is near the umbilical shoulder and two poorly developed lobes occur on the umbilical wall. Of critical importance is the nature of the saddle which separates the first 'lateral' lobe into two unequal, asymmetric parts. This saddle is low, less than one-half the height of the first lateral saddle, and is unconstricted. The first lateral lobe begins to bifurcate at a diameter of 3 mm and at 5 mm it is strongly divided. Also at about 3 mm diameter, the ventral lobe changes from a slightly inflated funnel shape to a trifid form.



TEXTFIGURE 20. Diagrammatic representation of an internal suture of *Metapronorites ellesmerensis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33670 at a diameter of about 50 mm.

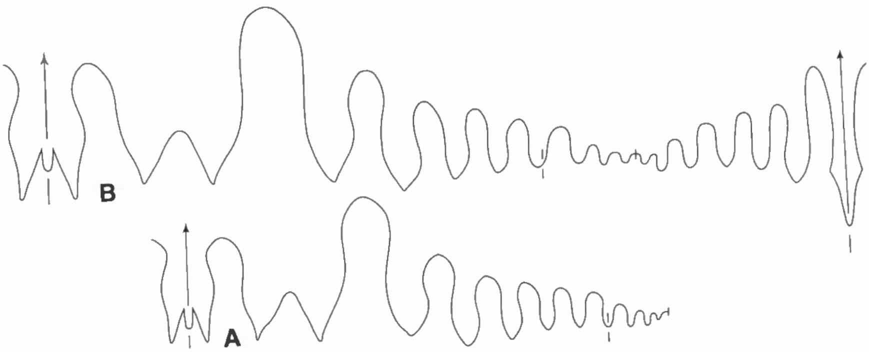


TEXTFIGURE 21

Diagrammatic cross-section of *Metapronorites ellesmerensis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33673 at a diameter of 60 mm.

TABLE 4. Dimensions (in mm) and proportions of *Metapronorites ellesmerensis* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 31932	85.0	45.1	25.5	12.5	0.53	0.30	0.15
Paratype GSC 31933	35.0	19.2	10.0	6.0	.55	.29	.17
Paratype GSC 31934	33.8	18.0	—	6.0	.53	—	.18
Paratype GSC 31935	10.0	4.4	3.3	3.2	.44	.33	.32
Paratype GSC 31938	8.8	3.0	2.8	3.1	.34	.32	.35



TEXTFIGURE 22. Diagrammatic representation of sutures of *Metapronorites timorensis* (Haniel) from the Lower Permian Somohole beds in Timor; A is based on topotype SUI 37232 at a diameter of about 45 mm and B based on topotype SUI 37233 at a diameter of about 65 mm.

Comparisons. Representatives of *M. ellesmerensis* differ from the type species, *M. timorensis*, in the number of sutural elements; the former species has 26 lobes at maturity and the latter 30 or 32. Differences in conch form also are apparent. The type species has a uniformly rounded venter but *M. ellesmerensis* has a flattened venter. Additionally, *M. ellesmerensis* can be distinguished from all other representatives of the genus because it possesses ventral ribs at maturity and because all lobes of the former are devoid of denticulation.

Occurrence. The type locality of *Metapronorites ellesmerensis* is near the base of the Hare Fiord Formation, at GSC locality 56430 on the north side of Hare Fiord, Ellesmere Island. The species is known from a comparable horizon in the Hare Fiord Formation at a number of localities on Ellesmere and Axel Heiberg Islands (GSC locs. C14582, C4083, C4012, C4013). It is known also from red beds near the top of the "Tellevak Limestone" in the Blue Mountains of Ellesmere Island.

Age. Atokan (Moscovian).

Metapronorites pseudotimorensis (Miller), 1930

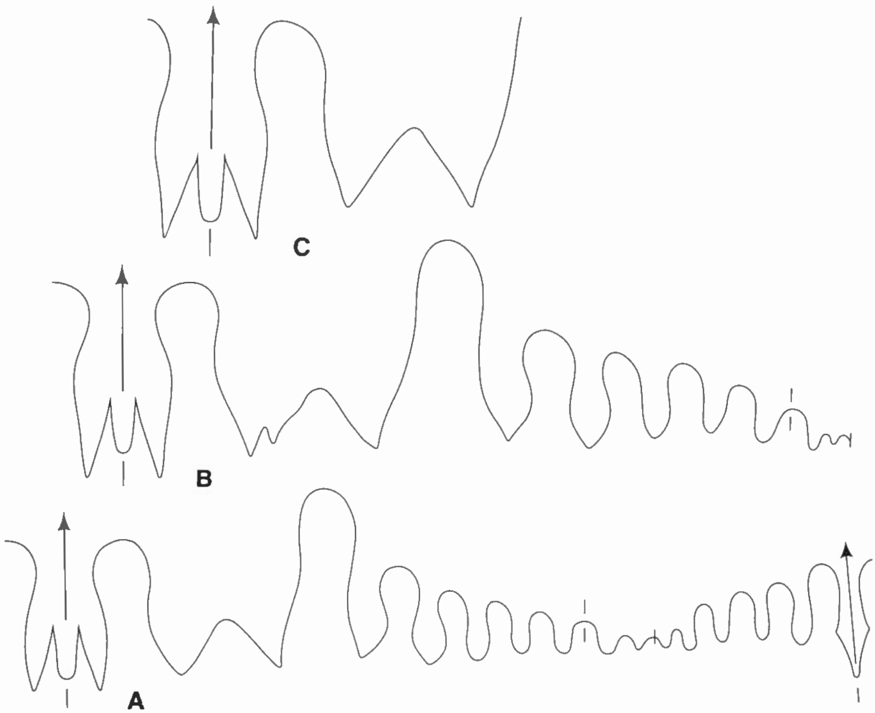
Plate 2, figures 1, 2, 3, 7, 8; Textfigures 23, 24

Pronorites pseudotimorensis MILLER, 1930, p. 391–395, Pl. 38, figs. 18–26; PLUMMER and SCOTT, 1937, p. 59–60, Pl. 2, figs. 16, 17.

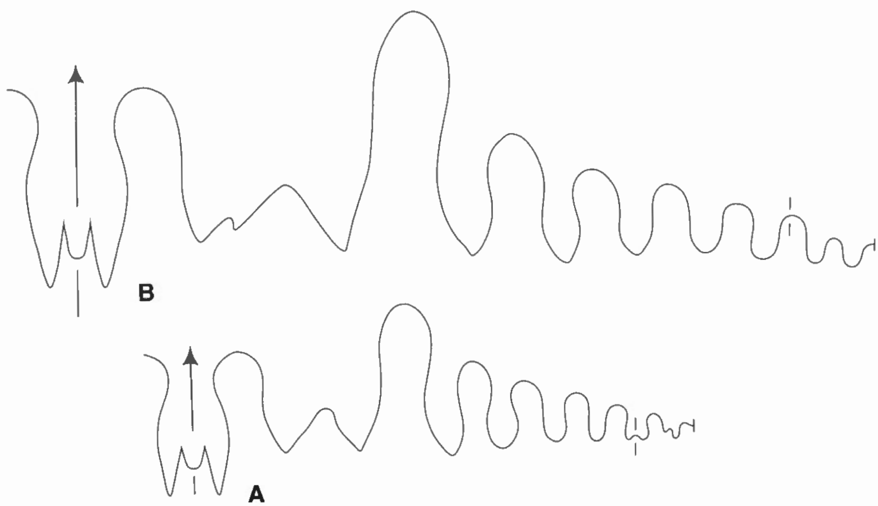
Neopronorites pseudotimorensis (Miller) MILLER and FURNISH, 1940a, p. 33.

Metapronorites pseudotimorensis (Miller) RUZHENCEV, 1949, p. 69; 1950, p. 59, 61; NASSICHUK, 1971, p. 83.

Description. About 60 specimens of *M. pseudotimorensis* have been recovered from Ellesmere Island. They are preserved as internal moulds in dense black skeletal foraminiferal limestone and only a few specimens are entire. Most specimens have a diameter between 20 and 40



TEXTFIGURE 23. Diagrammatic representation of sutures of *Metapronorites pseudotimorensis* (Miller) form Missourian strata in the Gaptank Formation, West Texas; A is based on paralectotype YPM 12931E at a diameter of about 35 mm, B is based on paralectotype YPM 12931D at a diameter of about 47 mm, and C is based on the lectotype YPM 12931A at a diameter of about 50 mm.



TEXTFIGURE 24. Diagrammatic representation of sutures of *Metapronorites pseudotimorensis* (Miller) from the Canyon Fiord Formation on Ellesmere Island (GSC loc. C10885); A is based on hypotype GSC 33676 at an approximate conch diameter of 30 mm and B is based on hypotype GSC 33675 at an approximate conch diameter of 45 mm.

mm but a few have a reconstructed diameter that closely approximates 60 mm. The venter is broadly rounded and the lateral flanks are flat. At a size of 40 mm, whorl width is 14 mm (W/D 35 per cent), whorl height is 22 mm (H/D 55 per cent), and the umbilicus is 6.2 mm (U/D 16 per cent). Shell ornament is absent. The mature suture has 28 lobes; 8 pairs occur between the ventral lobe and the umbilical seam and 5 pairs occur internally, between the dorsal lobe and the umbilical seam. Two pairs of the external lobes occur on the umbilical wall. The first lateral lobe is subdivided into two subequal parts by a low broad saddle that is about one-third the height of the first lateral saddle. Both divisions of the first lateral lobe are bluntly pointed and non-serrate up to a diameter of 34 mm but, beyond that size, the ventrad division is invariably bidentate. External lateral lobes are invariably non-serrate and become progressively smaller from the ventral area to the umbilicus. On one incomplete specimen at a reconstructed diameter of about 30 mm, the 6th lateral lobe, which is on the axis of the umbilical shoulder, is bifid; the saddle that divides this lobe is about one-quarter the height of the adjacent 5th lateral saddle.

Comparisons. In the original description of *Metapronorites pseudotimorensis* by Miller (1930), one specimen and sutures of several others, all of which were referred to as cotypes, were illustrated. The specimen shown by Miller (1930, Pl. 38, figs. 18–20) is selected to serve as lectotype.

Considerable sutural variation is apparent on typical representatives of *M. pseudotimorensis*. For example, none of the lateral lobes of the lectotype shows denticulation even at a reconstructed diameter of 40 mm; however, on one paralectotype at a size of about 30 mm the ventral subdivision of the first lateral lobe is clearly bidentate. On another paralectotype at a size of 40 mm, the ventral subdivision of the first lateral lobe is bidentate on one side of the shell but not on the other. Comparable variation in the denticulation of lateral elements is apparent in *M. cuneilobatus* Ruzhencev from Zhigulevian strata in the southern Urals. Ruzhencev (1949) indicated that the principal difference between *M. cuneilobatus* and *M. pseudotimorensis* was in the relative number of internal lateral lobes possessed by each; *M. cuneilobatus* has 5 such lobes. Miller (1930) showed that, at a size of 20 mm, *M. pseudotimorensis* has 4 internal lateral lobes but a re-examination of the type material shows 5 internal lateral lobes at a size of 30 mm; thus, *M. cuneilobatus* is probably conspecific with *M. pseudotimorensis*.

Subtle sutural differences separate *M. pseudotimorensis* from *M. stelcki* Nassichuk. In the latter, the ventral side of the divided first lateral lobe is tridentate rather than non-dentate or bidentate. Curiously, one specimen of *M. pseudotimorensis* from Ellesmere Island has a divided 6th lateral lobe. This feature has been observed elsewhere only on one specimen of *M. stelcki*.

Metapronorites pseudotimorensis differs from the older *M. ellesmerensis* in that the latter possesses ventral ribs at maturity and lacks denticulation. *Metapronorites pseudotimorensis* differs from the type species which has more lobes at comparable size and which has a broadly rounded, rather than a flattened venter.

Occurrence. Metapronorites pseudotimorensis typically occurs in Missourian (Zhigulevian) strata in the Gaptank Formation in the Glass Mountains, West Texas. In Arctic Canada, it was found in the Canyon Fiord Formation on Raanes Peninsula, Ellesmere Island (Textfig. 13). It was found at two levels in a section that was measured 6 miles east of the head of Blind Fiord on Raanes Peninsula (85°23′N, 78°23′30″W); GSC locality C10885 is 1,145 feet above the base of the formation and GSC locality C10891 is 1,462 feet above the base.

Age. Desmoinesian (Moscovian).

Order **GONIATITIDA** Hyatt, 1884
Superfamily CHEILOCERATACEAE Frech, 1897
Family MAXIMITIDAE Ruzhencev, 1960
Genus ***Maximites*** Miller and Furnish, 1957

Type species. *Imitoceras cherokeense* Miller and Owen, 1939, original designation; from the lower Desmoinesian (Moscovian) Cherokee Formation in Missouri.

Diagnosis. The conch of *Maximites* is subglobular during early ontogeny but is subdiscoidal to ellipsoidal at maturity; its diameter is invariably less than 10 mm. Whorls are markedly involute and the umbilicus is either completely closed or less than 5 per cent of the conch diameter. Ornament consists of faint, biconvex transverse growth lamellae and fine, sinuous longitudinal lirae. Despite the relatively small size of this genus, sutures are closely spaced, suggesting maturity. Details of the external suture best characterize the taxon; the bifid ventral lobe is narrow and deep, with variously rounded prongs, and the first lateral lobe is broad and shallow. The siphuncle is about one-quarter the distance from venter to dorsum. Sutural formula is: VLU:ID.

Discussion. Relationships of *Maximites* were discussed by Miller and Furnish (1957) and by Ruzhencev (1960); additional data were provided by Beghtel (1962). The genus was originally included in the Pseudohaloritidae by Miller and Furnish (1957) but now is considered to belong with *Neoaganides* in the Maximitidae. The fundamental distinction between the Maximitidae and the Pseudohaloritidae is that representatives of the latter possess ceratitic lobes whereas those of the former are simple goniatitic. *Maximites* can be distinguished from *Neoaganides*, which ranges in age from Late Pennsylvanian through Permian, on the basis of sutural details and on the position of the siphuncle at maturity. In *Maximites*, the ventral lobe is bifid and the siphuncle is situated less than one-quarter the distance from venter to dorsum. In *Neoaganides*, the ventral lobe is rounded and undivided, and the siphuncle is nearer the dorsum.

Miller and Owen's (1939) syntypes of the type species of *Maximites* (SUI 13485) show considerable variation in sutural detail. During early ontogenetic stages the ventral lobe is clearly undivided, as in typical *Neoaganides*. A restudy of forms from the Desmoinesian Wewoka Formation of Oklahoma confirms an observation by Beghtel (1962) that a gradation exists between the sutures of *Maximites* and *Neoaganides*. However, in all the Wewoka specimens the siphuncle is in a *Maximites* position. Undescribed specimens from the Missourian Seminole Formation of Oklahoma in the University of Iowa collections are assigned to *Maximites* on the basis of the divided ventral lobe and the position of the siphuncle.

Since the ventral lobe is markedly bifid in the Atokan *Maximites alexanderi* from Arctic Canada and is less strongly bifid in Desmoinesian and Missourian forms of comparable size (including typical *Maximites*), direct relationships with the older Imitoceratidae, all of which have undivided ventral lobes, are obscure. Furthermore, a rounded ventral lobe in early stages of *Maximites*, which later becomes bifid, and the rounded lobe in mature representatives of the younger *Neoaganides* are curious anomalies rendering both the progenitor and successor of *Maximites* uncertain.

Species composition and distribution.

Maximites alexanderi n. sp.; from Atokan strata in the Hare Fiord Formation, Ellesmere Island, Arctic Canada.

M. cherokeense (Miller and Owen, 1939); from the lower Desmoinesian (Moscovian) Cherokee Formation, Missouri.

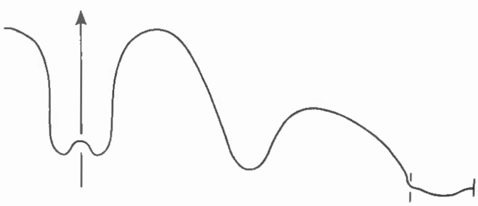
Undescribed Desmoinesian representatives of *Maximites* have been found in the Wewoka and Holdenville Formations of Oklahoma and an undescribed *Maximites* is known from the lower Missourian (Zhigulevian) Seminole Formation in Oklahoma; all these materials are in collections at the University of Iowa.

Maximites alexanderi Nassichuk, n. sp.

Plate 4, figure 7; Textfigure 25

Description. Three specimens of *Maximites alexanderi* are known from the Canadian Arctic. The largest specimen has a diameter of 8 mm; the ultimate volution is body chamber. Whorl width of this specimen, which serves as the holotype, is 4.1 mm and the whorl height 4.7 mm; the umbilicus is practically closed. The shell is smooth except for faintly preserved growth lamellae.

The external suture comprises a narrow bifid ventral lobe with distinctly rounded prongs, a pair of narrowly rounded, straight-sided lateral lobes, and a pair of broad, shallow umbilical lobes. The ventral side of the umbilical lobe is slightly inflected to form an incipient secondary lobe. The first lateral saddle is narrowly rounded and slightly asymmetric. The siphuncle is situated slightly less than one-quarter the distance from venter to dorsum.



TEXTFIGURE 25

Diagrammatic representation of the external suture of *Maximites alexanderi* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33678 at a conch diameter of 3 mm.

Comparisons. Maximites alexanderi differs from typical *M. cherokeense* in possessing a more pronounced bifurcation of the ventral lobe and a more nearly parallel arrangement of the sides of the ventral lobe. Despite the extreme variation in sutural and conch details of Desmoinesian forms described by Beghtel (1962), consistent differences between these and the Arctic species are readily apparent. In *M. alexanderi*, the ventral lobe is more bifid and the base of the umbilical lobe is slightly flexed ventrad.

Occurrence. Maximites alexanderi is known only from a mound-like carbonate development near the base of the Hare Fiord Formation on the north side of Hare Fiord at GSC locality 56430 (Textfig. 10; 81°07.5′N, 84°17′W).

Age. Atokan (Moscovian).

Superfamily NEODIMORPHOCERATACEAE Furnish and Knapp, 1966

Family NEODIMORPHOCERATIDAE Furnish and Knapp, 1966

Genus ***Neodimorphoceras*** Schmidt, 1925

Type species. *Dimorphoceras texanum* Smith, 1903; from the Virgilian Cisco Group, Young County, Texas.

Diagnosis. Neodimorphoceras has a discoidal conch and the umbilicus is nearly closed. The venter is typically narrow with a median concavity but, in some species, the venter is broadly rounded and lacks a median concavity. During early ontogenetic stages, shell ornament consists of prominent ribs which form shallow ventral and lateral sinuses; ribs become increasingly subdued during growth. At maturity, ribs are absent but conspicuous growth lamellae form a moderately deep ventral sinus and a relatively shallow lateral sinus. Delicate longitudinal lirae occur on the mature venter of some species.

The external suture best characterizes the genus; the ventral lobe is broad and is subdivided into 2 broad lobes by a median saddle of variable height. Prongs of the ventral lobe are bifid with the subdivision of each prong initiating on the ventral flank of the prong. Tertiary lobes on each prong are subequal and asymmetric. The most ventrad of these tertiary elements is invariably the shorter and may be narrowly rounded or accuminate. The longitudinal axes of the tertiary elements are essentially parallel. The first lateral saddle is broad, asymmetric, and narrowly rounded, whereas the first lateral lobe is considerably narrower and distinctly accuminate.

Sutural formula is: $(V_{1\cdot1}V_{1\cdot2}V_{1\cdot2}V_{1\cdot1})LU{:}ID$.

Discussion. A good deal of controversy surrounds the question of relationships of *Neodimorphoceras*, and this has been exemplified in recent studies by Furnish and Knapp (1966) and by Ruzhencev and Bogoslovskaya (1969a). Furnish and Knapp (ibid.) included *Neodimorphoceras* (Atokan–Virgilian) and its progenitor *Dimorphoceratoides* Furnish and Knapp (Morrowan) along with *Shuichengoceras* Yin (Morrowan) in the Neodimorphoceratinae and suggested that the group derived from the dimorphoceratid *Cymoceras* McCaleb (Morrowan). *Shuichengoceras* and *Dimorphoceratoides* differ from *Neodimorphoceras* in that the first two genera have divergent, nonparallel tertiary lobes of the ventral prongs. Relationships of the above three genera are discussed in considerable detail by Furnish and Knapp (ibid.). Yin's (1935) presentation of the suture of *Shuichengoceras* shows a sharp, angular relationship between sutural elements $V_{1\cdot1}$ and $V_{1\cdot2}$ as well as a sharply angular first lateral saddle. As suggested by Furnish and Knapp (ibid.), a study of Yin's illustrations of the poorly preserved representatives of the genus does not corroborate his sutural presentation and a close relationship with *Politoceras* Librovitch is apparent. Further clarification of relationships of *Shuichengoceras* can come only from a re-examination of Yin's type material.

Ruzhencev and Bogoslovskaya (1969a) stressed distinction of the group from true dimorphoceratids by raising the status of Neodimorphoceratinae to familial level. These authors considered *Cymoceras* to be a synonym of *Shuichengoceras* which they included in the family along with *Politoceras*, *Neodimorphoceras*, and *Dimorphoceratoides*; however, recently discovered mature representatives of *Cymoceras* from the American Midcontinent can now be shown to be distinct from *Shuichengoceras* (Furnish, pers. com., 1973). The Soviet authors considered the family to be derived from the Namurian Ramositidae Ruzhencev and Bogoslovskaya which contains *Ramosites* Ruzhencev and Bogoslovskaya and *Cravenoceratoides* Hudson. The shell ornament of the Ramositidae might be interpreted to resemble that of the Neodimorphoceratidae but sutural relationships remain obscure.

Considering several diverging points of view regarding relationships of *Neodimorphoceras* that have been expressed by Gordon (1965), Furnish and Knapp (1966), and Ruzhencev and Bogoslovskaya (1969a), it is clear that *Politoceras*, *Shuichengoceras*, and *Cymoceras* require reassessment before meaningful lineages can be established. Ruzhencev and Bogoslovskaya (1969a) indicated that derivation of *Neodimorphoceras* from *Dimorphoceratoides*, as was suggested by Furnish and Knapp (1966), was impractical since *Neodimorphoceras* was absent from strata of Moscovian age. Such an observation is incorrect, since Furnish and Knapp (ibid., p. 305) reported the genus from Desmoinesian (Moscovian) strata in Oklahoma. Curiously, Ruzhencev (1950, p. 116) acknowledged the presence of *N. oklahomae* in the Wewoka Formation. Furthermore, *Neodimorphoceras* occurs in pre-Desmoinesian, Atokan (i.e., lower Moscovian) strata in Arctic Canada and Arkansas. Ruzhencev and Bogoslovskaya (1969a) also suggested that derivation of *Neodimorphoceras* from *Dimorphoceratoides* was questionable on sutural grounds; that is, the tertiary subdivision of the ventral prongs of *Dimorphoceratoides* is broader and flatter than in *Neodimorphoceras*. It is perhaps more relevant and significant to consider that the origin of tertiary elements on the prongs of both genera is similar rather than to compare proportions of tertiary elements.

A possible representative of *Neodimorphoceras* from upper Cantabrian strata near Inguanzo in Spain was illustrated by Wagner-Gentis (1970). This species is represented by crushed, immature specimens and was designated "Gen. et sp. indet. Fam. Neodimorphoceratidae" by Wagner-Gentis (ibid.). Other crushed ammonoids devoid of sutures occurring in Cantabrian strata in the same section near Inguanzo were identified by Wagner-Gentis (ibid.) as cf. *Eoasianites* sp. and *Aristoceras* sp.

Species composition and distribution.

Neodimorphoceras daixense Ruzhencev, 1947; from Orenburgian strata in the southern Urals.

N. lenticulare (Girty, 1911); from the Desmoinesian (Moscovian) Wewoka Formation in Oklahoma.

N. oklahomae (Girty, 1911); from the Desmoinesian (Moscovian) Wewoka Formation in Oklahoma, and from comparable strata in the Mineral Wells Formation, northern Texas (Plummer and Scott, 1937; Beghtel, 1962).

N. sverdrupi n. sp.; from Atokan (Moscovian) strata in the Hare Fiord Formation and equivalent strata ("Tellevak Limestone") on Ellesmere Island. An undescribed species from the Atokan Winslow Formation in Arkansas (Furnish and Knapp, 1966) closely resembles and may be conspecific with *N. sverdrupi.*

N. texanum (Smith, 1903); from Virgilian (Orenburgian) strata in the Gaptank and Graham Formations of Texas; *see* Miller and Downs (1950) for references.

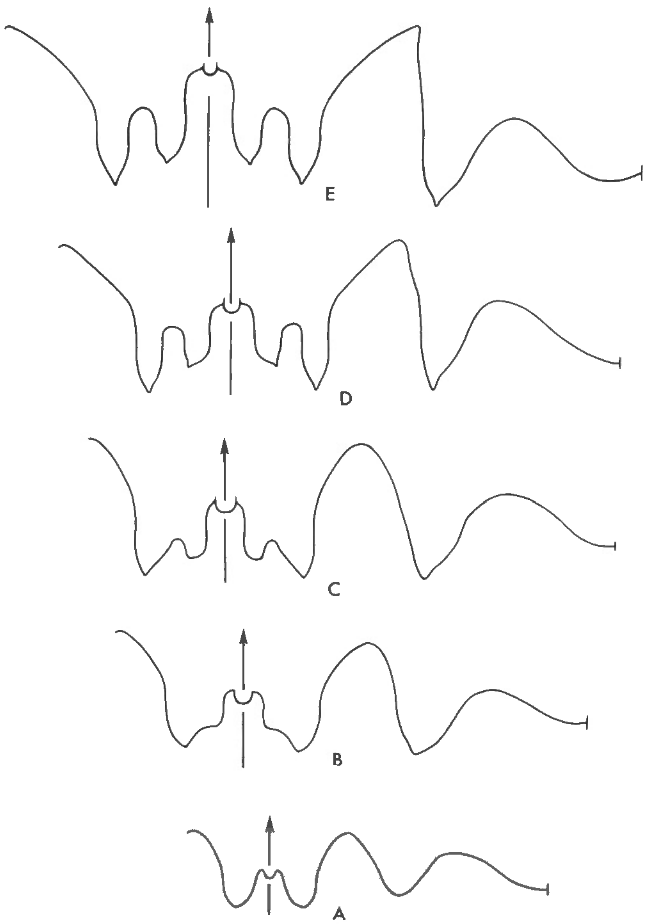
N.? sp. indet.; from upper Cantabrian (post-Westphalian, pre-Stephanian) strata in eastern Asturias, Spain (Wagner-Gentis, 1970).

Neodimorphoceras sverdrupi Nassichuk, n. sp.

Plate 4, figures 10, 11, 13;
Plate 6, figures 5, 6, 8, 9; Textfigure 26

Description. The conch of *N. sverdrupi* is remarkably involute and discoidal from a diameter of at least 5 mm to full maturity; the venter is evenly rounded throughout ontogeny. The specimen selected to serve as holotype is nonseptate beyond a diameter of 30 mm but attains, in an additional volution, a maximum size of about 50 mm. One large fragmentary paratype is septate to a reconstructed diameter of about 65 mm.

Ornament consists of sinuous biconvex transverse ribs to a size of about 10 mm. At maturity, growth lamellae form deep ventral and shallower lateral sinuses and moderately high ventrolateral and dorsolateral salients. The growth lamellae are expressed as flat-bottomed, flat-sided 'ridges,' separated from one another by narrower, flat-bottomed grooves. On the internal mould, these features are expressed as shallow rounded troughs and wider, low, rounded ridges. At a conch diameter of 19 mm, growth lamellae are 0.4 mm apart on the venter and at 30 mm they are 1 mm apart. On the holotype, at a diameter of 50 mm, faint longitudinal lirae, which are present on the dorsolateral flanks, produce a subdued reticulation. One large paratype has fine longitudinal lirae across the venter.



TEXTFIGURE 26

Diagrammatic representation of the sutural ontogeny of *Neodimorphoceras sverdrupi* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A and B are based on paratype GSC 33686 at conch diameters of 3.2 mm and 5.4 mm respectively, C is based on paratype GSC 33683 at a conch diameter of 11 mm, D is based on the holotype GSC 33681 at a conch diameter of 30 mm, and E is based on paratype GSC 33682 at an approximate conch diameter of 50 mm.

Details of the external suture which best characterize the species are: a high, narrow secondary ventral saddle and nearly symmetrical, accuminate tertiary ventral lobes. The saddle separating these tertiary elements on each ventral prong is evenly rounded, slightly constricted and about the same width as the tertiary lobes.

Comparisons. Neodimorphoceras sverdrupi differs from the type species *N. texanum* (Smith) in details of conch and sutural form. In the latter species, a groove is apparent on the venter even at a diameter of 20 mm and the saddle dividing the tertiary ventral lobes is about the same height as the secondary ventral saddle. In *N. sverdrupi*, no ventral groove is developed

TABLE 5. Dimensions (in mm) and proportions of *Neodimorphoceras sverdrupi* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Paratype GSC 33682	*70.0	*38.0	*27.0	—	*0.54	*0.39	—
Holotype GSC 33681	51.5	27.0	20.0	3.0	.52	.39	0.05
Paratype GSC 33683	20.0	11.0	8.3	1.3	.55	.41	.06
Paratype GSC 33684	14.0	8.9	6.8	—	.64	.48	—
Paratype GSC 33685	8.2	4.5	4.1	—	.55	.51	—
Paratype GSC 33686	5.6	2.8	3.0	—	.50	.53	—

* approximate.

even at a diameter of 70 mm, and the tertiary ventral saddles are about one-half the height of the secondary ventral saddle. A study of topotype material of *N. oklahomae* (Girty) from the Wewoka Formation of Oklahoma indicates that this species differs from *N. sverdrupi* in details of ornament, conch form, and of sutural development. In the former species, at a conch diameter of 8 mm, transverse growth lines are more strongly pronounced, the venter is slightly flattened and the umbilicus is proportionately larger than *N. sverdrupi*. Also, at a diameter of 8 mm, the first lateral lobe of *N. oklahomae* is narrow and rounded whereas, in *N. sverdrupi* at the same size, it is much broader and more highly angular. At maturity, the tertiary ventral prongs of *N. sverdrupi* are more nearly symmetrical than in *N. oklahomae*. Examples of *N. lenticulare* (Girty) from the Wewoka Formation of Oklahoma were examined; throughout ontogeny, tertiary elements on the ventral prongs of *N. lenticulare* are considerably broader than in *N. sverdrupi*, and a comparable degree of symmetry of tertiary ventral lobes is not attained in *N. lenticulare*.

The youngest known representative of the genus, *N. daixense*, differs from *N. sverdrupi* in that, on the former, the secondary ventral saddle is proportionately broader and shorter and the tertiary ventral lobes are longer and more inflated than on *N. sverdrupi*.

Occurrence. *Neodimorphoceras sverdrupi* n. sp. is known from three localities on Ellesmere Island. The type locality is near the base of the Hare Fiord Formation at Hare Fiord, Ellesmere Island (GSC loc. 56430). It is known also from a comparable horizon in the Hare Fiord Formation at van Hauen Pass, Ellesmere Island (GSC loc. C4250). A single specimen was recovered from near the top of the "Tellevak Limestone" in the Blue Mountains, Ellesmere Island (GSC loc. C4085).

Age. Atokan (Moscovian).

Family Gonioloboceratidae Spath, 1934

A recent discussion of the family by Furnish and Glenister (1971) stands as a principal reference and precludes more than a general statement in the current study. Additional pertinent data are available in works by Elias (1962), Miller and Downs (1950a), and Plummer and Scott (1937). Generally included in the family are:

Eogonioloboceras Librovitch, 1957 (Viséan)

Arcanoceras Ruzhencev, 1965 (Namurian)

Gonioglyphioceras Plummer and Scott, 1937 (Moscovian)

Goniolobоceratoides Nassichuk, n. gen. (Moscovian)

Goniolobоceras Hyatt, 1900 (Moscovian–Orenburgian)

Mescalites Furnish and Glenister, 1971 (Asselian).

Furnish and Glenister (1971) suggested that details of ventral sutural elements of *Eogonioloboceras* and *Arcanoceras* show closer affinities with the Girtyoceratidae but that, on the same basis, the Early and Middle Carboniferous (Morrowan–Moscovian) *Wiedeyoceras* Miller, 1932 and the Middle Pennsylvanian (Moscovian) *Wewokites* might be included logically in the Gonioloboceratidae.

Kullmann (1962) erected *Medioloboceras* (type *Medioloboceras mediolobum* Kullmann) from Namurian strata in Spain and included it in the Gonioloboceratidae. Ruzhencev and Bogoslovskaya (1971b, p. 176) quite correctly placed *Medioloboceras* in synonymy with *Eumorphoceras*, subgenus *Sulcogirtyoceras* Ruzhencev.

Representatives of the family have a discoidal to lenticular highly involute conch. Shell ornament includes biconvex growth lines with ventral and lateral sinuses. The suture has 8 lobes; the ventral lobe is broad and the secondary ventral saddle is about half the height of the first lateral saddle. A tertiary ventral saddle developed on representatives of some genera. Prongs of the ventral lobe are variously narrow or broad and are either accuminate or narrowly rounded. The first lateral lobe is broad, accuminate, and decidedly asymmetric and subangular.

Genus ***Gonioloboceratoides*** Nassichuk, n. gen.

Gonioloboceras MILLER and OWEN, 1939, p. 156–158, Pl. 17, figs. 7–11 (*not* figs. 6, 12, 13).

Type species. *Gonioloboceratoides curvatus* Nassichuk, n. gen., n. sp.; from Atokan strata in the Hare Fiord Formation at Hare Fiord, northern Ellesmere Island.

Diagnosis. The conch of *Gonioloboceratoides* is discoidal and highly involute; the umbilicus approximates 10 per cent of the conch diameter. The umbilical shoulder is narrowly rounded and the walls are flat. The venter is generally evenly rounded throughout ontogeny but may be slightly flattened at full maturity. Shell ornament consists of fine growth lamellae that form ventral and lateral sinuses.

Prongs of the ventral lobe are broad and rounded during early ontogeny but bluntly pointed at maturity. The first lateral saddle is markedly asymmetric, rounded and is nearly twice as broad as the asymmetric, V-shaped first lateral lobe.

Discussion. Gonioloboceratoides is characterized by sutural features that have been recognized during early ontogenetic stages of *Gonioloboceras*. In particular, prongs of the ventral lobe of *Gonioloboceratoides* and those of immature *Gonioloboceras* are proportionately broader and less accuminate than those of mature *Gonioloboceras*. Miller and Owen (1939) recognized primitive features in some of the types of their *Gonioloboceras eliasi* from Desmoinesian (Moscovian) strata in Missouri, particularly broad ventral prongs, but preferred to consider their species to be a primitive *Gonioloboceras* related to *Gonioloboceras welleri* rather than a distinct genus. Similarly, Furnish and Glenister (1971) indicated that primitive sutural features that are apparent on '*Goniloboceras*' *eliasi* are of trivial significance. It is clear that considerable variation exists in the type specimens of *G. eliasi* that were illustrated by Miller and Owen (1939); those on their Plate 17, figures 7–11 have broad ventral prongs and are clearly referable to *Gonioloboceratoides* whereas those represented in figures 12, 13 and possibly the immature specimen represented in figure 6 on the same plate are referable to *Gonioloboceras*, possibly *G. welleri*. *Gonioloboceratoides* thus is distinguished from *Gonioloboceras* and all other gonioloboceratids on the basis of proportionately wider, more bluntly pointed ventral prongs. Some species of *Gonioglyphioceras* have rather broad ventral prongs (*see G. gracile in* Girty, 1915b, Pl. 35, fig. 4) but this genus is lenticular with a thin, concave furrow on the venter. The venter of *Gonioloboceratoides* is broadly rounded and lacks a furrow throughout its development.

Species composition and distribution.

Gonioloboceratoides curvatus n. sp.; from Atokan (Moscovian) strata in the Hare Fiord Formation, Ellesmere Island.

G. eliasi (Miller and Owen) 1939 [part; Pl. 17, figs. 7–11 (*not* figs. 6, 12, 13)]; from the lower Desmoinesian (Moscovian) Cherokee Formation, in Missouri.

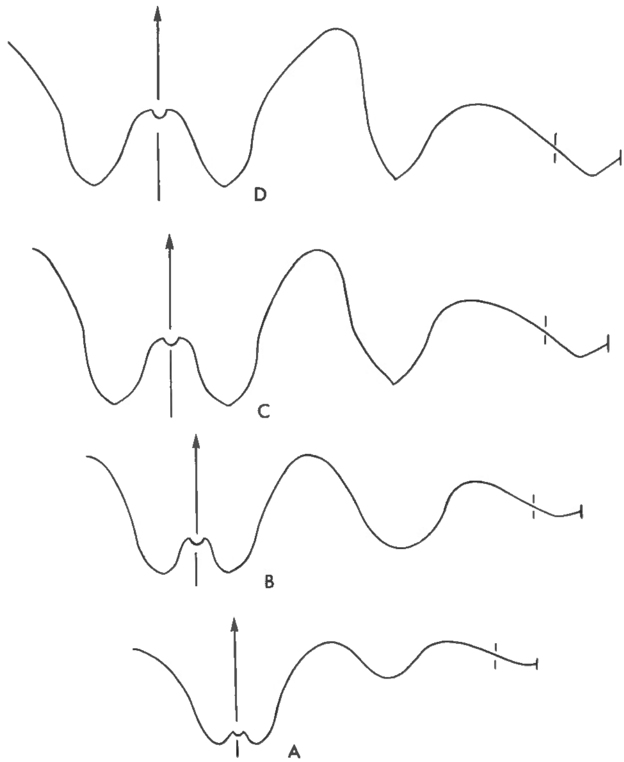
Several species described as *Gonioloboceras* in the literature are only moderately well described and illustrated but bear certain resemblances to *Gonioloboceratoides*. Included are *Gonioloboceras goniolobum* figured by Unklesbay (1962, Pl. 7, fig. 12) from the Desmoinesian Wewoka Formation in Oklahoma and *Gonioloboceras* cf. *G. eliasi* figured by Delépine (1941, Pl. 7, figs. 22, 23) from lower Westphalian strata in Morocco. Both species have moderately broad ventral prongs and a rather broadly rounded first lateral saddle. Ultimate generic assignment of these forms must await additional study.

Gonioloboceratoides curvatus Nassichuk, n. sp.

Plate 1, figure 11; Plate 4, figures 2, 12;
Plate 5, figures 7, 8; Textfigure 27

Description. Seven moderately well-preserved specimens of *Gonioloboceratoides curvatus* have been recovered from Ellesmere Island. The largest of these is entirely septate to its maximum diameter of 45 mm. The shell is ellipsoidal and the whorls involute; at maturity the umbilicus is about 10 per cent of the conch diameter. The umbilical walls are nearly straight and the shoulders narrowly rounded. Delicate biconvex growth lamellae are visible on one small paratype. During early ontogeny, up to a diameter of 10 mm, 3 or 4 constrictions occur per volution. Each constriction possesses a moderately deep ventral sinus, a shallow lateral sinus and a corresponding low ventrolateral salient. Constrictions are developed only faintly on the umbilical shoulders but are prominent across the venter.

The species is best characterized by details of external sutural elements which change considerably during ontogeny. The ventral lobe is consistently broad, as is the low secondary ventral saddle. Prongs of the ventral lobe are broad and rounded up to a diameter of about 30 mm; beyond that size they are bluntly angular. The ventral side of the asymmetric first lateral saddle is markedly flexed at about the height of the secondary ventral saddle. The



TEXTFIGURE 27

Diagrammatic representation of the sutural ontogeny of *Gonioloboceratoides curvatus* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A is based on paratype GSC 33690 at a conch diameter of 6 mm, B is based on paratype GSC 33689 at a conch diameter of 8 mm, C and D are based on the holotype GSC 33688 at conch diameters of 25 mm and 43 mm respectively.

height of this latter saddle, at a conch diameter of 7 mm, is about one-eighth the depth of the ventral lobe, but at maturity it is about one-half the depth of the ventral lobe. The first lateral lobe is shallow and evenly rounded in early stages of growth but gradually deepens and, at maturity, is slightly inflated, V-shaped, and is about the same depth as the ventral prongs.

Comparisons. The conch of *G. curvatus* is practically identical with that of the holotype of *G. eliasi*. The two species are distinguished on the basis of sutural detail; prongs of the ventral lobe of *G. curvatus* are relatively broader than those of *G. eliasi*. Also, the first lateral saddle of *G. curvatus* is more broadly rounded than that of *G. eliasi*.

TABLE 6. Dimensions (in mm) and proportions of *Gonioloboceratoides curvatus* Nassichuk and *Gonioloboceratoides eliasi* (Miller and Owen)

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
G. curvatus							
Holotype GSC 33688	45.0	24.6	17.1	5.0	0.55	0.38	0.11
Paratype GSC 33689	15.3	8.8	7.8	1.5	.57	.51	.10
Paratype GSC 33690	11.0	6.0	7.2	—	.55	.65	—
G. eliasi							
*Holotype SUI 13524	25.7	15.0	9.6	2.5	.58	.37	.10
**Topotype U. of Iowa	12.0	7.0	6.4	—	.58	.53	—
**Topotype U. of Iowa	9.4	4.7	5.7	—	.50	.61	—

*Holotype unavailable; measurements from figured specimen of Miller and Owen (1939, Pl. 17, figs. 7, 8).
**Unnumbered topotypes J. Harmer Collection, University of Iowa.

Occurrence. Gonioloboceratoides curvatus is known from a single locality on northern Ellesmere Island. It was found near the base of the Hare Fiord Formation at GSC locality 56430, on the north side of Hare Fiord (Textfig. 10).

Age. Atokan (Moscovian).

Superfamily GONIATITACEAE Haan, 1825

Family AGATHICERATIDAE Arthaber, 1911

Genus ***Proshumardites*** Rauser-Tschernoussova, 1928

Type species. *Proshumardites karpinskii* Rauser-Tschernoussova, 1928; O.D.; from Namurian strata in Fergana, Central Asia.

Diagnosis. Proshumardites is characterized by an extremely involute, subglobose to globose conch; the ratio of umbilical diameter to conch diameter is less than 10 per cent. Longitudinal lirae are coarse and widely spaced. Prongs of the broad ventral lobe are separated by a high, narrow saddle. Saddles L_2/L_1 are considerably lower than the first lateral saddle. Lateral lobe L_1 is invariably larger than L_2.

Sutural formula is: (V_1V_1) $(L_2L_1L_2)$U:ID.

Discussion. Miller and Furnish (1939) showed that *Agathiceras* passed through a *Proshumardites* stage during its early ontogenetic development and is derived directly from the latter genus; Rauser-Tschernoussova (1928) had suggested that *Proshumardites* was the progenitor of *Shumardites* Smith. Further direct evidence to show that *Agathiceras* derived from *Proshumardites* is provided by the species from the Canadian Arctic. In *P. aequalis* n. sp. the prongs of the ventral lobe are narrowly rounded, as they are in *Agathiceras*, and the lateral elements $L_2L_1L_2$ are inflated and more nearly approach the size of the ventral prongs than any previously described representative of the genus. In fact, the sutural proportions of the Arctic species approach those of the younger (Desmoinesian–Virgilian) *Agathiceras ciscoense* Smith. As pointed out by Ruzhencev (1955), *Shumardites*, which belongs in the Shumarditidae, does not pass through a *Proshumardites* stage of development but rather through an *Aktubites* stage during which internal lateral lobes as well as the dorsal lobe become trifid.

Pericleites Renz, 1910, from Namurian strata in east-central Greece (Attica), bears a distinctive resemblance to *Proshumardites.* Schindewolf (1939) restudied typical *Pericleites* and concluded that it was a valid genus, possibly a primitive shumarditid.

Ruzhencev and Bogoslovskaya (1971b) reviewed *Pericleites* and concluded that, in addition to the type species, one other species, *Pericleites uralicus,* belongs in the genus. The latter species was originally described as *Proshumardites uralicus* by Librovitch (1941). Ruzhencev and Bogoslovskaya (1971b) placed the following species in synonymy with *Pericleites uralicus: Proshumardites* (*Trigonoshumardites*) *wocklumerioides* Kullmann, 1962; *Proshumardites* (*Proshumardites*) *serbicus* Kullmann *in* Stevanovic and Kullmann, 1962.

The conch of *Pericleites* is comparable with that of *Proshumardites* but these genera differ in details of suture and ornament; *Pericleites* lacks longitudinal striae and has external lobes that are relatively more attenuate than *Proshumardites.* Ruzhencev and Bogoslovskaya (1971b) concluded that, within the family, two lineages developed as offshoots from the early Namurian *Dombarites* Librovitch, which is the oldest representative of the family. *Dombarites* is purported to have given rise to *Proshumardites* and *Agathiceras* Gemmellaro in one lineage and to *Pericleites* and *Gaetanoceras* Ruzhencev in another.

Species composition and distribution.

Proshumardites aequalis n. sp.; from Atokan strata on Ellesmere and Axel Heiberg Islands, Arctic Canada.

P. delepinei Schindewolf, 1939; from Namurian strata in Spain and Morocco (Shindewolf, 1939; Delépine, 1937, 1941; Schmidt, 1951; Pareyn, 1961; Kullmann, 1962; Wagner-Gentis, 1963) and from Namurian strata (Nm_1c_2) in central Asia, and in the southern Urals (Ruzhencev and Bogoslovskaya, 1971b).

P. karpinskii Rauser-Tschernoussova, 1928; from Namurian strata in Fergana, central Asia (Rauser-Tschernoussova, 1928), from Algeria (Pareyn, 1961), and Spain (Kullmann, 1962).

P. morrowanus Gordon, 1965; from the Morrowan Hale and Bloyd Formations in Arkansas and Oklahoma (Gordon, 1965; McCaleb, 1968).

P. primus Plummer and Scott, 1937; from Atokan strata in West Texas (Plummer and Scott, 1937), from the Desmoinesian (Moscovian) Wewoka Formation, Oklahoma (Beghtel, 1962); from Westphalian strata in Morocco (Delépine, 1941; Pareyn, 1961) and from Westphalian-B strata in Spain (Wagner-Gentis *in* Moore, Neves, Wagner and Wagner-Gentis, 1971); Wagner-Gentis (ibid.) also described *P.* sp. from the same locality as *P. primus* and the two possibly are conspecific.

P. principalis Ruzhencev and Bogoslovskaya, 1971b; from Namurian (Nm_1c_2) strata in the southern Urals.

Undescribed specimens of *Proshumardites* at the University of Iowa were collected from the Atoka Formation in Oklahoma and the Atokan Winslow Formation in Arkansas. According to Furnish (pers. com., 1969), several undescribed specimens representing an advanced species now are known to occur in the Alaska Range, southern Alaska.

Besides its occurrence in Atokan strata in the Canadian Arctic, the only other occurrence of *Proshumardites* in Canada is in strata of comparable age in the southern Yukon, where an undescribed species is known from the Taku Group at Bove Island, in Tagish Lake.

Proshumardites aequalis Nassichuk, n. sp.

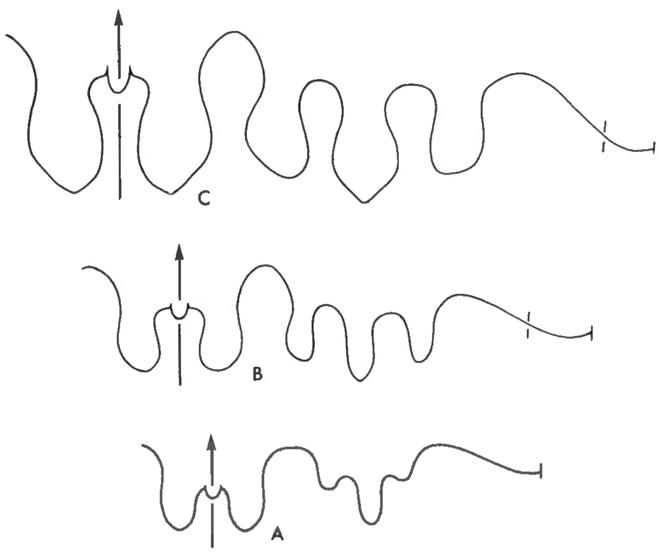
Plate 5, figures 1, 3, 4, 5, 9, 10; Textfigures 28, 29

Description. At least 40 well-preserved specimens and several fragments of *Proshumardites aequalis* n. sp. have been recovered. The most nearly complete specimen, which attains a diameter of 16.5 mm, is selected as the holotype.

Proportions of the subglobular, involute conch are reasonably consistent throughout ontogeny and the umbilical diameter at maturity is less than 5 per cent of the conch diameter.

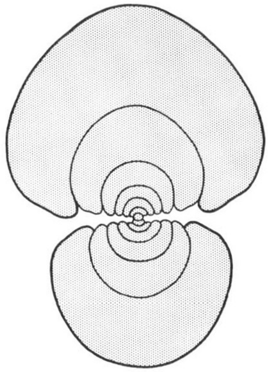
The most conspicuous feature of shell ornament is a series of flat-topped, coarse, longitudinal ridges with steep walls, separated by flat-bottomed troughs. One of the largest specimens, at a diameter of 21 mm, has 52 such external ridges. About 46 are present in a paratype at a diameter of 6 mm. The ridges are slightly wider spaced in the umbilical area than on the venter, and on the holotype, at a diameter of 14 mm, they are 0.5 mm apart on the lateral flanks. Fine, hair-like transverse growth lines are apparent in the inter-ridge troughs. Four transverse constrictions are present in a complete volution, each forming shallow dorsolateral and ventral sinuses and a low ventrolateral salient.

Prongs of the ventral lobe are narrowly rounded, inflated and are separated by a high constricted ventral saddle. Lateral lobes L_1 and L_2 are prominently inflated medianly and are narrowly rounded apicad. These elements are discrete at a diameter of 3 mm and, at that size, the depth of L_1 closely approximates that of the prongs of the ventral lobe. The latter relationship persists to maturity.



TEXTFIGURE 28

Diagrammatic representation of the sutural ontogeny of *Proshumardites aequalis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A is based on paratype GSC 33697 at a conch diameter of 2.5 mm, B is based on paratype GSC 33694 at a conch diameter of 4 mm, and C is based on the holotype GSC 33691 at a conch diameter of 11 mm.



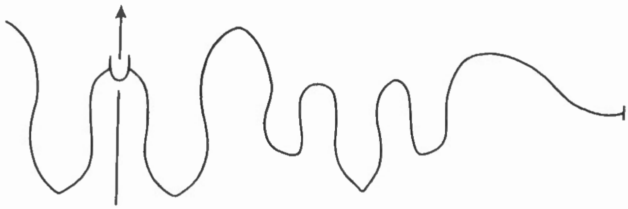
TEXTFIGURE 29

Diagrammatic cross-section of *Proshumardites aequalis* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33693 at a conch diameter of 12 mm.

TABLE 7. Dimensions (in mm) and proportions of *Proshumardites aequalis* n. sp. and *Proshumardites primus* Plummer and Scott

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
P. aequalis n. sp.							
Holotype GSC 33691	16.5	9.0	10.5	0.8	0.55	0.64	0.05
Paratype GSC 33692	14.1	8.0	9.0	.6	.57	.64	.05
Paratype GSC 33693	12.0	7.0	—	.6	.58	—	.05
Paratype GSC 33695	10.1	6.1	6.8	.5	.60	.67	.05
Paratype GSC 33694	10.0	6.0	7.0	.5	.60	.70	.05
Paratype GSC 33696	6.8	4.0	5.0	.3	.59	.74	.04
P. primus Plummer and Scott							
Cotype Univ. Texas 11195A	10.3	6.0	8.1	—	.58	.79	—

Comparisons. A re-examination of Plummer and Scott's (1937) cotypes of *P. primus* from rocks of Atokan age in West Texas shows the species to be more closely related to *P. aequalis* than to any other described form. However, certain differences between the two species, particularly details of the suture line, are readily apparent. Saddles V_1/L_2 and L_2/L_1 of *P. aequalis* are more strongly constricted than in *P. primus* and the secondary lateral saddles are proportionately higher in the Arctic species. *Proshumardites aequalis* can be distinguished readily from the type species *P. karpinskii* and all other described species because, on the former, external lobes lack attenuation and are relatively more inflated medianly.



TEXTFIGURE 30
Diagrammatic representation of the external suture of *Proshumardites primus* Plummer and Scott; based on cotype Univ. Texas 11195A, at a conch diameter of 10 mm.

Occurrence. Proshumardites aequalis is known from GSC locality 56430 near the base of the Hare Fiord Formation on the north side of Hare Fiord, Ellesmere Island (Textfig. 10); the type locality (81°07.5′N, 84°17′W). A single specimen was found near the base of the same formation at GSC locality C4012 near the head of Whitsunday Bay, Axel Heiberg Island (Textfig. 9).

Age. Atokan (Moscovian).

Superfamily NEOGLYPHIOCERATACEAE Plummer and Scott, 1937

Family Cravenoceratidae Ruzhencev, 1957

Genus *Cravenoceras* Bisat, 1928

Type species: *Homoceras malhamense* Bisat, 1924; from lower Namurian (E_1) strata in England.

Diagnosis. The conch of mature *Cravenoceras* is broad and has an evenly rounded venter; its width varies from 50 to 90 per cent of the diameter. The conch is moderately involute (U /D typically approximates 50 per cent but may be as little as 30 per cent on some species). Shell ornament consists of growth lamellae that are considerably more prominent during early ontogeny than they are at maturity and which are essentially straight across the venter. On some species, growth lines form an extremely shallow sinus or a low, broad salient across the venter. Additionally, very fine longitudinal lirae are preserved on some species. The external suture has a narrow ventral lobe. Ventral prongs are narrow and pointed and are separated from one another by a saddle that is less than half the height of the broadly rounded first lateral saddle. The first lateral lobe is deep and attenuate with straight or very slightly concave sides.

Discussion. Cravenoceras has been reviewed recently in considerable depth by Gordon (1965), Elias (1970), and by Ruzhencev and Bogoslovskaya (1971b). Because of these studies and because Arctic representatives of the genus described herein are poorly preserved and add little to general understanding of the taxon, a general taxonomic review is omitted here, and the above-mentioned studies stand as principal references. There is little general agreement between Gordon (ibid.) and Ruzhencev and Bogoslovskaya (ibid.) on species to be included in the genus; the Soviet workers assigned numerous species that Gordon (1965) included in *Cravenoceras* to other genera. Most of the species that Gordon (1965) cited as *Cravenoceras* were included by Ruzhencev and Bogoslovskaya (1971b) in either *Glaphyrites* Ruzhencev, 1936 or *Stenoglaphyrites* Ruzhencev and Bogoslovskaya, 1971 (type species, *Cravenoceras involutum* Gordon, 1965). In the opinion of the Soviet authors, *Stenoglaphyrites* is distinct from *Cravenoceras* even at the familial level and is distinguished from the latter genus by possessing a more highly involute conch and proportionately broader ventral prongs. Similarly, according to these workers, the enigmatic "*Glaphyrites*" differs from *Cravenoceras* by possessing a broader, deeper first lateral lobe as well as more highly developed and broader ventral prongs.

Gordon (1965) placed *Richardsonites* Elias (type, *Gastrioceras richardsonianum* Girty, 1909) in synonymy with *Cravenoceras* but, because of its rather wide ventral prongs, Ruzhencev and Bogoslovskaya (1971b) considered *Richardsonites* to be distinct from *Cravenoceras* but closely similar to *Glaphyrites*. Elias (1970), on the other hand, generally agreed with Gordon's treatment of *Cravenoceras* and considered *Richardsonites* to be a subgenus of *Cravenoceras*.

Elias (1970) described "*Homoceras*" n. sp. G from Namurian strata in the Goddard Shale Formation in Oklahoma and suggested that the Oklahoma species was derived directly from the British *Cravenoceras darwenense*. Ruzhencev and Bogoslovskaya (1971b) placed *Cravenoceras darwenense* in synonymy with *Glaphyrites*. It is unlikely that Elias's "*Homoceras*" would qualify for inclusion in the Homoceratidae as revised by Ruzhencev and Bogoslovskaya (1971a) but it probably fits the Soviet concept of *Glaphyrites* sensu lato.

According to Ruzhencev and Bogoslovskaya (1971b), *Cravenoceras* is related closely to the early Namurian *Pachylyroceras* Ruzhencev and Bogoslovskaya, 1971 and *Dombarigloria* Ruzhencev and Bogoslovskaya, 1971. Both of the last, however, differ from *Cravenoceras* in possessing prominent longitudinal lirae. The early Namurian *Alaoceras* Ruzhencev and Bogoslovskaya, 1971 differs from *Cravenoceras* in possessing umbilical nodes.

Species composition and distribution.

Cravenoceras is particularly widespread geographically and is confined to Namurian strata. Ruzhencev and Bogoslovskaya (1971b) used the genus to mark the *Uralopronorites–Cravenoceras* genozone, which corresponds in a general way to Bisat's E_1 Zone in Great Britain. A single species of *Cravenoceras*, however, *C. cowlingense* Bisat, occurs in the lower part of E_2 Zone (E_2a_1); that is, in the base of Ruzhencev and Bogoslovskaya's *Fayettevillea–Delepinoceras* genozone. The latter authors (ibid.) appear to favour inclusion of subzone E_2a_1 in the *Uralopronorites–Cravenoceras* genozone.

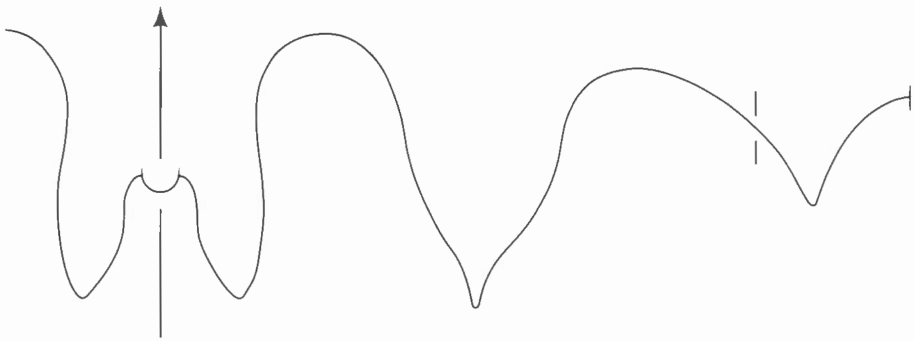
In addition to *C. tozeri* n. sp., which occurs in Namurian (E) strata on Melville Island, Arctic Canada, one other species, *Cravenoceras* cf. *C. hesperium*, is known from Canada, from Chesteran strata in the upper part of the Hart River Formation in the northern Yukon.

As mentioned earlier, lists of species of *Cravenoceras* recently have been published by Gordon (1965) and by Ruzhencev and Bogoslovskaya (1971b) and are not duplicated here. For completion, however, the genus has been recorded from the following countries: Great Britain and Ireland ($E_1 + E_2$), Belgium (E_2), Germany ($III_{\gamma 2}$, E_1, E_2), Czechoslovakia ($E_1 + E_2$), Poland (E_2), Morocco (E), Algeria (S^{3c}?, S^{4a}, S^{4b}, ^{4c}S), China (E_1), and U.S.A. ($E_1 + E_2$).

Cravenoceras tozeri Nassichuk, n. sp.

Plate 5, figures 2, 6; Plate 6, figures 1, 3;
Plate 7, figures 3, 4; Textfigure 31

Description. Some 200 specimens of *C. tozeri* were found at a single locality at Barrow Dome on Melville Island. Most specimens are fragmented or abraded but a few are well-enough preserved to display shell ornament as well as the complete suture. The conch is moderately broad (W/D varies from 50 to 60 per cent). Whereas the umbilicus of the holotype and of



TEXTFIGURE 31. Diagrammatic representation of the external suture of *Cravenoceras tozeri* n. sp. from the Otto Fiord Formation on Melville Island (GSC loc. C16904); based on paratype GSC 33701 at a diameter of 27 mm.

nearly half of all other specimens is 40 per cent of the conch diameter, it is closer to 50 per cent in the remaining mature specimens. These differences are interpreted here to represent sexual dimorphism and both forms are included in *C. tozeri*. Umbilical shoulders are smooth and subangular; umbilical walls are flat. Two or three lateral constrictions occur on each volution to maturity. Shell ornament consists of delicate growth lines which are generally straight across the venter; on some specimens growth lines form a very low, broad ventral salient.

TABLE 8. Dimensions (in mm) and proportions of *Cravenoceras tozeri* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Narrow umbilicus							
Holotype GSC 33698	35.0	10.0	20.5	14.5	0.29	0.59	0.41
Paratype GSC 33701	28.0	9.0	15.5	12.0	.32	.56	.43
Wide umbilicus							
Paratype GSC 33700	36.5	9.0	17.0	17.8	.25	.47	.49

Comparison. The conch of *C. tozeri* bears close resemblance to the Soviet subspecies *Cravenoceras beleutense evolutum* Ruzhencev and Bogoslovskaya, 1971b, from lower Namurian (Nm_1b_2) strata in the southern Urals. The two species can be distinguished from each other, however, since the Soviet species has a proportionately broader umbilicus and a slightly lower saddle between the ventral prongs. Similarly, the conch of *C. tozeri* resembles that of *C. africanum* Delépine, 1939 from Morocco (E Zone) and Algeria (S^{4c} Zone = E_2 Zone), but the suture of *C. africanum* is illustrated insufficiently for more than a general comparison.

Occurrence. Cravenoceras tozeri was recovered from GSC locality C16904 on the north side of Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). The locality is 2 miles northeast (brg. 07°) from the centre of the dome (76°39′15″N, 109°02′30″W). Specimens were recovered from a stratified sequence of lime mudstones that are interbedded with anhydrite and limestones (Otto Fiord Formation).

Age. Chesteran (Namurian E_2).

Genus *Syngastrioceras* Librovitch, 1938

Type species. *Gastrioceras orientale* Yin, 1935; from the Morrowan (Kayalian) Wangchiapa Limestone, Kueichow Province, China.

Diagnosis. Shell varies from thickly discoidal to subglobular. The umbilicus is typically close to 40 per cent of the conch diameter but closely approximates 10 per cent in some species. Umbilical shoulders are angular or narrowly rounded and the umbilical walls steep.

Shell is typically smooth but some species possess faint transverse lamellae on the lateral flanks. Constrictions form a broad ventral salient during early ontogenetic stages but do not persist to full maturity.

Details of the external suture best characterize the genus; the secondary ventral saddle is high, and the first lateral saddle is narrow, subangular, and asymmetric. The first lateral lobe is broad, inflated medianly, and markedly attenuate.

Discussion. A group of genera with a simple eight-lobed suture, including *Eoasianites* Ruzhencev, 1933, *Glaphyrites* Ruzhencev, 1936, and *Syngastrioceras* Librovitch, 1938, has been discussed extensively in the literature. Despite this attention, there is only limited general agreement concerning relationships of this group at the generic or higher taxonomic levels. Various authors have concluded that *Syngastrioceras* is synonymous with either *Gastrioceras* Hyatt, or *Glaphyrites*, or *Eoasianites*. The present writer supports the contention of Ruzhencev (1950, 1962) that *Gastrioceras* and *Eoasianites*, both gastrioceratids that possess umbilical nodes at least during early growth stages, are distinct from *Syngastrioceras*, which lacks umbilical nodes. *Syngastrioceras* is distinguished also from typical *Gastrioceras* and *Eoasianites* as well as *Neoicoceras* Hyatt by possessing a relatively narrow umbilicus and a subangular or narrowly rounded first lateral saddle as well as a relatively broad, attenuate first lateral lobe. Distinction between *Glaphyrites* (type *Gastrioceras modestum* Böse, 1919) and *Eoasianites* is less clear. Ruzhencev (1936, 1950) indicated that features which distinguish *Glaphyrites* from *Eoasianites* are a relatively small umbilicus and the absence of umbilical nodes on the former as well as a different mode of sutural development. Ruzhencev (1960b, 1962) included *Glaphyrites* in the Homoceratidae. Miller and Furnish (1940a) showed that representatives of the type species of *Glaphyrites* possess umbilical nodes during early growth stages and considered *Glaphyrites* to be synonymous with *Eoasianites*. Despite the umbilical nodes present on typical *Glaphyrites*, which suggest a relationship with the Gastrioceratidae, the suture and conch form of this genus appear to be distinct from typical *Eoasianites*.

Ruzhencev and Bogoslovskaya (1971b) suggested that differences between *Syngastrioceras* and *Glaphyrites* are so slight that the former logically might be considered to be a subgenus of the latter. The Soviet authors chose not to follow this procedure, however, and indicated that the two genera are separable on the basis of the form of the first lateral lobe; that of *Syngastrioceras* "cupola-shaped" with inflated or pouched flanks and that of *Glaphyrites* "funnel-shaped" with relatively straighter flanks. Ruzhencev and Bogoslovskaya (1971b) discredited the form of the first lateral saddle, that is the tendency toward "pointedness" of this element, as a valid criterion to distinguish *Syngastrioceras*. They objected to the implication that the first lateral saddle of *Syngastrioceras* is angular, as is shown in an inaccurate drawing of the suture of the type species, *S. orientale*, by Yin (1935, p. 20, Fig. 5). It is clear from Yin's illustration of the holotype that the first lateral saddle is not angular but laterally compressed and narrowly rounded. This feature, in conjunction with a broad, inflated first lateral lobe, serves to identify *Syngastrioceras* as a distinct taxon.

Yin (1935) erected *Gastrioceras kueichowense*, which is slightly more evolute and more compressed than typical *Syngastrioceras* and which, additionally, appears to have a slightly more angular or sharper first lateral saddle than *S. orientale*. McCaleb (1968) suggested that "*G.*" *kueichowense* as well as *Syngastrioceras suborientale* (Yin) are probably sexual dimorphs of *Syngastrioceras orientale*. Ruzhencev and Bogoslovskaya (1971b), impressed by the apparent angularity of the first lateral saddle of "*G.*" *kueichowense*, assigned it, as well as *Syngastrioceras ukrainicus* Librovitch to *Pseudoglaphyrites* Ruzhencev and Bogoslovskaya, 1971 [type species, *Pseudoglaphyrites sholakensis* Ruzhencev and Bogoslovskaya, 1971]; the present author sees no fundamental differences between the sutures of typical *Syngastrioceras* and typical *Pseudoglaphyrites* and the two are considered synonyms. "*Gastrioceras*" *kueichowense* is considered herein to belong in *Phaneroceras* Plummer and Scott.

Considerable merit must be given to the suggestion by Ruzhencev and Bogoslovskaya (1971b) that *Paracravenoceras* Gordon is a synonym of *Syngastrioceras*; some representatives of each taxon have comparable conch and sutural proportions. For example, *Paracravenoceras barnettense* (Plummer and Scott) has a narrowly rounded, asymmetric first lateral saddle and a broad first lateral lobe and might be considered a synonym of *Syngastrioceras*. Some authors have assigned this species, which clearly requires additional study, to *Schartymites* Librovitch (Ruzhencev, 1960b). The type species of *Paracravenoceras*, *P. ozarkense* Gordon, is more difficult to assess in that it is based on small specimens that have a broadly rounded first lateral saddle, similar to immature *Syngastrioceras*, but evidence for a "pointed" or narrowly rounded saddle is absent. Despite the configuration of the saddle of *P. ozarkense*, Ruzhencev and Bogoslovskaya (1971b) considered the similarity of the first lateral lobe to warrant assignment to *Syngastrioceras*.

Some species of *Syngastrioceras* with a particularly narrow umbilicus, such as *S. smithwickense*, bear a superficial resemblance to *Neogastrioceras* n. gen. and *Clistoceras* Nassichuk; this question is discussed further in this report under the heading of '*Clistoceras*.'

A variety of opinions has been expressed by several authors concerning a species from the Hale Formation, Arkansas, that was designated *Cravenoceras*? *morrowense* by Miller and Moore (1938) and a species with the same designation described from the Union Valley Formation, Oklahoma by Miller and Owen (1944). McCaleb (1968) and Gordon (1969) agreed that primary types described by Miller and Moore (1938, Pl. 43, Figs. 1, 2, 3) as *Cravenoceras*? *morrowense* are in fact *Pygmaeoceras* (ibid., Figs. 2, 3) and *Syngastrioceras oblatum* (ibid., Fig. 1). Earlier, Gordon (1965) included all Miller and Moore's (1938) figured types of "*C.?*" *morrowense* in *Glaphyrites*. McCaleb (1968) placed forms that Miller and Owen (1944) designated *Cravenoceras*? *morrowense* in *Syngastrioceras oblatum* but the conch and sutural proportions of Miller and Owen's Oklahoma (Union Valley Formation) species clearly indicate that the latter must be assigned to *Neogastrioceras*.

McCaleb (1968) indicated that *Syngastrioceras oblatum*, which occurs in the Bloyd Formation of Arkansas and Oklahoma, exhibits sexual dimorphism and that "sexes" are distinguished by relative umbilical diameters. This is an attractive procedure as it relates fossil organisms to living biologic units or populations but, for taxonomic purposes, care must be exercised so that species that are in fact 'real' are not obscured by synonymy.

Syngastrioceras is represented by three species on Ellesmere and Axel Heiberg Islands, *S. orientale* (Yin), *S. smithwickense* (Plummer and Scott), and *S. constrictum* n. sp. Additionally *S. oblatum* occurs on Melville Island. At all localities evidence for sexual dimorphism is not apparent.

Species composition and distribution.

It is clear that presentation of a complete list of species of *Syngastrioceras* is premature prior to a review of types of a great number of species in the literature that have been referred by various authors to *Eoasianites*, *Glaphyrites*, *Somoholites*, and other genera. Such a review is beyond the scope of this report and only unequivocal representatives of *Syngastrioceras* are included in the following list.

Syngastrioceras aktubense Ruzhencev and Bogoslovskaya, 1971; from Namurian (Nm_1c_2) strata in the southern Urals.

S. cadiconiformis (Wagner-Gentis, 1963); typically from Namurian strata in Spain. Saunders (1971) reported this species from Chesteran strata in Arkansas and Oklahoma.

S. constrictum n. sp.; from Atokan strata in Arctic Canada.

S. globosum (Easton, 1943); from the lower Morrowan (Halian) Hale Formation, Arkansas and Namurian (Nm_1c_2) strata in the southern Urals.

S. laxumbilicale Ruzhencev and Bogoslovskaya, 1971; from Namurian strata in the southern Urals (Nm_1c_1—Nm_1c_2).

S. oblatum (Miller and Moore, 1938); from Morrowan (Bloydian) strata in Arkansas and Oklahoma (Gordon, 1965; McCaleb, 1968) and possibly Nevada (Gordon, 1969).

S. orientale (Yin, 1935); from the Wangchiapa Limestone (Kayalian) in China, from Bashkirian strata in Japan (Kato, 1962), from middle Carboniferous strata in the Ural Mountains (Librovitch, 1946, 1947), as well as Atokan strata in Arctic Canada.

S. sholakensis Ruzhencev and Bogoslovskaya, 1971; from Namurian (Nm_1c_2) strata in the southern Urals.

S. smithwickense (Plummer and Scott, 1937); from Atokan strata in Texas, Oklahoma, Arkansas as well as Arctic Canada.

S. suborientale (Yin, 1935); from the Wangchiapa Limestone (Kayalian), China and from the Ural Mountains (Librovitch, 1946, 1947).

S. ukrainicus (Librovitch, 1939); from Kayalian and Moscovian strata in the Donetz Basin and the Ural Mountains.

Syngastrioceras oblatum (Miller and Moore), 1938

Plate 6, figures 2, 4, 7; Textfigure 33A

Description. Two immature specimens of *S. oblatum*, each with a diameter of approximately 12 mm, were found associated with species of *Branneroceras*, *Gastrioceras*, and *Bisatoceras* on Melville Island. Specimens are well-preserved limonitic moulds; shell material is missing and sutures are clearly visible. The venter is broadly rounded and the umbilical shoulder is smooth and angular. Four constrictions occur on the ultimate volution and these form a broad salient across the venter.

Prongs of the ventral lobe are half the width of the first lateral saddle; prongs are slightly inflated medianly, are attenuate and are separated from one another by a secondary ventral saddle that is about half the height of the first lateral saddle. The first lateral saddle is about three-quarters the width of the first lateral lobe, and is asymmetric and subangular. The first lateral lobe is inflated medianly and is markedly attenuate and considerably deeper than the ventral prongs.

TABLE 9. Conch dimensions and proportions of *Syngastrioceras oblatum* (Miller and Moore)

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33704	12.9	4.1	10.0	4.3	0.32	0.78	0.33

Comparisons. Specimens of *Syngastrioceras oblatum* are extremely abundant and show a wide range of variability in the Brentwood Member of the Bloyd Formation in Arkansas (type locality), and in equivalent strata in Oklahoma. McCaleb (1968) recognized two basic morphological forms of the species in Arkansas and interpreted these as sexual dimorphs; one dimorph is characterized by a narrow umbilicus (U/D 15–25 per cent at maturity) and the other by a wider umbilicus (U/D 30–35 per cent). Conch proportions of the Arctic *S. oblatum* are consistent with those of McCaleb's (ibid.) widely umbilicate dimorph at a comparable size.

Occurrence. Syngastrioceras oblatum was recovered from a single locality at Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). It occurs at GSC locality C16903 which is near the northern edge of Barrow Dome, 2 miles due north of the midpoint of the dome (76°39′15″N, 109°03′W).

Age. Bloydian (Westphalian-A = Kayalian).

Syngastrioceras orientale (Yin), 1935

Plate 7, figures 1, 6; Textfigure 32

Gastrioceras orientale YIN, 1935, p. 19–21, Pl. 2, figs. 1, 2; Pl. 4, fig. 10.
Syngastrioceras orientale (Yin) LIBROVITCH, 1938, p. 103; RUZHENCEV, 1962, p. 376, Textfig. 143.
Eoasianites sp. KATO, 1962, p. 33–34, Pl. 6, figs. 1–4.

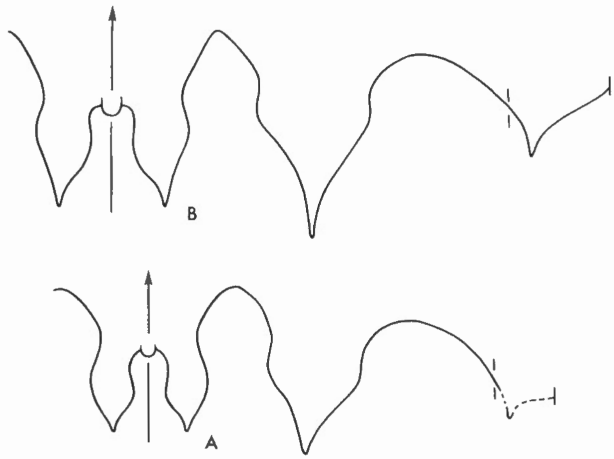
Description. Two specimens of *S. orientale* were recovered from skeletal limestones in the Blue Mountains on Ellesmere Island. Specimens are well preserved and the largest is septate to its full diameter of 55.5 mm. The conch is subglobular at maturity, and the venter is broadly rounded. The umbilicus is moderately large throughout ontogeny and at maturity is at least 40 per cent of the conch diameter. The umbilical shoulder is smooth and sharply defined; the umbilical wall is steep and slightly convex.

Shell ornament consists of delicate growth lamellae that are faintly visible only on the lateral flanks.

The sutural configuration is consistent during ontogeny and characteristic features such as inflated and attenuate lobes and a subangular first lateral saddle are apparent from a size of at least 20 mm.

TABLE 10. Dimensions (in mm) and proportions of *Syngastrioceras orientale* (Yin) from Ellesmere Island

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33707	55.5	19.5	46.6	23.0	0.35	0.84	0.41



TEXTFIGURE 32

Diagrammatic representation of external sutures of *Syngastrioceras orientale* (Yin) from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56428); A is based on hypotype GSC 33708 at a conch diameter of 30 mm, B is based on hypotype GSC 33707 at a conch diameter of 52 mm.

Comparisons. *Syngastrioceras orientale* has a wider conch and umbilicus than all other representatives of the genus. The Arctic specimens of *Syngastrioceras orientale* compare precisely with Yin's (1935) illustrations of the type species from the Wangchiapa Limestone in Central China. Yin's illustration of the holotype (ibid., Pl. 2, fig. 1) shows the first lateral saddle to be narrowly rounded, unlike the angularity shown in his textfigure 5, but more 'pointed' than is indicated by Ruzhencev's interpretation of the suture (Ruzhencev, 1962, Textfig. 143d). The width of *S. constrictum* n. sp. is comparable with *S. orientale* but the former has a considerably smaller umbilicus.

Occurrence. *Syngastrioceras orientale* is known from the Wangchiapa Limestone (Morrowan) of western Kueichow Province, central China (Yin, 1935) and has been reported also from the Donetz Basin and Ural Mountains in the Soviet Union (Librovitch, 1939). The species also occurs in probable Bashkirian strata in Japan (Kato, 1962). Arctic representatives of *S. orientale* are known from a collection made by Peter Harker at GSC locality 56428 in the Blue Mountains, Ellesmere Island (Textfig. 10). Stratigraphic data for this locality are scant; the collection is from near the top of the "Tellevak Limestone" probably from the same horizon that yielded several hundred specimens of *S. constrictum* several miles to the south at GSC locality C4085.

Age. Atokan (Moscovian).

Syngastrioceras smithwickense (Plummer and Scott), 1937

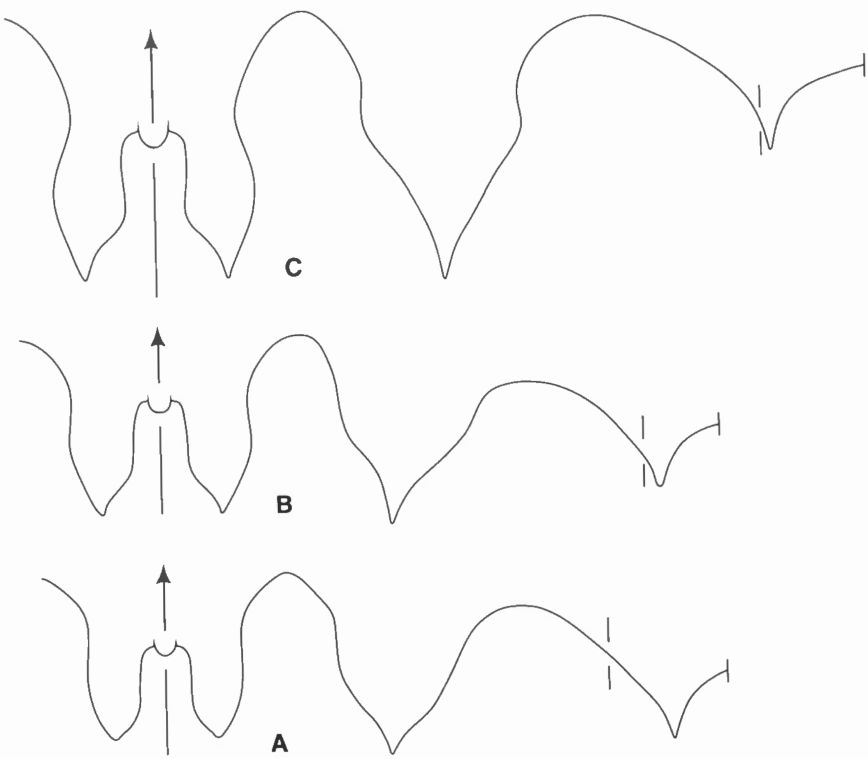
Plate 7, figure 5; Textfigure 33B

Nuculoceras smithwickense PLUMMER and SCOTT, 1937 (part), p. 109, Pl. 8, figs. 6–8, 10, 11 (*not* fig. 9).
Eoasianites smithwickensis McCALEB, 1963, p. 871, Pl. 111, figs. 1–4.
Clistoceras? *smithwickense* NASSICHUK and FURNISH, 1970, p. 399.

Description. Several specimens of *S. smithwickense* are known from the Hare Fiord and Nansen Formations on Ellesmere Island. The conch is subglobose and extremely involute but the umbilicus is open throughout development; U/D approximates 10 per cent. A few small specimens have faint transverse growth lines preserved. Additionally, 3 or 4 constrictions per volution are present and these form a very shallow broad ventral sinus and a low lateral salient.

TABLE 11. Dimensions (in mm) and proportions of *Syngastrioceras smithwickense* (Plummer and Scott) from Ellesmere Island

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33705	24.0	12.0	19.5	2.0	0.50	0.81	0.08



TEXTFIGURE 33. Diagrammatic representation of external sutures of 3 species of *Syngastrioceras* from Arctic Canada; A, *Syngastrioceras oblatum* (Miller and Moore) from the Otto Fiord Formation on Melville Island (GSC loc. C16903); based on hypotype GSC 33704 at a conch diameter of 11 mm. B, *Syngastrioceras smithwickense* (Plummer and Scott) from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on hypotype GSC 33705 at a conch diameter of 19 mm. C, *Syngastrioceras constrictum* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on hypotype GSC 33711 at a conch diameter of 23 mm.

Prongs of the ventral lobe are about half the width of the first lateral saddle; the latter is asymmetric and narrowly rounded and becomes progressively more 'pointed' during ontogeny. Ventral prongs are slightly wider than the secondary ventral saddle. The ventral saddle is about two-thirds the height of the first lateral saddle. The first lateral lobe is broad and attenuate and moderately inflated laterally. The umbilical lobe is situated just inside the umbilical shoulder.

Comparisons. Syngastrioceras smithwickense differs from most other representatives of the genus in having a particularly small umbilicus at maturity. It closely resembles immature representatives of *S. constrictum* except that the latter has a proportionately broader conch and umbilicus.

Assignment of *S. smithwickense* to *Syngastrioceras* is based on the form of the suture and conch. The suture has elongate ventral prongs and a broad, inflated first lateral lobe as well as an asymmetric first lateral saddle. The umbilicus is open throughout ontogeny and the umbilical walls are steep; U/D is greater than 8 per cent. Unfortunately, the primary types on which the species is based (Plummer and Scott, 1937, Pl. 8, figs. 6–11) are rather small. Plummer and Scott's illustrations of the suture of the species (ibid., Pl. 8, figs. 6, 11), were based on immature specimens that do not adequately show characteristics which define the genus.

Occurrence. The type locality of *S. smithwickense* is in the Atokan Smithwick shale in central Texas. The type species also occurs in comparable strata in West Texas and in the Atoka Formation in Oklahoma and the Winslow Formation in Arkansas. In Canada, it occurs at several localities on Ellesmere Island (Textfig. 10). It is known from near the base of the Hare Fiord Formation at Hare Fiord (GSC loc. C14582) and in the Krieger Mountains (GSC loc. C4083). It has been found also near the top of the "Tellevak Limestone" in the Blue Mountains of Ellesmere Island (GSC loc. C4085).

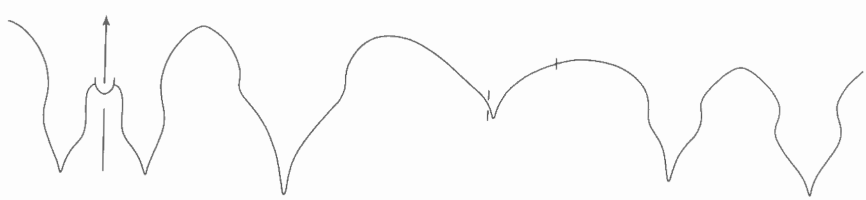
Age. Atokan (Moscovian).

Syngastrioceras constrictum Nassichuk, n. sp.

Plate 7, figure 2; Plate 8, figures 1, 2; Textfigures 33C, 34

Description. More than 100 specimens of *Syngastrioceras constrictum* were collected from northern parts of Ellesmere and Axel Heiberg Islands. Most of these have a diameter between 30 and 50 mm and are fully septate, but a few specimens have a diameter of 70 mm; on the latter most of the ultimate volution is body chamber. The conch is globular and has a narrow umbilicus; the width of the conch closely approximates the diameter.

Shell ornament consists of delicate transverse growth lamellae and from 4 to 6 shallow transverse constrictions which persist up to a conch diameter of about 30 mm. Lamellae and



TEXTFIGURE 34. Diagrammatic representation of the suture of *Syngastrioceras constrictum* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on paratype GSC 33715 at an approximate diameter of 35 mm.

constrictions form a shallow ventrolateral sinus and a corresponding low, broad ventral salient. On some larger specimens, broad, low transverse ridges, 3 to 5 mm apart, occur on the body chamber. Also, a faint runzelschicht pattern is preserved on the shell surface of some specimens across the venter and flanks.

The external suture closely resembles that of the type species; that is, the first lateral saddle is narrow and subangular and the first lateral lobe is broad, inflated and markedly attenuate.

TABLE 12. Dimensions (in mm) and proportions of *Syngastrioceras constrictum* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Paratype GSC 33710	68.0	30.0	56.0	15.0	0.44	0.82	0.22
Holotype GSC 33709	54.0	23.0	47.5	10.0	.43	.88	.19
Paratype GSC 33710	45.0	20.5	40.5	8.0	.46	.90	.18
Paratype GSC 33713	31.5	14.0	31.0	5.0	.44	.98	.16

Comparisons. The sutural pattern of *S. constrictum* is similar to *S. orientale* but the two species are distinguished on the basis of conch form. *Syngastrioceras constrictum* has a narrower umbilicus and a more narrowly rounded venter. *Syngastrioceras constrictum* is considerably broader than the Morrowan *S. oblatum*. McCaleb (1968) showed that a sexual dimorph of *S. oblatum* from Arkansas has a narrow umbilicus comparable to *S. constrictum* but the conch of the latter is broader than all variants of the Arkansas species.

Occurrence. Syngastrioceras constrictum is known from several localities in the Hare Fiord Formation in the Blue Mountains of northern Ellesmere Island (Textfig. 10). It is most abundant at the type locality (GSC loc. C4085) near the top of the "Tellevak Limestone" but it is known from a comparable horizon at several localities nearby (GSC locs. C10808, C10810).

Age. Atokan (Moscovian).

Genus *Clistoceras* Nassichuk, 1967

Type species. *Clistoceras globosum* Nassichuk, 1967, from Atokan strata on Ellesmere Island.

Diagnosis. The conch of *Clistoceras* is fusiform during early growth stages but is globular at maturity. The venter tends to become progressively more narrowly rounded during ontogeny. The conch has a narrow umbilicus which in some species is closed beyond early growth stages by helicolateral deposits; U/D is invariably less than 5 per cent. Typically, helicolateral deposits also occur on the ventrolateral flanks and, because of their presence, succeeding whorls are indented on the dorsolateral flanks. Shell ornament includes fine growth lamellae that form shallow ventral and lateral sinuses and correspondingly shallow dorsolateral salients. During early growth stages, one or two constrictions occur on each volution and these are parallel with growth lamellae.

Prongs of the ventral lobe are narrowly rounded, non-attenuate and have moderately straight sides. The secondary ventral saddle is slightly wider than the ventral prongs and is about half the height of the first lateral saddle. The first lateral saddle is broad and moderately symmetrical. The first lateral lobe is broad and symmetrical and is only slightly attenuated. The umbilical lobe is either on the umbilical shoulder or just outside the umbilicus.

Discussion. In the original definition of *Clistoceras* provided by Nassichuk (1967a), the helicolateral deposits and a closed umbilicus were among criteria designated to identify the genus. The definition is emended slightly here to include globose to subglobose forms with an open umbilicus (U/D less than 5 per cent) and which may or may not possess helicolateral deposits. Thus helicolateral deposits, although spectacular on the type species, are considered to be of trivial taxonomic significance. The reasons for emending the genus are as follows. The original description of the type species was based on 10 specimens, all with helicolateral deposits. Large collections have been made from the type locality in recent years and at least 40 topotypes are available. On some of the topotypes, considerable variation in conch form is evident but sutures are consistent and possible sexual dimorphs have been identified. Furthermore, some specimens lack helicolateral deposits entirely.

Clistoceras is clearly a close relative of species of *Syngastrioceras* and *Neogastrioceras* n. gen., and in the Arctic is directly associated with them. All three genera are globose and all contain highly involute species. Large collections of *Syngastrioceras* from Ellesmere Island show a remarkable variation in conch form and particularly in umbilical size. In the type species, *S. orientale*, U/D approximates 40 per cent but in *S. involutum* U/D generally approximates 20 per cent at maturity; in some specimens of the latter, U/D is close to 15 per cent. Also, during early development of *S. constrictum*, that is, at a diameter less than 20 mm (the size of mature *Clistoceras*), U/D approximates 10 per cent. Similarly, the umbilicus of typical *Neogastrioceras* (*N. arcticum*) is of comparable size. Thus, the identification of these three genera of comparable conch form must certainly depend on sutural and not conch differences. *Neogastrioceras* readily can be distinguished from *Clistoceras* and *Syngastrioceras* because it is the only one of the three genera in which ventral prongs are broader than the first lateral lobe at maturity. Distinction between the sutures of typical *Clistoceras* and *Syngastrioceras* are subtle but nevertheless differences are real and consistent. Prongs of the ventral lobe of typical *Syngastrioceras* are prominently inflated and attenuated even during early ontogeny. Furthermore, the prongs of *Syngastrioceras* are at least the same width as the secondary ventral saddle; the secondary ventral saddle is about two-thirds the height of the first lateral saddle. Sides of the top half of the secondary ventral saddle are parallel with the longitudinal axis of the venter. Prongs of the ventral lobe of *Clistoceras*, however, are bluntly pointed, non-attenuate and are practically straight-sided, not inflated. The secondary ventral saddle is slightly broader than the ventral prongs and is one-half the height of the first lateral saddle; sides of the secondary ventral saddle are not parallel with the ventral axis but show a marked tendency toward convergence orad. In addition, the first lateral saddle of *Clistoceras* is proportionately broader and more symmetrical than its counterpart in *Syngastrioceras*.

Globose goniatites with a conch form similar to *Clistoceras* have been recovered from Atokan strata at several localities in the United States. Plummer and Scott (1937) described *Nuculoceras smithwickense* from the Smithwick shale horizon in central Texas and McCaleb (1963) described a conspecific form from the Winslow Formation in Arkansas as *Eoasianites smithwickense*. Considering that both the Texas and Arkansas forms are the same general age as typical *Clistoceras* and have comparable features of conch morphology, there is no doubt that they are closely related. The fundamental differences that exist between the suture of the American species and *Clistoceras*, however, necessitate distinction at the generic level; the American species is assigned to *Syngastrioceras* and not to *Clistoceras*. Prongs of the ventral lobe of *S. smithwickense* are elongate and sharply pointed and are separated from one another by a high, narrow secondary ventral saddle. The umbilicus of *S. smithwickense* is open throughout its development (U/D 10–15 per cent); perhaps of secondary importance, helicolateral deposits have never been recognized on *S. smithwickense*.

Nassichuk (1967a) suggested that helicolateral deposits that close the umbilicus on *Clistoceras* are distinct from the umbilical callus of *Nautilus pompilius*. The helicolateral deposits overlie and are overlain by primary shell material but in *Nautilus* the umbilical callus is continuous with and part of the nacreous shell layer. Tozer (1972) suggested that helicolateral deposits are comparable with deposits that close the umbilicus of *Nautilus* and the Triassic ammonite *Nathorstites*. Tozer (ibid.) also implied that helicolateral deposits on *Clistoceras* are secondary deposits that filled both the umbilicus and a markedly undercut umbilical wall. Such an interpretation is unacceptable considering that shell material actually was deposited on the helicolateral deposits and that the deposits themselves bear clearly defined growth lines and rounded ridges that suggest a certain periodicity of development during growth.

Species composition and distribution.

Clistoceras globosum Nassichuk, 1967; from Atokan strata in the Hare Fiord Formation, Ellesmere Island, Arctic Canada.

C. sp.; from Atokan strata in the Hare Fiord Formation, Ellesmere Island, Arctic Canada.

A single undescribed representative of the genus from Malaya in the University of Iowa collections has a conch form and suture similar to *C. globosum* but helicolateral deposits, if once present, are not preserved.

Clistoceras globosum Nassichuk, 1967

Plate 8, figures 5, 6, 8; Plate 9, figures 1, 3, 6, 7, 8, 9; Textfigure 35

Clistoceras globosum NASSICHUK, 1967a, p. 241, Pl. 28, figs. 1–11.

Description. The original description of *Clistoceras globosum* by Nassichuk (1967a) was based on the holotype (GSC 19964), which has a diameter of 17.7 mm, and 9 smaller paratypes. Forty additional topotypes now are available; the largest of these has a diameter of 25 mm. All primary types are globose and the width closely approximates the diameter at maturity; W/D equals 86 per cent on the holotype. In the new materials, it is clear that some specimens are proportionately narrower than the primary types throughout ontogeny and these might conceivably be considered sexual dimorphs; in both "dimorphs" the form of helicolateral deposits is comparable. Conch dimensions and proportions of both broad and narrow dimorphs of *Clistoceras globosum* are represented in Table 13.

The external suture is characterized by a broad and nearly symmetrical first lateral lobe and saddle. The umbilical element U is broad and asymmetric and is situated on the dorsolateral flank. Prongs of the ventral lobe are more or less non-inflated and are bluntly pointed. The secondary ventral saddle between the ventral prongs is slightly broader than the ventral prongs and is about one-half the height of the first lateral saddle.

Shell ornament includes growth lines that form a shallow and broad ventral sinus and a relatively deep lateral sinus. Faint and broadly spaced ridges occur parallel to growth lines to maximum size. Similarly aligned constrictions, one or two per volution, occur to a diameter of 10 mm; on one specimen constrictions persist to a diameter of 15 mm. A mature modifica-

TABLE 13. Dimensions (in mm) and conch proportions of *Clistoceras globosum* Nassichuk

Specimen	Diameter	Height	Width	H/D	W/D
Wide conch					
Holotype GSC 19964	17.7	9.3	15.2	0.53	0.86
Paratype GSC 19965	16.6	8.8	15.0	.53	.90
Paratype GSC 19967	10.0	5.4	10.0	.50	.93
Paratype GSC 19968	9.3	4.5	9.0	.48	.97
Narrow conch					
Topotype GSC 33719	18.0	9.6	14.0	.53	.78
Topotype GSC 33717	15.4	7.2	12.3	.50	.79

tion, flattening of the lateral flanks, is apparent on the relatively large holotype and on topotypes of comparable size. Curiously, a relatively coarse runzelschicht pattern is developed across the venter and a finer pattern is developed in a black layer on the surface of the helicolateral deposits. In places where the latter black layer extends continuously across the venter and the helicolateral deposits, runzelschicht is distinct but, even where the black layer is absent across the venter, the runzelschicht pattern is visible in the underlying clear calcite shell layer. Runzelschicht was not observed immediately beneath helicolateral deposits.

TEXTFIGURE 35

Diagrammatic representation of the external suture of *Clistoceras globosum* Nassichuk from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on the holotype GSC 19964 at a conch diameter of 12.5 mm.

Occurrence. *Clistoceras globosum* has been found at GSC locality 56430 (type locality) near the base of the Hare Fiord Formation, on the north side of Hare Fiord, Ellesmere Island and at GSC locality C4085 near the top of the "Tellevak Limestone" on the west side of the Blue Mountains on Ellesmere Island (Textfig. 10).

Age. Atokan (Moscovian).

Clistoceras sp.

Plate 8, figures 7, 9

Description. One specimen of *Clistoceras* sp. is known from the Blue Mountains of northern Ellesmere Island. The specimen has a conch diameter of 24.5 mm and a width of 17 mm (W/D=70 per cent). The umbilicus is small but open at maximum size (U/D=1 per cent). Faint growth lines are more or less straight across the venter and flanks. One prominent constriction occurs on the ultimate volution, near the apertural end.

Prongs of the ventral lobe are bluntly pointed and are separated from one another by a ventral saddle that is about three-quarters the height of the first lateral saddle. The first lateral saddle is broad and evenly rounded. The first lateral lobe is about the same width as the first lateral saddle and has sides that are only slightly curved or inflated. The umbilical lobe is situated just outside the umbilicus.

Comparisons. Whereas the conch of *Clistoceras* sp. has a W/D relationship of 70 per cent at full size, the narrowest topotype of the type species, *C. globosum*, has a corresponding ratio of 78 per cent. The external sutures of the two species are closely comparable except that the first lateral saddle of *C. globosum* is slightly more angular. Furthermore, the ventral saddle of *C.* sp. is proportionately higher than that of *C. globosum.*

Occurrence. Clistoceras sp. occurs at GSC locality C4085 near the top of the "Tellevak Limestone" member of the Hare Fiord Formation, in the Blue Mountains of northern Ellesmere Island (Textfig. 10).

Age. Atokan (Moscovian).

Genus ***Neogastrioceras*** Nassichuk, n. gen.

Type species. *Neogastrioceras arcticum* n. sp. from Atokan strata in the Hare Fiord Formation, Ellesmere Island.

Diagnosis. The conch of *Neogastrioceras* is pachyconic (sensu Ruzhencev and Bogoslovskaya, 1971b) at maturity; that is, the ratio of width to diameter falls in the range 51 to 70 per cent. The umbilicus is small, typically close to 15 per cent of the conch diameter. Delicate growth lines and moderately impressed constrictions form a shallow ventral sinus. The external suture has broad prongs of the ventral lobe that equal or exceed the width of the first lateral saddle which is asymmetric and subangular.

Discussion. The conch of *Neogastrioceras* bears a resemblance to several involute species of a close relative, *Syngastrioceras,* and individual sutural elements are comparable. However, these genera are readily distinguished from one another by differences in sutural proportions. In particular, prongs of the ventral lobe of *Syngastrioceras* are proportionately narrower than the first lateral saddle throughout ontogeny but in *Neogastrioceras* the ventral prongs are wider than the first lateral saddle at maturity.

Ruzhencev and Bogoslovskaya (1971b) erected *Pseudoglaphyrites* for *Glaphyrites*-like forms with broad ventral prongs and a relatively sharply pointed first lateral saddle; type species *Pseudoglaphyrites sholakensis* Ruzhencev and Bogoslovskaya. Those authors suggested that *Pseudoglaphyrites* was closely comparable with "*Glaphyrites*" except for proportions of ventral prongs and the first lateral saddle but failed to discuss the rather obvious similarities between their new genus and *Syngastrioceras;* in particular the subangular first lateral saddle and the broad and inflated first lateral lobe. A suture of the holotype *Pseudoglaphyrites sholakensis* at a diameter close to 50 mm was presented by Ruzhencev and Bogoslovskaya (1971b, p. 293, Textfig. 72a). It is clear from this illustration that the ventral prongs of "*Pseudoglaphyrites*" *sholakensis* are only slightly wider than those of typical *Syngastrioceras*, *S. orientale*, at a comparable size. Furthermore, the first lateral saddle of *S. orientale* is even more sharply pointed or angular than that of *P. sholakensis*.

McCaleb (1968, p. 50, Textfig. 13) showed that, during most of the ontogenetic development of *Syngastrioceras oblatum*, prongs of the ventral lobe are relatively slender but at full size closely approximate the width of the rather sharply pointed first lateral saddle. Thus, it is clear that the generic characteristics cited by Ruzhencev and Bogoslovskaya (1971b) to identify "*Pseudoglaphyrites*" are insufficient to distinguish the genus from *Syngastrioceras* and the two are considered synonyms.

Species composition and distribution.

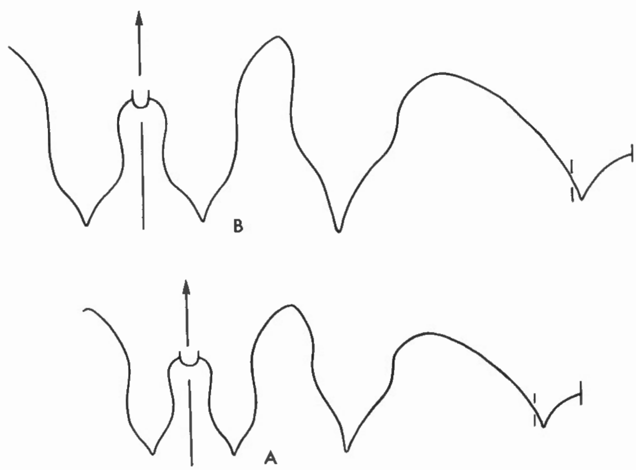
Neogastrioceras arcticum n. sp.; from Atokan strata on Ellesmere Island, Arctic Canada. A species that was designated *Cravenoceras morrowense* by Miller and Owen (1944) from the Morrowan Union Valley Formation in Oklahoma is closely comparable with *N. arcticum* and may be a synonym. Types of the Oklahoma species are not available for direct comparison.

Neogastrioceras arcticum Nassichuk, n. sp.

Plate 8, figures 3, 4, 10; Plate 9, figures 12, 14; Textfigures 36, 37

?Cravenoceras ?morrowense MILLER and OWEN, 1944, Pl. 65, figs. 3, 4; Pl. 66, figs. 3, 4.

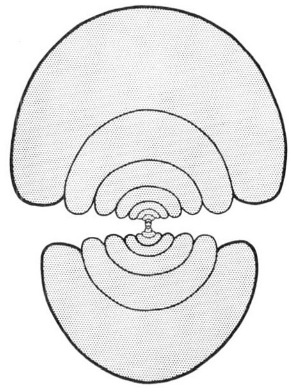
Description. At least 100 specimens of *N. arcticum* were recovered from northern Ellesmere Island. Specimens range from about 2 mm diameter to about 55 mm; the holotype attained a diameter of 40 mm.



TEXTFIGURE 36

Diagrammatic representation of external sutures of *Neogastrioceras arcticum* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A based on paratype GSC 33729 at a conch diameter of 22 mm, B based on the holotype GSC 33723 at a conch diameter of 28 mm.

The conch of *N. arcticum* is globular in early stages of growth and subspherical at maturity. Whorls are extremely involute throughout ontogenetic development; at maturity the umbilicus is on the order of 15 per cent of the conch diameter. The umbilical shoulder, where the shell is much thicker than on the flanks, is narrowly rounded and the umbilical wall is slightly convex. On the holotype, the living chamber occupied at least an entire volution.



TEXTFIGURE 37

Diagrammatic cross-section of *Neogastrioceras arcticum* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33724 at a conch diameter of 32 mm.

Ornament is characterized by faint transverse growth lines and from 2 to 5 constrictions per volution. Constrictions are deep and conspicuous to a diameter of some 8 mm but become proportionately broader at maturity, with the adoral side of the constrictions more sharply defined than the apicad side. Constrictions and growth lines form a low ventral salient and a corresponding shallow lateral sinus until a diameter of some 20 mm; beyond that size a shallow ventral sinus and low lateral salient are apparent.

The external suture best characterizes the species, particularly the broad prongs of the ventral lobe, and the narrow, asymmetric, narrowly rounded first lateral saddle. The tendency toward angularity of the first lateral saddle is apparent from a diameter of 5 mm.

TABLE 14. Dimensions (in mm) and proportions of *Neogastrioceras arcticum* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33723	39.0	19.0	25.6	5.5	0.49	0.66	0.14
Paratype GSC 33724	32.0	16.1	23.3	3.9	.50	.73	.12
Paratype GSC 33725	23.0	11.0	19.7	—	.48	.85	—
Paratype GSC 33726	11.5	4.1	11.2	1.5	.36	.97	.13
Paratype GSC 33727	7.1	—	8.0	1.1	—	1.05	.14

During early ontogeny, the form and proportions of external sutural elements closely resemble those of *Syngastrioceras*; that is, ventral prongs are narrower than the narrowly rounded first lateral saddle. As growth progresses, the ventral prongs become proportionately broad and the first lateral saddle increasingly angular and asymmetric.

Comparisons. The conch of *Neogastrioceras arcticum* closely resembles that of a species from the Union Valley Formation, Oklahoma that was designated *Cravenoceras*? *morrowense* by Miller and Owen (1944, Pl. 65, figs. 3, 4; Pl. 66, figs. 3, 4). Sutural proportions of the Oklahoma species closely approximate those of *N. arcticum*; the two may be synonyms but the types of the former, currently missing from the University of Iowa collections, must be re-examined.

Occurrence. The type locality of *N. arcticum* is in the Hare Fiord Formation on the north side of the Hare Fiord, Ellesmere Island (Textfig. 10) at GSC locality 56430. A few immature representatives of the species were found in the Nansen Formation at GSC locality C4085.

Age. Atokan (Moscovian).

Subfamily BISATOCERATINAE Miller and Furnish, 1957

Genus *Bisatoceras* Miller and Owen, 1937

Type species. *Bisatoceras primum* Miller and Owen, 1937; from Missourian (Zhigulevian) strata in the Seminole Formation in Oklahoma.

Diagnosis. The conch of *Bisatoceras* is subdiscoidal, and has a small, nearly closed umbilicus. Whorl width approximates 75 per cent of the whorl height at maturity; during early growth stages whorls are globular. Ornament includes transverse growth lamellae which form ventral and lateral sinuses and ventrolateral and dorsolateral salients. Two or three lateral constrictions are apparent on each whorl during early ontogenetic stages but constrictions are absent at full maturity.

Details of the suture best characterize the genus. Prongs of the ventral lobe are accuminate and inflated and are broader than the first lateral saddle. The secondary ventral saddle is nearly as high as the rounded first lateral saddle and is slightly narrower than the ventral prongs. The first lateral lobe is narrow and accuminate and the umbilical lobe is shallow and rounded.

Discussion. The familial assignment of *Bisatoceras* has long been uncertain and different opinions have been expressed in fairly recent summaries of Carboniferous ammonoids. For example, in an American "Treatise," Miller, Furnish, and Schindewolf (1957) included *Bisatoceras* in the Goniatitidae Hann, 1825. A completely different point of view was stated in a Soviet treatise ("Osnovy") by Ruzhencev (1962), where *Bisatoceras* was included in the Homoceratidae Spath, 1934. Considerable new data on both the Goniatitidae and the Homoceratidae have been entered into the literature since 1970; the former family was revised by Ruzhencev and Bogoslovskaya (1970) and the latter family by Ruzhencev and Bogoslovskaya (1971a). According to the Soviet authors (ibid., 1970), the Goniatitidae includes *Goniatites* Haan, 1825; *Hibernicoceras* Moore and Hodson, 1958; *Neogoniatites* Ruzhencev and Bogoslovskaya, 1970; and *Hypergoniatites* Ruzhencev and Bogoslovskaya, 1970. Similarly, Ruzhencev and Bogoslovskaya (1971a) erected 8 new genera which they included with *Homoceras* in the Homoceratidae; these authors considered the family to belong in the Gastrioceratacea.

In the opinion of the present writer, *Bisatoceras* probably should be included with the poorly known *Homoceratoides* Bisat, 1924 and *Neoglaphyrites* Ruzhencev, 1938 (= *Euroceras* Ruzhencev and Bogoslovskaya, 1971b) in the Bisatoceratinae which is provisionally included in the Cravenoceratidae. *Neoglaphyrites*, which is discussed under its own heading in this report, can be distinguished from *Bisatoceras* on the basis of subtle differences in conch and sutural form. Little can be said concerning possible relationships between *Bisatoceras* and *Homoceratoides* Bisat [type, *H. prereticulatum* Bisat, 1924 from Namurian (H) strata in England] until the latter is better known. The suture of *H. prereticulatum* has not been well illustrated but it is clear that the conch and ornament of this species more closely resemble those of *Reticuloceras* than *Bisatoceras*; that is, the umbilicus is moderately wide and the shell is ribbed. Relationships between *Bisatoceras* and *Homoceratoides* are inferred from the fact that the suture of *H. divaricatum* (Hind), which ranges from Namurian (R) to Westphalian-A, possesses comparatively broad ventral prongs. It is clear that *Homoceratoides* requires additional attention, for similarities with *Bisatoceras* may be more apparent than real; the suture, conch form and ornament of the former may indicate a closer relationship with the Neodimorphoceratidae.

Several authors have suggested that the longitudinal lirae on *Bisatoceras secundum* warrant generic distinction but Furnish (pers. com., 1973) has long insisted that the so-called lirae on types of this species are runzelschicht. Maximova (1940, p. 859) proposed that *B. secundum* form the basis for a new genus, *Pseudobisatoceras*; this view was maintained by Ruzhencev (1960b, 1962) but the present writer prefers retention of *B. secundum* in *Bisatoceras* since the suture and conch form must ultimately serve as fundamental criteria in recognition of genera.

McCaleb (1968) indicated that a morphologic gradation can be demonstrated between *B. secundum* and other representatives of the genus and that the species should be retained in *Bisatoceras*. Moreover, McCaleb (1968) claimed to have observed fine longitudinal lirae on typical representatives of the type species, *B. primum*, and also on *B. greenei*. Despite the exceptional preservation of available Arctic specimens, longitudinal lirae have not been observed.

A number of other species that were originally assigned to *Bisatoceras* by various authors subsequently have been placed in different genera. For example, Maximova (1940) erected *Bisatoceras satrus* from Asselian strata in the Urals (*Schwagerina* beds) but Ruzhencev (1951) assigned that species, which is devoid of shell sculpture and has an open umbilicus, to *Neoglaphyrites* Ruzhencev. Similarly, Gordon (1965) erected *Bisatoceras paynei* from the lower Morrowan (Namurian) Hale Formation in Arkansas but Ruzhencev and Bogoslovskaya (1971b) assigned "*B.*" *paynei* to *Schartymites* Librovitch, 1939. *Schartymites* has proportionately narrower ventral prongs and a broader first lateral saddle than *Bisatoceras*.

Bisatoceras renni from Arctic Canada has ventral prongs that have a prominent apical indentation on the ventral side. This indentation is reminiscent of an apparent incipient lobe that occurs in a comparable position on the neodimorphoceratin *Cymoceras* McCaleb. *Cymoceras* is readily distinguished from *Bisatoceras*, however, because the sides of each of the ventral prongs diverge markedly orad on the former but are more or less parallel with the axis of the venter on the latter.

Species composition and distribution.

Bisatoceras akiyoshiense Nishida, 1971; from Atokan strata in Japan.

B. greenei Miller and Owen, 1939; from the Desmoinesian (Moscovian) Cherokee Formation in Missouri (Miller and Owen, 1939) and the Atoka Formation in Oklahoma (Unklesbay, 1954; Beghtel, 1962). Also, Gordon (1964) described

Bisatoceras cf. *B. greenei* from the middle part of the Tihvipah Limestone (Middle Pennsylvanian) in California. According to Furnish (pers. com., 1973), *B. greenei* also occurs in the Middle Pennsylvanian Pumpkin Creek Limestone in southern Oklahoma and also in Middle Pennsylvanian strata in southern Iowa. A single specimen, tentatively designated *Bisatoceras* cf. *B. greenei*, is known from the Nansen Formation on northwestern Axel Heiberg Island, Arctic Canada.

B. hoeni n. sp.; from Namurian strata on Axel Heiberg and Melville Islands.

B. kotti n. sp.; from Atokan strata in the Hare Fiord and Nansen Formations on Ellesmere Island.

B. renni n. sp.; from Morrowan strata in the Otto Fiord Formation on Melville Island.

B. micromphalus McCaleb, 1968; from the Morrowan (Bloydian) Bloyd Formation, Arkansas.

B. nevadense Gordon, 1969, from Morrowan strata in Nevada.

B. primum Miller and Owen, 1937; from the Missourian (Zhigulevian) Seminole Formation, Oklahoma.

B. secundum Miller and Moore, 1938; from the Bloyd Formation in Arkansas and equivalent strata in the Kendrick Shale of eastern Kentucky.

B. solominae Popow, 1970; from Middle Carboniferous strata in the Verkhoyan Region of the Soviet Union.

B. sp.; from Desmoinesian (Moscovian) strata in the Canyon Fiord Formation, Ellesmere Island.

Several "new" species were recognized in the Desmoinesian Wewoka Formation of Oklahoma by Beghtel (1962) in an important but unpublished study. Similarly, the genus has been recognized in probable Atokan collections from the Alaska Range, Alaska (Furnish, pers. com., 1970).

Bisatoceras hoeni Nassichuk, n. sp.

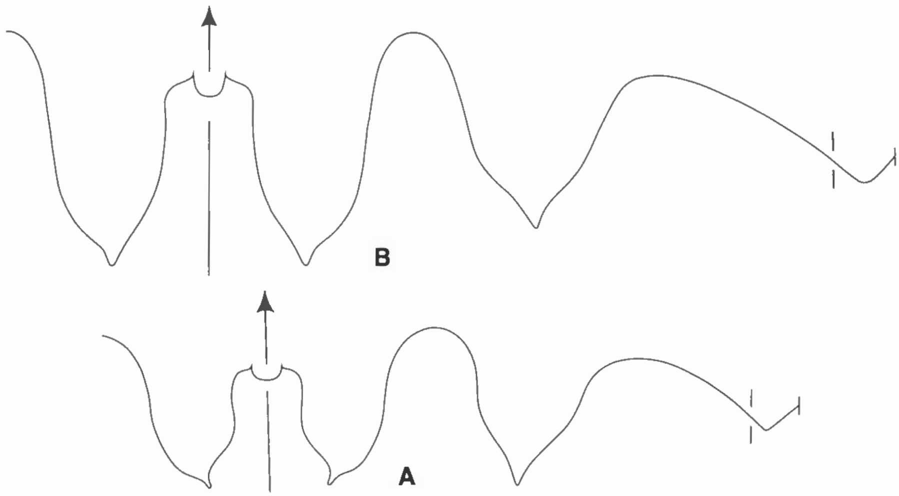
Plate 10, figures 2, 5, 6, 9; Textfigure 38B

Bisatoceras sp. Hoen, 1964, p. 8.

Description. Two well-preserved specimens of *Bisatoceras hoeni*, the holotype and one paratype, are available from the type locality in "South Fiord Dome," western Axel Heiberg Island. About 100 other variously deformed specimens were found on Melville Island. The conch of *B. hoeni* is rather broad; the width is slightly more than 50 per cent of the conch diameter. The venter and flanks are broadly rounded. The umbilicus of *B. hoeni* is open and approximates half of one per cent of the conch diameter. The umbilical shoulder is uniformly rounded and the umbilical walls slope gently toward the umbilical axis.

The shell of mature representatives of *B. hoeni* is smooth except for delicate growth lamellae that form extremely shallow ventral and lateral sinuses and corresponding low, broad, ventrolateral and dorsolateral salients. Constrictions are absent from the holotype and paratype from Axel Heiberg Island but vestiges of constrictions are visible on smaller poorly preserved materials from Melville Island.

Prongs of the ventral lobe are straight-sided and closely approximate the width of the secondary ventral saddle as well as the first lateral saddle. The first lateral lobe is broad and slightly inflated medianly.



TEXTFIGURE 38. Diagrammatic representation of external sutures of *Bisatoceras renni* n. sp. and *Bisatoceras hoeni* n. sp. A, *Bisatoceras renni* n. sp. from the Otto Fiord Formation on Melville Island (GSC loc. C16903); based on holotype GSC 33735 at a conch diameter of 20 mm. B, *Bisatoceras hoeni* n. sp. from the Otto Fiord Formation on Axel Heiberg Island (GSC loc. 47996); based on the holotype GSC 33731 at a conch diameter of 27 mm.

TABLE 15. Dimensions (in mm) and proportions of *Bisatoceras hoeni* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Paratype GSC 33732	32.0	18.0	16.5	2.0	56.3	52.0	0.06
Holotype GSC 33731	29.3	17.2	16.3	—	58.7	55.6	—

Comparisons. The conch of *Bisatoceras hoeni* is broader than that of the younger Arctic *B. kotti.* Additionally, the first lateral lobe of *B. hoeni* is broader than that of *B. kotti*; conversely, ventral prongs of *B. kotti* are proportionately broader than those of *B. hoeni.* Similarly, the first lateral lobe of *B. hoeni* exceeds the width of that of the type species *B. primum* as well as species that closely resemble *B. kotti, B. greenei,* and *B. nevadense.*

Occurrence. The type locality of *Bisatoceras hoeni* is in a large limestone block in south-central "South Fiord Dome" (Textfig. 7), a large evaporite piercement structure on western Axel Heiberg Island (GSC loc. 47996). The species is known also from north-central Barrow Dome (Textfig. 4) on northeastern Melville Island (GSC loc. C16901).

Age. Halian (Namurian).

Bisatoceras renni Nassichuk, n. sp.

Plate 10, figure 10; Textfigure 38A

Description. Two specimens of *B. renni* are available from Melville Island. Neither specimen is well preserved but the suture is unique and this appears to warrant recognition as a distinct taxon. The holotype is fragmentary, and consists of nearly half a volution; by reconstruction the diameter closely approximates 18 mm and at that size the whorl height is 9.7 mm and the whorl width 11 mm. Shell ornament is absent from the holotype but on the small paratype it consists of sinuous growth lamellae that form shallow ventral and lateral sinuses.

Prongs of the ventral lobe are sharply attenuate and are separated by a slightly narrower secondary ventral saddle that is about three-quarters the height of the first lateral saddle. Ventral prongs have a prominent apicad indentation on their ventral sides; prongs are the same width as the first lateral saddle.

Comparisons. Bisatoceras renni differs from all other representatives of the genus by its unique, prominently indented ventral prongs. Prongs of the younger (Atokan) *B. kotti* have a comparable indentation only during early ontogeny. *Bisatoceras kotti* has a proportionately narrower first lateral saddle and first lateral lobe than *B. renni*. The conch of *B. renni* is closely comparable with that of *B. hoeni* but these species are readily distinguished from one another by sutural proportions.

Occurrence. Bisatoceras renni was recovered from a single locality near the northern edge of Barrow Dome, northern Sabine Peninsula, Melville Island (Textfig. 4). It was found at GSC locality C16903, which is 2 miles due north of the midpoint of Barrow Dome (76°39′15″N, 109°03′W).

Age. Bloydian (Westphalian-A = Kayalian).

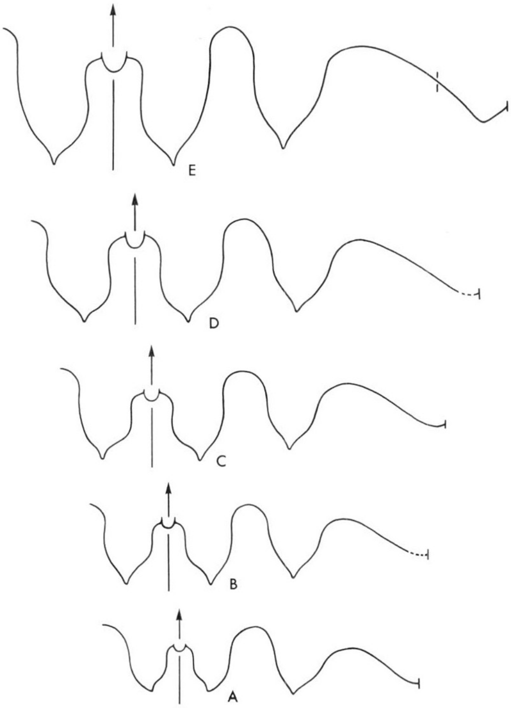
Bisatoceras kotti Nassichuk, n. sp.

Plate 10, figures 1, 3, 4, 7, 8; Plate 11, figures 6, 8; Textfigures 39, 40

Description. Some twenty-five representatives of *B. kotti* are available from Ellesmere Island. Most are in an excellent state of preservation and clearly show sutural and ornamental details. The conch is subdiscoidal at maturity, and whorls are moderately compressed but, during early stages of growth, to about 5 mm, whorls are strongly depressed. At 10 mm diameter, the ratio of whorl height to whorl width closely approximates unity. The umbilicus, at maturity, is nearly closed and this is partly due to a thickening of the shell in the umbilical area. At maturity shell ornament consists of sinuous transverse growth lamellae which form shallow ventral and lateral sinuses and low ventrolateral and dorsolateral salients. Lateral constrictions, 2 or 3 per volution, are present to a diameter of some 5 mm.

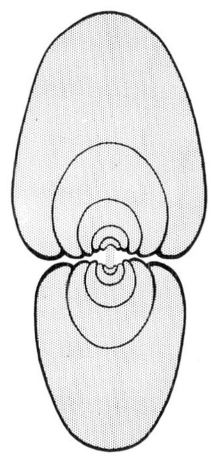
The prongs of the ventral lobe are broad and asymmetric throughout ontogeny, and are considerably more inflated on the ventral side than on the dorsal side. The broad secondary ventral saddle, about three-quarters the width of the narrowly rounded first lateral saddle, is nearly as high as the latter element at maturity. The first lateral lobe is shorter than, but about the same width as, the ventral prongs.

Comparisons. Bisatoceras kotti differs from the Missourian type species *B. primum* in possessing proportionately narrower ventral prongs and a more symmetrical first lateral saddle. *Bisatoceras kotti* bears a close resemblance to *B. nevadense* Gordon and may prove to be conspecific; the suture of *B. nevadense* presented by Gordon (1969, p. C7) is adequate only for generic recognition. *Bisatoceras greenei* also differs slightly with respect to details of the external suture but, in addition, the conch of *B. greenei* is consistently narrower than *B. kotti* throughout ontogeny. For example, the holotype of *B. greenei*, at a diameter of 15.5 mm, has a whorl width of 8.4 mm whereas, at a comparable diameter, *B. kotti* has a whorl width of 9.4 mm.



TEXTFIGURE 39

Diagrammatic representation of the sutural ontogeny of *Bisatoceras kotti* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430). A is based on paratype GSC 33746 at a conch diameter of 6 mm, B is based on the same paratype GSC 33746 at a conch diameter of 9 mm, C is based on paratype GSC 33742 at a conch diameter of 10 mm, D is based on paratype GSC 33738 at a conch diameter of 12 mm, E is based on the holotype GSC 33737 at a conch diameter of 20 mm.



TEXTFIGURE 40

Diagrammatic cross-section of *Bisatoceras kotti* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on paratype GSC 33747 at a conch diameter of 33.5 mm.

TABLE 16. Dimensions (in mm) and proportions of *Bisatoceras kotti* n. sp. and *Bisatoceras greenei* Miller and Owen, 1939

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Bisatoceras kotti n. sp. from Ellesmere Island							
Paratype GSC 33747	33.3	19.4	15.2	0.5	0.59	0.46	0.02
Holotype GSC 33737	31.0	17.5	13.4	.4	.56	.43	.01
Paratype GSC 33743	28.0	15.7	13.0	—	.56	.46	—
Paratype GSC 33738	19.5	10.1	10.7	—	—	.55	—
Paratype GSC 33739	15.0	7.5	8.3	—	—	.66	—
Paratype GSC 33740	10.0	6.3	6.6	—	.63	.66	—
Paratype GSC 33741	6.2	3.9	4.7	—	.63	.75	—
Bisatoceras greenei Miller and Owen; from the Cherokee Formation Missouri, after Miller and Owen, 1939, p. 155 (holotype), and Beghtel, 1962, p. 115 (topotype)							
Holotype John Britts Owen 660	18.0	10.5	8.0	—	0.60	0.44	—
Topotype SUI 17006	10.5	6.5	5.2	—	.62	.50	—

Occurrence. The type locality of *Bisatoceras kotti* is GSC locality 56430, near the base of the Hare Fiord Formation on the north side of Hare Fiord, Ellesmere Island (Textfig. 10). The species also occurs near the base of the Hare Fiord Formation at GSC locality C14582 on the west side of Stepanow Creek at Hare Fiord, Ellesmere Island. *Bisatoceras kotti* is known also from near the base of the Hare Fiord Formation at three localities on eastern Axel Heiberg Island (Textfig. 9); GSC localities C4010 and C4012 are near the head of Whitsunday Bay and GSC locality C4013 is 4 miles southeast of the northern end of Buchanan Lake, eastern Axel Heiberg Island. In addition, *B. kotti* is known from several localities near the top of the "Tellevak Limestone" in the Blue Mountains east of Hare Fiord (Textfig. 10) on northern Ellesmere Island (GSC locs. C4085, 48921, 58920, and 58922).

Age. Atokan (Moscovian).

Bisatoceras sp.

Description. Three immature and fragmented specimens, all less than 10 mm in diameter, are from the Canyon Fiord Formation on Raanes Peninsula, Ellesmere Island. All specimens clearly show features that define the genus including an involute conch, biconvex growth lamellae, and broad ventral prongs. At a size of 10 mm the whorl width is 6 mm. At the same size the ventral prongs, which are highly symmetrical, are as wide as the uniformly rounded first lateral saddle. The first lateral lobe is broader than the first lateral saddle. The internal suture is visible on one specimen at a diameter of 9 mm; the dorsal lobe and internal lateral lobe are both inflated medianly and are of equal width but the dorsal lobe is relatively more elongate.

Comparisons. Specific comparisons are particularly meaningful when they are based on mature specimens. In the case of *B.* sp., all specimens are immature and only general comparisons are possible. The conch proportions of *B.* sp. closely resemble those of the Atokan *B. kotti* as well as *B. greenei* Miller and Owen but, even on immature specimens, subtle sutural differences are apparent. The ventral prongs of *B.* sp. are decidedly more symmetrical than *B. kotti* and *B. greenei;* on both the latter species a prominent pouch is developed on the ventral side of the prongs even at a size of 5 mm.

Occurrence. Bisatoceras sp. was recovered from the Canyon Fiord Formation on Raanes Peninsula, Ellesmere Island (Textfig. 13). GSC locality C10885 is 1,145 feet above the base of the formation 6 miles east of the head of Blind Fiord (85°23′00″N, 78°23′30″W).

Age. Desmoinesian (Moscovian).

Genus *Neoglaphyrites* Ruzhencev, 1938

Type species. *Glaphyrites* (*Neoglaphyrites*) *bashkiricus* Ruzhencev, 1938.

Diagnosis. The conch of *Neoglaphyrites* is ellipsoidal and moderately involute; the umbilicus is deep and is typically less than 15 per cent of the conch diameter but in some species the ratio is closer to 20 per cent. The umbilical shoulder is sharply rounded and the umbilical wall steep. Shell ornament is not preserved on the type species. On Canadian Arctic materials, delicate growth lines form ventral and lateral sinuses and ventrolateral and dorsolateral salients. The suture is characterized by broad prongs of the ventral lobe that are separated by a high secondary ventral saddle; prongs closely approximate the width of the first lateral lobe. The first lateral saddle is evenly rounded and is nearly symmetrical. The umbilical lobe is V-shaped and internal lobes are deep and narrow.

Discussion. Neoglaphyrites was erected by Ruzhencev (1938) to accommodate ellipsoidal shells with a small but open umbilicus and which possessed broad prongs of the ventral lobe. Neither the type species, *N. bashkiricus*, nor the only other described representative of the genus, *N. satrus*, has shell ornament preserved. Because of this absence of shell ornament, Ruzhencev (1951) suggested a few alternate opinions in the event that typical *N. bashkiricus* with shell sculpture is discovered eventually in the Urals: If *Neoglaphyrites* is shown to have sinuous bisulcate transverse striae as in *Bisatoceras*, then the separation of *Neoglaphyrites* from *Bisatoceras* may be open to question. If, on the other hand, the transverse shell sculpture on typical *Neoglaphyrites* resembles "*Glaphyrites*" then Ruzhencev (ibid.) indicated that there could be no question concerning the distinction of *Neoglaphyrites* from *Bisatoceras*. It is an unusual taxonomic procedure to erect ammonoid genera on such a proviso but, despite the configuration of growth lamellae, the proportions of the conch and suture of *Neoglaphyrites* are distinct from those of all other genera; thus, these features are the basis on which the taxon stands. Ultimate discovery of transverse striae on typical *Neoglaphyrites* should not affect the validity of the genus but might affect higher classification at the subfamilial level. Representatives of the Arctic *Neoglaphyrites bisulcatus* have transverse shell ornament that closely resembles *Bisatoceras*. Distinction between *Neoglaphyrites* and *Bisatoceras* is dependent upon two morphologic features. In the former genus, the umbilicus is clearly open and the umbilical walls narrowly rounded throughout ontogeny; thus the umbilical shoulder is clearly defined. Furthermore, the umbilical lobe of *Neoglaphyrites* is accuminate, V-shaped. In *Bisatoceras* the umbilicus is essentially closed, the umbilical shoulder is indiscernible, and the umbilical lobe more or less broadly rounded.

Ruzhencev and Bogoslovskaya (1971b) erected the subdiscoidal, highly involute *Euroceras* (type *E. ellipsoidale* Ruzhencev and Bogoslovskaya) from Namurian strata in the southern Urals. Although the Soviet authors did not compare *Euroceras* with *Neoglaphyrites* and have placed the two in different subfamilies, it is clear that these genera are closely related and in this report are considered to be synonyms. Both are subdiscoidal and highly involute and possess wide prongs of the ventral lobe. Additionally, whereas shell sculpture is not preserved on typical *Neoglaphyrites*, the sculpture of the Arctic *N. bisulcatum* is closely comparable with that of typical "*Euroceras*." For practical purposes, the differences between the two are subtle differences in conch and sutural proportions which are of trivial significance.

Species composition and distribution.

Neoglaphyrites bashkiricus Ruzhencev, 1938; from Orenburgian strata in the Bashkir region of the southern Urals.

N. bisulcatus n. sp.; from Atokan (Moscovian) strata on Ellesmere Island, Arctic Canada.

N. ellipsoidale (Ruzhencev and Bogoslovskaya, 1970); from Namurian strata in the southern Urals.

N. satrus (Maximova, 1940); from Asselian strata near the Urezan River, southern Urals.

Neoglaphyrites bisulcatus Nassichuk, n. sp.

Plate 11, figures 1, 2, 5, 9; Textfigure 41

Description. About 50 representatives of *N. bisulcatus* were recovered from northern Ellesmere Island. The largest of these has a diameter of 67 mm and is septate to a diameter of 55 mm; most specimens have a diameter less than 30 mm. The shell is ellipsoidal and extremely involute; the umbilical diameter is close to 10 per cent of the conch diameter.

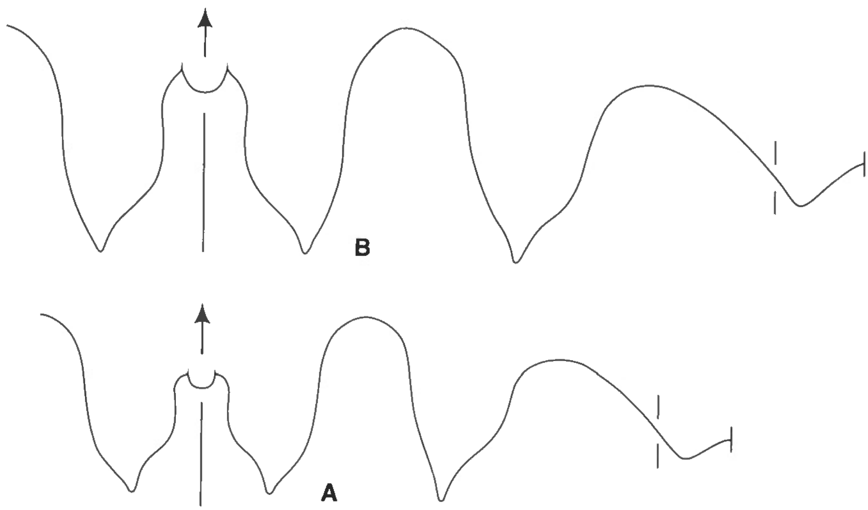
Shell ornament includes fine sinuous growth lamellae that form shallow ventral and lateral sinuses and low ventrolateral and dorsolateral salients. Four or five constrictions that are parallel with growth lamellae occur in each volution up to a diameter of about 20 mm; beyond that size constrictions are absent and growth lamellae generally are not preserved. On several specimens, a faint runzelschicht pattern is preserved on the venter.

Prongs of the ventral lobe are considerably narrower than the first lateral lobe up to a diameter of about 15 mm; at larger sizes the widths of both of these elements are approximately equal. The dorsal and internal lateral lobes were observed on a single specimen; both are deep and narrow. The dorsal lobe is attenuate and is slightly inflated at its midpoint. It is in contact with the dorsal lobe of the preceding suture.

TABLE 17. Dimensions (in mm) and proportions of *Neoglaphyrites bisulcatus* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33749	67.5	33.2	33.5	9.5	0.49	0.50	0.14
Paratype GSC 33750	33.2	19.0	20.1	3.7	.54	.61	.11
Paratype GSC 33753	23.4	12.0	14.1	—	.51	.60	—

Comparisons. Ruzhencev (1951) concluded that *N. satrus* and the type species *N. bashkiricus* have closely comparable sutures and can be distinguished only on the basis of conch form; shell sculpture is not preserved on either species. *Neoglaphyrites satrus* is proportionately narrower than *N. bashkiricus* and has a higher whorl section and a smaller umbilicus. *Neoglaphyrites bisulcatus* can be distinguished from *N. satrus* and *N. bashkiricus* by having proportionately narrower prongs of the ventral lobe and a correspondingly broader first lateral saddle. Also, the secondary ventral saddle separating prongs of the ventral lobe is proportionately lower in *N. bisulcatus* than in the Soviet species. Lack of shell sculpture on the latter species precludes further comparisons.



TEXTFIGURE 41. Diagrammatic representation of external sutures of *Neoglaphyrites bisulcatus* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); A is based on paratype GSC 33751 at a conch diameter of 18 mm, B is based on paratype GSC 33752 at a conch diameter of 23 mm.

Occurrence. About 50 representatives of *N. bisulcatus* were found at the type locality (GSC loc. C4085) near the top of the "Tellevak Limestone" in the Blue Mountains, northern Ellesmere Island (Textfig. 10). Additional specimens were found lower in the same section at GSC locality C10760. Several other specimens were found in the Nansen Formation at GSC locality 57698 near Lands Lokk on northwestern Ellesmere Island (Textfig. 11). The species also occurs 100 feet above the base of the Hare Fiord Formation at GSC locality C4083 in the Krieger Mountains (Textfig. 10) on Ellesmere Island (80°54′N, 84°11′W).

Age. Atokan (Moscovian).

Family Neoicoceratidae Hyatt, 1900

Genus *Neoicoceras* Hyatt, 1900

Type species. *Goniatites elkhornensis* Miller and Gurley, 1896, original designation; from Lower Pennsylvanian, Pottsvillian (Morrowan) strata, Kentucky.

Diagnosis. The conch of *Neoicoceras* is rather narrow and highly evolute; typically, the width is slightly more than half the diameter and the umbilicus approximates 70 per cent of the conch diameter at maturity. The shell is smooth except for faint transverse lamellae. It must be stressed that the umbilical region of the holotype of the type species is devoid of nodes but that this part of the specimen is worn. The suture has 8 lobes; the first lateral saddle is nearly symmetrical and is about the same width as the first lateral lobe.

Discussion. For more than 60 years *Neoicoceras*, which is based on a single worn specimen, was an enigma and the subject of considerable speculation among ammonoid workers. Not until the holotype of *N. elkhornense* was figured by Plummer and Scott (1937) was it unanimously accepted as an ammonoid. A sophisticated study of the type by Furnish and Knapp (1966) rendered the taxon valid for practical purposes even though those authors implied that data on the genus were incomplete, particularly early growth stages. The present author considers the form of the conch and suture of *Neoicoceras* to be distinct but recognizes the need for additional data to distinguish the genus from various species that have been assigned to the closely related *Eoasianites* Ruzhencev. Such a distinction requires a systematic review of both "genera." The taxonomic approach adopted for *Neoicoceras* in this report is strictly typological; that is, the Arctic *N. martini* clearly resembles the type *Neoicoceras* more closely than it does type *Eoasianites*. The latter has a narrower umbilicus and conch than the former. Distinction between the two may depend ultimately on recognition of the presence or absence of umbilical nodes at least during early growth stages; that is, *Eoasianites* with nodes and *Neoicoceras* without nodes.

By not attempting to systematically review the many species that have been referred to *Eoasianites* in the literature, some of which may prove to be *Neoicoceras*, the author avoids controversy concerning another enigmatic *Eoasianites*-like form, *Glaphyrites* Ruzhencev; the latter was mentioned in this report under the heading *Syngastrioceras*. Briefly, Ruzhencev (1936) based *Glaphyrites* on small specimens designated *Gastrioceras modestum* by Böse, 1917, from the Gaptank Formation, West Texas. Ruzhencev (ibid.) indicated that the genus was distinct from *Eoasianites* on the basis of a narrower conch and subtle sutural differences. Ruzhencev (1962) included *Glaphyrites* in the Goniatitaceae despite the fact that Miller and Furnish (1940a) demonstrated that the "type species" of *Glaphyrites* has umbilical ribs or nodes on inner whorls which is characteristic of the Gastrioceratceae. Ruzhencev and Bogoslovskaya (1971b) placed the genus in the Neoglyphioceratceae. Furthermore, Miller and Furnish (ibid.) showed that the umbilical proportions of Böse's species are comparable to those of typical *Eoasianites*.

In an extensive study of many hundreds of *Glaphyrites*-like forms from the Desmoinesian (Moscovian) Wewoka Formation of Oklahoma, Beghtel (1962) reiterated an earlier contention by Miller and Furnish (1940) that *Eoasianites* and *Glaphyrites* are part of a morphological continuum and should be considered as synonyms. Ruzhencev (1936, 1951, 1962) and Ruzhencev and Bogoslovskaya (1971b) suggested that, on the basis of sutural proportions, particularly of the ventral lobe, both genera have different origins. *Glaphyrites* derived from *Cravenoceras* much earlier (during the Namurian) than *Eoasianites* derived from the main lineage of the Gastrioceratidae (during the Zhigulevian).

Saunders (1971) suggested that the species described herein as *Neoicoceras martini* is in fact *Somoholites*. Nassichuk earlier (1965) had indicated that *N. martini* possessed widely spaced, faint longitudinal lirae; the single specimen that showed this feature is now known to be a poorly preserved schistoceratid. The lobes of *N. martini* are pouched considerably less than are those of *Somoholites*.

Species composition and distribution.

Neoicoceras elkhornense (Miller and Gurley, 1896); from Morrowan strata in Kentucky.

N. martini n. sp.; from Atokan strata on Ellesmere Island, Arctic Canada.

N. walkeri (Webster and Lane, 1967); from Chesteran strata in Nevada.

Neoicoceras martini Nassichuk, n. sp.

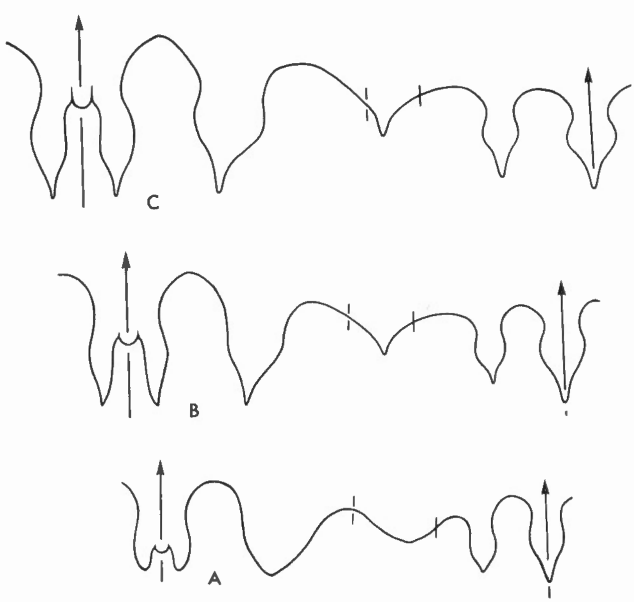
Plate 8, figure 11; Plate 9,
figures 2, 4, 5, 10, 11, 13; Textfigure 42

Description. More than 100 representatives of *N. martini* have been recovered from Ellesmere Island. Along with *Neogastrioceras arcticum* and *Boesites gracilis*, it is one of the most abundant ammonoids recovered from the Hare Fiord Formation. Several specimens have a diameter of about 60 mm and the holotype is septate to a diameter of about 50 mm.

The conch is subglobose in early ontogenetic stages (less than 5 mm diameter) but becomes subellipsoidal at maturity. It is prominently evolute beyond a diameter of 5 mm, and the umbilicus is close to 60 per cent of the conch diameter at maturity. Some minor variation in size of the umbilicus is apparent and this conceivably may be attributed to sexual dimorphism. Whorls are markedly depressed throughout most of ontogenetic development. During early stages the umbilical shoulders are rounded, but at maturity they are sharply angular; umbilical walls are straight at maturity.

The shell is smooth except for faint transverse lamellae and constrictions; the latter are present only during early growth stages. Two or three constrictions occur on each volution up to a size of 20 mm. Each forms a broad ventral salient and a lateral sinus. Runzelschicht is preserved on the dorsal shell.

Prongs of the ventral lobe are slightly inflated and narrow, about the same width as the high secondary ventral saddle. The first lateral lobe is narrow and moderately inflated as well as strongly attenuated. Dorsal elements are noticeably inflated and attenuate at least from a diameter of 4 mm.



TEXTFIGURE 42
Diagrammatic representation of the sutural ontogeny of *Neoicoceras martini* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A is based on paratype GSC 33803 at a conch diameter of 5 mm, B is based on paratype GSC 33802 at a conch diameter of 12 mm, C is based on paratype GSC 33797 at a conch diameter of 25 mm.

Comparisons. Neoicoceras martini differs from the type species, *N. elkhornense*, in that the former has a proportionately narrower umbilicus and a slightly different sutural configuration. In particular, the lobes of *N. martini* are slightly more "inflated" or laterally pouched than are those of the type species.

TABLE 18. Dimensions (in mm) and proportions of *Neoicoceras martini* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33794	47.0	11.0	27.0	26.5	0.23	0.57	0.56
Paratype GSC 33797	26.1	7.2	14.9	12.4	.28	.57	.48
Paratype GSC 33798	22.9	6.1	14.0	11.2	.27	.61	.49
Paratype GSC 33795	20.2	5.9	12.9	9.0	.29	.64	.45
Paratype GSC 33796	17.0	5.4	11.0	8.0	.32	.65	.47
Paratype GSC 33801	13.0	4.1	9.9	6.0	.31	.76	.46
Paratype GSC 33799	8.5	3.0	6.6	—	.35	.77	—
Paratype GSC 33800	4.2	1.9	4.2	1.0	.45	1.00	.26

Occurrence. The type locality of *N. martini* (GSC loc. 56430) is near the base of the Hare Fiord Formation near the north shore of Hare Fiord, Ellesmere Island (81°07′06″N, 84°17′W). The species also occurs in a comparable position in the Hare Fiord Formation about one-half mile along strike to the east of the type locality, west of Stepanow Creek at GSC locality C14582 (Textfig. 10).

Age. Atokan (Moscovian).

Family Pseudoparalegoceratidae Librovitch, 1957

Genus ***Phaneroceras*** Plummer and Scott, 1937

Type species. *Gastrioceras compressum* Hyatt, 1891; from Atokan (Bendian) limestones near Bend, San Saba County, Texas.

Diagnosis. The conch of *Phaneroceras* is discoidal at maturity and moderately evolute; typically the umbilicus approximates 40 per cent of the conch diameter. Shell sculpture includes lateral constrictions and sinuous growth lines that form a moderately deep ventral sinus and a relatively shallow lateral sinus. Faint longitudinal lirae occur in the umbilical region of some species. The suture has 8 lobes; prongs of the ventral lobe are slightly narrower than the first lateral lobe. The umbilical lobe is situated either on the umbilical wall or on the umbilical shoulder.

Discussion. Phaneroceras and *Pseudoparalegoceras* are the only representatives of the family and, as shown in the following paragraph, some authors maintain that the two are synonyms. Ruzhencev and Ganelin (1971) erected *Paraphaneroceras* (type, *Diaboloceras peroccidens* Gordon, 1969) and included it in the Pseudoparalegoceratidae on the basis of the external suture, particularly wide ventral prongs. *Paraphaneroceras*, however, unlike all other representatives of the family, has a well-defined reticulate shell ornament and umbilical nodes to full maturity. These features suggest that *Paraphaneroceras* belongs in the Schistocerataceae;

the genus appears closely related to *Diaboloceras* Miller and Furnish and *Branneroceras* Plummer and Scott.

Distinction between *Phaneroceras* and the generally younger *Pseudoparalegoceras* Miller, 1934 is based on the relative position of the umbilical lobe; in *Phaneroceras* the lobe is on the umbilical wall whereas in *Pseudoparalegoceras* the lobe is outside the wall. In distinguishing the two genera on this basis it is necessary to point out that the position of the umbilical lobe on both *Phaneroceras* and *Pseudoparalegoceras* changes slightly during ontogeny. Thus, proper identification depends on specimens of maximum size. In "*Eoparalegoceras*" Delépine, 1939, which occurs in Westphalian strata in Morocco, the umbilical lobe is either on or just inside the umbilical shoulder; "*Eoparalegoceras*" is here considered to be a synonym of *Phaneroceras*. Miller and Furnish (1940c) considered the relative position of sutural elements to depend at least to some degree on the form of the conch and designated *Phaneroceras* and *Eoparalegoceras* as synonyms of *Pseudoparalegoceras* which has priority. This preference has been adopted by most American workers in recent years; for example, Murray, Furnish, and Carrillo (1960) and McCaleb (1968). Gordon (1965) employed *Phaneroceras* as a subgenus of *Pseudoparalegoceras* and considered *Eoparalegoceras* to be a synonym of *Phaneroceras*. Although trinomial taxonomy is widely employed, the writer prefers retention of a binomial scheme and considers the position of umbilical element 'U' to be of generic significance.

Despite the abundance of *Phaneroceras* in the Midcontinent region and on Ellesmere Island, seldom are early growth stages well enough preserved to provide information concerning the origin of the genus. Since *Phaneroceras* lacks umbilical nodes, the genus is excluded from the Gastrioceratidae; similarly, the mode of sutural development and lack of reticulate shell ornament excludes *Phaneroceras* from the Schistoceratidae. Curiously, a striking similarity exists between *Phaneroceras* and the Arctic *Neoglaphyrites bisulcatus*. On both, prongs of the ventral lobe approximate the width of the first lateral lobe and biconvex transverse growth lines and constrictions form ventral and lateral sinuses. Additional similarities are apparent between the sutures and conchs of *Phaneroceras* and *Syngastrioceras* as was pointed out by Gordon (1968). Thus, *Phaneroceras* appears to be more closely allied with the Goniatitaceae than with any other superfamily.

Species composition and distribution.

Phaneroceras amotapense (Thomas, 1928); from Upper Carboniferous strata in the Amotape Mountains, northwestern Peru and from Atokan strata in the Sierra Madre Oriental, southwestern Tamaulipas, Mexico (Murray, Furnish, and Carrillo, 1960).

P. clariondi (Delépine, 1939, 1941); from Westphalian strata in Morocco.

P. compressum (Hyatt, 1891); from the Atokan Smithwick Shale near Bend, San Saba County, central Texas (Hyatt, 1891); from the Atokan Marble Falls Limestone in central Texas (Plummer and Scott, 1937); from the Atokan Winslow Formation and the Morrowan Bloyd Formation in Arkansas (McCaleb, 1963; Gordon, 1965); from Atokan strata in Japan (Nishida, 1971); and from strata of the same age in Arctic Canada.

P. kesslerense (Mather, 1915); from Morrowan and Atokan strata in Arkansas and Oklahoma (Mather, 1915; Miller and Moore, 1938; McCaleb, 1963; Gordon, 1965).

P. kueichowense (Yin, 1935); from Morrowan strata in China (*see* comments below).

P. lenaense Andrianov, 1966; from Middle Carboniferous strata in Western Verkhoyan.

P. lenticulare Plummer and Scott, 1937; from the Atokan Smithwick Shale, central Texas (Plummer and Scott, 1937), from the Barnett Hill Member of the Atoka Formation, Oklahoma (Murray, Furnish, and Carrillo, 1960; McCaleb, 1963), from Middle

Carboniferous strata in the Verkhoyan region of the Soviet Union (Popow, 1970), and from Atokan strata in Arctic Canada.

P. williamsi (Miller and Downs, 1948); from Morrowan and Atokan strata in Arkansas and Oklahoma (Miller and Downs, 1948; Unklesbay and Palmer, 1958; Unklesbay, 1962).

The form referred to *Gastrioceras kueichowense* by Yin (1935, p. 17, Pl. 1, figs. 6, 7) has been referred to *Pseudoglaphyrites* by Ruzhencev and Bogoslovskaya (1971b) but, on the basis of conch and sutural proportions, it should be referred to *Phaneroceras* as suggested by Gordon (1965). Yin (ibid.) recognized similarities between his species and *Pseudoparalegoceras russiense* (Tzwetaev); *P. kueichowense*, however, differs from *P. russiense* in that the umbilical lobe is situated on the umbilical wall on the former and outside the wall on the latter.

An undescribed representative of *Phaneroceras* is known from Atokan strata in the Taku Group, in the southern Yukon Territory.

Pseudoparalegoceras Miller is represented by the Moscovian species, *P. russiense* (Tzwetaev) and *P. tzwetaevae* Ruzhencev from the Russian Platform and Ural Mountain areas, respectively. In the United States, *P. brazoense* Miller and Furnish occurs in Desmoinesian (Moscovian) strata in Texas, New Mexico and Oklahoma. *Pseudoparalegoceras bellilineatum* is known from the Atokan Smithwick Shale horizon in the Magdalena Formation, West Texas. *Pseudoparalegoceras hansoni* Unklesbay and Pauken (1966) occurs in the Rainbow Mountain area of the Alaska Range, Alaska.

Phaneroceras lenticulare Plummer and Scott, 1937

Plate 11, figures 4, 7; Plate 15,
figures 4, 5, 6; Textfigures 43, 44

Phaneroceras lenticulare PLUMMER and SCOTT, 1937, p. 193, 194, Pl. 10, figs. 5, 6, 9 (*not* figs. 1–4, 7, 8); POPOW, 1970, p. 126, Pl. 16, figs. 1, 5.

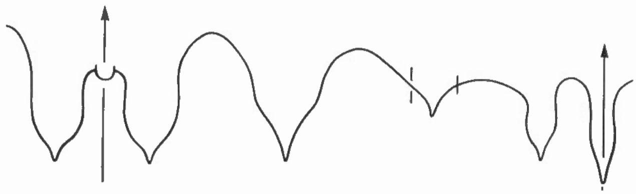
?*Phaneroceras compressum* PLUMMER and SCOTT, 1937, Pl. 11, fig. 13.

?*Pseudoparalegoceras lenticulare* MURRAY, FURNISH, CARRILLO, 1960, p. 735, Textfig. 4c.

Description. About 200 specimens of *Phaneroceras lenticulare* are available from Ellesmere Island. Most of these have a diameter of less than 40 mm but a few have a diameter close to 70 mm; one fragmentary specimen is septate to a diameter of about 80 mm. The conch is more or less ellipsoidal at maturity and the umbilicus closely approximates 30 per cent of the conch diameter. The umbilical shoulders are narrowly rounded at maturity and the umbilical walls steep.

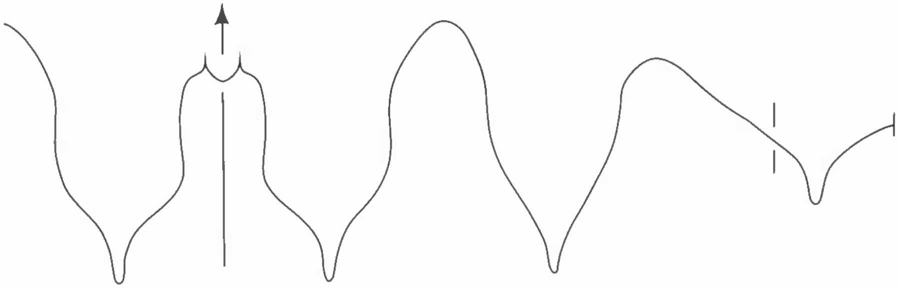
Lateral growth lines and longitudinal lirae are absent from all specimens. Lateral constrictions, four or five per volution, are deeply incised to a diameter of about 40 mm; they are less conspicuous beyond that size. Constrictions form a moderately deep ventral sinus and a shallow lateral sinus. Constrictions appear to have impressed the umbilical wall during early growth stages but not at maturity.

During early ontogeny, prongs of the ventral lobe are considerably narrower than the first lateral lobe but at maturity they are as wide as the first lateral lobe; the saddle separating the ventral prongs is nearly as high as the first lateral saddle. The umbilical lobe is on the umbilical wall, slightly outside of the midpoint of the wall; only a slight migration of the umbilical lobe towards the umbilical edge is apparent during ontogeny. The dorsal and internal lobes are elongate, attenuate, and of equal widths.



TEXTFIGURE 43

Diagrammatic representation of a suture of *Phaneroceras lenticulare* Plummer and Scott from the Hare Fiord Formation on Ellesmere Island (GSC loc. 58920); based on hypotype GSC 33760 at an approximate conch diameter of 48 mm.



TEXTFIGURE 44

Diagrammatic representation of an external suture of *Phaneroceras lenticulare* from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on hypotype GSC 33758 at an approximate conch diameter of 65 mm.

TABLE 19. Dimensions (in mm) and proportions of *Phaneroceras lenticulare* Plummer and Scott

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33754	63.7	26.0	31.5	18.0	0.41	0.49	0.28
Hypotype GSC 33755	37.9	15.0	19.3	11.5	.40	.51	.30
Hypotype GSC 33756	33.0	13.0	17.0	10.0	.39	.51	.30
Hypotype GSC 33757	18.1	7.5	10.1	5.8	.41	.54	.32

Comparisons. Several of Plummer and Scott's (1937) illustrated representatives of *P. lenticulare* are widely umbilicate and probably should be included in *P. compressum*. The concept of the former species is restricted to the poorly illustrated and poorly preserved holotype (Plummer and Scott, 1937, Pl. 10, figs. 5, 9) on which U/D approximates 30 per cent at a size of 25 mm. Murray, Furnish, and Carrillo (1960) indicated that, at a diameter of 25 mm, U/D of *P. lenticulare* varies from 30 to 35 per cent. At a comparable size, U/D on the holotype of *P. kesslerense* from the Morrowan Bloyd Formation in Arkansas (Mather, 1915, Pl. 16, figs. 10–10b) is close to 40 per cent. McCaleb (1963) and Gordon (1965) have concluded that *P. williamsi* Miller and Downs (1948) is synonymous with *P. kesslerense* but this conclusion requires additional support. A small paratype of *P. williamsi* illustrated by Miller and Downs (1948, Pl. 102, fig. 3) at a diameter of 35 mm has a U/D ratio of 37 per cent; at a diameter of 80 mm the holotype of *P. williamsi* has a U/D ratio of 31 per cent. A similar reduction in umbilical proportions of Arctic representatives of *P. lenticulare* is apparent; at a size of 25 mm, U/D approximates 31 per cent but, at a size of 63 mm, U/D is 28 per cent. All other species of *Phaneroceras* have a U/D ratio in excess of 35 per cent at maturity.

Plummer and Scott (1937) and Gordon (1965) suggested that *P. lenticulare* is further characterized by 6 constrictions per volution which persist to full maturity. On Arctic representatives of the species, either 4, 5 and rarely 6 constrictions per volution persist to maturity.

Occurrence. The type locality of *P. lenticulare* is in the Atokan Smithwick Shale in central Texas; the same unit has yielded the widely umbilicate *P. compressum*. Murray, Furnish, and Carrillo (1960) reported *P. lenticulare* from the Barnett Hill Member of the Atoka Formation in Oklahoma; McCaleb (1963) reported *P. kesslerense* from the same unit. Popow (1970) reported *P. lenticulare* from Middle Carboniferous strata in the northern Verkhoyan region of the Soviet Union. The umbilicus of Soviet representatives of the species is slightly larger than that of Canadian specimens of comparable size.

Phaneroceras lenticulare has been recovered from several localities in the Blue Mountain area of Ellesmere Island (Textfig. 10). It is particularly abundant near the top of the "Tellevak Limestone" at GSC localities C4085 and C4087; both these localities are in a common horizon and are several hundred feet apart along strike. The species is less abundant in the same horizon of the Tellevak in the same general area at GSC localities C5820 and C5428. It also occurs near the base of the Hare Fiord Formation at GSC locality C4083 in the Krieger Mountains and at GSC locality C4250 near van Hauen Pass. *Phaneroceras lenticulare* has been found at one locality on northwestern Axel Heiberg Island, GSC locality C22190, which is 360 feet above the base of the Nansen Formation 8.4 miles south of Bunde Fiord and 6 miles west of Bunde River (Textfig. 8).

Age. Atokan (Moscovian).

Phaneroceras compressum (Hyatt), 1891

Plate 11, figure 3

Gastrioceras compressum HYATT, 1891, p. 355–356, Textfigs. 57–59; SMITH, 1903, p. 86, Pl. 9, figs. 1–3.

Phaneroceras compressum PLUMMER and SCOTT, 1937, p. 191–193, Pl. 9, figs. 4, 5, 7–10, (*not* Pl. 9, fig. 6; Pl. 11, fig. 13).

Pseudoparalegoceras compressum MILLER and FURNISH, 1940c, Textfig. 3B; MURRAY, FURNISH, and CARRILLO, 1960, p. 736, Textfig. 5C; UNKLESBAY, 1962, p. 91–93, Pl. 15, fig. 10; McCALEB, 1963, p. 876, 877; p. 112, figs. 1, 2, 6; 1968, p. 57–59, Pl. 4, figs. 5–7, Pl. 12, fig. 7; ?NISHIDA, 1971, Pl. 4, figs. 1–3, Pl. 5, figs. 1, 2.

Pseudoparalegoceras (*Phaneroceras*) *compressum* GORDON, 1965, p. 264–265, Pl. 29, figs. 1–4, 18–20.

Description. Two specimens from Ellesmere Island are referred to *P. compressum*. One is septate to its maximum size of 74 mm; at full size the umbilicus of this specimen has a diameter of 31.7 mm (U/D equals 43 per cent), the whorl width is 31 mm (W/D equals 42 per cent) and the whorl height is 25.5 mm (H/D equals 34 per cent). The umbilical shoulder is narrowly rounded and the wall flat. The specimen is a recrystallized internal mould, shell ornament and constrictions are absent, and the suture is indistinct but can be partly reconstructed by observing the ultimate septum. The umbilical lobe is only slightly inside the umbilical shoulder. The other specimen is deformed but is fully septate to its full size of 120 mm; the umbilical diameter is about 40 per cent of the conch diameter.

Comparisons. *Phaneroceras compressum* is distinguished from all other representatives of the genus by a proportionately large umbilicus; the umbilical diameter is greater than 40 per cent of the conch diameter. The Arctic representatives of the species differ from the lectotype

(Hyatt, 1891, Textfigs. 57–59) in that, on the former the umbilical lobe is relatively nearer to the umbilical edge.

McCaleb (1968) suggested that *P. williamsi* described by Unklesbay and Palmer (1958) from the Burgner Formation in Missouri is in fact *P. compressum.* At a size of 84 mm, the species of Unklesbay and Palmer has a U/D ratio of 32 per cent; thus, the original assignment to *P. williamsi* is correct. Curiously, this Burgner species was not recorded in a synonymy of *P. compressum* by McCaleb (1968).

Occurrence. Phaneroceras compressum occurs at two localities on Ellesmere Island; at GSC locality C4083 near the base of the Hare Fiord Formation near Mount Barrell, Ellesmere Island (Textfig. 10) and at GSC locality 52455 near the base of the Canyon Fiord Formation, north of Cañon Fiord, Ellesmere Island (Textfig. 12).

Typical *P. compressum* is from Atokan limestones near Bend, San Saba County, central Texas. The species has been recorded also from the Atokan Marble Falls limestone in central Texas (Plummer and Scott, 1937) and from the Atokan Winslow Formation, Arkansas (McCaleb, 1963; Gordon, 1965). The latter authors also have recorded the species from the Morrowan Bloyd Formation in Arkansas.

Nishida (1971) described *P. compressum* from Atokan strata in Japan. Some of Nishida's illustrated specimens (ibid., Pl. 4, figs. 1a, 1b; Pl. 5, figs. 1a, 1b, 1c) have an umbilicus that approximates 40 per cent of the conch diameter at maturity, slightly less than typical *P. compressum.* On the other hand, the illustration on Nishida's Plate 5, figure 2 shows the umbilicus to approximate 50 per cent of the conch diameter, similar to the proportions of the lectotype.

Age. Atokan (Moscovian).

Family Somoholitidae Ruzhencev, 1938

Genus *Somoholites* Ruzhencev, 1938

Type species. *Gastrioceras beluense* Haniel, 1915; from Lower Permian strata (Somohole beds) in Timor.

Diagnosis. The conch of *Somoholites* is thickly discoidal and moderately evolute; U/D typically approximates 40 per cent. Shell ornament includes fine longitudinal lirae on the venter and flanks. Faint growth lamellae form a low, broad ventral salient. The suture is characterized by sharply attenuate external and internal lobes that possess prominent lateral pouches. Prongs of the ventral lobe are moderately asymmetric and the secondary ventral saddle is about half the height of the first lateral saddle. The first lateral lobe and the first lateral saddle have approximately the same width.

Discussion. Somoholites and the Somoholitidae have received considerable attention in the literature and only a brief review is provided here. Of particular significance are comprehensive works by Ruzhencev (1950, 1951) and Saunders (1971). Ruzhencev (1960b, 1962) placed the Somoholitidae in the Goniatitaceae and included within the family, in a phylogenetic progression, *Owenoceras* Miller and Furnish, 1940a, *Preshumardites* Plummer and Scott, 1937, and *Neoshumardites* Ruzhencev, 1936. Topotypes of the type species of "*Preshumardites*" (type, *Gastrioceras gaptankense* Miller, 1930) from Missourian strata in the Gaptank Formation, West Texas have been re-examined and *Preshumardites* is considered to be a synonym of *Neoshumardites* which has priority. Ruzhencev and Bogoslovskaya (1970) revised the Goniatitaceae to include only the Goniatitidae, the Delepinoceratidae, and the Agathiceratidae; these authors assigned the Somoholitidae to the Neoglyphioceratаceae.

Saunders (1971) modified the definition of *Somoholites* to include species with inflated lobes that lack longitudinal ornament. Saunders included only *Somoholites* and *Neoshumardites* in the Somoholitidae which he retained in the Goniatitaceae; on the basis of comparable sutures, he considered *Owenoceras* to be a neoicoceratid.

Saunders' proposal to include non-lirate as well as lirate forms in *Somoholites* is attractive in that it supports the suture as the basis for taxonomy but at the same time the procedure invites new taxonomic questions. Saunders (ibid.) correctly stressed that the suture and conch of *Somoholites* sensu lato resemble those of *Eoasianites* and *Syngastrioceras*, both of which lack longitudinal ornament. The last two genera typically have moderately inflated external lateral and internal lobes and both have a subangular first lateral saddle. There is no question that Saunders' species *Somoholites deroeveri* and *Somoholites sagittarius* possess the sutural characteristics of *Somoholites* and one of them, *S. deroeveri*, also has longitudinal ornament. The writer considers that some of the non-lirate species that Saunders (ibid.) included in *Somoholites* are, in fact, referable to other established genera mainly because of sutural differences. For example, "*Somoholites*" *cadiconiformis* (*Eoasianites cadiconiformis* Wagner-Gentis, 1963) should be included in *Syngastrioceras* as was suggested by Ruzhencev and Bogoslovskaya (1971b). Certainly sutural elements of *S. cadiconiformis* are pouched to a degree comparable with typical *Syngastrioceras*, and slightly more than typical *Eoasianites;* additionally, the first lateral saddle of *S. cadiconiformis* has a marked tendency toward angularity.

"*Syngastrioceras*" *walkeri* was described from Upper Mississippian (Chesteran) deposits in Nevada by Webster and Lane (1967). Saunders (1971) suggested that this species may be *Somoholites* but that confirmation of this would depend on the degree to which internal lobes of the Nevada species are pouched. Clearly the species of Webster and Lane lacks a subangular first lateral saddle and a relatively broad first lateral lobe, features that characterize *Syngastrioceras*. Additionally, reference to *Somoholites* is impractical and the evolute Nevada species must be assigned to *Neoicoceras*. The latter genus recently has been assessed by Furnish and Knapp (1966) and is discussed under its own heading in this report.

Species composition and distribution.

Somoholites artus Ruzhencev, 1951; from Lower Permian (Asselian) strata in the southern Urals and possibly the Hare Fiord Formation on Ellesmere Island (Nassichuk and Spinosa, 1972).

S. bamberi n. sp.; from Desmoinesian (Moscovian) strata in the Canyon Fiord Formation, Ellesmere Island.

S. beluensis (Haniel, 1915); from Lower Permian (Sakmarian) strata in Timor, the southern Urals (Ruzhencev, 1938, 1950, 1951) and the Yukon Territory, Canada (Nassichuk, 1971).

S. deroeveri Saunders, 1971; from probable Sakmarian strata in Timor. According to Saunders (1971), a species from Ellesmere Island which was described as *Neoshumardites* cf. *N. sakmarae* by Nassichuk, Furnish, and Glenister (1965) is referable to *S. deroeveri*.

S. dolium Ruzhencev, 1950; from Orenburgian strata in the southern Urals.

S. glomerosus Ruzhencev, 1950; from Zhigulevian and Orenburgian strata in the southern Urals.

S. ikensis Ruzhencev, 1950; from Orenburgian strata in the southern Urals.

S. merriami (Miller and Furnish, 1940c); from strata of probable Pennsylvanian age in Oregon and Middle Pennsylvanian (Atokan) age in Oklohama (Saunders, 1971) and Arctic Canada.

S. sagittarius Saunders, 1971; from Alleghenian (Moscovian) strata in Ohio and equivalent strata (Desmoinesian) in Oklahoma.

S. shikhanensis Ruzhencev, 1938; from Sakmarian strata in the southern Urals.

S. sholakensis Ruzhencev, 1950; from Zhigulevian strata in the southern Urals.

Somoholites merriami (Miller and Furnish), 1940

Plate 12, figures 1, 5

Eoasianites merriami MILLER and FURNISH, 1940c, p. 541–543, Pl. 65, figs. 1, 2, Textfig. 7b.

Neoshumardites merriami (Miller and Furnish) NASSICHUK, FURNISH, and GLENISTER, 1965, p. 15, Textfig. 2a.

Somoholites merriami (Miller and Furnish) SAUNDERS, 1971, p. 109–110, Pl. 23, figs. 11, 12, Textfig. 3a.

Description. One specimen of *Somoholites merriami* from the Hare Fiord Formation and four others from the type section of the Nansen Formation on Ellesmere Island are poorly preserved; on most specimens shell material is absent and sutures are generally distorted. Conch dimensions and proportions of the best-preserved specimen, that from the Hare Fiord Formation, are listed in the following table. Three or four constrictions occur on each volution; constrictions form a low, broad ventral salient.

Prongs of the ventral lobe are prominently inflated medianly and are highly asymmetric; prongs are about one-half the width of the first lateral saddle and are separated from one another by a ventral saddle that is about half the height of the narrowly rounded to subangular first lateral saddle. The first lateral lobe is conspicuously pouched medianly and is extremely attenuate; it extends considerably lower than the ventral prongs.

TABLE 20. Dimensions (in mm) and proportions of *Somoholites merriami* (Miller and Furnish)

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33764	46.5	13.5	34.5	19.0	29.0	0.74	0.41

Comparisons. Somoholites merriami can be distinguished from the younger type species *S. beluensis* (Haniel) by differences in both the conch and suture; *S. merriami* is proportionately broader than *S. beluensis* and the secondary ventral saddle of the latter is considerably higher than it is in the former. *Somoholites bamberi* n. sp. has more asymmetric ventral prongs and more inflated pouches on the flanks of the first lateral lobe.

Occurrence. Somoholites merriami is based on a single specimen (the holotype) from strata in the "Upper Mills Ranch inlier" in the upper Crooked River Basin, southeastern Crook County, Oregon. Age of the inlier cannot be defined precisely within the range Middle Pennsylvanian–Early Permian but the presence of *S. merriami* appears to suggest a Pennsylvanian age. The species has been recovered also from the Atoka Formation on Barnett Hill, north of Clarita, Coal County, Oklahoma (Saunders, 1971).

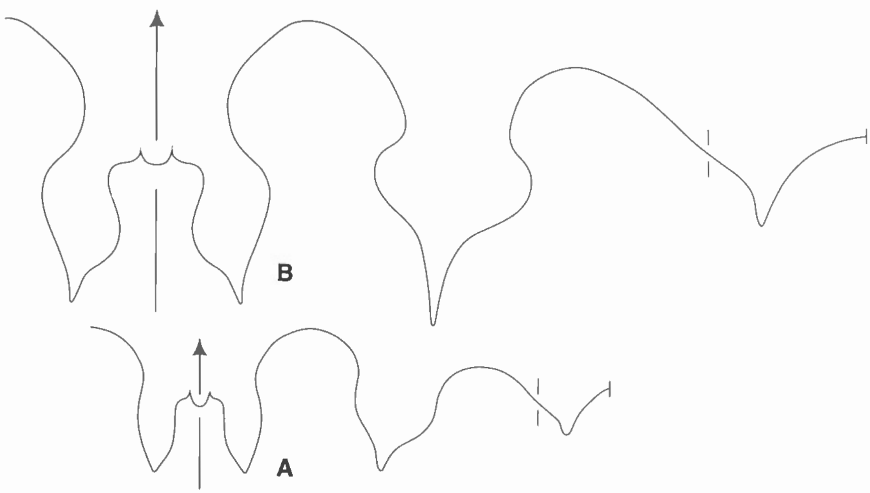
Somoholites merriami is known from two localities in Ellesmere Island: GSC locality C4083 is 100 feet above the base of the Hare Fiord Formation on the west side of Wood Glacier in the Krieger Mountains (80°54′N, 84°11′W); GSC locality C20561 is 1,530 feet above the base of the type section of the Nansen Formation on Girty Creek, near the head of Hare Fiord (82°06'N, 81°12'W).

Age. Atokan (Moscovian).

Somoholites bamberi Nassichuk, n. sp.

Plate 12, figure 9; Textfigure 45

Description. More than 100 specimens of *S. bamberi* were recovered from Raanes Peninsula on Ellesmere Island. All except a few specimens are fragmentary but sutures are generally well preserved. During early ontogeny, up to a diameter of 3 mm, whorl width and whorl height are equidimensional, but beyond that size width greatly exceeds height. The mature conch is broad and evolute and, on the holotype at a size of 18 mm, W/D approximates 80 per cent and U/D 40 per cent. The venter is broadly rounded at maturity and the umbilical shoulders are narrowly rounded, subangular. The umbilical wall, which was rounded during early ontogeny, is flat at maturity. Shell ornament generally is not preserved beyond a size of 15 mm; up to that size delicate growth lamellae form a broad ventral salient. On several specimens with diameters less than 10 mm, longitudinal lirae occur across the venter and flanks and these, with the lateral lamellae, form a delicate reticulate pattern on the shell. Two or three constrictions occur on each whorl at maturity and these form a low, broad ventral salient.



TEXTFIGURE 45. Diagrammatic representation of external sutures of *Somoholites bamberi* n. sp. from the Canyon Fiord Formation on Ellesmere Island (GSC loc. C10885); A is based on the holotype GSC 33767 at a conch diameter of 15 mm, B is based on paratype GSC 33768 at an approximate conch diameter of 50 mm.

The external suture is characterized by highly asymmetric ventral prongs and a prominently pouched first lateral lobe. Internal elements also possess conspicuous lateral pouches. The pouches on the external lateral lobe are well developed even at a diameter of 5 mm and they become progressively more inflated throughout ontogeny. At a size of 5 mm, the first lateral lobe is about three-quarters the width of the broadly rounded first lateral saddle and the ventral prongs are slightly more than half the height of the first lateral saddle.

These proportions remain fairly constant throughout ontogeny except that at full size the first lateral lobe more closely approximates the width of the first lateral saddle.

TABLE 21. Dimensions (in mm) and proportions of *Somoholites bamberi* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Paratype GSC 33768	*50.0	—	*32.0	—	—	0.64	—
Holotype GSC 33767	*18.0	6.2	14.2	7.7	0.34	.79	0.43
Paratype GSC 33766	13.3	4.5	11.5	6.5	.34	.86	.49

*Measurement by reconstruction.

Comparisons. Somoholites bamberi can be distinguished readily from all other Carboniferous and most Permian representatives of the genus by peculiarities of the suture line, particularly the ventral prongs. These are considerably more asymmetric on *S. bamberi* than they are on most species; the only exception is the Early Permian *S. deroeveri* Saunders which, at a diameter of 20 mm, has a sutural configuration practically identical with *S. bamberi* at a size of 50 mm. The Desmoinesian *S. sagittarius* Saunders is very similar to *S. bamberi* but ventral prongs of the latter are slightly more asymmetric than those of the former. On a size-for-size basis, the suture of *S. bamberi* resembles that of the Soviet Zhigulevian *S. sholakensis* but the latter species has a proportionately narrower umbilicus and a wider conch than *S. bamberi.*

Occurrence. Somoholites bamberi occurs at GSC locality C10885 (type locality) which is 1,145 feet above the base of the Canyon Fiord Formation, 6 miles east of the head of Blind Fiord on Raanes Peninsula (Textfig. 13), Ellesmere Island (85°23'N, 27°23'30"W). The species also occurs higher in this same section at GSC locality C10891 which is 317 feet above the type locality.

Age. Desmoinesian (Moscovian).

Superfamily GASTRIOCERATACEAE Hyatt, 1884

Family Reticuloceratidae Librovitch, 1957

Genus ***Bilinguites*** Librovitch, 1946

Type species. *Reticuloceras superbilingue* Bisat, 1924; from Marsdenian (Upper Namurian, R_2 Zone) strata in England.

Diagnosis. The conch of *Bilinguites* is subdiscoidal and moderately involute at maturity; W/D varies from about 40 to 50 per cent and U/D approximates 30 per cent. The mature venter is narrowly rounded typically but on some species it is either subangular or angular. Two parallel, longitudinal grooves with rounded bottoms occur on the ventrolateral flanks; grooves are separated from each other by a rounded ridge. Strongly developed growth lines form a prominent tongue- (lingua) shaped projection (salient) between the ventrolateral grooves and corresponding deep sinuses across the venter and flanks. Relatively weak longitudinal lirae may occur across the venter and flanks.

The external suture is characterized by elongate, pointed ventral prongs, the sides of which are essentially parallel with the ventral axis. The first lateral saddle is broad and evenly rounded and the first lateral lobe is more or less V-shaped.

Discussion. The type species of *Bilinguites* is based on immature and poorly preserved (compressed) specimens (*see* Bisat, 1924, Pl. 5, fig. 6). Because of this and because little is known of the suture on type materials, the form and relationship of the taxon have remained obscure and, indeed, most European workers consider *Bilinguites* to be an advanced form of *Reticuloceras*. The present author accepts the contention of the Soviet workers Librovitch (1946) and Ruzhencev (1962) that the genus is clearly distinguishable from *Reticuloceras* on the basis of shell form and ornament; new materials from Arctic Canada lend additional support to this distinction. Furthermore, Canadian materials provide refinements to the criteria employed by Librovitch (1946) in defining the genus. Librovitch (1946, 1957) indicated that *Bilinguites* lacks an angular venter during all stages of growth. Whereas such an observation is undoubtedly accurate for immature specimens, it is clear from the literature that a number of mature specimens described from Europe are deformed so that proper details of the venter have been rendered obscure. Salter (1864, p. 20, Fig. 14b) showed the venter of *B. bilingue* (Salter) to be subangular. Comparable subangular and even sharply angular venters are apparent on *B. canadensis* and *B.* sp. from Arctic Canada.

All representatives of *Bilinguites* have been assigned to three species of R_2 age in the literature. Bisat (1924) considered *B. bilingue* (Salter) and *B. pseudobilingue* (Bisat) to be advanced mutants of *Reticuloceras reticulatum* which is confined typically to strata of R_1 age. Similarly, Wright (1927) suggested that *B. metabilingue* (Wright) is intermediate between *B. bilingue* and *B. pseudobilingue*. An excellent summary relating these species to various of Bisat's (1924) designated mutants of *Reticuloceras reticulatum* was provided by Hudson (1945). As suggested by Manger (1971) and Quinn (1971), *Arkanites* McCaleb, Quinn, and Furnish from the Prairie Grove Member (R_2) of the Hale Formation in Arkansas and Oklahoma resembles *Bilinguites* at least in a general way. The two are distinct, however, on the basis of conch form and shell ornament. *Arkanites* typically has a proportionately flatter venter than *Bilinguites*, however a few representatives of the former are known to have a rather acute venter. Margins of the venter of *Arkanites* are marked by a single deeply impressed groove. *Bilinguites* has a narrowly rounded or angular venter and two grooves on each ventrolateral flank. The lateral flanks of *Arkanites* contain coarse ribs which terminate as fine nodes at the umbilicus whereas *Bilinguites* has relatively fine lateral growth lines and a relatively smooth umbilical shoulder. The suture of *Arkanites* differs from that of *Bilinguites* in that the former has relatively more pointed ventral prongs and a proportionately less symmetric first lateral saddle as well as a broader, more inflated first lateral lobe. Manger (1971) suggested that both genera should be included in the Reticuloceratidae. Some considerable merit must be afforded Manger's (ibid.) suggestion because, in the Arctic materials described herein from Melville Island, the ornament, conch form, and suture of some immature representatives of *Bilinguites* closely resemble *Arkanites*. For additional observations concerning relationships of *Arkanites* reference is made to Quinn (1971).

Species composition and distribution.

Bilinguites bilingue (Salter, 1864); from Namurian (R_2) strata in England, and equivalent strata in Belgium (Demanet, 1938, 1941); Germany (Schmidt, 1925); Poland (Korejwo and Teller, 1968); and Morocco (Delépine, 1941).

B. canadensis n. sp.; from Morrowan (Halian) strata in Arctic Canada.

B. heibergensis n. sp.; from Morrowan (Halian) strata in Arctic Canada.

B. metabilingue (Wright, 1927); from Namurian (R_2) strata in England and equivalent strata in Belgium (Bouckaert, 1961). According to Ruzhencev and Bogoslovskaya (1971b), the species is also known from Germany and Algeria.

B. superbilingue (Bisat, 1924); from Namurian (R_2 and G_1) strata in England and equivalent strata in Belgium (Demanet, 1938, 1941); Germany (Schmidt, 1925); Poland (Korejwo and Teller, 1968); and Algeria.

B. sp.; from Morrowan (Halian) strata in Arctic Canada.

B. sp.; from Morrowan (Halian) strata in the Primrose Sandstone, southern Oklahoma. The species has never been described but may be the ammonoid referred to by Elias (1956, p. 98) as "a form intermediate between the British goniatite *Eumorphoceras pseudobilingue* Bisat and the American *Branneroceras branneri* (Smith)...."

Bilinguites canadensis Nassichuk, n. sp.

Plate 13, figures 1–4, 6, 9; Textfigure 46B, C

Reticuloceras sp. (part) Nassichuk, 1969, p. 206.

Description. Approximately 300 specimens of *B. canadensis* were found within a sequence of shales and argillaceous limestones in Barrow Dome on northern Melville Island. Whereas many specimens are broken or partly eroded, a good number are entirely preserved; most are recrystallized internally. Some specimens are slightly compressed but on all of them shell material is retained and sutures are visible.

A good deal of variation in conch form is evident. On the holotype the umbilicus approximates one-third the conch diameter but, in general, the umbilicus ranges from 20 to 40 per cent of the diameter of mature specimens. During early stages of growth, the venter is broadly rounded but, between diameters of 20 and 30 mm, a rather sharp angular keel is developed on the venter. Two conspicuous parallel grooves or furrows occur on each ventrolateral flank. During early ontogeny, one or two constrictions may occur in each volution but constrictions are absent at maturity.

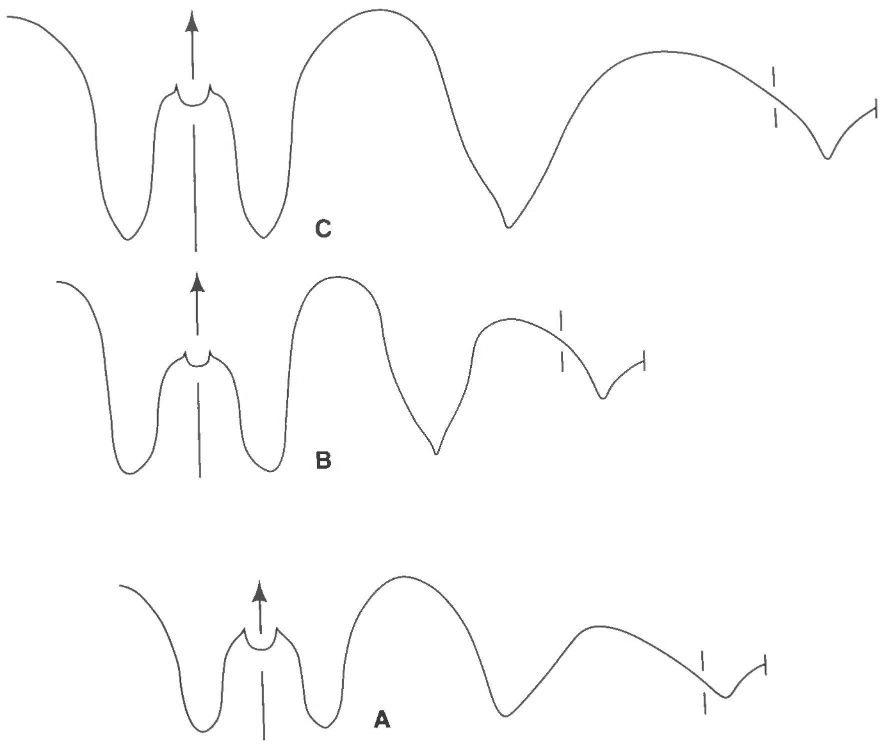
Shell ornament consists of fine growth lines that form a high tongue-shaped salient on each side of the shell between the ventrolateral grooves and corresponding deep ventral and lateral sinuses. During early ontogeny, growth lines are rib-like and form umbilical nodes as they cross the umbilical shoulder but at maturity the umbilical shoulders and walls are relatively smooth.

Prongs of the ventral lobe are about two-thirds the height of the first lateral saddle. Prongs are narrow, rather straight-sided and bluntly pointed. The first lateral saddle is broadly rounded and the first lateral lobe is narrow, only slightly inflated and accuminate.

Comparisons. Bilinguites canadensis differs from all previously described representatives of the genus in possessing a rather sharp ventral keel at maturity. Typical *B. bilingue* (Salter, 1864), closely resembles *B. canadensis* in general conch form and proportions but has a narrowly rounded or subangular ventral keel rather than a sharply angular one. Two fragmentary specimens from Axel Heiberg Island, described herein as *Bilinguites* sp., have sharply angular ventral keels but are considerably broader than typical *B. canadensis.*

TABLE 22. Dimensions (in mm) and proportions of *Bilinguites canadensis* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33772	36.0	15.5	14.0	11.5	0.43	0.39	0.32
Paratype GSC 33773	18.5	8.2	10.6	5.4	.44	.57	.30
Paratype GSC 33774	14.5	6.3	8.0	3.7	.43	.55	.26
Paratype GSC 33775	12.0	4.8	6.8	3.0	.40	.57	.25



TEXTFIGURE 46. Diagrammatic representation of external sutures of *Bilinguites heibergensis* n. sp. and *Bilinguites canadensis* n. sp. A, *Bilinguites heibergensis* n. sp. from the Otto Fiord Formation on Axel Heiberg Island (GSC loc. 47996); based on paratype GSC 33782 at a conch diameter of 23 mm. B, C, *Bilinguites canadensis* n. sp. from the Otto Fiord Formation on Melville Island (GSC loc. C16901), B based on paratype GSC 33777 at a conch diameter of 26 mm, C based on paratype GSC 33776 at a conch diameter of 32 mm.

Occurrence. Bilinguites canadensis occurs at GSC locality C16901 near the centre of Barrow Dome, northern Sabine Peninsula. The locality is 0.6 mile northeast of the centre of the dome (78°38′N, 109°01′30″W). The source of Carboniferous rocks within Barrow Dome is known to be the Otto Fiord Formation.

Age. Halian (Namurian).

Bilinguites heibergensis Nassichuk, n. sp.

Plate 12, figures 3, 4, 6, 10; Textfigure 46A

Reticuloceras sp. HOEN, 1964, p. 8.
Eumorphoceras sp. (part) HOEN, 1964, p. 8.
Reticuloceras sp. (part) NASSICHUK, 1968, p. 206.

Description. Bilinguites heibergensis is based on 5 specimens from a large block of bioclastic limestone that is enveloped by gypsum and anhydrite in "South Fiord Dome," on western Axel Heiberg Island. The most nearly complete specimen, which attained a diameter of 32 mm, is selected as holotype. One large, fragmentary paratype attained a diameter of approximately 65 mm. On these two specimens the umbilicus is 25 per cent (smaller specimen) and 30 per cent (larger specimen) the diameter of the conch. Curiously, on one paratype of intermediate size (diameter 37 mm), U/D approximates 38 per cent and this anomaly may reflect sexual dimorphism. At full size (32 mm), the holotype has a whorl width of 15 mm (W/D, H/D 47 per cent). The venter is narrowly rounded until maturity when it becomes subangular.

During early growth stages, up to a size of 15 mm, prominent growth lines form nodes across the umbilical shoulders and walls. At maturity, the umbilical shoulders and walls are smooth. Shell ornament includes only delicate growth lamellae that form a high tongue-like salient centred between shallow grooves that occur on the ventrolateral flanks and correspondingly deep ventral and lateral sinuses.

Comparisons. Bilinguites heibergensis is considerably broader than *B. canadensis* and the former lacks a comparable sharply angular venter. Hoen (1964) listed some specimens herein assigned to *B. heibergensis* as *Eumorphoceras* sp. Although the conch of *B. heibergensis* resembles *Eumorphoceras* in gross aspect, both the suture and ornament necessitate reference of the former to *Bilinguites*.

Occurrence. The type locality of *B. heibergensis* is GSC locality 47996, a large limestone block enveloped in gypsum and anhydrite in the southeast quadrant of "South Fiord Dome," on west-central Axel Heiberg Island (Textfig. 7). The evaporites and limestones in South Fiord Dome are thought to have derived from the Otto Fiord Formation. The species also occurs at GSC locality C16901 in Barrow Dome, Melville Island (Textfig. 4) where it is associated with *Bilinguites canadensis*. The latter locality is 0.6 mile northeast of the centre of the dome (76°38′N, 109°01′30″W).

Age. Halian (Namurian).

Bilinguites sp.

Plate 12, figures 2, 7, 8

Eumorphoceras sp. HOEN, 1964, p. 8.

Description. Two fragmentary specimens referred to *Bilinguites* sp. were associated with *Bilinguites heibergensis* on Axel Heiberg Island. By reconstruction, these specimens have diameters of 40 mm and 47 mm respectively; on the larger specimen U/D approximates 36 per cent. Both have a sharply angular venter and a pair of shallow longitudinal grooves on the ventrolateral flanks. During early ontogeny the venter is broadly rounded. The umbilical shoulders and walls are smooth at maturity but contain rib-like nodes during early growth stages. Shell ornament consists of delicate growth lines that form moderately deep ventral and lateral sinuses and a high tongue-like saddle between the ventrolateral grooves. Although inner whorls of both specimens are septate, sutures have been obscured by recrystallization.

Comparisons. Bilinguites sp. has an angular venter similar to *B. canadensis* but the latter species has a considerably narrower conch than *Bilinguites* sp. *Bilinguites heibergensis* is directly associated with *B.* sp. and, whereas the former has a narrowly rounded or subangular venter even at a size of 65 mm, the latter has an angular venter between a size of 30 mm and 40 mm. Thus, it is not realistic to suggest that the angular venter of *Bilinguites* sp. is an "old age" form of *B. heibergensis.*

Occurrence. Bilinguites sp. occurs associated with *B. heibergensis* at GSC locality 47996 in a limestone block in the southeast quadrant of South Fiord Dome on west-central Axel Heiberg Island (Textfig. 7). Source of evaporites and limestones in South Fiord Dome is the Otto Fiord Formation.

Age. Halian (Namurian).

Family GASTRIOCERATIDAE Hyatt, 1884

Genus *Gastrioceras* Hyatt, 1884

Type species. *Ammonites listeri* Sowerby, 1812: subsequent designation by Foord and Crick, 1897; from Westphalian-A (G_2) strata in England.

Diagnosis. Gastrioceras displays considerable variation in conch form but is typically broad (W/D between 65 and 70 per cent) and widely umbilicate (U/D approximately 50 per cent); on some species W/D is close to 50 and U/D is close to 30 per cent. Tubercles persist on the umbilical shoulder of the type species to full maturity; transverse striae are coarse and widely spaced and form shallow ventral and lateral sinuses. In the type species, longitudinal lirae are confined to the umbilical shoulders where a reticulate pattern is developed. On some species longitudinal lirae persist across the venter at least during early ontogeny and in others both longitudinal lirae and transverse striae are absent from the venter.

On the external suture, prongs of the ventral lobe are separated by a low ventral saddle that is about half the height of the broad and evenly rounded first lateral saddle. Ventral prongs are generally twice as wide as the first lateral lobe and three times as wide as the first lateral saddle. The first lateral lobe is variously lanceolate or V-shaped and is about half the width of the first lateral saddle.

Discussion. Since Hyatt proposed *Gastrioceras* in 1884, a wide variety of species has been assigned to the genus by various authors. *Gastrioceras* has been subjected to considerable revision in the literature and a monograph on the taxon is currently being prepared by W. H. C. Ramsbottom; it is hoped that Ramsbottom's work will clarify some of the problems discussed in this report. Numerous extant Carboniferous and Permian genera that are characterized by a moderately evolute conch, umbilical nodes at least during early stages of growth and a simple 8-lobed 'gastrioceran' suture are based on species that were originally assigned to *Gastrioceras*. Some of these genera are:

Pseudoparalegoceras Miller, 1934
Uraloceras Ruzhencev, 1936
Phaneroceras Plummer and Scott, 1937
Somoholites Ruzhencev, 1938
Syngastrioceras Librovitch, 1938
Altudoceras Ruzhencev, 1940
Donetzoceras Librovitch, 1946
Pygmaeoceras Gordon, 1960.

Additional taxa have been proposed to accommodate various species of '*Gastrioceras*' with atypical conch and shell features; some of these are based on poorly preserved materials and require additional clarification. Schmidt (1938) proposed *Agastrioceras* (type, *Glyphioceras subcrenatum* var. *carinata* Frech, 1899, Pl. 46b, fig. 5b) for *Gastrioceras*-like forms that developed a sharp ventral keel at maturity. Taxonomic assignment of '*A.*' *subcrenatum* (Frech) [= *Gastrioceras carbonarium* Buch] as well as matters of authorship and synonymy have been explained by Ramsbottom and Calver (1960) and by Patteisky (1965). Since the original specimen on which the genus is based (Frech, 1899, Pl. 46b, fig. 5b) was destroyed in Wroclaw, Poland, some authors have suggested that the genus should be retained in the category "inquirenda." Patteisky (1965), however, revised the definition of *Agastrioceras* to include rather involute species that possess umbilical nodes only during early growth stages and suggested that a ventral keel on the type species reflected nothing more than deformation; that is, specimens representing the type species are compressed within concretions. According to Patteisky (ibid.), the most important feature that distinguishes *Agastrioceras* is the relative development of whorl width and whorl height during ontogeny. In the initial three whorls (after the protoconch), whorl width is relatively uniform, but beginning with the fourth whorl, width increases much faster than height. In the opinion of this writer, such a development is a general rule in the ontogeny of goniatites rather than an exception and cannot be considered a generic criterion. The conch and shell ornament of *Agastrioceras* is distinct from typical *Gastrioceras;* these differences might logically warrant separation of *Agastrioceras* into a different family, perhaps the Reticuloceratidae as was suggested by Patteisky (1965). It is clear, however, that additional data are required on the suture of *Agastrioceras* before relationships can be fully assessed.

Ruzhencev and Bogoslovskaya (1969b) proposed *Cancelloceras* (type, *Gastrioceras cancellatum* Bisat, 1924) for *Gastrioceras*-like forms with a well-developed reticulate shell ornament. All the species Ruzhencev and Bogoslovskaya (1971b) assigned to *Cancelloceras* are from G_1 strata in Europe and those authors proposed the genus as an index for R_2 and G_1 strata (*Bilinguites–Cancelloceras* genozone) in their scheme. Although an attractive proposal, there is some indication that the genus may be recognized in younger G_2 (Westphalian-A) strata in western Europe, i.e., *Gastrioceras amaliae* Schmidt, *G. catharinae* Schmidt, and *G. martini* all have reticulate shell ornament similar to type *Cancelloceras.* Patteisky (1965) has suggested that '*G.*' *amaliae* in fact may be referable to '*Agastrioceras*' and '*G.*' *catharinae* to *Hudsonoceras.* The question of the validity of *Cancelloceras* cannot be discussed objectively without a review of closely related *Branneroceras* Plummer and Scott and *Retites* McCaleb; a brief review is provided under *Branneroceras* in this report.

Bisat (1940) suggested that typical *Gastrioceras, G. listeri* (G_2), is derived from a lineage that exhibited progressive degeneration of longitudinal lirae and ventrolateral salients (linguae) in the lateral shell ornament. Preceding *G. listeri* in the lineage, Bisat (ibid.) included four species from G_1 strata that some authors now consider to belong in *Cancelloceras:*

'*G.*' *branneroides*

'*G.*' *cancellatum*

'*G.*' *rurae*

'*G.*' *crenulatum.*

Bisat also implied that *Branneroceras branneri* with its coarse reticulate ornament logically might be included in the lineage with the latter species.

Gastrioceras was modified further by Gordon (1965) who proposed the subgenus *Lissogastrioceras* (type, *Gastrioceras fittsi* Miller and Owen, 1944) for representatives of the genus that lack shell ornament across the venter. Gordon (ibid.) suggested that all North

American species of *Gastrioceras* belong in *Lissogastrioceras* and that many European species are 'intermediate' between *Lissogastrioceras* and *Gastrioceras* sensu stricto. A number of North American species of *Gastrioceras* now are known to have well-defined shell ornament across the venter. Definitive relationships between *Lissogastrioceras* and *Gastrioceras* sensu stricto may exist but they are obscured by the fact that strata bearing *Lissogastrioceras* in North America cannot yet be related adequately to strata bearing *Gastrioceras* sensu stricto in Europe. *Lissogastrioceras fittsi* is the oldest representative of the subgenus and is confined to the Morrowan Bloyd Formation in North America where it is directly associated with *Branneroceras branneri;* other representatives of the subgenus extend into considerably younger (Moscovian) strata. Typical *Gastrioceras listeri* is confined to G_2 (Westphalian-A) strata in Europe.

On Melville Island, *Gastrioceras* displays wide variation in both conch form and shell ornament. *Gastrioceras melvillensis* n. sp. has a wide, evolute conch and displays reticulate shell ornament during much of its growth. At full maturity, longitudinal lirae are absent and the shell has a coarsely strigate ornament resembling *Gastrioceras* sensu stricto. *Gastrioceras melvillensis* appears to demonstrate that *Gastrioceras* sensu stricto was derived from '*Cancelloceras*' or some other reticulate-shelled genus. *Gastrioceras liratum* n. sp. is unique in that it possesses coarse longitudinal lirae on the venter and flanks, similar to the Permian *Paragastrioceras*, and relatively subdued lateral striae. Some authors undoubtedly will consider *G. liratum* to represent either a distinct subgenus of *Gastrioceras* or a new genus but the present writer considers such a designation to be premature considering the distinctly *Gastrioceras*-like suture of *G. liratum* and numerous uncertainties surrounding taxonomic relationships of '*Cancelloceras*,' *Branneroceras*, '*Lissogastrioceras*,' and *Gastrioceras*. *Gastrioceras* sp. is represented by immature and generally poorly preserved, smooth-shelled specimens from Melville Island; conch form resembles that of *Branneroceras* but both the suture and the form of umbilical nodes necessitate reference to *Gastrioceras*.

In addition to the above-cited Morrowan species from Melville Island, one other species is known from Arctic Canada. *Gastrioceras glenisteri* occurs in both Atokan and Desmoinesian (Moscovian) strata on Ellesmere Island. It has a smooth venter as is typically characterized by the subgenus *Lissogastrioceras*.

The question of sexual dimorphism in *Gastrioceras* has received considerable attention in the literature by Demanet (1943) and others and shall not be reviewed here. There is no established procedure for taxonomic designation of sexual dimorphs. One method is to treat the sexes as distinct 'species' and another is to assign both sexes a common trivial name with some added identifying modification. For example, Furnish and Knapp (1966) accommodated the sexes of *G. occidentale* as form α (alpha) and form β (beta).

A number of species that have been assigned to the genus are based on immature or deformed specimens and, although a superficial resemblance to *Gastrioceras* is clear, additional study is required to establish validity. For example, '*Gastrioceras*' *montgomeryense* (Miller and Gurley, 1896) is a Late Pennsylvanian species that is based on immature specimens of uncertain stratigraphic origin and which may be a schistoceratid (Plummer and Scott, 1937; Gordon, 1965; Furnish and Knapp, 1966). '*Gastrioceras*' *wongi* Grabau, 1924 appears to have been derived from Permian strata in northern China and may be a paragastrioceratid, as was suggested by Furnish and Knapp (1966). The latter group, however, is characterized by longitudinal lirae on the shell surface whereas, in '*G.*' *wongi*, only fine transverse growth lines are preserved. *Gastrioceras liratum* from G_2 strata on Melville Island is characterized by prominent paragastrioceratid-like longitudinal lirae and particularly faint lateral lines.

Species composition and distribution.

Because of the previoulsy discussed uncertainties which surround the generic concept, species of '*Gastrioceras*' are grouped in the following list according to general morphology and to usage by various authors. Despite rather precise work by Patteisky (1965) on *Agastrioceras* and by Ruzhencev and Bogoslovskaya (1969b, 1971b) on *Cancelloceras*, both taxa require additional research to clarify relationships with *Gastrioceras* sensu stricto and *Branneroceras*.

The first occurrences of *Gastrioceras* sensu lato are '*G.*' *lineatum* Wright and *G. sigma* Wright, both of which are found near the base of the R_2 Zone in England. Patteisky (1965) and Ruzhencev and Bogoslovskaya (1971b) assigned '*G.*' *lineatum* to *Agastrioceras*. Similarly Pareyn (1961) recorded *Gastrioceras* sp. from his S^5 fauna (R Zone) in North Africa. In general, in western Europe *Gastrioceras* sensu lato ranges from Namurian (R_2) through Westphalian-A (G_2) strata (Ramsbottom and Calver, 1960). It appears to be absent from Namurian strata in the Soviet Union but is known from Kayalian strata in both the Donetz Basin (Librovitch, 1939, 1946) and the Ural Mountains (Ruzhencev and Bogoslovskaya, 1971b).

In North America, *Gastrioceras* sensu lato ranges from Halian [upper Namurian (R_2 or G_1)] to Desmoinesian (Moscovian). Most North American occurrences of the genus are in the Midcontinent region of Arkansas and Oklahoma as well as in Arctic Canada but a few have been recorded from more easterly parts of the United States. Furnish and Knapp (1966) described *Gastrioceras occidentale* (Miller and Faber) from Pottsvillian strata in the Breathitt Formation in eastern Kentucky and suggested that this species "falls in the group of *G. subcrenatum* as employed by European authors" (Ramsbottom and Calver, 1960, p. 574). In northwestern Europe, *G. subcretatum* marks the boundary between the Namurian and Westphalian. Eagar (1970) documented the occurrence of *Gastrioceras* aff. *G. subcrenatum* associated with *Anthracoceras* sp. from the Hance Formation in southeastern Kentucky and indicated a late Morrowan (Westphalian-A) age. *Gastrioceras* aff. *G. subcrenatum* is practically identical with *Gastrioceras occidentale*.

With the exception of the Arctic species *G. melvillensis* and *G. liratum* as well as *G. formosum* McCaleb from the Winslow Formation in Arkansas, *G.* aff. *G. subcrenatum* from the Hance Formation in Kentucky and undescribed species in the Hale Formation in Arkansas and in the Buckhorn Asphalt and the Boggy Formation in Oklahoma, all North American species resemble '*Lissogastrioceras*' in that they are devoid of shell ornament across the venter. *Gastrioceras melvillensis* has a reticulate shell ornament during much of its development but only prominent lateral strigae are present at full maturity. *Gastrioceras formosum* possesses growth lamellae across the venter but these are considerably more delicate than on typical *Gastrioceras*. *Gastrioceras liratum* and the above-mentioned unnamed species in the Buckhorn and Boggy in Oklahoma are unique in that they possess completely atypical longitudinal lirae; they are included in the genus on the basis of suture and conch form.

A. Species Patteisky (1965) referred to *Agastrioceras* Schmidt emend. Patteisky, 1965.
   - a) *Gastrioceras lineatum* Wright, 1927; from R_2 strata in England.
   - b) *Gastrioceras sigma* Wright, 1927; from R_2 strata in England.
   - c) *Gastrioceras subcrenatum* (Frech) 1899; from Westphalian-A strata in Germany and possibly North America (Hance Formation, Kentucky).
   - d) *Agastrioceras adleri* Patteisky, 1965; from Westphalian-A strata in Germany.
   - e) *Gastrioceras carinatum* (Frech) 1899; from R_2 or G_1 strata in Germany, Poland, and Belgium.
   - f) ?*Gastrioceras amaliae* Schmidt, 1938; from just above the "Plasshofsband" coal seam (Westphalian-A) in northwestern Germany.

B. Species referred to *Cancelloceras* Ruzhencev and Bogoslovskaya, 1969 by Ruzhencev and Bogoslovskaya (1971b).

a) *Gastrioceras branneroides* Bisat, 1940; frcm G_1 strata in Wales and possibly Algeria.

b) *Gastrioceras cancellatum* Bisat, 1923; from G_1 strata in England, Belgium, Poland, and Morocco and possibly the Donetz Basin in Russia.

c) *Gastrioceras crencellatum* Bisat, 1924; from G_1 strata in England, Belgium and Germany.

d) *Gastrioceras crenulatum* Bisat, 1924; from G_1 strata in England, Belgium, Germany, and Algeria (includes *G. crenulatum deleaui* Termier and Termier).

e) *Gastrioceras cumbriense* Bisat; from G_1 strata in England, Belgium, Germany, Morocco and possibly Poland and the Soviet Union.

f) *Gastrioceras carbonarium* Buch, 1832; from probable G_1 strata in Germany.

g) *Gastrioceras demaneti* Patteisky, 1965; from probable G_1 strata in Germany.

h) *Gastrioceras rurae* Schmidt, 1925; from G_1 strata in Germany.

Comments: All species assigned to *Cancelloceras* by Ruzhencev and Bogoslovskaya (1971b) are from their *Bilinguites–Cancelloceras* genozone ($R_2 + G_1$). Wagner-Gentis (*in* Moore, Neves, Wagner, and Wagner-Gentis, 1971) described a single fragmentary specimen of ?*Gastrioceras* from Namurian B strata in northern Leon, northwestern Spain. Shell ornament was not preserved on this specimen and affinities are not clear.

C. Species devoid of shell ornament across the venter, which qualify for inclusion in subgenus *Lissogastrioceras*.

a) *Gastrioceras adaense* Miller and Owen, 1944 [synonym *G. grileyi* Miller and Owen, 1944]; from Morrowan (Bloydian) strata in the Union Valley sandstone, Oklahoma and equivalent strata in the Johns Valley shale and the Witts Springs Formation in Arkansas.

b) *Gastrioceras araium* McCaleb, 1968; from the Morrowan Bloyd Formation in Arkansas.

c) *Gastrioceras attenuatum* McCaleb, 1968; from the Morrowan Bloyd Formation in Arkansas and equivalent strata in the Gene Autry Shale in Oklahoma.

d) *Gastrioceras fittsi* Miller and Owen, 1944; from the Morrowan Bloyd Formation in Arkansas and equivalent strata elsewhere in Arkansas and Oklahoma.

e) *Gastrioceras glenisteri* n. sp. from Atokan and Desmoinesian (Moscovian) strata on Ellesmere Island, Arctic Canada.

f) *Gastrioceras occidentale* (Miller and Faber, 1892); from Pottsvillian (Bloydian) strata in Kentucky (*see* Furnish and Knapp, 1966).

g) *Gastrioceras* sp.; from Morrowan (Bloydian) strata on Melville Island, Arctic Canada.

D. Species in which growth lines are particularly conspicuous relative to longitudinal lirae, which are either absent or confined to umbilical regions (*Gastrioceras* sensu stricto).

a) *Gastrioceras circumnodosum* Foord, 1903; from the *G. listeri* horizon (Westphalian-A) in England and Germany, as well as the Soviet Union.

b) *Gastrioceras coronatum* Foord and Crick, 1897; from the *G. listeri* horizon (Westphalian-A) in England.

c) *Gastrioceras kahrsi* Wedekind, 1914; from Westphalian strata in Germany.

d) *Gastrioceras depressum* Delépine, 1937; from Westphalian strata in Belgium and Germany.

e) *Gastrioceras kenadsae* Delépine, 1941; from Westphalian strata in Morocco.

f) *Gastrioceras listeri* (Sowerby), 1912; from the "*G. listeri*" horizon in the lower Coal Measures (Westphalian-A) in England (*see* Ramsbottom and Calver, 1960). *Gastrioceras listeri* also occurs in Westphalian strata in Morocco (Delépine, 1941), Belgium (Demanet, 1943), Germany (Schmidt, 1925; Patteisky, 1965), Algeria (Termier and Termier, 1952), and possibly the Soviet Union (Librovitch, 1946).
g) *Gastrioceras macrocephalum* (Frech) 1902; from Westphalian strata in Germany (*see* also Schmidt, 1925).
h) *Gastrioceras normale* Chalmers, 1936; from the *G. listeri* horizon (Westphalian-A) in England.
i) *Gastrioceras retorsum* Chalmers, 1936; from the *G. listeri* horizon (Westphalian-A) in England.
j) *Gastrioceras stenolobum* Delépine, 1941; from Westphalian strata in Morocco.
k) *Gastrioceras weristerense* Demanet, 1943; from Westphalian strata in Belgium and Germany.

Gastrioceras melvillensis Nassichuk, n. sp.

Plate 13, figures 5, 8, 10, 12; Textfigure 47B

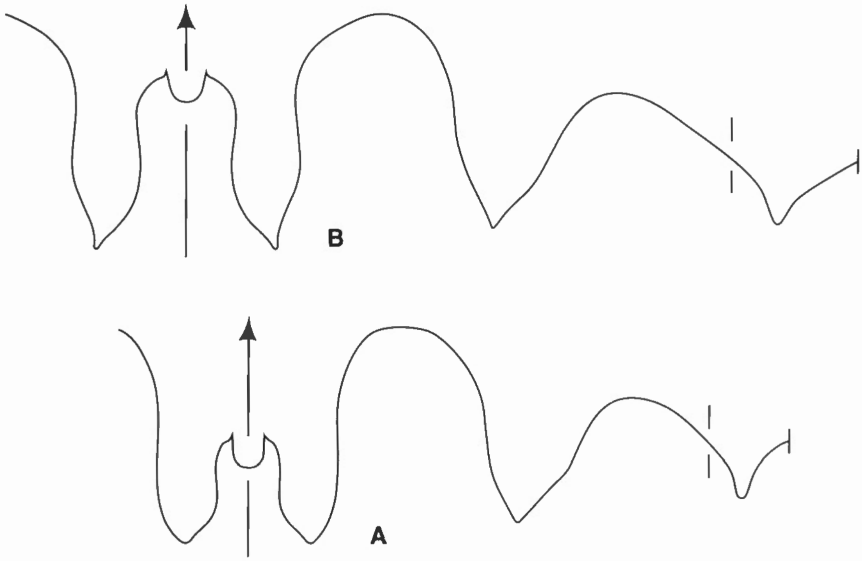
Description. Ten specimens of *Gastrioceras melvillensis* were found at a single locality within Barrow Dome, on Melville Island. Eight of the specimens are crushed fragments of individual whorls. Two specimens, one of which is the holotype, are preserved as complete whorls and retain shell ornament.

The conch of *Gastrioceras melvillensis* is extremely evolute; on the holotype, at a diameter of 27 mm, the umbilicus approximates 45 per cent of the conch diameter. The width of the conch is slightly more than 50 per cent of the diameter. By reconstruction, the largest specimen available has a diameter of about 38 mm and, at that size, the whorl width is 22 mm and whorl height 10.5 mm.

Shell ornament includes delicate growth lines that form a moderately deep ventral sinus and a correspondingly high ventrolateral salient. Longitudinal lirae occur on the venter and flanks where they produce a reticulate pattern; lirae also occur between rib-like nodes on the umbilical shoulder and wall but are absent from the surface of nodes. Longitudinal lirae are conspicuous during early stages of growth but become increasingly faint during ontogeny. They are barely discernible on the holotype at full size (27.5 mm), and are absent from a large paratype at a size of 38 mm. Faint constrictions extend from between nodes on the umbilical shoulder and extend across the venter giving the shell surface a ridged appearance. Nodes are laterally elongate and narrow and are sharply defined; nodes extend from the midpoint of the umbilical wall onto the flanks to about the position of the first lateral lobe.

The external suture includes narrow, attenuate ventral prongs and a broadly rounded first lateral saddle. The first lateral lobe is attenuate and moderately inflated medianly and is considerably narrower than the first lateral saddle. The internal suture is not preserved on any specimens.

Comparisons. Conch proportions and umbilicus of *G. melvillensis* are closely comparable with those of the type species, *G. listeri*, but the two species are readily distinguished from one another by characteristics of shell ornament. On *G. listeri*, shell ornament consists of prominent transverse strigae across the venter and flanks with minor longitudinal lirae confined to the umbilical region. On *G. melvillensis*, lateral growth lines are relatively subdued and longitudinal lirae persist across the venter. The reticulate shell ornament of *G. melvillensis* resembles that of a number of species of *Gastrioceras* referred to '*Cancelloceras*' by



TEXTFIGURE 47. Diagrammatic representation of external sutures of *Gastrioceras* sp. and *Gastrioceras melvillensis* n. sp. both from the Otto Fiord Formation on Melville Island (GSC loc. C16903). A, *Gastrioceras* sp. based on hypotype GSC 33786 at a conch diameter of 13 mm; B, *Gastrioceras melvillensis* n. sp. based on paratype GSC 33787 at a conch diameter of 28 mm.

Ruzhencev and Bogoslovskaya (1971b). *Gastrioceras melvillensis* differs from the '*Cancelloceras*' group, however, by possessing a wider umbilicus and more conspicuous umbilical nodes.

Occurrence. The type locality of *Gastrioceras melvillensis* is GSC locality C16903 at Barrow Dome on Melville Island (Textfig. 4). The locality is on the northern edge of the dome, 2 miles due north of the midpoint of the dome (76°39'15"N, 109°03'W). A single poorly preserved specimen of *Gastrioceras* that is tentatively referred to *G. melvillensis* is associated with *Branneroceras branneri* in the type section of the Otto Fiord Formation near van Hauen Pass on northern Ellesmere Island (Textfig. 10); GSC locality C10690 is 1,163 feet above the base of the formation (81°03'30"N, 85°31'W).

Age. Bloydian (Westphalian-A = Kayalian).

Gastrioceras liratum Nassichuk, n. sp.

Plate 13, figures 7, 11; Textfigure 48A

Description. Four specimens of *Gastrioceras liratum* are known from Melville Island. The largest of these has a diameter of 18.7 mm and is selected to serve as holotype. The conch is broad and moderately evolute; at maturity W/D approximates 70 per cent and U/D 48 per cent. Prominent umbilical nodes extend from the umbilical wall onto the lateral flanks to about the position of the first lateral lobe; 18 nodes occur in the ultimate whorl of the holotype. A faint, barely perceptible depression or constriction forms a shallow ventral sinus and a low ventrolateral salient.

Prominent longitudinal lirae extend across the venter and flanks but are not preserved in the umbilical regions; 20 lirae occur between the umbilical shoulders of the holotype at full size.

Prongs of the ventral lobe are narrow, pointed, and slightly inflated medianly; prongs are about one-quarter the width of the first lateral saddle and one-half the width of the more or less V-shaped first lateral lobe.

TABLE 23. Dimensions (in mm) and proportions of *Gastrioceras liratum* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33788	18.7	5.4	13.0	9.0	28.9	70.0	48.1

Comparisons. The conch and suture of *Gastrioceras liratum* are normal for the genus but the species is distinguished from the type species and most other representatives of the genus by the prominent longitudinal lirae across the venter and flanks. Slightly less conspicuous lirae are preserved on undescribed specimens of *Gastrioceras* from the Atokan Buckhorn Asphalt in Oklahoma which are in the University of Iowa collections.

Occurrence. Gastrioceras liratum was recovered from a single locality near the north side of Barrow Dome, on northern Sabine Peninsula, Melville Island (Textfig. 4). It was found at GSC locality C16903, which is 2 miles due north of the midpoint of Barrow Dome (76°39′15″N, 109°03′W).

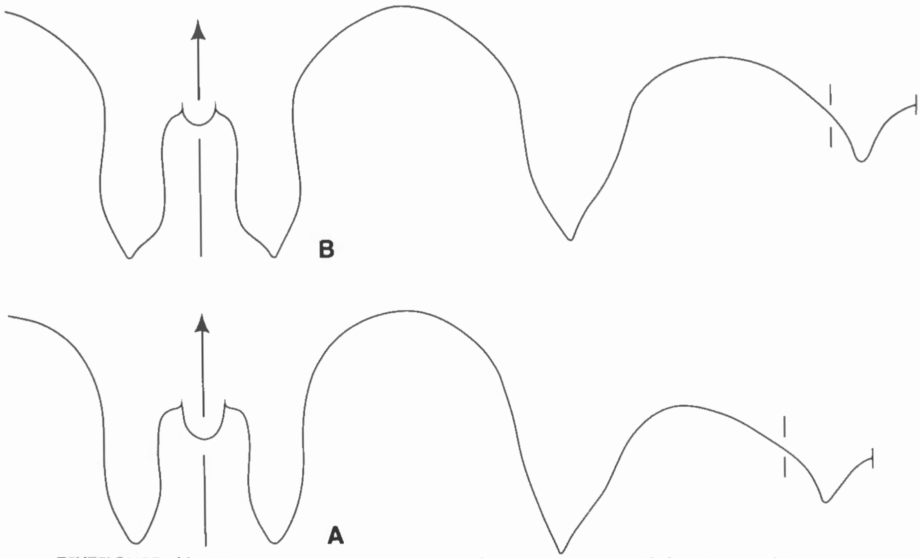
Age. Bloydian (Westphalian-A = Kayalian).

Gastrioceras sp.

Plate 14, figures 2, 5; Textfigure 47A

Description. Ten small and poorly preserved specimens of *G.* sp., all with a diameter of less than 20 mm, were found on Melville Island. They were associated with a variety of species which show considerable variation in conch form; *Branneroceras branneri*, *Branneroceras hillsi*, *Gastrioceras liratum*, and *Gastrioceras melvillensis*. The conch of *G.* sp. is moderately broad and evolute; W/D approximates 54 per cent and U/D 46 per cent. Umbilical shoulders are narrowly rounded and the umbilical walls are steep and flat. Rib-like nodes extend from the umbilical shoulders onto the lateral flanks. All specimens lack shell ornament and the venters are smooth except for shallow constrictions which form a shallow sinus across the venter. Two or three such constrictions occur in each volution.

Comparisons. Gastrioceras sp. is narrower than typical representatives of the subgenus *G.* (*Lissogastrioceras*) *fittsi* Miller and Owen, 1944. Whereas the umbilical nodes of *G.* (*L.*) *fittsi* are more or less circular in plan, those of the Arctic species are laterally elongate. The conch of *G.* sp. resembles that of *G. araium* McCaleb from Morrowan (Bloydian) strata in Arkansas and Oklahoma but the species can be distinguished readily from each other on the basis of the external suture. In particular, the ventral prongs and first lateral saddle of *G. araium* are proportionately broader than those of *G.* sp.



TEXTFIGURE 48. Diagrammatic representation of external sutures of *Gastrioceras liratum* n. sp. and *Gastrioceras glenisteri* n. sp. A, *Gastrioceras liratum* n. sp. from the Otto Fiord Formation on Melville Island (GSC loc. C16903); based on the holotype GSC 33788 at a conch diameter of 17 mm. B, *Gastrioceras glenisteri* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); based on paratype GSC 33791 at a conch diameter of 19 mm.

Occurrence. Gastrioceras sp. occurs at GSC locality C16903 within Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). This locality is near the northern edge of Barrow Dome, 2 miles due north of the midpoint of the dome (76°39′15″N, 109°03′W).

Age. Bloydian (Westphalian-A = Kayalian).

Gastrioceras glenisteri Nassichuk, n. sp.

Plate 14, figures 1, 4, 10, 11; Textfigure 48B

Description. Six specimens of *G. glenisteri* are available from the "Tellevak Limestone" on Ellesmere Island. Five specimens from the type locality (GSC loc. C4085) have a diameter less than 35 mm but one specimen from another locality in the same area has a reconstructed diameter of at least 85 mm. The conch of *G. glenisteri* is subglobose with a moderately wide umbilicus; conch dimensions and proportions of the holotype are provided in Table 24. The venter and flanks of the conch are smooth except for constrictions, which form a broad and extremely shallow ventral sinus; seven constrictions occur on the ultimate volution of the holotype. Prominent rounded nodes persist on the umbilical shoulder during all stages of growth; 18 nodes occur on the ultimate volution of the holotype. On the surface of two or three nodes on the holotype, a delicate reticulate shell ornament is preserved but this feature is not apparent on inter-node depressions or on the umbilical wall.

Prongs of the ventral lobe are slightly inflated medianly and are one-third the width of the first lateral saddle. The dorsal lobe and the internal lateral lobe are both narrow with comparable widths and both are markedly attenuate.

TABLE 24. Dimensions (in mm) and proportions of *Gastrioceras glenisteri* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33790	27.2	9.0	24.0	10.0	33.1	88.2	36.8

Comparisons. The conch of *Gastrioceras glenisteri* bears a resemblance to *G. fittsi* Miller and Owen from the Morrowan Brentwood and Union Valley Formations in Arkansas and Oklahoma but the two species have different umbilical diameters; U/D on *G. fittsi* approximates 50 per cent and on *G. glenisteri* less than 40 per cent. Similarly, conch proportions of *G. attenuatum* McCaleb from the Morrowan Bloyd Formation in Arkansas and the Gene Autry Shale in Oklahoma resemble those of *G. glenisteri* but *G. attenuatum* has a relatively deeper and narrower first lateral lobe.

Gastrioceras glenisteri is proportionately broader than *G. formosum* McCaleb from the Atokan Winslow Formation in Arkansas and has a slightly broader umbilicus at full size, but these species can be distinguished also on the basis of sutural differences. The ventral prongs of *G. glenisteri* are considerably narrower than on *G. formosum* and the first lateral lobes of these species have completely different shapes; that of *G. formosum* is narrow and asymmetric whereas that of *G. glenisteri* is relatively broad and V-shaped. The sutures of *G. formosum* resemble those of an undescribed species from the Buckhorn Asphalt and the Boggy Formation in Oklahoma that are in the University of Iowa collections but the two have different umbilical diameters; U/D approximates 30 per cent on *G. formosum* and 50 per cent on the latter undescribed species.

Occurrence. Gastrioceras glenisteri is known from two localities in the upper part of the "Tellevak Limestone" on northern Ellesmere Island (Text-fig. 10). It occurs at GSC locality C4085 (Atokan) in the Blue Mountains and at GSC locality C21750 (Desmoinesian) in the Krieger Mountains.

Age. Atokan and Desmoinesian (Moscovian).

Superfamily SCHISTOCERATACEAE Schmidt, 1939

Family MELVILLOCERATIDAE n. fam.

The Melvilloceratidae is proposed to accommodate subdiscoidal to discoidal, moderately involute ammonoids with reticulate shell ornament, umbilical ribs during early ontogeny and sharply attenuate ventral prongs that are separated by a high median saddle. Included in the family are *Melvilloceras* n. gen. and *Trettinoceras* n. gen. from upper Namurian and Moscovian strata, respectively, in Arctic Canada. Both genera possess certain morphologic features which individually are characteristic of other established families but which collectively are unique. The most primative melvilloceratid, *Melvilloceras*, has shell ornament and a conch form that resemble its probable progenitor, *Reticuloceras* Bisat, which characterizes the Reticuloceratidae. Representatives of both families are moderately involute and possess umbilical ribs during early growth stages. According to Patteisky (1965), *Agastrioceras* Schmidt, which resembles *Melvilloceras* in a general way, is assigned to the Reticuloceratidae. Unfortunately, details of the suture of *Agastrioceras* remain obscure, thus relationships must remain uncertain. Further comments on *Agastrioceras* are provided under the heading '*Gastrioceras*' in this report.

The suture of *Melvilloceras* and *Trettinoceras*, however, is considerably more developed than that of even advanced reticuloceratids such as *Pygmaeoceras*. Ventral prongs of the former are elongate, inflated and sharply attenuate whereas those of reticuloceratids are generally relatively short, straight sided and bluntly pointed. The external suture of the melvilloceratids is similar to that of a primitive schistoceratid *Branneroceras*. *Branneroceras*, however, is relatively more evolute than both *Melvilloceras* and *Trettinoceras* and retains umbilical nodes or riblets to full maturity; on both of the last genera umbilical nodes are absent beyond early maturity.

One feature which has been used to lend credence to the assignment of *Branneroceras* to the Schistoceratidae is the presence of triangularity in the early whorls of some specimens. Comparable triangularity is evident in the early whorls of some representatives of *Trettinoceras*. Whereas *Branneroceras* appears to have given rise to *Diaboloceras*, the immediate successor to *Trettinoceras*, if any exists, remains unknown.

Genus *Melvilloceras* Nassichuk, n. gen.

Type species. *Melvilloceras sabinensis* n. sp.; from Morrowan (Bloydian) strata (Otto Fiord Formation) within Barrow Dome, Melville Island, Arctic Canada.

Diagnosis. The conch of *Melvilloceras* is subdiscoidal and moderately involute; W/D is less than 45 per cent and U/D is less than 25 per cent. The venter is narrowly rounded and flanks are broadly rounded or flattened. Umbilical nodes are prominent during early growth stages but are subdued or absent beyond early maturity, Shell ornament is delicately reticulate; growth lines are relatively more conspicuous than longitudinal lirae and form a moderately deep ventral sinus, a moderately high ventrolateral salient and a shallow, broad ventrolateral sinus. Four to six constrictions are parallel with growth lines to maturity. The external suture is characterized by ventral prongs that are attenuate and are separated from one another by a secondary ventral saddle that is greater than half the height of the broadly rounded first lateral saddle. The first lateral lobe is broad and pointed with straight or slightly curved sides.

Discussion. The conch of *Melvilloceras* bears a marked resemblance to that of typical representatives of the Namurian *Reticuloceras* Bisat but the two are distinguished readily on the basis of the external suture. Whereas the ventral prongs of *Reticuloceras* are narrow, bluntly pointed and are separated from one another by a ventral saddle that is less than half the height of the first lateral saddle, the ventral prongs of *Melvilloceras* are proportionately broad and attenuate and are separated by a ventral saddle that is greater than half the height of the first lateral saddle.

The suture of *Melvilloceras* is reminiscent of that of *Branneroceras* but these genera have different conch forms; the latter is considerably more evolute than *Melvilloceras*. Moreover, the whorl height of *Branneroceras* is close to the whorl width but, in *Melvilloceras*, height exceeds width. Furthermore, *Branneroceras* has distinctive umbilical riblets to full maturity whereas on *Melvilloceras* riblets or nodes either are absent or are only faintly expressed at maturity. *Melvilloceras* is associated directly with abundant *Branneroceras* at a single location on Melville Island; the latter genus displays considerable variation in conch form and ranges from being highly evolute (*B. branneri*) to moderately involute (*B.* sp.).

Melvilloceras probably derived from a *Reticuloceras* stock and is most likely the progenitor of *Trettinoceras* n. gen.; both are moderately involute and both show a reduction in prominence of umbilical nodes or riblets during ontogeny. The conch of *Trettinoceras* is considerably broader than *Melvilloceras* and the two genera are distinguishable from one another on the basis of differences in the external suture. The conch and reticulate shell ornament of *Melvilloceras* is reminiscent of the advanced reticuloceratid *Pygmaeoceras* Gordon, 1960. The latter, however, has a relatively simpler suture, particularly shorter and less attenuate ventral prongs.

Species composition and distribution.

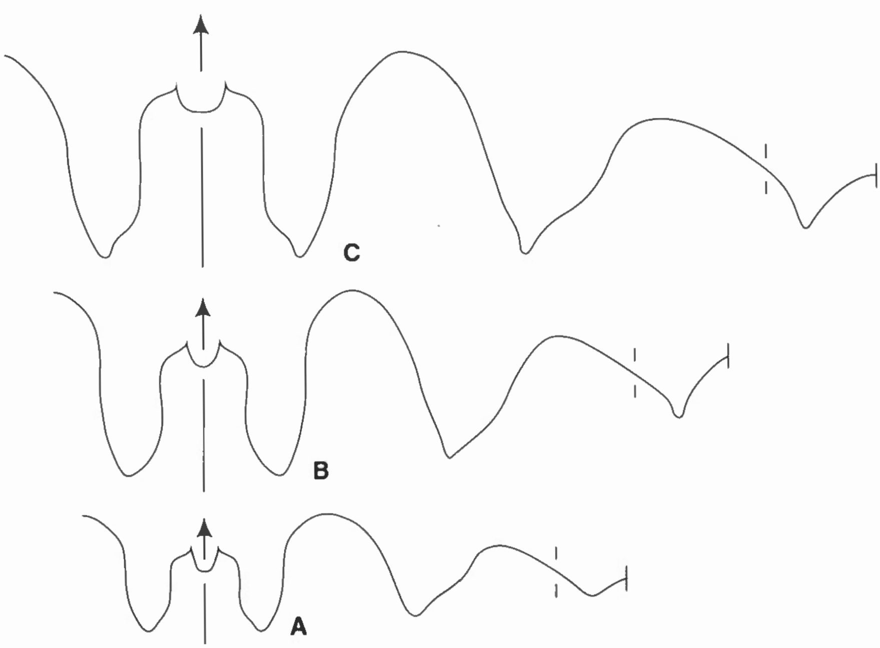
Melvilloceras sabinensis n. sp.; from Morrowan (Bloydian) strata on Melville Island, Arctic Canada.

Melvilloceras sabinensis Nassichuk, n. sp.

Plate 14, figures 3, 6, 7, 8, 9; Textfigure 49

Description. About 40 specimens of *M. sabinensis* were recovered from the type locality on Melville Island. The largest specimen, the holotype, has a diameter of 23 mm and most other specimens range in size from about 15 to 20 mm. All specimens are well preserved, and on many of them the shell surface is distinctly ornamented. The conch of *M. sabinensis* is subdiscoidal, moderately involute; proportions are presented in Table 25. Whorls are circular through all stages of growth. During early ontogeny, the ratio between shell width and height approximates unity but, from a size of about 12 mm to full maturity, height is proportionately greater than width.

During early ontogeny laterally elongate riblets or nodes extend across the umbilical shoulders but at a size of 20 mm the umbilical shoulders are smooth. Five or six lateral



TEXTFIGURE 49. Diagrammatic representation of the sutural ontogeny of *Melvilloceras sabinensis* n. gen., n. sp. from the Otto Fiord Formation on Melville Island (GSC loc. C16905). A is based on paratype GSC 33809 at a conch diameter of 13 mm, B is based on paratype GSC 33808 at a conch diameter of 19 mm, C is based on paratype GSC 33807 at a conch diameter of 22 mm.

constrictions are prominent on each volution to a size of 15 mm; constrictions are barely discernible beyond that size. Shell ornament consists of delicate growth lamellae that form a moderately deep ventral sinus as well as a shallow lateral sinus and a corresponding moderately high ventrolateral salient. Fine longitudinal lirae occur on the venter and ventrolateral flanks where a delicate reticulate network is defined, but longitudinal lirae are absent from the external ventrolateral flanks and the umbilical regions.

Prongs of the ventral lobe are narrow and attenuate, and from early ontogeny (D = 8 mm) are separated from one another by a ventral saddle that is about two-thirds the height of the broadly rounded first lateral saddle. The first lateral lobe is narrow and attenuate and the umbilical lobe is situated on the umbilical shoulder.

TABLE 25. Dimensions (in mm) and proportions of *Melvilloceras sabinensis* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33804	23.3	10.6	10.2	4.5	45.5	43.8	19.3
Paratype GSC 33805	19.5	9.0	9.1	4.0	46.2	46.7	20.5
Paratype GSC 33805	18.0	8.4	9.0	3.2	46.7	50.0	17.8

Occurrence. Melvilloceras sabinensis occurs at GSC locality C16905 within Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). The locality is 1.3 miles northeast (brg. 71°) of the centre of Barrow Dome (76°38′N, 108°58′30″W).

Age. Bloydian (Westphalian-A = Kayalian).

Genus *Trettinoceras* Nassichuk, n. gen.

Type species. *Trettinoceras ellesmerensis* Nassichuk, n. sp.; from Atokan strata near the base of the Hare Fiord Formation, Ellesmere Island.

Diagnosis. The conch of *Trettinoceras* is subdiscoidal and moderately evolute; typically the umbilicus is slightly less than 30 per cent of the conch diameter at maturity. Early whorls are variously circular or triangular.

Shell ornament is reticulate and sinuous growth lamellae are relatively more pronounced than longitudinal lirae. Umbilical nodes are prominent during early growth stages but are absent at full maturity.

The external suture is characterized by broad prongs of the ventral lobe and a relatively narrow, elongate first lateral lobe. The umbilical lobe is positioned near the umbilical shoulders. A slight flexure occurs on the external flank of the umbilical wall but there is no indication of an incipient lobe on the umbilical wall.

Discussion. Trettinoceras is distinguished from its probable progenitor *Melvilloceras* in that the former has a proportionately broader conch and wider ventral prongs than the latter. Also, the umbilical lobe of *Trettinoceras* is situated near the axis of the umbilical shoulder but on *Melvilloceras* it is near the middle of the umbilical wall. A comparable outward migration of umbilical element 'U' during phylogenesis is apparent between *Brannerocera*s and *Diaboloceras* in the closely related Schistoceratidae. McCaleb (1968) demonstrated that, during ontogeny of the type species *B. branneri*, the umbilical lobe migrated from a central position on the umbilical wall to an ultimate position on the umbilical shoulder. In the younger *Diaboloceras*, the umbilical lobe is invariably outside of the umbilicus.

Species composition and distribution.

Trettinoceras ellesmerensis n. sp.; from Atokan strata in the Hare Fiord Formation, Ellesmere Island, Arctic Canada.

Trettinoceras ellesmerensis Nassichuk, n. sp.

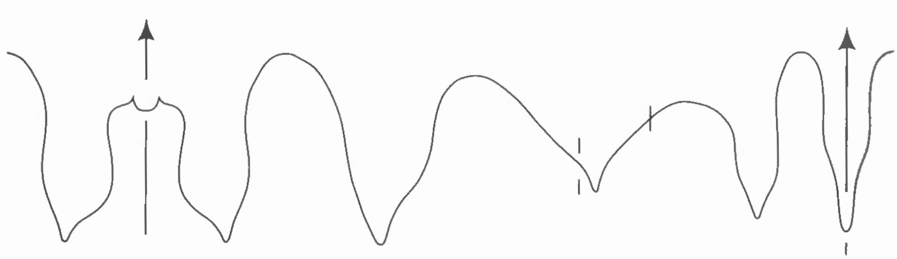
Plate 15, figures 1, 2, 8, 10, 11, 12; Plate 16, figures 8, 17; Textfigures 50, 51

Description. Twenty-five specimens of *Trettinoceras ellesmerensis* are available from a single locality on Ellesmere Island. Most specimens are immature, less than 20 mm in diameter, but 2 phragmocones have diameters of about 45 mm. The conch is subdiscoidal and the umbilicus is less than 30 per cent of the shell diameter at maturity. At a diameter of 3 mm whorls have a triangular outline, but at a diameter of 12 mm the outline of whorls is circular.

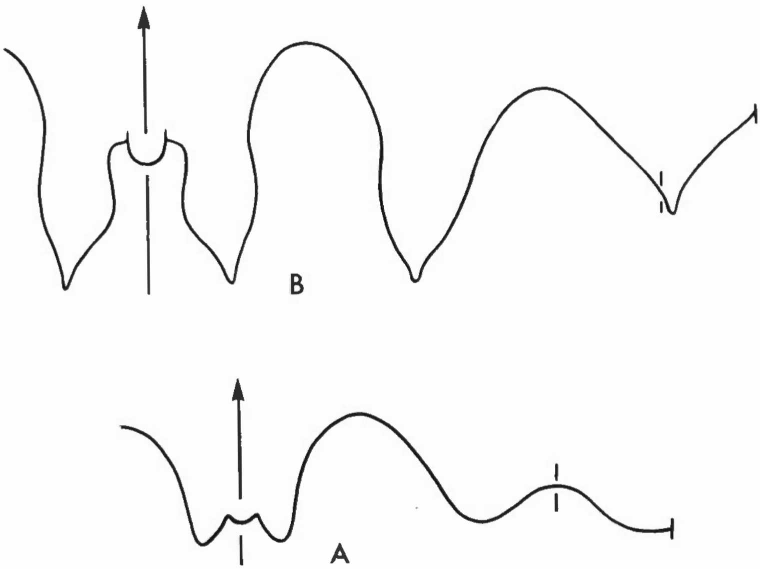
Delicate longitudinal lirae occur on the venter and flanks but are absent from the umbilical wall. Prominent transverse lamellae form shallow ventral and lateral sinuses. Umbilical nodes are prominent; these extend across the umbilical shoulders onto the lateral flanks during early growth stages but are absent beyond a diameter of 23 mm. Up to a size of 10 mm, 2 or 3 constrictions occur per volution; none occur beyond that size.

TABLE 26. Conch dimensions (in mm) and proportions of *Trettinoceras ellesmerensis* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33810	43.0	17.9	21.0	11.0	0.41	0.49	0.26
Paratype GSC 33811	31.1	12.4	18.0	10.0	.40	.58	.32
Paratype GSC 33812	27.4	11.1	15.5	6.7	.41	.56	.24
Paratype GSC 33813	14.6	5.8	10.0	4.7	.40	.69	.32



TEXTFIGURE 50. Diagrammatic representation of a mature suture of *Trettinoceras ellesmerensis* n. gen. n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); based on the holotype GSC 33810 at a conch diameter of 42 mm.



TEXTFIGURE 51. Diagrammatic representation of external sutures of *Trettinoceras ellesmerensis* n. gen., n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A is based on paratype GSC 33814 at a conch diameter of 2.5 mm, B is based on the holotype GSC 33810 at a conch diameter of 27 mm.

The suture has a full complement of 8 lobes even at a diameter of 2 mm. At that size, the ventral lobe is subdivided and the umbilical lobe is positioned just outside the seam. During ontogeny, lobes become progressively more attenuate and the umbilical lobe migrates to a position more or less coincident with the axis of the umbilical shoulder. At maturity, prongs of the ventral lobe are relatively short and about the same width as the secondary ventral saddle. The first lateral lobe is inflated on the dorsal side and the apex of this lobe is directed slightly dorsad.

Occurrence. Trettinoceras ellesmerensis is known from GSC locality 56430, near the base of the Hare Fiord Formation on the north side of Hare Fiord, northern Ellesmere Island (Textfig. 10).

Age. Atokan (Moscovian).

Family SCHISTOCERATIDAE Schmidt, 1929

Characteristic features of the exclusively Pennsylvanian Schistoceratidae include discoidal evolute conchs with reticulate shell ornament; growth lines are biconvex. All genera possess umbilical nodes during all stages of development. During evolution of the group, umbilical elements were added to a basic gastrioceran suture by subdivision in the umbilical region.

Composition of the Schistoceratidae cannot be assessed fully until better information is available on numerous evolute species with reticulate shell ornament that have been referred in the literature to *Gastrioceras* Hyatt or *Cancelloceras* Ruzhencev and Bogoslovskaya, 1969b but which may be, in fact, referable to either *Branneroceras* Plummer and Scott or *Retites* McCaleb. This question is discussed further under the headings '*Gastrioceras*' and '*Brannero-*

ceras.' For the present, the earliest representative of the family is considered to be *Retites* McCaleb which originated during Namurian (R_1) time from a lineage within the Gastrioceratidae. *Retites* is the probable progenitor of *Branneroceras* which, in North America, first appeared during early Morrowan, Bloydian time. *Branneroceras* gave rise to *Diaboloceras* which occurs in Morrowan, Atokan, and lower Desmoinesian strata.

Diaboloceras is the first of the schistoceratids in which subdivision of the umbilical lobe is apparent; an incipient lobe occurs on the umbilical wall of advanced species. In *Paralegoceras* Hyatt, which occurs in Atokan strata, the incipient umbilical lobe completed migration to an internal position. Similarly, even younger schistoceratids, *Eoschistoceras* Ruzhencev and *Schistoceras* Hyatt (= *Paraschistoceras* Plummer and Scott and *Metaschistoceras* Plummer and Scott), experienced successively more complex sutural subdivision in the umbilical area.

Gordon (1969) described *Diaboloceras peroccidens* from probable Morrowan strata in Nevada and Ruzhencev and Ganelin (1971) designated it as the type species for *Paraphaneroceras* which the Soviet authors included in the Pseudoparalegoceratidae because of its proportionately broad ventral prongs. The mature conch and shell ornament of *Paraphaneroceras* are indistinguishable from *Diaboloceras*; however, the two genera can be separated from one another on the basis of sutural proportions. In particular, the ventral prongs of *Paraphaneroceras* are considerably broader than those of *Diaboloceras*. This difference is not sufficient to warrant separation at the familial level and *Paraphaneroceras* is included in the Schistoceratidae.

Genus ***Branneroceras*** Plummer and Scott, 1937

Type species. *Gastrioceras branneri* Smith, 1896; from Morrowan rocks in the Bloyd Formation on Pilot Mountain, Boone County, Arkansas.

Diagnosis. *Branneroceras* is typically narrow and evolute. At a diameter of 38 mm the holotype of the type species (USNM 26439) has a conch width of 14.5 mm (W/D 38 per cent) and an umbilical diameter of 21.5 mm (U/D 57 per cent). In some species, W/D approximates 50 per cent and U/D 30 per cent. Inner whorls are generally circular but may be triangular or even quadrangular. Laterally elongate ribs extend from the umbilical shoulder onto the lateral flanks and persist to full maturity. Shell ornament is reticulate and growth lines form a ventral sinus and a ventrolateral salient. The external suture is distinctly gastrioceran and is characterized by narrow, inflated and attenuate ventral prongs that are separated from one another by a relatively broad secondary ventral saddle; the ventral saddle is more than half the height of the first lateral saddle. The first lateral saddle is broad and evenly rounded and the first lateral lobe is comparatively narrow, asymmetric and attenuate.

Discussion. *Branneroceras* bears a marked resemblance to a number of species that have been referred to '*Gastrioceras*' in the literature, and it is considered briefly under the heading of the latter genus in this report. *Branneroceras* has been assigned to *Gastrioceras* by a number of authors, but the two genera can be distinguished from each other clearly by differences in conch form and shell ornament, and to a lesser degree by the external suture. They are considered to be distinct even at the familial level. *Gastrioceras* sensu stricto has a relatively broad conch and the shell lacks reticulate ornament across the venter and flanks, whereas *Branneroceras* is narrow and the shell has a prominent reticulate ornament on venter and flanks. The sutures of *Branneroceras* and *Gastrioceras* are similar but the first lateral saddle of typical *Gastrioceras* is considerably broader than that of *Branneroceras*.

Yin (1935) described *Gastrioceras perornatum*, *Gastrioceras reticulatum*, and *Gastrioceras yohi* from southern China. All clearly belong in *Branneroceras* and closely resemble the type species *B. branneri.* Gerth (1950), however, selected Yin's *G. perornatum* to serve as the type species for his genus *Tshunkuoceras.* Gerth's genus is a junior synonym of *Branneroceras.*

Ruzhencev (1962) proposed that *Branneroceras* be divided into two subgenera, *Branneroceras* Plummer and Scott, and *Marianoceras* Librovitch (type, *Goniatites marianus* Verneuil, 1845). The latter, which occurs in upper Namurian strata in the Urals (Librovitch, 1946), is slightly broader than typical *Branneroceras* and, according to illustrations by Verneuil (1945), has relatively broader prongs of the ventral lobe.

Branneroceras is distinguished from its probable progenitor *Retites* McCaleb (1964) principally by differences in the suture line. The ventral prongs of *Branneroceras* are long and narrow (longer than half the height of the first lateral saddle) whereas those of *Retites* are proportionately shorter (less than half the height of the first lateral saddle). In North America, *Retites* is confined to Morrowan strata and occurs only in the Hale Formation (Halian) in Arkansas but *Branneroceras* first occurs in the overlying Bloyd Formation (Bloydian). *Retites* was unknown outside the United States until it was reported from Spain by Wagner-Gentis (*in* Moore, Neves, Wagner, and Wagner-Gentis, 1971). Wagner-Gentis reported *Retites semiretia* and *Retites merensis* Wagner-Gentis from strata dated by spore identification as late Namurian-B (R_2). Although Wagner-Gentis (ibid.) differentiated the Spanish *Retites* from *Branneroceras* on the basis of shell ornament, she quite properly suggested that the suture should be seen before additional relationships are assessed. *Branneroceras* is considerably more widespread than *Retites* and has been reported from China, Morocco, the Soviet Union (Donetz Basin), Central Asia (Tien Shan), and possibly Japan and Yugoslavia as well as Arctic Canada. Gordon (1965, 1969) indicated that *B. branneri* also occurred in the Prairie Grove Member of the Hale Formation in Arkansas but this is because Gordon (ibid.) considered *Retites* to be a synonym of *Branneroceras.*

Gordon (1965) erected '*Branneroceras*' *textum* and '*Branneroceras*' *henbesti* from the Prairie Grove Member of the Hale Formation in Arkansas. The sutural proportions of Gordon's species suggest that they are intermediate between *Retites* and *Branneroceras;* Ruzhencev and Bogoslovskaya (1971b) placed both species in *Retites.* In a published abstract, Manger (1971) assigned '*B.*' *textum* Gordon and '*B.*' *henbesti* Gordon to "New Genus A." The present writer retains Gordon's species in '*Gastrioceras*' since sutures are comparable and shell ornament appears to be non-reticulate. It appears necessary to limit taxa until the vaguely known European *Cancelloceras* is better known. Gordon (1965) indicated that on a species that he described as *Gastrioceras* (*Branneroceras*) aff. *G. branneri* from the Johns Valley shale in Arkansas, the umbilical lobe is outside of the umbilicus at maturity. Gordon (ibid., p. 255) described the latter species but failed to figure it; he suggested that sutural characteristics probably warranted separation from *Branneroceras branneri.* It appears that Gordon's species might better be assigned to *Diaboloceras* or *Trettinoceras* but ultimate taxonomic assignment depends on additional sutural information. Ruzhencev and Bogoslovskaya (1969b) erected *Cancelloceras* (type, *Gastrioceras cancellatum* Bisat, 1923) for *Gastrioceras*-like forms with reticulate shell ornament. According to those authors, the genus is confined to the G_1 Zone in Great Britain and either R_2 or G_1 strata in Germany, Poland, Morocco, and Algeria. Some evidence suggests that the genus also may occur in younger (G_2) strata.

Librovitch (1946) indicated that *Branneroceras* occurred in association with *Bilinguites* and *Reticuloceras* in upper Namurian (F) strata in the Donetz Basin; that is, in the *Bilinguites–Cancelloceras* genozone of Ruzhencev and Bogoslovskaya (1971b). The latter authors (1971b) questioned Librovitch's identification of *Branneroceras* and suggested that it was based on either an incorrect identification or an incorrect understanding of phylogenetic relationships. The present writer is impressed generally by Librovitch's astute observations in ammonoid taxonomy, but it is clear that the Donetz Basin faunas require additional study. The sutures of *Branneroceras* and *Retites* have been well illustrated in the literature but, unfortunately, the same is not true of '*Cancelloceras*.' Librovitch (1957) placed the type species of *Cancelloceras* in synonymy with *Branneroceras* but Ruzhencev and Bogoslovskaya (1969b, 1971b) suggested that the two genera can be distinguished since *Cancelloceras* has a "wider shell, more involute whorls and a less dissected ventral lobe." It must be pointed out that, in the original description of '*G.*' *cancellatum* (Bisat, 1924), a suture drawing was not illustrated but Bisat (ibid.) stated that the suture has a wide ventral lobe and a high median saddle. At a diameter of 13 mm the median saddle was about half the height of the ventral lobe. At a comparable diameter, the median saddle of typical *Branneroceras* is of a similar height. Bisat (ibid.) indicated that, on a typical representative of '*G.*' *cancellatum* from Ring Road Leeds (lectotype designated by Ramsbottom and Calver, 1960), at a diameter of 13.5 mm the umbilicus has a diameter of 4½ mm (U/D 33 per cent) and the shell has a width of 8¾ mm (W/D 65 per cent). McCaleb (1968) showed that at a comparable diameter (14 mm) a narrowly umbilicate form of *Branneroceras*, that is *Branneroceras branneri* var. *halense*, has the following ratios: U/D 43 per cent and W/D 50 per cent. The present writer has described an involute *Branneroceras* from Melville Island, *B. nicholasi*, with an umbilicus even narrower than *B. branneri* var. *halense*; U/D 35 per cent, W/D 40 per cent. Thus, one readily apparent distinction between *Cancelloceras* and *Branneroceras* is differences in the width of respective shells, but an additional feature should be stressed. Bisat (1924) indicated that, on '*G.*' *cancellatum*, umbilical tubercles "die out between 30 and 40 mm diam. of conch." A comparable disappearance of tubercles at maturity does not occur on typical *Branneroceras* but does occur on the reticulate *Reticuloceras* Bisat, *Melvilloceras* n. gen., and *Trettinoceras* n. gen., as well as on *Agastrioceras* sensu Patteisky (1965). *Reticuloceras* has a narrower conch and umbilicus than '*G.*' *cancellatum* and *Trettinoceras* has broader ventral prongs. Some specimens of the latter genus show triangular coiling of inner whorls.

To emphasize the apparent arbitrary nature of taxa within the *Branneroceras*–*Cancelloceras* 'group,' an example can be drawn from a species from Wales originally designated *Gastrioceras branneroides* by Bisat (1940). Bisat (ibid.) referred this species to *Gastrioceras* rather than to *Branneroceras* since the Welsh form is "more involute," has more prominent lateral striae and has relatively smoother umbilical plications. McCaleb (1968) extensively reviewed *Branneroceras* from Arkansas and suggested that the conch form and ornament of '*G.*' *branneroides* fell within the range of variation of typical *Branneroceras*. Ruzhencev and Bogoslovskaya (1971b) included '*G.*' *branneroides* in *Cancelloceras*. Thus, the Welsh species has been assigned to three genera by three different authors without any consideration given to details of the external suture.

Some difference of opinion exists in the literature concerning the generic assignment of "*Gastrioceras* (*Branneroceratoides*)" *tetragonum* Kullmann, 1962 and "*Gastrioceras* (*Branneroceratoides*)" *termierorum* Kullmann, 1962, both of which are based on small specimens from lower Namurian E_2 rocks in Yugoslavia (Serbia). McCaleb (1968) placed both of Kullmann's species in synonymy with *Branneroceras branneri*. In considering the opinion that *Branneroceras* derived from *Retites* (R_1 Zone), the presence of *Branneroceras* in considerably older E_2 strata is difficult to reconcile. Ruzhencev and Bogoslovskaya (1971b), apparently influenced by the designated age of parent strata, assigned both of Kullmann's species to *Entogonites tetragonus*. It should be pointed out that Kullmann's specimens are small and worn and require additional study but there is at least a superficial resemblance to *Branneroceras*. The early whorls of some of Kullmann's figured specimens have a tetragonal whorl outline. This feature is generally well developed in early whorls of *Tetragonites* but also occurs, perhaps less well developed, in *Branneroceras* (McCaleb, 1958).

It is recognized generally that a good deal of variation in umbilical diameter is exhibited by the type species *B. branneri* whereas the suture is comparatively stable. One variant, *B. branneri branneri* (Smith), is characterized by a wide umbilicus (U/D approximately 55 per cent) whereas another variant, *B. branneri halense* Miller and Moore, has a comparatively narrow umbilicus (U/D approximately 40 per cent). Since it has been demonstrated that both of these varieties occur together (Miller and Moore, 1938; Gordon, 1965; McCaleb, 1968), it is reasonable to assume that morphological differences between them may reflect sexual dimorphism (McCaleb, 1968).

Species composition and distribution.

Branneroceras branneri (Smith); from Morrowan (Bloydian) strata in Arkansas and Oklahoma (*see* various authors listed *in* Gordon, 1965 and McCaleb, 1968). *Branneroceras branneri* has been reported from C_2ba strata in the Donetz Basin in the Soviet Union (Aisenverg *et al.*, 1960), Bashkirian strata in Tien Shan in Central Asia (Sergougnkova, 1963) and in Namurian-C and basal Westphalian-A strata in Spain (Wagner-Gentis *in* Moore, Neves, Wagner, and Wagner-Gentis, 1971). The species also occurs in Arctic Canada (this paper) and possibly Yugoslavia (Kullmann *in* Stevanovic and Kullman, 1962), and Japan (Nishida, 1971).

B. costatum (Termier and Termier) [synonyms *Branneroceras* sp. Termier and Termier, 1952 and *Branneroceras termierorum* (Kullmann *in* Stevanovic and Kullmann, 1962)]; from Morrowan strata in Algeria (Termier and Termier, 1952).

B. hillsi n. sp.; from Morrowan (Bloydian) strata on Melville Island.

B. marianus (Verneuil, 1845); from upper Namurian strata in the Ural Mountains.

B. nicholasi n. sp.; from Morrowan strata in Arctic Canada.

B. perornatum (Yin) [synonyms *Branneroceras reticulatum* (Yin) and *Branneroceras yohi* (Yin)]; from Morrowan (Bloydian) strata in the Wangchiapa Limestone, China (Yin, 1935).

B. sp.; from Morrowan strata on Melville Island, Arctic Canada.

Branneroceras branneri (Smith)

Plate 16, figures 1, 3, 4, 7, 9, 10, 15, 16; Textfigure 52

Gastrioceras branneri SMITH, 1896, p. 257–258, Pl. 23, figs. 1–6; 1903, p. 83–84, Pl. 11, figs. 8–13; 1914, Pl. 1, figs. 12–14; MATHER, 1915, p. 242, Pl. 16, figs. 12, 12a; SCHINDEWOLF, 1923, Textfig. 12c; MILLER and FURNISH, 1940c, p. 530, Textfig. 3A; SHIMER and SHROCK, 1944, p. 573, Pl. 235, figs. 6–8; MILLER, FURNISH, and SCHINDEWOLF, 1957, p. L61, Textfig. 81c; UNKLESBAY, 1962, p. 72–74, Pl. 8, figs. 10, 11, Pl. 10, fig. 4, Textfig. 6c.

Goniatites branneri (Smith) WILLIAMS, 1900, p. 359.

Gastrioceras branneri branneri Smith MILLER and OWEN, 1944, p. 422–423, Pl. 63, figs. 1, 2, Pl. 65, figs. 1, 2, Textfig. 3c; MILLER and DOWNS, 1948, p. 680, Pl. 103, figs. 10, 11.

Gastrioceras (Branneroceras) branneri Smith GORDON, 1965, p. 253–255, Pl. 27, figs. 16–23, 27–30.

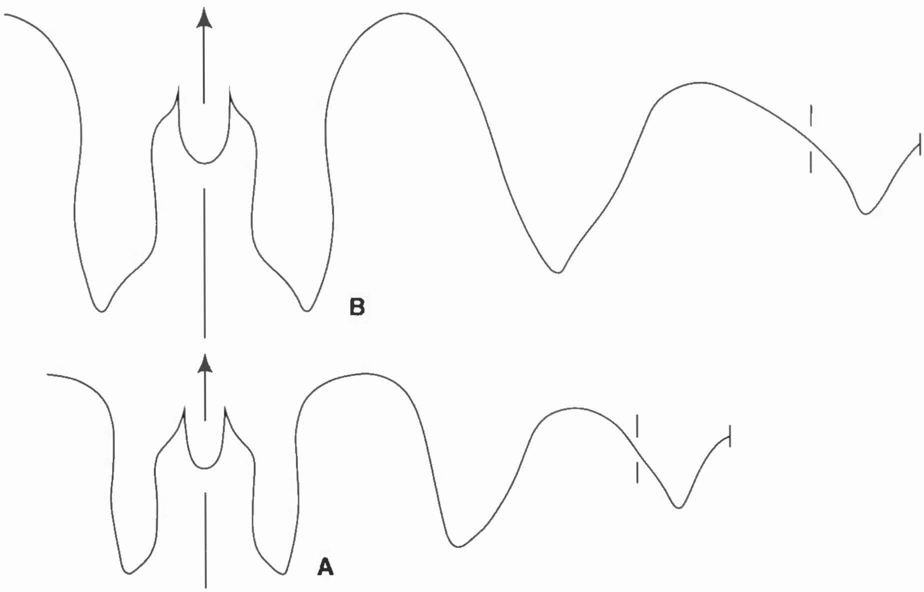
?Gastrioceras (Branneroceras) branneri branneri KULLMANN *in* STEVANOVIC and KULLMANN, 1962, p. 86–87, Pl. 2, fig. 1.

Gastrioceras sp. HARKER *in* NORRIS, 1963, p. 540.

Branneroceras branneri var. *branneri* (Smith) MILLER and MOORE, 1938, p. 348–350, Pl. 44, figs. 13, 14; BISAT, 1940, p. 332, figs. 3A, 3B.

Branneroceras branneri var. *halense* MILLER and MOORE, 1938, p. 350–351, Pl. 44, figs. 13, 14.

Branneroceras branneri (Smith) PLUMMER and SCOTT, 1937, p. 218–221, Pl. 11, figs. 1–7; MILLER and MOORE, 1938, p. 348–350, Pl. 44, figs. 5–12; RUZHENCEV, 1950, Textfig. 48d; 1962, p. 381, Pl. 23, figs. 7, 8; MILLER and FURNISH, 1958a, p. 262, Pl. 34, figs. 5, 6; Quinn, 1962b, Textfig. 1, 1972, p. 1381; McCALEB, 1968, p. 60–65, Pl. 8, figs. 1–16, Pl. 9, figs. 1–18, Pl. 12, fig. 4, Textfigs. 18, 19, 20B; GORDON, 1968, p. A17; 1969, p. C9; RUZHENCEV and BOGOSLOVSKAYA, 1969b, p. 1332, 1971b, p. 25.



TEXTFIGURE 52. Diagrammatic representation of external sutures of *Branneroceras branneri* (Smith) from the Otto Fiord Formation on Melville Island (GSC loc. C16903). A is based on hypotype GSC 33815 at a conch diameter of 24 mm, B is based on hypotype GSC 33826 at a conch diameter of 30 mm.

Description. Some 100 specimens of *Branneroceras branneri* are available from Melville and Ellesmere Islands. A few specimens have a diameter as great as 30 mm but most have a diameter of less than 15 mm. Conch diameters and proportions are extremely variable but generally range between those of *Branneroceras branneri* var. *branneri* (U/D greater than 50 per cent) and *Branneroceras branneri* var. *halense* (U/D approximately 40 per cent). Most specimens resemble the latter. On most specimens, early whorls are circular in outline but a few show inner whorls to be triangular.

TABLE 27. Dimensions (in mm) and proportions of *Branneroceras branneri* (Smith) from Melville Island

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33815	25.6	7.5	12.3	14.3	0.29	0.48	0.55
Hypotype GSC 33817	15.7	4.3	7.1	8.5	.27	.45	.54

Thin riblets extend from the umbilical shoulder onto the flanks to about the position of the first lateral lobe. At a diameter of 25 mm, 35 riblets occur in one volution. Shell ornament is reticulate, and lateral growth lamellae form a shallow ventral sinus and a low ventrolateral salient.

The external suture generally falls within the range of variation demonstrated in Arkansas specimens by McCaleb (1968). Prongs of the ventral lobe are elongate, narrow and attenuate and the first lateral lobe is rather symmetrical and slightly narrower than the broadly rounded first lateral saddle. The umbilical lobe is situated on or just inside the umbilical shoulder.

Comparisons. The conch of *Branneroceras branneri* is practically indistinguishable from *B. perornatum* (Yin) and *B. costatum* (Termier and Termier). McCaleb (1968) placed *B. perornatum* in synonymy with *B. branneri* but the present writer prefers to isolate *B. perornatum* and especially *B. costatum* from the type species until details of the suture line and of shell ornament of these two species are better known. Considering the range of variation demonstrated by the type species, it is conceivable that all these mentioned species ultimately may be placed in synonymy with *B. branneri.*

Branneroceras branneri is distinguished from *B. nicholasi* by having a considerably larger umbilicus; U/D on *B. branneri* approximates 50 per cent while U/D on *B. nicholasi* is closer to 35 per cent. *Branneroceras branneri halense* has an umbilicus comparable to that of *B. hillsi* but the latter has a proportionately broader first lateral saddle.

Occurrence. Branneroceras branneri is known from shale, calcareous mudstone and limestone "blocks" surrounded by contorted anhydrite at two localities within Barrow Dome, an evaporitic piercement structure on Melville Island (Textfig. 4). It occurs at GSC locality C16903, 2 miles due north of the centre of the dome (76°39′15″N, 109°03′W), and at GSC locality C16905, 1.3 miles north (brg. 71°) of the centre of the dome (76°38′N, 108°58′30″W). Similarly, *B. branneri* has been found at two localities within an evaporitic piercement structure (Amund Ringnes piercement dome) on Amund Ringnes Island (Textfig. 6); GSC locality 26264 is in a 6-foot-thick limestone layer interbedded with gypsum one-half mile east of the western edge of the dome and GSC locality C22183 is less than one-quarter mile east of the western edge of the dome (78°32′N, 97°27′W). Representatives of *B. branneri* also have been found in the type section of the Otto Fiord Formation near van Hauen Pass (Textfig. 10), northern Ellesmere Island (80°03′30″N, 85°31′W); GSC locality C10677 and C10690 are 576 feet and 1,163 feet, respectively, above the base of the type section. Finally, the species also occurs in the Otto Fiord Formation in the Krieger Mountains of northern Ellesmere Island (Textfig. 10); GSC locality C21241 is 300 feet above the base of the Otto Fiord Formation on the east side of the first unnamed glacier west of Wood Glacier (80°54′30″N, 84°15′W).

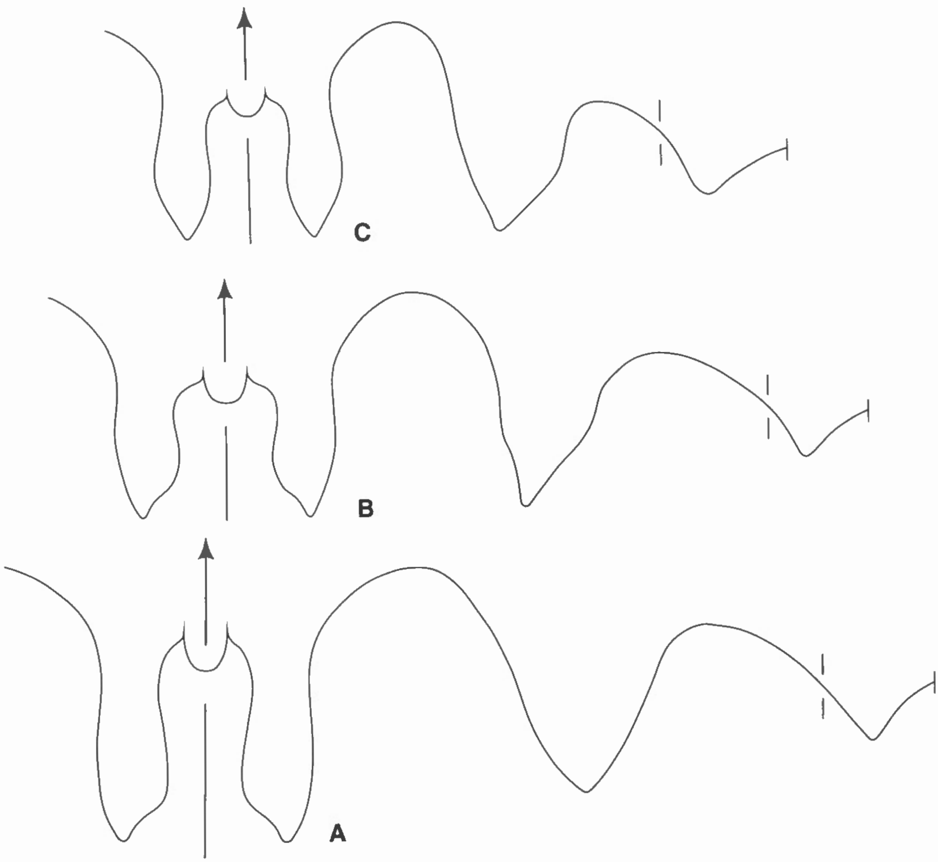
Age. Bloydian (Westphalian-A = Kayalian).

Branneroceras nicholasi Nassichuk, n.sp.

Plate 16, figures 2, 6, 11, 12, 13, 14; Textfigure 53A

Description. Some thirty specimens of *B. nicholasi* were found on Melville Island. Specimens are well preserved, limonitic, and show delicate details of shell ornament. Specimens range in size from about 15 to 35 mm, but most have a diameter of about 20 mm.

Whorls are circular during all stages of growth. Up to a diameter of 10 mm, whorl width either exceeds or closely approximates whorl height, but at larger sizes, whorl height is greater than width.



TEXTFIGURE 53. Diagrammatic representation of external sutures of *Branneroceras nicholasi* n. sp., *Branneroceras hillsi* n. sp., and *Branneroceras* sp. from the Otto Fiord Formation on Melville Island. A, *Branneroceras nicholasi* n. sp. from GSC loc. C16905, based on paratype GSC 33828 at a conch diameter of 29.5 mm. B, *Branneroceras hillsi* n. sp. from GSC loc. C16903, based on the holotype GSC 33831 at a conch diameter of 28 mm. C, *Branneroceras* sp. from GSC loc. C16903, based on hypotype GSC 33834 at a conch diameter of 20 mm.

TABLE 28. Dimension (in mm) and proportions of *Branneroceras nicholasi* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33827	28.5	11.3	11.0	9.8	40.0	38.6	35.0
Paratype GSC 33830	22.0	8.4	8.3	6.4	38.2	37.7	29.1
Paratype GSC 33829	18.0	7.0	7.0	6.0	38.8	38.8	33.3

Umbilical riblets are distinct during early ontogeny but are markedly reduced in intensity between diameters of 15 and 25 mm, and are absent at a diameter of about 30 mm. Six or seven constrictions occur on each volution and these are distinct during all stages of growth. The shell has a reticulate ornament; fine growth lamellae form a moderately deep ventral sinus, a shallow ventrolateral sinus and low ventrolateral salient. Longitudinal lirae are well defined across the venter and ventrolateral flanks.

Comparisons. Branneroceras nicholasi differs from *B. branneri* and *B. hillsi* in possessing a considerably smaller umbilicus. Also, *B. nicholasi* is slightly narrower than both these species and has more prominent as well as more numerous lateral constrictions.

Occurrence. Branneroceras nicholasi occurs at GSC locality C16905 in a sequence of shales and calcareous mudstones within Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). The locality is 1.3 miles northeast (brg. 71°) of the centre of the dome (76°38′N, 108°58′30″W).

Age. Bloydian (Westphalian-A = Kayalian).

Branneroceras hillsi Nassichuk, n. sp.

Plate 17, figures 1, 3; Textfigure 53B

Description. Twenty specimens of *Branneroceras hillsi* were associated with *Branneroceras branneri* and *Branneroceras* sp. on Melville Island. The conch is moderately evolute and U/D approximates 40 per cent. The venter is broadly rounded and the flanks slightly compressed. Three or four shallow constrictions occur on each volution. Shell ornament is preserved on only a few specimens, ornament is clearly reticulate and lateral growth lines are considerably more pronounced than longitudinal lirae. Sharply defined riblets extend from about the midpoint of the umbilical wall onto the lateral flanks to about the position of the first lateral lobe. Prongs of the ventral lobe are slightly inflated medianly and approximate two-thirds the width of the secondary ventral saddle. The first lateral saddle is broadly rounded and the first lateral lobe asymmetric and accuminate.

TABLE 29. Dimensions (in mm) and proportions of *Branneroceras hillsi* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Paratype GSC 33832	32.0	12.1	15.1	12.1	38.0	47.0	38.0
Holotype GSC 33831	29.1	10.5	14.8	11.6	36.0	50.9	39.9

Comparisons. The umbilicus of *B. hillsi* is only fractionally smaller than that of a rather involute variant of *B. branneri*, *B. branneri halense*. The two species can be distinguished, however, on the basis of the external suture; the first lateral saddle of *B. hillsi* is proportionately broader and more asymmetric than that of *B. branneri.*

Occurrence. Branneroceras hillsi occurs at GSC locality C16903 within Barrow Dome on northern Sabine Peninsula, Melville Island (Textfig. 4). The locality is 2 miles due north of the centre of the dome (76°39′15″N, 109°03′W).

Age. Bloydian (Westphalian-A = Kayalian).

Branneroceras sp.

Plate 16, figure 5; Plate 17, figure 2; Textfigure 53C

Description. Several moderately involute specimens of *B.* sp. are directly associated with *Branneroceras branneri* at one locality in Barrow Dome on Melville Island. The conch of *B.* sp. resembles *B. branneri* except that the umbilicus of the former is considerably smaller; U/D is slightly less than 30 per cent on *B.* sp. but is at least 40 per cent on *B. branneri.*

All specimens of *B.* sp. are rather severely abraded but it is clear from one specimen that the shell has a reticulate ornament that is about normal for the genus. One specimen has a diameter of 23 mm and has 3 constrictions preserved in the ultimate volution. Fine riblets extend from the umbilical shoulder onto the lateral flanks.

The external suture is practically identical with that of the associated *B. branneri.* One large specimen shows unusual septal crowding; on this specimen 40 septa occur in a single volution at a diameter of 30 mm, whereas on all other specimens a maximum of 20 septa occupy one volution.

TABLE 30. Dimensions (in mm) and proportions of *Branneroceras* sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33834	23.0	7.8	11.1	6.8	0.34	0.48	0.30

Comparisons. Branneroceras sp. can be distinguished from all other representatives of the genus by its particularly narrow umbilicus (U/D 30 per cent). *Branneroceras nicholasi* has only a slightly larger umbilicus (U/D 35 per cent), but the former has a narrower conch and more abundant lateral constrictions, 6 or 7 per volution.

Occurrence. Branneroceras sp. is directly associated with *B. branneri* at Barrow Dome, Melville Island (Textfig. 4). It occurs at GSC locality C16903, which is on the northern edge of the dome, 2 miles due north of the midpoint of the dome.

Age. Bloydian (Westphalian-A = Kayalian).

Genus *Diaboloceras* Miller and Furnish, 1940

Type species. *Diaboloceras varicostatum* Miller and Furnish, 1940, original designation; from the Atokan "Smithwick Shale horizon" of the Magdalena Formation, West Texas.

Diagnosis. The conch of *Diaboloceras* is subdiscoidal and evolute; the umbilicus is at least one-third of the conch diameter at maturity. Inner whorls are triangular. Shell ornament is reticulate in all stages of development. Umbilical nodes persist through all growth stages but are relatively subdued at full maturity. The suture typically has 10 lobes but only the ventral lobe is completely subdivided; an incipient lobe derived from the umbilical lobe may occur on the umbilical wall. On several species there is no indication of incipient subdivision of the umbilical lobe and thus the suture has only 8 lobes.

Discussion. Diaboloceras has been thoroughly reviewed in recent years by Gordon (1965), Furnish and Knapp (1966), and additional data which are particularly relevant to *D. neumeieri* were presented by Quinn and Carr (1963), and by McCaleb (1968). Gordon (1965) selected one of the syntypes on which the type species is based (Miller and Furnish, 1940c, Pl. 63, figs. 8–10) to serve as lectotype.

Species of *Diaboloceras* on which the umbilical lobe is undivided can be distinguished from its progenitor *Branneroceras* by subtle differences in the external suture. The first lateral lobe of *Branneroceras* is proportionately broader than *Diaboloceras*. Furthermore, the umbilical lobe of *Branneroceras* is more symmetrical than that of *Diaboloceras*; this element is situated on the umbilical wall of *Branneroceras* but is outside the umbilicus, on the flanks, of *Diaboloceras*.

A fundamental distinction between *Diaboloceras* and *Paralegoceras* is that, in the latter, the suture is considerably more advanced. In species of *Diaboloceras* on which an incipient umbilical lobe has developed, it is situated on the umbilical wall but, in *Paralegoceras*, it has migrated to an internal position.

Gordon (1965) employed *Diaboloceras* as a subgenus of *Paralegoceras* but he later (1969) dropped the subgeneric usage in his description of "*Diaboloceras*" *peroccidens* from Nevada. This species was designated the type species of *Paraphaneroceras* by Ruzhencev and Ganelin (1971). These Soviet authors included *Paraphaneroceras* in the Pseudoparalegoceratidae but the present writer considers it to be a schistoceratid, closely related to *Diaboloceras*.

Plummer and Scott (1937) based "*Gastrioceras*" *smithwickense* on several immature specimens with triangular coils from the type locality of *D. varicostatum*, the "Smithwick Shale" in West Texas. Quinn and Carr (1963) re-examined primary types of the latter species and designated it *Diaboloceras smithwickense*. These authors suggested that *D. smithwickense* resembled *D. varicostatum* except that the former lacked an incipiently divided umbilical lobe. Gordon (1965) suggested that Plummer and Scott's species is probably synonymous with *D. varicostatum* but Furnish and Knapp (1966) included the Texas "*G.*" *smithwickense* in *D. neumeieri*. The present writer prefers the latter interpretation which is based on comparable suture development in the umbilical area. Should this interpretation be correct, it is curious that the type locality of an apparently advanced form (*D. varicostatum*) should be the same as that of an apparently less advanced form (*D. neumeieri*). Both species were secured from a shale slope in the "Smithwick Shale horizon" of the Magdalena Formation, West Texas and may not have derived from a common horizon.

Immature specimens from Middle Carboniferous strata in the Urals that have triangular whorls and that were designated *Trigonogastrioceras uralicum* by Librovitch (1947) may in fact be *Diaboloceras*.

Nishida (1971) reported *Diaboloceras*? sp. indet. from Middle Carboniferous (Atokan) strata in the Akiyoshi Limestone Group, Japan. All Nishida's specimens are immature, and the generic assignment is tentative as the features that distinguish *Diaboloceras* from several other schistoceratids, particularly *Paralegoceras*, are generally not apparent until maturity is reached.

Thomas (1928) indicated that "*Gastrioceras*" *pacificum* from Peru possessed 3 internal lobes but that the internal suture was not well preserved. It is conceivable that a re-examination of Thomas' species will show another pair of small lobes just inside the umbilical seam; such a discovery would necessitate the assignment of "*G.*" *pacificum* to *Paralegoceras* as was suggested by Gordon (1965). According to Furnish (pers. com., 1971), the Peruvian species is almost certainly *Paralegoceras*.

Wagner-Gentis (*in* Moore, Neves, Wagner, Wagner-Gentis, 1971) based *Rodiezmoceras* (type species, *Rodiezmoceras bisati* Wagner-Gentis) on 3 fragmentary specimens with reticulate shell ornament from Westphalian-B strata in northwestern Spain. According to Wagner-Gentis (ibid.), *Rodiezmoceras* differs from *Branneroceras* in details of shell ornament and the position of the umbilical lobe; the latter element is on the umbilical shoulder or wall of *Branneroceras* but on the lateral flank of *Rodiezmoceras*. The present writer suggests that *Rodiezmoceras* is more closely related to if not, in fact, a synonym of *Diaboloceras*. Wagner-Gentis (ibid.) suggested that the type *Rodiezmoceras bisati* resembles *Paralegoceras percostatum* Schmidt, 1955 from upper Namurian or lower Westphalian strata in Spain. However, as is discussed under "*Winslowoceras*" in this report, Schmidt's species is probably referable to either *Axinolobus* Gordon or *Winslowoceras* Miller and Downs.

Species composition and distribution.

Diaboloceras involutum n. sp.; from Atokan and Desmoinesian strata on Ellesmere Island, Arctic Canada.

D. neumeieri Quinn and Carr, 1963; from the Morrowan Bloyd Formation and Gene Autry Shale in Arkansas and Oklahoma, respectively (Quinn and Carr, 1963; Furnish and Knapp, 1966; McCaleb, 1968), from the Morrowan Kendrick Shale in Kentucky and equivalent strata in Alabama (Furnish and Knapp, 1966), from Atokan strata in the Magdalena Formation, West Texas (Furnish and Knapp, 1966), and from Carboniferous (Kayalian) rocks in North Africa (Menchikoff, 1930) and the Verkhoyan region of the Soviet Union (Popow, 1970). In Arctic Canada it occurs in Atokan strata on Ellesmere and Axel Heiberg Islands.

D. ruzhencevi Andrianov, 1966; from Kayalian strata in the Verkhoyan region of the Soviet Union.

D. varicostatum Miller and Furnish, 1940c; from the Atokan "Smithwick Shale horizon" in the Magdalena Formation, West Texas, from the Coody Sandstone Member of the Atoka Formation in Oklahoma (Miller and Furnish, 1958a), and equivalent strata in Arkansas (McCaleb, 1963; Gordon, 1965).

Diaboloceras neumeieri Quinn and Carr, 1963

Plate 17, figures 7, 8

Gastrioceras sp. MENCHIKOFF, 1930, p. 199, Pl. 16, figs. 3a, 3b.

?*Gastrioceras smithwickense* PLUMMER and SCOTT, 1937, p. 242–243, Pl. 13, figs. 5–8.

?*Diaboloceras smithwickense* (Plummer and Scott) QUINN and CARR, 1963, p. 112, 114, 118.

Diaboloceras neumeieri QUINN and CARR, 1963, p. 114–118, Pl. 1; FURNISH and KNAPP, 1966, p. 303–304, Pl. 35, figs. 6–9; McCALEB, 1968, Pl. 10, figs. 4, 5; Pl. 12, figs. 5, 6.

Diaboloceras aff. *neumeieri* POPOW, 1970, p. 126–127, Pl. 16, fig. 2.

?*Diaboloceras singulare* POPOW, 1970, p. 127–128, Pl. 16, fig. 3.

Description. Four specimens of *Diaboloceras neumeieri*, all greater than 25 mm in diameter, are available. A number of immature specimens of *Diaboloceras* occur in a collection from GSC locality C4085 in the Blue Mountains. Juvenile forms do not lend themselves to ready specific distinction since a considerable variation in the shape of whorls and in conch proportions is apparent. Nevertheless, those with a relatively large umbilicus are assigned tentatively to *D. neumeieri* and those with a small umbilicus to *D. involutum* n. sp. The shell of *D. neumeieri* is evolute; U/D approximates 50 per cent at maturity. The venter is broadly rounded and the umbilical walls are straight. Up to a diameter of about 20 mm inner whorls are sharply triangular, but beyond that size triangularity diminishes, and at a diameter of 30 mm whorls are circular. Shell ornament is reticulate, growth lines are relatively coarser than longitudinal lirae and form ventral and lateral sinuses. Up to a diameter of 20 mm, 3 or 4 constrictions per volution occur parallel with growth lines. The venter is marked by a prominent ridge to maximum diameter (25 mm); a shallow groove marks the midpoint of the ridge; ridges and grooves are absent on mature specimens. Laterally elongate tubercles are prominent on the umbilical shoulder throughout ontogeny.

The external suture has a broad first lateral lobe that is slightly more than twice as broad as prongs of the ventral lobe. The first lateral lobe is narrow and asymmetric. The umbilical lobe crosses the umbilical wall at a low angle and is only slightly flexed at the midpoint of the wall.

Comparisons. Diaboloceras neumeieri differs from the type species, *D. varicostatum,* in sutural detail. The umbilical lobe of the latter species crosses the umbilical wall more or less perpendicular to the longitudinal axis and an incipient lobe is well developed on the wall. In *D. neumeieri,* however, the umbilical lobe crosses the umbilical wall at a relatively low angle and an incipient lobe is represented only by a slight flexure on the umbilical wall. *Diaboloceras neumeieri* has a suture that is remarkably similar to *D. involutum* n. sp. and the two species are distinguished on the basis of conch proportions. In particular, *D. neumeieri* has a proportionately larger umbilicus.

TABLE 31. Conch dimensions (in mm) and proportions of *Diaboloceras neumeieri* Quinn and Carr

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Hypotype GSC 33835	44.4	14.9	26.0	20.7	0.34	0.47	0.47
Hypotype GSC 33836	38.0	11.5	18.0	18.8	.30	.47	.50
Hypotype GSC 33837	24.8	5.5	13.6	13.0	.22	.55	.52

Occurrence. Diaboloceras neumeieri has been found at three localities in the Sverdrup Basin. It was recovered from near the base of the Hare Fiord Formation near Whitsunday Bay on Axel Heiberg Island (GSC locs. C4010 and C4012), and from near the top of the "Tellevak Limestone" in the Blue Mountains on Ellesmere Island (GSC loc. C4085). The holotype of *D. neumeieri* is from the upper Morrowan Trace Creek Shale Member of the Bloyd Formation in northwestern Arkansas (Quinn and Carr, 1963) but the species is known also from other Morrowan localities in Arkansas (Furnish and Knapp, 1966; McCaleb, 1968). Furnish and Knapp (1966) described the species from the Morrowan Kendrick Shale in the Breathitt Formation (Pottsvillian) in eastern Kentucky. They indicated that the species has been found in the Morrowan Gene Autry Shale of southern Oklahoma and that a form closely resembling *D. neumeieri* has been found associated with *Gastrioceras occidentale* in upper Morrowan strata in Alabama. Stratigraphic relationships of "*Gastrioceras* sp." (= *Diaboloceras neumeieri*), which was described by Menchikoff (1930) from Northern Africa, are unknown. Representatives of the species described by Popow (1970) from the northern Verkhoyan region of the Soviet Union are from Middle Carboniferous (C_2) strata. Forms originally described by Plummer and Scott (1937) as *Gastrioceras smithwickense* from the Atokan "Smithwick Shale horizon" of the Magdalena Formation, West Texas are tentatively assigned to *D. neumeieri.* Quinn and Carr (1963) designated the Texas species as *D. smithwickense* and Gordon (1965) considered it to be a synonym of *D. varicostatum.*

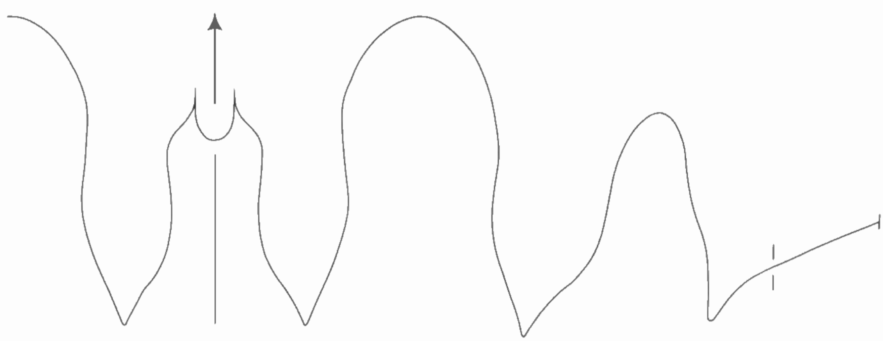
Age. Atokan (Moscovian).

Diaboloceras involutum Nassichuk, n. sp.

Plate 15, figures 3, 7, 9; Plate 17, figures 4, 5, 6, 9; Textfigure 54

Description. Twenty well-preserved specimens of *D. involutum* were recovered from the type locality in the "Tellevak Limestone" in the Blue Mountains of Ellesmere Island. Half of these are immature specimens with diameters less than 20 mm. A number of crushed specimens from dark grey silty limestones near the base of the Hare Fiord Formation are assigned to this species on the basis of comparable umbilical diameters and comparable external sutures.

During earliest growth stages, at diameters of less than 10 mm, all specimens have sharply triangular whorls. The stage at which triangularity is no longer apparent varies considerably, from a diameter of about 15 mm in some specimens to about 30 mm in others. On most of the small specimens, a shallow groove marks the venter but, on a few of them, a slight ridge occurs on the venter; faint grooves occur on either side of the ventral ridge. Shell ornament includes a reticulate pattern of growth lines and longitudinal lirae; the lirae are particularly conspicuous across the venter but are absent from the umbilical wall. Umbilical nodes persist to full maturity. A slight flexure on the dorsal side of the umbilical lobe occurs in about the middle of the umbilical wall.



TEXTFIGURE 54. Diagrammatic representation of an external suture of *Diaboloceras involutum* n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085), based on the holotype GSC 33838 at a conch diameter of 50 mm.

Comparisons. *Diaboloceras involutum* is similar to the type species, *D. varicostatum*, in terms of conch proportions and shell ornament but is distinct from it in details of the external suture. In particular, the incipient lobe that develops from the umbilical lobe is relatively well developed on *D. varicostatum* but it is little more than a flexure on the umbilical wall of *D. involutum*. The umbilical lobe of *D. varicostatum* crosses the umbilical wall perpendicular to the longitudinal axis, but the same element of *D. involutum* crosses the wall at a much lower angle. Sutural details of *D. involutum* closely resemble those of *D. neumeieri*; the latter species, however, has a considerably larger umbilicus. The ratio U/D of the holotype of *D. neumeieri* at a maximum size (170 mm) is 59 per cent whereas on the holotype of *D. involutum* at maximum size (82.5 mm) it is 41 per cent.

Occurrence. Typical representatives of *Diaboloceras involutum* were recovered from GSC locality C4085 near the top of the "Tellevak Limestone" in the Blue Mountains of northern Ellesmere Island. Other specimens were recovered several hundred feet below the type locality in the same section, at GSC locality C10775. Similarly, the species also occurs in red beds along strike from the type locality, at GSC locality C10837.

TABLE 32. Dimensions (in mm) and proportions of *Diaboloceras involutum* n. sp.

Specimen	Diameter	Height	Width	Umbilicus	H/D	W/D	U/D
Holotype GSC 33838	82.5	28.0	35.8	34.0	0.34	0.43	0.41
Paratype GSC 33839	53.0	16.8	25.0	22.0	.32	.47	.42
Paratype GSC 33840	49.5	16.5	23.3	20.2	.33	.47	.41
Paratype GSC 33841	37.5	12.4	19.0	15.5	.33	.51	.41
Paratype GSC 33842	29.0	9.2	16.1	11.7	.32	.55	.40

A number of deformed (flattened) representatives of *Diaboloceras* from shaly limestones near the base of the Hare Fiord Formation (GSC locs. C4011, C4083, C14582, 47867) on Ellesmere and Axel Heiberg Islands are included in *D. involutum* on the basis of comparable umbilical diameters. All the above-cited occurrences are in Atokan strata but the species also occurs in Desmoinesian strata at GSC locality C21750, near the top of the "Tellevak Limestone" in the Krieger Mountains of northern Ellesmere Island.

Age. Atokan and Desmoinesian (Moscovian).

Family WELLERITIDAE Plummer and Scott, 1937

The Welleritidae includes thinly discoidal, moderately evolute members of the superfamily in which auxiliary lobes were added in the umbilical region and an adventitious lobe was derived from the relatively broad first lateral saddle. The latter feature in particular serves to distinguish the family from the Schistoceratidae. Included in the family are the Atokan *Winslowoceras* Miller and Downs, 1948, and *Eowellerites* Ruzhencev, 1957, and the Atokan and Desmoinesian *Wellerites* Plummer and Scott, 1937.

Genus *Winslowoceras* Miller and Downs, 1948

Type species. *Winslowoceras henbesti* Miller and Downs, 1948; from the Atokan Winslow Formation in Arkansas.

Diagnosis. The conch of typical *Winslowoceras* has a wide umbilicus; U/D is at least 40 per cent. Whorls are compressed and the venter is narrow and concave at maturity. Shell ornament is reticulate; strong lateral growth lines form a moderately deep ventral sinus, a shallow lateral sinus, and a high ventrolateral salient. During early ontogeny, ribs occur parallel with growth lines across the umbilical shoulders and onto the lateral flanks. Details of the external suture are particularly diagnostic. Prongs of the ventral lobe are short and narrow and are separated from one another by a secondary ventral saddle that is about half the height of the first lateral saddle. The first lateral lobe is deep, narrow, and attenuate, and the second lateral saddle is higher than the first. Sutural elements are added during ontogeny by subdivision of the umbilical lobe; sutural formula is: $(V_1V_1)\ LU_{1\cdot1}U_{1\cdot2}{:}ID$.

Discussion. During earliest stages of development, *Winslowoceras* displays a simple 8-lobed suture. During adolescence the umbilical lobe subdivided ($U \rightarrow U_{1\cdot1}U_{1\cdot2}$) and the ventral subdivision migrated to an external position where it appears as a "lateral" lobe. Thus, *Winslowoceras* has 10 lobes at maturity. Although the immediate progenitor of *Winslowoceras* is uncertain there is little doubt that *Eowellerites* is a direct descendent. A fundamental difference between the two genera is that on the former, the first lateral saddle is either broadly rounded or slightly flattened ventrad, whereas on the latter, an adventitious lobe developed from the first lateral saddle.

Schmidt (1955) described "*Paralegoceras*" *percostatum* from Spain but he recognized a close similarity between his species and *Winslowoceras*. Schmidt's (ibid.) description and illustration of the ventral part of the suture of "*P.*" *percostatum* lacks significant detail for proper generic assignment. McCaleb and Furnish (1964) and McCaleb (1968) tentatively assigned the Spanish species to *Axinolobus* but Gordon (1965) referred it to *Winslowoceras*.

Termier and Termier (1950) figured "*Paralegoceras*" sp. from Westphalian strata in Algeria. The writer concurs with the opinion of Miller and Furnish (1958a) and Gordon (1965) that the Algerian species is probably *Winslowoceras*.

Popow (1970) described *Winslowoceras domokhotovi* from the Verkhoyan region in the Soviet Union but Popow's species is in fact *Christioceras*. Similarly, Abramov (1970) referred *C. domokhotovi* to "*Parawinslowoceras*."

Species composition and distribution.

Winslowoceras greelyi n. sp.; from Atokan strata in the Hare Fiord Formation, Ellesmere Island.

W. henbesti Miller and Downs, 1948; from the Atokan Winslow Formation in Arkansas (Miller and Downs, 1948; McCaleb, 1963).

The only other confirmed representative of the genus is *W.* sp. described and illustrated by Termier and Termier (1950, p. 71, Pl. 156, figs. 16, 17) from Westphalian strata in Algeria. "*Paralegoceras*" *percostatum* described by Schmidt (1955) from upper Namurian or lower Westphalian strata in Spain must be assigned eventually to either *Winslowoceras* or *Axinolobus*.

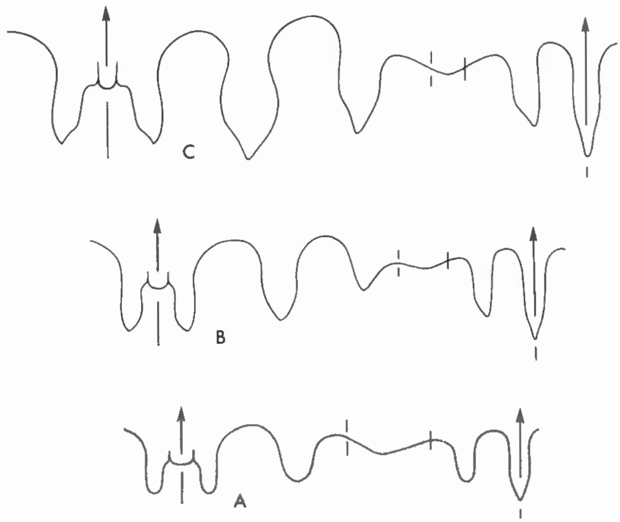
Winslowoceras greelyi Nassichuk, n. sp.

Plate 18, figures 1, 3, 4, 6, 7, 8; Textfigure 55

Description. Some 50 specimens of *Winslowoceras greelyi* were recovered from a single locality on Ellesmere Island. Forty-five of these are immature and have a diameter of less than 15 mm, but one fragmentary specimen has a reconstructed diameter of 45 mm. The largest entire specimen has a diameter of 26.5 mm and is selected as holotype.

During early growth stages, the conch is discoidal and whorls are moderately depressed, but at maturity, the conch is sublenticular and whorls are moderately compressed. The venter is evenly rounded on all except the largest specimen, which has a slight ventral concavity at full size. The conch is markedly evolute throughout ontogeny; U/D at maturity exceeds 40 per cent. Inner whorls have a faintly triangular outline up to a diameter of about 12 mm.

Faint longitudinal lirae and coarse growth lines form a reticulate ornament on the surface of the shell. The ridge-like growth lines form conspicuous ventral and dorsolateral sinuses. Prominent ribs extend parallel with growth lines across the umbilical wall and onto the ventrolateral flanks to about the position of the first lateral saddle; ribs persist to maximum size. Two growth lines are superposed on each rib whereas a single growth line occupies each inter-rib depression. On one of the paratypes, 30 ribs occur in a single volution. Longitudinal ventral grooves, which coincide with the position of the prongs of the ventral lobe, occur on either side of a low, rounded central ridge covering the siphuncle. The grooves are barely



TEXTFIGURE 55

Diagrammatic representation of the sutural ontogeny of *Winslowoceras greelyi* from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); A, B, and C based on paratype GSC 33846 at diameters of 6 mm, 12 mm, and 22 mm, respectively.

discernible at a conch diameter of less than 5 mm but are particularly deep and conspicuous at a size of 15 mm. Grooves decrease in depth to a diameter of 23 mm beyond which size they are no longer apparent.

Details of the suture best characterize the species, particularly the narrow, asymmetric prongs of the ventral lobe, each of which is about half the width of the secondary ventral saddle. The first and second lateral saddles are broadly and evenly rounded, and are about the same width, but the second is slightly higher than the first. The first lateral lobe is markedly inflated and accuminate.

TABLE 33. Dimensions (in mm) and proportions of *Winslowoceras greelyi* n. sp. and *Winslowoceras henbesti* Miller and Downs

Specimen	Diameter	Height	Width	Umbilicus	W/H	W/D	U/D
Winslowoceras greelyi (wide umbilicus)							
Paratype GSC 33846	22.2	6.5	8.2	12.3	1.26	0.37	0.55
Paratype GSC 33846	18.6	4.8	7.2	9.3	1.50	.39	.50
W. greelyi (narrow umbilicus)							
Holotype GSC 33845	26.5	8.6	8.8	11.0	1.02	.33	.42
Paratype GSC 33847	19.0	5.6	6.7	8.0	1.20	.35	.42
W. henbesti (after Miller and Downs, 1948)							
Holotype U.S.N.M.	73.0	24.0	14.0	29.0	.59	.20	.40
W. henbesti (after McCaleb, 1963)							
Topotype	20	4.0	6.0	8.0	1.5	.30	.40
Topotype	20	5.1	6.0	5.5	1.8	.50	.28

Comparisons. Representatives of *Winslowoceras greelyi* n. sp. are slightly more advanced than representatives of the type species *W. henbesti* that were recovered some 350 feet above the base of the type Winslow Formation in Arkansas. McCaleb (1963) noted that the specimens of *W. henbesti* that were secured from 1,000 feet higher in the same formation at Natural Dam, Arkansas, are somewhat more advanced than those on which the type species is based; lobes on the former are more attenuate and an incipient flexure on the first lateral saddle is more pronounced. The Arctic species appears to have attained an evolutionary stage somewhat intermediate between forms found in the two Winslow horizons.

Occurrence. *Winslowoceras greelyi* occurs at GSC locality 56430 in a small carbonate mound, near the base of the Hare Fiord Formation, on the north side of Hare Fiord, Ellesmere Island (81°07′06″N, 84°17′W).

Age. Atokan (Moscovian).

Family Christioceratidae Nassichuk and Furnish, 1965

Distinction between the Christioceratidae and all other representatives of the Schistocerataceae is based primarily on differences in the mode of sutural development. During early ontogeny the whorl cross-section of the only known christioceratid, *Christioceras*, was more or less circular and umbilical element 'U' was outside the umbilicus; internal sutural element 'I' was positioned externally, in the umbilicus. During ontogeny, 'I' became subdivided and by maturity the ventrad subdivision had migrated to the external lateral flank while the dorsad subdivision migrated for the first time to an internal position. At maturity, all laterally positioned external lobes became completely subdivided and prongs of the ventral lobe became incipiently divided.

Genus *Christioceras* Nassichuk and Furnish, 1965

Type species. *Christioceras trifurcatum* Nassichuk and Furnish, 1965; from Atokan strata in the Hare Fiord Formation, Ellesmere Island.

Diagnosis. The conch of *Christioceras* is lenticular, moderately evolute at maturity, lateral flanks are flat, and the venter is concave. Shell ornament includes broad and subdued longitudinal lirae on the flanks as well as delicate growth lines; the growth lines form ventral and dorsolateral sinuses and a ventrolateral salient. During early growth stages, prominent ribs extend from the umbilicus across the venter but, at maturity, ribs are confined to the vicinity of the umbilicus and the ventrolateral shoulders.

The mature suture has 10 lobes, 7 of which are in an external position. All 3 pairs of laterally positioned lobes are subdivided; one of these represents 'L,' another was derived from 'U' and another from 'I.' Prongs of the ventral lobe diverge sharply apicad and are incipiently divided.

Discussion. Although new collections have been made in the type area, little can be added to the discussion of the general morphology and relationships of *Christioceras* that was provided by Nassichuk and Furnish (1965). Popow (1970) described "*Winslowoceras*" *domokhotovi* Popow from the Soviet Union but all features of Popow's species, including the suture, ornament and conch form, clearly indicate that it is referable to *Christioceras*.

Species composition and distribution.

Christioceras domokhotovi (Popow, 1970); from the Middle Carboniferous Ekachan suite (C_2-C_3) in Southern Verkhoyan in the Soviet Union. This species was assigned to "*Winslowoceras*" by Popow (1970) and to "*Parawinslowoceras*" by Abramov (1970).

C. trifurcatum Nassichuk and Furnish, 1965; from Atokan strata in the Hare Fiord Formation, Ellesmere Island.

C. sp.; from the "Smithwick Shale horizon" (Atokan) of the Magdalena Formation at the base of the Sierra Diablo Escarpment, West Texas (Nassichuk and Furnish, 1970).

Christioceras trifurcatum Nassichuk and Furnish, 1965

Plate 18, figures 2, 5; Textfigure 56

Christioceras trifurcatum NASSICHUK and FURNISH, 1965, p. 724–728, Textfigs. 1, 2.

Description. The original description of *C. trifurcatum* by Nassichuk and Furnish (1965) was based on the holotype and 3 paratypes; 10 additional specimens from the type locality (topotypes) and additional specimens from 3 other localities are now available. All specimens from the type locality are smaller than the holotype, which has a diameter of 22 mm, but two specimens from another locality (GSC loc. C4085) have a diameter of about 40 mm. On both of the last specimens, the ultimate volution constitutes body chamber. Thus, on no specimens were sutures observed that were more advanced than those on the holotype. During early growth stages, up to a diameter of 4 or 5 mm, the conch is discoidal and the whorl section is rounded, more or less equidimensional. Beyond a size of 6 mm, the lateral flanks begin to flatten and the conch assumes a sublenticular and ultimately a lenticular character; at a diameter of 8 mm, a ventral concavity is established.

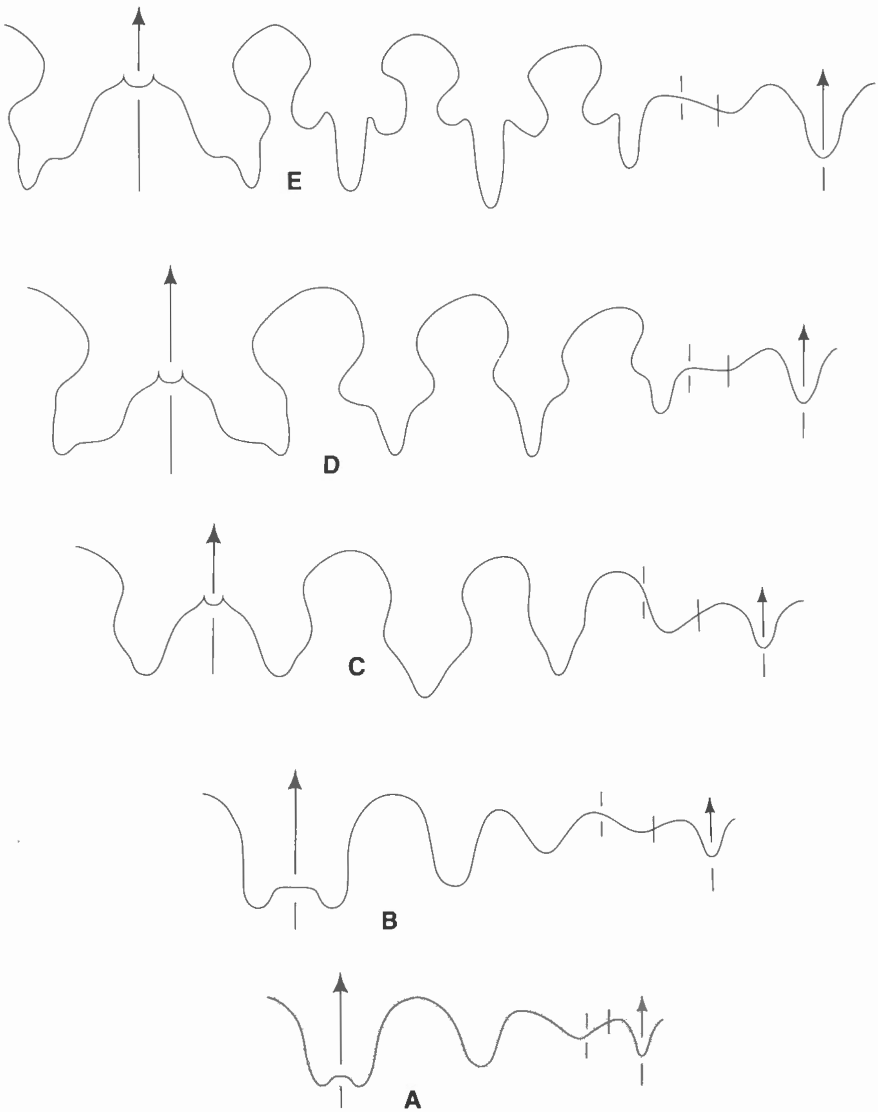
During early ontogeny, ribs extend from the umbilicus to the venter. At maturity, vestiges of ribs consist of umbilical nodes which cross the umbilical wall onto the lateral flanks and ventrolateral nodes which occur on the margins of the venter. At a size of 40 mm, 32 umbilical nodes occur in half a volution. Longitudinal ornament is absent during early ontogeny, but at maturity faint but broad and widely spaced longitudinal lirae form a subdued reticulate pattern with delicate growth lines. These growth lines form a deep ventral sinus, a high, broadly rounded ventrolateral salient and a relatively shallow dorsolateral sinus.

Some details of sutural development have been discussed under the subfamilial and generic headings.

Comparisons. Christioceras sp., described by Nassichuk and Furnish (1970) from West Texas, cannot be objectively compared with *C. trifurcatum* since all representatives of the former are immature shells. There is no apparent distinction between the two species during early

TABLE 34. Dimensions (in mm) and proportions of *Christioceras trifurcatum* Nassichuk and Furnish

Specimen	Diameter	Height	Width	Umbilicus	Venter(W)	W/H	W/D	U/D
Holotype GSC 19879	22.0	9.6	3.3	7.5	0.4	0.35	0.15	0.33
Paratype GSC 19880	9.3	3.5	2.3	3.7	.6	.66	.23	.40
Paratype GSC 19881	3.9	1.0	1.3	2.0	—	1.30	.33	.51



TEXTFIGURE 56. Diagrammatic representation of the sutural ontogeny of *Christioceras trifurcatum* Nassichuk and Furnish from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430), based on the holotype and paratypes. A, B, early growth stages revealed on paratype GSC 19882. A, sutural pattern at a conch diameter of 2.5 mm at the fourth volution; B, sutural pattern at a diameter of 4 mm at the fourth volution; C, immature suture based on paratype GSC 19880 at a conch diameter of 8 mm; D, sutural pattern based on paratype GSC 19882 at a conch diameter of 14 mm; E, mature suture based on holotype GSC 19879 at a conch diameter of 19 mm, eighth volution.

ontogenetic stages. Similarly, the Soviet species *C. domokhotovi* (Popow), which is represented by a single specimen, is smaller than the holotype of *C. trifurcatum*. Popow's description and illustration of *C. domokhotovi* are suitable to indicate that a comparable level of development was attained by *C. trifurcatum*. However, the former is based on an immature specimen and further taxonomic comparison must await a review of the Soviet material.

Occurrence. The type locality of *Christioceras trifurcatum* is in a carbonate mound near the base of the Hare Fiord Formation on the north side of Hare Fiord, Ellesmere Island (GSC loc. 56430). The species also occurs less than one-quarter of a mile along strike to the east of the type locality in the basinal limestone-siltstone facies of the Hare Fiord Formation (GSC loc. C10672). *Christioceras trifurcatum* also was recovered from a comparable horizon near the base of the Hare Fiord Formation at GSC locality C4083 between Mount Schuchert and Mount Barrell in the Krieger Mountains, Ellesmere Island. Several specimens were found at GSC locality C4085 near the top of the "Tellevak Limestone" in the Blue Mountains, Ellesmere Island.

Age. Atokan (Moscovian).

Superfamily SHUMARDITACEAE Plummer and Scott, 1937

Family Shumarditidae Plummer and Scott, 1937

Genus ***Parashumardites*** Ruzhencev, 1939

Type species. *Shumardites senex* Miller and Cline, 1934; from Missourian (Zhigulevian) strata in the Nellie Bly Formation, Oklahoma.

Diagnosis. The conch of *Parashumardites* is thickly discoidal and moderately evolute; U/D ranges from near 30 per cent to about 50 per cent. The umbilicus is broadly rounded and umbilical shoulders are narrowly rounded to subangular. Shell ornament consists of delicate transverse lamellae that are gently curved on the flanks and more or less straight across the venter.

Prongs of the ventral lobe are broad, simple and inflated apicad and are separated from one another by a ventral saddle that is two-thirds the height of the first lateral saddle. The first lateral, umbilical, internal lateral and dorsal lobes are all trifid; sutural formula is $(V_1V_1)(L_2L_1L_2)U_2U_1:U_2(I_2I_1I_2)(D_2D_1D_2)$.

Discussion. A single fragmentary specimen of *Parashumardites* sp. from Ellesmere Island was described by Nassichuk (1969) and the genus is listed here only to complete the record of Carboniferous ammonoids in Arctic Canada. In addition to a description of the type species by Miller and Cline (1934), standard reference for the genus are works by Ruzhencev (1939, 1950). Additional data on the genus were provided by Nassichuk (1969).

Species composition and distribution.

Parashumardites eurinus Ruzhencev, 1950; from Zhigulevian strata in the southern Urals.

P. fornicatus (Plummer and Scott, 1937); from Missourian (Zhigulevian) strata in the Graford Formation of north-central Texas.

P. mosquensis Ruzhencev, 1939; from Zhigulevian strata in the Moscow Basin.

P. senex (Miller and Cline, 1934); from Missourian (Zhigulevian) strata in the Nellie Bly Formation, Oklahoma.

P. sellardsi (Plummer and Scott, 1937); from Missourian (Zhigulevian) strata in the Gaptank Formation, West Texas.

P. sp.; from strata of probable Missourian age in the Nansen Formation, Ellesmere Island, Canada (Nassichuk, 1969).

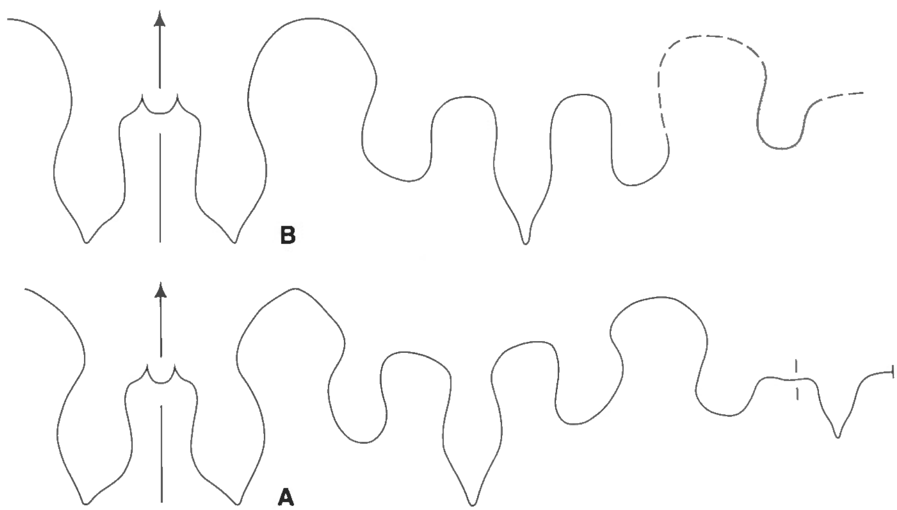
P. sp.; from strata of late Virgilian (Orenburgian) age in the Gaptank Formation at the old Montgomery ranch (Brooks Ranch) in the eastern Glass Mountains, West Texas. Undescribed specimens in the University of Iowa collections.

Parashumardites sp.

Textfigure 57B

Parashumardites NASSICHUK, 1967b, p. 11.
Parashumardites sp. NASSICHUK, 1969, p. 124–127, Textfig. 15B.

Description. One fragmentary specimen, comprising one-quarter of a single volution at an approximate diameter of 40 mm, is entirely septate and is preserved as a partial cast. By reconstruction, the conch is moderately evolute but precise conch proportions are not available. Shell ornament is not preserved. The external suture is sufficiently preserved to provide only a generic assignment and, for this reason, the species is not formally comparable with established species.



TEXTFIGURE 57. Diagrammatic representation of external sutures of *Parashumardites* A, *Parashumardites senex* (Miller and Cline) from the Missourian Nellie Bly Formation, Oklahoma; based on topotype SUI 32366 at a conch diameter of 41 mm. B, *Parashumardites* sp. from the Nansen Formation, Ellesmere Island (GSC loc. 80159); based on hypotype GSC 23603 at a conch diameter of about 40 mm.

Occurrence. GSC locality 80159 is in a massive skeletal limestone on the north side of Hare Fiord, on the east side of Stepanow Creek (Textfig. 10) on northern Ellesmere Island (81°08′N, 84°06′W). Nassichuk (1969) suggested that the locality is 400 feet above the base of the Hare Fiord Formation. In the vicinity of Stepanow Creek, however, the Hare Fiord Formation "interfingers" with the Nansen Formation and the strata which yielded *Parashumardites* sp. appear to resemble the lithology of the Nansen Formation rather than the Hare Fiord Formation.

Age. Missourian (Zhigulevian).

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APPENDIX

During the study of Carboniferous ammonoids and stratigraphy in the Sverdrup Basin, the writer collected a variety of fossil representatives of other biologic groups. Some of these have been examined by various specialists whose observations have contributed significantly to the correlations offered in this report. The following is a tabulation of identifications made by these specialists.

Coral Identifications *by* E. W. Bamber

A. *Otto Fiord Formation*

(i) GSC locality 73159; Barrow Dome, Melville Island; fossils from a limestone xenolith in anhydrite; stratigraphic relationships unknown:

Lophophyllidium sp.
Barytichisma sp.
age: Pennsylvanian.

(ii) GSC locality C10695; 1,195 feet above the base of the formation, one-half mile south of the type section, 1.6 miles north of van Hauen Pass, Ellesmere Island:

Cyathocarinia sp.
Lophamplexus sp.
age: latest Viséan to Early Permian.

B. *Hare Fiord Formation*

(i) GSC locality C21721; 200 feet above the base of the Hare Fiord Formation on the east side of the first glacier west of Wood Glacier, Krieger Mountains, northern Ellesmere Island:

Durhamina cf. *D. stuckenbergi* (Dobrolyubova)
age: Kayalian—Moscovian.

C. *Canyon Fiord Formation*

(i) GSC locality C483; 6 miles NW of the head of McCormick Inlet, northwestern Melville Island. Limestone unit at base of Canyon Fiord Formation:

brachiopods indet.
Multithecopora sp.
Neokoninckophyllum spp.
Profusulinella sp. (identified by R. Thorsteinsson)
age: The corals indicate a Bashkirian or Moscovian age. *Profusulinella* indicates an early Moscovian age.

(ii) A section of the Canyon Fiord Formation on north-central Bjorne Peninsula, southwestern Ellesmere Island (77°44′00″N, 87°02′00″W).

GSC locality C10528; 40 feet above base of formation:

Chaetetes sp.
age: Moscovian?

GSC locality C10530; 1,600 feet above base of formation:

?*Timania* sp.
age: *Timania* ranges from Moscovian to Early Permian and is found mainly in Upper Carboniferous strata.

GSC locality C10531; 1,792 feet above base of formation:

?*Caninophyllum*
age: Carboniferous or Permian.

GSC locality C10532; 2,005 feet above base of formation:

Roemeripora sp.
?*Heintzella* sp.
Caninophyllum ovibos (Salter)
age: Late Carboniferous (Zhigulevian–Orenburgian) to Early Permian.

Conodont Identifications *by* P. K. Bender

A. *Otto Fiord Formation*

(i) Section one-half mile south of the type section, 1.6 miles north of van Hauen Pass, Ellesmere Island (81°03′30″N, 85°32′00″W).

GSC locality C10676; 238 feet above base of section:

Streptognathodus lateralis Higgins and Bouckaert
Gnathodus noduliferus (Ellison and Graves)
Idiognathodus delicatus Gunnell
Hindeodella sp.
age: North America: Morrowan (Bloydian).
Europe: Westphalian-A (G_2).

GSC locality C10677; 576 feet above base of section:

Streptognathodus lateralis Higgins and Bouckaert
Gnathodus noduliferus (Ellison and Graves)
Idiognathodus delicatus Gunnell
Ligonodina sp.
age: North America: Morrowan (Bloydian).
Europe: Westphalian-A (G_2).

GSC locality C10681; 626 feet above base of section:

Idiognathodus delicatus Gunnell
Ozarkodina delicatula (Stauffer and Plummer)
Hindeodella sp.
age: North America: Morrowan (Bloydian).
Europe: Westphalian-A (G_2).

GSC locality C10684; 766 feet above base of section:

Streptognathodus lateralis Higgins and Bouckaert
Gnathodus noduliferus (Ellison and Graves)
age: North America: Morrowan (Bloydian).
Europe: Westphalian-A (G_2).

GSC locality C10686; 801 feet above base of section:

Streptognathodus lateralis Higgins and Bouckaert
Idiognathodus delicatus Gunnell
Hindeodella sp.
age: North America: Morrowan (Bloydian).
Europe: Westphalian-A (G_2).

GSC locality C10690; 1,163 feet above base of section:

Gnathodus ouachitensis (Harlton)
age: Morrowan (Bloydian) to ?early Atokan.

GSC locality C10691; 1,200 feet above base of section:

Ozarkodina delicatula (Stauffer and Plummer)
age: late Morrowan (Bloydian) to early Atokan.

GSC locality C10692; 1,309 feet above base of section:

Gnathodus ouachitensis (Harlton)
Ozarkodina delicatula (Stauffer and Plummer)
age: Morrowan (Bloydian) to ?early Atokan.

(ii) GSC locality C23895; 100 feet below top of the type section, about 2 miles north of van Hauen Pass, Ellesmere Island:

Gnathodus ouachitensis (Harlton)
Idiognathodus sp.
Ozarkodina sp.
Hindeodella sp.
Ligonodina sp.
Lonchodina sp.
age: Morrowan (Bloydian) to ?early Atokan.

(iii) GSC locality C20460; 10 feet above base of section, about 2 miles northeast of Girty Creek, head of Hare Fiord, northern Ellesmere Island:

Streptognathodus lateralis Higgins and Bouckaert
Cavusgnathus lautus Gunnell
age: North America: Morrowan.
Europe: H_1-G_2.

(iv) GSC locality C10836; 340 feet above base of section, in the southwestern region of the Blue Mountains, 2 miles northeast of Hare Fiord Diapir, northern Ellesmere Island (80°42′41″N, 85°52′05″W) (bottom of formation not exposed; this locality near top of formation):

Streptognathodus lateralis Higgins and Bouckaert
Gnathodus noduliferus (Ellison and Graves)
Idiognathodus delicatus Gunnell
Ozarkodina delicatula (Stauffer and Plummer)
Hindeodella sp.
age: Morrowan (Bloydian).

B. *Hare Fiord Formation*

(i) GSC locality C24402; 5 feet above base of the type section, 2 miles north of van Hauen Pass, Ellesmere Island:

Gnathodus ouachitensis (Harlton)
Idiognathodus cf. *I. claviformis* Gunnell
Hindeodella sp.
Metalonchodina bidentata (Gunnell)
Ligonodina sp.
age: late Morrowan (Bloydian)—early Atokan.

(ii) GSC locality 56430; approximately 100 feet above base of formation, about 2 miles west of Stepanow Creek on the north side of Hare Fiord, northern Ellesmere Island:

Gnathodus opimus Igo and Koike
Gnathodus cf. *G. bassleri* (Harris and Hollingsworth)
Idiognathodus delicatus Gunnell
Ozarkodina delicatula (Stauffer and Plummer)
Hindeodella sp.
Lonchodina sp.
age: North America: Morrowan (Bloydian)—Atokan.
Europe: Namurian-C—Westphalian-A.

(iii) GSC locality C4085; in the upper 10 feet of the "Tellevak Limestone" in the lower part of the Hare Fiord Formation on the southwest side of Blue Mountains, 3.6 miles northeast of Hare Fiord Diapir (80°44′00″N, 85°40′54″W):

Gnathodus opimus Igo and Koike
Gnathodus ouachitensis (Harlton)

Idiognathodus delicatus Gunnell
Hibbardella acuta Murray and Chronic
Ozarkodina delicatula (Stauffer and Plummer)
Synprioniodina microdenta Ellison
Hindeodella sp.
Metalonchodina bidentata (Gunnell)
Hibbardella subacoda (Gunnell)
Ligonodina typa (Gunnell)
Lonchodina sp.
Neoprioniodus sp.
age: North America: Morrowan (Bloydian)—Atokan.
Europe: Namurian-C—Westphalian-A.

(iv) Section 4 miles southeast of the northern end of Buchanan Lake, eastern Axel Heiberg Island. GSC locality C4013; at base of the Hare Fiord Formation:

Gnathodus opimus Igo and Koike
Gnathodus cf. *G. bassleri* (Harris and Hollingsworth)
Gnathodus ouachitensis (Harlton)
Anchignathus coloradoensis (Murray and Chronic)
Idiognathodus delicatus Gunnell
Hibbardella acuta Murray and Chronic
Ozarkodina delicatula (Stauffer and Plummer)
Synprioniodina microdenta Ellison
Hindeodella sp.
Metalonchodina bidentata (Gunnell)
Hibbardella subacoda (Gunnell)
Ligonodina sp.
Lonchodina sp.
Neoprioniodus sp.
age: Morrowan (Bloydian)—Atokan.

Brachiopod Identifications *by* J. L. Carter

A. *Otto Fiord Formation*

(i) GSC locality C4126; limestone inclusion near the north-central edge of Barrow Dome, Sabine Peninsula, Melville Island:

Crurithyris sp.
Hustedia n. sp.
Cleiothyridina? cf. *Athyris cestriensis* Snider
Composita sp.
Anthracospirifer cf. *A. welleri* (Branson and Greger)
Ovatia cf. *O. minor* Snider
Beecheria cf. *B. compressa* Snider
Girtyella sp.
age: Chesteran (early Namurian).

(ii) GSC locality C4125; limestone inclusion 1.3 miles northeast of the centre of Barrow Dome, Sabine Peninsula, Melville Island:

Camerisma sp.
Phricodothyris n. sp.?
Rugosochonetes sp.
age: early Morrowan (Halian).

(iii) Section one-half mile southwest of the type section, 1.6 miles north of van Hauen Pass, northern Ellesmere Island. Ages for localities C10676 to C10692 are given below, following the species cited at locality C10692.

GSC locality C10676; 238 feet above base of formation:

Crurithyris sp.
terebratulid gen. et sp. indet.

GSC locality C10677; 576 feet above base of formation:

Rhipidomella sp.
Stenoscisma sp.
?*Martinia* sp.
indeterminate productid

GSC locality C10681; 628 feet above base of formation:

Rhipidomella sp.
indeterminate davidsoniacean
?*Krotovia* cf. *K. pustulata* (Keyserling) as figured by Mironova (1967)
"*Marginifera*" *timanica* (Chernychev, 1902)
Karawankina sp.
?*Kutorginella* sp.
Wellerella sp.
Stenoscisma sp.
Coledium cf. *C. globulina* (Phillips)
?*Nucleospira* sp.
Neospirifer poststriatus (Nikitin) as figured by Chernychev (1902)
Meristorygma arctica Carter
Tangshanella sp.
Martinia sp.
Phricodothyris sp.

GSC locality C10682; 734 feet above base of formation:

Dielasma sp.
age: *see* comments below.

GSC locality C10689; 962 feet above base of formation:

"*Marginifera*" cf. *Productus pseudoartiensis* Stuckenberg

GSC locality C10690; 1,163 feet above base of formation:

Rhipidomella sp.
indeterminate small davidsoniacean similar to that of locality C10681
Rugosochonetes sp.
"*Marginifera*" cf. *Productus pseudoartiensis* Stuckenberg
"*Marginifera*" cf. *M. pulchra* Rotai, 1951
Stenoscisma sp.
Coledium cf. *C. globulina* (Phillips)
Meristorygma arctica Carter
?*Eomartiniopsis* sp.
Crurithyris sp.
indeterminate small terebratulid

GSC locality C10692; 1,309 feet above base of formation:

Rhipidomella sp.
"*Marginifera*" cf. *M. pulchra* Rotai
indeterminate small stenoscismatacean
?*Tangshanella* sp.
Crurithyris sp.
indeterminate small terebratulid

age: "Brachiopods from the above seven localities indicate a Morrowan (Bashkirian) to Missourian (Gzhelian) age; further age refinements will depend on larger collection of fossils that are suitably preserved for serial sectioning."

Blastoid Identifications *by* D. B. Macurda

A. *Hare Fiord Formation*

(i) GSC locality 56430; approximately 100 feet above the base of the formation 2 miles west of Stepanow Creek on the north side of Hare Fiord, northern Ellesmere Island:

Angioblastus ellesmerensis Breimer and Macurda
age: Atokan.

Calcareous Foraminifers, Algae, and Incertae Sedis Identifications *by* B. L. Mamet

A. *Otto Fiord Formation*

(i) Section one-half mile south of the type section, 1.6 miles north of van Hauen Pass, Ellesmere Island (81°03′30″N, 85°32′00″W).

GSC locality C10677; 576 feet above base of formation:

apterrinellids
Asphaltina sp.
Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Biseriella sp.
Bradyina sp.
Bradyina cribrostomata Rauzer-Chernoussova and Reitlinger
Calcisphaera sp.
Climacammina sp.
Diplosphaerina sp.
Endothyra sp.
Eotuberitina sp.
Neoarchaediscus sp.
Palaeotextularia sp.
Planospirodiscus sp.
Pseudoendothyra sp.
Pseudoglomospira sp.
Pseudoissinella sp.
primitive *Pseudostaffella* sp.
red algae
Rectangulina sp.
Tetrataxis sp.
Vicinesphaera sp.

GSC locality C29163; 580 feet above base of formation:

Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Diplosphaerina sp.
Endothyra sp.
Neoarchaediscus sp.
Planoendothyra sp.
Planospirodiscus sp.
Tetrataxis sp.

GSC locality C29164; 582 feet above base of formation:

Asteroarchaediscus sp.
Biseriella sp.
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
new kamaenid genus
Neoarchaediscus sp.
Parathurammina sp.
Planospirodiscus sp.
Tetrataxis sp.

GSC locality C10678; 608 feet above base of formation:

apterrinellids
beresellid filaments
Beresella sp.
Eotuberitina sp.
Neoarchaediscus sp.

Tetrataxis sp.
Uraloporella sp.

GSC locality C29165; 615 feet above base of formation:

apterrinellids
Asteroarchaediscus sp.
Calcisphaera sp.
Diplosphaerina sp.
Eolasiodiscus sp.
Neoarchaediscus sp.
Planospirodiscus sp.
Pseudoglomospira sp.
Tetrataxis sp.

GSC locality C10680; 626 feet above base of formation:

apterrinellids
archaediscids
calcisphaerids
endothyrids
Pseudoglomospira sp.
Tetrataxis sp.

GSC locality C10681; 628 feet above base of formation:

apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Diplosphaerina sp.
Endothyra sp.
Endothyra of the group *E. similis* Rauzer-Chernoussova and Reitlinger
Neoarchaediscus sp.
Planoendothyra sp.
Pseudoglomospira sp.
Tetrataxis sp.

GSC locality C10684; 766 feet above the base of the formation:

apterrinellids
Asteroarchaediscus sp.
Calcisphaera sp.
Endothyra sp.
Neoarchaediscus sp.
Neoarchaediscus parvus (Rauser-Chernoussova)
Planoendothyra sp.
Planospirodiscus sp.
Tetrataxis sp.
Tetrataxis of the group *T. angusta* Vissarionova

GSC locality C10686; 801 feet above the base of the type section:

apterrinellids
Eotuberitina sp.
Neoarchaediscus sp.
Orthovertella sp.
Planospirodiscus sp.

GSC locality C29166; 850 feet above base of formation:

cf. *Anthracoporella* sp.
apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Bradyina sp.

Calcisphaera laevis Williamson
Endothyra sp.
Eostaffella sp.
Millerella sp.
Neoarchaediscus sp.
ozawainellids
Pseudoendothyra sp.
Pseudoglomospira sp.
Stacheiinae

GSC locality C10689; 962 feet above base of formation:

cf. *Anthracoporella* sp.
apterrinellids
Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Asteroarchaediscus cf. *A. gnomellus* Brenckle
Calcisphaera sp.
Diplosphaerina sp.
Earlandia sp.
Endothyra sp.
Eotuberitina sp.
Neoarchaediscus sp.
Ortonella sp.
Rectangulina sp.
Stacheiinae
Tetrataxis sp.
Ungdarellaceae

GSC locality C29167; 1,030 feet above base of formation:

algae, undetermined genus
cf. *Anthracoporella* sp.
Asphaltina sp.
Asteroarchaediscus sp.
Beresella sp.
beresellid algae
Bradyina sp.
Calcisphaera sp.
Diplosphaerina sp.
Eostaffella sp.
Eotuberitina sp.
kamaenid algae
Millerella sp.
Neoarchaediscus sp.
ozawainellids
Pseudostaffella sp.
Zellerina sp.

GSC locality C29168; 1,050 feet above base of formation:

cf. *Anthracoporella* sp.
Asteroarchaediscus sp.
Diplosphaerina sp.
Eotuberitina sp.
Neoarchaediscus sp.
ozawainellids
Zellerina sp.

GSC locality C10690; 1,163 feet above base of formation:

apterrinellids
Asteroarchaediscus sp.

Biseriella sp.
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Neoarchaediscus sp.
Tetrataxis sp.

GSC locality C10692; 1,309 feet above base of formation:

cf. *Anthracoporella* sp.
apterrinellids
Asphaltina sp.
Asteroarchaediscus sp.
Calcisphaera sp.
Eotuberitina sp.
Endothyra sp.
cf. *Komia*? sp.
Neoarchaediscus sp.
Neoarchaediscus grandis (Reitlinger)
ozawainellids
Rectangulina sp.
Tetrataxis sp.
Stacheiinae
Ungdarellaceae
age: late Morrowan or early Atokan (Zone 20 or lower part of Zone 21). "I have previously never encountered *Beresella-Pseudobradyina*? below Zone 21 in North America. *Pseudostaffella* is also not encountered below Zone 21, but in Eurasia this fusulinid is common in Zone 20. *Beresella* has not previously been recorded from as low as Zone 20, but in several of these samples it is associated with definite Zone 20 faunas."

(ii) Type section of Otto Fiord Formation, 2 miles north of van Hauen Pass, Ellesmere Island.

GSC locality C20530; about 700 feet above base of type section:

Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Asteroarchaediscus aff. *A. gnomellus* Brenckle
Beresella sp.
Biseriella sp.
Bradyina sp.
Bradyina of the group *B. cribrostomata* Rauzer-Chernoussova and Reitlinger
Calcisphaera sp.
Diplosphaerina sp.
Endothyra sp.
Eotuberitina sp.
cf. *Komia*? sp.
Palaeotextularia of the group *P. longisepta* Lipina
Planoendothyra sp.
Pseudobradyina? sp.
Pseudoendothyra sp.
primitive *Pseudostaffella* sp.
Tetrataxis sp.
Ungdarella sp.
Ungdarellaceae
age: late Morrowan or early Atokan (Zone 20 or lower part of Zone 21)

(iii) Section about 7 miles northeast of Girty Creek, head of Hare Fiord, northern Ellesmere Island:

GSC locality C20460; 2 feet above base of section:

Asphaltina sp.
Asteroarchaediscus sp.

Asteroarchaediscus gnomellus Brenckle
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Biseriella sp.
Biseriella parva (Chernycheva)
Calcisphaera laevis Williamson
Calcisphaera pachysphaerica (Pronina)
Climacammina sp.
Earlandia sp.
Endothyra sp.
Eostaffella sp.
cf. *Eostaffellina* sp.
Neoarchaediscus sp.
Neoarchaediscus parvus (Rauser-Tschernoussova)
Neoarchaediscus parvus regularis (Rauser-Tschernoussova)
Palaeotextularia sp.
Planospirodiscus taimyricus Sossipatrova
Planospirodiscus sp.
Pseudoendothyra sp.
Stacheoides sp.
Tetrataxis sp.
Zellerina sp.
Zellerina discoidea (Girty)
age: Zone 18; early Namurian.

GSC locality C20462; 11 feet above base of section:

apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Biseriella parva (Chernycheva)
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Eotuberitina sp.
Pseudoglomospira sp.
age: Zone 18; as C20460.

GSC locality C20507; 246 feet above base of section:

apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Neoarchaediscus sp.
Tetrataxis sp.
Tetrataxis of the group *T. conica* Ehrenberg *emend* von Möller
age: $\geqslant$ Zone 18; early Namurian or younger.

(iv) GSC locality C10836; 340 feet above base of section (bottom of formation not exposed; this locality is near the top of the formation); in the southwestern region of the Blue Mountains; 2 miles northeast of Hare Fiord Diapir, northern Ellesmere Island:

Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Archaediscus of the group *A. krestovnikovi* Rauser-Tschernoussova
Biseriella sp.
Biseriella parva (Chernycheva)
Neoarchaediscus sp.

Neoarchaediscus parvus (Rauser-Tschernoussova)
Neoarchaediscus parvus of the group *N. incertus* (Grozdilova and Lebedeva)
Planospirodiscus sp.
age: Zone 18 (or younger); Namurian.

(v) GSC locality C21230; 341 feet above the base of the section (the true base of the formation is not exposed); on the east side of the first glacier west of Wood Glacier, Krieger Mountains, northern Ellesmere Island (80°54′30″N, 85°15′00″W):

Beresella sp.
Bradyina sp.
Climacammina sp.
cf. *Deckerella* sp.
Pseudoendothyra sp.
Pseudostaffella (nearly quadratic)
age: Zone 22 or slightly younger (23); Moscovian. This is the youngest foraminiferal assemblage ever observed in the Otto Fiord Formation.

(vi) GSC locality C21241; 300 feet above the base of the section (the true base of the formation is not exposed); on the east side of the first glacier west of Wood Glacier, Krieger Mountains, northern Ellesmere Island (80°54′30″N, 84°15′00″W):

apterrinellids
Beresella sp.
Climacammina sp.
Diplosphaerina sp.
Earlandia sp.
Endothyra sp.
Komia sp.
Profusulinella sp.
Pseudoglomospira sp.
Tetrataxis sp.
Tuberitina sp.
Volvotextularia sp.
age: Kayalian or slightly younger.

(vii) GSC locality C4009; 200 feet below the top of the Otto Fiord Formation, 6.8 miles north of the head of Whitsunday Bay, Axel Heiberg Island (87°12′00″N, 79°27′00″W):

Asteroarchaediscus sp.
Neoarchaediscus sp.
Neoarchaediscus postrugosus (Reitlinger)
Planospirodiscus sp.
also vague ghosts of endothyrids and palaeotextulariids
age: Zone 20 (Bashkirian).

B. *Hare Fiord Formation*

(i) GSC locality C23301; 100 feet above the base of the Hare Fiord Formation, on the north side of Hare Fiord, 2 miles west of Stepanow Creek, northern Ellesmere Island (81°07′30″N, 84°20′00″W):

Ammovertella sp.
apterrinellids
Asteroarchaediscus sp.
Beresella? sp.
Biseriella sp.
Bradyina sp.
Calcitornella sp.
Earlandia sp.
Endothyra sp.
Eolasiodiscus sp.

Eotuberitina sp.
Palaeotextularia sp.
Planoendothyra sp.
Planospirodiscus (evolved forms) sp.
Tetrataxis of the group *T. angusta* Vissarionova
Tuberitina sp.
Volvotextularia sp.
age: early Moscovian.

(ii) Section through the "Tellevak Limestone member" of the Hare Fiord Formation on the west side of the Blue Mountains, 1.6 miles southeast of the southern tip of an elongate unnamed glacial lake a few miles northwest of Mount Schuchert (80°50′00″N, 85°04′00″W).

GSC locality C10798; 123 feet above base of section:

kamaenid algae
Globivalvulina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Tetrataxis of the group *T. angusta* Vissarionova

GSC locality C10801; 162 feet above base of section:

Eotuberitina sp.
Planoendothyra sp.
porcellaneous foraminifers
Tetrataxis sp.
Tuberitina bulbacea Galloway and Harlton

GSC locality C10812; 789 feet above base of section:

apterrinellids
Asteroarchaediscus sp.
Asteroarchaediscus of the group *A. baschkiricus* (Krestovnikov and Teodorovitch)
Calcisphaera sp.
Eolasiodiscus sp.
porcellaneous forms
Tetrataxis sp.
Tuberitina bulbacea Galloway and Harlton

GSC locality C10817; 1,000 feet above base of section:

apterrinellids
Asteroarchaediscus sp.
Asteroarchaediscus of the group *A. baschkiricus* (Krestovnikov and Teodorovitch)
Calcisphaera sp.
Planoendothyra sp.
Tetrataxis of the group *T. angusta* Vissarionova
Tuberitina bulbacea Galloway and Harlton
Neoarchaediscus sp.
age: The microfauna is too poor to give a precise zonation. It is not younger than "Middle Pennsylvanian" i.e. Atokan–Desmoinesian.

(iii) GSC locality C10772; 179 feet below the top of the "Tellevak Limestone member" of the Hare Fiord Formation, 3.4 miles northeast of Hare Fiord Diapir in the southern Blue Mountains, northern Ellesmere Island (80°43′33″N, 85°45′25″W). The ammonoid *Diaboloceras involutum* n. sp. occurs at this locality:

apterrinellids
Asteroarchaediscus sp.
Calcitornella sp.
Diplosphaerina sp.
Endothyra sp.
Eolasiodiscus sp.
Eotuberitina sp.

Globivalvulina of the group *G. bulloides* (Brady)
Neoarchaediscus sp.
Palaeonubecularia sp.
Planoendothyra sp.
primitive *Profusulinella* sp.
cf. *Sphaeroporella*? sp.
Tetrataxis sp.
age: early Moscovian.

(iv) Localities in the upper part of the "Tellevak Limestone member" of the Hare Fiord Formation on the east side of the first glacier west of Wood Glacier in the Krieger Mountains, northern Ellesmere Island.

GSC locality C21664; 330 feet below the top of the Tellevak Limestone:

apterrinellids
Calcitornella sp.
Climacammina sp.
Earlandia sp.
Eolasiodiscus sp.
Eotuberitina sp.
primitive *Globivalvulina* sp.
Komia sp.
Komia abundans Korde
Neoarchaediscus sp.
numerous evolved *Planospirodiscus* sp.
Tetrataxis of the group *T. angusta* Vissarionova
Tuberitina sp.
age: early Moscovian ("Vereyan").

GSC locality C21659; 290 feet below the top of the Tellevak Limestone:

apterrinellids
Asteroarchaediscus sp.
Climacammina sp.
Earlandia sp.
Endothyra sp.
Eolasiodiscus sp.
Eotuberitina sp.
Komia sp.
Neoarchaediscus sp.
primitive "*Ozawainella*" sp.
Palaeonubecularia sp.
Planospirodiscus sp.
Pseudoglomospira sp.
Tetrataxis sp.
Tuberitina sp.
age: early Moscovian ("Vereyan"); as C21664 (both being Zone 22).

GSC locality C21657; 280 feet below the top of the Tellevak Limestone:

Diplosphaerina sp.
Endothyra sp.
Eotuberitina sp.
Palaeonubecularia sp.
Planoendothyra sp.
Tetrataxis sp.
Tuberitina sp.
age: microfacies nondiagnostic.

GSC locality C21750; 240 feet below the top of the Tellevak Limestone. (The ammonoids *Gastricoeras glenisteri* and *Diaboloceras involutum* also occur at this locality):

Eotuberitina sp.
Climacammina sp.
Earlandia sp.
Endothyra sp.
cf. *Eoschubertella* sp.
Globivalvulina of the group *G. bulloides* (Brady)
Ozawainella sp. (in the Russian sense)
Profusulinella sp.
staffellids
age: Desmoinesian age equivalent, middle Moscovian.

GSC locality C21650; 230 feet below the top of the Tellevak Limestone:

Diplosphaerina sp
Earlandia sp.
Endothyra sp.
cf. *Eoschubertella* sp.
Globivalvulina of the group *G. bulloides* (Brady)
Komia sp.
Komia abundans Korde
Ozawainella sp. (in the Russian sense)
Profusulinella sp.
staffellids
age: Desmoinesian age equivalent, middle Moscovian; as C21750.

GSC locality C21648; 210 feet below the top of the Tellevak Limestone:

Bradyina cribrostomata Rauser-Tschernoussova and Reitlinger
Climacammina sp.
Climacammina of the group *C. moelleri* Reitlinger
Endothyra sp.
Fusulinella sp.
Globivalvulina of the group *G. bulloides* (Brady)
Komia sp.
Komia abundans Korde
Komia aff. *abundans* Korde
Ozawainella sp. (in the Russian sense)
Profusulinella sp.
Stacheiinae
Tetrataxis sp.
Ungdarella sp.
age: Desmoinesian (middle Moscovian).

GSC locality C21644; 180 feet below the top of the Tellevak Limestone:

apterrinellids
Bradyina sp.
Climacammina sp.
Eotuberitina sp.
Globivalvulina sp.
Komia sp.
Komia abundans Korde
"*Nostocites*"? sp.
Ozawainella sp. (in the Russian sense)
Pseudostaffella sp.
Staffella sp.
Planoendothyra sp.
Tetrataxis sp.
Tuberitina bulbacea Galloway and Harlton
age: Desmoinesian (middle Moscovian); as C21648.

C. *Nansen Formation*

(i) Type section of the Nansen Formation, along Girty Creek, 2.6 miles northeast of the head of Hare Fiord, northern Ellesmere Island.

GSC locality C20385; one foot above the base of the type Nansen Formation:

Asteroarchaediscus sp.
Biseriella sp.
Biseriella parva (Chernycheva)
Calcisphaera sp.
Diplosphaerina sp.
Endothyra sp.
Eostaffella sp.
cf. *Eostaffellina* sp.
cf. *Planospirodiscus* sp.
Zellerina sp.
Zellerina discoidea (Girty)
age: Zone 18; upper *Eumorphoceras* Zone equivalent.

GSC locality C20390; 14 feet above the base of the type Nansen Formation:

apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Biseriella parva (Chernycheva)
Calcisphaera sp.
Diplosphaerina sp.
Earlandia sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Brown *emend* Brady
Eostaffella sp.
kamaenid algae
Neoarchaediscus sp.
Neoarchaediscus sp. of the group *N. parvus* (Rauser-Tschernoussova)
"*Neoarchaediscus*" *gregorii* (Dain *in* Grozdilova and Lébedeva)
Neoarchaediscus incertus (Grozdilova and Lebedeva)
Pseudoendothyra sp.
Pseudolituotuba sp.
Tetrataxis sp.
Zellerina sp.
Zellerina designata (Zeller)
age: Zone 18; upper *Eumorphoceras* Zone equivalent.

GSC locality C20395; 40 feet above the base of the type Nansen Formation:

apterrinellids
Asteroarchaediscus sp.
Biseriella sp.
Biseriella parva (Chernycheva)
Calcisphaera laevis Williamson
Calcisphaera pachysphaerica (Pronina)
Climacammina sp.
Earlandia sp.
Diplosphaerina sp.
Endothyra sp.
Eostaffella sp.
Eostaffellina sp.
Neoarchaediscus sp.
Tetrataxis sp.
Zellerina sp.
age: Zone 18; upper *Eumorphoceras* Zone equivalent.

GSC locality C20402; 96 feet above the base of the type Nansen Formation:

Asteroarchaediscus sp.
Asteroarchaediscus baschkiricus (Krestovnikov and Teodorovitch)
Biseriella parva (Chernycheva)
Calcisphaera sp.
Endothyra sp.
Eostaffella sp.
Eostaffellina sp.
"*Neoarchaediscus*" *gregorii* (Dain *in* Grozdilova and Lebedeva)
Neoarchaediscus parvus (Rauser-Tschernoussova)
Planospirodiscus sp.
Planospirodiscus aff. *P. taimyricus* Sossipatrova
Pseudoendothyra sp.
Tetrataxis sp.
Zellerina sp.
age: Zone 18; upper *Eumorphoceras* Zone equivalent.

GSC locality C20414; 229 feet above the base of the type Nansen Formation:

Asteroarchaediscus sp.
Biseriella parva (Chernycheva)
Endothyra sp.
Eostaffella sp.
Eostaffellina sp.
Neoarchaediscus sp.
Planospirodiscus sp.
Pseudoendothyra sp.
Zellerina sp.
age: Zone 18; upper *Eumorphoceras* Zone equivalent.

GSC locality C20415; 238 feet above the base of the type Nansen Formation:

Asteroarchaediscus sp.
cf. *Eosigmoilina*?–*Quasiarchaediscus*? sp.
Eostaffella sp.
Planospirodiscus sp.
Zellerina sp.
age: probably Zone 19?; *Homoceras*-age equivalent.

GSC locality C20416; 268 feet above the base of the type Nansen Formation:

Asteroarchaediscus sp.
Calcisphaera sp.
Climacammina sp.
Earlandia sp.
cf. *Eosigmoilina*?–*Quasiarchaediscus*? sp.
Eostaffella sp.
Neoarchaediscus incertus (Grozdilova and Lebedeva)
Neoarchaediscus parvus (Rauser-Tschernoussova)
Palaeotextularia sp.
Planospirodiscus sp.
Planospirodiscus minimus (Grozdilova and Lebedeva)
Planospirodiscus taimyricus Sossipatrova
Tetrataxis of the group *T. conica* Ehrenberg *emend* von Möller
age: probably Zone 19?; as C20415.

GSC locality C20417; 283 feet above the base of the type Nansen Formation:

apterrinellids
Asteroarchaediscus sp.
Calcisphaera sp.
Climacammina sp.
Eostaffella sp.

cf. *Eosigmoilina*?–*Quasiarchaediscus*? sp.
Neoarchaediscus sp.
Planospirodiscus sp.
Tetrataxis sp.
age: probably Zone 19?; as C20415.

GSC locality C20546; 1,340 feet above the base of the type Nansen Formation:

Bradyina sp.
Bradyina magna Roth and Skinner
Climacammina sp.
Climacammina of the group *C. moelleri* Reitlinger
Eolasiodiscus sp.
Eotuberitina sp.
kamaenid algae
Ozawainella sp.
cf. *Pseudobradyina*? sp.
Pseudoendothyra sp.
Pseudoglomospira sp.
Staffella sp.
Tuberitina sp.
Ungdarella sp.
age: Moscovian.

GSC locality C20557; 1,480 feet above the base of the type Nansen Formation:

cf. *Anthracoporellopsis*? sp.
apterrinellids
Bradyina sp.
Bradyina magna Roth and Skinner
Climacammina sp.
Climacammina of the group *C. moelleri* Reitlinger
cf. *Deckerella* sp.
Endothyra sp.
Fusulinella sp.
Globivalvulina sp.
Komia sp.
cf. *Planoendothyra*? sp.
Profusulinella sp.
Pseudobradyina sp.
Staffella sp.
Tetrataxis sp.
age: Moscovian.

GSC locality C20559; 1,515 feet above the base of type Nansen Formation:

apterrinellids
Beresella sp.
Bradyina sp.
Bradyina magna Roth and Skinner
Climacammina sp.
Climacammina of the group *C. moelleri* Reitlinger
Deckerella sp.
Earlandia sp.
Endothyra sp.
Fusulinella sp.
Globivalvulina sp.
Komia sp.
Pseudobradyina sp.
Staffella sp.
age: Moscovian.

GSC locality C20568; 1,580 feet above the base of the type Nansen Formation:

Bradyina sp.
Deckerella sp.
Globivalvulina sp.
Komia sp.
Pseudobradyina sp.
Tetrataxis sp.
Tuberitina bulbacea Galloway and Harlton
age: middle Moscovian or younger.

GSC locality C20570; 1,689 feet above the base of the formation:

apterrinellids
Bradyina sp.
Climacammina of the group *C. moelleri* Reitlinger
Deckerellina sp.
Earlandia sp.
Globivalvulina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Haplophragmina sp.
Tetrataxis sp.
Tuberitina sp.
numerous fusulinids
age: middle Moscovian or younger.

D. *Canyon Fiord Formation*

(i) GSC locality C483; basal beds of the Canyon Fiord Formation, 6 miles northwest of the head of McCormick Inlet, Melville Island:

apterrinellids
Beresella sp.
Bradyina sp.
Earlandia sp.
Globivalvulina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Profusulinella sp.
age: Moscovian.

(ii) GSC locality C24070; basal beds of the Canyon Fiord Formation, 7 miles southwest of the head of Trold Fiord, Ellesmere Island:

apterrinellids
Beresella sp.
Bradyina sp.
Climacammina sp.
Climacammina of the group *C. moelleri* Reitlinger
Dvinella sp.
endothyrids
Earlandia sp.
Endothyra of the group *E. mosquensis* Reitlinger
Eolasiodiscus sp.
Globivalvulina sp.
Globivalvulina of the group *G. bulloides* (Brady)
Komia sp.
Palaeotextularia sp.
Pseudoglomospira sp.
Polytaxis sp.
Tetrataxis sp.

Ungdarella sp.

age: These small forams and algae associated with numerous fusulinids (*Profusulinella, Fusulina, Pseudostaffella*, etc.) indicate a Moscovian age. The assemblage belongs to Thompson's "*Fusulina*" zone and corresponds to the Des Moines Series of the American craton.

GSC locality C10885; 1,145 feet above the base of the Canyon Fiord Formation, 6 miles east of the head of Blind Fiord, southwestern Ellesmere Island (78°23′30″N, 85°23′00″W):

Asteroarchaediscus? sp.
Climacammina sp.
Endothyra sp.
Eoschubertella sp.
Planoendothyra sp.
Profusulinella sp.
Pseudoendothyra sp.
palaeotextulariidae
age: Zone 22 or younger (Atokan–Desmoinesian).

Fusulinid Identifications *by* Charles A. Ross

A. *Otto Fiord Formation*

(i) GSC locality C21230; 100 feet below the top of the Otto Fiord Formation on the east side of the first glacier west of Wood Glacier, Krieger Mountains, northern Ellesmere Island:

Pseudostaffella gorskyi (Dutkevich)
Eostaffella kashira var. *rhomboides* Rauser
age: Moscovian (Kashirian).

B. *Hare Fiord Formation*

(i) Section through the "Tellevak Limestone member" of the Hare Fiord Formation, on the east side of the first glacier west of Wood Glacier, Krieger Mountains, northern Ellesmere Island (same section as previous Otto Fiord locality).

GSC locality C21342; 215 feet above the base of the formation:

Eoschubertella cf. *E. obscura* var. *mosquensis* Rauser
Profusulinella (*Aljutovella*) cf. *P.* (*A.*) *cybae* Lentovich
Staffella (*Parastaffella*) sp.
Pseudostaffella ex gr. *P. gorskyi* (Dutkevich)
age: early Moscovian (Vereyan or Kashirian)

Crinoid Identifications *by* H. L. Strimple

A. *Hare Fiord Formation*

(i) GSC locality 56430; 100 feet above the base of the Hare Fiord Formation, on the north side of Hare Fiord, 2 miles west of Stepanow Creek, northern Ellesmere Island:

Oklahomacrinus sp.
Cydonocrinus sp.
Calyocrinus sp.
age: Atokan

PLATES 1 to 18

Plate 1

Figures 1, 3, 5, 6. (Page 51)

Boesites gracilis n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 3, holotype GSC 31913, x3; 5, 6, paratype GSC 31914, x3.

Figures 2, 9, 10. (Page 62)

Metapronorites ellesmerensis n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 2, paratype GSC 20019, x2; 9, 10, paratype GSC 31935, x3.

Figures 4, 7, 8. (Page 53)

Boesites scotti Miller and Furnish from the "Smithwick Shale" horizon in the Magdalena Formation, McCulloch County, West Texas; 4, topotype SUI 11875, x4.25; 7, 8, topotype SUI 2027, x3.75.

Figure 11. (Page 75)

Gonioloboceratoides curvatus n. gen., n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33688, x2.

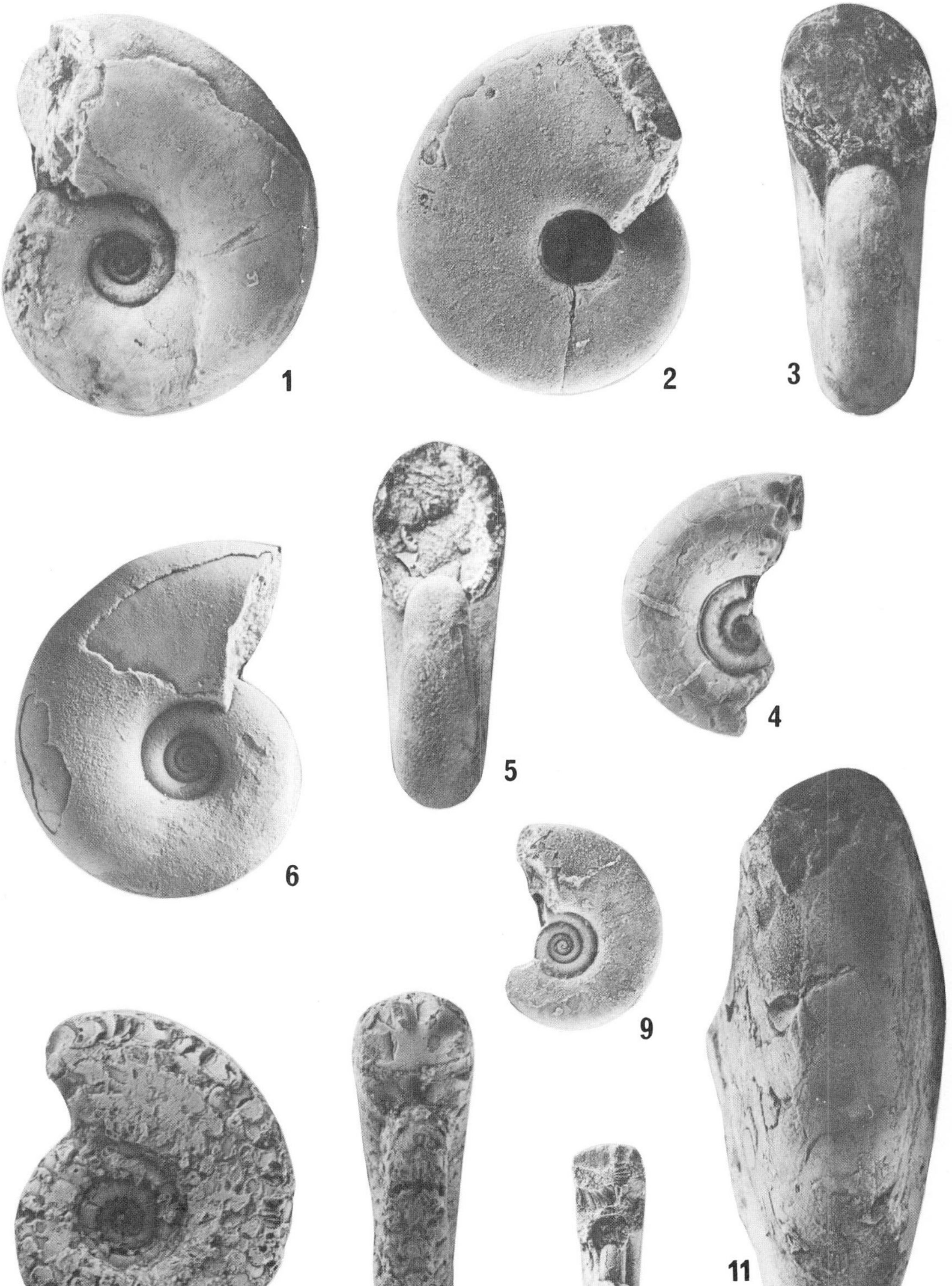

PLATE 2

Figures 1, 3. (PAGE 65)

Metapronorites pseudotimorensis (Miller) from the Canyon Fiord Formation on Ellesmere Island (GSC loc. C10885); 1, hypotype GSC 33675, x1.5; 3, hypotype GSC 33676, x2.

Figures 2, 7, 8. (PAGE 65)

Metapronorites pseudotimorensis (Miller) from the Gaptank Formation in West Texas; 2, 7, lectotype YPM 12931A, x2; 8, paralectotype YPM 12931D, x1.5.

Figures 4, 5, 6. (PAGE 65)

Metapronorites timorensis (Haniel) from the Somohole beds in Timor; 4, topotype SUI 37232, x1.5; 5, 6, topotype SUI 37233, x2.

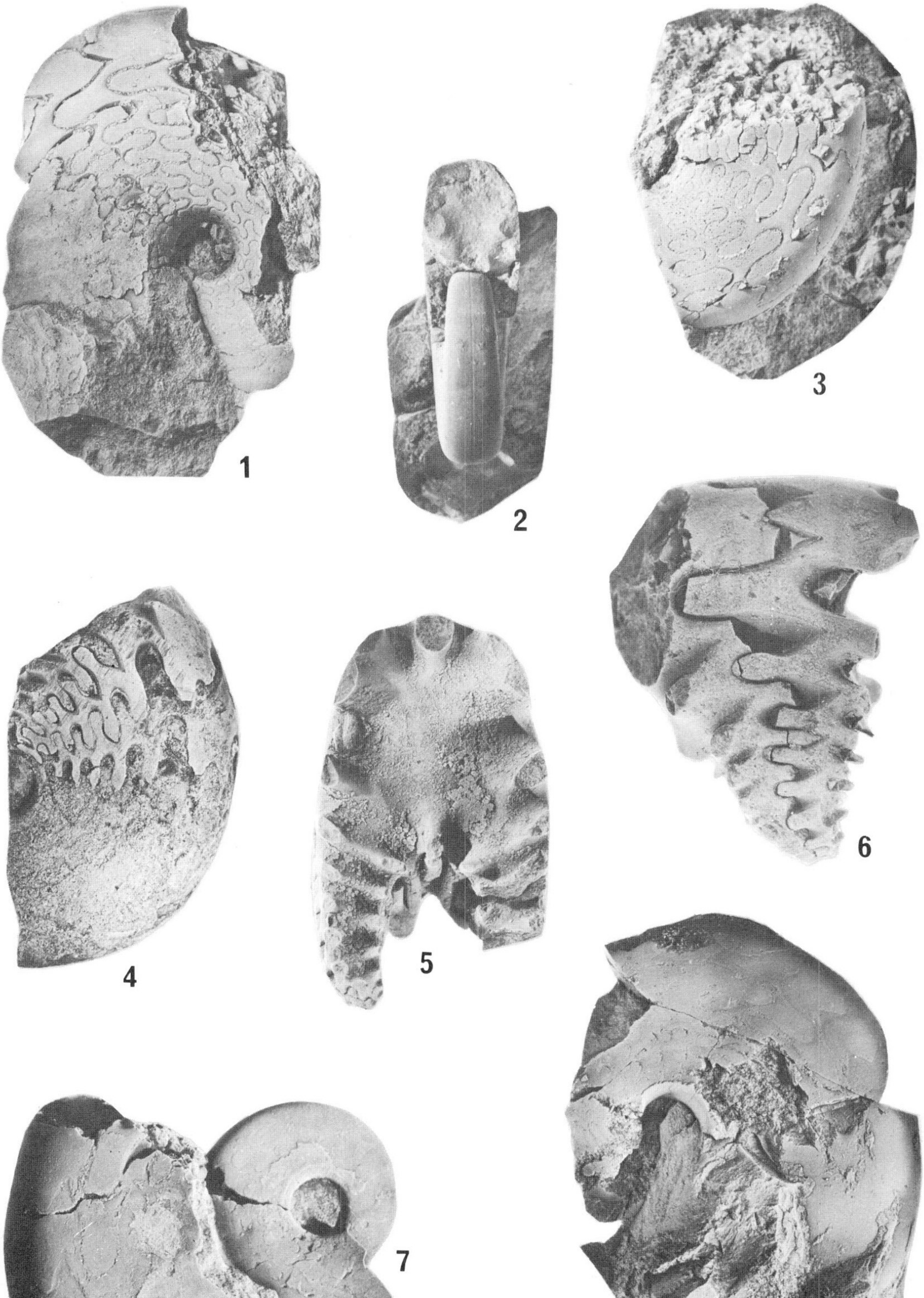
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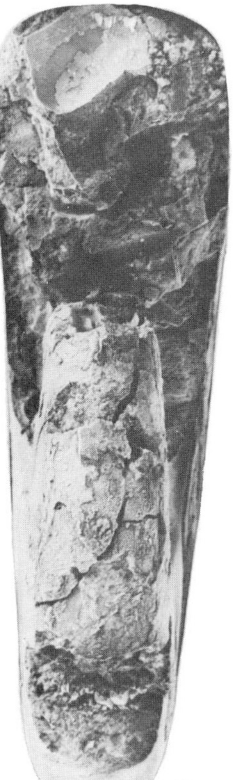
Plate 3

Figures 1, 2, 4, 5, 6. (Page 62)

Metapronorites ellesmerensis n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 4, holotype GSC 31932, x1.25; 2, paratype GSC 33672, x2; 5, paratype GSC 20019, x3.75; 6, paratype GSC 31937, x2.

Figure 3. (Page 59)

Pseudopronorites arkansiensis (Smith) from the Hare Fiord Formation on Ellesmere Island (GSC loc. C14582); hypotype GSC 31928, x1.25.



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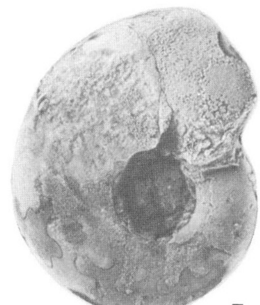

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Plate 4

Figures 1, 3, 4, 5, 8, 9. (Page 56)

Stenopronorites sersoni n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); 1, 3, holotype GSC 31921, x1.5; 4, paratype GSC 31924, x1.5; 5, paratype GSC 31927, x2; 8, 9, paratype GSC 31923, x1.5.

Figure 6. (Page 62)

Metapronorites ellesmerensis n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); paratype GSC 33671, x2.

Figures 2, 12. (Page 75)

Goniolobocerato ides curvatus n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); paratype GSC 33689, x3.

Figure 7. (Page 69)

Maximites alexanderi n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33679, x4.25.

Figures 10, 11, 13. (Page 71)

Neodimorphoceras sverdrupi n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 10, paratype GSC 33683, x3; 11, paratype GSC 33687, x2; 13, paratype GSC 33682, x2.5.

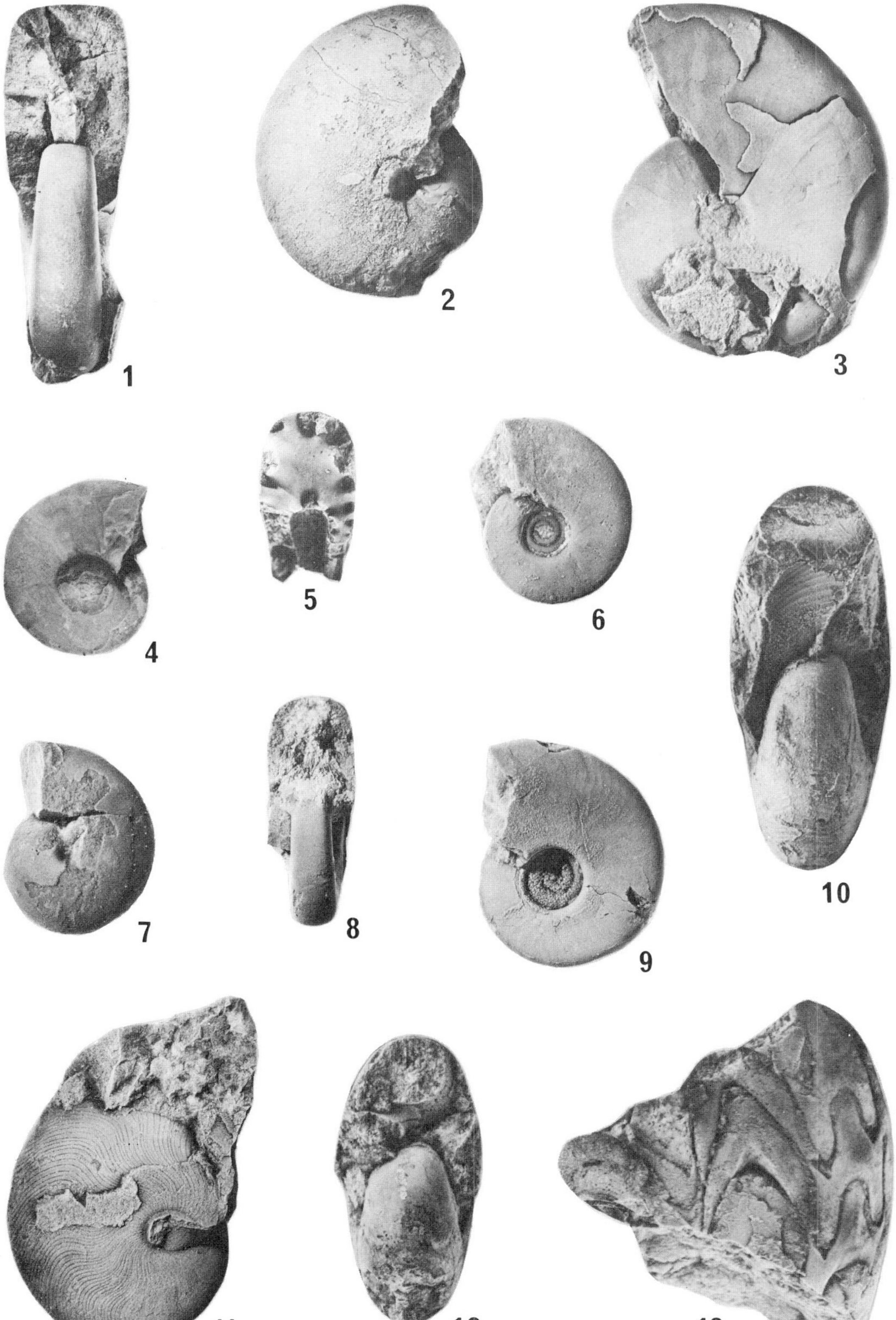
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Plate 5

Figures 1, 3, 4, 5, 9, 10. (Page 79)

Proshumardites aequalis n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 3, 4, holotype GSC 33691, x3; 5, paratype GSC 33692, x3; 9, paratype GSC 33687, x4; 10, paratype GSC 33695, x3.

Figures 2, 6. (Page 82)

Cravenoceras tozeri n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16904); paratype GSC 33703, x2.

Figures 7, 8. (Page 75)

Gonioloboceratoides curvatus n. gen., n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33688, x2.

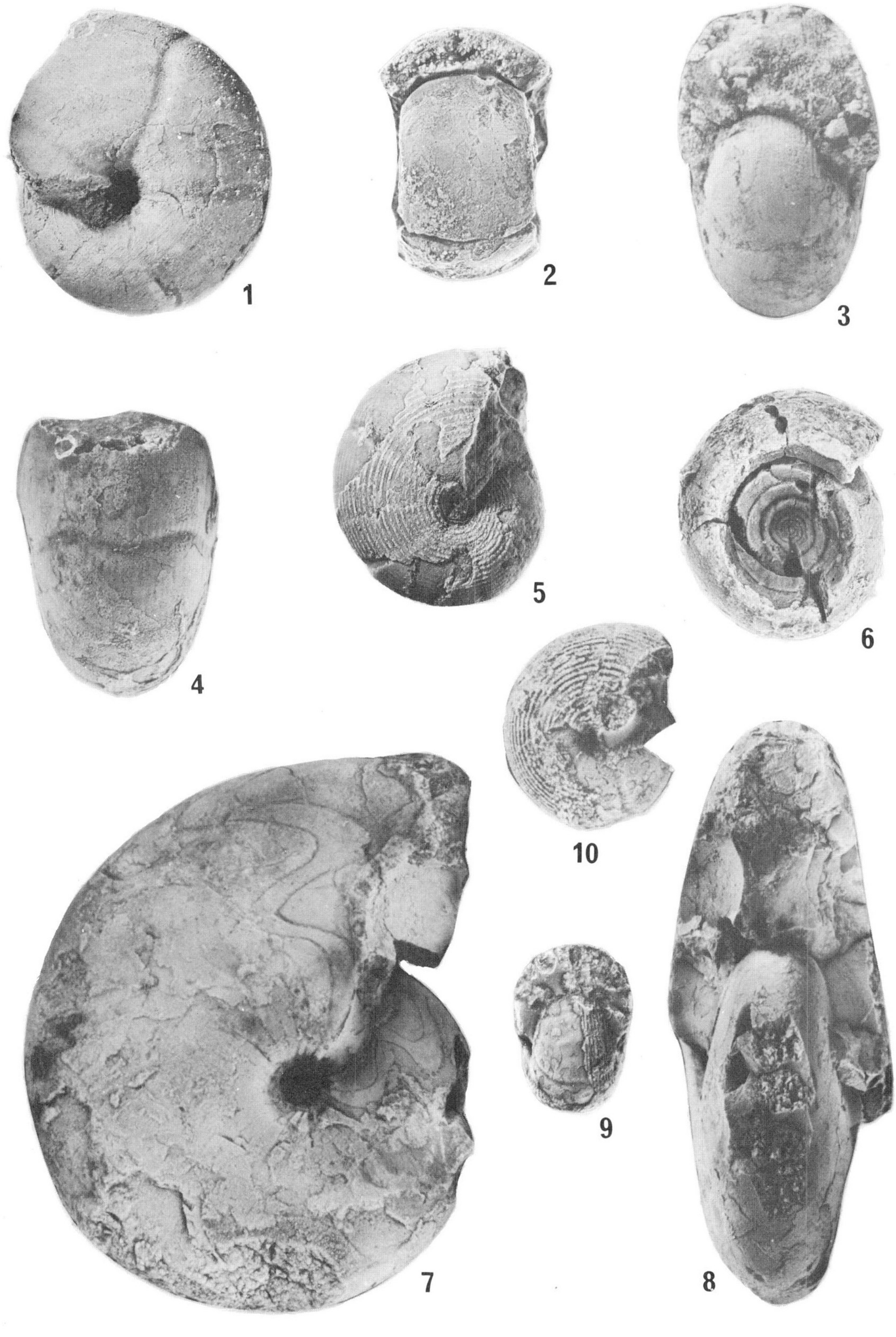
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Plate 6

Figures 1, 3. (Page 82)

Cravenoceras tozeri n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16904); paratype GSC 33702, x2.

Figures 2, 4, 7. (Page 86)

Syngastrioceras oblatum (Miller and Moore) from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); hypotype GSC 33704, x3.

Figures 5, 6, 8, 9. (Page 71)

Neodimorphoceras sverdrupi n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 5, 6, paratype GSC 33684, x2; 8, 9, holotype GSC 33681, x2.

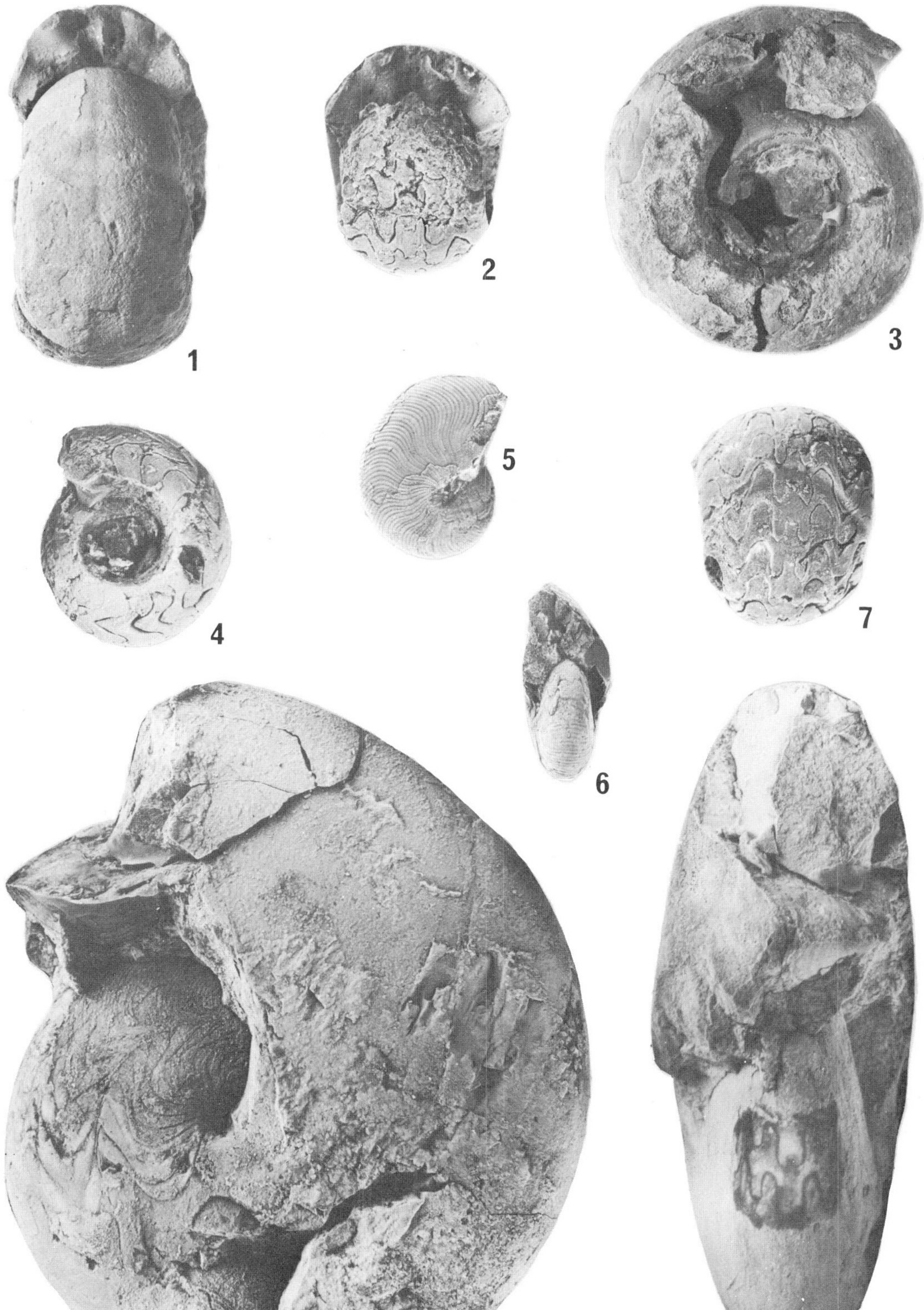
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Plate 7

Figures 1, 6. (Page 87)

Syngastrioceras orientale (Yin) from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56428); hypotype GSC 33707, x1.6.

Figure 2. (Page 90)

Syngastrioceras constrictum n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); paratype GSC 33712, x1.25.

Figures 3, 4. (Page 82)

Cravenoceras tozeri n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16904); 3, paratype GSC 33699, x2; 4, holotype GSC 33698, x2.

Figure 5. (Page 88)

Syngastrioceras smithwickense (Plummer and Scott) from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); hypotype 33705, x2.

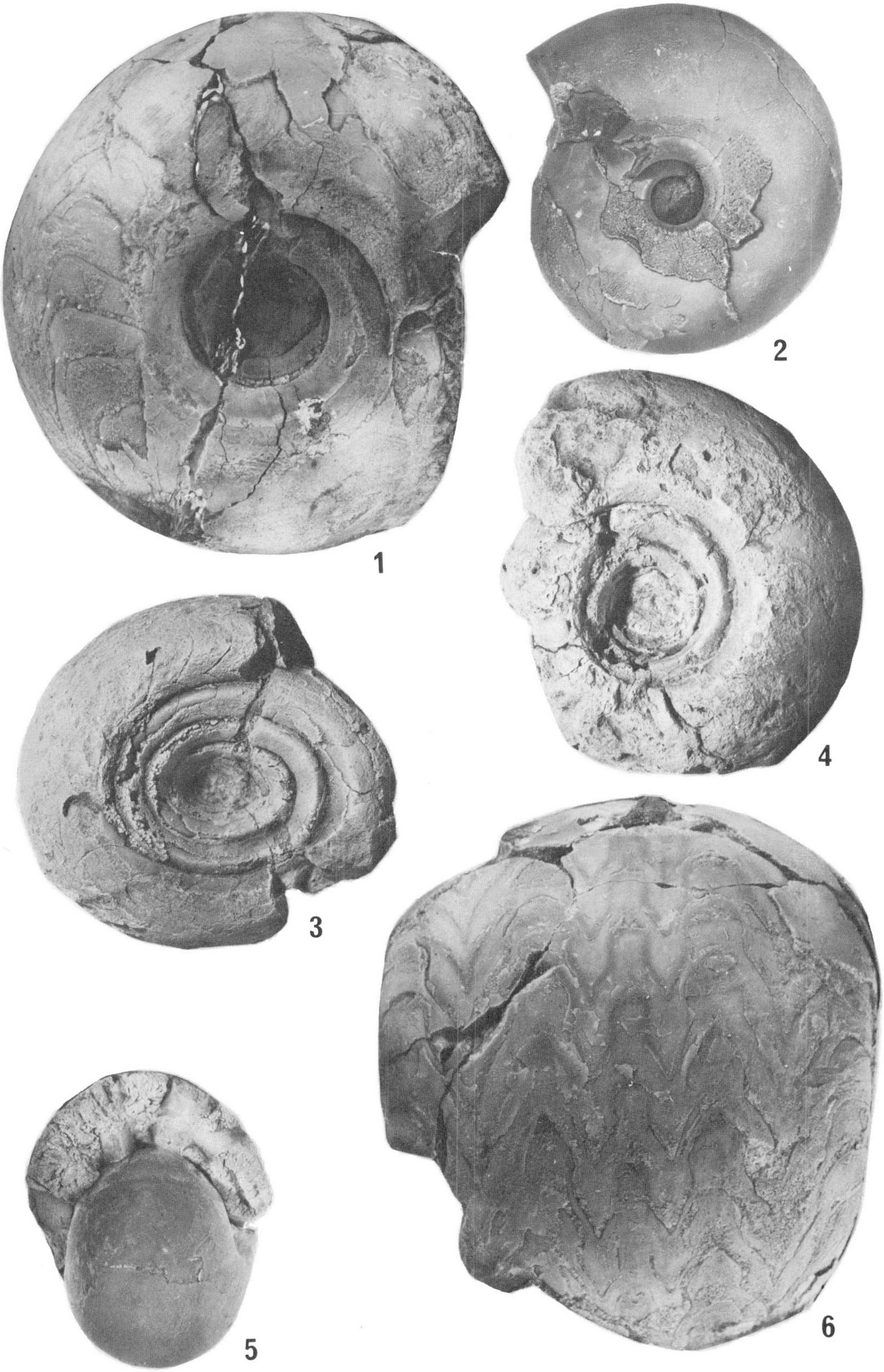
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Plate 8

Figures 1, 2. (Page 90)

Syngastrioceras constrictum n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); 1, holotype GSC 33709, x1.5; 2, paratype GSC 33714, x1.5.

Figures 3, 4, 10. (Page 96)

Neogastrioceras arcticum n. gen., n. sp., from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 3, 4, paratype GSC 33725, x2; 10, paratype GSC 33728, x1.5.

Figures 5, 6, 8. (Page 93)

Clistoceras globosum Nassichuk from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 5, topotype GSC 33721, x2; 6, topotype GSC 33720, x3; 8, paratype GSC 19966, x4.25.

Figures 7, 9. (Page 95)

Clistoceras sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); hypotype GSC 33722, x2.

Figure 11. (Page 109)

Neoicoceras martini n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33794, x1.75.

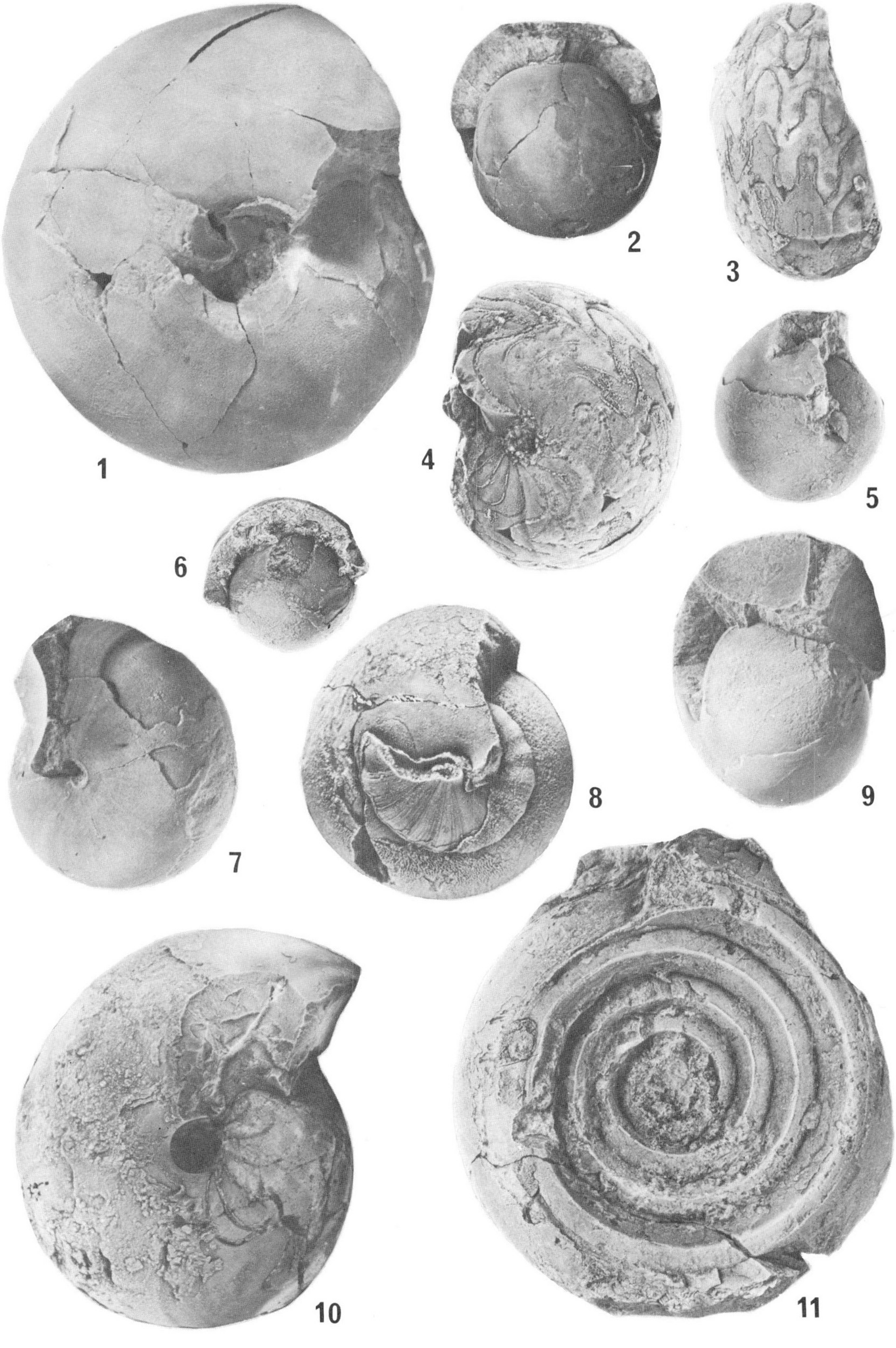
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PLATE 9

Figures 1, 3, 6, 7, 8, 9. (PAGE 93)

Clistoceras globosum Nassichuk from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 6, holotype GSC 19964, x2.4; 3, 7, paratype GSC 19968, x4; 8, 9, paratype GSC 19970, x4.5 (8) and x5.3 (9).

Figures 2, 4, 5, 10, 11, 13. (PAGE 109)

Neoicoceras martini n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 2, paratype GSC 33798, x2; 4, paratype GSC 33797, x2; 5, paratype GSC 19975, x2; 10, 11, paratype GSC 33799, x3.25; 13, paratype GSC 33801, x3.3.

Figures 12, 14. (PAGE 96)

Neogastrioceras arcticum n. gen., n. sp., from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33723, x1.5.

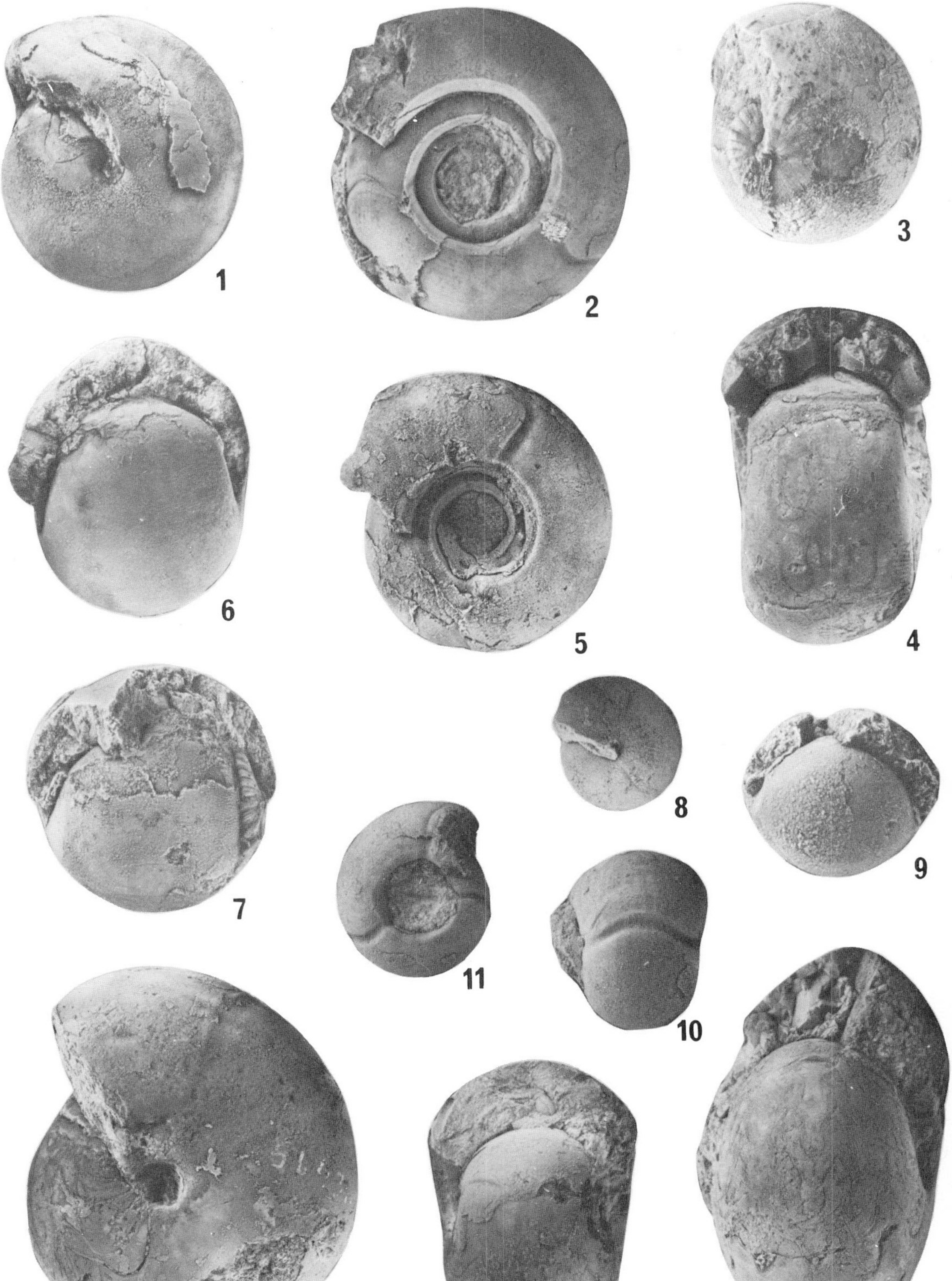
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PLATE 10

Figures 1, 3, 4, 7, 8. (PAGE 102)

Bisatoceras kotti n. sp. from the Hare Fiord Formation on Ellesmere Island (1, 3, 4 from GSC loc. 56430; 7, 8 from GSC loc. 58922); 1, 3, paratype GSC 33738, x3; 4, paratype GSC 33739, x3; 7, 8, hypotype GSC 33745, x1.3.

Figures 2, 5, 6, 9. (PAGE 100)

Bisatoceras hoeni n. sp. from the Otto Fiord Formation on Melville and Axel Heiberg Islands (2, 6 from "South Fiord Dome," Axel Heiberg Island: GSC loc. 47996 and 5, 9, from Barrow Dome on Melville Island: GSC loc. C16901); 2, 6, holotype GSC 33731, x2; 5, 9, hypotype GSC 33734, x2.

Figure 10. (PAGE 101)

Bisatoceras renni n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); holotype GSC 33735, x2.

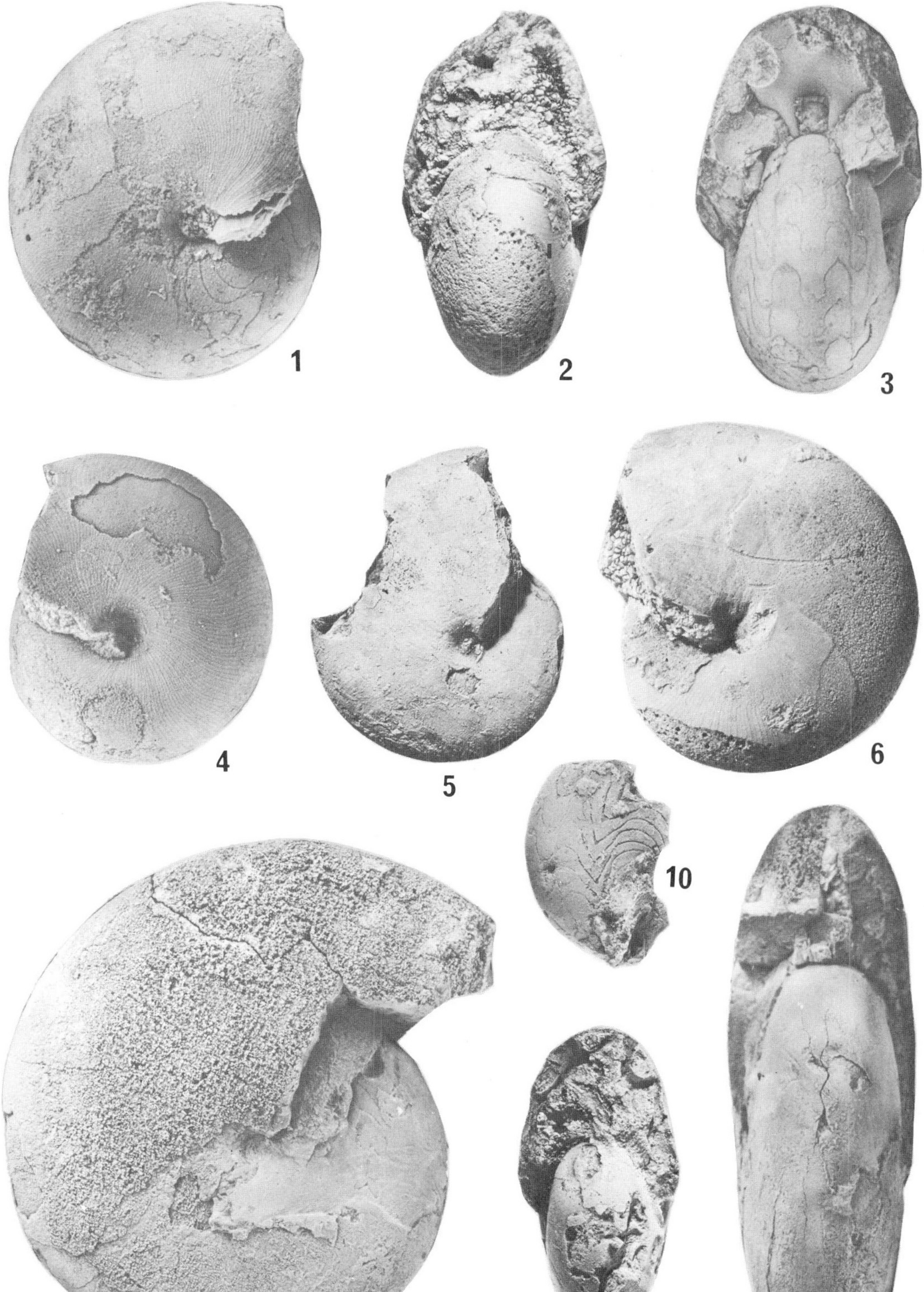
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Plate 11

Figures 1, 2, 5, 9. (Page 106)

Neoglaphyrites bisulcatus n. sp. from the Hare Fiord Formation on Ellesmere Island (1 from GSC loc. C10760; 2, 5, 9 from GSC loc. C4085); 1, hypotype GSC 33749, x1; 2, 9, holotype GSC 33748, x2; 5, paratype GSC 33751, x2.

Figure 3. (Page 114)

Phaneroceras compressum (Hyatt) from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4083); hypotype GSC 33762, x1.

Figures 4, 7. (Page 112)

Phaneroceras lenticulare Plummer and Scott from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); hypotype GSC 33754, x1.

Figures 6, 8. (Page 102)

Bisatoceras kotti n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); holotype GSC 33737, x2.

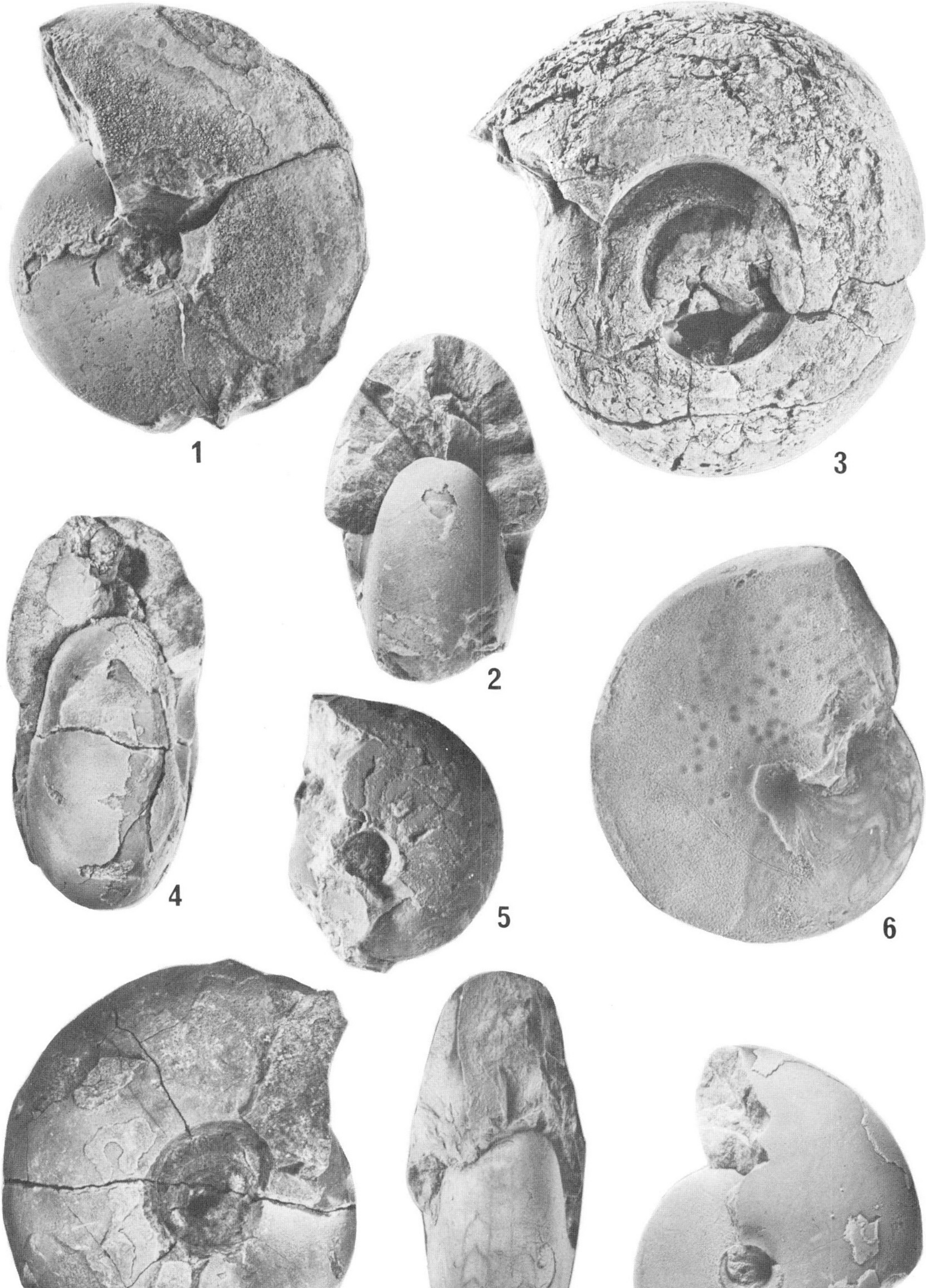
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Plate 12

Figures 1, 5. (Page 117)

Somoholites merriami (Miller and Furnish) from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4083); hypotype GSC 33764, x1.25.

Figures 2, 7, 8. (Page 123)

Bilinguites sp. from the Otto Fiord Formation at "South Fiord Dome," Axel Heiberg Island (GSC loc. 47996); 2, 7, hypotype GSC 33784, x1.5; 8, hypotype GSC 33783, x1.5.

Figures 3, 4, 6, 10. (Page 123)

Bilinguites heibergensis n. sp. from the Otto Fiord Formation at "South Fiord Dome," Axel Heiberg Island (GSC loc. 47996); 3, 10, holotype GSC 33780, x1.5; 4, 6, paratype GSC 33781, x1.5.

Figure 9. (Page 118)

Somoholites bamberi n. sp. from the Canyon Fiord Formation on Ellesmere Island (GSC loc. C10885); holotype GSC 33767, x2.

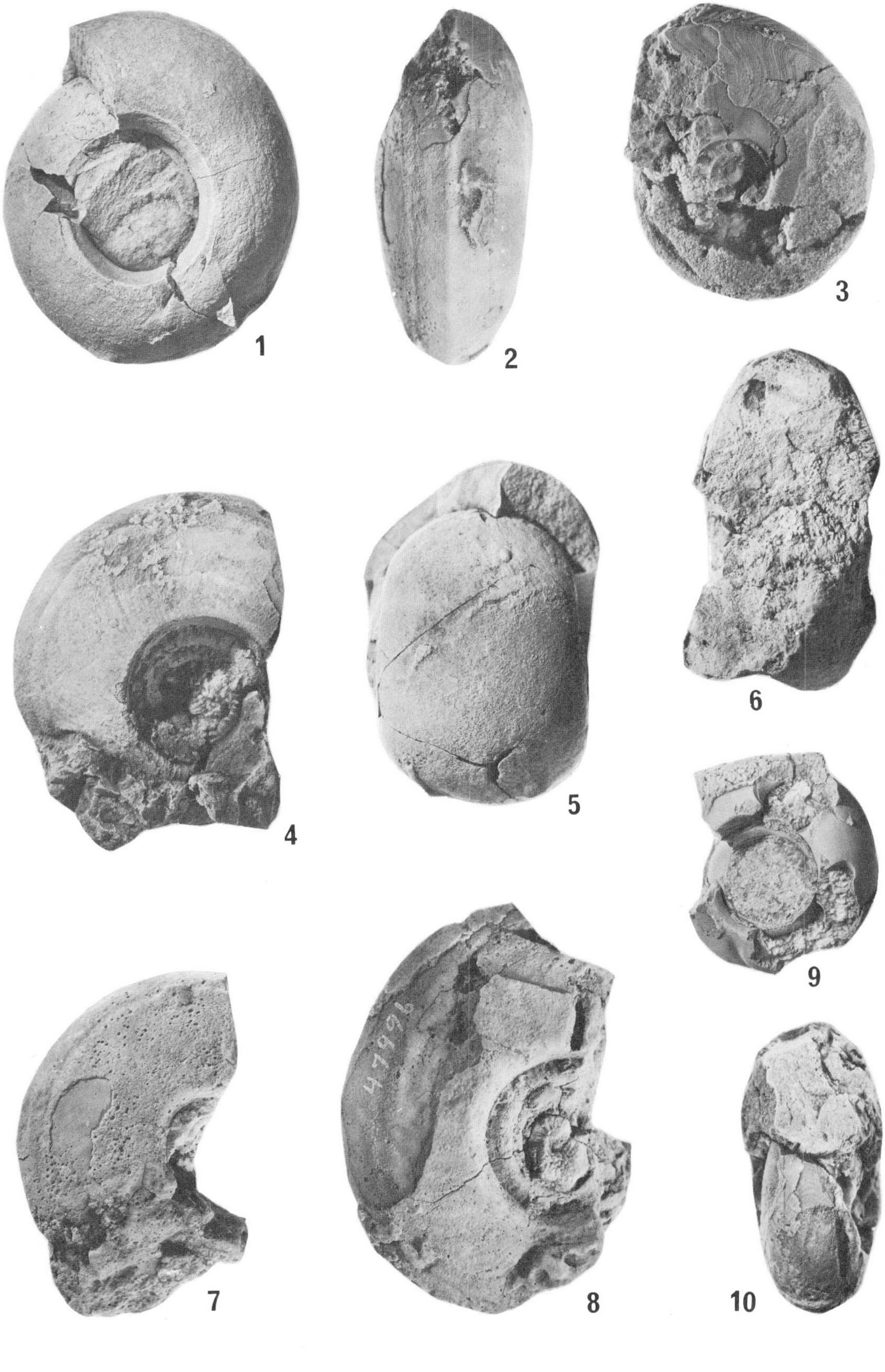
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PLATE 13

Figures 1, 2, 3, 4, 6, 9. (PAGE 121)

Bilinguites canadensis n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16901); 1, 9, holotype GSC 33772, x1.5; 2, 3, paratype GSC 33779, x2; 4, 6, paratype GSC 33778, x2.

Figures 5, 8, 10, 12. (PAGE 129)

Gastrioceras melvillensis n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); 5, 12, paratype GSC 33787, x1.5; 8, 10, holotype GSC 33785, x2.

Figure 7, 11. (PAGE 130)

Gastrioceras liratum n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); holotype GSC 33788, x2.


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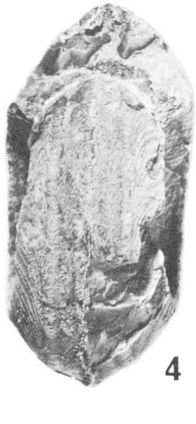
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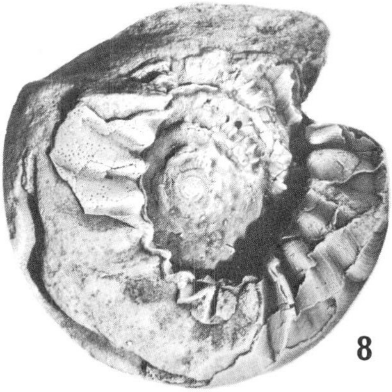
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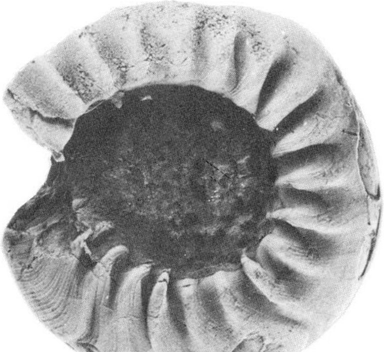
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Plate 14

Figures 1, 4, 10, 11. (Page 132)

Gastrioceras glenisteri n. sp. from the Hare Fiord Formation on Ellesmere Island (1, 4 from GSC loc. C4085; 10, 11, from GSC loc. C21750); 1, 4, holotype 33790, x1.5; 10, 11, hypotype GSC 33792, x1.

Figures 2, 5. (Page 131)

Gastrioceras sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); hypotype GSC 33786, x2.

Figures 3, 6, 7, 8, 9. (Page 135)

Melvilloceras sabinensis n. gen., n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16905); 3, 8, holotype GSC 33804, x2; 6, 7, paratype GSC 33806, x2; 9, paratype GSC 33805, x2.

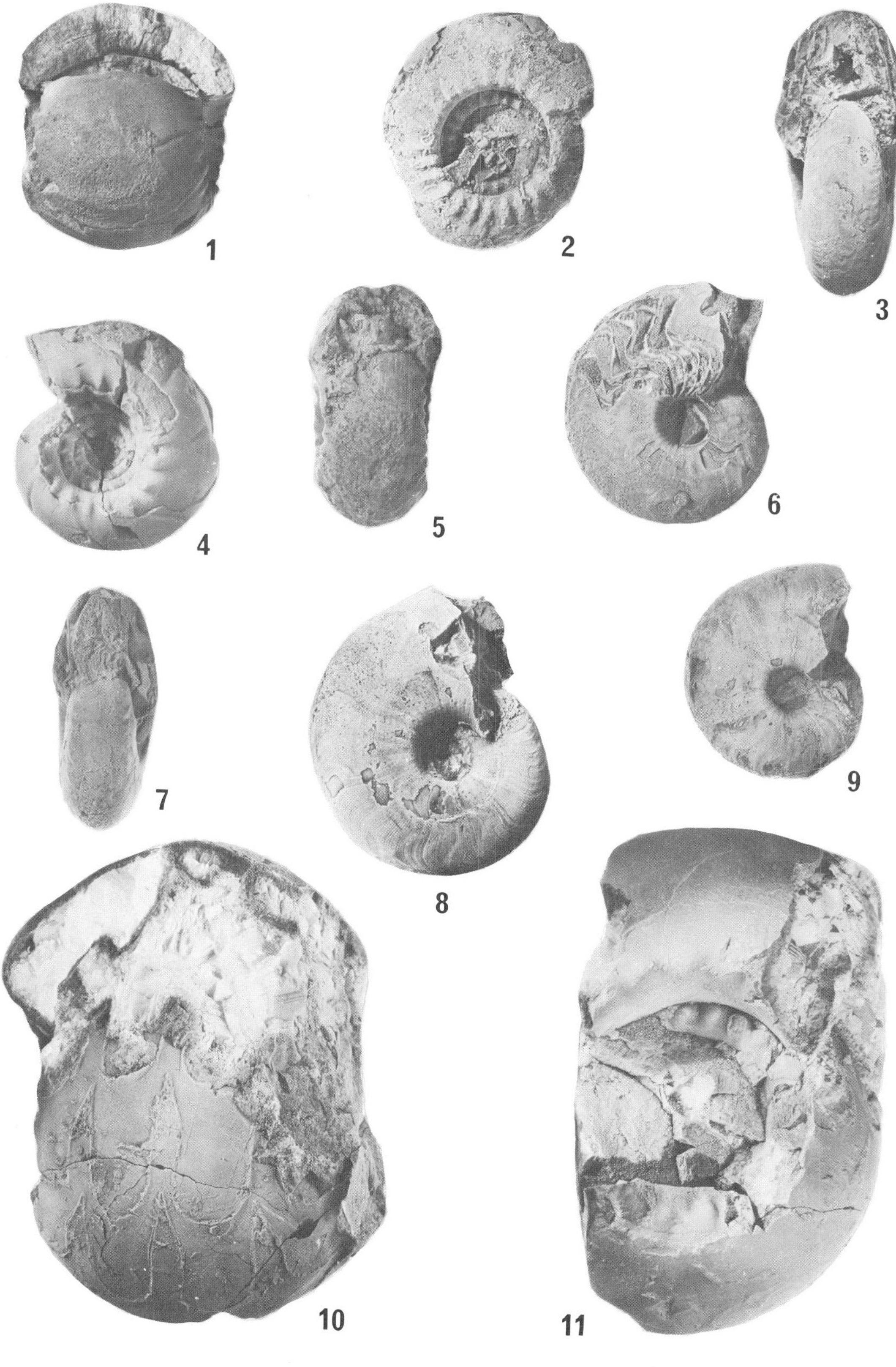
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Plate 15

Figures 1, 2, 8, 10, 11, 12. (Page 137)

Trettinoceras ellesmerensis n. gen., n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 2, paratype GSC 33811, x2; 8, 11, paratype GSC 33813, x2; 10, 12, holotype GSC 33810, x2.

Figures 3, 7, 9. (Page 151)

Diaboloceras involutum n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C14582); 3, hypotype GSC 33844, x1.25; 7, 9, hypotype GSC 33843, x1.25.

Figures 4, 5, 6. (Page 112)

Phaneroceras lenticulare Plummer and Scott from the Hare Fiord Formation on Ellesmere Island (4, from GSC loc. 58920; 5, 6 from GSC loc. 56428); 4, hypotype GSC 33760, x1.25; 5, hypotype GSC 33761, x1; 6, hypotype GSC 33759, x1.4.

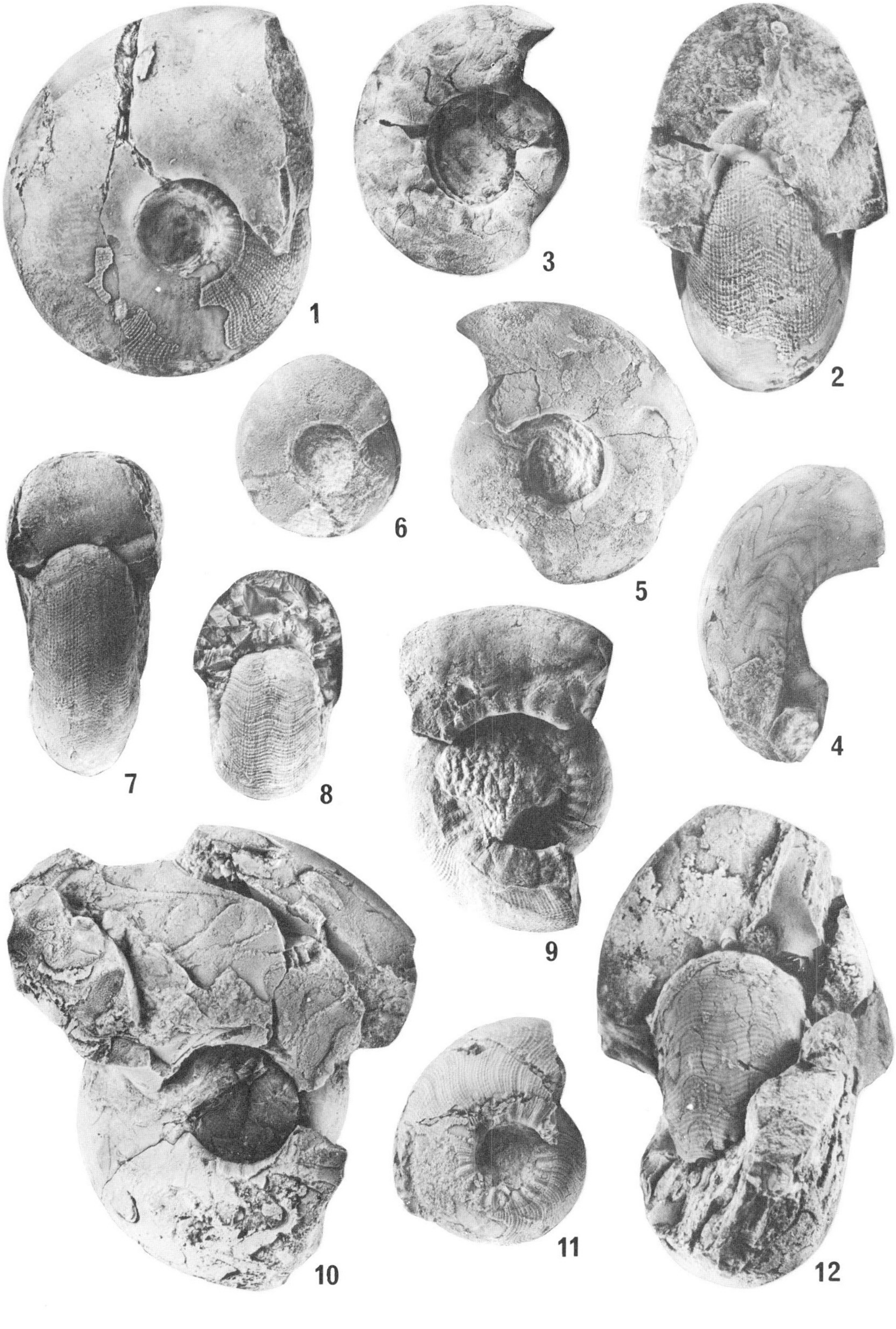
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Plate 16

Figures 1, 3, 4, 7, 9, 10, 15, 16. (Page 142)

Branneroceras branneri (Smith) from the Otto Fiord Formation at Barrow Dome, Melville Island (1, 4, 7, 10, 15 from GSC loc. C16903; 3, 9, 16 from GSC loc. C16905); 1, 3, 9 hypotype GSC 33822, x2; 4, 7, hypotype GSC 33817, x2; 10, 15, hypotype GSC 33819, x2; 16, hypotype GSC 33823, x2.

Figures 2, 6, 11, 12, 13, 14. (Page 144)

Branneroceras nicholasi n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16905); 2, paratype GSC 33829, x2.4; 6, 14, paratype GSC 33830, x2; 11, paratype GSC 33829, x2; 12, 13, holotype GSC 33827, x2.

Figure 5. (Page 147)

Branneroceras sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); hypotype GSC 33834, x2.

Figures 8, 17. (Page 137)

Trettinoceras ellesmerensis n. gen., n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); paratype GSC 33812, x2.

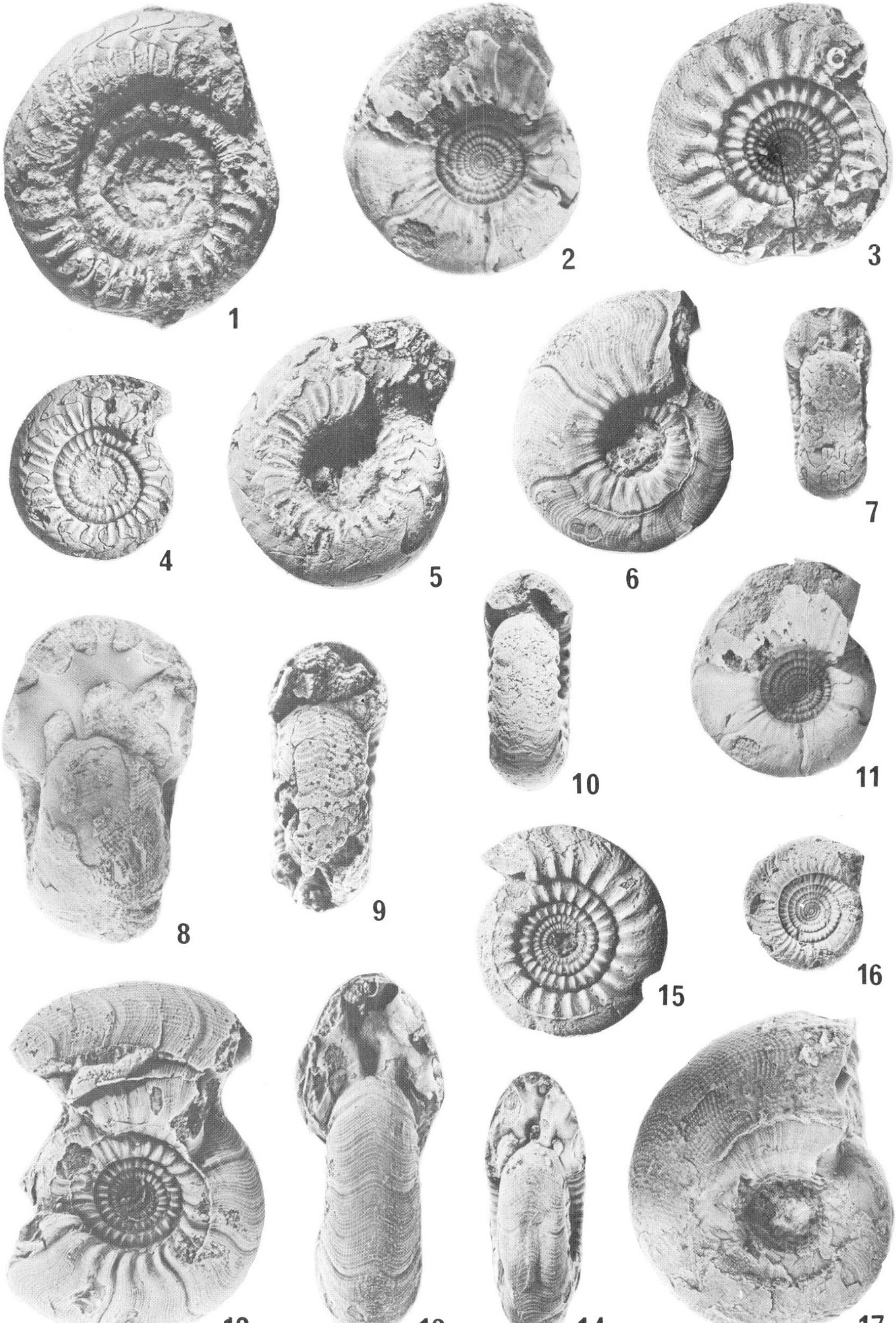
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Plate 17

Figures 1, 3. (Page 146)

Branneroceras hillsi n. sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); 1, holotype GSC 33831, x2; 3, paratype GSC 33832, x2.

Figure 2. (Page 147)

Branneroceras sp. from the Otto Fiord Formation at Barrow Dome, Melville Island (GSC loc. C16903); hypotype GSC 33833, x2.

Figures 4, 5, 6, 9. (Page 151)

Diaboloceras involutum n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. C4085); 4, 5, holotype GSC 33838, x1; 6, 9, paratype GSC 33840, x1.4.

Figures 7, 8. (Page 149)

Diaboloceras neumeieri Quinn and Carr from the Hare Fiord Formation on Axel Heiberg Island (GSC loc. C4012); hypotype GSC 33837, x2.

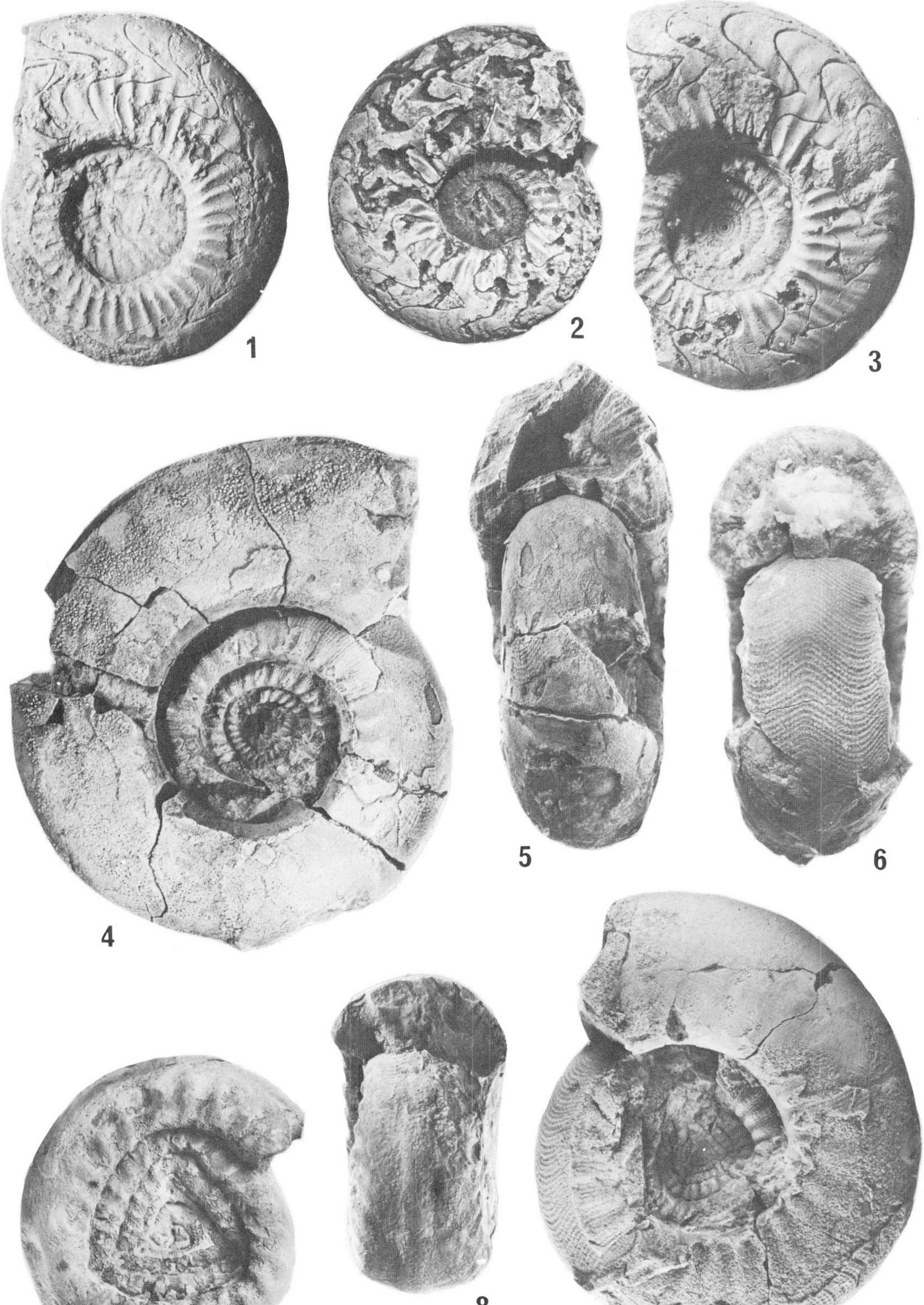
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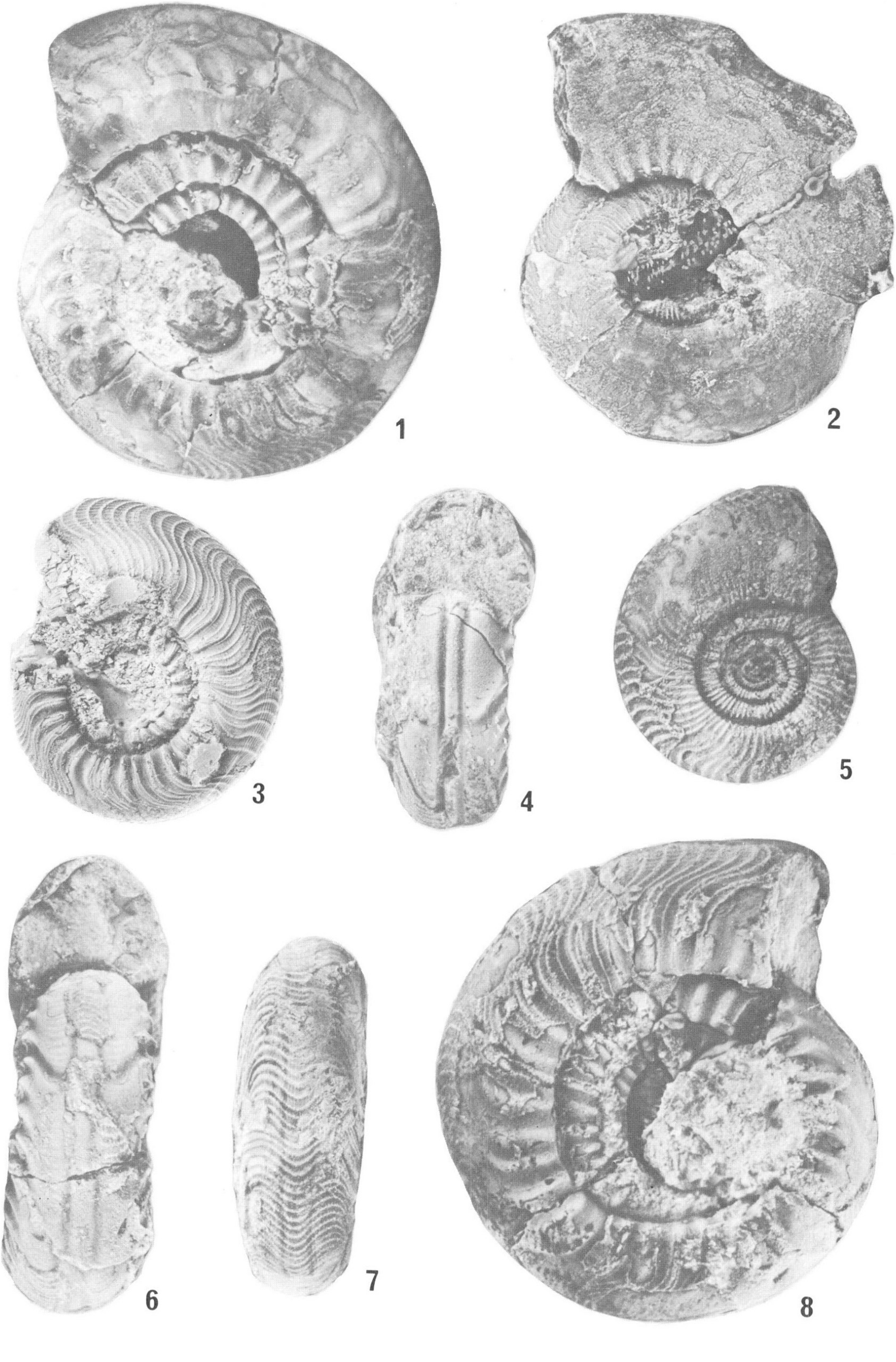
Plate 18

Figures 1, 3, 4, 6, 7, 8. (Page 153)

Winslowoceras greelyi n. sp. from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 1, 6, 8, paratype GSC 33846, x3.3; 3, holotype GSC 33845, x2; 4, paratype GSC 33848, x3.4; 7, paratype GSC 33847, x3.

Figures 2, 5. (Page 156)

Christioceras trifurcatum Nassichuk and Furnish from the Hare Fiord Formation on Ellesmere Island (GSC loc. 56430); 2, holotype GSC 19879, x3.3; 5, paratype GSC 19880, x5.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