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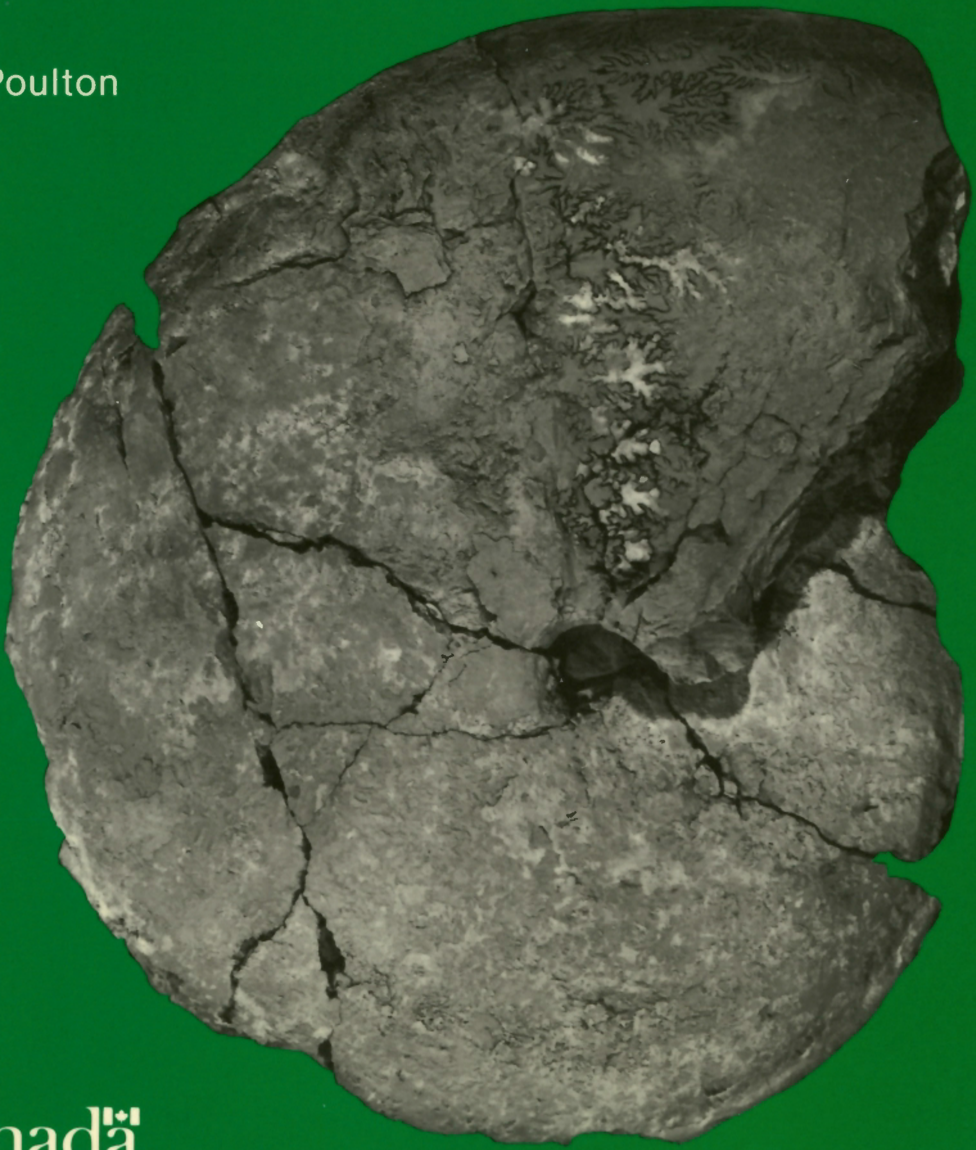
T.P. Poulton



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Oxycerites birkelundi from GSC locality 93570, see Plate 35.

PREFACE

Ammonites have long been recognized to be among the finest tools for correlation of Mesozoic rocks and have served as the inspiration for many current ideas on fossil species concepts, on the style and rate of evolution, and on paleobiogeographic provincialism.

This study describes the ammonites from a single, richly fossiliferous, and well exposed locality in northern Yukon where a succession of seven faunas is present. A new zonation for northwestern Canada is proposed based on this succession. The ammonites are mainly Boreal, and correlations of each zone with the published successions across the Arctic are discussed. The presence of some fossils with Pacific affinities contributes to resolution of the long-standing problems of correlation of Bathonian zones intercontinentally, via northern Yukon and Western Canada. Eight new species and one new genus are described.

Stratigraphic paleontological studies such as this lead to the development of widely accepted standards of correlation, essential tools in reconstructing the geological framework of Canadian sedimentary basins and evaluating their mineral and hydrocarbon resources.

OTTAWA, 1986

R.A. Price
Director General
Geological Survey of Canada

PRÉFACE

On reconnaît depuis longtemps l'utilité des ammonites dans la corrélation des roches mésozoïques; elles ont servi également de guide dans l'évolution de concepts traitant des espèces fossiles, par leur style et leur avancement évolutif, et ainsi que leur provincialisme palébiogéographique.

Cette étude décrit des ammonites provenant d'une localité unique, très fossilifére du Yukon septentrional où se situe une succession comprenant sept faunes. Cette succession a fourni la base de données qui nous permet de proposer une nouvelle zonation pour le Canada du nord-ouest. Les ammonites sont, pour la plupart, boréales, et des corrélations de chaque zone avec des successions de l'Arctique déjà rapportées y sont discutées. La présence de quelques fossiles ayant des affinités avec ceux du Pacifique contribue à la résolution de problèmes de longue durée portant sur la corrélation intercontinentale des zones bathoniennes, via le Yukon septentrional et le Canada occidental. On y décrit huit nouvelles espèces et un nouveau genre.

Des études stratigraphiques et paléontologiques telles que celle-ci nous mène à l'élaboration des standards de corrélation reconnus globalement. De tels standards sont essentiels à la compréhension de la structure géologique des bassins sédimentaires due Canada et à l'évaluation de leur potentiel économique en ressources minérales et en hydrocarbures.

OTTAWA, 1986

R.A. Price
Le directeur général
de la Commission géologique du Canada

CONTENTS

Illustrations

Figures

Tables

ZONATION AND CORRELATION OF MIDDLE BOREAL BATHONIAN TO LOWER CALLOVIAN (JURASSIC) AMMONITES, SALMON CACHE CANYON, PORCUPINE RIVER, NORTHERN YUKON

Abstract

The Middle Bathonian through Lower Callovian ammonites from the Salmon Cache Canyon section on Porcupine River are dominantly Boreal, represented by an upward succession of *Arctocephalites, Arcticoceras* and *Cadoceras* species. They are very similar to equivalent faunas in northern Alaska, East Greenland and northern Siberia, but differ at the species level, so that a new zonation for northern mainland Canada is proposed. In upward succession, the zones are: *spathi, porcupinensis, amundseni, frami, harlandi, ishmae* (from East Greenland; restricted), *barnstoni*, and *bodylevskyi*. Correlations with the Boreal zonations elsewhere are suggested. Additionally, a small proportion of Pacific and cosmopolitan ammonites in the collections permit further refinement of the correlation of the Boreal with the Pacific and ultimately with the Northwest European standard zonation. The Boreal Bathonian-Callovian boundary is placed in the interval between the *barnstoni* and *bodylevskyi* Zones.

One new genus is proposed – *Loucheuxia*, of subfamily Eurycephalitinae. New species erected are *Arctocephalites spathi, A. porcupinensis, A. praeishmae, A. amundseni, A. frami, A.*(?) *belli, Loucheuxia bartletti*, and *Oxycerites birkelundi*.

Keywords: *Bathonian, Callovian, ammonites, Yukon,* ***Arcticoceras, Arctocephalites, Cadoceras, Kepplerites, Louchuxia, Oxycerites.***

Résumé

Des ammonites d'âge Bathonien moyen au Callovien inférieur, provenan de la coupe de Salmon Cache Canyon et située sur la rivière Porcupine, sont pour la plupart boréales. Elles sont représentées par une succession ascendante des espèces d'*Arctocephalites*, d'*Arcticoceras*, et de *Cadoceras*. Elles ressemlent beaucoup aux faunes équivalentes localisées en Alaska septentrional, au Groenland oriental et en Sibérie septentrionale; cependant, elles se distinguent au niveau espèce, ce qui a mené à l'établissement d'une nouvelle zonation proposée pour le Canada continental nordique. En succession ascendante, les zones sont less suivantes: *spathi, porcupinensis, amundseni, frami, harlandi, ishmae* (du Groenland oriental; restreinte); *barnstoni*, et *bodylevskyi*. Des corrélations accompagnées de zonations boréales provenant d'ailleurs sont suggérées. De plus, une proportion mineure d'ammonites cosmopolites et due domaine pacifique présente dans les collections permet la corrélation plus précise entre le domaine boréale et le domaine pacifique, et, en fin de compte, la corrélation peut se faire aussi avec la zonation standard de l'Europe du nord-ouest. La frontière boréale du Bathonien au Callovien se situe dans l'intervalle entre les zones de *barnstoni* et de *bodylevskyi*.

On propose l'établissement d'un nouveau genre, *Loucheuxia*, de la sous-famille Erycephalitinae. Donc, les nouvelles espèces établies sont: *Arctocephalites spathi, A. porcupinensis, A. praieshmae, A. amundseni, A. frami, A.*(?) *belli, Loucheuxia bartletti*, et *Oxycerties birkelundi*.

Mots clés: *Bathonian, Callovian, ammonites, Yukon,* ***Arcticoceras, Arctocephalites, Cadoceras, Kepplerites, Louchuxia, Oxycerites.***

INTRODUCTION

The Boreal Bathonian section at Salmon Cache Canyon on Porcupine River is of interest for two reasons. Firstly, it exposes a succession of closely spaced concretionary layers that are richly fossiliferous, possibly the most biostratigraphically complete single section of its age anywhere in the Boreal Realm, and certainly the most complete section outside of eastern Greenland. The section, therefore, potentially provides a standard succession for the Boreal Bathonian of Arctic North America, and contributes in a major way to the development of an intercontinental Boreal Bathonian standard. Secondly, together with the predominant Boreal ammonite species, there also occur others with southern affinities. Some of these, together with a consideration of the ammonite succession elsewhere, permit some further elaboration of the correlation of the Boreal zonation with that of the circum-Pacific succession and with the Northwest European standard zonation. Unfortunately, these last ammonites belong mainly to genera that are long ranging and are too rare and poorly preserved to identify specifically, so that unequivocal correlations are not yet possible. Unlike most Boreal successions elsewhere, these faunal elements indicate access to Pacific seas to the south (Poulton, in press).

Outside of the typical area of Northwest Europe, recognition of the Bathonian-Callovian boundary remains elusive because of the absence of the critical guide fossils due to faunal provincialism. Although this interval is not well exposed in the Salmon Cache Canyon section, the ammonites present contribute to the resolution of this problem indirectly via correlation with East Greenland.

Only the Salmon Cache Canyon section and its faunas are described here. There are numerous other occurrences of equivalent faunas (see Poulton, 1978; Poulton et al., 1982), but they are mostly from localities that do not provide a succession of fossiliferous horizons or additional faunal data. They will be dealt with in a later publication. Because of their importance, the ammonite species found in this section are profusely illustrated, in order to document their variation within individual beds where possible, and their range of variation from one bed to another. Description of the ammonite faunas has required the description of many specimens collected as loose material below the section. For some of the less common, non-Boreal species, which are particularly significant forms for correlation southward, loose material is all that is available. Many of the loose specimens can be assigned confidently to the bed from which they came because of their association in a single concretion with a variety of other characteristic fossils, or because the character of the matrix of the concretion allows it to be compared with a particular lithologically distinctive bed in the section.

Faunal provincialism

Ammonoids, because of their rapid evolution displayed in a complex morphology, their abundance in marine rocks worldwide, and the wide geographic distribution of individual species, remain the principal guide fossils for correlation of Mesozoic marine rocks. Faunal provincialism, however, sets limits to what can be achieved in worldwide correlation. In practice, therefore, the succession of faunas must be recognized in each faunal province independently, and final interprovincial synthesis is achieved by correlation in regions of overlap. To this day, precise correlation of many of the zones of the Arctic Middle Jurassic with those of Northwest Europe and the western part of the Americas has not been achieved (e.g. Callomon, 1958), and a complete zonation for the Middle Jurassic of the circum-Pacific area is still lacking. Furthermore, the faunas present in the Jurassic of many areas, including some in Northern and Western Canada, are still undescribed, and the succession in some critical areas remains poorly documented.

The fact that marine Jurassic faunas exhibit provincialism was discussed extensively first by Neumayr (1883), with regard to the Upper Jurassic of Europe. He also expressed the basic principal that underlies provincialism, and gave some interpretations of its causes. That distinct faunal provinces in the Jurassic existed as far back as Bajocian time was recognized by Arkell (1956), who simplified distribution patterns into three faunal realms - Tethyan, Pacific and Boreal. Imlay (1965) discussed the evidence for, and application of, the faunal realms to North America in particular. The literature on Mesozoic marine faunal provincialism is large and is not reviewed here (see Jeletzky, 1971 for such a discussion), and hypotheses regarding its causes are many. Some amount of latitudinal climatic differentiation, together with restricted patterns of circulation in marine basins, in large part due to the interference by continental masses, seem to be widely accepted and sufficient causes for the distribution patterns as we see them.

With increasing knowledge of ammonite distributions arising from continued taxonomic work around the globe, it is apparent that neither their biogeographic patterns nor the biostratigraphy are as well understood or as clearcut as has been thought, even in Europe (e.g. Ziegler, 1980). For example, the abundance of phylloceratids and the presence of *Cadomites* in the mainly Boreal faunas described in this report is surprising, and indicates the premature character of generalizations regarding Jurassic ammonite distributions in the western Americas.

Faunal provincialism has made correlation of the European type Bathonian successions with those outside Europe difficult. Only recently have Bathonian rocks and fossils been widely recognized outside of Northwest Europe. The greatest advances were first made in the Arctic Atlantic areas, principally East Greenland.

Among the first of the Arctic species to be described was *Ammonites ishmae* Keyserling (now *Arcticoceras*), found in an isolated position in northern European Russia (Keyserling, 1846). Its similarity to European *Macrocephalites* led early workers to conclude that it was of Callovian age (the Callovian was, at that time, included in the Upper Jurassic). Other species that were ascribed to the Middle Jurassic could not be matched exactly with those of Europe, and a number of new names were introduced. Some were compared with *A. ishmae* of northern Russia. Given European generic identifications, collections over wide areas of the Arctic were dated as Callovian. Finally, it was recognized by Spath (1928, 1932) that the Arctic ammonites represented new genera – *Arcticoceras, Arctocephalites*, and *Cranocephalites* – that are entirely unknown in the classical areas of Europe. Spath (1932) dated these Arctic genera as Late Bathonian and Early Callovian, mainly on the strength of their general similarities and supposed phylogenetic relationship to the Indo-European Macrocephalitidae, at that time believed to range into the Bathonian more extensively than is currently thought.

Arkell (1956) recognized a widespread Bathonian regression and subsequent Callovian transgression over much of Europe and the circum-Tethys region. Misled by the mainly Callovian datings of faunas from the Arctic and Western North America, he concluded erroneously that the Bathonian regressive episode was worldwide. This conclusion reinforced the Callovian and Late Bathonian dating of faunas in North America and USSR which bore no relation to those of Europe, but which did resemble those of East Greenland.

Callomon (1959, 1975; Callomon and Birkelund, 1980) erected the current Boreal zonation for East Greenland (see Tables 1, 3). He proposed a Bathonian age for *Cadoceras calyx* and other faunas as old as the oldest *Cranocephalites* species, *C. borealis*. In order to emphasize the differences and the difficulty of correlating between the typical and the boreal successions, he proposed the term 'Boreal Bathonian' for the latter.

Previous work

The first Jurassic fossils that probably came from the Salmon Cache locality were discovered in the possession of Hudson's Bay Company chief factor, Mr. George Barnston, by H.Y. Hind, leader of the Assiniboine and Saskatchewan Exploring Expedition of the Northwest Territory, under instruction from the provincial secretary of Canada. The single sample contained two species of ammonite, both of which were described as new by F.B. Meek (1859), who mistakenly thought them to be Cretaceous, although he recognized their Jurassic affinities. The sample was presumed to have been carried to the trading post in Mackenzie River valley by trappers.

The next Jurassic fossils from this locality were collected along Porcupine River by R.G. McConnell in 1888. They also were misidentified as Cretaceous, by J.F. Whiteaves (McConnell, 1891, p. 123D, 124D).

Only a few sporadic regional mapping and petroleum exploration studies were conducted until 1955, when J.A. Jeletzky began a systematic stratigraphic study of the Mesozoic rocks of northern Yukon and adjacent Northwest Territories.

The Late Jurassic age of McConnell's (1891) 'Sandstone and quartzite series' was first recognized by Jeletzky (1960, Correlation Chart) who later (Jeletzky, 1977) named them the Porcupine River Formation. The ammonites collected by McConnell and Jeletzky from the underlying shales were described as Jurassic species, and a brief summary description of the section measured by Jeletzky was published (Frebold, 1961, p. 2, 6, 10). A redescription of the holotype of *Cadoceras barnstoni* (Meek) (Frebold, 1964) and a description of one specimen of *Iniskinites* collected by D.K. Norris during the course of a regional mapping project called Operation Porcupine (1962-present) have appeared since then (Frebold, 1978).

Present study and acknowledgments

At the suggestion of J.A. Jeletzky, the Salmon Cache Canyon section was studied in 1975, when the author and J.H. Callomon began a detailed regional study of the pre-Late Jurassic rocks and faunas of the area. Callomon and the author, together with T. Birkelund, R.L. Detterman, and D.H. McNeil, restudied the section in 1981. In addition to their continuing assistance and advice on the section and its ammonites, including preliminary identifications, Callomon and Birkelund made available a great deal of unpublished information, including manuscripts, and showed the writer collections from the similar East Greenland succession. The present report incorporates some of this information on East Greenland, in part paraphrased with permission. Much of the description of the Salmon Cache Canyon section itself, as well as the original base of Figure 4 (excluding the range chart), were done by Callomon. Additionally, Callomon made available to the author an unpublished manuscript reviewing taxonomically and reinterpreting the successions of Western North American Middle Jurassic ammonites (Callomon, 1984). H. Frebold made preliminary identifications of the 1975 collections from Salmon Cache Canyon. All of the results stated in this report regarding the North American faunas are the responsibility of the author however, arising from independent study or restudy of the fossils and rocks. Study of type and other material from Arctic and Western North America was facilitated by the courtesies of T.E. Bolton and R.W. Imlay.

Two preliminary reports arising from this study, and mentioning the Salmon Cache section in summary form, with since-revised ammonite identifications, have been published (Poulton and Callomon, 1976; Poulton, 1978) and other comprehensive reports on the Jurassic stratigraphy of the area are available (Poulton, 1982; Poulton et al., 1982). J.H. Callomon (1984) has summarized the ammonite succession at Salmon Cache Canyon with an independent interpretation, in a revision of Western and Arctic North American Middle and Upper Jurassic ammonites. J.A. Jeletzky and D.K. Norris have provided much advice to the writer and critical discussion on the geologic situation of the section. Particular thanks go to B.C. Rutley and W.B. Sharman for their patience and skill in the preparation of the photographs, and to P.L. Greener and H. King, for the production of the typescript. The entire manuscript, in an earlier form, was critically read by T. Birkelund and J.H. Callomon, and all but the taxonomic section was read, and significantly improved, by E.T. Tozer.

GEOLOGICAL SETTING

Regional stratigraphic relationships

The Lower and Middle Jurassic siltstone-sandstone succession at Salmon Cache Canyon is part of the nearshore, shallow marine Bug Creek Group (see Table 2), that extends southwest from west-central Mackenzie Delta to the low hills that comprise the northeastern extension of Keele Range between Old Crow Flats and Eagle Plain (figs. 1, 2). The Lower and Middle Jurassic rocks of this belt are enriched in sand and, as one progresses southeast onto the craton, the sandstone beds become pebbly. The succession is thinner and more strongly punctuated by unconformities to the southeast than it is to the northwest, where it passes into the stratigraphically more complete siltstone-shale facies of the Kingak Formation in Brooks-Mackenzie Basin (Poulton, 1978; Poulton et al., 1982; Balkwill et al., 1983).

TABLE 1

Correlation Chart, Middle Bathonian to Lower Callovian ammonite zones in Boreal Realm, and the Northwest European zonation. Double vertical line separating Northwest Europe from other columns indicates intervals of still uncertain correlation.

BOREAL SUBSTAGES	NORTHERN YUKON ZONES (This report)	NORTHERN ALASKA Imlay (1955, 1976)	CANADIAN ARCTIC ARCHIPELAGO Frebold (1961, 1964)	NORTH SEA Callomon (1975, 1979)	FRANZ JOSEF LAND Newton and Teall (1897) Pompeckj (1899) Whitfield (1906)	SVALBARD Sokolov and Bodylevsky (1931) Pchelina (1967) Rawson (1982)	NOVAYA ZEMLYA Frebold (1951) Bodylevsky (1967) Cherkesov and Burdykina (1981)
LOWER CALLOVIAN			*Cadoceras septentrionale*, *C. septentrionale* var. *latidorsata*				
	BODYLEVSKYI		*Cadoceras bodylevskyi*, *C.* sp. cf.*C. falsum* *C. barnstoni* *C. barnstoni* var. *arcuata*			*Kepplerites svalbardensis*, *K. "tychonis"*	
UPPER BATHONIAN							
	BARNSTONI						
				Kepplerites stephanoides, *Arcticoceras cranocephaloides*			
	ISHMAE	*Arcticoceras ishmae (?)*	*Arcticoceras ishmae*	*Arcticoceras* cf. or aff. *A. ishmae*, *Arcticoceras michaelis*, *Arcticoceras* sp. indet.		*Arcticoceras* cf.*ishmae (?)*	*Arcticoceras ishmae*, *A.* cf. *excentricum*
	HARLANDI					*Arcticoceras harlandi*, *Costacadoceras bluethgeni*	
MIDDLE BATHONIAN							*"Arctocephalites aff. groenlandicus"*
	FRAMI						
	AMUNDSENI						
	PORCUPINENSIS	*Arctocephalites* cf. *elegans*, *A.* cf. *arcticus*	*Arctocephalites "elegans"*, *A. callomoni*, *A.* cf. *A. arcticus*, *A.* aff. *A. pilaeformis and A. arcticus*	*Arctocephalites arcticus*, *Arctocephalites* cf. *sphaericus*	*Arctocephalites arcticus*, *A. nudus*, *A. pilaeformis*, *A. koettlitzi*, *A. ellipticus*, *A. callomoni (?)*		*Arctocephalites elegans*, *A.* cf. *ellipticus*, *A. ornatus*, *A. arcticus*, *A.* spp. *Oxycerites* aff. *jugatus*
	SPATHI						

EAST GREENLAND Callomon (1959, 1975, 1979, pers. comm.) Birkelund et al. (1971) Surlyk et al. (1973) Zones		NORTHERN SIBERIA Bodylevsky (1937) Voronetz (1962) Basov et al. (1967) Meledina (1966, 1968, 1973, 1977) Saks et al. (1976) Meledina and Nal'nyaeva (1972) Dzhinoridze and Meledina (1966) Zones		NORTHERN EUROPEAN RUSSIA Bodylevsky (1960) Saks et al. (1976)	NORTHWEST EUROPE Zones	STANDARD SUBSTAGES
CALLOVIENSE	*Sigaloceras calloviense*	EMILIANZEVI	*Cadoceras emilianzevi, C. subtenuicostatum*	*Sigaloceras calloviense*	CALLOVIENSE	LOWER CALLOVIAN
	Cadoceras septentrionale					
NORDENSKJOLDI	*Cadoceras nordenskjoldi, etc.*	'ELATMAE'	*Cadoceras "elatmae", C. anabarense, C. falsum*	*Cadoceras elatmae,* C. cf. *glabrum, C. simulans, C. tschernyschevi, Kepplerites* cf. *tychonis*	MACROCEPHALUS	
APERTUM	*Cadoceras apertum, C.* spp., *Kepplerites traillensis, K.* spp.					
CALYX	*Cadoceras calyx, C.* spp. *Kepplerites vardekloeftensis, K.* spp.				DISCUS	UPPER BATHONIAN
VARIABILE	*Cadoceras variabile, C.* spp. *Kepplerites rosenkrantzi, Arcticoceras* spp.		*Cadoceras subcalyx, C. (?) excelsus, C. densicostatum, C. variabile*			
CRANOCEPHALOIDES	*Kepplerites tychonis, Arcticoceras* sp. aff. *A. cranocephaloides*					
	K. stephanoides, K. tychonis var. fasciculata Arcticoceras cranocephaloides					
ISHMAE	*Arcticoceras ishmae, Oxycerites birkelundi Oecotraustes*	ISHMAE	*Arcticoceras ishmae, A. excentricum, A. stepankovi, Costacadoceras* spp. *Siemiradzkia* sp.	*Arcticoceras ishmae, Costacadoceras* spp.		
	Arcticoceras spp.				HODSONI	
GREENLANDICUS	*Arctocephalites* cf. *greenlandicus A. (?) freboldi A. (?)* aff. *A. (?) crassum*				MORRISI	MIDDLE BATHONIAN
	Arctocephalites greenlandicus A. (?) crassum A. (?) aff. *crassum*					
	Arctocephalites (?) cf./aff. *crassum*	ELEGANS	*Arctocephalites kigilakhensis, A. ornatus, A.* cf. *greenlandicus, A. nudus,* and cf. *nudus, A. arcticus* and cf. *arcticus, A. callomoni, A. elegans, A. voronezae, A.* aff. *ellipticus, Siemiradzkia* sp.		SUBCONTRACTUS	
ARCTICUS	*Arctocephalites arcticus, A. nudus, A. ornatus, A. elegans, A. sphaericus, A. delicatus, A. koettlitzi, A. ellipticus, A. pilaeformis, A. platynotus*	JUGATUS	*Oxycerites jugatus, O. undatus, O.* sp.ind. *Arctocephalites callomoni, A. voronezae, A.* cf. *elegans, A. arcticus, A. ornatus, A.* aff. *ellipticus*		PROGRACILIS	

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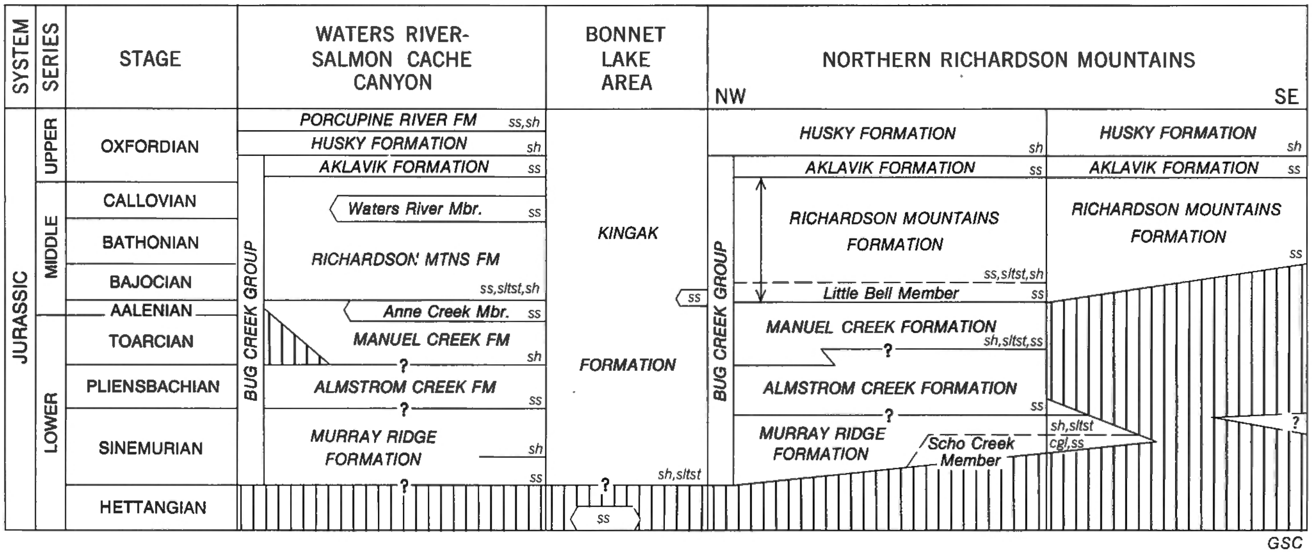
TABLE 2

Table of formations, northern Yukon Territory.



SYSTEM	SERIES	STAGE	WATERS RIVER-SALMON CACHE CANYON	BONNET LAKE AREA	NORTHERN RICHARDSON MOUNTAINS NW	NORTHERN RICHARDSON MOUNTAINS SE
JURASSIC	UPPER	OXFORDIAN	*PORCUPINE RIVER FM* ss,sh *HUSKY FORMATION* sh *AKLAVIK FORMATION* ss	*KINGAK FORMATION*	*HUSKY FORMATION* sh *AKLAVIK FORMATION* ss	*HUSKY FORMATION* sh *AKLAVIK FORMATION* ss
	MIDDLE	CALLOVIAN	BUG CREEK GROUP *Waters River Mbr.* ss		BUG CREEK GROUP *RICHARDSON MOUNTAINS FORMATION* ss,sltst,sh	*RICHARDSON MOUNTAINS FORMATION* ss
		BATHONIAN	*RICHARDSON MTNS FM* ss,sltst,sh			
		BAJOCIAN		ss	*Little Bell Member* ss	
		AALENIAN	*Anne Creek Mbr.* ss		*MANUEL CREEK FORMATION* sh,sltst,ss	
	LOWER	TOARCIAN	*MANUEL CREEK FM* sh ?		?	
		PLIENSBACHIAN	*ALMSTROM CREEK FM* ss ?		*ALMSTROM CREEK FORMATION* ss ?	
		SINEMURIAN	*MURRAY RIDGE FORMATION* sh ss ?	? sh,sltst	*MURRAY RIDGE FORMATION* *Scho Creek Member*	sh,sltst cgl,ss ?
		HETTANGIAN		ss		

GSC

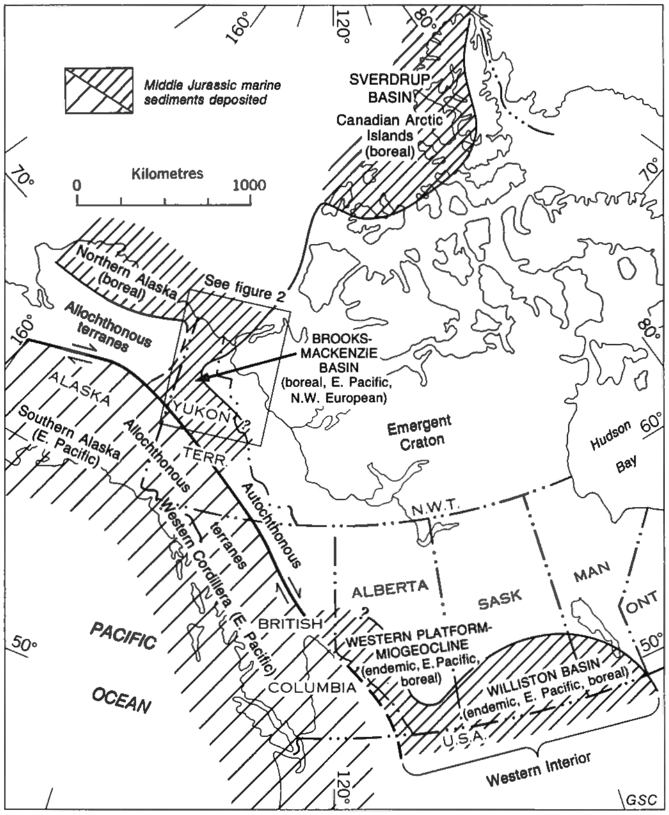


Figure 1. *Configuration of marine sedimentary basins and major tectonic features of the Middle Jurassic of Western Canada, showing basic paleobiogeographic character of Late Bathonian ammonites.*

The basin-margin sandstone succession varies in detail alongstrike, partly due to local tectonic influences (Fig. 3). The Salmon Cache Canyon locality lies southwest of the more typical development of the Bug Creek Group, on the edge of a small promontory of the Jurassic shoreline (Eagle Arch). A short distance farther southwest, the sandstone facies disappears alongstrike, passing into shales and siltstones in the northern Ogilvie Mountains (Poulton, 1982). The facies changes, together with other lithological and facies variations, indicate that the probable sources of the sediments were from the southeast (Poulton et al., 1982).

The Salmon Cache Canyon locality has been interpreted by Jeletzky (1975) as part of an irregular shoreline succession related to what he called the Keele-Old Crow Landmass. This landmass supposedly formed the western margin of a narrow trough that extended north-south across northern Yukon Territory, and joined Brooks-Mackenzie Basin with Jurassic seas to the south. The existence of this westerly landmass and of the trough itself in Lower and Middle Jurassic times are not now accepted by the present writer, following detailed stratigraphic study (Poulton et al., 1982, Appendix 3; Poulton, 1982). One line of reasoning that lent support to the interpretation of the narrow seaway joining Arctic and more southerly Western North American seas was the supposed similarity of the faunas of the two areas. However, the Western Interior and Arctic forms are not as closely related as was thought by Imlay (1945, 1948, 1967), the former being predominantly endemic. Most of the Bathonian faunas of southern Alaska and the Western Cordillera are now known to be vastly different from those of the Arctic, and characterize the "Eastern Pacific Realm" of Westermann (1981). At any rate, a marine connection not through the Yukon (e.g. Imlay and Detterman, 1973; Jeletzky, 1975), but around the western edge of northern Yukon through Alaska, could well explain whatever similarity there is. No landmass is now thought to have been present in central Alaska in Early and Middle Jurassic times. Instead, open ocean lay off the south edge of a northern landmass that existed in the region of the present Arctic shelf, prior to Late Jurassic or Cretaceous tectonic emplacement of allochthonous terranes from far to the south (Poulton, 1982, 1984). This picture is supported by the recent suggestion (Callomon, 1981) that Phylloceratina, present in abundance in some beds at Salmon Cache Canyon, indicates close access to oceanic environments rather than to restricted shelf seas.

Local stratigraphic relationships

The Bathonian and Lower Callovian rocks at Salmon Cache Canyon represent the Richardson Mountains Formation of the Bug Creek Group (Poulton et al., 1982) in an unusually condensed and richly fossiliferous facies. Norris (1981) assigned the rocks to the Kingak Formation. The difference in treatment reflects the fact that the Salmon Cache locality is near the arbitrary Bug Creek - Kingak facies boundary. The prominent Lower Callovian sandstone at the top of the section described here appears to represent the locally developed Waters River Member (see Table 2).

The Bathonian rocks described in this report are separated from older beds of the section by the Porcupine River. To the north, across the river, sandstones and shales with Sinemurian, Aalenian and Upper Boreal Bajocian ammonites overlie Permian sandstones and siltstones (Poulton, 1978, p. 451).

Twenty-two kilometres northeast of the section along structural strike, on the ridge between Waters River and Berry Creek, the Callovian and younger parts of the section are exposed. A thin sandstone with *Cadoceras*, i.e. the Waters River Member of Poulton et al. (1982), represents the topmost unit described in detail in this report, with *Cadoceras bodylevskyi*. Above it is a poorly exposed, argillaceous unit; then the Aklavik sandstone with *Cardioceras*; a black shale that represents the lower Husky Formation of the Richardson Mountains (see Poulton, 1982), and finally the thick, ridge-forming Porcupine River sandstone formation (Jeletzky, 1977). The *Cadoceras* beds and the Porcupine River sandstone (with Late Oxfordian or younger *Buchia* species) are faulted against each other at Salmon Cache Canyon so that none of the intermediate units are seen. In addition, there may possibly be some erosional truncation of these units southward, below the Porcupine River Sandstone, as it laps onto the cratonic promontory, Eagle Arch.

BIOSTRATIGRAPHIC SUBDIVISIONS

A succession of eight zones with distinctive ammonoid faunas has been recognized at Salmon Cache Canyon. The ranges of ammonite species are shown in Figure 4. Because only a few of the East Greenland or northern Siberia species appear in northern Yukon, new zonal names are given using some of the best known faunas. These are assumed to be teilzones of regional extent. The lower part of the succession is best exposed and has yielded the most fossils, so it lends itself to subdivision into zones that are based on first appearances of species.

All the zonal names are new except the *ishmae* Zone, which was first used for strata in East Greenland by Callomon (1975). It replaces the *kochi* Zone, following Callomon's (*ibid.*) recognition of the synonymy of *Arcticoceras kochi* Spath with *A. ishmae* (Keyserling). As used here, the *ishmae* Zone is restricted compared to Callomon's (*ibid.*) usage, comprising only the *ishmae* Subzone of his terminology.

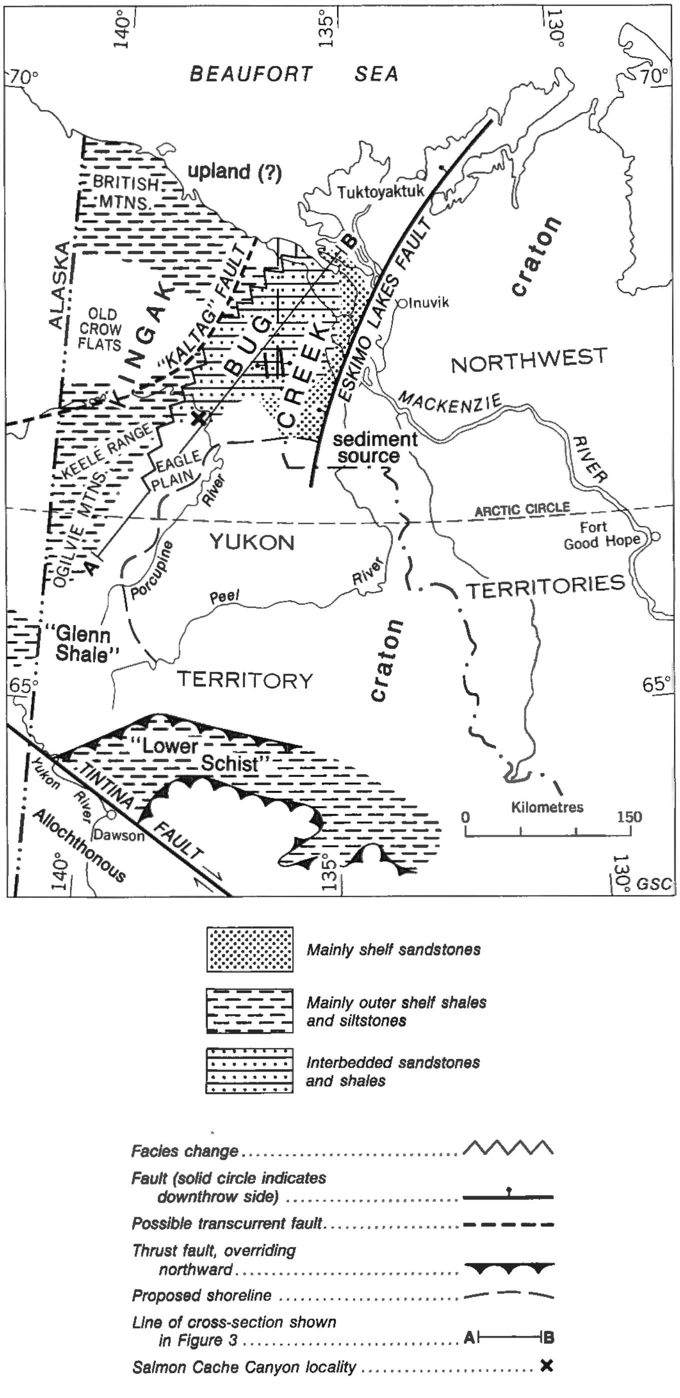


Figure 2. *Sedimentary facies belts, location of the Salmon Cache Canyon Section(X) and line of cross-section (AB) shown in Figure 3.*

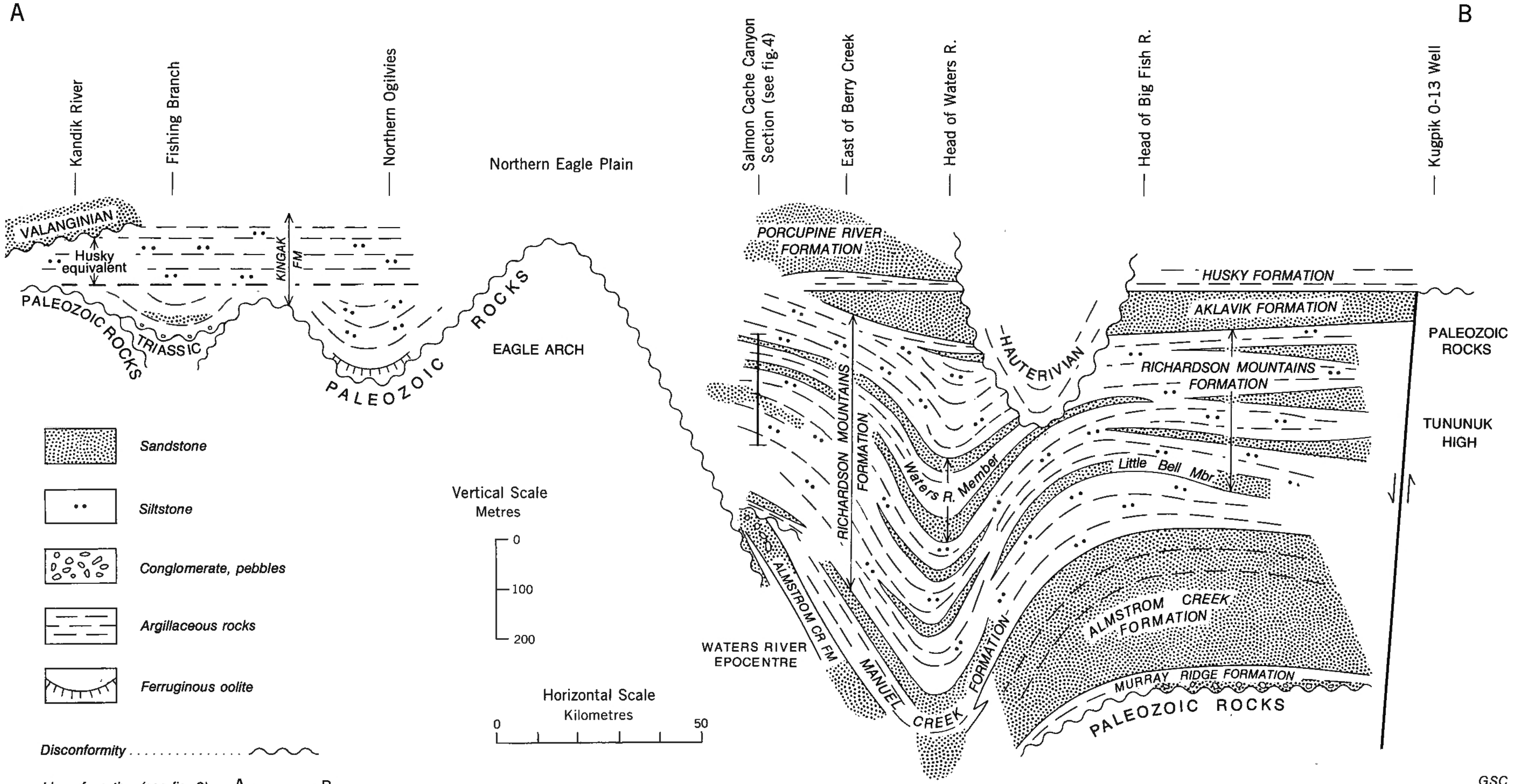
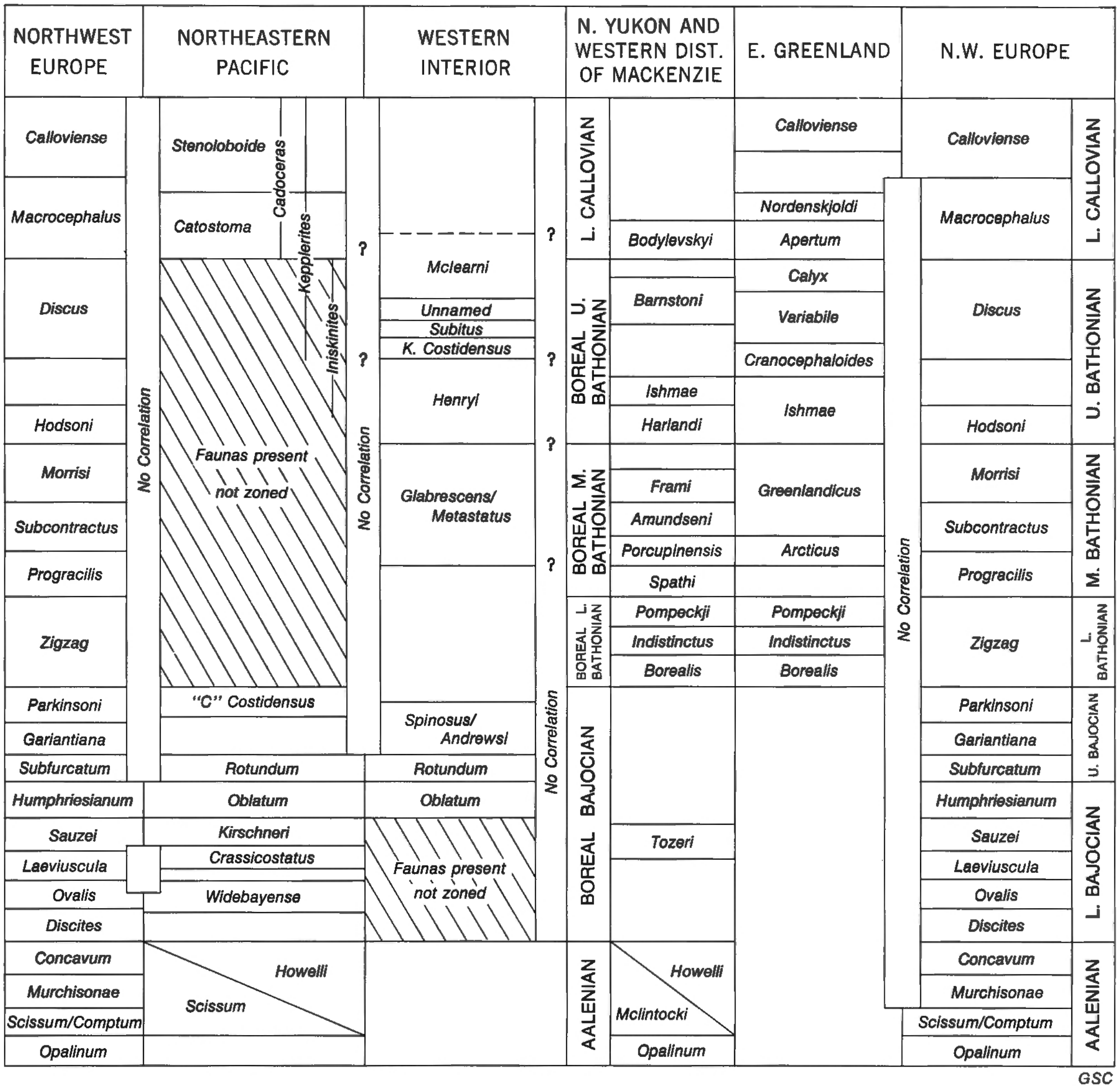


Figure 3. *Southwest-northwest cross-section of Lower and Middle Jurassic rocks along stratigraphic strike. Line of section shown in Figure 2. Bold bar indicates the section described in this report.*

TABLE 3

Chart showing the current placement of Middle Jurassic ammonite zones and their correlations in Western and Arctic North America, East Greenland, and Northwest Europe.



NORTHWEST EUROPE	NORTHEASTERN PACIFIC	WESTERN INTERIOR	N. YUKON AND WESTERN DIST. OF MACKENZIE		E. GREENLAND	N.W. EUROPE	
Calloviense No Correlation	Stenoloboide Cadoceras No Correlation		L. CALLOVIAN		Calloviense	Calloviense	L. CALLOVIAN
Macrocephalus	Catostoma Kepplerites	?		Bodylevskyi	Nordenskjoldi Apertum No Correlation	Macrocephalus	
Discus	Faunas present not zoned Iniskinites	? Mclearni Unnamed Subitus K. Costidensus	BOREAL U. BATHONIAN	Barnstoni	Calyx Variabile Cranocephaloides	Discus	U. BATHONIAN
		? Henryi		Ishmae	Ishmae		
Hodsoni		Henryi		Harlandi	Ishmae	Hodsoni	
Morrisi		? Glabrescens/ Metastatus	BOREAL M. BATHONIAN	Frami	Greenlandicus	Morrisi	M. BATHONIAN
Subcontractus		Glabrescens/ Metastatus		Amundseni	Greenlandicus	Subcontractus	
Progracilis		?		Porcupinensis Spathi	Arcticus	Progracilis	
Zigzag			BOREAL L. BATHONIAN	Pompeckji Indistinctus Borealis	Pompeckji Indistinctus Borealis	Zigzag	L. BATHONIAN
Parkinsoni	"C" Costidensus	Spinosus/ Andrewsi No Correlation	BOREAL BAJOCIAN			Parkinsoni	U. BAJOCIAN
Gariantiana		Spinosus/ Andrewsi				Gariantiana	
Subfurcatum	Rotundum	Rotundum				Subfurcatum	
Humphriesianum	Oblatum	Oblatum				Humphriesianum	L. BAJOCIAN
Sauzei	Kirschneri	Faunas present not zoned		Tozeri		Sauzei	
Laeviuscula	Crassicostatus	Faunas present not zoned		Tozeri		Laeviuscula	
Ovalis	Widebayense	Faunas present not zoned				Ovalis	
Discites		Faunas present not zoned				Discites	
Concavum	Howelli		AALENIAN	Howelli		Concavum	AALENIAN
Murchisonae	Scissum			Mclintocki		Murchisonae	
Scissum/Comptum	Scissum			Mclintocki		Scissum/Comptum	
Opalinum				Opalinum		Opalinum	

GSC

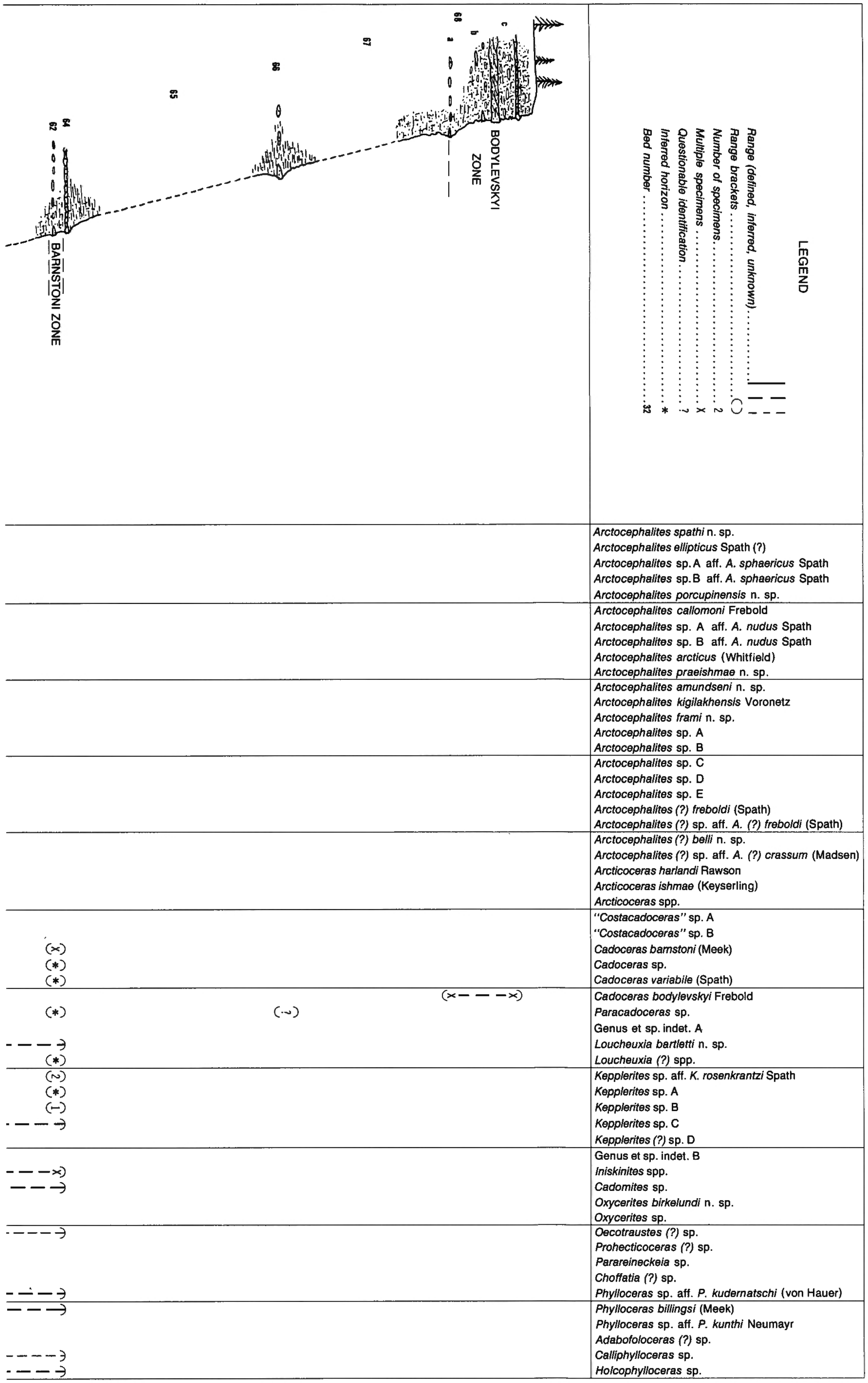
Only the ammonites are treated here. The faunas also include abundant *Inoceramus,* belemnites, and some *Oxytoma, Goniomya, Meleagrinella* and other bivalves. Foraminifera are present also, as are palynomorphs, which are being reported in a companion paper by E.H. Davies and Poulton.

Spathi Zone (Beds 2-14)

Arctocephalites spathi n. sp. is the most common form in the collections. Other species, all small and mostly, but not all compressed, include *A. ellipticus* Spath(?), *A.* sp. A aff. *A. sphaericus* Spath, and *A.* sp. B. aff. *A. nudus* Spath. The base of the zone is placed at the base of the lowest beds with *Arctocephalites,* that is, *A. spathi.* A large, ribbed body chamber of *Cranocephalites*(?) in Bed 1 immediately below it may indicate the presence there of equivalents of the *pompeckji* Zone of East Greenland.

One concretion, lying loose at the base of the section but assumed to come from this zone, contains *A. spathi*(?) and *Oecotraustes*(?) sp.

This interval is that characterized by "*Arctocephalites elegans*" in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978).


LEGEND
Range (defined, inferred, unknown)
Range brackets
Number of specimens 2
Multiple specimens ×
Questionable identification ?
Inferred horizon *
Bed number 32
BODYLEVSKYI ZONE
BARNSTONI ZONE
68
a
b
c
67
66
65
64
62
Arctocephalites spathi n. sp.
Arctocephalites ellipticus Spath (?)
Arctocephalites sp. A aff. A. sphaericus Spath
Arctocephalites sp. B aff. A. sphaericus Spath
Arctocephalites porcupinensis n. sp.
Arctocephalites callomoni Frebold
Arctocephalites sp. A aff. A. nudus Spath
Arctocephalites sp. B aff. A. nudus Spath
Arctocephalites arcticus (Whitfield)
Arctocephalites praeishmae n. sp.
Arctocephalites amundseni n. sp.
Arctocephalites kigilakhensis Voronetz
Arctocephalites frami n. sp.
Arctocephalites sp. A
Arctocephalites sp. B
Arctocephalites sp. C
Arctocephalites sp. D
Arctocephalites sp. E
Arctocephalites (?) freboldi (Spath)
Arctocephalites (?) sp. aff. A. (?) freboldi (Spath)
Arctocephalites (?) belli n. sp.
Arctocephalites (?) sp. aff. A. (?) crassum (Madsen)
Arcticoceras harlandi Rawson
Arcticoceras ishmae (Keyserling)
Arcticoceras spp.
"Costacadoceras" sp. A
"Costacadoceras" sp. B
Cadoceras barnstoni (Meek)
Cadoceras sp.
Cadoceras variabile (Spath)
Cadoceras bodylevskyi Frebold
Paracadoceras sp.
Genus et sp. indet. A
Loucheuxia bartletti n. sp.
Loucheuxia (?) spp.
Kepplerites sp. aff. K. rosenkrantzi Spath
Kepplerites sp. A
Kepplerites sp. B
Kepplerites sp. C
Kepplerites (?) sp. D
Genus et sp. indet. B
Iniskinites spp.
Cadomites sp.
Oxycerites birkelundi n. sp.
Oxycerites sp.
Oecotraustes (?) sp.
Prohecticoceras (?) sp.
Parareineckeia sp.
Choffatia (?) sp.
Phylloceras sp. aff. P. kudernatschi (von Hauer)
Phylloceras billingsi (Meek)
Phylloceras sp. aff. P. kunthi Neumayr
Adabofoloceras (?) sp.
Calliphylloceras sp.
Holcophylloceras sp.
(×)
(*)
(*)
(×— — —×)
(*)
(?)
(*)
(2)
(*)
(1)
(×)

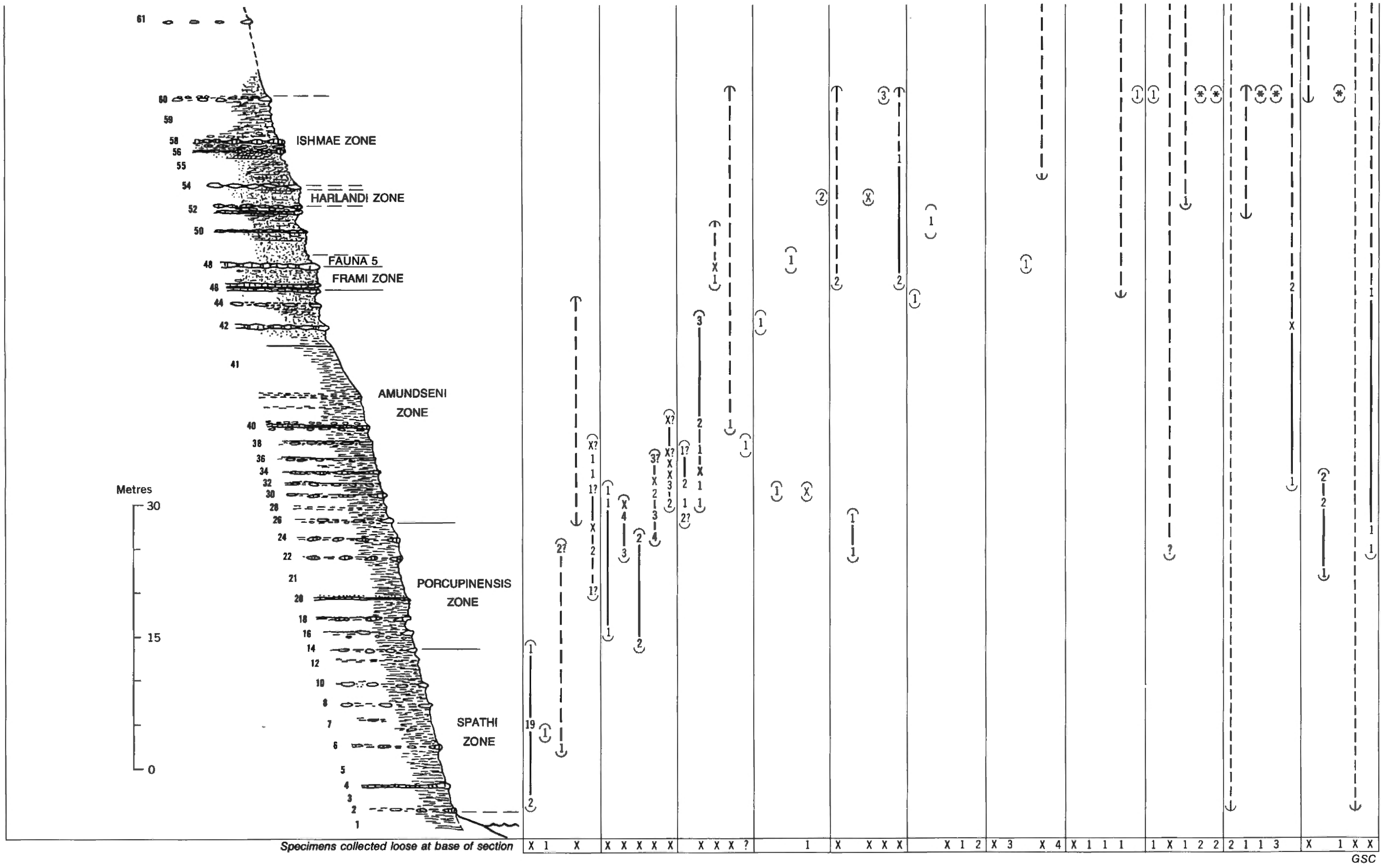


Figure 4. Graphic illustration of the Salmon Cache Canyon section showing ammonite zones and species distribution.

Porcupinensis Zone (Beds 15-25)

Several similar species are approximately equally abundant in this zone. *Arctocephalites porcupinensis* n. sp. is the most conspicuous in some beds in the the lower part, but was not seen in the lowest beds. The lowest appearance of the entire suite of species in Bed 15 is taken to mark the base of the zone. These include *A. callomoni* Frebold, *A.* spp. A and B aff. *A. nudus* Spath, *A.* sp. A aff. *A. sphaericus* Spath, *A. arcticus* (Whitfield) – appearing only in the uppermost part of the zone – and *Arctocephalites*(?) sp. aff. *A.*(?) *crassum* (Madsen). Thus, most specimens are still small and moderately compressed, although there is an increasing proportion of inflated forms. The lowest appearance of *Phylloceras* sp. aff. *P. kunthi* Neumayr, of Genus *Calliphylloceras*, and possibly also of Genus *Iniskinites* (represented by a single small undeterminable fragment that is now lost) is in this zone.

The lower part of this interval is that characterized by "*Arctocephalites* sp". in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978).

Amundseni Zone (Beds 26-45)

The lowest bed is characterized by the appearance of the largest species, *Arctocephalites amundseni* n. sp., in a fauna that is otherwise similar to that below, with mostly smaller species. Other elements of the lower part of this zone are *A. arcticus* (Whitfield), *A. porcupinensis* n. sp., *A.* sp. A aff. *A. nudus* Spath, *A. praeishmae* n. sp., *A.* sp. D, *Arctocephalites*(?) sp. aff. *A.*(?) *crassum* (Madsen), *A.*(?) *freboldi* (Spath), and *Phylloceras* sp. aff. *P. kunthi* Neumayr.

Higher beds are characterized by a mixture of species – *Arctocephalites porcupinensis*(?), *A.* spp. aff. *A. arcticus* and *A. callomoni*, *A. praeishmae*, *A.* sp. B, and, possibly, *A.* sp. A. *Arctocephalites kigilakhensis* Voronetz becomes increasingly abundant upward so that an upper Kigilakhensis Subzone, in which *A. kigilakhensis* and *A. praeishmae* are most conspicuous and *A. amundseni* is rare or absent, can be distinguished. *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer) first appears in the upper part of this interval.

Arctocephalites sp. B aff. *A. sphaericus* Spath, one specimen of which was found in loose material with *Phylloceras* sp. aff. *P. kudernatschi* (GSC locality 92546) is thought to also be present in the *amundseni* Zone.

The interval comprising the *amundseni* and *frami* Zones is that characterized by "*Arctocephalites greenlandicus*" in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978).

Frami Zone (Beds 46-47)

This fauna is dominated by *Arctocephalites frami* n. sp., the lowest occurrence of which in Bed 46 defines the base of the zone. Additionally, *Arctocephalites*(?) *belli* n. sp., *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer), and *Calliphylloceras* sp. occur, and the lowest occurrence of *Arcticoceras*, that is, *A.* sp. indet. is in this interval.

Unnamed Zone (Bed 48)

This fauna is represented by only one fossiliferous bed, containing a unique assemblage of *Arctocephalites*(?) sp. E, and genus et species indet. A.

Harlandi Zone (Bed 53)

This fauna, known from only one fossiliferous bed, contains *Arcticoceras harlandi* Rawson, *Cadomites* sp., *Arctocephalites*(?) sp. aff. *A.*(?) *freboldi* (Spath), and other *Arctocephalites* sp. indet., represented by small, smooth body chambers having apertural constrictions and cross-sections similar to those of *A. harlandi* shown in Plate 19 (figs. 7, 8).

This interval is that characterized by "*Arctocephalites* sp. cf. *greenlandicus*" in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978).

Ishmae Zone (Beds 55-60)

The zone is represented, in three fossiliferous horizons, by *Arcticoceras ishmae* (Keyserling), *A. ishmae*(?), and *Kepplerites*(?) sp. D.

These beds have contributed many distinctive, hard, dark red, dense concretions to the talus below the section, some of which are richly fossiliferous and document the following forms in this zone (each GSC locality number, except C-95372, represents a single concretion, so that there is no doubt of the association).

GSC loc. 92552: *Loucheuxia bartletti* n. sp.
Iniskinites sp.
Phylloceras billingsi (Meek)

GSC loc. 92554: *Arcticoceras ishmae* (Keyserling)
Oxycerites birkelundi n. sp.
Loucheuxia bartletti n. sp.
Iniskinites sp.

GSC loc. 92564: *Arcticoceras ishmae* (Keyserling)(?)
Arctocephalites(?) *belli* n. sp.
Choffatia(?) sp.
Phylloceras billingsi (Meek)

GSC loc. C-95354: *Arcticoceras ishmae* (Keyserling)
Oxycerites birkelundi n. sp.

GSC loc. C-95372: (the following species occur together in a single concretion; the concretion also contains other material):

Arcticoceras ishmae (Keyserling)
Oxycerites birkelundi n. sp.
Choffatia(?) sp.

GSC loc. C-95374: *Arcticoceras*(?) sp.
Oxycerites sp.
Loucheuxia bartletti n. sp.

GSC loc. C-95382: *Arcticoceras* sp. indet.
Oxycerites sp.

The presence of *Oxycerites* in this zone represents its lowest, and apparently only, occurrence in the section, and that of *P. billingsi* represents the first appearance of that species. Other forms that were found loose but that probably come from this zone include *Parareineckeia* sp., *Adabofoloceras*(?) sp., gen. et sp. indet. B, and possibly also *Arctocephalites* sp. A(?) (University of Alberta loc. 45413). Furthermore, J.H. Callomon (pers. comm., 1975), while in the field, tentatively identified *Siemiradzkia* sp. and *Oecotraustes* sp. in loose material that he thought came from this zone but these identifications could not be confirmed by detailed studies of the collections by the writer.

Barnstoni Zone (Bed 62)

This fauna, characterized above all by *Cadoceras barnstoni* (Meek) and *Phylloceras billingsi* (Meek), also contains in place *Cadoceras* sp., *Iniskinites* sp., and the lowest *Kepplerites*, *K.* sp. aff. *K. rosenkrantzi* Spath and *K.* sp. B.

Additionally, a rich fauna is documented in distinctive, yellow-weathering concretions that occur abundantly in the talus below the section. Each number records the association in a single concretion:

GSC loc. 92553: *Cadoceras barnstoni* (Meek)
Cadoceras variabile Spath
Arcticoceras(?) sp.
Iniskinites(?) sp.
Phylloceras billingsi (Meek)

GSC loc. 92473x: *Loucheuxia bartletti* n. sp.
Phylloceras sp. aff. *P. kudernatschi* (von Hauer)

GSC loc. 92568: *Cadoceras barnstoni* (Meek)
Cadoceras sp.
Phylloceras billingsi (Meek)

GSC loc. C-95370: *Cadoceras barnstoni* (Meek)
Iniskinites sp.
Phylloceras billingsi (Meek)
Phylloceras sp. aff. *P. kudernatschi* (von Hauer)

GSC loc. C-95381: *Loucheuxia*(?) sp.
Phylloceras billingsi (Meek)

GSC loc. C-95383: *Loucheuxia*(?) sp.
Phylloceras sp.
Calliphylloceras sp.

Kepplerites sp. A, found loose in the talus, probably also comes from this bed.

Unnamed Zone (Bed 66)

No ammonites are positively identified in the material presently available for detailed study (GSC loc. 92470). J.H. Callomon tentatively identified *Paracadoceras* at this level while in the field. This genus is sparsely represented in the talus below the section but is not associated with other ammonites.

Bodylevskyi Zone (Bed 68)

This fauna contains only *Cadoceras bodylevskyi* Frebold. This is the interval characterized by *C. septentrionale* Frebold in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978).

DESCRIPTION OF THE SECTION

Section PU-3-75, 81. Salmon Cache Canyon, Porcupine River, northern Yukon. Bluffs are found on the west bank, just south of the major bend where the river changes course from north to west; lat. 67°25 to 26'N, long. 137°46'30"W. The section was described and measured, and the fossils collected by T.P. Poulton and J.H. Callomon in 1975; and by T.P. Poulton, J.H. Callomon, T. Birkelund, R.L. Detterman, and D.H. McNeil in 1981. The collections and generalized description of J.A. Jeletzky (in Frebold, 1961, p. 2) have been incorporated. The section, with preliminary fossil identifications, has previously been illustrated by Poulton and Callomon (1976, p. 348, col. 5) and Poulton (1978, Pl. II, fig. 2; the coordinates given there are incorrect), and it appears in Figures 4 to 7 of this report.

Much of the slope is obscured by talus, and the section was pieced together from a study of various outcrops. Marker-beds are, however, prominent, persistent and characteristic, leaving the succession in no doubt. The lower beds (1-20), are best exposed at the northernmost end of the bluff. Beds 22 to 40 form a prominent and well exposed, regularly banded series some 100 to 200 m farther south, bounded by the most southerly of three gullies beyond which the slopes are heavily obscured by talus. The northernmost of the three gullies gives a clear section up to and including the prominent marker ironstone, Bed 58, at the top of the cliff, just under the trees. This is the highest bed exposed anywhere along the northern half of the cliff. The remaining part of the section, Beds 59 to 68, is exposed intermittently in a prominent gully some 200 m from the southern end of the cliff. This gully widens and becomes tree covered just under the highest point of the cliff. Different parts of the section were exposed in 1975 and 1981, which permitted the filling of gaps, correction of errors, and addition of greater detail in the second year. The different exposure in 1981 was due in part to heavy slumping following a forest fire that occurred between 1975 and 1981.

The section belongs to the Richardson Mountains Formation (Poulton et al., 1982) of the Bug Creek Group, in an untypically fossiliferous and ferruginous facies. The upper sandstones (Units 68a-c) probably represent the Waters River Member.

Unit	Description	Thickness (m)	Height above base (m)
	Top of section at top of bluffs near their south end.		
	LOWER CALLOVIAN		
	Bodylevskyi Zone (type locality)		
68c	**Sandstone:** dark grey, weathering medium to dark rusty grey; fine grained; argillaceous(?), carbonaceous and with wood fragments; strongly bioturbated, indistinctly bedded, with crossbedded lenses; soft, recessive, abundant rusty red concretions throughout lower 1 m; a prominent, continuous unit 2.6 m above base, comprising a 10 to 15 cm-thick upper layer and a 0.25 to 0.3 m-thick lower layer, each hard, continuous, claret coloured, separated by 15 cm of rubbly, soft sandstone GSC loc. 92544 *Cadoceras bodylevskyi* Frebold *Entolium* GSC loc. C-95367 in lower 1 m *Cadoceras bodylevskyi* Frebold belemnites *Goniomya* sp.	4	155.9
68b	**Sandstone:** buff, weathers rusty buff, blocky; fine grained; thin bedded to 0.5 m-bedded, massive or with fine, irregular laminae and ripples; crossbedded lenses; resistant	2.1	151.9
68a	**Sandstone:** dark grey, weathers medium to dark rusty grey; fine grained; argillaceous(?), carbonaceous; strongly bioturbated, indistinctly bedded; soft, recessive; crossbedded lenses; abundant, fossiliferous, 0.2 to 0.3 m, flattened, ovoid concretions between 0.8 and 1.2 m below top of unit, weathering rusty orange-red and vertically fractured; a similar row of less flattened concretions also occurs at base of unit GSC loc. C-95384 *Cadoceras bodylevskyi* Frebold	3	149.8

Unit	Description	Thickness (m)	Height above base (m)
	Unnamed Zone		
67	**Siltstone** to fine grained **sandstone:** light grey, weathers buff, rubbly, blocky; strongly bioturbated at base, becoming finely laminated to 0.3-0.6 m-bedded upwards; resistant	6	146.8
66			
65	**Silty mudstone** (probably): recessive; covered by slumping and talus from above	38	140.8
64	**Ironstone concretionary layer**	0.3	102.8
63	**Silty mudstone** (probably): recessive, covered	1.5	102.5
	UPPER BOREAL BATHONIAN		
	Barnstoni Zone (type locality)		
62	**Concretionary layer:** large, ochre-yellow weathering concretions GSC loc. 92543 *Cadoceras barnstoni* (Meek) *Cadoceras* sp. *Kepplerites* sp. aff. *K. rosenkrantzi* Spath *Iniskinites* sp. *Oecotraustes*(?) sp. *Phylloceras billingsi* (Meek) *Retroceramus* sp. *Goniomya* sp. *Camptonectes* sp. belemnites GSC loc. C-86389 *Cadoceras barnstoni* (Meek) *Kepplerites* sp. One loose concretion lying on the beach (GSC loc. C-95381) resembles Bed 62 lithologically and, like it, contains *P. billingsi*, but is unique in containing small angular to subangular chert pebbles, not seen in the section itself	0.3	101
	Unnamed Zone		
61	**Silty mudstone** (probably): recessive, mostly covered by slumping. Concretions in this interval (e.g. GSC loc. 92542) are thought to come from Bed 62 (see above)	17	100.7
	Ishmae Zone (type locality: East Greenland)		
60	**Siltstone/mudstone:** two rows, 0.2 m to 0.3 m thick; weathering dark rusty red; indurated, concretionary, hard; lower layer continuous, top layer containing concretions 0.6 to 1.5 m long, closely spaced; layers separated by 0.15 to 0.2 m of soft siltstone/mudstone; fossil wood, fossils in nests GSC loc. 92540 *Arcticoceras ishmae* (Keyserling) *Kepplerites*(?) sp. D *Astarte* sp. *Retroceramus* sp. belemnites	0.7	83.7
59	**Siltstone/mudstone:** medium grey; and fine grained **sandstone:** argillaceous; laminated or bioturbated; weathering fine 'chippy'; recessive; scattered ironstone concretions in lower 0.6 m		

Unit	Description	Thickness (m)	Height above base (m)
	GSC loc. C-95366 near base *Arcticoceras* sp.	4.8	83
	Underlying beds (56-58) at this location are continuous along the length of the bluff to the north end, where they were measured, and they are described below; this part was measured previously by Jeletzky (in Frebold, 1961, p. 2)		
	Lower part of section measured near north end of bluffs; top of bluffs just below trees; higher beds here are totally obscured by slumping		
	Note: units 56-58 form prominent ironstone marker horizon extending entire length of bluffs; subdivided as follows:		
58	**Ironstone:** brown; concretionary; more or less continuous; vertically fractured; belemnites	0.15	78.2
57b	**Ironstone:** lenticular; soft and rubbly; locally thickened to include claret coloured or black concretions	0.7	78.05
57a	**Silty mudstone** and **siltstone:** varies to fine sandstone; pyritic, ferruginous; belemnites	0.2	77.35
56	**Ironstone:** weathers claret; sideritic, concretionary, continuous; vertically fractured GSC loc. 92468 *Arcticoceras ishmae* (Keyserling)(?)	0.15	77.15
55	**Siltstone:** light buff-grey; argillaceous, sandy; hard; and **sandstone:** thin bedded, crosslaminated and crossbedded, in 0.15 m layers alternating with soft sandy and silty mudstone and siltstone, grading up to harder, thin sandstone at top; yellow weathering; small-scale crossbedding; unit soft, forms gentle slope GSC loc. 35634 *Arcticoceras*(?) sp. (*A. kochi* of Frebold, 1961) GSC loc. C-95373 collected 0.15 m below top of unit *Arcticoceras* sp. belemnites *Belemnoteuthis*	3.4	77
	Harlandi Zone (type locality)		
54	Layer of **ironstone concretions:** claret coloured; large, flattened, ovoid; forms top of steep slope of Bed 53	0.3	73.6
53	**Sandstone:** fine grained; argillaceous; 'chippy' and rubbly, or distinctly bedded, crossbedded; somewhat pyritic; forms a steep slope GSC loc. 92539 *Arcticoceras harlandi* Rawson GSC loc. C-95365 at base *Cadomites* sp. *Arcticoceras harlandi* Rawson *Arctocephalites*(?) sp. aff. *A.*(?) *freboldi* Spath	2.1	73.3

Unit	Description	Thickness (m)	Height above base (m)
	MIDDLE BOREAL BATHONIAN		
	Unnamed Zone		
	The beds in the interval comprising beds 41 to 51 have a slight northerly dip, at odds with those below and above (Fig. 5). This discrepancy may be due to slumping in the cliff-exposure situation, or to deposition as large-scale foresets, but no significant faunal gaps or erosional surfaces are detectable below or above them.		
52	**Sandstone:** grey; fine grained; ferruginous; soft, rubbly; low-angle crossbedding; widely spaced, ovoid, claret coloured concretions throughout; passes laterally into a thinner (0.7 m) package of two rows of red-brown ironstone concretions separated by soft sandstone/siltstone; the lower concretionary band is continuous GSC loc. 92538 *Arctocephalites*(?) sp. *Retroceramus* sp. belemnites *Belemnoteuthis*	1.1	71.2
51	**Silty mudstone** and **siltstone:** grades up into alternating thin layers of ripple-bedded sandstone and siltstone/mudstone; soft; micaceous; clayey nests of belemnites, especially at top	1.75	70.1
50	**Ironstone:** claret coloured; concretionary; continuous GSC loc. 92537 "*Costacadoceras*" sp. indet. B *Retroceramus* sp.	0.25	68.35
	Approximate top of Unit 4 of Jeletzky (in Frebold, 1961, p. 2)		
49	**Sandstone:** light grey-buff; fine grained; distinctly bedded, soft, rubbly; grades up into alternating thin layers of ripple-bedded sandstone and mudstone/siltstone	3.6	68.1
48	**Ironstone:** in rounded concretions; continuous, forming top of sandstone bluff GSC loc. C-95364 gen. et sp. indet. A *Arctocephalites*(?) sp. E	0.3	64.5
	Frami Zone (type locality)		
47	**Sandstone:** grey; fine grained; rubbly; scattered burrows in lower part; some round ironstone concretions about 0.3 m above base and others 0.3 m below top; bluff-forming; belemnites common; nests of *Retroceramus* GSC loc. C-95363 *Arctocephalites frami* n. sp. GSC loc. 92536 *Arctocephalites frami* n. sp. GSC loc. 35631 from beds 47 to 50 *Arctocephalites frami* n. sp.	2.1	64.2
	Approximate top of Unit 3 of Jeletzky (in Frebold, 1961, p. 2)		

Unit	Description	Thickness (m)	Height above base (m)
46	**Ironstone:** red-brown; two layers separated by thin mudstone/siltstone; blocky, vertically fractured; continuous; prominent; forming base of sandstone bluff GSC loc. 92535 *Arctocephalites frami* n. sp. GSC loc. C-95362 *Arctocephalites*(?) *belli* n. sp. *Arcticoceras* sp. indet. *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer) belemnites *Belemnoteuthis*	0.6	62.1
	Amundseni Zone (type locality)		
45	**Siltstone/mudstone:** rubbly, bioturbated; soft, recessive GSC loc. C-95368 collected 0.6 m below top *Holcophylloceras* sp.	1.2	61.5
44	**Siltstone/mudstone:** bioturbated; indurated; contains a row of large, widely spaced, rounded, ferruginous concretions GSC loc. C-95361 *Retroceramus* sp. GSC loc. 92534 "*Costacadoceras*" sp. A	0.3	60.3
43	**Siltstone:** fine grained; grades upward into alternating thin layers of ripple-laminated sandstone and siltstone/mudstone; recessive; belemnites	2.2	60
42	**Ironstone:** concretionary, nodular; continuous, resistant; pockets of belemnites at base, bivalves GSC loc. 92532 *Arctocephalites kigilakhensis* Voronetz *Arctocephalites* sp. indet. C *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer)	0.4	57.8
	A distinctive, recessive slope between banded series above and below, subdivided as follows:		
41g	**Siltstone:** fine grained; grades upward into alternating thin layers of ripple-laminated sandstone and siltstone/mudstone; belemnites	2.175	57.4
41f	**Clay:** light grey; soft; bentonitic?	0.025	55.225
41e	**Siltstone** or **mudstone:** soft, recessive; forms gentle slope	5.2	55.2
41d	**Siltstone:** grey; continuous; indurated, hard, resistant	0.4	50
41c	**Siltstone:** light grey; moderately hard	1.1	49.6
41b	**Siltstone:** ferruginous; slightly harder and more resistant than Unit 41a	0.3	48.5
41a	**Siltstone:** light grey; moderately hard; a row of yellow-weathering concretions at base containing nest of small ammonites – *Arctocephalites* sp.	1.9	48.2
	Top of moderately resistant, regularly banded series. This series comprises ten alternations of recessive siltstone/mudstone and hard ironstone or ferruginous mudstone.		
	Top of Unit 2 of Jeletzky (in Frebold, 1961, p. 2)		

Unit	Description	Thickness (m)	Height above base (m)
40	**Mudstone:** indurated; with a persistent bed of hard ironstone concretions 0.15 m thick; resistant, prominent GSC loc. 35619 *Arctocephalites praeishmae* n. sp.(?) *Arctocephalites* sp. A *Arctocephalites kigilakhensis* Voronetz GSC loc. C-95359 *Arctocephalites praeishmae* n. sp.(?) *Arctocephalites* sp. indet. pectinid bivalve, indet.	0.3	46.3
39	**Siltstone:** light grey; softer than the others, recessive; pockets of belemnites in centre	1.5	46.0
38	**Mudstone:** indurated and resistant; with concretions	0.3	44.5
37	**Siltstone:** light grey; soft, recessive; with a prominent, rusty weathering, consolidated bed in centre, 0.1 to 0.15 m thick	1.4	44.2
36	**Siltstone:** indurated and resistant; with brown ironstone concretions at base GSC loc. C-95358 *Arctocephalites amundseni* n. sp.(?) *Arctocephalites kigilakhensis* Voronetz *Arctocephalites arcticus* (Whitfield)(?) *Arctocephalites praeishmae* n. sp.(?) *Arctocephalites* spp. indet. aff. *A. nudus* Spath GSC loc. 35616 from beds 36, 37 or 38 *Arctocephalites porcupinensis* n. sp.(?) *Arctocephalites* sp. B	0.3	42.8
35	**Siltstone:** light coloured; bioturbated; soft, recessive; with a thin bed of indurated shale containing small concretions 0.6 m above base; belemnites	1.3	42.5
34	**Concretions:** two resistant layers; rusty weathering; discontinuous; layers 0.1 to 0.15 m thick, separated by 0.3 m of indurated but more recessive siltstone; local pockets of fossils, partly preserved in barite; abundant pyrite GSC loc. 92458 *Arctocephalites praeishmae* n. sp. *Arctocephalites porcupinensis* n. sp.(?) abundant *Retroceramus* sp. *Pleuromya* *Corbula* *Meleagrinella* belemnites *Belemnoteuthis*	0.6	41.2
33	**Silty mudstone** and **siltstone:** light coloured; sandy; soft, recessive, bioturbated	0.7	40.6
32	**Mudstone/siltstone** and fine grained **sandstone:** weathers rusty brown; argillaceous; indurated and with ironstone concretions at base; locally abundant ammonites, belemnites GSC loc. C-95357 *Arctocephalites porcupinensis* n. sp. *Arctocephalites praeishmae* n. sp. *Arctocephalites kigilakhensis* Voronetz *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer) *P.* sp. aff. *P. kunthi* Neumayr *Retroceramus* sp. belemnites *Belemnoteuthis*		

Unit	Description	Thickness (m)	Height above base (m)
	GSC loc. 92531 *Arctocephalites arcticus* (Whitfield) *Arctocephalites praeishmae* n. sp.	0.3	39.9
31	**Silty mudstone** and **siltstone:** bioturbated; soft, recessive; locally concentrated large belemnites GSC loc. C-86396 from top of unit *Arctocephalites kigilakhensis* Voronetz *Arctocephalites praeishmae* n. sp. *Arctocephalites porcupinensis* n. sp.(?) *Arctocephalites arcticus* (Whitfield) *Arctocephalites* sp. indet. D *Arctocephalites callomoni* Frebold *Phylloceras* sp. indet. *Passaloteuthis*(?) sp. GSC loc. 92457	0.9	39.6
30	**Siltstone** and fine grained **sandstone:** weathers rusty red and brown; argillaceous; strongly bioturbated; indurated and with abundant concretions grading to continuous concretionary band; calcareous; hard; sparsely fossiliferous GSC loc. C-86395 *Arctocephalites amundseni* n. sp. *Arctocephalites*(?) *freboldi* Spath *Arctocephalites* sp. indet. *Arctocephalites callomoni* Frebold *Phylloceras* sp. belemnites *Passaloteuthis*(?) sp. GSC loc. 92530 (loose, but not far fallen) *Arctocephalites arcticus* (Whitfield)	0.3	38.7
29	**Silty mudstone** or **siltstone:** recessive; belemnites common	0.9	38.4
28	**Siltstone:** weathers rusty grey and slightly resistant; slightly indurated and with concretions; bioturbated; ammonites partly preserved in barite GSC loc. 92529 *Arctocephalites praeishmae* n. sp. *Arctocephalites kigilakhensis* Voronetz GSC loc. C-86394 *Arctocephalites amundseni* n. sp. *Arctocephalites* sp. A aff. *A. nudus* Spath *Arctocephalites praeishmae* n. sp. *Phylloceras* sp. aff. *P. kunthi* Neumayr *Retroceramus* sp. *Belemnoteuthis*(?) sp.	0.4	37.5
27	**Siltstone** and **silty mudstone:** argillaceous; soft, recessive; layer of belemnites in middle GSC loc. 92528 belemnites	1.0	37.1
26	**Siltstone** or **silty mudstone:** weathers rusty red and resistant; indurated and with some concretions; strongly bioturbated; prominent GSC loc. C-86393 in concretionary layer at base *Arctocephalites arcticus* (Whitfield) *Arctocephalites amundseni* n. sp. *Arctocephalites* sp. A aff. *A. nudus* Spath *Arctocephalites*(?) sp. aff. *A.*(?) *crassum* (Madsen)	0.4	36.1

Unit	Description	Thickness (m)	Height above base (m)
	Porcupinensis Zone (type locality)		
25	**Siltstone** and **silty mudstone:** as in Unit 23 at base; becomes light coloured and soft upward	2.1	35.7
24	**Silty mudstone:** red-brown; indurated; contains large concretions; fractures into blocks GSC loc. 92527 *Arctocephalites porcupinensis* n. sp. *Arctocephalites arcticus* (Whitfield) *Arctocephalites* sp. B aff. *A. nudus* Spath *Holcophylloceras* sp. *Retroceramus* sp. *Meleagrinella* sp. *Corbula*(?) sp. belemnites *Cylindroteuthis* *Passaloteuthis*(?)	0.3	33.6
23	**Siltstone/mudstone:** very sandy; becomes argillaceous, fine grained sandstone; hard, strongly bioturbated and with abundant trace fossils, some belemnites	1.2	33.3
22	**Siltstone** and **mudstone:** weathers slightly resistant and rusty brown; slightly indurated, some hard patches and widely spaced concretions with blocky fracture GSC loc. 92525 *Arctocephalites* sp. A aff. *A. nudus* Spath *Arctocephalites porcupinensis* n. sp. *Arctocephalites* sp. A aff. *A. sphaericus* Spath(?) *Arctocephalites*(?) sp. aff. *A.*(?) *crassum* (Madsen) *Iniskinites*(?) sp. *Phylloceras* sp. *Holcophylloceras* sp. belemnites *Corbula*(?)	0.3	32.1
	Base of regularly banded series		
21	**Silty mudstone:** sandy, with pebble bed at base comprising small, rounded, phosphatic nodules and worn ammonite and belemnite fragments; unit slightly more resistant than the other recessive beds below GSC loc. C-86398 at base *Arctocephalites* sp. indet. aff. *A. porcupinensis* n. sp. *Phylloceras* sp. aff. *P. kunthi* Neumayr	4.65	31.8
20	**Ironstone:** red-brown; hard; lenticular but continuous GSC loc. C-86392 *Arctocephalites porcupinensis* n. sp.(?)	0.15	27.15
19	**Silty mudstone:** light to dark grey; sandy; bioturbated; weathering rubbly, more resistant than lower recessive units; a few ferruginous mudstone/siltstone concretionary lenses 0.2 m thick and 1.0 to 1.5 m long; abundant, large belemnites *Pachyteuthis*(?), *Cylindroteuthis*(?), mainly concentrated about 1 m above base; unit forms steeper slope GSC loc. 92524 belemnites GSC loc. C-86391 belemnites	2.05	27
18	**Siltstone/mudstone:** ferruginous; indurated; with lenses of red-brown ironstone	0.15	24.95
17	**Silty mudstone:** very light; soft	1.075	24.8

Unit	Description	Thickness (m)	Height above base (m)
16	**Silty mudstone:** ferruginous; indurated; weathers red-brown, soft, friable, some concretions; *Belemnoteuthis* GSC loc. C-86390 *Arctocephalites callomoni* Frebold	.025	23.725
15	**Silty mudstone:** a slightly more indurated ferruginous mudstone layer with widely spaced concretions lies 0.5 m below top of unit; scattered nests of fossils including *Arctocephalites* sp. cf. *A. arcticus* (Whitfield), belemnites, "*Ostrea*"	2.5	23.7
	Spathi Zone (type locality)		
14	**Ferruginous mudstone:** weathers red-brown; indurated but not prominent; widely spaced, red ironstone concretions; minor ammonites and *Retroceramus* GSC loc. 92456 *Arctocephalites* sp. indet. GSC loc. 35639 *Arctocephalites* sp. B aff. *A. nudus* Spath GSC loc. 92484 *Arctocephalites spathi* n. sp. GSC loc. C-86388 *Arctocephalites*(?) sp. indet.	0.2	21.2
13	**Silty mudstone**	1	21
12	**Ferruginous mudstone** or **siltstone:** concretionary, hard, weathering rusty, not prominent	0.3	20
11	**Silty mudstone:** a few concretions	2.25	19.7
10	**Ferruginous mudstone:** a hard layer with some red weathering, hard, grey concretions; pyritic; poorly preserved ammonite body chamber fragments and belemnites; *Belemnoteuthis*	0.25	17.45
9	**Silty mudstone:** some scattered ferruginous mudstone concretions	2.2	17.2
8	**Ferruginous mudstone:** medium grey, weathers rusty brown and red; locally with concretions; fine vertical jointing; unfossiliferous	0.35	15
7	**Silty mudstone** (as in Unit 1): some scattered ferruginous mudstone concretions; lower part better indurated; weathers with yellow and white (?jarosite) powder; ammonites and belemnites in lowest 2 m GSC loc. 35638 *Arctocephalites spathi* n. sp. GSC loc. 92523 from base of Bed 7 and Bed 6 *Arctocephalites spathi* n. sp. *Arctocephalites* sp. A aff. *A. sphaericus* Spath *Arctocephalites ellipticus* Spath(?)	4.45	14.65
6	**Mudstone concretions:** large; ovoid; ferruginous; layer as thick as 0.2 m, and 0.3 to 1.5 m long, spaced at intervals of 2.4 to 6 m in an indurated mudstone layer; fine vertical fracturing with calcite veining; common, variously oriented ammonites and large belemnites	0.2	10.2

Unit	Description	Thickness (m)	Height above base (m)
5	**Silty mudstone** (as in Unit 1): soft	3.95	10
4	**Siltstone:** medium grey; argillaceous; ferruginous; hard; weathering rusty brown and red with fine vertical joints; continuous, unfossiliferous	0.15	6.05
	Approximate top of Unit 1 of Jeletzky (in Frebold, 1961, p. 2)		
3	**Silty mudstone** (as in Unit 1): soft; mostly covered	2.7	5.9
2	**Mudstone concretions:** light to medium khaki-grey; lenticular; widely spaced; weather ochre-brown, hard; resistant; splintery fracture, with calcite fill; only a single 1.5 m long concretion is exposed; a few ammonites and belemnites GSC loc. 92522 *Arctocephalites spathi* n. sp. GSC loc. 35635 *Arctocephalites spathi* n. sp.	0.2	3.2
	LOWER BOREAL BATHONIAN(?) *Pompeckji* Zone(?)		
1	**Mudstone:** light to medium grey; silty, bioturbated; soft, weathers to mud; a few ammonites and belemnites; only 1 m exposed GSC loc. 92521 *Cranocephalites*(?) sp. indet.	3	3
	Lowest beds are exposed just above river level.		

Additional Loose Material

The rubble lying loose at the base of the section contains many specimens, some of which are better preserved or show more morphological detail than those of the same species collected in place in the section. In other cases, individual, richly fossiliferous blocks in the rubble permit documentation of particular associations of ammonites that cannot be seen clearly or at all in the section itself. In other cases, species not found in the section appear in these blocks in association with ammonites that permit recognition of the interval from which they were derived, at least approximately. In addition to the evidence of faunal associations, many of the large blocks can be traced to the bed from which they originated by their distinctive lithology.

The rubble is differentiated from south to north, the northern part being dominated by material from low in the section (Bed 60 and below), the southern part by higher beds.

Other material, collected by earlier workers and thought to have come from the Salmon Cache locality but for which precise locality data is unavailable, was also studied. Much of it has been previously described by Frebold (1961).

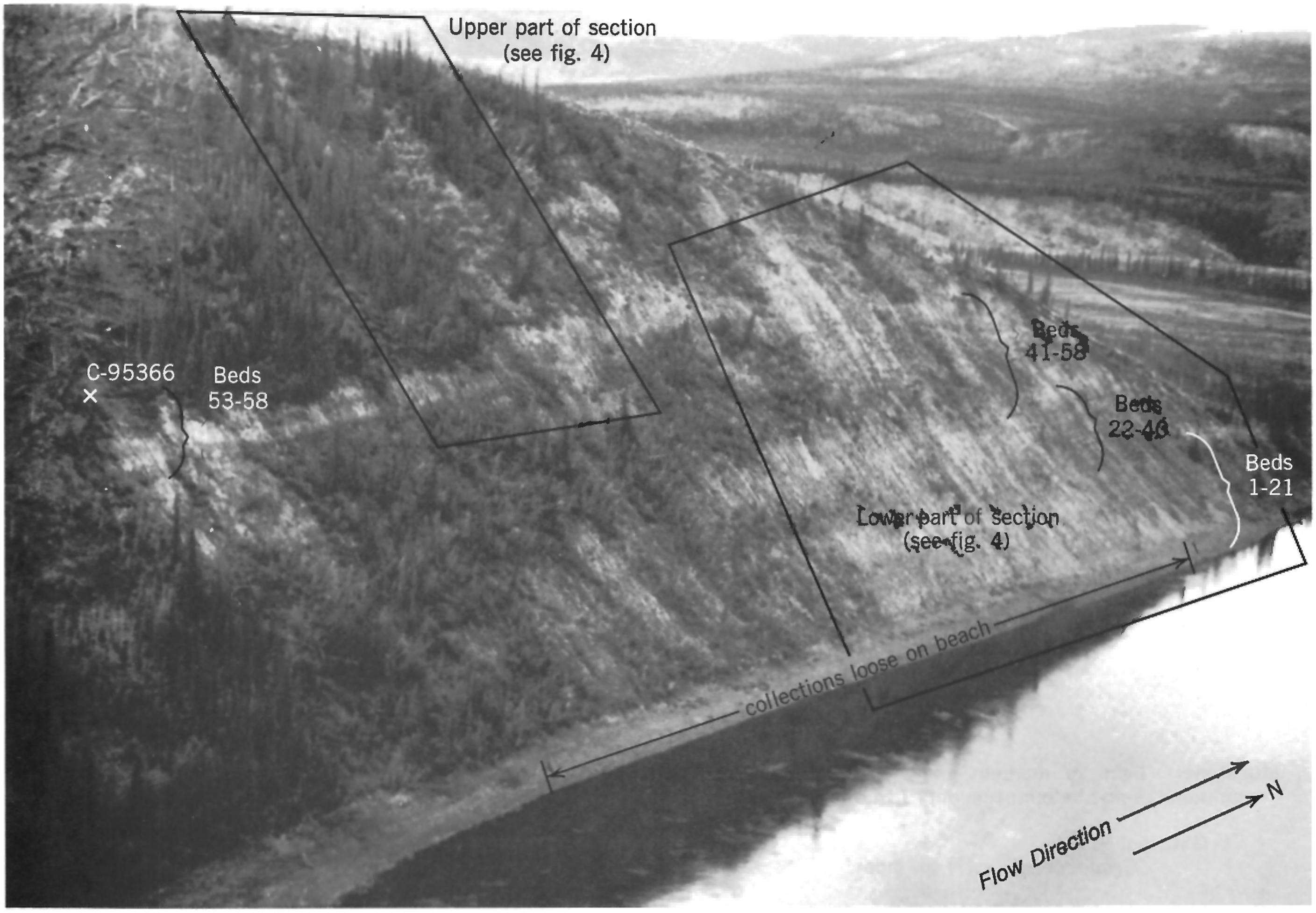


Figure 5. *Aerial view of the entire Middle Bathonian to Lower Callovian section at Salmon Cache Canyon. Enlargements of areas indicated are shown in Figures 6 and 7.*

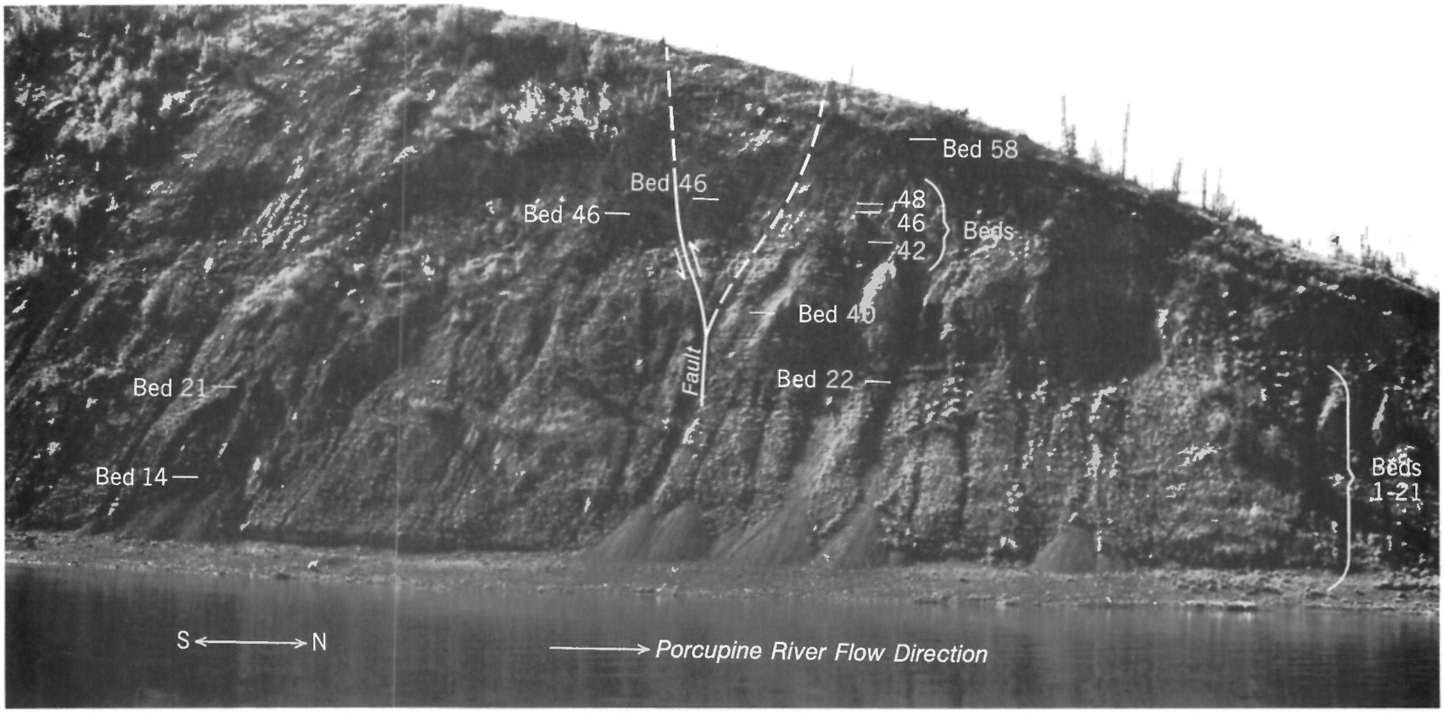


Figure 6. *Lower part of section (spathi through ishmae Zones), at north end of exposure.*

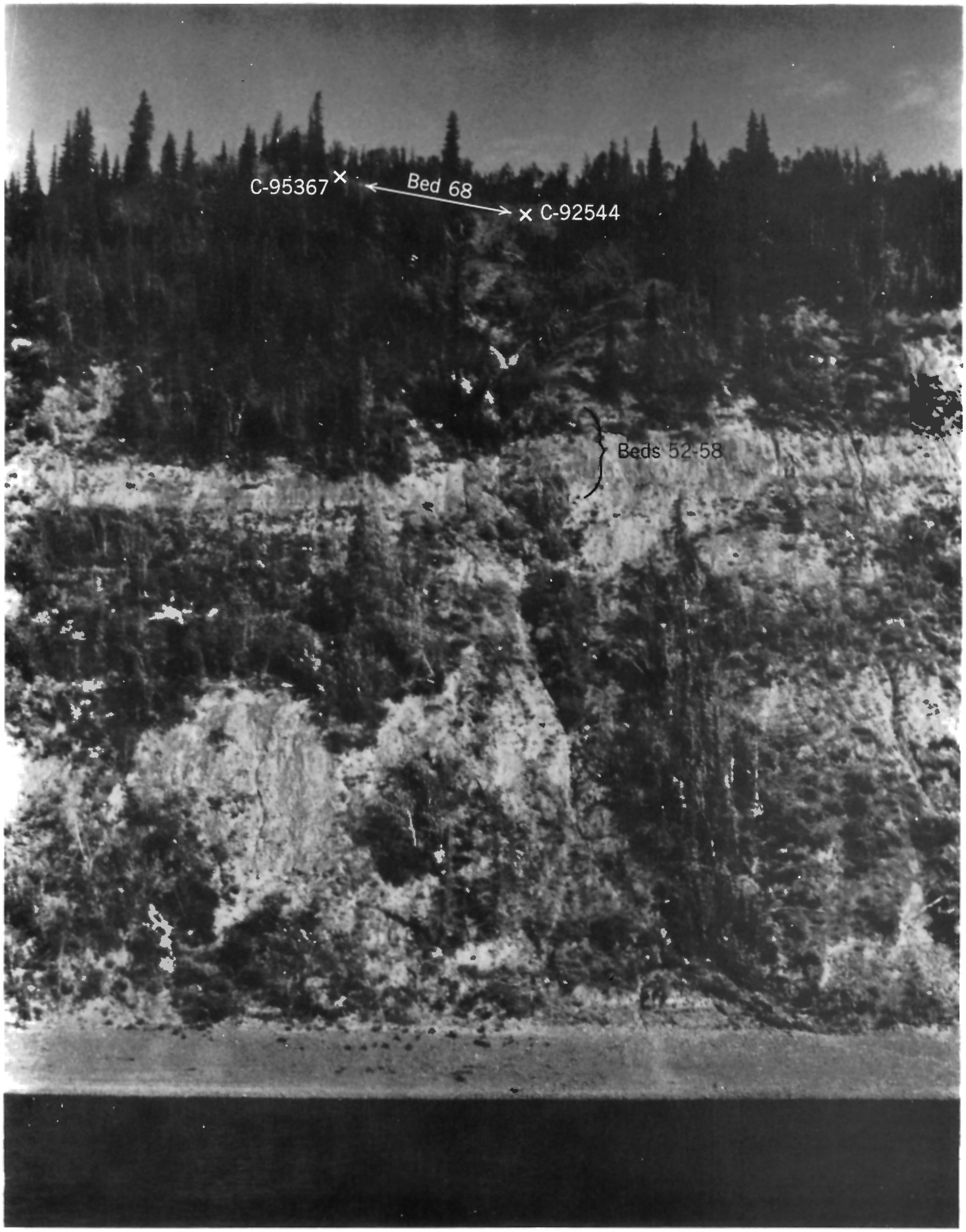


*Figure 7. Upper part of section (**ishmae** through **bodylevskyi** Zones), at south end of exposure.*

FOSSIL LOCALITIES

The fossil localities from which useful ammonite specimens were derived are listed below, and their stratigraphic position or situation in talus is indicated. All localities are in the section at Salmon Cache Canyon, or on the beach below it.

GSC loc. Number	Collector, date, stratigraphic and locality data
20510	R.G. McConnell, 1888. "Porcupine River". Assumed to be from talus on beach below the Salmon Cache Canyon section.
35616	J.A. Jeletzky, 1958. "Unit 2, 132-133 feet above its base". From beds 36, 37, or 38 of this report.
35619	Same as above. "Unit 2, 141-143 feet above its base". From Bed 40 of this report.
35631	Same as above. "Unit 4, 3 feet above its base". From some part of beds 47 to 50 of this report.
35634	Same as above. "Unit 5, 10-12 feet above its base". From Bed 55 of this report.
35635	Same as above. "9 feet above base of section". From Bed 2 of this report.
35638	Same as above. "6 feet above base of Unit 2". From Bed 7 of this report.
35639	Same as above. "40 feet above base of Unit 2". From Bed 14 of this report.
35692	Same as above. Talus on beach below section.
92458	T.P. Poulton and J.H. Callomon, 1975. Bed 34.
92467	Same as above. Loose on section below Bed 68 and clearly fallen from there.
92469	Same as above. Loose on section below Bed 60, derived from beds 60 and 62.
92473	Same as above. Talus on beach below section.
92473a	Same as above. An individual concretion, derived from Bed 62.
92473x	Same as above. An individual concretion, probably derived from Bed 62.
92484	Same as above. Outcrop on beach at about its centre, traced into Bed 14 at north end of bluff where lower part of section was measured.
92520	Same as above. Talus on beach below section.
92521	Same as above. Bed 1.
92522	Same as above. Bed 2.
92523	Same as above. Bed 7.
92525	Same as above. Bed 22.
92527	Same as above. Bed 24.
92529	Same as above. Bed 28.
92530	Same as above. Loose on section at Bed 30, not far fallen.
92531	Same as above. Bed 32.
92532	Same as above. Bed 42.
92534	Same as above. Bed 44.
92535	Same as above. Bed 46.
92536	Same as above. Bed 47.
92537	Same as above. Bed 51.
92538	Same as above. Bed 52.
92539	Same as above. Bed 53.
92540	Same as above. Bed 60.
92543	Same as above. Bed 62.
92544	Same as above. Bed 68c.
92545	Same as above. An individual concretion in talus on beach, coming from low in the section.
92546	Same as above. An individual concretion in talus on beach, coming from low in the section.
92551	Same as above. An individual concretion in talus on beach, coming from Bed 62.
92552	Same as above. An individual concretion in talus on beach, derived from Bed 60.
92553	Same as above. An individual concretion in talus on beach, derived from Bed 62.
92554	Same as above. An individual concretion in talus on beach, derived from Bed 60.
92561	Same as above. Talus on beach.
92563	Same as above. An individual concretion in talus on beach, probably derived from Bed 60.
92564	Same as above. An individual concretion in talus on beach, derived from Bed 60.
92565	Same as above. An individual concretion in talus on beach.
92566	Same as above. An individual concretion in talus on beach, derived from Bed 60.
92567	Same as above. An individual concretion in talus on beach, probably coming from low in the section.
92568	Same as above. An individual concretion in talus on beach, derived from Bed 62.
92570	Same as above. An individual concretion in talus on beach, probably derived from or just below Bed 60.

FOSSIL LOCALITIES (cont.)

GSC loc. Number	Collector, date, stratigraphic and locality data
C-27140	D.K. Norris, 1973. Talus on beach below section.
C-86389	R.L. Detterman, 1981. A single concretion loose on section near its south end, derived from Bed 62.
C-86390	T.P. Poulton, J.H. Callomon, T. Birkelund, R.L. Detterman, D.H. McNeil, 1981. Bed 16.
C-86392	Same as above. Bed 20.
C-86393	Same as above. Bed 26.
C-86394	Same as above. Bed 28.
C-86395	Same as above. Bed 30.
C-86396	Same as above. Bed 31.
C-86398	Same as above. Bed 21.
C-95354	Same as above. An individual concretion in talus on beach, derived from Bed 60.
C-95357	Same as above. Bed 32.
C-95358	Same as above. Bed 36.
C-95359	Same as above. Bed 40.
C-95361	Same as above. Bed 44.
C-95362	Same as above. Bed 46.
C-95363	Same as above. Bed 47.
C-95364	Same as above. Bed 48.
C-95365	Same as above. Bed 53.
C-95366	Same as above. Bed 59.
C-95367	Same as above. Bed 68c.
C-95368	Same as above. Bed 45.
C-95369	Same as above. Talus on beach below section.
C-95369a	Same as above. An individual concretion, derived from Bed 62.
C-95370	Same as above. An individual concretion in talus on beach, derived from Bed 62.
C-95372	Same as above. Talus on beach below section.
C-95372x	Same as above. An individual concretion.
C-95373	Same as above. Bed 55.
C-95374	Same as above. An individual concretion in talus on beach, derived from Bed 60.
C-95375	Same as above. An individual concretion in talus on beach, derived from beds 60 or 62.
C-95381	Same as above. An individual concretion in talus on beach, possibly derived from Bed 62.
C-95382	Same as above. An individual concretion in talus on beach, derived from Bed 60.
C-95383	T.P. Poulton and J.H. Callomon, 1975. An individual concretion in talus on beach, derived from Bed 62.
C-95384	T.P. Poulton, J.H. Callomon, T. Birkelund, R.L. Detterman, D.H. McNeil, 1981. Bed 68a.

CORRELATION

The current status of interprovincial ammonite correlations for most of the Middle Jurassic is shown in Table 3. Due to extreme faunal provincialism, the Boreal successions of the Arctic cannot be entirely correlated in detail in the entire interval between the Lower Aalenian and the Lower Callovian *calloviense* Zone with the 'International Standard' based on Northwest Europe (see Cox, 1964; Westermann, 1958; Torrens, 1974).

Ammonites described here that also occur in Northwest Europe, such as *Cadomites*, are long ranging at the generic level and they apparently differ from their European counterparts or are unidentifiable at the specific level. Others, such as *Oecotraustes*(?), *Prohecticoceras*(?) and *Choffatia*(?) are not identifiable with certainty even at the generic level in the Arctic collections. Excluding the Aalenian from the Bajocian, the only Arctic ammonite that is almost certainly early Bajocian is *Arkelloceras*. The name Tozeri, after *A. tozeri* Frebold (1951) can be used as a zonal name if any is needed; its detailed correlation outside Arctic North America and Siberia remains uncertain, but Sei and Kalacheva (1974) reported *Arkelloceras* in association with *Bradfordia*, and occurrences of *Arkelloceras* in Alberta (Westermann, 1964) and southern Alaska (Imlay, 1964, 1976) further indicate an Early Bajocian age.

Similarly, confident detailed correlation of only a few horizons in the Bajocian of the Northeast Pacific province with Northwest Europe are possible (e.g. Hall and Westermann, 1980; Westermann, 1980).

The northern Yukon Bathonian collections contain, in addition to the dominant Boreal faunas, forms such as *Iniskinites* and *Parareineckeia*, which are characteristic of the northeastern part of the Eastern Pacific Realm. Their presence permits some statements regarding correlation with the successions of the Canadian Western Cordillera and southern Alaska, although their ranges in those areas are not well resolved. Certain *Cadoceras* and *Kepplerites* species of southern Alaska offer correlations with the Boreal Realm, and still higher, the uppermost Callovian *Quenstedtoceras* fauna of southwesternmost British Columbia (Frebold and Tipper, 1975) can be correlated in detail outside of the Western Cordillera. Hence the northern Yukon faunas described in this report offer some clues to the correlation of Pacific and European successions via the Boreal Realm. Insufficient study and differing faunas from one outcrop area to another in southern Alaska and the Western Cordillera, are largely responsible for the absence still of a zonation that is widely applicable. Recent comprehensive attempts at such correlations have been made by Westermann (1980), and Callomon (1984).

The sequence of Western Interior North American faunas can be correlated with that from parts of the Western Cordillera and the International Standard through much of Bajocian time (e.g. Westermann, 1980). *Kepplerites* species suggest certain correlations in the Upper Bathonian and basal Callovian, shown in Table 3. Most species of other genera are too long ranging to be of significance for detailed correlations. Not until the Lower Oxfordian *Cardioceras* faunas occur is more confident correlation possible. Additionally, reassignment of at least some of the Western Interior *Warrenoceras* faunas (*henryi* Zone on Table 3; after Westermann, 1980) to *Eurycephalites* may indicate further correlations in the Bathonian with South American *Eurycephalites* faunas.

In the Middle Jurassic of the Western Interior, the Upper Bathonian or Lower Callovian *Kepplerites* faunas are similar to Arctic species, but the correlation shown in Table 3 is still uncertain. *Ammonites henryi* is not *Arcticoceras*, as was indicated by Westermann (1980) following previous authors (see section on 'Taxonomic Paleontology - *Arcticoceras*'), thus correlation with the widespread zone of *Arcticoceras ishmae* is not certain. Nevertheless, the general similarity of these species, and their stratigraphic positions above also mutually similar species groups of homeomorphic subfamilies – *Paracephalites glabrescens* in the south and *Arctocephalites* in the north – lead to the correlation shown in Table 3.

Regional correlations within the Arctic Jurassic, and attempts to correlate its zones with those of the Northwest European Standard, occupy many pages in the literature. Only brief summaries, which are necessary to evaluate the contribution of the Salmon Cache section, to update certain previous statements, or to justify and explain the correlation charts (Tables 1, 3) are presented here.

The most important tools for correlation within the Arctic are the Cadoceratinid genera *Arctocephalites*, *Arcticoceras* and *Cadoceras*. The few poorly preserved specimens of the Kosmoceratid genus *Kepplerites* are also of outstanding importance because of their well known succession in East Greenland, and their occurrence in the Western Interior and Western Cordillera of North America, and in Europe.

Lower Boreal Bathonian

The *Cranocephalites* faunas may be Lower Boreal Bathonian in age. Several species, including what is probably the youngest one, *C.* sp. aff. *C. pompeckji* (Madsen), occur in the northern Richardson Mountains, at localities in which their stratigraphic relations with other species cannot be determined in detail (Poulton, 1978). *Cranocephalites*(?) sp. in Bed 1 of the Salmon Cache Canyon section probably represents this interval, immediately below the *Arctocephalites* faunas which are the subject of this report. Extended discussion of the *Cranocephalites* faunas is beyond the scope of this report; further references to them are found in Meledina (1973) and Callomon (1975, 1985).

Middle Boreal Bathonian

This substage is characterized by *Arctocephalites* faunas. Different zonations have been published for East Greenland (Callomon, 1959, 1985; Callomon and Birkelund, 1980) and northern Siberia (e.g. Meledina, 1973) and the present report presents yet another for northwestern Canada. These different regional zonations reflect the different specific content of the *Arctocephalites* evolutionary plexus from one area to another, and, in its lower part in northern Siberia, the association with *Oxycerites* spp.

The ammonites from East Greenland have been described particularly extensively (Madsen, 1909; Ravn, 1911; Spath, 1932; Donovan, 1957; Callomon, 1959, 1975, 1979; Birkelund et al., 1971; Callomon and Birkelund, 1985). A detailed zonation has been published (Callomon, 1959; Callomon and Birkelund, 1980; Callomon, 1985).

It is not yet possible to correlate any of the Middle Boreal Bathonian zones with those of Northwest Europe or elsewhere with any confidence. Ammonites other than *Arctocephalites* are uncommon, and the majority of them are not well enough represented to be specifically identified; in addition, they belong to genera that are long ranging in Europe. These include *Oxycerites* and *Siemiradzkia* in Siberia (e.g. Ershova and Meledina, 1968) and *Oecotraustes*(?), *Prohecticoceras*(?) and *Choffatia*(?) in northern Yukon.

Following Imlay (1980) and Westermann (1980), the Middle Boreal Bathonian Interval is presumed to be approximately correlative with the *glabrescens/metastatus* Zone of the Western Interior of North America, although no ammonite genera occur in common between them. This correlation is based on the general position of these faunas in the biostratigraphic sequence. Differences between the Arctic and Western Interior homeomorphic genera that are indices for these zones – *Arctocephalites* and *Paracephalites* – are given under 'Taxonomic paleontology – *Arctocephalites*'.

No detailed correlations are possible yet with the Western Cordilleran faunas of North America.

Spathi Zone

The characteristic, small ammonites of the *spathi* Zone of this report apparently do not occur in a discrete interval elsewhere in the Boreal Realm. The zone may therefore be represented by a non-sequence elsewhere in Arctic North America and in East Greenland and Siberia (see Table 1). Correlation with the Northwest European Standard zonation, with the Pacific Realm, or the Western Interior is not possible in detail because of the complete absence of any ammonites in common (Table 3).

Porcupinensis Zone

The association of *Arctocephalites arcticus* (Whitfield) and other small to medium sized species with a few large and inflated specimens such as *A.*(?) sp. aff *A.*(?) *crassum* (Madsen) and *A.* sp. aff. *A. sphaericus* Spath suggests correlation of this zone with the *arcticus* (formerly *nudus*) and lower *greenlandicus* Zones of East Greenland. The differentiation of those two zones was based on the larger size of ammonites in the latter. No such consistent size change is seen in Salmon Cache Canyon, where the zones are based on first appearances of species, diagnosed by other characteristics as well as size. Nevertheless, there is a gradual increase in the numbers of larger species upward in the succession, so that the *arcticus* Zone of East Greenland may well correlate with only the lower part of the *porcupinensis* Zone.

The greatest variety of forms in East Greenland is in the lowest part of the *arcticus* Zone, immediately above the zone of *Cranocephalites pompeckji*, and comprising *Arctocephalites arcticus*, *A. koettlitzi*, *A. ellipticus*, *A. pilaeformis*, *A. nudus*, *A. elegans*, *A. ornatus*, *A. ornatus* var. *pleurophora*, *A. sphaericus*, and *A. platynotus*. This varied assemblage of small to medium size ammonites is closest to that of the *porcupinensis* Zone of northern Yukon. In contrast to the succession in East Greenland, *A. arcticus* is not the earliest *Arctocephalites* species found in northern Yukon, although two early species, *A.* spp. A and B aff. *A. nudus*, from the upper part of the *spathi* Zone, may be among the forms that would be considered variants of *A. arcticus* by Callomon (1975). Typical examples of *A. arcticus* do not appear until high in the *porcupinensis* Zone of northern Yukon, just below the first appearance of much larger *A. amundseni*, a look-alike of *A. greenlandicus*, and *A. arcticus* or *A.* sp. aff. *A. arcticus* are present nearly to the top of the *amundseni* Zone. *A.* spp. aff. *A. nudus* occurs throughout the *spathi* and lower *amundseni* Zones. Apparently no such overlap is present in the East Greenland succession. This diminished value of *A. arcticus* for biostratigraphic subdivision in northern Yukon, and the absence of typical *A. greenlandicus* itself, necessitated the new, local, zonal nomenclature presented here. The appearance, in northern Yukon, of *A.* spp. aff. *A. nudus* lower in the succession than *A. arcticus* suggests also that the synonymy of the two species proposed by Callomon (1979) may not be in the best interest of their stratigraphic utilization.

The various *Arctocephalites* faunas described from northern Alaska (Imlay, 1976), western Axel Heiberg Island of Arctic Canada [Frebold, 1964; one specimen (Pl. I, fig. 2a, b) is wrongly labelled *Cadoceras septentrionale* there], the subsurface of the North Sea (Callomon, 1975, 1979), Franz Josef Land (Newton and Teall, 1897; Pompeckj, 1899, 1900; Whitfield, 1907; Spath, 1932; Samoilovich and Bodylevsky, 1933; Ognev, 1933; Frebold, 1951, p. 80) all contain only small to medium sized species. They are therefore correlated with the *arcticus* Zone of East Greenland and the lower part of the *porcupinensis* Zone of northern Yukon.

The two specimens described as *Arctocephalites*? spp. from Prince Patrick Island (Frebold, 1957a), one of which was found with *Cranocephalites vulgaris*, are not sufficiently well preserved to be identified generically or to allow confident correlation with zonations established elsewhere. The record of *Arctocephalites* in Svalbard (Spath, 1932; Frebold, 1930) was based on an unfigured specimen from Svenskøya cited by Pompeckj (1899) as *Macrocephalites ishmae* var. *arcticus*, and, according to Rawson (1982), requires further confirmation.

Judging by the *Arctocephalites* fauna reported, the lower '*elegans*' Zone and the '*jugatus*' Zone of northern Siberia (Voronetz, 1962; Ershova and Meledina, 1968; Meledina, 1973) and Novaya Zemlya (Cherkesov and Burdykina, 1981) are correlative with the *porcupinensis* Zone.

The correlation of the northern Siberia *jugatus* Zone with the *aspidoides* Zone by Ershova and Meledina (1968) and subsequent Soviet workers, places inordinate emphasis on the presence of the long ranging genus *Oxycerites* (Late Bajocian to Callovian; see Westermann, 1958; Elmi and Mangold, 1966). Furthermore, *O. aspidoides* Oppel, with which some of the northern Siberian specimens were compared, has recently been found to come from Bajocian-Bathonian boundary beds in its type area in southern Germany (Dietl, 1982) rather than from the Upper Bathonian. Another associate of *Arctocephalites* spp. in the lower Lena River region was reported by Tuchkov (1972) as *Procerites (Phaulozigzag) procerus* (Seebach) and correlated with the lower Bathonian Zigzag Zone of Northwest Europe. Its re-identification as *Siemiradzkia* by Meledina (1968) renders its age significance less meaningful, the genus ranging throughout the Bathonian.

The presence of small specimens in older beds and large ones in younger beds seen in East Greenland (i.e. *arcticus* vs. *greenlandicus* Zones) is not seen in northern Siberia either. Rather, medium sized species such as *A. kigilakhensis* Voronetz are among the lowest representatives, and large species such as *A. greenlandicus* Spath or *A. amundseni* n. sp. are represented by only one reported specimen, that is, *A.* sp. cf. *A. greenlandicus* (see Voronetz, 1962; Meledina, 1973).

In Novaya Zemlya, several undeterminable specimens and others that are probably *Arctocephalites arcticus* are present (Salfeld and Frebold, 1924; Frebold, 1930, 1951; Bodylevsky, 1967).

Amundseni and Frami Zones

Correlation of the base of the *amundseni* Zone with some level in the lower part of the *greenlandicus* Zone of East Greenland (Table 1) is based on the first appearance of large compressed species, *Arctocephalites amundseni* and *A. greenlandicus*, respectively. The lowest beds of the *greenlandicus* Zone of East Greenland contain only "*Arctocephalites* sp. cf. or aff. *A. crassum*" (J.H. Callomon, pers. comm.). Similar, large, inflated species in northern Yukon, including *Arctocephalites*(?) *belli*, range throughout the *porcupinensis* through *frami* Zones, indicating that they serve only for the most general correlation of this interval with the *greenlandicus* Zone. The varied assemblage of small to medium sized species that continues upward through the *amundseni* Zone in northern Yukon has not been reported in association with the larger species in East Greenland.[1]

Reports of '*Arctocephalites* aff. *greenlandicus*' in Novaya Zemlya (Bodylevsky, 1967), of *A.* cf. *greenlandicus* in northern Siberia (in the '*elegans* Zone') (e.g. Meledina, 1977) and of '*Cadoceras* sp. cf. *crassum*' in Svalbard (Pchelina, 1970, p. 185) may indicate that correlative beds are present in those areas as well. *Arctocephalites* sp. aff. *A. sphaericus* or aff. *A. callomoni* and *A.*(?) sp. indet. ['*Oligocadoceras* cf. *tetonense*' and '*O.* aff. *muelleri*' respectively of Meledina (1977); = '*Cadoceras declinatum*' of Meledina (1973)], occurring just below the lowest *Arcticoceras* (Meledina, 1973, Fig. 35) or with '*Arcticoceras* sp. indet. cf. *kochi*' (Meledina, 1977, p. 190) may represent one of the *amundseni* or *frami* Zones.

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[1] Following fieldwork by the writer in 1985 on western Axel Heiberg Island in Arctic Canada, it is now clear that there is a much more complete succession of faunas than was reported by Frebold (1964). In particular, beds equivalent to the *greenlandicus* Zone are well developed there. The faunas are currently being described.

Upper Boreal Bathonian

This substage is characterized across the Arctic by *Arcticoceras* species in its lower part and by the earliest species of *Cadoceras* and *Kepplerites* in its upper part. These latter genera occur in the Northeast Pacific, North American Western Interior, and Northwest European faunal provinces as well, and their first appearances everywhere, as well as the similar morphological characters of these early representatives of the two genera in different areas, suggest the general correlations shown in Table 3.

The lowest occurrence of *Kepplerites* in the *ishmae* Zone in northern Yukon, and its profusion in the *barnstoni* Zone, is paralleled by approximately the same distribution of *Iniskinites*, although the latter genus may possibly be represented also by small, undeterminable fragments in older beds. Thus, the oldest beds with both *Kepplerites* and *Iniskinites* in the Western Cordillera of North America are tentatively correlated with these two zones of Northern Yukon. They are present in Oregon and western Idaho (Imlay, 1964, 1980, 1981), southern Alaska (Imlay, 1962, 1975, 1980, 1981), central British Columbia (Tipper and Richards, 1976; Frebold, 1978), and Queen Charlotte Islands (Tipper and Cameron, 1980; Frebold, 1979). In southern Alaska and Queen Charlotte Islands, *Iniskinites* may appear below *Kepplerites*, as it seems to do in northern Yukon (see also Imlay, 1980; Westermann, 1980). More detailed correlations between the Boreal and Eastern Pacific faunal realms is not yet possible because the precise sequence of ammonites in the latter region is still being worked out. Other genera in common, such as *Parareineckeia* and *Choffatia*, are generally poorly represented and their significance uncertain, although they seem to support the general correlations shown in Table 3.

No early *Cadoceras* species closely resembling *C. barnstoni* occur in the Western Cordillera. The earliest representatives, such as *C. catostoma* and *C. glabrum*, are close in the character of their umbilicus to *C. bodylevskyi* and other, probably Lower Callovian Arctic species, and they first occur well above the lowest *Kepplerites* and *Iniskinites*.

The correlations indicated here and in Table 3 have implications for the stratigraphic range and significance of *Eurycephalites* in the Eastern Pacific Faunal Realm, if that genus is truly synonymous with *Lilloettia* Crickmay and *Warrenoceras* Frebold as is stated elsewhere in this report. Thus, this genus first appears in the Upper Bathonian *henryi* Zone of which it is characteristic in the Western Interior, but in the Western Cordillera, it occurs in younger beds, above the lowest *Iniskinites* and *Kepplerites*. Significantly perhaps, only those (oldest) specimens from the Western Interior of the United States have septal suture patterns that closely resemble the one figured for *Eurycephalites* by Arkell et al. (1957). They are of low amplitude and are relatively simple in contrast to the sutures of those specimens from Canada, and of the Cardioceratidae (this report) and other Macrocephalitidae (Thierry, 1978). Clearly, the lowest occurrences of *Kepplerites*, *Iniskinites*, and *Cadoceras* on the one hand, and *Eurycephalites* on the other are inconsistent from one area to another, rendering difficult and uncertain any correlations proposed at the present time.

Harlandi Zone

The index species was first named from Svalbard (Rawson, 1982), and similar if not identical species occur in the lower part of the *ishmae* Zone of East Greenland, thus identifying the zone in those areas. Closely similar, if not synonymous, *Arcticoceras excentricum* Voronetz (1962; see also Meledina, 1973, 1977) from northern Siberia probably indicates the presence of the zone there, as does *A.* cf. and aff. *excentricum* in Novaya Zemlya (Cherkesov and Burdykina, 1981). This fauna has not been separated from that of *A. ishmae* in Siberia, however. *Macrocephalites ischmae* (sic) var. *arctica* (Pavlow, 1914), from the Lena River of northern Siberia, is probably an *Arcticoceras* of the type that includes *A. excentricum* Voronetz and *A. harlandi* Rawson. The characteristic species of *Arcticoceras* have coarsely spaced, strong ribs, which are not strongly projected on the venter.

Correlation of the *harlandi* Zone with any particular zone in Northwest Europe is entirely unsupported, the only genus in common, *Cadomites*, being long ranging in Europe. Nevertheless, the correlation of the *ishmae* and what was the *aspidoides* (or *orbis*) Zone discussed in the following pages, supports a general correlation of the immediately underlying *harlandi* and *hodsoni* Zones (Table 3).

Ishmae Zone

The index species, *Arcticoceras ishmae* (Keyserling), described first from the Ishma River of northern European Russia (Keyserling, 1846) is now known to be present right across the Arctic, providing a firm basis for correlation within the Boreal Realm (Table 1; see also Bodylevsky, 1960; Saks et al., 1976). Callomon (1975) showed *A. kochi* Spath to be a junior synonym of *A. ishmae*, and replaced the earlier zonal name to recognize this synonymy. He also erected a distinct zone, the *cranocephaloides* Zone, for beds in East Greenland that had earlier been included in the upper part of the *ishmae* Zone. The present writer further restricts the *ishmae* Zone by separating the *harlandi* Zone from its lower part. *Oxycerites birkelundi* n. sp. is present with *A. ishmae* in northern Yukon and East Greenland.

The *ishmae* Zone has been identified in the Canadian Arctic Archipelago on Prince Patrick Island (Frebold, 1961) and western Axel Heiberg Island (Frebold, 1964). The *ishmae* Zone may be represented by small fragments of *Arcticoceras* in northern Alaska (Imlay, 1976, p. 3, figs. 22, ?17, 18) and is present in the subsurface of the North Sea (Callomon, 1975), Svalbard (Pchelina, 1967, 1970), and northern Siberia (e.g. Bodylevsky and Kiparisova, 1937; Meledina, 1973, 1977) where it has not been differentiated from the beds with *A. excentricum*. *A. ishmae* is also present in Novaya Zemlya (Cherkesov and Burdykina, 1981), although earlier described specimens, '*Macrocephalites ischmae*' (Salfeld and Frebold, 1924) are probably undeterminable (Bodylevsky, 1967). Specimens identified as '*Macrocephalites*' *ishmae* and '*M.*' cf. *ishmae* by Samoilovich and Bodylevsky (1933) and Ognev (1933) are not positively identifiable.

Reports of *Pseudocadoceras* spp. with *Arcticoceras* in northern Siberia have been taken as confirmation of the Callovian age of *Arcticoceras* (Meledina and Nal'nyaeva, 1972). The identifications of *Pseudocadoceras* (Meledina, 1972, p. 109, Pl. VIII, fig. 2-5; Meledina, 1973, 1977) refer to evolute small specimens of the type described by Rawson (1982) as probable microconchs of *Arcticoceras* under the name *Costacadoceras*. The same is true of specimens of *C. ognevi* Bodylevsky (1960, p. 57) figured by Voronetz (1967, Pl. XXIII, fig. 2). *Cadoceras* cf. *ognevi* had been considered (Bodylevsky, 1960, p. 51; Meledina and Nal'nyaeva, 1972, p. 71) to characterize an interval between *Arcticoceras* below, and other *Cadoceras* species above. The stratigraphic significance of '*Pseudocadoceras*' s.l. is therefore diminished and certainly these microconchs no longer are considered to be reliable indicators of Callovian age.

Correlation of the Boreal *ishmae* Zone with the *codyense/henryi* Zone of the Western Interior of North America (Imlay, 1980; Westermann, 1980) was based on their general stratigraphic position below the first occurrences of *Kepplerites* and above mutually similar *Paracephalites* and *Arctocephalites* faunas discussed elsewhere in this report. Although the index genera of these zones – *Arcticoceras* and *Eurycephalites* (i.e. *Lilloettia* and *Warrenoceras*), respectively, are now assigned to different subfamilies, as are the somewhat older genera *Arctocephalites* and *Paracephalites*, the general morphological similarities between the Arctic and Western Interior genera are striking, and the general correlation of morphologically similar members of the two parallel-evolving but independent lineages is supported by the present study (Table 3).

The general similarity of the *Eurycephalites* faunas with *Arcticoceras* even extends to the ventrally projected ribs of some species of *Xenocephalites* such as *X. crassicostatum* and *X. saypoensis*, which may be the microconch dimorph of the Western North American Subfamily Eurycephalitinae.

Although the lowest well developed *Kepplerites*, and the greatest abundance of the genus are in the *barnstoni* and *K. costidensus* Zones, two undeterminable species of *Kepplerites*(?) occur in the *ishmae* Zone of northern Yukon, and *K.* sp. indet. occurs with the *henryi* Zone fauna of western United States. The distributions support the correlation just stated, *Kepplerites costidensus* and higher *Kepplerites* species occurring above the *Warrenoceras* (i.e. *Eurycephalites*) beds of Western Interior United States, but with a zone of overlap in and just above the *Gryphaea* bed of southern Alberta. An interval of overlap of *Kepplerites* with *Arcticoceras* in East Greenland comprises the *cranocephaloides* and earliest part of the *variabile* Zones there (Callomon, 1975).

Correlation of the Arctic *ishmae* Zone with any particular interval in Northwest Europe remains tenuous, but the correlation suggested by Birkelund et al. (1971; see also Westermann, 1981) with the *aspidoides* (*orbis*, see Dietl, 1982) Zone is reasonable. Some support for this correlation is offered by the presence of *Choffatia*(?) in northern Yukon. Most Bathonian *Choffatia* species occur in the *aspidoides* or *orbis* Zones (e.g. Hahn, 1969; Deitl, 1981) in southwestern Germany. Only one species each of *Choffatia (Choffatia)* and *C. (Homeoplanulites)* occur in the *hodsoni* (or *retrocostatum*) Zone of southwest Germany, the former only in the uppermost beds (Hahn, 1969), although Torrens (1974) reports the genus to be common in the *retrocostatum* Zone of England.

Prohecticoceras is questionably identified in a loose boulder which may come from the *ishmae* Zone or just below it in Salmon Cache Canyon. This is consistent with its appearance being the guide for the *hodsoni* (or *retrocostatum*) Zone of Northwest Europe (Torrens, 1974).

The correlation of the *ishmae* and *macrocephalus* Zones, still followed by many Soviet writers, was based on general similarities between *Arcticoceras* and *Macrocephalites*, and led to identification by early workers of the Arctic ammonites with their European homeomorph. This correlation is not supported by any other data.

Upper parts of the *ishmae* Zone, characterized by a particularly large and coarsely ribbed species of *Arcticoceras*, and the interval between the *ishmae* and *barnstoni* zones, are not exposed at Salmon Cache Canyon. Some large specimens of *Arcticoceras* found loose below the section may indicate that equivalents of the upper *ishmae* and *cranocephaloides* Zones of East Greenland (Callomon and Birkelund, 1980) are, in fact, present at Salmon Cache Canyon.

Barnstoni Zone

Frebold (1964) described one specimen of *Cadoceras barnstoni* from Ellef Ringnes Island, indicating the presence there of the *barnstoni* Zone.

The *variabile* Zone of East Greenland is correlated approximately with the *barnstoni* Zone of northern Canada, based on the similarity of the *Cadoceras* species. The East Greenland zone was restricted, compared to previous usage, by the separation of the *calyx* Zone from its upper part (Callomon, 1975). The lowest occurrence of *Kepplerites* in East Greenland is in the *cranocephaloides* Zone (Callomon, 1975), but the genus is not common in the Salmon Cache Canyon section until the *barnstoni* Zone, the *cranocephaloides* equivalents not being exposed if they are present. Although some of the *Kepplerites* from Salmon Cache Canyon closely resemble *K. rosenkrantzi* from the *variabile* Zone of Greenland, they have runcinate venters with ventrolateral nodes in the juvenile and intermediate growth stages, a development not seen in East Greenland until the *calyx* or *apertum* Zones. Other northern Yukon specimens are similar to specimens from these East Greenland zones, but in a more general way. Thus, the *barnstoni* Zone of northern Yukon may well be slightly younger than the restricted *variabile* Zone of East Greenland.

In northern Siberia, the assemblage of *Cadoceras subcalyx*, *C.*(?) *excelsus*, *C. densicostatum* and *C. variabile* (Voronetz, 1962), as well as the isolated species *C. ventroplanum*, probably represent the *barnstoni* or *variabile* Zones. *C. subcatostoma* Voronetz (1962) resembles certain elements of this fauna but its associates do not, so it may be younger. Bodylevsky (1960) thought *Cadoceras laptievi* to be among the oldest *Cadoceras* species, characterized by coarse ribs that persist over the entire extent of the body chamber, and a rounded umbilical edge, even on the body chamber. This age assumption may be correct judging by the stratigraphic occurrence of similar *C. barnstoni* (Meek) and *C. variabile* Spath, but the age of *C. laptievi* is not proven.

The interval between the *barnstoni* and *bodylevsky* Zones is not well exposed at Salmon Cache Canyon, but equivalents of the *calyx* Zone of East Greenland are assumed to be present.

Two *Cadoceras* beds, about 77 m apart stratigraphically, have been recognized on Axel Heiberg Island (Frebold, 1964). The lower of them contains *Cadoceras bodylevskyi*, *C.* sp. cf. *C. falsum* and *C. barnstoni* var. *arcuata*, species that are represented in at least two distinct faunas, the *barnstoni* and *bodylevskyi* Zones at Salmon Cache Canyon. They are separated by an interval of about 55 m at Salmon Cache Canyon, so that the Lower *Cadoceras* bed on Axel Heiberg Island may be correlated with some level intermediate between the two *Cadoceras* beds at Salmon Cache Canyon. *Kepplerites svalbardensis* and *K. tychonis*

Ravn probably represent this interval in Svalbard (Frebold, 1929, 1930, 1951; Sokolov and Bodylevsky, 1931; Pchelina, 1970).

Lower Callovian

Bodylevskyi Zone

None of the *Cadoceras* species in East Greenland are sufficiently similar to those of the *bodylevskyi* Zone at Salmon Cache Canyon to permit a confident correlation of the two areas, although the juvenile and intermediate growth stages of some *C. apertum* and some *C. bodylevskyi* are very similar. Similarly, the *C. elatmae* (Nikitin) fauna of northern European Russia may be correlative, judging by *C. elatmae* itself, although some of the associated *Cadoceras* species and *Kepplerites* cf. *tychonis* Ravn (see Bodylevsky, 1960; Saks et al., 1976) resemble the older *barnstoni* fauna of northern Yukon, so that no firm correlation is indicated. It is not clear that specimens from northern Siberia identified as *Cadoceras 'elatmae'* are indeed synonymous with their namesake in northern European Russia. *C. 'elatmae'* from the Anabar River of northern Siberia (Pavlow, 1914) and the widespread Siberian assemblage in which *C. 'elatmae'*, *C. falsum*, and *C. anabarensis* are most commonly reported, and which represent the *'elatmae'* Zone of Meledina (1977), are probably in part equivalent to the *bodylevskyi* Zone of northern Yukon, judging by the similarity of some of those species (particularly those identified as *C. elatmae* itself) to *C. bodylevskyi*. Nevertheless, the variation in morphotypes, and differences in assemblages from one place to another in Siberia indicate complex, poorly understood relationships, so the correlation is not straightforward. Additionally, these species, including *C. 'elatmae'* (Voronetz, 1962, Pl. XII, figs. 1a, b; Pl. XXVI, figs. 1a, b; Meledina, 1977) have a wider umbilicus than the specimens of *C. bodylevskyi* from Salmon Cache Canyon. The subdivision of *Cadoceras* beds into only two zones (Meledina, 1977) suggests that they may be overly comprehensive. The assemblage of *Cadoceras emilianzevi*, *C. subtenuicostatum*, *C. falsum* (Meledina, 1977, p. 189, 190) and another associate *C. lenaense* (*ibid.*, p. 192) is probably younger than those in the Salmon Cache Canyon section.

The Saratov region on the Lower Volga has yielded *Parkinsonia* repeatedly (Arkell, 1956, p. 484; Kamysheva-Elpatyevskaya et al., 1959). It is about the northeasternmost locality with Northwest European faunal character, narrowly separated from the Boreal areas by the Russian Platform. *Cadoceras elatmae* is reported to occur with *Macrocephalites macrocephalus* (Kamysheva-Elpatyevskaya et al., 1959), indicating the correlation of the Boreal and Northwest European zones, in an area where they may intermix. Apparently, neither species from this critical area has been figured. The correlations presented in this report are consistent with such an interpretation however, based primarily on space considerations in filling the pre-Calloviense, post-*ishmae/aspidoides* interval on the correlation chart.

The *macrocephalus* Zone of Northwest Europe is taken to be basal Callovian, following Callomon (1964), although some small ammonites in the Upper Bathonian beds of Germany may be *Macrocephalites* (Dietl, 1981). Since Callomon (1959) interpreted the *tychonis* Zone of East Greenland to be equivalent to the Northwest European *macrocephalus* Zone, the true level from which *Kepplerites tychonis* Ravn came has been discovered (Callomon and Birkelund, 1980). It occurs in the upper part of the *cranocephaloides* Zone, and the earlier interpretation is no longer valid.

Younger zones

J.H. Callomon (pers. comm., 1981) has identified *C. septentrionale* in East Greenland from the beds between those with *C. nordenskjoldi* below and *Sigaloceras calloviense* above. *C. septentrionale* is thought to be younger than the beds with *C. bodylevskyi* at Salmon Cache Canyon, based on the stratigraphic relationships of these two species on Axel Heiberg Island as reported by Frebold (1964). The higher *Cadoceras* fauna on Axel Heiberg Island, containing *C. septentrionale* and *C. septentrionale* var. *latidorsata* (Frebold, 1964), does not appear in the Salmon Cache Canyon section, although the ammonites from it have been described from other isolated localities in the northern Richardsons (Frebold, 1964). *Cadoceras arcticum* Frebold (1961, 1964) from Cornwall Island and isolated localities in northern Yukon is probably younger than any species in the Salmon Cache Canyon section. The specimen of *C. arcticum* from Cornwall Island has an abrupt umbilical edge and a relatively deep, steep-sided, narrow umbilicus as does *C. septentrionale*. Beds equivalent to those with *C. arcticum* may be represented in Franz Josef Land by *'Ammonites (Cadoceras) modiolaris'* (Newton and Teall, 1897).

TAXONOMIC PALEONTOLOGY

Publication of the Ammonoidea volume (L) Mollusca 4 of the Treatise on Invertebrate Paleontology (Arkell et al., 1957) has expedited and prompted a large number of studies aimed at formulating a more complete and widely accepted taxonomic scheme for the ammonites. A preliminary general taxonomic scheme has been presented by the compilers of the second edition of the Treatise (Donovan et al., 1981). The most significant changes relevant to the present report are by J.H. Callomon (in Donovan et al., 1981; 1985) for the superfamily Stephanoceratacea. His suprageneric taxonomy is adopted here, although he pointed out that uncertainties remain and that some arbitrary decisions are involved. The overall effect is a simplification of the taxonomy, reducing the number of higher taxa to a necessary minimum, based on relationships deduced from tracing lineages wherever bed-by-bed successions have been collected, and with consideration for the co-occurrence of dimorphic pairs and of the loci of evolution, that is, of faunal provincialism. The phylogenetic relationships of what was a complex hodge-podge of many homeomorphic genera scattered around the globe, each being treated differently by different authors, have thus been clarified to a large extent.

As a trade-off for a simpler taxonomic and phylogenetic scheme, the identification of isolated specimens has become more subjective. To a certain extent then, correct identification of a particular ammonite in certain groups may require not only knowledge of its morphology but also that of its associates, indicating its morphological variability, and that of its dimorph partner. Also, knowledge of its stratigraphic position (situation within lineage) and its geographic position [which lineage(?), considering extreme faunal provincialism to be the case] may be necessary. This is a phylogenetically based taxonomy (see Sylvester-Bradley, 1962, for example).

Principal among the morphological criteria for differentiating between major taxa are the modifications of the adult mouth border: a ventral projection or lappet and apertural constriction in Cardioceratidae; little or no modification, often constrictions only on the flanks in Sphaeroceratidae; lateral lappets in Stephanoceratidae and Kosmoceratidae. With regard to Sphaeroceratidae, the weak ventrolateral lappets seen on two microconchs of *Iniskinites* from Salmon Cache Canyon may be significant.

Species concept

When large numbers of fossils occur together in a single bed, a continuous range of morphological variation between individual specimens may indicate their assignment to a single or a small number of species (e.g. Reeside and Cobban, 1960). This approach is further upheld by observations of modern populations, in which the number of species of a genus present is generally one, and is further supported by theoretical considerations.

In this report, however, the author describes the co-occurrence of as many as six or seven species of *Arctocephalites* (e.g. Beds 31, 36). Some of the species exhibit considerable morphological variation; others do not. They are delimited where little or no morphological overlap was recognized between them, and for the most part where more than one characteristic feature distinguishes them. In particular, a significant difference in size, inflation, or shape of the cross-section is almost invariably accompanied by a difference in orientation, branching character or spacing of the ribs at equivalent growth stages, so that no simple, continuous variation from one species to another, or co-relation of variation of two features is readily apparent. The morphologically defined yet somewhat variable species thus recognized, regardless of what, if any, relation they have to biological species, co-occur in different combinations from one bed to another, and have different, mostly short, stratigraphic ranges. They are, therefore, the most useful units for identification and/or correlation of isolated or small samples, and for comparison and correlation of the assemblages with those from the regions. The author's approach at the species level is thus typological, except where sufficient material is present to demonstrate continuous variation between different, co-occurring morphotypes.

A comparison with the equivalent assemblages in East Greenland, northern Siberia, and other Arctic areas, indicates only a limited proportion of morphospecies thus defined that are in common with those of northern Yukon, throughout the stratigraphic extent of the evolutionary plexus. At the same time, the overall similarity between the morphospecies in those regions within the same faunal realm indicates nearly continuous marine connections and provides data on the effect of long distances in separating them.

Dimorphism

Sexual dimorphism has now become a widely accepted concept. The major tenets and problems of the assignment of two different morphotypes to macroconch and microconch of the same species, even where traditional typological methods have placed them in different genera or even families, have been stated by Callomon (1963, 1981) and Makowski (1963). Microconchs are smaller than macroconchs of the same species, and are generally ribbed to their aperture. As adults, they exhibit more elaborate development of lappets, as well as incipient uncoiling and septal approximation or other modification. Microconchs are commonly in a minority with respect to macroconchs.

Only a few certainly recognizable microconchs of the Cardioceratidae have been illustrated previously – for *Arcticoceras ishmae* and *Arctocephalites arcticus* (Callomon, 1975), for *Arcticoceras/Cadoceras* sp. nov.? aff. *variabile* Spath (Callomon and Birkelund, 1980, Pl. 1, fig. 2a, b), and for *Arcticoceras harlandi* Rawson (1982). Rawson (*ibid.*) gave a new specific name to the presumed microconch of *A. harlandi* and a new generic name, *Costacadoceras*, to the morphotype that is thought to represent the microconch of the entire lineage of *Arcticoceras* and many *Arctocephalites*. Definitely identifiable microconchs are rare in the Salmon Cache Canyon section. Two have been been illustrated here, as "*Costacadoceras*" spp. The numerous, very small ammonites that occur prolifically in pods at several horizons generally exhibit neither lappets nor uncoiling, and are considered to represent episodes of juvenile mortality. The taxonomic implications associated with the recognition of sexual dimorphism have been discussed by Callomon (1981).

Another type of dimorphism exhibited by several of the species of *Arctocephalites* and *Arcticoceras* is described here. Consistently, the larger dimorph becomes smooth at or close to the beginning of the body chamber, and exhibits a well defined constriction on the internal mould, and a ventral lappet at the aperture. In contrast, the smaller dimorph remains ribbed to its termination just beyond the apertural constriction, at a diameter that corresponds more or less precisely with that at which the body chamber of the larger dimorph begins. The small dimorphs, therefore, are about three quarters to a full whorl smaller than the macroconchs and about half their diameter, or slightly more. No other significant difference in the larger dimorph or other adult modification has been seen. Most of the species are based on the larger dimorphs. The smaller ones, much in the minority in the collections, are recognized in the abundantly represented species *Arctocephalites porcupinensis*, *A. kigilakhensis*, possibly *A. frami*, and in *Arcticoceras ishmae*. In a few cases (e.g., *A. porcupinensis*, GSC loc. 92525), the two dimorphs occur together in the same sample. This type of dimorphism is assumed to represent a limited sort of polymorphism. The more extensive East Greenland collections of subfamily Cadoceratinae exhibit a more complete variation in the size of adult shells and in the persistence of ornament.

Other examples of dimorphism in the material described here might be the association of the assumed dimorphic pair – *Oxycerites* and *Oecotraustes*, as well as the presence of both large and small specimens (with ventrolateral lappets) of *Iniskinites*.

Suborder AMMONITINA Hyatt, 1889

Superfamily STEPHANOCERATACEAE Neumayr, 1875

Family CARDIOCERATIDAE Siemiradzki, 1891

The genera *Arctocephalites*, *Arcticoceras*, *Paracadoceras*, and *Cadoceras* are of primary concern in this report. For the most part, the separation of one from another is based on arbitrarily delimited morphological criteria. Together with a consideration of the different stratigraphic positions of *Arctocephalites*, *Arcticoceras* and *Cadoceras* in a continuous succession with intermediate forms at the boundary horizons, they lead to the current, widely accepted definition of those genera. *Costacadoceras* was erected recently (Rawson, 1982) for small, evolute ammonites that are probably microconchs of associated *Arcticoceras* and *Arctocephalites* species. Two specifically and otherwise generically unidentifiable specimens are referred here to *Costacadoceras*.[1]

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[1] Since this report was written, an important review of family Cardioceratidae has appeared (Callomon, 1985).

Subfamily ARCTOCEPHALITINAE Meledina, 1968

The subfamily was erected because of a reported difference from other Cardioceratidae in the number of umbilical lobes of the septal suture pattern (Meledina, 1968). Although this does not appear to be a significant enough difference for separation of the northern Yukon *Arctocephalites* species from members of the younger subfamily Cadoceratinae, the subfamily differentiation is convenient in separating other genera from *Cadoceras* on the basis of their narrower umbilici and usually more compressed cross-sections. An extended discussion of the subfamily and its affinities has been published by Meledina (1973).

Stronger and more asymmetrical subdivision of the first lateral saddle characterizes the suture patterns of *Cadoceras* and *Paracadoceras* species figured here compared to those of *Arctocephalites* and *Arcticoceras*, except for *Arctocephalites* sp. B, which has sutures closer to those of *Cadoceras barnstoni* (Meek). A general evolutionary trend to greater differentiation of the first lateral saddle may be present.

It is beyond the scope of this report to discuss in detail the genera *Cranocephalites* Spath, *Boreiocephalites* Meledina or *Umaltites* Sei and Kalacheva, because they are older than the faunas treated here. However, the differences between *Cranocephalites* and *Arctocephalites* are mentioned briefly under the latter genus, and *Umaltites* is described under *Loucheuxia* (subfamily Eurycephalitinae).

Genus *Arctocephalites* Spath, 1928

The genus is based on *Ammonites ishmae* var. *arcticus* Newton and Teall (1897) from Franz Josef Land.

Arctocephalites is currently considered to comprise those members of the continuous Boreal cadoceratinid succession that link older *Cranocephalites* Spath with younger *Arcticoceras*. The older genera are distinguished principally and most readily by being strongly ribbed on the entire body chamber, whereas *Arctocephalites* becomes smooth. Spath (1932, p. 14, 15, 32), in his first extensive report dealing with *Cranocephalites* and *Arctocephalites*, following the original definition of the latter genus, distinguished *Cranocephalites* by its excentric body chamber and tendency to simplified sutures and to show little or no loss of ornamentation.

Following the interpretation of Callomon (1959), *Arcticoceras* Spath (1924) is distinguished somewhat more arbitrarily by having ribs that are strengthened and projected over the venter. This distinction, like that separating *Arctocephalites* from *Cranocephalites*, has stratigraphic significance. Intermediate forms do occur however, as is noted below under the specific descriptions, and the morphological and stratigraphic separation of the two genera is not entirely abrupt.

The species of *Arctocephalites* clearly form a single, complex evolutionary plexus in which some morphotypes are widely recognized and others are apparently local. Their biostratigraphic utility and, in particular, the finer subdivision of the succession given here justifies the continued use of specific nomenclature for each of the major morphotypes.

Most of the morphospecies of subfamily Arctocephalitinae from the Arctic are compressed forms; however, inflated varieties occur with them at all levels. Too few inflated forms are present in the northern Yukon collections to prove whether or not they are closely related to the compressed forms they occur with. However, the opportunity provided by T. Birkelund and J.H. Callomon to see the more extensive East Greenland collections has convinced the writer of the general correctness of their approach – that complete variation between the compressed and inflated forms exists at each level. The inflated forms associated with typical *Arctocephalites* are therefore assigned here to *Arctocephalites*(?). Nevertheless, intermediate forms are rare, perhaps for paleoecological reasons, and other characters generally accompany the greater inflation; notably, larger adult size and phragmocone, coarser spaced and stronger ribbing, and persistence of coarse, umbilical tubercles. Additionally, projected ribbing on the venter of compressed specimens in the *Arcticoceras*-bearing levels generally does not appear on the inflated specimens at the same level. Hence the query following the generic assignment and the differentiation at the specific level.

Reports of *Arctocephalites* in several areas of Western North America are based on specimens that are not sufficiently well preserved to extend the range of the genus south of the Boreal Realm, or that have been reassigned to other taxa, as summarized below.

Arctocephalites has long been reported from the Fernie Group of southern Alberta and from the Western Interior of United States. These occurrences have been disputed however (Frebold, 1957, 1963), and are no longer generally accepted, but they are of interest when defining the paleobiogeographic distribution of the genus, so that a discussion of them is in order. Spath (1932, p. 13) mentioned "young Canadian examples of *Arctocephalites*", referring to Buckman's (1929) genera *Metacephalites* and *Miccocephalites*, but elsewhere (Spath, 1932, p. 33) correctly indicated that they are almost impossible to identify and cannot stand as genera. Imlay (1945, 1948) quoted the report of *Arctocephalites* in the Fernie Group and described other specimens from Western Interior United States as *Arctocephalites*. He (Imlay, 1945, 1948, 1967) emphasized the similarity of some Western Interior species with *Arctocephalites* species from Greenland. Westermann (1980) has recently identified an "*A. glabrescens* Zone" and correlated it with that of *A. elegans* of the Arctic, and Imlay (1980) has accepted Frebold's (1963) arguments for treating *Paracephalites* Buckman (1929) as a distinct genus. The newer specimen, which Frebold (1963, p. 12, Pl. 1, fig. 2; Pl. II, fig. 2; 1964, Pl. 29, fig. 2) described as *P. metastatus*, has differently curved ribbing than the original material, and appears to show gradual ventral loss of ribbing toward the aperture, suggesting its possible affinities with *Eurycephalites* instead of *Paracephalites* but certainly allying it with subfamily Eurycephalitinae. The present writer considers *Paracephalites*, including *Metacephalites* Buckman (1929) and *Miccocephalites* Buckman (1929), to be an endemic Western Interior genus, and assigns it to the subfamily Eurycephalitinae. Imlay (1962) had assigned other Western Interior species to *Arctocephalites*? or *Arctocephalites* (*Crancocephalites*) but later (1967; 1980, p. 27, 28) accepted their re-assignment to *Paracephalites*, quoting from Frebold (1963) its generic differences from *Arctocephalites* and *Cranocephalites*. These differences include a wider umbilicus that opens up at a later growth stage, and retention of ribbing to a later stage on the adult body chamber. Donovan (1957, p. 134) stated that North American specimens (i.e., *Paracephalites*) do not closely resemble *Arctocephalites* because of the coarse ribbing in the inner whorls and concave-backward ribs on the middle whorls displayed by the former. These differences are supported by the present writer's restudy of the original type material.

Elsewhere in non-Arctic North America, ***Arctocephalites*** has been reported from southern Alaska (Imlay, 1962, 1980) and has been questionably identified in central British Columbia (Frebold and Tipper, 1973; Tipper and Richards, 1976). The assignment of the three specimens from central British Columbia to ***Arctocephalites***? is indeed questionable. They occur in a fauna the general characteristics of which suggest an age older than ***Arctocephalites*** beds elsewhere and have been assigned to an enigmatic genus *Umaltites*, originally described in far eastern USSR by Sei and Kalacheva (1979). Certain small forms from southern Alaska earlier assigned to *Arctocephalites*, *Arctocephalites*? and possibly others to *Arctocephalites (Cranocephalites)* by Imlay (1962) have been reassigned to *Chinitnites* Imlay (1975) and *Tuxednites* Imlay (1980). The determination of another, only partially preserved specimen figured from southern Alaska (Imlay, 1980, Pl. 8, figs. 18-21) is uncertain.

Arctocephalites spathi n. sp.

Plate 1, figures 1-17; Plate 2, figures 1-10

?*Arctocephalites elegans* Spath. Frebold, 1961, Pl. XI, fig. 1a, b.
?*Arctocephalites* cf. *A. ornatus* Spath. Frebold, 1961, p. 11, 12.
?*Arctocephalites*? sp. indet. Frebold, 1961, p. 12.
Arctocephalites elegans Spath. Poulton and Callomon, 1976, Fig. 61.3; Poulton, 1978, Fig. 2.
?*Arctocephalites elegans* Spath. Meledina, 1973, p. 67, Pl. XV, figs. 2, 3, Pl. XVIII, fig. 1.

Material and occurrence. Eighteen poorly- to well-preserved specimens, including: holotype GSC 68261 and paratypes GSC 68262, 68264 and 68652, from GSC locality 92523 (Bed 7); one (paratype GSC 68267) from GSC locality 92484 (Bed 14); one fragment (paratype GSC 68263) from GSC locality 92522 (Bed 2); and probably two specimens previously described but not figured by Frebold (1961, p. 11, 12) from GSC localities 35635 and 35638 (figured specimens GSC 15107 and GSC 15110 from Beds 2 and 7, respectively). Thus the species is present in Beds 2 to 14, and characterizes the *spathi* Zone. Other specimens have been found loose below the section (GSC loc. 92520; for example, paratypes GSC 68265, 68266, 68269). One unfigured specimen found loose (GSC loc. 92567) occurs in the same concretion with *Oecotraustes*(?) sp.

Description. There is little variation in the strength, spacing, nature of subdivision, or orientation of the ribs. The ribs persist longer on the ventral half of the flanks and on the venter. The shell becomes smooth approximately at the beginning of the body chamber, although there appears to be considerable variation from one specimen to another. The body chamber varies from about two thirds to three quarters of a whorl in length.

Up to a whorl height of about 20 mm, the ribs are fine, nearly straight, and subradial. At about that size, the ribs become slightly falcoid, curving forward just above the rounded umbilical edge, and becoming straight or nearly straight over the ventral two thirds of the flank. Most ribs bifurcate about one third of the way up the whorl. There is some trifurcation and some intercalation of secondary ribs, so that a distinct appearance of trifurcation results. This is true at all growth stages seen.

There are two distinct size ranges, but other characters and the stratigraphic range indicate that they represent the same species. The average adult diameter of the smaller specimens (Pl. 11) is 65 to 70 mm. The best of the larger specimens (Pl. 2, figs. 1, 2) is 90 mm in diameter, although distortion of this specimen cannot be entirely discounted because it is incomplete. In part, the larger size is associated with the significantly higher cross-section of the early parts of the body whorl. Otherwise there is little variation in the cross-section of the shell, in any of the material.

The suture is typical of the genus (see figs. 8, 9).

The strongly developed terminal constriction on the internal mould is preserved in several specimens (e.g. Pl. 1, figs. 3, 13). Reappearance of weak ribs on the apertural few centimetres of the body chamber is seen in two specimens (Pl. 2, figs. 3, 6).

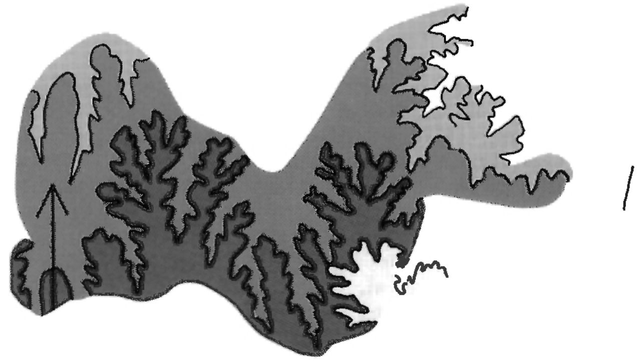

*Figure 8. Septal suture pattern of **Arctocephalites spathi** n. sp.; figured specimen GSC 68652, from GSC locality 92523; whorl height 2.5 cm.*

*Figure 9. Septal suture pattern of **Arctocephalites spathi** n. sp.; figured specimen GSC 68267, from GSC locality 92484; whorl height 2.7 cm.*

The typical shape and cross-section of the species is best shown in an undistorted specimen that is preserved in a matrix identical to that of Bed 7 (Pl. 1, figs. 14, 15), but was collected loose below the section (GSC loc. 92520). The typical curvature of the ribs is not well seen on this specimen, however. Slightly straighter and stronger ribs are seen on another, otherwise typical specimen collected loose in the identical matrix (Pl. 1, figs. 16, 17). These ribs approach in appearance those of *A. elegans* Spath (1932, Pl. 10, fig. 4), although the specimens differ from that species as described below.

Discussion. The somewhat falcoid shape and forward slope of the ribs in the adult, the regular intercalation of secondaries or trifurcation of primaries, combined with the size and shape of the shell, separate this species from all others. In particular, the shape of the ribs and their more abrupt disappearance on the body chamber separate it from *A. elegans*, *A. ornatus* Spath and *A. arcticus* Spath. The primaries are longer in *A. elegans* and are strengthened where they subdivide. The cross-section of the body chamber is narrower than in the latter species.

Many of the specimens from the lower part of the section listed as *A. elegans* in preliminary reports (Poulton and Callomon, 1976; Poulton, 1978) are reassigned to the present species. Additionally, judging by the figures of Meledina (1973), it seems likely that many reports of *A. elegans* in northern Siberia may also refer to the new species. Judging by the strength and orientation of their ribbing, the specimens figured by Voronetz (1962, Pl. X, fig. 3) and Efimova et al. (1968, Pl. 94, figs. 1, 2) probably have closer affinities to *A. spathi* n. sp., *A. arcticus* and *A. porcupinensis* n. sp., respectively, although none is identifiable with certainty from the figures given.

A. voronezae Meledina is more inflated and the ribs appear to be more nearly radial.

Name. In recognition of the contributions of L.F. Spath to Mesozoic paleontology in general and to the Boreal Middle Jurassic ammonites in particular.

Arctocephalites ellipticus Spath(?)

Plate 3, figures 1-6

?*Arctocephalites ellipticus* Spath, 1932, p. 33, Pl. XIII, fig. 6a, b.

Material and occurrence. One fragment (figured specimen GSC 68270) from GSC locality 92523 (Beds 6, 7; *spathi* Zone) and another specimen (figured specimen GSC 68271) collected loose below the section (GSC loc. 92520).

Discussion. The cross-section is nearly as wide as it is high and the flanks are flat, as in *A. ellipticus* Spath. The low profile and curvature of the ribs are also similar. For these reasons, the northern Yukon specimens are questionably identified with Spath's species although it is based on a single fragment and another, only partially preserved specimen. The regular bifurcation of ribs in the earliest growth stages of that species illustrated by Spath cannot be seen in the Yukon material. The flanks of the northern Yukon specimens appear to be flatter in the intermediate growth stages than those that Spath illustrated.

Among the specimens collected from loose material below the section, one (Pl. 3, figs. 4-6) is apparently identical to that described from Bed 6 (Pl. 3, figs. 1-3) in its intermediate growth stages, and occurs in an identical matrix. It illustrates the oral portions of the body chamber, cross-section, and ribbing at an intermediate growth stage. The suture pattern is shown in Figure 10.

Figure 10. *Septal suture pattern of* ***Arctocephalites ellipticus*** *Spath(?); figured specimen GSC 68271, from GSC locality 92520; whorl height 2.5 cm.*

Arctocephalites sp. A aff. *A. sphaericus* Spath

Plate 3, figures 7-10

aff. *Arctocephalites sphaericus* Spath, 1932, Pl. VIII, fig. 1.
Arctocephalites cf. *sphaericus* Spath. Callomon, 1979, Pl. 1, fig. 2a, b, c and possibly 3a, b.

Material and occurrence. A fragment (figured specimen GSC 68272) from GSC locality 92523 (Bed 6; *spathi* Zone) in which parts of two whorls are preserved, the largest exposing the oralmost septum; possibly also two still smaller fragments (e.g. figured specimen GSC 68273) from GSC locality 92525 (Bed 22; *porcupinensis* Zone).

Description. The shell is wider than high, and is coarsely ribbed to a whorl height of 35 mm. The ribs are strong and coarse. They bifurcate regularly about one third of the way up the flank. They are gently and continuously curved forward.

At the oralmost end of the largest preserved fragment, very fine, irregular corrugation (growth lines) is superimposed on the ribs of the venter (Pl. 3, fig. 7).

Discussion. This form is distinguished from *Arctocephalites spathi* n. sp. with which it is associated, by its wider than high cross-section, the coarser ribs at an equivalent diameter, and the somewhat greater and continuous forward inclination of the ribs. The difference in the cross-section is seen even in the smaller whorls preserved in the largest fragment. It does not have flattened flanks as does the widest of that species.

The inflated cross-section separates this form from all species except *A. callomoni* Frebold and *A. sphaericus* Spath. The nearly straight and subradial ribs of *A. callomoni* further distinguish that species.

The inner whorls of the holotype of *A. sphaericus* (Spath, 1932, Pl. XVII, fig. 1) have not been illustrated, so that an exact comparison with that species cannot be made. The curvature of ribs is much less in a paratype from East Greenland (Spath, 1932, Pl. XVI, fig. 5) and in specimens described by Spath (*ibid.*, Pl. VIII, fig. 2, Pl. VI, fig. 3) as *A.* aff. *sphaericus* and *A.* cf. *sphaericus* than it is in the present specimens. Also, only one of the specimens figured by Spath (*ibid.*, Pl. VIII, fig. 2) shows regularly bifurcating ribs similar to those of the present specimens, whereas Spath (1932, p. 40) considered triplicate ribs to characterize *A. sphaericus.*

In the curvature and regular bifurcation of ribbing, this form resembles the specimen with a similar sphaerocone cross-section described by Callomon (1979, Pl. 1, fig. 2a, b, c) as *A.* cf. *sphaericus* from the North Sea. It differs from them in the greater arching of the ribs over the venter. The ribs of a chorotype of *A.* cf. *sphaericus* from East Greenland figured by Callomon (1979, Pl. 1, fig. 3a, b) are slightly falcoid rather than being continuously curved forward. Thus, the forward curvature of the ribs illustrated by Callomon (1979, Pl. 1, figs. 2, 3) and seen in the present form may justify their specific separation from Spath's concept of *A. sphaericus.*

Arctocephalites sp. B aff. *A. sphaericus* Spath

Plate 4, figures 3-6

aff. *Arctocephalites sphaericus* Spath, 1932, p. 40, Pl. XVII, fig. 1.

Material and occurrence. One complete specimen (figured specimen GSC 68281) from GSC locality 92520 and several fragments collected from loose material below the section (GSC locs. 92520, 92473, 92561, 92546). None can be confidently assigned to a particular horizon in the section, but the lithologies of the matrix are compatible with those of the *amundseni* Zone. One fragment (unfigured; GSC loc. 92546) is associated in a single block with a specimen of *Phylloceras* sp.

Description. The large specimen (Pl. 4, figs. 3-6) has a terminal constriction at the end of a body chamber that is smooth for about three quarters of a whorl. Although the shell is distorted, its diameter was approximately 11 cm (whorl height 5.5 cm).

The inner whorls are strongly recrystallized. The smallest that can be clearly seen has a height of about 3.8 cm, and is located about one quarter of a whorl before the beginning of the body chamber, about where the ribs begin to fade. It is strongly ribbed. The ribs bifurcate regularly about a third of the way up the flank. They are nearly straight, pass over the venter without projection, and are inclined slightly forward. The primaries are strengthened nearly into bullae; the secondaries are of equal strength or perhaps slightly weaker over the venter, as on the flank.

At this intermediate growth stage and on the body chamber, the greatest thickness is around the umbilicus, and the venter is somewhat acuminate. The umbilicus is intermediate in size, steeply walled and deep, and the umbilical walls meet the flank in a rounded edge. Several unfigured specimens at intermediate growth stages found loose below the section conform well with the above description.

Discussion. The adult diameter is like that of the holotype of *A. sphaericus* Spath (1932, Pl. XVII, fig. 1). The inner whorls are inflated, but the adult cross-section less so. In the combination of these characters the species differs from *A. frami* n. sp., *A. amundseni* n. sp. and *A. kigilakhensis* Voronetz. The species is more inflated than most other *Arctocephalites* species, including *A. greenlandicus* Spath, but less so than *A. callomoni* Frebold. In the intermediate growth stages, the venter is slightly acuminate, more so than in other specimens described above as *A.* sp. A aff. *A. sphaericus.* Adult *Arctocephalites*(?) *freboldi* and *A.*(?) *crassum* are more inflated and have wider umbilici, although their juvenile and intermediate stages are similar to the present species.

Arctocephalites porcupinensis n. sp.

Plate 3, figures 11-22; Plate 4, figures 1, 2

Arctocephalites sp. Poulton and Callomon, 1976, Figure 61.3; Poulton, 1978, Figure 2.

Material and occurrence. Two reasonably well preserved specimens (including holotype GSC 68274 and paratype GSC 68277) and many fragments from GSC locality 92525 (Bed 22); four partial specimens (including paratypes GSC 68275, 68276 and 68279) and many fragments from GSC locality 92527 (Bed 24); one fragmentary specimen (figured specimen GSC 68280) from GSC locality C-95357 (Bed 32). One small fragment (unfigured) from GSC locality 92458 (Bed 34), one (figured specimen GSC 68278) from GSC locality C-86392 (Bed 20), another from GSC locality C-86396 (unfigured; Bed 31); others from GSC locality C-86398 (unfigured; Bed 21) and from GSC locality 35616 (unfigured; Beds 36 to 38) may possibly represent this species also. Thus the species is present in Beds 22, 24, and 32, and possibly also occurs as low as Bed 20 and as high as Bed 38, characterizing some beds in the lower part of the *porcupinensis* Zone, for which it is name-bearer, and extending high into the *amundseni* Zone. Two poorly preserved imprints are present in the earliest collections made along Porcupine River by R.G. McConnell in 1888 (GSC loc. 20510).

Description. Two specimens (Pl. 3, figs. 17, 22) have a constriction on the internal mould at a whorl height of 20 to 25 mm (diameter of 45 mm), indicating adulthood. At this size, the shell is still strongly ribbed on the venter. One other specimen (Pl. 3, fig. 11) is still strongly ribbed to a maximum preserved diameter of 60 mm, and lacks any constriction, and there are similar fragments of large shells in the collection from GSC locality 92527. The first two specimens (Pl. 3, figs. 17, 22) and the last (Pl. 3, fig. 11) are therefore described as smaller and larger dimorphs respectively, of the same species. The termination of septae cannot be seen on any of the specimens, but the sediment fill of the body chambers occupies nearly a complete whorl. The compressed cross-section and character of the ribbing ally these specimens and differentiate them from other species. No sutures are preserved.

On the best preserved of the two smaller dimorphs available in Bed 22 (Pl. 3, figs. 17-20), strong but finely spaced, nearly rectiradiate ribs that bifurcate regularly about halfway up the flank characterize the shell up to a whorl height of 14 mm, although their character on the innermost whorls is unknown. The regular bifurcation is accomplished by intercalation in that specimen (Pl. 3, fig. 20). At a whorl height of approximately 14 mm, the ribs become strongly inclined forward, that is, prorsiradiate, the bifurcation becomes irregular and takes place lower on the flank, intercalation of secondary ribs occurs, and the ribbing as a whole becomes weak, particularly on the flanks. This smooth stage of growth persists for about one quarter of a whorl length and is replaced at a whorl height of approximately 18 mm (diameter 41 mm) by strong, prorsiradiate ribs which bifurcate irregularly halfway up the flank and have intercalated secondaries. The ribs are stronger over the venter, where they also are somewhat projected, the flanks being dominated by fine growth lines. The ribs persist, at least on the internal mould, to the terminal constriction.

The same description applies also to a specimen from Bed 24 (Pl. 3, fig. 22) that has a constriction at a diameter in excess of 48 mm and another in which the terminal constriction is absent. In this specimen however, the regularly bifurcating, nearly rectiradiate ribs persist farther, and the smooth stage is short and weakly developed. Also, the adult prorsiradiate ribs are stronger over the entire flank on the internal mould than those of the previous specimens.

For the two poorly preserved specimens from Bed 22 that are larger dimorphs (Pl. 3, fig. 11), the same description of ribbing given for the smaller dimorph applies, except that the loci of change of ribbing character are retarded. Thus, the demise of strong, rectiradiate ribbing with regular bifurcation halfway up the flank occurs at a whorl height of approximately 20.5 mm, and the resumption of strong ribbing that is, however, distinctly prorsiradiate, occurs at a whorl height of 25 mm. These adult ribs are stronger and more coarsely spaced than those of the microconch, and bifurcate more regularly, at a point about half of the height of the whorl. On the internal mould, they are equally strong over the full height of the whorl, perhaps stronger near the umbilicus.

One of the two specimens of larger dimorphs from GSC locality 92527 (Pl. 3, figs. 13, 14) shows strong ribbing of the last two to three centimetres on the internal mould, following a short, smooth stage. The external shell surface is ornamented by fine growth lines only on the umbilical half of the whorl. On the other specimen (unfigured) the internal mould is smooth in its last 1.5 cm. Both of these specimens, although distorted, exhibit the inflated cross-section of the adult. The largest specimen in Bed 22 (Pl. 3, fig. 11) is strongly ribbed in its last 3.5 cm, and is assumed to be nearly complete, although no terminal constriction is seen, because the entire three quarters of the whorl that is preserved is nonseptate. No terminal constriction can be unequivocally identified on these specimens due to the broken character of the aperture.

One specimen from GSC locality C-95357, tentatively identified as *A. porcupinensis*, gradually becomes smooth at a whorl height of about 2.1 cm. After a smooth stage of about one third of a whorl, strong ribbing resumes. It curves forward smoothly and relatively strongly, and bifurcates regularly. This may well be the apertural part of an adult specimen, although no constriction is apparent. If this specimen is not adult, it may well be the juvenile of its associated species, either *A. praeishmae* n. sp. or *A. kigilakhensis* Voronetz. These species do not characteristically exhibit the smooth growth stage at a whorl height of about 2.3 to 2.6 cm, however.

Discussion. Characteristic features of this species are the change of the ribbing character at successive growth stages, and the compressed cross-section in intermediate growth stages. These characters, together with the regularly bifurcating, strong ribbing at intermediate growth stages, differentiate it from all other species.

In four specimens identified as *Arctocephalites* sp. A aff. *A. nudus* Spath from Bed 26 (Pl. 6, figs. 10, 11), the shell is small and compressed, like typical *A.* sp. A aff. *A. nudus* Spath, and like *A. porcupinensis* n. sp. The ribs bifurcate regularly and pass from a rectiradiate to a gently forward-sloping orientation at a whorl height of about 1.6 cm. Also like *A. porcupinensis*, the umbilicus is small and steep-sided, with a reasonably abrupt edge. Resumption of ribbing after an intermediate smooth stage does not occur as it does in *A. porcupinensis*, however. The forward slope of the ribs in later growth stages, shell cross-section, and character of the umbilicus, ally this species with *A. praeishmae* n. sp., which is, however, larger, and has ribs that are more curved in their forward-sloping orientation.

Name. From Porcupine River.

Arctocephalites callomoni Frebold

Plate 4, figures 7-9; Plate 5, figures 1-13;
Plate 6, figures 4, 5

Arctocephalites callomoni Frebold, 1964, p. 4, 5, Pl. III, figs. 1a to 2; Pl. IV, fig. 1, Pl. V, fig. 3, Pl. VIII, fig. 3.

?*Arctocephalites callomoni* Frebold. Meledina, 1973, p. 66, Pl. XIII, fig. 1a, b.

Material and occurrence. One fragmentary specimen (hypotype GSC 68282) from GSC locality C-86390, (Bed 16), one poorly preserved, partial specimen (hypotype GSC 68283) from GSC locality C-86396 (top of Bed 31), a juvenile specimen (hypotype GSC 68284) from GSC locality C-86395 (Bed 30), and one nearly complete specimen and several fragmentary specimens (including hypotypes GSC 68285, 68286, 68287 and 68288) found loose below the section (GSC locs. 92520, C-95369, C-95372). The species is thus represented in the *porcupinensis* and *amundseni* Zones.

Description. In the best preserved specimen (Pl. 5, figs. 6-9), the smallest growth stage clearly seen has a whorl height of 2.3 cm. It is inflated, and is widest around the umbilical edge. Around this locus, strong, slightly swollen, short, primary ribs subdivide into two or three secondaries each. These are straight, nearly radial, and pass over the venter without deflection.

The ribs and shape are the same until a whorl height of 3.5 cm is reached, where the ribs begin to fade out gradually, first on the ventral parts of the shell, at about the beginning of the body chamber. At this growth stage there are three secondaries to each primary rib.

The body chamber is smooth, and about three quarters of a whorl or possibly slightly more in length. It is widest around the umbilicus. It becomes slightly depressed and excentric near the apertural end, and there is indication of an apertural constriction on the umbilical part preserved.

The umbilicus is deep and steep-walled, with a rounded but distinct edge.

The smallest part of the shell that is preserved in the specimen found in Bed 16 (Pl. 4, figs. 7-9) has a whorl height of 1.8 cm. It is highly inflated, and nearly subcircular in cross-section. The umbilical margin is rounded, the umbilicus deep and apparently nearly straight sided. The ribs taper off a short distance into the umbilicus.

Ribs are strongly defined and nearly radial or with a very slight adoral slant. They bifurcate more or less regularly halfway up the flank.

The ribs nearly disappear before a whorl height of 3 cm is reached, just before the beginning of the body chamber. Only those parts of the primary ribs nearest the umbilical margin are preserved; they are strong and slightly inclined forward.

The body chamber is nearly circular in cross-section, and is widest around the umbilicus. Only its adapical portions are preserved. It bears very faint corrugations that are very gently inclined forward, and that may be irregular in their distribution.

The internal whorls of the best specimen found in place in Bed 31 (Pl. 5, figs. 1, 2) are dissolved away, but enough can be seen to state that they are evenly rounded in cross-section, moderately inflated, and perhaps slightly acuminate, with finely spaced rectiradiate ribs. Part of the body chamber has a similar cross-section, and a small umbilicus with steep walls and a rounded edge. The greatest width is around the umbilicus. Weak and finely spaced, forward-curved primary ribs can be seen, which appear to fade out orally within the fragment, and ventrally about halfway up the flank. Very weak, forward-projected ribs also appear on the venter.

The inner whorls of another specimen from Bed 30 (Pl. 5, figs. 3-5) are inflated and carry fine, rectiradiate ribs that bifurcate near the rounded umbilical edge. These characters ally it with the specimen described above, although neither specimen is specifically identifiable.

Intermediate and adult growth stages are preserved in another, larger specimen (Pl. 5, figs. 10-13). The ribs are strong, nearly straight, inclined gently forward and appear to bifurcate regularly. They fade out on the early part of the body chamber, of which more than an entire whorl is preserved, with no sign of an apertural constriction.

In one of the loose fragments (Pl. 6, figs. 1-3), the cross-section is strongly inflated. The ribs are strong and coarse and bifurcate regularly, with some intercalated secondaries. They are nearly straight and subradial.

Another fragment (Pl. 6, figs. 4, 5) exhibits part of an intermediate growth stage with a diameter of 5 cm, and the first part of the body chamber. The first part is strongly ribbed, with swollen short primaries bifurcating near the umbilical edge and with minor intercalation of secondaries. The ribs are nearly radial, inclined very gently forward. The last septum appears at a whorl height of 4 cm. The body chamber is smooth and evenly rounded. The umbilicus is vertically walled, deep, and with a distinct, rounded edge. This fragment is clearly somewhat more inflated than the best specimen described above.

Discussion. The primary type material described from Axel Heiberg Island exhibits considerable difference in inflation and maximum adult size from one specimen to another (Frebold, 1964), even though the specimens were all collected in one bed. This same variation is seen in the northern Yukon specimens, all collected loose, which exhibit no significant differences from the primary type specimens. There seems also to be a minor difference in the size of the umbilicus. The specimen from Siberia figured by Meledina (1973, Pl. XIII, fig. 1a, b) may well represent a somewhat compressed form of the species.

The orientation of the ribs, and greater inflation separate this species from *A.* sp. cf. *sphaericus* Spath from the North Sea and East Greenland (Callomon, 1979, Pl. 1, fig. 2a, b, c and Pl. 1, fig. 3a, b respectively). The regular bifurcation of the ribs separates it from most of the various specimens compared by Spath (1932) to *A. sphaericus* except one (*ibid.*, Pl. VIII, fig. 2), which is less inflated. No other species are closely similar.

The shell of one specimen (Pl. 5, figs. 1, 2) appears to be a bit more compressed and more acuminate than other specimens, but it is more inflated than most other *Arctocephalites* species.

Arctocephalites sp. A aff. *A. nudus* Spath

Plate 6, figures 6-14

aff. *Arctocephalites nudus* Spath, 1932, p. 35, Pl. XI, fig. 1.
?*Arctocephalites elegans* Spath. Frebold, 1961, Pl. XI, fig. 3.

Material and occurrence. Four specimens, including figured specimens GSC 68291 and 68292 from GSC locality C-86393 (Bed 26), one complete specimen and probably several fragments, including figured specimen GSC 68290, from GSC locality C-86394 (Bed 28), and probably also three fragments, including specimens GSC 68289 and 68293, from GSC locality 92525 (Bed 22). The species thus occurs in the upper part of the *porcupinensis* Zone and lower part of the *amundseni* Zone, and it is also abundantly represented in loose material below the section.

Description. Up to a whorl height of 1.7 cm (diameter 4 cm), the ribs are fine, rectiradiate, and bifurcate regularly about halfway up the flank. There are many secondaries; only a few are intercalated. Over a distance of about 3 cm, up to a whorl height of about 2.1 cm, the ribs become gently inclined forward, and fade out onto the smooth body chamber.

The last three quarters of the shell is smooth, the apertural constriction is well displayed. Adult diameter is 5.5 cm. At intermediate growth stages, the cross-section is compressed, flanks flattened, venter slightly acuminate, and umbilicus relatively wide, steep-sided, with rounded edges. The greatest thickness is around the umbilical edge.

The body whorl becomes somewhat more inflated although it remains higher than wide.

Discussion. This species bears a close resemblance to *A. nudus* and *A.* sp. B aff. *A. nudus* in its size, cross-section, and ribbing, but it is smaller, and the ribs disappear at a correspondingly smaller size. The body chamber does not become as strongly inflated as it does in *A. nudus* and *A.* sp. B aff. *A. nudus*, and the umbilical margin is less rounded.

The fragments from Bed 22 (e.g. Pl. 6, figs. 6, 7, 14) comprise only small-diameter, smooth body chambers, with cross-sections and umbilici like those of the specimen from Bed 28 (Pl. 6, figs. 5, 9). One of them (Pl. 6, figs. 6, 7) and one of the specimens figured as *A. elegans* Spath by Frebold (1961, Pl. XI, fig. 3) have a moderately inflated body chamber, characters indicating their intermediate status between *A.* spp. A and B aff. *A. nudus*. Additionally, the specimen figured by Frebold (1961, Pl. XI, fig. 3) has forward-curved ribs, allying it with *A. praeishmae* n. sp. One specimen (Pl. 6, figs. 10, 11) is identical to the others except for its compressed, acuminate body chamber.

Arctocephalites sp. B aff. *A. nudus* Spath

Plate 6, figures 15-18

aff. *Arctocephalites nudus* Spath, 1932, p. 35, Pl. XI, fig. 1.
?*Arctocephalites* aff. *nudus* var. *magna* Spath, 1932, Pl. XI, fig. 7a, b.
?*Macrocephalites koettlitzi* Pompeckji, 1900, p. 70, Pl. II, fig. 12a-c.
Arctocephalites elegans Spath. Frebold, 1961, Pl. X, fig. 2, Pl. XI, fig. 4, Pl. IX, fig. 1(?).
?*Arctocephalites nudus* Spath. Voronetz, 1962, p. 42, Fig. 15, Pl. VIII, fig. 3.

Material and occurrence. Two specimens (figured specimens GSC 68294, 68295) from GSC locality 92527 (Bed 24). The best specimens, from GSC locality 35639 (Bed 14), have already been illustrated by Frebold (1961, Pl. X, fig. 2, Pl. XI, fig. 4). Thus, the species occurs in the *spathi* and *porcupinensis* Zones and occurs in loose material below the section (GSC loc. 92520).

Description. One whorl fragment from Bed 24 (Pl. 6, figs. 17, 18) shows the loss of ribbing at a whorl height of approximately 25 mm. The ribs are fine on the internal mould, and bifurcate regularly halfway up the flank, where there is also consistent intercalation of secondaries. The ribs are nearly straight and are only slightly inclined forward. They persist farther on the venter than they do low on the flanks. The cross-section is rounded, but in the earliest portion of a whorl seen, is slightly acuminate.

Another, more complete specimen from the same bed (Pl. 6, figs. 15, 16) shows the adult shell to be three quarters of a whorl long, and essentially smooth to the aperture, where there is a terminal constriction. Ribbing persists to a whorl height of approximately 23 mm.

Discussion. This species is similar to *A. spathi* n. sp., particularly in the character of the ribbing, with its intercalated secondaries. However, the ribs are not as sinuous as in that species; they are nearly straight and with a greater degree of trifurcation or intercalation of ribs. The cross-section is more inflated than in *A. spathi*. Other species, such as *A. porcupinensis* n. sp. and *A. arcticus* (Whitfield) do not exhibit the regular intercalation of secondaries.

Particularly characteristic of this species is the small size at which the shell becomes completely smooth. In this it differs from most other species, but is allied with the holotype of *A. nudus* Spath (1932, Pl. XI, fig. 1a, b) and with *A. koettlitzi* (Pompeckj). They have similar cross-sections, with rounded flanks that merge smoothly with the steep umbilical slopes, and with complete enclosure of earlier whorls by the final whorl. Spath's (1932, p. 35) separation of those two species was probably based on insufficient criteria, but the broad acceptance that his specific name has received justifies its use even if the two are conspecific. The umbilicus of the present species appears to be a bit more open than in Spath's holotype.

Callomon (1975, p. 383) has stated that new collections from East Greenland show that *A. nudus* is only a variant of *A. arcticus*. The northern Yukon specimens, although not certainly synonymous with the holotype of *A. nudus*, are apparently different from *A. arcticus* in the early size at which they become smooth, the finer ribbing, and the trifurcate or intercalated rather than bifurcate ribbing.

The specimen from northern Siberia figured by Voronetz (1962) is closely similar, but is larger in diameter than either the East Greenland holotype of *A. nudus* or the Canadian specimens.

Arctocephalites arcticus (Whitfield)

Plate 7, figures 1-12; Plate 8, figures 1-4

Ammonites (Macrocephalites) ishmae Keyserling var. *arcticus* Newton and Teall, 1897, p. 500-501, Pl. XL, fig. 1.
Ammonites (Cadoceras) arcticus Whitfield, 1906, p. 132, Pl. XVIII, figs. 1, 2.
Arctocephalites arcticus Newton. Spath, 1928, p. 174.
?*Macrocephalites* cf. *ishmae* Keyserling var. *arctica* Newton and Teall. Frebold, 1930, Pl. XXIII, fig. 1, 1a only.
Arctocephalites arcticus (Newton) Spath, 1932, p. 32, PL. XII, fig. 2.
?*Arcticoceras* sp. nov.? Spath, 1932, p. 58, Pl. XI, fig. 3a, b.
?*Arctocephalites elegans* Spath. Frebold, 1961, Pl. XI, fig. 2.
Arctocephalites arcticus (Newton and Teall). Meledina, 1973, p. 65, Pl. XII, fig. 1a, b, ?fig. 2.
Arctocephalites arcticus (Newton-Whitfield). Callomon, 1975, p. 383, fig. 5C-G.

Material and occurrence. Four fragmentary specimens (hypotypes GSC 68296, 68297, 68298, 68299) from GSC locality 92527 (Bed 24); several fragments together with a nearly complete specimen (hypotype GSC 68301) from GSC locality 92531 (Bed 32); a crushed but complete specimen (hypotype GSC 68300) from GSC locality 92530 (loose at Bed 30 level): three complete but crushed specimens from GSC locality C-86393 (Bed 26) and another (hypotype GSC 68304) from GSC locality C-86396 (Bed 31); possibly three poorly preserved specimens from GSC locality C-95358 (Bed 36). The species range from Beds 24 to 32 and possibly as high as Bed 36. Upper *porcupinensis* and lower (and middle?) *amundseni* Zones. It is also common in the loose material below the section (e.g. hypotype GSC 68305 from GSC loc. 92520).

Description. All the specimens available in which the adult status can be determined are macroconchs; Callomon (1975) has illustrated microconchs from East Greenland and the North Sea. Two partial specimens (Pl. 7, figs. 4, 5, 8, 9) in Bed 24 are strongly ribbed to a whorl height of approximately 25-30 mm, corresponding to a diameter of 65 mm. One of them (Pl. 7, figs. 4, 5) becomes smooth at that stage; corresponding parts of the other fragment are not preserved.

The ribs are nearly straight and are nearly rectiradiate, or inclined slightly forward in large specimens. They are strong and coarsely spaced. They bifurcate regularly one third to halfway up the flank, at which point they are enlarged in 2 specimens (Pl. 7, figs. 4, 5, 8, 9) to form incipient bullae. There is only a minor degree of intercalation of secondary ribs, and this mainly in the larger growth stages.

A partial body chamber in Bed 24 (Pl. 7, figs. 6, 7) has a whorl height of 43 mm and maximum width of 38 mm. The terminal constriction and apertural margins are exposed. The shell has only fine growth lines, and the internal mould is smooth except for irregularly developed weak ribbing here and there.

This description applies also to the several specimens in Bed 32, one of which (Pl. 7, figs. 11, 12) shows the entire body chamber and part of the ribbing on the largest inner whorl. The oralmost few centimetres are weakly and irregularly corrugated. The body chamber, judging by the sediment fill, is three quarters of the whorl length. This specimen does not appear to have any apertural constriction, but another, poorly preserved specimen from this bed (unfigured) shows the apertural constriction to be present at approximately the same growth stage as is shown in Plate 7, figures 6, 7.

Except in the extreme apertural area, where the cross-section is more rounded, the cross-section of the shell is somewhat acuminate, the flanks sloping markedly toward the venter. One fragment from Bed 24 (Pl. 7, figs. 1-3) is more inflated than the other specimens.

A complete but poorly preserved specimen from Bed 31 conforms well with the above description (Pl. 8, figs. 1, 2). It shows the apertural constriction, and the gradual loss of ribs about 2 to 3 cm beyond the last septum. This specimen also shows the typical, exceptionally rounded character of the umbilical edge.

The gradually increased forward curvature of the ribs orally, and other typical characters described above, as well as gradual loss of ribs well before the oralmost septum, are nicely displayed in a specimen (Pl. 8, figs. 3, 4) collected loose below the section. It occurs in a matrix similar to that of specimens described above from the section itself.

The position at which the ribs fade out in relation to the oralmost septum appears to vary considerably from one specimen of this species to another.

Discussion. Characteristic of the typical forms of *A. arcticus* are the moderate but not large size to which coarse ribbing with regular bifurcation persists, the straightness and nearly rectiradiate orientation of the ribs, the low position on the flank at which they bifurcate, and the tendency to form incipient bullae there. These characters differentiate it from most other species of *Arctocephalites* and ally it with *A. greenlandicus* Spath, which is, however, larger. One specimen (Pl. 7, fig. 10) is transitional to *A. praeishmae* n. sp.

The three specimens figured by Newton and Teall (1897) are different from one another in their cross-section as pointed out by Pompeckj (1900, p. 73). Following Pompeckj (1900), Spath (1928, p. 174) and Callomon (1975, p. 383), only Newton's figures 1 and 1a are taken to represent the species, and the specimens described here conform best to that specimen in their cross-section, although most are even more compressed. They also conform well in ribbing character to the much more inflated specimen figured by Newton and Teall (1897, Fig. 2; i.e. *Arctocephalites pilaeformis* Spath, 1932, p. 33), however, so that Whitfield's (1900, p. 132) inclusion of them all as one species does not seem totally justified on morphological grounds alone. The adult specimens from northern Yukon resemble the one figured by Whitfield (1900, Pl. XVIII, fig. 1) so that Spath's (1928, p. 174) and Callomon's (1975, p. 383) rejection of that specimen from the species is perhaps unwarranted. Most recently, Callomon has also considered *A. arcticus* not to include Whitfield's species at all, and he has also considered *A. nudus* Spath to be only an extreme variant of *A. arcticus*.

The adult ribs of one specimen collected loose below the section (Pl. 8, figs. 3, 4) are curved forward as in *A. elegans* Spath (1932, Pl. 10, fig. 4), but they bifurcate more regularly than in Spath's specimen, and the secondaries are stronger.

Arctocephalites praeishmae n. sp.

Plate 7, figures 13-16; Plate 8, figures 5-12

Arctocephalites elegans Spath. Frebold, 1961, Pl. 10, fig. 1a, b.

Material and occurrence. One fragment (paratype GSC 68303) from GSC locality 92529 (Bed 28); one nearly complete but poorly preserved specimen (paratype GSC 68307) from GSC locality C-86394 (Bed 28); three complete specimens, including paratypes GSC 68308 and 68309, and several fragments from GSC locality C-86396 (Bed 31); many specimens from GSC locality C-95357 (Bed 32); a crushed but complete specimen (paratype GSC 68302) from GSC locality 92531 (Bed 32); a crushed but nearly complete specimen (holotype GSC 68306) and several fragments from GSC locality 92458 (Bed 34); possibly several fragments from GSC localities C-95358 (Bed 36), 35619 and C-95359 (both Bed 40). Thus the species is well represented from Beds 28 to 34, and possibly occurs also as high as Bed 40 (*amundseni* Zone). Other specimens were found in float below the section (GSC loc. 92520).

Description. All the reasonably complete adult specimens, and the specimen figured as *A. elegans* Spath by Frebold (1961, Pl. 10, fig. 1a, b) have similar, strong, smoothly and gently forward-curved ribs to a whorl height of about 2.6 cm, corresponding to a diameter of 5.6 cm. At smaller growth stages (e.g. Pl. 7, fig. 15), the forward curvature of the ribs is less pronounced.

The ribs bifurcate regularly about one third to halfway up the flank. Intercalation of secondary ribs occurs but is uncommon. There may be slight swelling at the point of bifurcation. There is some minor variation in their spacing from one specimen to another. The ribs die out over a short interval of two or three ribs duration, at a whorl height of about 2.6 cm. There is some tendency for the flanks to become smooth at a smaller growth stage than the venter.

The body chamber, three quarters of a whorl to nearly an entire whorl in length, is ribbed on its early parts, then is entirely smooth for slightly over half of a whorl length, except for fine growth lines on the external surface. A prominent apertural constriction on the internal mould occurs at a whorl height of 3.5 to 4 cm (adult diameter 7.2 to 7.5 cm). Very weak corrugations reappear on the venter near the aperture on one specimen (Pl. 8, fig. 7) and primary ribs on another from GSC locality C-86396 (not figured).

The umbilicus is small and steep-walled, with a rounded but distinct edge.

The greatest thickness is about a third of the way up the flank. The shell is compressed and markedly acuminate.

Discussion. This species is distinguished from associated typical *A. arcticus* (Whitfield) by its moderate to strong, smooth, forward curvature of the ribs, generally smaller adult size and more compressed cross-section. One specimen, however (Pl. 7, fig. 10), found loose at the level of Bed 30, is intermediate between typical *A. arcticus* and *A. praeishmae* n. sp. in its adult size and the character of the few ribs exposed. The majority of the specimens fall readily into one or the other form however, so that two distinct species are considered to be present.

It is about the same size as, or slightly larger than, *A. porcupinensis* n. sp., but apparently lacks the intermediate smooth stage during ontogeny. The rectiradiate orientation of early ribs is less pronounced, and persists to a larger growth stage than in *A. porcupinensis*. Some forms (e.g. Pl. 7, figs. 13, 14; Pl. 8, figs. 5, 6) resemble that species in that their compressed cross-sections are similar. The more compressed cross-section, smooth forward curvature of the ribs, and greater predominance and regularity of their bifurcation distinguish this species from *A. spathi* n. sp., although a similar, very slight tendency to a falcoid character can be seen in one specimen (Pl. 8, fig. 11). The curvature of the ribs and smaller size separate it from *A. greenlandicus* Spath and similar Canadian forms, although *A. kigilakhensis* Voronetz has similarly shaped ribs. It is distinguished from the holotype of *A. elegans* figured by Spath (1932, p. 37, Pl. X, fig. 4a, b) in the more abrupt and earlier loss of ribbing, and in the consistent presence of two rather than three secondary ribs to each primary, although the orientation of the ribs of the two species is similar.

Some specimens particularly resemble *Arcticoceras ishmae* (Keyserling) in shell shape and in the forward curvature of the ribs, which resemble the projected ribs on the venter of that species. *A. ishmae* is much larger, however, and the coarse ribbing persists to a correspondingly much larger growth stage.

Name. From its superficial similarity to the much larger and younger species *Arcticoceras ishmae*.

Arctocephalites amundseni n. sp.

Plate 9, figures 1-4; Plate 12, figures 5, 6

?*Cadoceras* aff. *C. pseudishmae* Spath. Frebold, 1961, p. 20, Pl. XVI, fig. 1.

Material and occurrence. A broken but nearly complete specimen (holotype GSC 68324) from GSC locality C-86394 (Bed 28), another (paratype GSC 68310) and a fragment, from GSC locality C-86395 (Bed 30); possibly also a poorly preserved specimen (figured specimen GSC 68311) from GSC locality C-95358 (Bed 36); possibly two fragments (unfigured type specimens GSC 68654, 68655) from GSC locality C-86393 (Bed 26). *Amundseni* Zone (lower part).

Description. The two best preserved specimens (Pl. 9, figs. 1, 2; Pl. 12, figs. 5, 6) are about 13 cm in adult diameter, and exhibit apertural constrictions.

The shell is moderately compressed and acuminate to a very slight degree. It is tightly coiled, with a small, steep-sided umbilicus that has an abruptly rounded edge. The greatest thickness is about one fifth of the way up the flank.

The smallest growth stage preserved has a whorl height of approximately 2.5 cm. It is strongly ribbed; the ribs bifurcate just below halfway up the flank, and are inclined gently forward. They pass over the venter nearly without projection.

At or near the beginning of the body chamber, at a whorl height of about 4 cm (diameter about 8 cm), the ribs gradually fade out over a distance of about 1 cm. The last ribs are inclined forward perhaps slightly more than in smaller growth stages. The body chamber is three quarters of a whorl in length. It bears fine growth lines on the external shell surface and becomes weakly corrugated in the apertural 2 to 3 cm. The corrugations are mainly irregular but are regular on the lower part of the flank. The specimen from Bed 36 (Pl. 9, figs. 3, 4) is apparently identical but cannot be positively identified because of the recrystallized inner whorls and its higher stratigraphic position.

Discussion. These specimens are closely similar to *A. frami* n. sp. described below, and to the holotype of *A. greenlandicus* Spath (1932, p. 34, Pl. IX, fig. 1a, b; Pl. X, fig. 2). They are strongly ribbed to a slightly larger diameter, however, and have a somewhat less acuminate cross-section. These differences would not justify their separation from *A. frami* were it not for the large stratigraphic difference between the two forms. This species is more inflated than *A. greenlandicus*. However, several unidentifiable fragments of body chambers occur in Bed 30 with *A. amundseni* that have more compressed cross-sections, flattened flanks, and an adult size like that of *A. greenlandicus*, although the last whorl of these fragments is entirely smooth, unlike the holotype of *A. greenlandicus*.

Two small fragments (unfigured type specimens GSC 68654 and 68655) of large, involute shells (from Bed 26) have high, nearly flattened flanks, and one appears to have a compressed cross-section. The ribs curve forward smoothly and gently. In one, they bifurcate high on the flank, in the other bifurcation cannot be seen. The large whorl height at which coarse ribbing still occurs, and the shell shape and ribbing character ally these fragments with the apertural part of the body chamber of the holotype of *A. greenlandicus*.

The specimen found in loose material below the section (Frebold, 1961, p. 20, Pl. XVI, fig. 1) is questionably assigned to this species because of the large growth stage to which ribbing persists.

Name. To commemorate the polar explorer who first reached the South Pole, first sailed through the Northwest Passage, and who died while engaged in an Arctic rescue mission.

Arctocephalites kigilakhensis Voronetz

Plate 10, figures 1-8; Plate 11, figures 1-12;
Plate 12, figures 1-4

Arctocephalites kigilakhensis Voronetz, 1962, p. 44, Pl. IX, fig. 2a, b.

Arctocephalites kigilakhensis Voronetz. Meledina, 1973, p. 70, Pl. XVI, figs. 1, 2.

Material and occurrence. One nearly complete but broken specimen (hypotype GSC 68316) from GSC locality C-86396 (Bed 31); another from C-95358 (Bed 36), three nearly complete specimens (hypotypes GSC 68314, 68312, 68313) and many fragments from GSC locality C-95357 (Bed 32); probably also a well preserved, complete, smaller dimorph from each of GSC localities 92529 and 35619 (hypotypes GSC 68315 and 68318; Beds 28 and 40); three fragmentary specimens from GSC locality 92532 (Bed 42); and another fragment (hypotype GSC 68319) from GSC locality 35619 (Bed 40); and several found loose below the section (e.g. hypotypes GSC 68317, 68322, 68323 from GSC locs. 92473, 35692, 92520).

Description. The inner whorls of the specimen from Bed 31 (Pl. 11, figs. 1-4) cannot be seen well because they are completely recrystallized and partly dissolved away. At a whorl height of about 1.5 cm, they are very slightly higher than wide, with strong but relatively finely spaced rectiradiate ribs. The degree of bifurcation compared to trifurcation or intercalation of secondaries cannot be seen clearly, but bifurcation seems to be predominant.

At a whorl height of 2.5 cm, the whorl is significantly higher than wide (less than 2 cm wide). The cross-section is very slightly acuminate, with flattened flanks that are widest a third of the way up the flank. The ribs are strong, relatively finely spaced, and bifurcate about one third of the way up the flank. They slope gently forward, crossing the venter with slight forward curvature. The forward slope increases gradually adorally. The ribs end fairly abruptly, leaving an entire whorl smooth. Slightly less than three quarters of the last whorl is occupied by the body chamber. It is markedly acuminate. The maximum adult whorl height is 6 cm, diameter 11 cm, and maximum width around the umbilicus 4.5 cm. The umbilicus is small and steep-sided, with an abruptly rounded edge.

In one specimen from Bed 36, (unfigured), very faint rib impressions persist over the venter for nearly the entire body whorl.

The several specimens from Bed 32 (Pl. 10, figs. 1-7) conform well with the above description. One specimen, which is missing the body chamber and which is badly crushed (Pl. 10, fig. 1) shows the shape of the ribs at a whorl height of about 2.5 cm, as well as the bifurcation, adoral coarsening, and forward slope. This specimen and others exhibit the coarser spaced, gently adorally curved, mainly bifurcating ribs at a whorl height of about 4 cm, and the gradual fading of the ribs onto the smooth body chamber. There is some slight variation in the spacing of ribs. The body chambers show slight differences in the degree of compression and roundness of the venter, but are otherwise uniform. One specimen from Bed 32 (Pl. 10, figs. 2-4) is unusually strongly compressed.

The suture pattern is poorly exposed on one specimen (Pl. 11, figs. 11, 12), but cannot be traced.

The smaller dimorphs are assigned to this species because of their closely similar although not entirely identical ribbing and size at the stage at which the terminal constriction appears with that at which the larger dimorph becomes smooth. At a whorl height of about 2.6 cm, in two of the smaller dimorphs (Pl. 10, fig. 8, Pl. 11, figs. 7, 8) and 3 cm in the others, the final stages of the outer whorl become slightly excentric, an apertural constriction occurs, and the whorl height is depressed. There is some variation in these specimens in the degree to which the cross-section is acuminate, and in the forward slope and spacing of the ribs, so that their assignment to a single species, or to *A. kigilakhensis* is tentative.

Discussion. The present material differs from the northern Siberian specimens (Voronetz, 1962; Meledina, 1973) only in having a slightly more compressed cross-section.

This species most closely resembles *A. frami* n. sp. and *A. amundseni* n. sp., and differs from *A. greenlandicus* Spath in the same ways that they do. It is, however, slightly smaller in adult diameter, becomes smooth at a significantly smaller whorl height, and above all, has much finer, more forward-sloping ribs. In this, it is morphologically transitional between these species, and coeval *A. praeishmae* n. sp. *A. praeishmae* has a much more compressed cross-section but is otherwise similar at equivalent growth stages. The ribbing of *A. kigilakhensis* is intermediate in the degree of forward curvature between that of *A. arcticus* (Whitfield) and that of *A. praeishmae*. In size and stratigraphic position the species is intermediate between *A. arcticus* and *A. frami*.

Arctocephalites frami n. sp.

Plate 12, figures 7-10; Plate 13, figures 1-11

?*Macrocephalites ishmae* Keyserling. Madsen, 1897, Pl. VIII, figs. 7-9.

Arcticoceras kochi Spath. Frebold, 1961, Pl. XII, fig. 1a, b, Pl. IX, fig. 3.

Material and occurrence. One partial specimen each from GSC localities 92535 (paratype GSC 68328; Bed 46), 92536 and C-95363 (paratypes GSC 68327 and 68325; both Bed 47) and two from 35631 (Beds 47 to 50, including paratype GSC 68330). The other from the last locality was described by Frebold (1961) as *Arcticoceras kochi*. The species comes from Beds 46 and 47, and possibly also as high as Bed 50 (*frami* Zone). The lithology of one fragment found loose below the section (paratype GSC 68329 from GSC loc. C-95369) indicates its probable source in these beds also. Other loose specimens come from GSC localities 92473 and C-95372 (e.g. paratype GSC 68326).

Description. Up to a whorl height of about 3 cm, corresponding to a diameter of approximately 6 cm, the shell is strongly ribbed. The ribs are coarsely spaced, and each bifurcates at or just below the middle of the whorl. There is minor intercalation of secondaries between them. The ribs are nearly straight and rectiradiate, although the oralmost of them slope gently forward. Except for these oralmost ones, the ribs cross the venter without deflection. There is a slight tendency for the ribs to be strengthened at their point of bifurcation. After about a diameter of 8 cm or so, there is almost a full whorl that is smooth. The ribs disappear first on the flanks, so that the last few centimetres of phragmocone are ribbed only on the venter. The loss of ribs thus more or less corresponds with the beginning of the adult body chamber. Weak and somewhat irregular ribs reappear on the venter near the peristome. The apertural constriction is seen on two specimens and is strongly projected on the venter. Similarly, the ventral part of the peristome is strongly projected, and may justify the term "ventral lappet" used by Spath (1932) to describe *A. greenlandicus*.

The cross-section is somewhat acuminate in all growth stages seen. The umbilicus is small, with a relatively sharp margin and steep walls.

Part of an inner whorl, 2.2 cm high, and 1.6 cm wide, can be seen (Pl. 13, figs. 8, 9). It is compressed and slightly acuminate, with a rounded but distinct umbilical edge. The umbilicus is a relatively wide 1 cm. It is finely ribbed; the ribs appear to be curved forward strongly and subdivide only a short distance above the umbilical edge.

At a whorl height of 4 cm, the shell is nonseptate, compressed and markedly acuminate, with convex flanks. It is widest at about one third of the height of the whorl. The umbilical edge is more rounded. The main part of this whorl fragment is nearly smooth, with fine growth lines. Parts of weak, prorsiradiate ribs are present on the venter. Strong ribs, strongly curved forward, reappear on the oralmost part of this fragment. This characteristic, together with a suggestion of uncoiling and of an apertural constriction, indicate that this fragment is the apertural part of an adult body chamber. The ribs are strengthened and projected over the venter.

The suture pattern is shown in Figure 11.

Discussion. Two of the specimens (Pl. 13, figs. 1-4 and 5-7) conform reasonably well with Spath's (1932) description and illustration of the holotype of *A. greenlandicus*, which was the only specimen available to him. They are a bit smaller, however, and the ribs do not persist to a diameter of 90 mm as he described for that specimen. They have a steeper umbilical wall, at least on the outer whorl, and a more compressed, somewhat acuminate cross-section. Furthermore, the body chamber appears to constitute approximately three quarters rather than half of a whorl, and at least the full length of the outer whorl is smooth.

They are larger than the otherwise apparently identical specimens of *A. arcticus* (Whitfield) from the northern Yukon with which they are allied in the regular bifurcation of the ribs and nearly straight, strong ribbing. The other differences between *A. greenlandicus* and *A. arcticus* cited by Spath (1932, p. 34) do not apply in the separation of *A. arcticus* from *A. frami* n. sp.

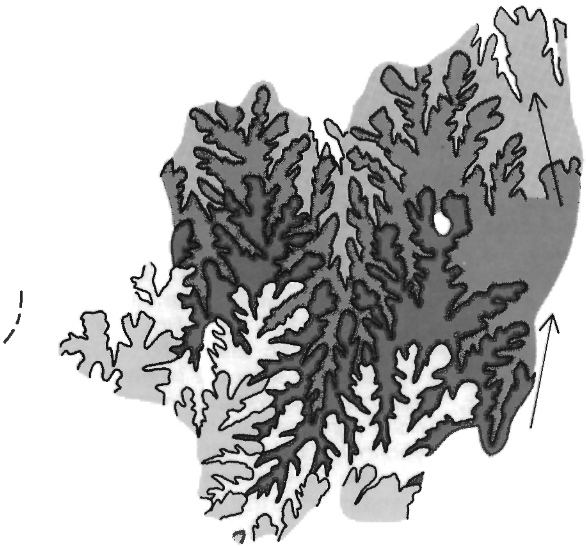

Figure 11. *Septal suture pattern of* ***Arctocephalites frami*** *n. sp.; paratype GSC 68326, from GSC locality 92473; whorl height 3 cm.*

Except for the slightly smaller size, the specimen shown in Plate 13, figures 8, 9, resembles *A. frami*, for which it could be a smaller morphotype. The projected ribbing may ally it with *Arcticoceras*, although this characteristic can only be seen near the aperture, where it also commonly appears in species of *Arctocephalites*.

The present species differs from younger *Arcticoceras* species and from older *Arctocephalites praeishmae* n. sp. and *A. kigilakhensis* Voronetz in the straight and nearly rectiradiate orientation of the ribs, although those few nearest the peristome are projected strongly forward as in those other species. It differs from most other species of *Arctocephalites* in its larger size, as well as in the strong, coarsely spaced, bifurcating ribs, and in their orientation. The specimen figured by Frebold (1961, Pl. XII, fig. 1a, b) appears to be larger than the others, although the others are broken and their true size difficult to judge. Furthermore, in the growth stages where the ribs gradually weaken on the flanks of the body chamber, the ribs are strong and slightly arched forward on the venter. All these characters ally the specimen with *Arcticoceras* to which genus Frebold (1961) assigned it. Its stratigraphic position and association with the other specimens described here prompted its reassignment to *Arctocephalites* however, as did the acuminate venter and somewhat more abrupt umbilical edge, typical of the other large *Arctocephalites* species described here. It is thickest near the umbilical margin, whereas specimens assigned here to *A. ishmae* are thickest about halfway up the flank. This specimen and that described from a higher level, Bed 55 (GSC loc. 35634) by Frebold (1961, Pl. IX, fig. 3) are transitional between *Arctocephalites* and *Arcticoceras*.

Name. After the vessel in which Nansen was frozen into Arctic pack ice for three years; which was used by Otto Sverdrup on his two Arctic exploration journeys, and later by Amundsen for transport to Antarctica.

Arctocephalites sp. A

Plate 14, figures 1-9; Plate 15, figures 7-9

Material and occurrence. One nearly complete specimen (figured specimen GSC 68331) and other, poorly preserved, questionably identified specimens (e.g. figured specimens GSC 68333 and 68337) collected loose below the section (GSC locs. 92520, 92561, 92565). They cannot be definitively assigned to a particular horizon in the section although the lithologies suggest their derivation from the upper *amundseni* through *ishmae* Zones. One small ventral fragment (figured specimen GSC 68336) occurs in Bed 40 (GSC loc. 35619; upper *amundseni* Zone). One specimen found loose (University of Alberta No. 45413) questionably assigned to this species occurs in a rock type like that of the *ishmae* beds. Another small fragment (figured specimen GSC 68332), found loose below the section (GSC loc. 92473), occurs in a yellow weathering matrix that cannot be assigned to any particular horizon.

Description. The large specimen (Pl. 14, figs. 1-4) has a diameter of at least 14.5 cm (whorl height 6 cm). No apertural constriction can be seen. Approximately the last three quarters of a whorl is nonseptate and smooth, the ribs beginning to fade out at about the beginning of the largest whorl preserved. The last part of the body chamber is slightly excentric.

The smallest growth stage seen has a whorl height of approximately 1.7 cm and a width of 2.4 cm. It is strongly depressed, with a slightly acuminate venter. The ribs are strong, bifurcate near the umbilical edge, and pass over the venter with a very slight forward projection.

At a growth stage with a whorl height of about 3.8 cm, the cross-section is higher. The ribs are strong and coarse, and bullate where they bifurcate about one third of the way up the flank. They are nearly straight, inclined slightly forward, and pass over the venter without forward projection.

At all growth stages, the greatest width is near the umbilical edge. The umbilicus is of moderate size, deep and steep-walled, with a rounded umbilical edge.

The suture pattern of one small fragment questionably assigned to this species is shown in Figure 12.

Discussion. The ribbing is much coarser at an equivalent growth stage and persists longer than in *A.* sp. B aff. *A. sphaericus* Spath. It is allied to *Arctocephalites*(?) *freboldi* (Spath) and differentiated from the only other similar species, *A.*(?) *crassum* (Madsen), by its slightly acuminate venter and coarser ribbing. The cross-section of *A.*(?) *freboldi* Spath is wider and more depressed however, and the same appears to be true of *A.*(?) *crassum*, judging by Madsen's (1909) figure (Pl. X, fig. 1).

The ventral fragment from Bed 40 (Pl. 15, fig. 7) shows the acuminate venter, coarse, very slightly projected ribs, and probably also the depressed cross-section, but it is not specifically identifiable.

Most of the small fragments found loose are allied in the coarseness of the ribbing and in the slightly acuminate venter. One, however (unfigured; U. of A. loc. 45413), is finer ribbed.

Arctocephalites sp. B

Plate 15, figures 1-6

Material and occurrence. One specimen (figured specimen GSC 68334) from GSC locality 35616 (Bed 36, 37 or 38; *amundseni* Zone) and possibly another (figured specimen GSC 68335) found loose (GSC loc. C-95372) in a matrix whose source cannot be identified with certainty.

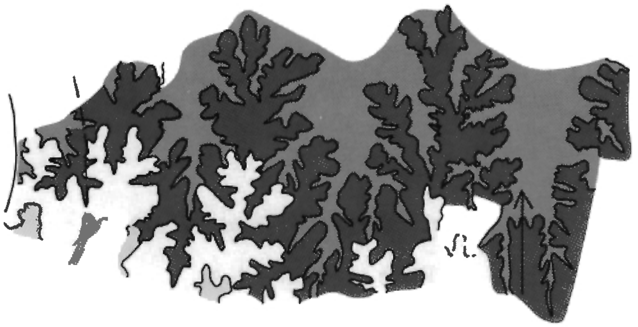

Figure 12. ***Badly corroded septal suture pattern of Arctocephalites*** *sp. A; figured specimen GSC 68337, from GSC locality 92520; whorl height 2.5 cm.*

Description. The internals of the larger specimen (Pl. 15, figs. 1-4) are recrystallized and broken so that only small ribbed fragments can be seen. One, with a whorl height of 2 cm, is coarsely and strongly ribbed. The ribs bifurcate and trifurcate just below halfway up the flank. They are very gently curved forward in their ventral parts. This fragment is moderately inflated; the flank, the umbilical margin, and ventrolateral edge are smoothly rounded.

The only other, and the largest whorl fragment available from the same specimen, is 4.7 cm high. It is nonseptate and nearly smooth, with very weak, irregular corrugations and fine lirae that are very gently inclined forward. The cross-section is smoothly rounded, although the thickness is greater at the umbilical margin than it is higher up on the flanks. The umbilicus is relatively open, perhaps by extraumbilication, the umbilical edge relatively abrupt, the umbilical wall steep, and the umbilicus deep.

The second specimen, found loose (Pl. 15, figs. 5, 6) consists of most of a whorl varying from 2 to almost 3 cm high, and a very small part of the overlapping, nearly smooth whorl, which is greater than 4 cm in height and bears the last septum. The ribs in the intermediate whorl are strong and coarsely spaced, and bifurcate regularly along a locus which shifts from about a third of the whorl height to near the umbilical edge adorally within the specimen. The points of bifurcation are slightly swollen into weak, elongated bullae. The ribs are nearly radial or very weakly sloped forward, and pass straight over the venter. The cross-section is evenly rounded, about as wide as it is high. The umbilicus is wide, nearly vertically walled, and the umbilical edge is abruptly rounded, the sharpness increasing adorally. Small fragments from the interior of the shell are moderately coarsely- and straight-ribbed, with an evenly rounded cross-section.

The ribs are weak and are absent near the last septum. The cross-section appears to be higher, with somewhat flattened flanks on the lower parts. The umbilicus is wide, and vertically walled, with an abruptly rounded edge.

Discussion. The coarse ribbing of the juvenile whorl fragment of the complete specimen resembles that of *A. arcticus* (Whitfield) although there is less regular bifurcation, and the cross-section is not at all acuminate. The greater degree of inflation and more rounded cross-section is even more pronounced in the body whorl, which is also larger in overall diameter. The adult umbilicus is much larger than in *A. arcticus*, and the lirae of the body whorl are not seen on that species. (The interpretation of *A. arcticus* is that preceding; the primary type does not show the adult stage.) In the inflated inner whorls, and coarse, nearly straight, partly trifurcating ribs, the inner whorls resemble *A. pilaeformis* Spath (1932, p. 33; Newton and Teall, 1897, Pl. XL, fig. 2, 2a) but, like *A. arcticus*, the outer whorls of that species are unknown. The inflated, nonacuminate cross-section separates this species from *A. frami* n. sp., which resembles it in size and ribbing. *A. voronezae* Meledina (1973) is similar in shape, coiling and ribbing but is a bit smaller. The coarse, bifurcating ribbing allies this species with *Arcticoceras harlandi* Rawson. *A. harlandi* is a larger species than *Arctocephalites* sp. B, judging by the ribbed and septate material available in the present collections, and the large body chamber figured by Rawson (1982), and it appears to have a slightly more compressed cross-section.

The first lateral saddle (Fig. 13) is more strongly and asymmetrically subdivided than is typical of the genus, resembling that of *Cadoceras*.

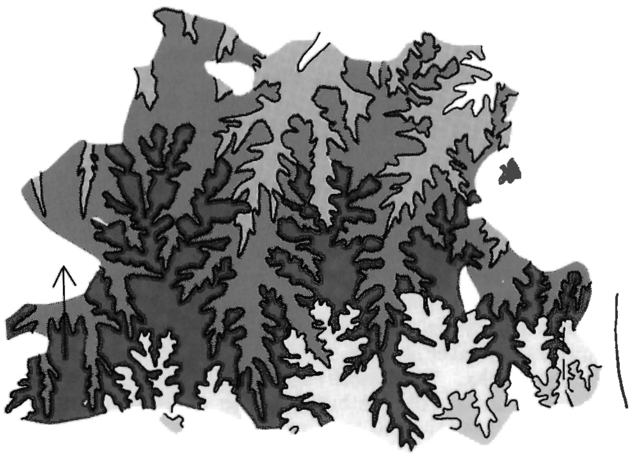

Figure 13. *Septal suture pattern of* ***Arctocephalites*** *sp. B(?); figured specimen GSC 68335, from GSC locality C-95372; whorl height 2.3 cm.*

Arctocephalites sp. C

Plate 15, figure 10

Material and occurrence. One small fragment (figured specimen GSC 68338) from GSC locality 92532 (Bed 42). *Amundseni* Zone.

Discussion. The character of the ribbing, its curvature, and the cross-section of this undeterminable fragment are similar to those of *A. spathi* n. sp., which occurs in much lower beds, and to *Loucheuxia bartletti* n. sp. which occurs much higher. No similarly ribbed species has been found at or about the same horizon.

Arctocephalites sp. D

Plate 15, figures 11, 12

Material and occurrence. One fragment of an adult (figured specimen GSC 68339) from GSC locality C-86396 (top of Bed 31). *Amundseni* Zone.

Description. The inner whorls are entirely recrystallized. The body chamber, nearly three quarters of a whorl in length, is nearly smooth, with very fine and weak wrinkles. It is compressed and slightly acuminate, flaring out and becoming slightly excentric near the aperture. The umbilicus is small, with vertical walls and an abruptly rounded edge. The umbilical part of the apertural constriction is present.

Discussion. Although the ribs cannot be seen, the general character allies this species with its associates *A. arcticus* (Whitfield) and *A. kigilakhensis* Voronetz, between which it is intermediate in size.

The specimen is similar in size, coiling and cross-section to the older species *Parachondroceras filicostatum* Imlay (1967, Pl. 13, figs. 23-25) and to a probably younger one *Eurycephalites codyense* (Imlay, 1953a, Pl. 4, figs. 1, 9), but is inadequately preserved to compare meaningfully with either of those species which are otherwise unrepresented in northern Yukon.

Arctocephalites(?) sp. E

Plate 19, figures 9, 10

Material and occurrence. One badly crushed but nearly complete specimen (figured specimen GSC 68350) from GSC locality C-95364 (Bed 48, Fauna 5).

Description. At a whorl height of about 2 to 2.5 cm, the shell has strong, moderately coarsely spaced, more or less straight and rectiradiate ribs, most of which trifurcate at a very slight swelling at one third of the height of the flank. The ribs appear to cross the venter without deflection. The ribs fade out over a distance of about 2 cm, first on the flanks, apparently just before the beginning of the body chamber.

Only the first part of the body chamber is preserved. It is smooth.

Although the shell is crushed, its cross-section can be seen on part of the body chamber. It is smoothly rounded, 4 cm high and about 2.8 cm wide. It is widest about one third of the way up the flank.

The umbilicus is small and nearly vertically walled, with a relatively abrupt, rounded edge. Neither the aperture nor the sutures are preserved.

Discussion. The only other species of similar size and generally similar character, *Arctocephalites kigilakhensis* Voronetz and *A. arcticus* (Whitfield) also have nearly rectiradicate or gently forward-sloping, regularly bifurcating ribs. The differences would not be sufficient to justify specific separation of the present form from either of these two species were it not for their considerable stratigraphic separation. Although the holotype of *A. elegans* Spath is of similar size, it is already mature, whereas the present specimen is only at the early part of the body chamber, and the ribbing of *A. elegans*, although trifurcating, is finer and more subdued.

One specimen assigned to *A. frami* n. sp. (Pl. 13, figs. 10, 11) is similar but has more regularly bifurcating ribs. It may reach a greater size as well.

Arctocephalites(?) *freboldi* (Spath)

Plate 16, figures 1-4

Cadoceras freboldi Spath, 1932, p. 65, Pl. XVIII, fig. 2a, b.
?*Cadoceras* cf. *freboldi* Spath. Frebold, 1961, p. 18, Pl. XV, fig. 1a, b.

Material and occurrence. One complete specimen (hypotype GSC 68340), possibly also a small fragment from GSC locality C-86395 (Bed 30), and another presumably found loose below the section and described by Frebold (1961). Lower *amundseni* Zone.

Description. The smallest growth stage that can be seen has a whorl height of about 2 cm, and a width of about 3 cm. It is very slightly acuminate. The ribs are strong, rectiradiate, pass straight over the venter, and bifurcate at a slight swelling of the short primaries around the umbilical edge. This growth stage is immediately overgrown by the penultimate whorl, which has a whorl height of 3.5 cm and a width of 6 cm. It is crossed by weak, regularly spaced ribs and fine, irregular corrugations. At this stage, the umbilical wall can be seen in cross-section. The umbilical edge is distinct but rounded, the umbilical wall relatively gently sloping, and distinctly cadoceratoid. The cross-section of the whorl is markedly acuminate with flattened ventrolateral parts.

Slightly more than three quarters of the last whorl preserved is nonseptate. Strong and widely spaced swellings occur around the umbilical edge, weakening orally but extending entirely to the oralmost part preserved. The cross-section is strongly acuminate, umbilical parts cadoceratoid.

The adapical quarter of the body chamber is crossed by weak, widely and regularly spaced ribs that cross the venter with a very weak adoral flexure. The remainder of the body whorl has only fine, weak, irregular striae crossing it. They are gently but increasingly flexed adorally toward the aperture. The umbilicus is wide, a full 2.7 cm at the maximum preserved diameter of 12.5 cm. The umbilical walls of the last whorl are steep, the umbilical margin rounded but distinct. No apertural constriction is preserved.

Discussion. The new northern Yukon material cannot be distinguished from the holotype of *A.*(?) *freboldi* (Spath). Spath (1932) figured only intermediate whorls of the holotype of *Cadoceras freboldi*; the outer whorl, showing the beginning of the body chamber is figured here, from a plaster cast supplied by T. Birkelund. The persistence of ribbing and septae nearly to the last preserved growth stage of the holotype indicate that it is incomplete.

Spath differentiated *C. freboldi* from otherwise similar *C. crassum* Madsen by the presence of coarser and more widely spaced ribs and the arched venter. The arched venter also separates *A.*(?) *freboldi* from the somewhat similar but probably younger *Imlayoceras* Frebold (1963) and from the older *Talkeetnites* Imlay (1980). The former is also more involute; also the latter more evolute. The rounded venter of one specimen described by Frebold (1961, p. 18, Pl. XV) from the Salmon Cache Canyon, renders its specific identification questionable, although its generic affinity with *A.*(?) *freboldi* is undoubted.

Similar forms that occur in the *harlandi* Zone (Bed 53; Pl. 17, figs. 4-6) are allied with *Arcticoceras harlandi* Rawson in their ribbing and other characteristics, but are more inflated. They are here described as *A.*(?) sp. aff. *A.*(?) *freboldi* (Spath) (see below).

The suture pattern of *A.*(?) *freboldi* (Fig. 6) resembles that of *Cadoceras* species more than *Arctocephalites* species in its stronger and more asymmetric subdivision of the first lateral saddle.

Arctocephalites(?) sp. aff. *A.*(?) *freboldi* (Spath)

Plate 17, figures 4-6

aff. *Cadoceras freboldi* Spath, 1932, p. 65, Pl. XVIII, fig. 2a, b.

Material and occurrence. Small parts of two whorls of one specimen (figured specimen GSC 68342) from GSC locality C-95365 (base of Bed 53, fauna 6).

Description. The smaller part (Pl. 17, figs. 5, 6), with a whorl height of 2.5 cm and a width of about 2.8 cm, is septate and strongly ribbed. The ribs are strong and coarsely spaced, slightly flexuous, and slope very slightly forward from the umbilical margin along which they are strengthened. They bifurcate halfway up the flank, and there is minor intercalation of secondaries. They are not deflected, but may be slightly strengthened across the venter.

The cross-section, wider than high, is very slightly acuminate. The umbilicus is moderately open, steep-sided, and has a rounded, indistinct edge. The ribs apparently die out at the umbilical edge, but on the next smaller whorl that can be seen in the umbilicus, extensions of the significantly finer spaced ribs ornament the umbilical wall.

The larger part of this specimen (Pl. 17, fig. 4), representing the next whorl, is badly crushed but appears to be wider than high, and depressed or smoothly rounded. It is strongly ribbed and nonseptate. At its adoral part, the ribs swing forward so strongly that this must represent the apertural part of the body chamber, although no constriction is preserved. The ribs apparently bifurcate regularly. They are deflected forward across the venter strongly at the adoral end, and only slightly at the adapical end.

Discussion. Although insufficient material is available to identify the specimen, it is illustrated in order to document this coarsely ribbed, very slightly acuminate, large and globose type at this high stratigraphic level. In its coarse ribbing and the general character of the intermediate whorls it resembles its closely related associate *Arcticoceras harlandi* Rawson. The latter is more compressed, however. While this species may well be considered to be merely an inflated variant of *A. harlandi*, it is described apart here in order to clearly document the presence of the inflated form at this level, consistent with the species concept adopted in this report.

Arctocephalites(?) *belli* n. sp.

Plate 17, figures 1-3; Plate 18, figures 6, 7;
Plate 19, figures 3, 4

Material and occurrence. Two poorly preserved partial specimens (paratypes GSC 68345, 68348) from GSC locality C-95362 (Bed 46) and one nearly complete specimen (holotype GSC 68341) collected loose in a boulder (GSC loc. 92564) below the section, which also contains poorly preserved *Arcticoceras ishmae* (Keyserling) and *Choffatia* (?) sp.

Description. The best preserved specimen (Pl. 17, figs. 1-3) is 13 cm in largest diameter, 9 cm in largest width. Only the outer whorl can be clearly seen. A shallow apertural constriction on the internal mould is weakly developed on the flanks, apparently somewhat more strongly developed over the venter. The body chamber is about two thirds of a whorl in length and appears to be nearly smooth on the internal mould, with only three widely spaced, weak tubercles along the umbilical edge near the last septum, and weak corrugation passing over the venter.

The last part of the phragmocone has strong, widely spaced, umbilical tubercles and relatively strong ribs, about two or three to a tubercle, passing straight across the venter. The umbilical edge is rounded, the umbilicus deep, vertically walled, and relatively wide.

The adult cross-section is very low, and about 8 cm wide at a whorl height of 4.5 cm. Approaching the aperture however, the whorl height increases to nearly equal the width, and the flanks become high and only gently convex. There appears to be little or no extra-umbilication.

Inner whorls cannot be seen well. Their cross-sections are wider than high except in these juvenile stages, with a diameter of about 2 cm or less. The ribbing at this small growth stage is sharp, straight, relatively coarse and exhibits regular bifurcation.

The suture line is shown in Figure 14.

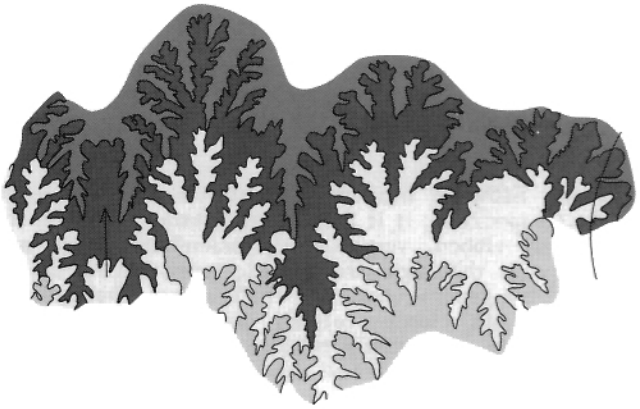

Figure 14. *Septal suture pattern of* ***Arctocephalites(?) belli*** *n. sp.; holotype GSC 68341, from GSC locality 92564; whorl height 4.2 cm.*

One of the poorly preserved specimens from Bed 52 (Pl. 18, figs. 6, 7) is ribbed to its largest preserved diameter, 10.3 cm, and is septate to a diameter of about 8.5 cm. Intermediate growth stages are strongly and coarsely ribbed, each rib bifurcating and some trifurcating at a well developed node or swelling just ventral of the umbilical margin. On the outermost whorl preserved, the ribs weaken gradually and become more numerous in proportion to the periumbilical swellings, which seem to remain strong. The ribs cross the venter with very slight forward projection. The cross-section is globose, nonacuminate, and about as high as it is wide.

The second fragment, from the same bed (Pl. 19, figs. 3, 4), consists of a small part of the penultimate whorl and the apertural part of the body chamber. The ribs of the intermediate growth stage are strong and flexed slightly forward, the flexure increasing adorally. The apertural part of the body chamber is smooth and has a marked apertural constriction. Little can be said of the shell shape, but the whorl height is relatively high as in the holotype (Pl. 17, figs. 1-3) and the curvature of the venter of the intermediate growth stage is somewhat more pronounced than in the other broader specimen from Bed 52 (Pl. 18, figs. 6, 7).

Discussion. A similar, large, coarsely ribbed, involute, cadoceratinid species from East Greenland was named *Cadoceras crassum* by Madsen (1909). His figures of the holotype (Pl. IX, figs. 1-3; Pl. X, fig. 1) indicate its near identity with *A.*(?) *belli*, although the high cross-section at the apertural end of the body chamber is not seen in Madsen's specimen. It is also slightly extra-umbilicate, and the inner whorls are higher and narrower than the outer, in contrast to the northern Yukon specimens. Additionally, no tubercles are present where the ribs bifurcate in *A.*(?) *crassum*.

Another large Arctic species, *A.*(?) *freboldi* (Spath), is differentiated from *A.*(?) *belli* by its acuminate cross-section, and another inflated species, *Arctocephalites callomoni* Frebold, does not reach the same size. *A.*(?) *belli* has a less globose cross-section than *A.*(?) sp. aff. *A.*(?) *crassum* (Madsen) described below, and *Arctocephalites* sp. A is more compressed than *A.*(?) *belli*.

Name. For John Bell, whose explorations for the Hudson's Bay Company led to recognition of McDougall Pass as a potential, although never utilized, overland trade route linking Interior Canada with the Yukon River system and, ultimately, the west coast of North America, and Asia.

Arctocephalites(?) sp. aff. *A.*(?) *crassum* (Madsen)

Plate 18, figures 1-5

aff. *Cadoceras crassum* Madsen, 1909, p. 193-195, Pl. IX, figs. 1-3; Pl. X, fig. 1.

Material and occurrence. A complete but crushed adult (figured specimen GSC 68343) from GSC locality C-86393 (Bed 26). A small fragment of a juvenile (figured specimen GSC 68344) from GSC locality 92525 (Bed 22) is also allied to *A.*(?) *crassum*. Upper *porcupinensis* and lower *amundseni* Zones.

Description. The smallest growth stage that can be seen in the strongly recrystallized and fragmented inner whorls has a whorl height of 2 cm, which may be slightly less than the real whorl height because of crushing, and a width of at least 5 cm. Therefore, the cross-section is very low.

The umbilicus is steep-walled, about 2.5 cm in diameter. The umbilical edge is rounded, and primary ribs extend down the umbilical walls.

The ribs are strong and the primaries are swollen on the umbilical edge. There, they subdivide into secondaries that are two and a half times as numerous. Beyond a whorl height of about 2.5 cm, the secondary ribs become weak, and fine growth lines are conspicuous over the venter. The ribs are more or less rectiradiate, passing straight over the gently rounded venter.

The adult shell has a diameter of about 10 or 10.5 cm, distorted due to crushing. The cross-section remains very broad and low, and appears to have become subquadrate, with flat, low flanks, meeting a very gently rounded broader venter at a gently rounded shoulder. The subquadrate outline may, however, be a result of the crushing.

The last three quarters of a whorl are not noticeably ribbed, although faint corrugations appear near the aperture. No constriction can be seen.

Discussion. Of the previously described species that are highly inflated, *Arctocephalites callomoni* Frebold is slightly smaller, ribbed to a smaller diameter, and has a higher whorl section. *A.*(?) *freboldi* (Spath) is probably larger and has a higher, acuminate cross-section. *Arctocephalites*(?) *crassum* (Madsen) is most similar to the present specimens, but has a slightly higher cross-section, particularly on the inner whorls, does not have noticeable swellings on the primaries, and does not have the subquadrate adult cross-section.

Arctocephalites(?) *belli* n. sp. is very similar, but is ribbed to a larger growth stage, has a less globose cross-section, and has a much higher, more nearly subquadrate cross-section in the adult.

The small specimen figured from Bed 22 (Pl. 18, figs. 4, 5) has the broad, low rounded cross-section of *A.*(?) *crassum* but its juvenile character prevents positive identification.

Genus *Arcticoceras* Spath, 1924

The current interpretation of genus *Arcticoceras* follows principally from Spath's (1932, Pl. XV, fig. 7a, b) figure of a topotype of *Ammonites ishmae* Keyserling, originating from the Petschora region of northwestern USSR, because Keyserling's (1846) original type material has still not been recovered. Spath's figure was reproduced by Arkell et al. (1957) and is widely taken to represent the species. The specimen is strongly ribbed to its end; its maximum preserved diameter measured from Spath's figure (1932, Pl. XV, fig. 7a) is 7.8 mm. Spath (1932) also briefly described another, larger specimen from the Petschora region as being essentially the same, with the ribs only just beginning to disappear at a diameter of more than 110 mm.

In many respects, *Arcticoceras* is similar to certain species of stratigraphically older *Arctocephalites*, and of younger *Longaeviceras*, *Cadoceras* and *Chamoussetia* (Spath, 1932; Imlay, 1953), between which it is an intermediate phylogenetic form. Spath (1932) showed projected costation in the young of some *Arctocephalites* species to foreshadow that of *Arcticoceras*. Callomon (1959), on the basis of extensive collecting in East Greenland, considered the sole difference between *Arcticoceras* and genus *Arctocephalites* to be the strong, sharp, and coarser character of the secondary ribbing in the former, and its tendency to swing forward on a sharpened venter. The northern Yukon collections support this assertion.

Longaeviceras and *Cadoceras* have smooth, cadicone adult shells, and *Chamoussetia* has an acute periphery (Arkell et al., 1957). *Pseudocadoceras* is small, sharply ribbed to its end, and has less strongly projected ribs on the venter. Most specimens identified in the literature as *Pseudocadoceras* are better assigned to *Costacadoceras* Rawson, microconch of *Arcticoceras*.

The following species from the Western Interior are now rejected from *Arcticoceras* (Donovan, 1957; Frebold, 1963): *A. codyense* Imlay, *A. henryi* (Meek and Hayden), and *A. rierdonense* Imlay. They were placed in the genus *Warrenoceras* Frebold (1963), which is here suggested to be synonymous with *Eurycephalites* Spath (1928). These are distinctly finer ribbed than the genotype, *A. ishmae*, some have a distinctly sharper venter, the persistence of the ribs is different, and the projection of ribs on the venter is absent or nearly so. Westermann (1980), however, continues to assign *A. henryi* to *Arcticoceras* and has correlated it, as a zonal indicator, with *A. kochi* (= *A. ishmae*). *A. crassicostatum* Imlay and *A. loveanum* Imlay, questionably placed in *Warrenoceras* by Frebold (1963), are coarser ribbed than other species assigned to that genus or to *Arcticoceras*, but like *Arcticoceras*, the ribs are strongly projected over the venter (see Imlay, 1953a, Pl. 3). These species are reassigned to *Xenocephalites* (= *Oligocadoceras*).

Arcticoceras harlandi Rawson

Plate 19, figures 1, 2, 5-8; Plate 20, figures 1-4

?*Arcticoceras stepankovi* Tuchkov. Efimova et al., 1968, Pl. 95.
Arcticoceras harlandi Rawson, 1982, p. 98, Pl. 2, figs. 1-7.
?*Arcticoceras* sp. nov.? Spath, 1932, p. 58, Pl. XI, fig. 3.
?*Arcticoceras excentricum* Voronetz, 1962, p. 46, Pl. X, fig. 4, Pl. IX.

Material and occurrence. Two partial specimens (figured specimens GSC 68346 and 68349) from GSC locality C-95365 (base of Bed 53), possibly another from GSC locality 92539 (Bed 53), and three specimens, including figured specimens GSC 68351, 68352 and 68347, collected loose below the section (GSC locs. 92520, 92473). The lithology of the matrix surrounding each loose specimen is not sufficiently diagnostic to determine the horizon from which they came, but is compatible with that of Bed 53, which the identifications of the specimens themselves suggest. *Harlandi* Zone.

Description. The medium sized, ribbed and septate specimens are united by their coarse ribbing and the high, evenly rounded cross-section. There is considerable variation in the size of the umbilicus, the degree of inflation, and the proportion of trifurcating rather than bifurcating ribs, from one specimen to another.

Half of one whorl of one specimen from Bed 53 (Pl. 19, figs. 1, 2) is available. It is entirely septate and ribbed. The whorl height is 4 to 4.2 cm, and its width is about 3.4 cm.

The ribs are strong and bifurcate with some trifurcation. They are very slightly sinuous, sloping slightly forward from the umbilical margin. They pass over the venter without flexure and without noticeable strengthening. There is a tendency to strengthening at the loci of bifurcation, at about one third of the height of the flank.

A very small portion of the umbilical part of the succeeding, nonseptate whorl can be seen. The primary ribs are subdued, and slope strongly forward. The body chamber must begin at a whorl height just greater than 4.2 cm.

The cross-section is full, smoothly rounded, and is higher than wide.

The umbilicus is moderately open and steep-sided, with a smoothly rounded, indistinct edge. The maximum width is reached one third to halfway up the flank.

In the degree of inflation particularly, but also in all other characters, one of the loose specimens (Pl. 19, figs. 5, 6) most closely resembles the specimen from Bed 53, described above.

The largest of the loose specimens (Pl. 20, figs. 1, 2) is about 10 cm in diameter, although the original dimension cannot be measured because of breakage. It is septate and coarsely ribbed to the end. The flanks are gently and evenly convex grading smoothly into the rounded venter and relatively abruptly into the umbilical wall, which is vertical. The umbilicus is about 11 mm in diameter, and apparently was of nearly constant diameter in earlier growth stages also. The shell was thickest at about halfway up the flank.

The ribs are inclined slightly forward and are very slightly projected over the venter. Very strong, relatively coarsely spaced primaries bifurcate or trifurcate at swellings just below the mid-point of the flank, and there are some intercalated secondaries between bifurcating ribs. The secondaries weaken somewhat on the oralmost parts of the preserved shell and are somewhat strengthened on the venter. The primaries remain very strong.

The suture line, typical of the genus, is shown in Figure 15.

Figure 15. Septal suture pattern of ***Arcticoceras harlandi*** *Rawson; figured specimen GSC 68347, from GSC locality 92473; whorl height 3.2 cm.*

Another loose specimen (Pl. 21, figs. 3, 4) is 7.2 cm in diameter. No septae are seen in the last preserved whorl, and no apertural constriction is present, thus it appears to be a juvenile. The description of the large specimen applies well to it also.

The shell of another juvenile specimen is ribbed to its maximum preserved diameter of 4.5 cm (Pl. 19, figs. 7, 8). The whorl height is 2.3 cm, the width 1.9 cm. The ribs are fine, curved smoothly forward, and bifurcate regularly to about one third to one half of the height of the flank. The flanks are flat, the venter smoothly rounded. The umbilicus is small with a rounded, relatively abrupt edge. The sutures cannot be seen. Several badly crushed, relatively small, smooth body chambers of similar cross-section and with apertural constrictions occur in the same collection.

Discussion. Most of the specimens conform well in the size and style of ribbing with the primary type material from Svalbard (Rawson, 1982). However, they are a bit more inflated, have a somewhat larger umbilicus and perhaps a slightly greater tendency to form tubercles where the ribs bifurcate. None of these characters warrant specific separation. The juvenile specimen figured (Pl. 19, figs. 7, 8) resembles those figured by Rawson (1982) in the fine spacing and orientation of the ribs, flattened flanks and in the coiling, but like all the other Canadian specimens, is considerably more inflated than those from Svalbard.

The very slight strengthening and slight ventral projection of ribs over the venter of two of the specimens, as well as the large size to which coarse ribbing persists, suggest assignment of this species to *Arcticoceras*. *Arctocephalites*(?) *crassum* and other similar species are more inflated and *A.*(?) *freboldi* and its allies are acuminate. The characteristic strong ventral projection of ribs of *Arcticoceras ishmae*, which Callomon (1959) considered to characterize *Arcticoceras*, is not yet well developed in this earliest species.

Arcticoceras excentricum Voronetz (1962, Pl. X, Fig. 4; Meledina, 1972, p. 107, Pl. VII, figs. 1-3) and similar specimens identified as *A. kochi* Spath and *A.* cf. *excentricum* by Meledina (1973, p. 81-84; Pl. XX, figs. 1, 2; Pl. XIX, fig. 2; Pl. XXI, figs. 1-4) from northern Siberia, are clearly closely related if not synonymous with *A. harlandi*. However, some specimens (e.g. Voronetz, 1962, Pl. XIV) are so much larger than *A. harlandi* from northern Yukon or Svalbard that their identity with that species is not certain. An associate of *A.* cf. *excentricum* in Siberia, according to Meledina (1973, Fig. 35, p. 113), referred to *Cadoceras declinatum* (Voronetz, 1962), is closely similar to an acuminate, somewhat inflated form that occurs with *A.*(?) *harlandi* in northern Yukon, described here as *Arctocephalites*(?) sp. aff. *A.*(?) *freboldi* (Pl. 17, figs. 4-6).

The illustration of *A. stepankovi* Tuchkov by Efimova et al. (1968, Pl. 95) suggests that, if it is not a medium sized *Arctocephalites* resembling *A. arcticus* (Whitfield) and *A. kigilakhensis* Voronetz, it may represent *A. harlandi*.

Arcticoceras ishmae (Keyserling)

Plate 20, figures 5-8; Plate 21, figures 1-5;
Plate 22, figures 1-7

Ammonites ishmae Keyserling, 1846, p. 331, Pl. 20, figs. 8-10.

?not *Macrocephalites ishmae* Keyserling. Madsen, 1909, Pl. VIII, figs. 7-9.
?*Macrocephalites ishmae* Keyserling. Sokolov, 1912, p. 15, Pl. I, fig. 1, Pl. III, fig. 13.
Arcticoceras ishmae (Keyserling). Spath, 1932, Pl. XV, fig. 7a, b.
Arcticoceras kochi Spath, 1932, p. 53, Pl. XII, fig. 1a, b, c; Pl. XIII, figs. 4, 5; Pl. XIV, figs. 1-3; Pl. XV, figs. 1, 4-6.
?*Arcticoceras michaelis* Spath, 1932, Pl. XIII, fig. 3a, b (microconch of *A. ishmae* according to Callomon, 1975, p. 362).
?*Arcticoceras kochi* var. *pseudolamberti* Spath, 1932, Pl. XIV, figs. 2, 3; Pl. XV, fig. 6 (synonym of *A. michaelis* according to Callomon, 1975, p. 382).
?*Arcticoceras* cf. *ishmae* (Keyserling). Bodylevsky, 1960, p. 61, Pl. 1, fig. 2a, b.
Arcticoceras kochi Spath. Frebold, 1961, p. 16, Pl. XVI, fig. 2; not Pl. 12, fig. 1a, b, or Pl. IX, fig. 3.
Arcticoceras ishmae (Keyserling). Frebold, 1961, p. 15, Pl. X, fig. 3; Pl. XIII, fig. 1a, b; Pl. XIV, figs. 1, 3a, b.
?*Arcticoceras* cf. *kochi* Spath. Meledina, 1972, p. 107, Pl. VI, figs. 1, 2.
Arcticoceras ishmae (Keyserling). Meledina, 1973, p. 80, Pl. XIX, fig. 1.
Arcticoceras pseudolamberti Spath. Meledina, 1973, p. 83, Pl. XX, fig. 3; Pl. XXII, fig. 1.
Arcticoceras ishmae (Keyserling). Callomon, 1975, p. 382, fig. 5B.
Arcticoceras ishmae (Keyserling). Imlay, 1976, p. 16, Pl. 3, figs. 17-19.

Material and occurrence. Three specimens, including hypotype GSC 68353, from GSC locality 92540 (Bed 60), and many specimens collected loose below the section, mostly in a dense ferruginous matrix which, together with the associated faunas, indicates their source in or near Bed 60. These include figured specimens GSC 68354 from GSC locality 92556; GSC 68355 from GSC locality 92564; GSC 68356 from GSC locality 92554; GSC 68357 and 68359 from GSC locality 92473; GSC 68358 from GSC locality 92520; and GSC 68360 from GSC locality C-95369. Additionally, Frebold (1961, Pl. XVI, fig. 2) previously described one specimen from the Salmon Cache Canyon locality, whose stratigraphic position is not recorded. *Ishmae* Zone.

Description. The species has been extensively described already from many areas around the Arctic (see synonymy list). Only additional data deduced from the northern Yukon material is given here. It was collected partly in place in a bed of very hard, rusty red, ferruginous concretions (Bed 60; GSC loc. 92540) and also in loose blocks of this rock type on the river bank immediately below the section. Although it is most likely that all the loose blocks are derived from the same bed, nevertheless it cannot be certainly stated that all the forms described here occur together.

The specimens assigned to *A. ishmae* are all similar in shell shape and ribbing character. However, there is wide variation in the maximum size attained, and correspondingly in the diameter at which the body chamber begins, the ribbing ends, or where the apertural constriction appears in the microconchs. Only a few specimens were collected in place in the section, and these are all similar in size. They conform well with the current concept of *A. ishmae* (e.g. Keyserling, 1846; Arkell et al., 1957; Callomon, 1975). Thus, the wide variation in size is recognized from the loose material, and cannot be documented within a single stratigraphic horizon. Nevertheless, because they differ only in size, and because no obvious groups are recognized, but rather a complete range of forms, all the specimens of similar shell shape and ribbing pattern are here treated under the description of *A. ishmae*.

The best specimen collected in place (Pl. 20, figs. 5-8) is intermediate in size, which is typical of most of the samples taken from the loose material. It becomes smooth at a diameter of about 8.5 cm (whorl height 4.3 cm), and reaches a maximum diameter of about 11 cm. A weak, preliminary constriction occurs where the shell becomes smooth. No sutures were recognized beyond a diameter of about 10 cm, and very slight whorl contraction, together with a peristomal constriction on the inner shell surface indicate the specimen's maturity. The same features are true of a second, and probably also a third specimen (unfigured) of the same size.

A small part of a shell (Pl. 22, fig. 1) corresponding in size to the specimen described just above exhibits the apertural constriction on a still strongly ribbed shell. One small fragment of the apertural part of another small shell (Pl. 22, figs. 6, 7) exhibits the nearly terminal apertural constriction low on the flanks, part of the ventral lappet extending well beyond it on the venter, and minor contraction of the whorl height.

A larger morphotype is represented by other specimens, one (Pl. 21, fig. 3) septate to a size of 11 cm in diameter, another (Pl. 21, figs. 1, 2) coarsely ribbed to a size of 10.5 cm diameter (whorl height 5.5 cm) and reaching a total diameter of about 15 cm, where there is a peristomal constriction and slight contraction of the whorl cross-section. Another equally large (unfigured) specimen is represented by a partial body chamber that occurs in a loose boulder together with smaller specimens of *A. ishmae*. Weak ribbing persists halfway along the last whorl, well beyond the last septum. One other fragment of a body chamber found loose (Pl. 22, figs. 4, 5) shows well the character of the peristomal constriction and projected venter at the peristome. A well developed "ventral lappet" occurs in large and small shells, extending more than 2 cm beyond the apertural constriction, which is itself strongly projected.

Another, smaller morphotype is represented only by a poorly preserved (unfigured) fragment found loose below the section in a concretion resembling those of the *ishmae* Zone (GSC loc. 92563). It is the smallest adult seen, with a whorl height of only 4 cm where the apertural contriction occurs. The body chamber is smooth except for weak ribs on the venter. The highest ribbed inner whorl that can be seen is 2 cm high.

The venter of *A. ishmae* is characteristically ribbed more strongly than are the flanks, and also is ribbed to a later stage than are the flanks. No clear relationship was observed between the persistence of ribbing and of septation.

The outer shell surface can be seen well on only one specimen (Pl. 20, figs. 5, 8), where, at 11 cm diameter, the internal mould has passed through a smooth stage and ribbing has reappeared on the venter, whereas only fine growth lines characterize the outer shell surface.

In one specimen, the suture line at a diameter of 10 cm (fig. 16), resembles that shown by Spath (1932, p. 64, Text-fig. 3a) for *A. kochi*, and by Sokolov (1912, Pl. 3, fig. 12) for *A. ishmae*. Another, at a diameter of 6.5 cm (Pl. 21, figs. 4, 5), resembles the more juvenile suture lines figured by Keyserling (1846, Pl. 22, fig. 15) for *A. ishmae* and by Efimova et al. (Pl. 95) for *A. stepankovi*.

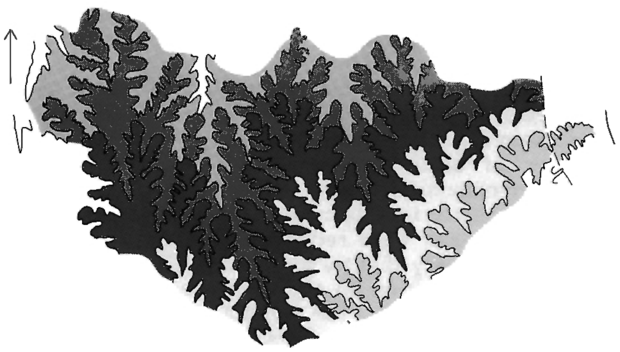

Figure 16. *Septal suture pattern of* ***Arcticoceras ishmae*** *(Keyserling); crushed figured specimen GSC 68355, from GSC locality 92564; whorl height 5.2 cm.*

The variation in the ornamentation of the final stage described by Spath (1932, p. 54) for *A. kochi* is well illustrated in the present material. All specimens are relatively strongly ribbed, and for this reason were identified as *A. kochi* by Frebold (1961). Most of the present specimens have a broader, more evenly rounded cross-section at all growth stages than those figured as *A. ishmae* by Spath (1932, Pl. 15, fig. 7a, b) or as *A. kochi* (Spath, 1932, Pl. 13, figs. 4, 5; Pl. 12, fig. 1a-c) and more closely resemble Keyserling's (1846, Pl. 20, fig. 9) original figure of *A. ishmae* Spath's (1932, Pl. 13, fig. 3a, b) *A. michaelis*, and Tuchkov's *A. stepankovi* (Efimova et al., 1968, Pl. 95). Nevertheless, the sharper venter of some specimens shows that there is enough variation within the species to include all these forms. The projection of the ribs over the venter is slightly variable in strength in some specimens resembling Spath's (1932) figures of *A. kochi*, and the projection is stronger than in any of the other forms described except those of *A. ishmae* described by Imlay (1976).

The larger forms are correspondingly more coarsely ribbed than the smaller ones and are slightly more inflated. They thus conform with Spath's (1932) description of *A. kochi*, but given Callomon's (1975 and in Imlay, 1976, p. 17) description of the mutual variation and co-occurrence of *A. kochi* and *A. ishmae* in the same bed in East Greenland, they are reservedly assigned to *A. ishmae*.

Callomon (1975) stated that *A. michaelis* Spath (1932, Pl. 13, fig. 3a, b) is a microconch dimorph of *A. ishmae*. No forms resembling *A. michaelis*, with its depressed outer whorl and open umbilicus, are among the Salmon Cache Canyon specimens however, and no clearly recognizable microconch was found. The cross-section of all the northern Yukon specimens is always higher than wide.

Judging by the illustration of Efimova et al. (1968), *A. stepankovi* Tuchkov is also very similar, although it is perhaps slightly more inflated and has less strongly projected ribs over the venter.

A younger species, *A. cranocephaloides*, which becomes cadicone as do succeeding *Cadoceras* species, was illustrated by Callomon (1975) from material from Greenland and the North Sea.

Two of the three specimens from Salmon Cache Canyon identified by Frebold (1961, Pl. IX, fig. 3; Pl. XII, fig. 1a, b) as *A. kochi* Spath occur together with *Arctocephalites frami* n. sp. and are here reassigned to that species for reasons given under its description. The third was found loose below the section. The fragmentary and otherwise poorly preserved specimens described as *A. ishmae* from Prince Patrick Island (Frebold, 1961) and northern Alaska (Imlay, 1976, Pl. 3, figs. 17-19) certainly appear to fall within the morphologic range of *A. ishmae*, although they are perhaps more acuminate than the northern Yukon specimens.

Arcticoceras spp. indet.

Plate 22, figures 8-13; Plate 23, figures 1-4

?*Arcticoceras kochi* Spath. Frebold, 1961, p. 16, Pl. IX, fig. 3.

Material and occurrence. Two small fragments, including figured specimen GSC 68362, from GSC locality C-95362, Bed 46 (*frami* Zone); one figured by Frebold (1961) from Bed 55 (*ishmae* Zone); several specimens found loose below the section, among them figured specimens GSC 68361 from GSC localities 92520, 68363 from GSC localities C-95369, and 68364 and 68365 from GSC locality C-95372. One of them (GSC 68364) occurs in a yellow weathering matrix, suggesting its origin in beds below the *ishmae* Zone. The remainder are assumed to come from the *ishmae* Zone.

Description and discussion. Two small fragments from Bed 46 (e.g. Pl. 22, figs. 10, 11) are tentatively assigned to *Arcticoceras* because of their strengthened and projected ribs on the venter. The fragments are too small to compare meaningfully with *A. ishmae* (Keyserling) or any other species. If they are truly *Arcticoceras*, then they are the lowest occurrence of the genus in this section or elsewhere.

One fragment found in loose material below the section (GSC loc. 92520) is more widely umbilicate, more coarsely ribbed at an equivalent growth stage, and more depressed than other specimens that are described as *A. ishmae*. The characteristic ventral strengthening and projection of ribs indicate its assignment to *Arcticoceras*. The gently curved flank grades into the rounded umbilical margin and the venter. This specimen exhibits some similarities to *Arcticoceras cranocephaloides* Callomon (1975, p. 382, fig. 4D-F), although a detailed description of that species has not yet appeared.

Another (unfigured) specimen found loose (GSC loc. 92520), is septate to the end, and somewhat more strongly compressed than others described as *A. ishmae*. In this it resembles a fragment described by Spath (1932, Pl. XII, fig. 1b).

One fragment of a small morphotype found in loose material below the section (Pl. 22, figs. 12, 13) is finer ribbed than other specimens described as *A. ishmae*, but shows characteristic projection and strengthening of ribs over the venter. In addition to the apertural constriction developed at a small, still strongly ribbed growth stage, it appears to become uncoiled, although part or all of this uncoiling may be an illusion due to deformation. The greater involution, larger size, continuous forward curvature of the ribs, and their projection over the venter distinguish this specimen from *Costacadoceras bluethgeni* Rawson (1982), although the generic name *Costacadoceras* Rawson (1982) was clearly intended to include a wide range of *Arcticoceras* microconch morphotypes such as this one.

Another relatively finely ribbed specimen found loose (Pl. 23, figs. 1, 2) resembles the specimen figured on Plate 20 (figs. 5-8) in other characteristics. It becomes smooth at a slightly smaller growth stage, and its body chamber is perhaps a bit more acuminate. Weak ribs reappear on the body chamber after about one third of a whorl length. The yellow-weathering, siliceous mudstone matrix of the specimen suggests its occurrence below the *ishmae* Zone.

One poorly preserved, fragmentary (unfigured) specimen found loose is strongly ribbed and has what appears to be the beginning of a ventral lappet at a whorl height exceeding 7 cm. This is, therefore, the largest shell of its kind in the collections, but it is too poorly preserved to identify conclusively. The venter cannot be seen except poorly near the aperture, rendering even its generic identification tentative.

A particularly coarsely ribbed fragment (Pl. 23, figs. 3, 4) was found loose. There is a slight tendency to form tubercles on the primaries about one third of the way up the flank, just below the locus of bifurcation. The last septum probably lies near the preserved apertural end of the fragment.

Genus *Costacadoceras* Rawson, 1982

This genus was erected (Rawson, 1982) for small, evolute species of subfamily Arctocephalitinae that resemble *Pseudocadoceras* except for their greater evolution, and which were assumed to be microconch dimorphs of *Arcticoceras* and *Arctocephalites* species with which they are associated. The genotype species, *C. bluethgeni* Rawson, was assumed to be the microconch of associated *Arcticoceras harlandi* Rawson (1982). Only two specimens described below, whose affinities are uncertain and which were not found associated with other ammonites, are described under the generic name "*Costacadoceras*". Many of the previous identifications of *Pseudocadoceras* species in Arctic regions refer to evolute forms that fall into this category.

"*Costacadoceras*" sp. indet. A

Plate 23, figures 5, 6

Material and occurrence. One small specimen (figured specimen GSC 68268) from GSC locality 92534 (Bed 44). *Amundseni* Zone.

Description. This small fragment has a wide umbilicus. The umbilical wall is high, gently sloping, and distinctly ribbed. It meets the continuously and smoothly rounded flank-venter about one third of the way up the whorl at an abruptly rounded edge. The flank-venter is strongly and sharply ribbed. The ribs are radial on the umbilical wall, prorsiradiate on the flank. Some are single and others bifurcate at a swelling along the umbilical edge. They are very slightly projected on the venter.

Discussion. This shell appears to be related to younger *Cadoceras* in the character of its umbilicus, and no time-equivalent species is similar, unless it is an unusually evolute microconch of one of the late *Arctocephalites* or early *Arcticoceras* species. The inflation, greater evolution, and higher, more distinct umbilical wall separate it from *Costacadoceras bluethgeni* Rawson.

"*Costacadoceras*" sp. indet. B

Plate 23, figures 7, 8

Material and occurrence. One small specimen (figured specimen GSC 68651) from GSC locality 92537 (Bed 51). Sole representative of an otherwise barren interval between faunas 5 and 6.

Description. The shell is moderately evolute. The umbilical walls are low and steep, finely ribbed, and merge smoothly with the flanks. The shell is inflated, the flanks convex, nearly subcircular. The fine, sharp ribs are nearly radial, and slightly projected over the venter. Most are single, some bifurcate halfway up the flank.

Discussion. This shell is much more inflated, and more nearly radially ribbed than *Costacadoceras bluethgeni* Rawson, which is assumed (Rawson, 1982) to be the microconch dimorph of *Arcticoceras harlandi* Rawson. Its affinities are uncertain.

Subfamily CADOCERATINAE Hyatt, 1900

The subfamily is now restricted following Meledina's (1968) transfer of *Arcticoceras* and earlier genera to subfamily Arctocephalitinae. She (*ibid.*) considered the subfamily Cadoceratinae to be independently derived from *Arctocephalites* contemporaneously with *Arcticoceras*. This is not supported by the age control available, which indicates a more or less continuous succession from *Arctocephalites* through *Arcticoceras* to *Cadoceras*.

Pseudocadoceras Buckman (1918), based on Middle Callovian *P. boreale* of England, has commonly been identified in older beds, particularly in Siberia. In particular, its supposed association with *Arcticoceras* (e.g. Meledina and Na'nyaeva, 1972), has been used to support the interpretation of a Callovian age for that genus. Those reports refer to evolute forms, for which, in Svalbard, Rawson (1982) erected *Costacadoceras*, considering it to be the microconch dimorph of *Arcticoceras* and *Arctocephalites*, and *Pseudocadoceras* itself is no longer considered to extend into beds as old as those with *Arcticoceras*. Similar forms occur in the northern Yukon collections, described under "*Costacadoceras*".

Genus *Cadoceras* Fischer, 1882

The genotype is *C. sublaeve* (Sowerby) of England, designated by Spath (1932, p. 58). *Cadoceras* is a widespread and common Boreal genus that has been the subject of much discussion in the literature, but that has yet to yield any obvious taxonomic subdivision or simple evolutionary trends of biostratigraphic utility.

An exception is the distinction of the oldest species, *C. barnstoni* (Meek) and *C. variabile* Spath, which have a narrower, steeper-sided umbilicus with more rounded edges than later, more typical species. They indicate its transitional development from *Arcticoceras*. These forms, characterized by northern Siberian *Cadoceras laptievi*, formed the basis for erection of the subgenus *Catacadoceras* by Bodylevsky (1960), who assumed but did not prove that species to be the oldest *Cadoceras*. Except for those early species, *Cadoceras* is differentiated from *Arcticoceras* by the sharp, umbilical edge and funnel-shaped, more or less open umbilicus.

Several other subgenera have been erected: *Stenocadoceras* Imlay (1953b), *Bryocadoceras* Meledina (1977), *Streptocadoceras* Meledina (1977), and *Oligocadoceras* Meledina (1977). Of these, there seems to be little reason to differentiate *Bryocadoceras* or *Streptocadoceras*, judging strictly by their designated type species – *C. falsum* Voronetz (1962), and *C. subtenuicostatum* Voronetz (1962), respectively. It is clear also that Meledina's (1977, p. 83) concept of *Streptocadoceras* included a broad range of forms, as is shown by her inclusion in the subgenus of such dissimilar species as *C. septentrionale* Frebold, *C. bodylevskyi* Frebold, *C. barnstoni* (Meek), *C. arcticum* Frebold, *C. crassum* Madsen, and *C. variabile* Spath. Bodylevsky (1960) considered *Rondiceras* Troitskaya to be a subgenus of *Cadoceras*. *Catacadoceras* Bodylevsky (1960) is available as a name for the earliest forms, such as *C. barnstoni* and *C. variabile*, with rounded umbilical edges and strong ribs that persist for the length of the body chamber. It is not used here, however, as the stratigraphic position of the type species, *C. laptievi* Bodylevsky (1960) is unproven, and the genus *Cadoceras* as a whole is poorly understood phylogenetically. *Stenocadoceras* has been treated recently as a genus to accommodate compressed species (Meledina, 1977). *Novocadoceras* Sasonov (1965), based on a small, probably immature specimen, has been placed in junior synonymy of *Pseudocadoceras* (Meledina, 1977), itself incompletely understood. *Paracadoceras* Crickmay (1930) is treated here as a genus (see below).

The record of *Cadoceras* in the Western Interior United States (Imlay, 1948, 1953a) is based on material that has subsequently been reinterpreted. *Cadoceras* does occur commonly in southern Alaska and in western British Columbia, however, so that with its appearance also in Northwest Europe, it is perhaps the most southerly, extensive representative of family Cardioceratidae.

Cadoceras barnstoni (Meek)

Plate 24, figures 1-18; Plate 25, figures 1-8;
Plate 26, figures 1-8

Ammonites barnstoni Meek, 1859, p. 184, Pl. 2, figs. 1, 2, 3.
Cadoceras barnstoni (Meek). Frebold, 1964b, p. 14, 15, Pl. VIII, fig. 3, Pl. XII, fig. 2.
?*Cadoceras (Catacadoceras) laptievi* Bodylevsky, 1960, p. 64, 65; Pl. 1, fig. 1, Pl. II, fig. 1.
Cadoceras crassum Madsen. Frebold, 1961, p. 17, Pl. XIV, fig. 2, Pl. XVII, fig. 1.
?*Cadoceras subcalyx* Voronetz, 1962, p. 51, Pl. XX, figs. 1, 2, 4.
?*Cadoceras subcatostoma* Voronetz, 1962, p. 54, Pl. XXIV, fig. 1, Pl. XXV, fig. 1.
?*Cadoceras ventroplanum* Voronetz, 1962, p. 54, Pl. XXIII, fig. 1a, b.

Material and occurrence. Four nearly complete specimens, none of which is adult, and many fragments (figured specimens GSC 68382, 68383, 68384, 68385, 68386, 68388 68389 and, 68398) from GSC locality 92543 (Bed 62), and abundant loose specimens below the section (including figured specimens GSC 68387, 68390, 68391, 68392, 68393, 68394, 68395, 68396, and 68397, and unfigured type specimens GSC 68656, 68657, and 68658), either lying alone or in association with other ammonites in yellow-weathering boulders that are lithologically characteristic of Bed 62 (GSC locs. 92520, 92473, 92553, 92568, C-95369). In addition, the holotype (GSC 4811) may well have been collected from this locality, although the only information given by the original author was "in the valley of Mackenzie River" (Meek, 1859), where it may have been carried by a trapper.

Description. The descriptions of the holotype by Meek (1859) and Frebold (1964, p. 14, 15) apply reasonably well to some of the specimens from Bed 62, and that specimen may well have come from float derived from this unit. However, bullae along the umbilical border are more strongly developed in some of the new material, the umbilical wall is less steep, except in the largest specimens, and the early growth stages are more openly displayed in the umbilicus.

Other specimens from Bed 62 are included in *C. barnstoni*, although they differ from the holotype and from the other specimens in their higher, more compressed cross-section at intermediate growth stages and in their slightly sharper umbilical edge. These variants are considered to be conspecific with other specimens referred to *C. barnstoni* however, because forms that are intermediate between the two in the characteristics mentioned above occur as loose specimens, below the section, and because no other reliable means of differentiating them has been discovered. The specimens with higher cross-sections generally lose this character in the large growth stages. The species therefore is morphologically diverse, and includes forms that do not appear to be differentiable from the holotypes of *C. subcatostoma* Voronetz or *C. ventroplanum* Voronetz.

The smaller specimens in Bed 62 permit illustration of the juvenile shell (Pl. 24, figs. 3-5, 6, 7). One specimen shows the juvenile to be smooth up to a diameter of about 5 mm, and then to bear fine, forwardly inclined ribs (Pl. 24, fig. 7). The cross-section is higher than wide at small diameters. Between diameters of about 17 and 65 mm, the whorl cross-section is smoothly rounded, and variable in cross-section, higher than wide to about as high as wide, with no distinct umbilical margin. The inner whorls and the change in cross-section with growth is well seen in one specimen collected loose below the section (Pl. 26, fig. 2).

The largest specimen found in place in Bed 62 (Pl. 24, figs. 7, 8) is still strongly ribbed and septate at a diameter of 8.7 cm, although the specimen is distorted by crushing. Only at this large a growth stage does the umbilical edge become sharp. A large, nearly complete specimen found in float (GSC loc. 92473), still bears strong umbilical nodes beyond a diameter of 9.2 cm (Pl. 25, figs. 5, 6) with forward sloping, weak ribs projecting ventrally and dying out over the venter. The body chamber of this specimen comprises half of the last preserved whorl. No oral constriction is seen.

The ribs are inclined forward and are strong. On early growth stages, some bifurcate and some are undivided. At intermediate growth stages, most ribs bifurcate regularly at bullae, and at later growth stages there are increasing numbers of intercalated secondaries. Thus, there is a tendency to maintain fairly consistent spacing of secondaries in spite of increasingly coarse spacing of primaries.

The suture line of one specimen from Bed 62 and of another found loose below the section are shown in figures 17 and 18, respectively. The first lateral saddle is more strongly and asymmetrically dissected than in *Arctocephalites* and *Arcticoceras.*

The character of the adult shell is best seen in several specimens collected loose below the section (e.g. Pl. 25, figs. 1, 2; Pl. 26, figs. 1, 2). The last whorl remains strongly ribbed to the end, although the ribbing is somewhat weaker over the venter. The ribs are increasingly inclined forward.

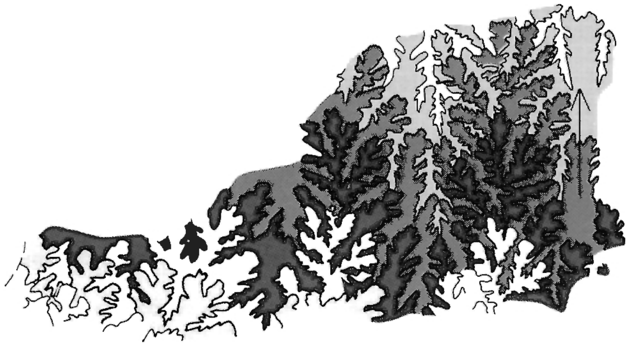

Figure 17. *Septal suture pattern of* ***Cadoceras barnstoni*** *(Meek); figured specimen GSC 68385, from GSC locality 92543; whorl height 2.7 cm.*

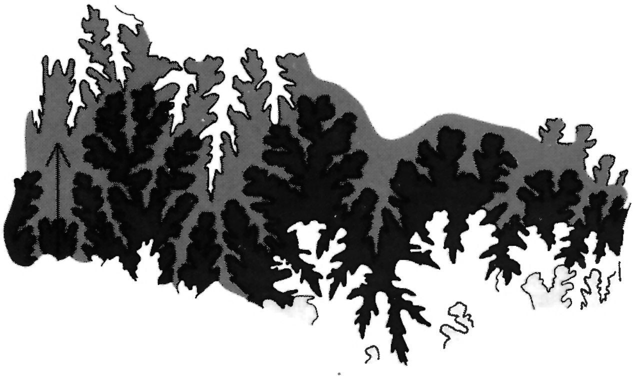

Figure 18. *Septal suture pattern of* ***Cadoceras barnstoni*** *(Meek); figured specimen GSC 68387, from GSC locality 92553; whorl height 3.2 cm.*

The cross-section is subquadrate, with flattened flanks forming a rounded edge with the rounded but somewhat flattened venter. Small fragments of a body chamber with a subquadrate cross-section occur in Bed 62, but none together with earlier parts of the shell. One specimen (unfigured type specimen GSC 68656; GSC loc. C-95369) exhibits marked contraction of the whorl adorally from the apertural constriction. The body chamber is about three quarters of a whorl in length. In another specimen (unfigured type specimen GSC 68657 from GSC loc. 92473), a constriction, probably oral, occurs. This specimen is weakly ribbed to the end.

In contrast to earlier whorls, the body whorl has a sharp umbilical margin and the ribs do not extend onto the umbilical wall. Also, weakly developed bullae lie along the umbilical edge rather than higher on the flank (Pl. 25, figs. 1, 2). There is a slight tendency for the last whorl to be excentric.

There is some variation in the maximum adult size. The largest, complete, subquadrate adult measures 12.4 cm in diameter (possibly larger than the real size because of distortion due to crushing), 6.2 cm in width, and has a whorl height of 4.3 cm just before the slightly excentric oral portion of the body whorl. Similarly, there seems to be considerable variation in the width/diameter and degree of depression at intermediate growth stages. One specimen found loose below the section (unfigured type specimen GSC 68658) is unusually broad, and still septate, at a whorl height of 4 cm, a diameter of about 8.5 cm and a width of 6.5 cm.

Discussion. This earliest species of *Cadoceras* differs from most others in its rounded umbilical margin, which allies it with predominantly older and transitionally related *Arcticoceras* species, but it differs from these species in having a wider, funnel-shaped umbilicus.

The loose material lying below the section contains specimens entirely typical of the holotype of *C. barnstoni* and others with higher, intermediate whorls. The holotype differs from that of *C. variabile* Spath (1932, Pl. XIX, fig. 1) in its possession of a lower whorl height and a more rounded umbilical margin.

Cadoceras (?) *perraraum* Voronetz (1962) appears to be very similar to the northern Yukon species, but has a wider cross-section, and is perhaps somewhat more involute.

Those Salmon Cache Canyon specimens with a higher whorl height appear to agree in most respects with the holotype of *C. variabile* Spath (1932, Pl. XIX, fig. 1). The adult cross-section of that holotype is not clear from Spath's figure 1a and was not figured specifically so that the subquadrate adult fragments taken to represent the same species in northern Yukon cannot be confirmed in the holotype. As already stated by Spath (1932, p. 76), the larger specimen he figured (Pl. XVIII, fig. 1a) has a narrower, steeper-walled umbilicus, approaching that of *Arcticoceras*, and may not represent the same species, so that the adult cross-section of the specimen he figured cannot be taken to represent that of *C. variabile.* The whorl height becomes lower and the umbilicus slightly more open in later growth stages of the Porcupine River specimens assigned to *C. barnstoni.* In contrast, one (Pl. 27, fig. 1) retains a high whorl height to a large diameter, and shows ventral weakening of the ribbing, as in the holotype of *C. variabile*, to which species it is assigned.

Similarly, the northern Yukon specimens with a higher whorl height are not easily distinguished from the figured types of *C. subcatostoma* Voronetz (1962, Pl. XXIV, fig. 1; Pl. XXV, fig. 1). Besides the close morphological similarity of these three species, their synonymy is further suggested by their co-occurrence in East Greenland. Another northern Siberian species, *C. subcalyx* Voronetz, is also very similar, if not identical. These two Siberian species appear to differ from *C. barnstoni* only in having coarse ribs persist to a larger growth stage. *C. subcalyx* also is thought to co-occur with *C. variabile* and *C.* cf./aff. *barnstoni* in East Greenland although it occurs in association with other *Cadoceras* species in Siberia that are of younger aspect. Adult specimens of *C. barnstoni* and one juvenile at least (Pl. 28, figs. 7, 8) have a flattened venter, indicating that *C. ventroplanum* Voronetz is probably also a form of this species. Its precise stratigraphic position and associations in northern Siberia are not documented, but it is another of the forms identified in the *variabile* beds of East Greenland.

No significant difference is seen between *C. barnstoni* and *C. laptievi* Bodylevsky, but the assumed rather than proven stratigraphic age of *C. laptievi* renders its synonymy also unproven. If Bodylevsky (1960) were correct in stating that *C. laptievi* is among the oldest *Cadoceras*, then it is probably a junior synonym of *C. barnstoni*, to both of which species the subgeneric name *Catacadoceras* Bodylevsky (1960) applies.

Cadoceras sp.

Plate 26, figures 9-11

One fragment (figured specimen GSC 68399), found loose below the section (GSC loc. 92520) in a rock type indicating its source in Bed 62, has poorly preserved inner whorls that appear to be similar to those of *C. barnstoni*, and an outer whorl that is strongly acuminate. It is much wider than high, with steep umbilical walls, a rounded but relatively abrupt umbilical edge, and weak, irregular ribs that are very slightly projected forward on the internal mould.

Cadoceras variabile Spath

Plate 27, figure 1

Cadoceras variabile Spath, 1932, p. 75, Pl. XIX, fig. 1a-d.
?*Cadoceras crassum* Madsen. Frebold, 1961, p. 17, Pl. XIV, fig. 2, Pl. XVII, fig. 1.
?*Cadoceras* sp. indet. Frebold, 1961, p. 21, Pl. XIX, fig. 1a, b.
Cadoceras variabile Spath. Voronetz, 1962, Pl. 20, fig. 3.

Discussion. Two partial specimens (figured specimen GSC 68400 and another figured by Frebold, 1961, Pl. XVII, fig. 1) found loose below the section (GSC locs. 92561, 35692), the first in a rock type indicating its source in Bed 62, differ from *C. barnstoni* (Meek) in high whorl height, ribs that fade out ventrally and adorally, narrow umbilicus and rounded umbilical edge even at large diameter. They thus closely resemble the holotype of *C. variabile* Spath. Other, similar juvenile specimens collected in Bed 62, or almost certainly derived from it, have been discussed under *C. barnstoni* from which this species cannot, apparently, be distinguished, at small to intermediate growth stages. The specimen figured here closely resembles one figured by Callomon and Birkelund (1980, Pl. 1, fig. 1a, b) as *Arcticoceras/Cadoceras* sp. nov.? aff. *variabile* Spath.

Cadoceras bodylevskyi Frebold

Plate 26, figure 12; Plate 27, figures 2-6;
Plate 28, figures 1-9

Cadoceras bodylevskyi Frebold, 1964, p. 10, 11, Pl. XVII, fig. 1a-c, Pl. XIX, figs. 1, 2.
Cadoceras septentrionale Frebold. Poulton and Callomon, 1976, Fig. 61.3; Poulton, 1978, Fig. 2.

Material and occurrence. Many specimens, including two nearly complete ones (figured specimens GSC 68402, 68405) from GSC locality 92544 (Bed 68c) and possibly others from GSC locality 92467, presumably derived from Bed 68c; 15 specimens (including figured specimens GSC 68401, 68403, 68404, and 68406) from GSC locality C-95367 (Bed 68c); many poorly preserved specimens from GSC locality C-95384 (Bed 68a). *Bodylevskyi* Zone. Other specimens occur loose below the section, although their fragile character makes them rare and fragmentary.

Description. The collection from GSC locality C-95367 contains a few, large, relatively globose specimens that are most similar to the specimens from GSC locality 92544, which are more typical species. These are described first below. Others are smooth and apparently adult at a much smaller diameter, and more compressed. Still other specimens are intermediate in size, at what probably is their adult stage, judging by the extent of their last (smooth) growth stage. One large specimen has relatively compressed inner whorls. All these specimens from a single bed are therefore taken to represent a single, widely variable species.

The shell of the large specimens is ribbed to a diameter of about 77 mm, the ribs fading out gradually over the space of a whorl length. This occurs near the beginning of the body chamber of the adult shell. The primary ribs, on the upper part of the umbilical wall, are straight, and essentially radial. Each primary rib bifurcates at a node at the umbilical margin, and there is some intercalation of secondaries. The first half of the body chamber is smooth except for the umbilical nodes, which continue to the aperture.

The secondaries are inclined very slightly forward but pass over the venter without projection. Fine, distinct, secondary ribbing and coarsely spaced but weak and irregularly spaced corrugation appear on the oralmost half of the body whorl. The body chamber appears to be a full whorl in length.

The umbilicus is deep and conical. The whorls embrace each other more strongly in the last growth stages and the umbilical walls of the outer whorl are nearly perpendicular.

The cross-section is wider than high at all growth stages seen, i.e. at whorl heights greater than 18 mm. There is considerable variation in the degree of arching (compare figures 1 and 5 of Plate 28).

The suture line cannot be traced in any of the specimens available.

Two of the loose specimens from GSC locality 92467, although probably derived from Bed 68c, have a more open umbilicus, which retains its width in the last whorls seen.

One extreme specimen (Pl. 27, figs. 2, 3) becomes smooth, except for umbilical nodes, at a whorl height of about 3 cm, corresponding to a diameter of about 6 cm. The ribs are essentially as described above. Irregular corrugations appear near the adoral end of the specimen, the last of which is most pronounced and may possibly represent an apertural constriction. However, the specimen is not entire and the end of septae cannot be seen, so that there may have been more body chamber than is now preserved. It is taken to be adult because of the extensive smooth part. It is quite strongly arched, compared to the specimens described above.

Another specimen (Pl. 28, figs. 3-5) becomes smooth at a somewhat larger growth stage and shows a considerable decrease in arching in the last part preserved. Still another (Pl. 28, figs. 1, 2) remains ribbed to a similar, relatively large growth stage, but remains strongly arched. There is, additionally, some variation in the degree of arching from one growth stage to another within individual specimens. All these co-occurring forms are thus intermediate between the two extemes – the large and depressed forms (Pl. 27, figs. 4-6), and the small, more strongly arched forms (Pl. 27, figs. 2, 3). Therefore, they are all taken to represent one species. The presence of so many intermediate forms would suggest that wide morphological variation, rather than sexual dimorphism, is the case.

Discussion. The species conforms with *C. bodylevskyi* Frebold (1964, Pl. XVII) from Axel Heiberg Island, in its cross-section, persistence of ribbing, extreme steepening of umbilical walls in the last growth stages of the large specimens, and the show of umbilical nodes in the early whorls in the umbilicus. The ribs are weaker in the present specimens, however, and those from GSC locality 92467 have a wider umbilicus in the last growth stages.

Of other Canadian species described, this species is very close to *C. septentrionale* Frebold (1964). However, ribbing persists further on the large specimens, and the umbilical margin is sharper than in *C. septentrionale*. The umbilical nodes are stronger on the body whorl.

The strong umbilical nodes separate this species from *C. voronetsae* Frebold (1964), as well as from *C. sublaeve* Sowerby, and *C. emelianzevi* Voronetz.

Cadoceras arcticum Frebold (1964) has more gently sloping umbilical walls, and less pronounced umbilical nodes in large growth stages.

Cadoceras elatmae (Nikitin, 1881, p. 116, Pl. XI(IV), figs. 20-23; Voronetz, 1962, Pl. XII, fig. 1a, b; Pl. XXVI, fig. 1a, b; Meledina, 1977, p. 70, Pl. 13; Pl. 14, fig. 1; Pl. 15, fig. 2; Pl. 16, fig. 1; Pl. 17, fig. 1; Pl. 20, fig. 1) from Russia, which is probably of about the same age as *C. bodylevskyi* of northern Yukon, judging by its stratigraphic relation in Siberia (see, for example, Meledina, 1977), is similar, but has a wider umbilicus.

Genus *Paracadoceras* Crickmay, 1930

The type specimen, *P. harveyi* Crickmay, is poorly preserved and is hardly sufficient for a generic diagnosis (see also Callomon, 1984). Its status must remain uncertain until better topotypic material is available. However, certain material from around the Arctic has a characteristic morphology and the name has been widely applied to these distinctive forms. They are moderately evolute and compressed in the juvenile stages but somewhat inflated, and still relatively evolute in intermediate and late growth stages. The juvenile is strongly ribbed, the ribs gradually fading on the ventral parts first, and the body chamber is smooth. The adult, and the stage at which ribbing fades, is small. The strong difference in ribbing character and whorl cross-section separates the northern Yukon specimens from those of more typical *Cadoceras*, represented by *C. sublaeve* (Sowerby).

Paracadoceras is sparsely represented at Salmon Cache Canyon.

Paracadoceras sp.

Plate 29, figures 1-6

Material and occurrence. Two fragmentary specimens (figured specimens GSC 68407, 68408) found loose in a boulder (GSC loc. 92561) together with *Cadoceras barnstoni* (Meek)(?) and *Phylloceras billingsi* (Meek), indicating derivation from Bed 62; one specimen (figured specimen GSC 68409) found loose together with *Phylloceras billingsi* (GSC loc. C-95372). *Barnstoni* Zone.

Description. Part of an intermediate whorl about 2 to 2.3 cm high is seen on one fragment (Pl. 29, fig. 6). It has strong, prorsiradiate ribs. Most of them bifurcate about halfway up the flank, where the primary ribs are slightly swollen; some ribs are undivided. The ribs are fine, stand high, and are swollen into bullae low on the flank. The flank and venter appear to be smoothly rounded; the umbilical edge cannot be seen.

The outer, nonseptate whorl of the same specimen (Pl. 29, fig. 5) is smooth except for short, swollen, prorsiradiate primaries, and very weak suggestions of secondaries over the venter (internal mould only). The cross-section is high, smoothly rounded with slightly flattened ribs, and has a fairly abrupt umbilical edge. The umbilical wall is high, smooth, and steep to vertical.

An associated fragment (Pl. 29, figs. 3, 4) is similar but is more depressed, and has a spiral swelling along the locus where the primaries disappear ventrally. Both these characters may be due to tectonic distortion. The suture line is shown in Figure 19. The first lateral saddle is deeply and somewhat asymmetrically dissected, as in *Cadoceras barnstoni* (Meek).

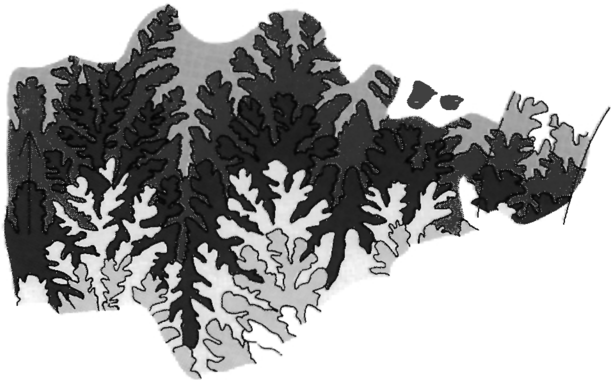

***Figure 19.** Septal suture pattern of **Paracadoceras** sp.; figured specimen GSC 68408, from GSC locality 92561; whorl height 2.9 cm.*

One other fragment (Pl. 29, figs. 1, 2) has swollen primaries and weak secondaries that are nearly effaced over the venter. The umbilical edge is abruptly rounded, the umbilical wall steep or vertical and high.

Genus et species indet. A

Plate 32, figures 2, 3

Material and occurrence. One incomplete and poorly preserved specimen (figured specimen GSC 68367) from GSC locality C-95364 (Bed 48).

Description. At a whorl height of about 1.5 cm, the shell has fine, finely spaced, smoothly forward-curved ribs that bifurcate regularly one third to one half of the way up the flank and which pass over the venter with considerable forward projection. Smaller growth stages cannot be seen.

The shell gradually becomes smooth at a whorl height of about 2.5 cm. The shell is still septate at this stage. No body chamber is preserved.

The cross-section is compressed and markedly acuminate, widest around the umbilical edge. The umbilicus is small, steep-sided, with a rounded but relatively abrupt edge.

Discussion. The forward projection of the ribs, acuminate venter, and strongly compressed cross-section, ally this form with slightly younger *Arcticoceras*. The fine ribbing, its orientation, and the shell shape are all closely similar to inner whorls of specimens from Svalbard identified as *Arcticoceras harlandi* Rawson (1982). That species occurs at Salmon Cache Canyon above the present specimen, which is not sufficiently well preserved to identify precisely, although the two are clearly closely related. This may well be the inner whorls of associated *A.*(?) sp. E or another closely related species. *Parachondroceras* Imlay (1967) is also similar, but the single, poorly preserved specimen does not warrant detailed comparison with this significantly older genus.

Family KOSMOCERATIDAE Haug, 1887

The family is represented by a few specimens of several different morphotypes of *Kepplerites*.

Subfamily GOWERICERATINAE Buckman, 1926

Genus *Kepplerites* Neumayr and Uhlig, 1892

Kepplerites and closely similar genera of the family Kosmoceratidae have been described from Late Bathonian and Callovian deposits of northwest Europe, Spitzbergen, the Trans-Caucasus area and North America, with spotty occurrences elsewhere. An extensive literature exists concerning the succession and relationships of *Kepplerites* and related forms, much of which is summarized by Spath (1932) and Arkell et al. (1957).

Spath (1932, p. 81) outlined a succession of three different assemblages of *Kepplerites* in Northwest Europe. The differences in degree and position of tuberculation of the young growth stage, and the degree to which a runcinate venter persists (as recorded by Spath), do not appear to hold well in the Boreal succession in East Greenland, where they are best known. Some of them were described earlier by Ravn (1911), Sokolov and Bodylevsky (1931), Spath (1932), Donovan (1953), and others in some detail. The criteria for specific differentiation include the degree and persistence of tuberculation and runcination of the venter, the degree of inflation, the coarseness and density of ribbing, and the size. The present material is neither sufficiently abundant nor well enough preserved to contribute significantly to the knowledge of the biostratigraphy or affinities of *Kepplerites*.

Kepplerites sp. aff. *K. rosenkrantzi* Spath

Plate 30, figures 1-10, 16

aff. *Kepplerites rosenkrantzi* Spath, 1932

Material and occurrence. Two well preserved but fragmentary specimens (figured specimens GSC 68422, 68423) from GSC locality 92543 (Bed 62), one (figured specimen GSC 68420) from GSC locality C-86389, and three (including figured specimens GSC 68419 and 68421) from GSC locality 92551 (loose below section). Associated ammonites in Bed 62 include *Cadoceras barnstoni* (*barnstoni* Zone). The lithology and fossil content of the matrix associated with the best preserved loose specimens (GSC loc. 92551) indicate this bed to be the source.

Description. The best specimen collected in place in Bed 62 has reasonably well preserved juvenile whorls (Pl. 30, figs. 8-10). From a whorl height of 5 mm (diameter about 14 mm) up to a whorl height of 11 mm (diameter about 24 mm) there is a lateral row of strong nodes slightly below halfway up the flank, which are loci of bifurcation of the ribs. Two rows of weaker nodes lie along the juncture of the flat venter and the flanks. The primary ribs are inclined gently forward, and the secondaries are nearly rectiradiate. The ribbing is relatively coarse.

At a whorl height of 13 mm, the umbilical wall becomes steeper, and the lateral nodes at the points of bifurcation are low on the flank. At larger growth stages, this characteristic is further developed, so that the umbilicus is deep.

The small whorls are about as high as they are wide and are nearly circular in cross-section, except for the flat venter. The umbilical wall becomes steeper with growth, and the lower part of the cross-section of the larger shell is subquadrate; the ventral part is unknown. Overlap of whorls is along the line of lateral nodes, and coiling becomes increasingly involute with growth.

Another specimen from GSC locality 92543 (Pl. 30, fig. 16) has strong ventrolateral nodes at a small growth stage. One found loose (Pl. 30, figs. 4, 5) has weakly developed lateral nodes at a whorl height of 3.5 cm (this may be due to abrasion), and flatter flanks than the other specimens, imparting an even more subquadrate cross-section.

The best specimen comes from talus below the section (Pl. 30, figs. 1-3). The description above applies except for the following few differences. Even at growth stages below a whorl height of 9 mm, the primaries and secondaries are both inclined forward more strongly. They are finer and more closely spaced. The lateral nodes are weaker. The specimen is septate to a whorl height of 38 mm. The suture pattern, at a whorl height of 3.2 cm, is shown in Figure 20.

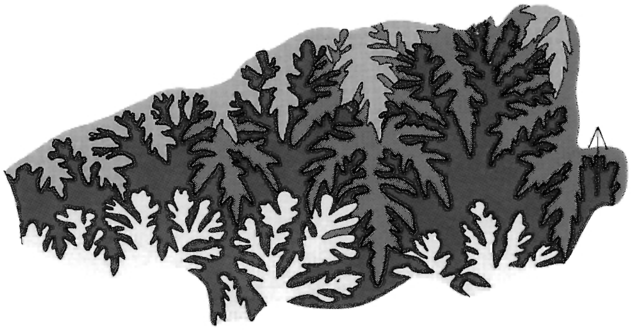

***Figure 20.** Septal suture pattern of **Kepplerites** sp. aff. K. **rosenkrantzi** Spath; figured specimen GSC 68419, from GSC locality 92551; whorl height 3.2 cm.*

Another small specimen found loose (Pl. 30, figs. 6, 7) shows the strong lateral and double ventral row of nodes in the juvenile stage, and the close spacing of the two ventral rows. Because the lateral row of nodes is strongly developed and lies high on the flank, the cross-section is much wider than high at a diameter of about 11 cm.

Discussion. Although all the species of the East Greenland succession are not yet described, and the specimens present in the Porcupine River section are not complete, they seem to conform best with Spath's (1932, p. 89, 90) description of *K. rosenkrantzi*. The characters in common, which also distinguish these specimens from other described species, include the well developed lateral row of tubercles and the runcinate venter in the early stages, and the relatively low, more rounded, somewhat inflated cross-section of the adult, as illustrated by Spath (1932, Pl. XXVI, fig. 1). The northern Yukon specimens differ from the East Greenland ones, however, in the slightly greater size to which the runcinate venter persists, and in the correspondingly somewhat steeper flanks and steeper umbilical wall of the intermediate whorls. The secondary ribs of the young growth stage in the northern Yukon specimens differ from those of most other described species in that there are twice as many of them as there are primaries, and in their coarse spacing. However, the early stages of most described *Kepplerites* have not been figured by previous workers, so a detailed comparison cannot be made. The early stage of *Toricellites approximatus* Buckman (1933, Pl. CCCXXXVI) are very similar to those of the northern Yukon specimens, although the runcinate venter does not persist to as large a size and the adult shell differs in the style of coiling, ribbing, and cross-section.

Kepplerites sp. A

Plate 30, figures 11-15

Material and occurrence. One fragmentary specimen (figured specimen GSC 68424) collected loose below the section (GSC loc. 92473). The lithology suggests its probable origin in Bed 62 (*barnstoni* Zone).

Discussion. The specimen is not sufficiently well preserved to identify or describe in detail. The ribbing at the intermediate and in the largest (nonseptate) growth stage is coarser than in *Kepplerites* sp. aff. *K. rosenkrantzi* described above, or in any other species described by Spath (1932) from East Greenland. Additionally, the cross-section is lower, and is smoothly rounded, not subquadrate.

Kepplerites sp. B

Plate 30, figures 17-21

Material and occurrence. One small fragment (figured specimen GSC 68425) from GSC locality 92543 (Bed 62) and another (figured specimen GSC 68426) found loose below the section (GSC loc. C-95372). The former is in the *barnstoni* Zone, and the latter may well have been derived from there also.

Discussion. The material is not sufficient to describe in detail. The inner whorl of the smaller fragment found in place (Pl. 30, figs. 17-19) is runcinate with incipient ventrolateral tubercles. The larger, still septate growth stage of the same specimen is similar to *K.* sp. aff. *K. rosenkrantzi*, but has a more rounded, apparently lower cross-section. The secondaries trifurcate finely at the still-strong lateral nodes, and there are a few additional intercalated secondaries.

The larger, loose fragment (Pl. 30, figs. 20, 21) shows an intermediate growth stage and part of the large body chamber. Both are subcircular in cross-section, the flanks merging smoothly with venter and umbilical wall, separating it from the other species of *Kepplerites* described here. The fine ribbing distinguishes it from *K.* sp. A. The body chamber becomes slightly contracted and the ribs sweep forward strongly near the preserved apertural end, indicating proximity to the aperture.

Kepplerites(?) sp. C

Plate 31, figures 8-10

Material and occurrence. One moderately well preserved specimen (figured specimen GSC 68430) found loose below the section (GSC loc. C-95372), in a matrix that indicates its derivation from the *ishmae* or *barnstoni*, or possibly even the *frami* or *harlandi* Zones.

Description. The smallest whorls that can be seen clearly are 2 cm high. Although they have been tectonically distorted, they appear to be flat-sided, significantly higher than wide, and with a venter that is smoothly rounded and not acuminate. The umbilicus is relatively wide, about 1 cm, with steep walls and an abruptly rounded edge. The primary ribs are closely spaced, and subdivided into many very fine secondaries near the umbilical edge, along a locus of small and weak, pointed tubercles. The secondaries, about three to each primary, sweep forward from the points of furcation, and then become nearly radial over the ventral half of the flank.

At a whorl height of about 2.9 cm, primaries are very short – almost absent – so that fine, closely spaced secondaries comprise nearly the entire ornamentation. Their orientation and curvature have been distorted tectonically. The cross-section is flat-sided, higher than wide, with an evenly rounded venter.

The last septum occurs at a whorl height of 4.4 cm. The cross-section is as described above. The umbilicus is about 1.5 cm wide, vertically walled, with a rounded edge, and perhaps shows a slight tendency to extra-umbilication. Well defined, fine ribs persist to the last preserved part, about one quarter of a whorl beyond the last septum. Finely spaced primary ribs occupy the lower sixth of the flank, tapering onto the umbilical wall and curving adorally as they pass over the umbilical edge. They subdivide there into much more numerous secondaries. The suture pattern is shown in Figure 21.

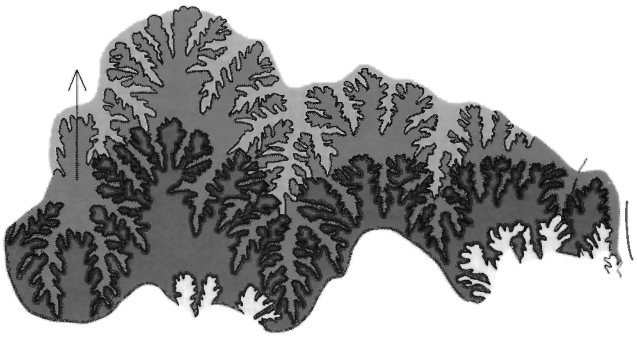

Figure 21. *Septal suture pattern of* ***Kepplerites(?)*** *sp. C, showing last and penultimate septae; figured specimen GSC 68430, from GSC locality C-95372; whorl height 4.3 cm.*

Discussion. The cross-section and relatively small umbilicus differentiate this specimen from other *Kepplerites* species described here. *Kepplerites*(?) sp. D is similar and may represent the same species (see below).

Kepplerites(?) sp. D

Plate 23, figures 9, 10; Plate 32, figure 1

Material and occurrence. One poorly preserved adult specimen (figured specimen GSC 68366) from GSC locality 92540, from Bed 60. *Ishmae* Zone.

Description. The small growth stages of the specimen are poorly preserved. At an intermediate growth stage (whorl height about 40 mm), the ribs are clearly differentiated into primary ribs on the lower half of the flank, passing into very fine secondaries on the upper half (Pl. 23, fig. 10). The primaries are strong on the test surface, but almost imperceptible on the internal mould. The ribs are somewhat sigmoidal, their upper parts being nearly rectiradiate so that they presumably pass more or less straight over the venter. Ribs, at least on the venter, persist to the last growth stage seen (Pl. 23, fig. 9; Pl. 32, fig. 1). The flanks are gently concave; the ventral and umbilical edges both smoothly rounded. The cross-section is somewhat compressed. The venter is smoothly rounded. The shell appears to be strongly involute. No sutures could be traced.

Discussion. The species resembles *Kepplerites*(?) sp. C in the general shape of the shell, the small umbilicus, and the shape and character of the ribs. It is not sufficiently well preserved to compare precisely, however. Its involute coiling and fine, thread-like ribbing, in some ways similar to that of *Phylloceras*, renders its generic assignment questionable.

Family SPHAEROCERATIDAE Buckman, 1920

Subfamily EURYCEPHALITINAE Thierry, 1976

The subfamily was transferred to family Sphaeroceratidae, and its derivation and that of subfamily Macrocephalitinae from Sphaeroceratinae was shown by Callomon (in Donovan et al., 1980). This is a circum-Pacific group that also reached northern Yukon, where it is represented by several specimens of *Iniskinites* and *Loucheuxia*, described below.

Species previously referred to *Macrocephalites* in western South and North America, and Arctic North America and Eurasia, are now assigned instead to other genera [family Cardioceratidae for the northern group, comprising *Arctocephalites*, *Arcticoceras*, and *Cadoceras*; and *Eurycephalites* for the eastern Pacific group (Hillebrandt, 1970; Thierry, 1976, 1978; Westermann, 1980)]. *Macrocephalites* is no longer thought to be represented in the Americas. Several western North American genera – *Lilloettia* Crickmay, *Buckmaniceras* Crickmay, and *Warrenoceras* Frebold – are assigned to *Eurycephalites* also, some by Westermann (1980), others by the present writer. The characteristic evanescent ribbing beginning around the umbilicus and spreading gradually ventrally is also seen on somewhat older *Morrisiceras* and *Megasphaeroceras*. Callomon in Donovan (1981) suggested that the former is only homeomorphically similar and that the latter is the earliest member of the subfamily. This character is lacking in the two genera (*Iniskinites* and *Loucheuxia*), described here, making them more similar to both ancestral Sphaeroceratinae and younger Macrocephalitinae, to which they could equally well be assigned on the basis of their morphology. The subfamily distinctions are arbitrary (Callomon in Donovan et al., 1981), and are partly based on stratigraphic and paleobiogeographic considerations.

Genus *Iniskinites* Imlay, 1975

Iniskinites was named (Imlay, 1975) to include many southern Alaskan ammonites, mainly inflated and finely ribbed, that had previously (Imlay, 1953b) been described as *Kheraiceras* Spath. Thus, the tulitid genus is no longer recognized in North America. *Iniskinites* has now been reported from southern Alaska (Imlay, 1953, 1975, 1980), central and western British Columbia (Tipper and Richards, 1976; Frebold, 1978, 1979), Oregon (Imlay, 1981), and northern Yukon (Frebold, 1978; this report). The similarity of the juvenile shells with Sphaeroceratidae or Tulitidae presents a striking contrast to the resemblance of the adult to *Cranocephalites*.

The presence of *Iniskinites* at Salmon Cache Canyon suggests that it may have potential for correlation of the Boreal and Pacific faunal successions. However, the genus is apparently long ranging in the northeast Pacific region, and the biostratigraphic restrictions of individual species are not yet well known.

Iniskinites yukonensis Frebold

Iniskinites yukonensis Frebold, 1978, p. 6, Pl. 9, figs. 1-3.

A single, entire specimen (holotype GSC 54757) found loose below the section (GSC loc. C-27140) was described by Frebold (1978). The inner whorls are not visible, so that detailed comparison with other juvenile specimens described here is not possible. The specimen was assumed to have come from the *barnstoni* Zone.

Iniskinites spp.

Plate 29, figures 7-19; Plate 31, figures 1-7

aff. *Scaphites ventricosus* McConnell, 1891, p. 123D.
Ammonites sp. indet. Frebold, 1961, p. 6, Pl. II, fig. 3.

Material and occurrence. Small and poorly preserved (unfigured) specimens of *Iniskinites* occur in Bed 62 (GSC loc. 92543), and the genus may be represented by undeterminable fragments as low in the section as Bed 22 (GSC loc. 92525). Several juvenile specimens occur loose below the section, in yellow-weathering concretions that clearly come from Bed 62 (including figured specimens GSC 68410 from GSC loc. 92551, GSC 68411 from GSC loc. 92561; GSC 68412 and 68416 from GSC loc. C-95369; GSC 68413 and 68414 found together from GSC loc. 92473; GSC 68415 from GSC loc. C-95370); one fragment of a large specimen found loose can be traced by its lithology to Bed 62 (figured specimen GSC 68427 from GSC loc. 92473); and two other figured specimens (GSC 68428 from GSC loc. 92554 and GSC 68429 from GSC loc. C-95372) by their lithology and associated faunas, to Bed 60. The stratigraphic position of the specimen (figured specimen GSC 15137 from GSC loc. 37917) mentioned by McConnell (1891) and described by Frebold (1961) is not known.

One globose specimen, with a maximum preserved diameter of 4 cm, is entirely septate (Pl. 29, figs. 16, 17). The ribs are fine, subdividing along the locus of the maximum width of the shell, about one third of the height of the whorl. The shell appears to begin to flare rapidly, and the primary ribs become stronger and more coarsely spaced in the oralmost part of the specimen. The suture line is shown in Figure 22. Another specimen is closely similar in the style and strength of ribbing and the coiling and cross-section (Pl. 29, figs. 9, 10). Its suture line is shown in Figure 23.

One fragment (Pl. 29, figs. 11, 12) is broader at the same whorl height, and maintains fine, primary ribbing to a larger growth stage. The fine ribbing and broad cross-section are also seen in another, similar fragment (Pl. 29, figs. 7, 8).

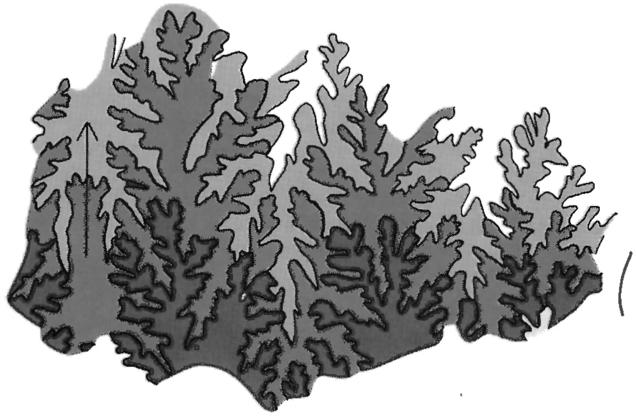

Figure 22. *Septal suture pattern of* ***Iniskinites*** *sp.; figured specimen GSC 68415, from GSC locality C-95370; whorl height 1.7 cm. Due to extreme approximation, all the sutures cannot be traced satisfactorily; the shaded portion is thought to reflect the actual suture pattern reasonably well.*

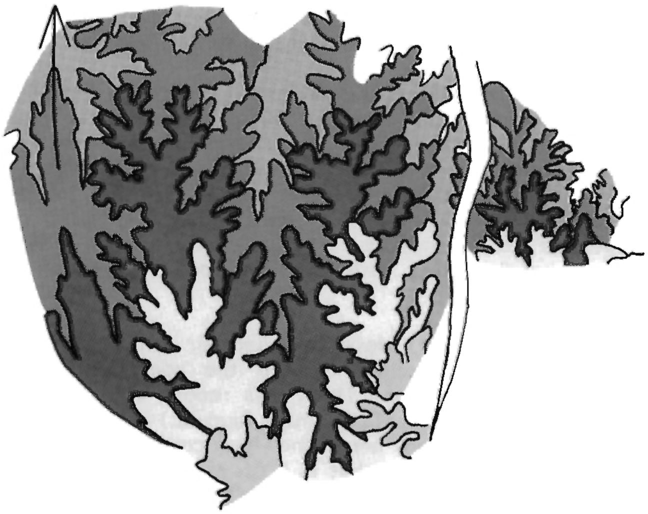

Figure 23. *Septal suture pattern of* ***Iniskinites*** *sp.; figured specimen GSC 68411, from GSC locality 92561; whorl height 2 cm.*

A smaller specimen (Pl. 29, figs. 13, 14) is similar in cross-section, whorl shape, and general orientation of the ribs. The ribbing is equally fine to a whorl height of about 8 mm, but then becomes significantly coarser than in the previously described specimens. Each of the coarse, primary ribs bifurcate along a locus about halfway up the flank and there are a few intercalated secondaries. Although the aperture is somewhat crushed, there appears to be some modification of the last 3 or 4 mm, suggesting that the specimen is a microconch dimorph. This portion is contracted, there is no terminal flare but rather a smooth hood, weakly projected at the ventrolateral positions. Ribbing here is weakened slightly and a bit more finely spaced than on immediately earlier parts of the shell. One other smaller specimen (Pl. 29, fig. 15) from the same block of rock becomes more coarsely ribbed at about the same growth stage.

Two small fragments exhibit very fine ribbing on an interior whorl (not figured), and significantly coarser ribbing on the outer, nonseptate whorl (Pl. 29, figs. 18, 19). This difference in the strength of ribbing differentiates the specimen from those described above. There is a slight forward slope to the ribs, accompanied by a slight adapical deviation along the venter. The cross-section is low, and smoothly rounded.

A fragment of a large ammonite, probably from the *barnstoni* Zone (Pl. 31, figs. 1-3), comprises part of the body whorl, and the external mould of part of the preceding whorl is preserved. This earlier whorl has a ventral portion that is broadly rounded. It is finely and regularly ribbed. The ribs are nearly straight but pass over the venter with a very slight deviation in the adapical direction.

The body whorl is coarsely ribbed. The ribs are inclined slightly orally and pass straight over the venter. Some are slightly weakened along a line along the venter. Some ribs bifurcate. The specimen may include an apertural constriction and slight weakening of the ribs near it, although this cannot be seen clearly.

The two small fragments of large specimens that probably come from the *ishmae* Zone are preserved in a dense, ferruginous matrix. One (Pl. 31, figs. 4, 5) comprises the apertural part of a large body chamber with the apertural constriction preserved on the umbilical part of the flank. The cross-section is evenly rounded, with flattened flanks, and appears to be widest near the umbilicus. The height is at least 6.5 cm, the width about 6 to 6.5 cm. Strong, subradial, regularly bifurcating ribs are present. They are slightly strengthened and projected over the venter.

The other, nonseptate fragment is strongly ribbed. The ribs are nearly radial, slightly sinuous, and bifurcate regularly about halfway up the flank. They pass over the venter without deflection. The cross-section is subquadrate, with flattened flanks and venter. The greatest width is low on the flanks, which slope toward each other ventrally. This specimen has similarities to both *Kepplerites* and *Iniskinites*, but is not identical with any described species of either genus.

Frebold (1961) described another small, specifically undeterminable specimen. Like the specimen shown in Plate 29, figures 13 and 14 of this report, it exhibits weak ventrolateral lappets. R.W. Imlay (unpubl.) has examined the specimens described here and has compared them with several named species, that is *I.* cf. *magniformis* (Imlay), cf. *varicostatus* (Imlay) and cf. *martini* (Imlay).

Genus *Loucheuxia* n. gen.

Loucheuxia is erected to accommodate more than 12 specimens assigned to the type species *L. bartletti* n. sp., or to *L.*(?) spp. indet. Although the genus is known certainly only at the Salmon Cache Canyon section, some species from the Western Cordillera of Canada and Oregon, currently assigned to *Iniskinites*, may represent *Loucheuxia* instead. They have more compressed cross-sections than other *Iniskinites* species and a different, sinuous curvature of the ribs. These species include *Iniskinites acuticostatus* Imlay (1981), *I. tenasensis* Frebold (1981) and perhaps *I. robustus* Frebold (1978). In addition to the differences listed above, *Loucheuxia* has a more open umbilicus than *Iniskinites* and a greater tendency to flat flanks. Additionally, based on the criteria noted above, *Arctocephalites*(?) *multicostatus* Frebold, from the Canadian Western Cordillera, may belong to *Loucheuxia*.

The character of the ribbing and general shell shape of *Loucheuxia* are close to those of western North American species assigned now to *Eurycephalites* (Spath, 1928) (i.e. *Lilloettia* Crickmay, 1930). However, the loss of ribs early in the ontogeny, beginning first around the umbilicus and gradually spreading ventrally, together with the convergent flanks in mature specimens of compressed species, distinguish *Eurycephalites*. The shell of *Loucheuxia* remains strongly ribbed, at least onto the early part of the adult body chamber, and the venter is broader, with subparallel, convex flanks. Only the early part of the body chamber is known, and the mouth border is totally unknown. Additionally, the primary ribs of *Loucheuxia* are not as strongly outnumbered by secondaries as they are in *Eurycephalites*. The variation in the degree of compression and coarseness of ribs described in Canadian *Eurycephalites* (i.e. *Lilloettia*; see Frebold in Frebold and Tipper, 1967) is also seen in *Loucheuxia*. The same differences separate *Loucheuxia* from South American species of *Eurycephalites*.

Some of the specimens assigned to *Loucheuxia* resemble species of *Macrocephalites* in their cross-sections and coiling characteristics. Unlike any *Macrocephalites* species, however, the ribbing of *Loucheuxia* becomes extremely coarse in the largest growth stage. The characteristic falcoid ribbing found in *Loucheuxia* is less well developed in *Macrocephalites*.

The North Pacific genus *Umaltites* Sei and Kalacheva (1979) was erected for specimens previously assigned to *Cranocephalites* or *Arctocephalites*, which are small when adult and have a smooth body chamber that is shorter than that of *Arctocephalites*. Sei and Kalacheva (1979) thought it to be transitional between Arctocephalitinae and Macrocephalitidae. The ribbed portion of the shell is very similar to the small growth stages of *Loucheuxia*, but the much smaller size and probably significantly older age of *Umaltites* differentiate the two.

Name. For the Loucheux Group of Athapaskan Indians who inhabit the northern Yukon and upper Mackenzie Delta area.

Loucheuxia bartletti n. sp.

Plate 32, figures 6-9; Plate 33, figures 1-10;
Plate 34, figures 1-6, 10-19

Material and occurrence. All the specimens were found loose below the section in concretions that also contain other ammonites, or that by their dense, ferruginous lithology, indicate their source as the *ishmae* Zone (e.g. paratype GSC 68370 from GSC loc. 92554; paratypes GSC 68371, 68375, and 68380 from GSC loc. 92552; paratype GSC 68374 from GSC loc. C-95374; holotype GSC 68369 and paratype 68372 from GSC loc. C-95372), the *barnstoni* Zone (paratype GSC 68373 from GSC loc. 92473x) or either the *ishmae* or the *barnstoni* Zone (paratypes GSC 68377 and 68381 from GSC loc. C-95375).

Description. The specimens available indicate considerable morphological variation, principally in the coarsening of ribbing and the degree of inflation. Natural subdivisions are not readily apparent however, unless the most coarsely ribbed specimen (Pl. 33, figs. 1-4) is considered to be different from the others because of that single character.

The holotype (Pl. 32, figs. 6, 7) is the largest of several, apparently identical specimens, with a maximum diameter of about 11 cm, whorl height of 6 cm, and width of about 5.5 cm. It is entirely or nearly entirely septate. The inner whorls cannot be seen.

The shell is moderately inflated, with gently rounded flanks, merging smoothly with the rounded venter and umbilical edge. The umbilicus is small, deep, and steep-walled. The maximum width is about one third to two fifths the height of the whorl.

The entire shell bears finely spaced, strongly developed, gently falcoid ribs. Their apparent adoral weakening may be due to poor preservation. The ribs are nearly radial near the umbilicus, curve forward on the lower part of the flank, and are again radial on the upper part of the flank, passing straight and equally strongly across the venter. The ribs bifurcate regularly about halfway up the flank.

The above description applies perfectly well to several other stout specimens (e.g. Pl. 33, figs. 5, 6, 9, 10; Pl. 34, figs. 18, 19) on which the ribs can be seen to taper down as tiny threads onto the umbilical wall.

A small (unfigured) specimen in the same piece of rock as the holotype is similar but is somewhat more coarsely ribbed, resembling the inner whorls of the specimen shown in Plate 33 (figs. 1-4), and thus documenting the co-occurrence of the more coarsely and finely ribbed morphotypes. The same situation is demonstrated by the co-occurrence in a single, concretionary boulder, of a specimen (Pl. 34, figs. 2-6) that is not different in any significant way from the holotype; a fragment that is compressed, has flattened flanks, and a more abrupt umbilical edge than the others (Pl. 34, figs. 15-17); and another, large specimen (Pl. 33, figs. 1-4) that has inflated, particularly coarsely ribbed inner whorls. This last, large specimen is still strongly ribbed on the largest preserved growth stage (whorl height approx. 6.5 cm; diameter about 11.5 cm), nearly one quarter of a whorl length beyond the last septum.

The flattened flanks and high, compressed cross-section of the smaller of those specimens is also seen on another, more coarsely ribbed specimen (Pl. 33, figs. 7, 8).

The suture line of the species is shown in figures 24 and 25.

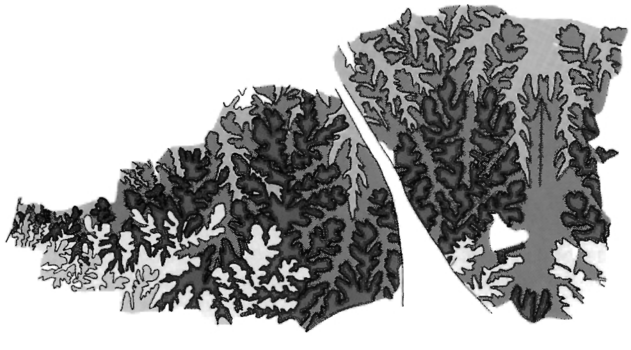

*Figure 24. Septal suture pattern of **Loucheuxia bartletti** n. sp.; paratype GSC 68375, from GSC locality 92552; whorl height 4.3 cm.*

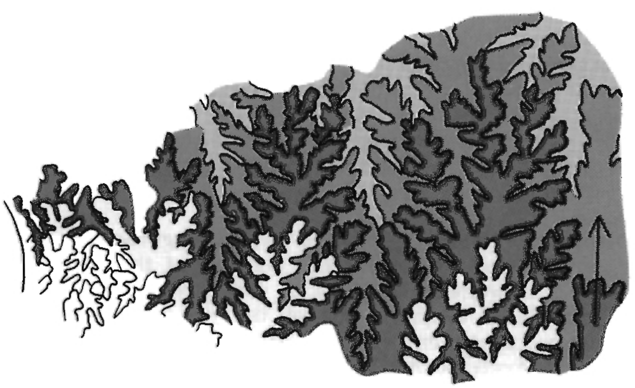

*Figure 25. Septal suture pattern of **Loucheuxia bartletti** n. sp.; paratype GSC 68381, from GSC locality C-95375; whorl height 2.7 cm.*

Discussion. The juvenile whorls, particularly in the falcoid curvature of the ribbing, resemble some species of *Arctocephalites*, particularly *A. spathi* n. sp., but the larger growth stages are readily distinguished by their size and the size at which the phragmocone terminates.

Name. For Captain "Bob" Bartlett, the seaman who commanded ships for Peary in his polar explorations off northern Greenland, as well as for Stefansson in his explorations of the northwest coast of Canada.

Loucheuxia(?) spp.

Plate 32, figures 4, 5; Plate 34, figures 7-9, 11-14

Material and occurrence. Four fragments found loose below the section in concretions whose other ammonites and lithologies indicate the probable source as Bed 62 (*barnstoni* Zone): figured specimens GSC 68368 and 68376, from GSC localities C-95381 and 92553 respectively, and GSC 68378 and 68379 together from GSC locality C-95383.

Description. One fragment (Pl. 32, figs. 4, 5) has a maximum whorl height of 4.7 cm and a width of 4.2 cm. The cross-section tends to be slightly acuminate, with flanks converging ventrally from a maximum width at about one third of the height of the flanks. The umbilicus is small with a rounded edge, and steep, or perhaps vertical, walls. The relatively finely spaced primary ribs taper onto the umbilical wall, are gently inclined forward, and subdivide, at about one third of the height of the flank. There is slight strengthening at the point of subdivision. The secondaries, about three or four to each primary, are straight, very gently inclined forward, and are strong, maintaining or perhaps slightly increasing their strength as they pass straight over the venter.

The shell of another specimen is highly involute, with a small, deep umbilicus, steep umbilical walls and a moderately sharp umbilical edge. It is strongly ribbed, and septate to the maximum whorl height preserved, 3.7 cm. These largest preserved whorls are moderately inflated, with a smooth, rounded profile except for the relatively sharp umbilical edge.

The ribs are nearly straight, inclined strongly forward. They are strong but relatively closely spaced, and bifurcate apparently fairly regularly, just below halfway up the whorl flank. They pass over the venter without projection.

The other two specimens (Pl. 34, figs. 11-14) have only slightly falcoid ribs and smoothly rounded cross-sections.

Discussion. These specimens have straighter ribs than any other assigned to *Loucheuxia*, and two of the specimens are more acuminate than most of the others. A very slight suggestion of strengthening of the ribs over the venter of these two specimens may indicate that they represent a late form of *Arcticoceras*, but the ribs are not projected. The ribs on the venter of an inner whorl are particularly strong, as in *Arcticoceras*, and one of the specimens (Pl. 34, figs. 7-9) cannot be distinguished from those fragments figured by Spath (1932, p. 55) as finely ribbed variants of *Arcticoceras ishmae*, var. *pseudolamberti*.

Family STEPHANOCERATIDAE Neumayr, 1875

Subfamily CADOMITINAE Westermann, 1956

Genus *Cadomites* Munier-Chalmas, 1892

Two specimens from northern Yukon are assigned to this genus although they have somewhat more depressed whorl sections than previously described species. Although those specimens bear some resemblance to *Kepplerites* and might be considered as early forms of the genus, their early whorls, poorly preserved and not figured here, are different from advanced (typical) *Kepplerites*. At a whorl height of 9 mm (diameter about 27 mm), the cross-section of one specimen (Pl. 29, figs. 20-23) appears to be broad and depressed, unlike the typical high, runcinate, juvenile whorls of *Kepplerites*. The low, rounded cross-section and coiling of the adult are also closer to *Cadomites*. Thus, the specimens described here are the first known *Cadomites* from the Boreal Realm.

Cadomites is widespread outside boreal regions and ranges throughout the Late Bajocian and Bathonian and possibly Lower Callovian (Arkell et al., 1957). In North America, it has been previously described from southern Alaska (Imlay, 1980, 1982).

Cadomites sp.

Plate 29, figures 20-24

Material and occurrence. One specimen (figured specimen GSC 68417) from GSC locality C-95365 (base of Bed 53; Fauna 6) and another (figured specimen GSC 68418) from a loose boulder that may come from nearly the same level, or as high as the *Cadoceras barnstoni* beds (GSC loc. C-95369).

Description. The inner whorls of the best specimen (Pl. 29, figs. 20-23), at a whorl height of about 0.6 cm (width about 1 cm, diameter about 1.5 cm) are depressed, with umbilical slopes at a 45° inclination, and a broad, gently convex venter. Closely spaced tubercles occur on the abrupt ventrolateral edge, from which primary ribs extend toward the umbilicus and much more numerous and finely spaced secondaries cross the venter with slight, adoral curvature.

At a whorl height of 1.4 cm (width 2.4 cm; diameter 3.5 cm), the shell is essentially similar. There are three to five secondaries to each primary. The ventrolateral edge and slope are rounded at this growth stage.

The shell remains similar until the largest growth stage preserved. The best specimen has a whorl height of 2.3 cm, a width of 3.6 cm, and a diameter of about 7.2 cm. The ventrolateral edge, venter, and umbilical slope are smoothly rounded, merging together. The ventrolateral tubercles are elongated, merging more indistinctly with the primaries, and there is a slight tendency for a second row of tubercles to develop on the primaries lower on the umbilical slope. The secondaries are weaker, more numerous, numbering five per primary approximately, and are more strongly curved forward. More or less the entire last whorl preserved is nonseptate. The aperture is not preserved.

The second specimen (Pl. 29, fig. 24) comprises only part of a whorl, with a height of about 2.8 cm, and an inside diameter of 3.5 cm. The cross-section is evenly rounded. The primary ribs are widely spaced and have a node at the locus of subdivision around the maximum whorl width, about halfway up the whorl.

Discussion. The specimens described from southern Alaska by Imlay (1980) have more closely spaced ribs except for one fragment (*ibid.*, Pl. 4, figs. 6, 7), which has a more abrupt ventrolateral edge. Another of the specimens described by Imlay (1982) is closely similar, but the whorl cross-section of the northern Yukon specimen is more depressed. The Alaskan specimens are older, occurring with *Cranocephalites costidensus*. The northern Yukon material differs from most other species described (e.g. Stephanov, 1963; Hahn, 1971; Kopik, 1974) in the straight and more nearly radial rather than prorsiradiate primary ribs, the distinctly forward-curved secondaries, and particularly, the more depressed whorl cross-section. These characteristics, together with the coarse spacing of the primary ribs, and the very fine spacing of the secondaries, are traits very much like those displayed by *C. crassispinosus* Kopik (1974). *C. rectelobatus* (von Hauer) illustrated by Hahn (1971, Pl. 9, fig. 9) has the low cross-section, but finer, less straight primaries.

Genus *Parareineckeia* Imlay, 1962

Characteristic features of the genus were given by Imlay (1962).

Only one fragmentary specimen represents the genus in northern Yukon. It probably occurs in the *Arcticoceras ishmae* beds. The genus has been found in beds spanning the entire Bathonian in southern Alaska according to Imlay (1953b, 1962, 1975, 1980). There, the youngest species of the genus, *P. shelikofana*, occurs in the lower part (*Iniskinites intermedius* Subzone) of the lowest zone that contains *Cadoceras*, the *Cadoceras catostoma* Zone. The oldest species occur with "*Cranocephalites*" *costidensus*.

Parareineckeia has also been described from central British Columbia (Frebold and Tipper, 1973), Oregon (Imlay, 1980, 1981) and is considered to be characteristic of the Pacific Realm (Imlay, 1975, 1980).

Westermann (1980) has placed *Parareineckeia* Imlay in family Stephanoceratidae (subfamily Cadomitinae Westermann, 1956). The genus originally had been described as an endemic western North America perisphinctid genus Imlay (1962) and by Bourguin (1968) in a review of the family Reineckeidae. The question of its affinities is not resolved in this report.

Parareineckeia sp.

Plate 36, figures 7, 8

Material and occurrence. A single, fragmentary specimen (figured specimen GSC 68438) was found loose below the section (GSC loc. 92520), not associated with other ammonites but in a very dense, ferruginous matrix like that containing *Arcticoceras ishmae* in the section (*ishmae* Zone).

Description. The shell is entirely evolute, each whorl having slightly concave flanks that slope steeply toward the umbilicus, an abrupt ventrolateral edge, and a gently convex, broad venter that is nearly twice as wide as the flank is high. The largest whorl flank seen has a height of 1.5 cm, the distance from the seam of overlap with the preceding whorl to the ventrolateral margin is 1.3 cm, and the width of the venter is approximately 2.5 cm. The flanks have finely spaced, strong, simple ribs. Each third one, approximately, is enlarged at the ventrolateral edge to form a strong node. The venter is ornamented with finer ribs, which are twice as numerous as the primaries. The suture pattern cannot be seen.

Discussion. The specimen seems to differ little from the holotype of *P. nelchinensis* Imlay, which is probably much older, occurring with *"Cranocephalites" costidensus* in southern Alaska and in central British Columbia (Imlay, 1980; Frebold and Tipper, 1973). The ribs of the present specimen are coarser, straighter, and more nearly rectiradiate than those of *P. shelikofana* (Imlay). *P. hickersonensis* Imlay has coarser ribs, which are also prorsiradiate to a greater degree.

Genus et species indet. B

Plate 38, figures 11, 12

Part of a medium sized nonseptate whorl (figured specimen GSC 68461) was found loose in a matrix, suggesting its derivation from in or about the *ishmae* Zone (GSC loc. C-95372). The primary ribs are short, and practically radial, or gently curved forward. Weak, closely spaced secondaries are present on the adapical part of the fragment, and are at least five times as numerous as the primaries. They are also nearly radial or gently inclined forward. The ribbing character allies the fragment with the specimens of *Kepplerites* sp. B, *Cadomites*, and *Paracadoceras* described here, but the badly crushed and distorted specimen appears to be more involute than any of these, and to have a smoothly rounded umbilical edge and a stout, rounded cross-section.

Superfamily HAPLOCERATACEAE Zittel, 1884

Family OPPELIIDAE Bonarelli, 1894

Subfamily OPPELIINAE Bonarelli, 1894

The four northern Yukon specimens include two with a distinct, hollow keel and a cross-section that becomes broader toward the aperture, described here as *Oxycerites birkelundi* n. sp. and two without, described here as *Oxycerites* sp.

The well developed keel of most Boreal forms described as *Oxycerites* (see Birkelund et al., 1971), including *O. birkelundi* described below, distinguishes them from most southern members of that genus. *Oxycerites (Liroxyites) kellumi* Imlay (1961, 1982) from the Upper Bajocian of Alaska, also possesses this low keel, so that the name *Liroxyites* Imlay is available for such Boreal and northeastern Pacific forms, although its original diagnosis (Imlay, 1961) did not involve the keel.

Genus *Oxycerites* Rollier, 1909

Since *Oxycerites* was erected, it has been treated by different authors as either a genus or as a subgenus of *Oppelia*. The writer follows Buckman (1924), Ershova and Meledina (1968) and Birkelund et al. (1971) in differentiating it from *Oppelia* generically, on the basis of its greater number of auxiliary lobes, its more disc-like shape with an acuminate venter, the lack of secondary ribs on the ventrolateral part of the shell, and the sharper umbilical angle.

Oxycerites birkelundi n. sp.

Plate 35, figures 3, 4, 9, 10; Plate 36, figures 5, 6

?*Oppelia (Oxycerites)* sp. Imlay, 1953b, p. 75, Pl. 26, figs. 1, 2.
?*Oxycerites* cf. and aff. *aspidoides* Oppel. Ershova and Meledina, 1968, p. 47-49, Pl. X, figs. 1-6.
Oxycerites aff. *jugatus* Ershova and Meledina. Birkelund, Hakansson and Surlyk, 1971, p. 246-249, Pl. 1, figs. 1a-b, 2; Pl. 2, figs. 1-4.

Material and occurrence. Two specimens (holotype GSC 68434 and paratype GSC 68437) found loose below the section (GSC locs. 92554, and C-95354, respectively), both in boulders together with *Arcticoceras ishmae* or *Arcticoceras* sp. and in a matrix indicating their source in or near Bed 60. *Ishmae* Zone.

Description. The largest specimen (Pl. 35, figs. 3, 4, 9, 10) is septate to its maximum diameter, 15.8 cm. The early part of the shell (Pl. 35, fig. 9) has closely spaced falcoid ribs on the ventral half of the flank. The umbilical half cannot be seen clearly, but the ribs appear to die out toward the umbilicus and there appears to be no spiral groove. Beyond a diameter of about 4.5 cm, the shell is apparently smooth although vague swellings continuing to the end of the shell may represent weak, coarsely spaced ribs. The whorl section, even at an early growth stage with a diameter of 3.5 cm (Pl. 35, fig. 10) exhibits flanks that are subparallel on their umbilical halves, becoming rounded ventrally and with slightly developed ventrolateral shoulders. The nearly parallel flanks and ventrolateral shoulders are exaggerated in the adult. The external shell sculpture is preserved only in a small area near the umbilicus on the outer whorl, where it comprises fine growth lines. No lirae appear to be present on the juvenile shell. The umbilical wall is high and steep, slightly reversed, meeting the flank at a sharp angle. A distinct keel is present on all growth stages seen. The suture line, typical of the family, is shown in Figure 26.

Figure 26. *Septal suture pattern of* ***Oxycerites birkelundi*** *n. sp.; figured specimen GSC 68434, from GSC locality 92554; whorl height 8.5 cm.*

The other specimen (Pl. 36, figs. 5, 6) is septate to its largest preserved diameter – 11.7 cm. The flanks are smoothly convex except near the umbilicus, where they are flat. Weak, widely spaced, broad, subradial to slightly rursiradiate ribs occur on the median part of their outer halves. Much more closely spaced, strongly rursiradiate ribs ornament the ventral half of the flank at a smaller growth stage (whorl height 3 cm). The change from finely spaced to more coarsely spaced ribs seems to be abrupt, at a whorl height of about 3.7 cm. A distinct keel is present, the umbilical edge is sharp.

Discussion. The present species is apparently identical to *Oxycerites* aff. *jugatus*, from the *Arcticoceras* beds of East Greenland, described by Birkelund et al. (1971). The comparison extends to the variation in strength of the ventrolateral ribs, and to the spiral ornament on the early and late growth stages. The species differs from *O. jugatus* (Ershova and Meledina, 1968; Meledina, 1973) reportedly associated with *Arctocephalites* in Siberia, in having somewhat weaker ribbing on the inner whorls, growing to a larger size, and in being ribbed, to some extent at least, at late growth stages. The suture line (Fig. 26) is nearly identical to that of *O. jugatus* (Ershova and Meledina, 1968, Fig. 1), and of *Oxycerites aspidoides* (Oppel; see Arkell, 1951) although in the standard figures of *O. aspidoides* (e.g. Arkell et al., 1957, Fig. 320, 1a) the pronouncedly bifid character of the second lateral saddle and the accessory saddles on its ventral side are not as distinct as in the northern Yukon specimen.

Another Siberian species, *O. undatus* Ershova and Meledina (1968) is smaller, more weakly ribbed, and is keeled only on juvenile growth stages. *Oxycerites* cf. and aff. *Oxycerites aspidoides*, also described by Ershova and Meledina (1968), from Siberia do not differ significantly from *O. birkelundi* but cannot be compared meaningfully because of poor preservation.

The sculpture, shape, and presence of the keel link the species with a specimen described as *Oppelia (Oxycerites)* from the Bureya Basin of far eastern USSR by Sei and Kalacheva (1979), although those authors (p. 28) did not correlate them with the other Siberian or Alaskan forms.

Certain North American species, such as *Oppelia (Liroxyites) kellumi* (Imlay, (1961, 1962b, 1982) and *Oppelia (Oxycerites) chinitnana* Imlay (1953b) of southern Alaska also have a distinct ventral keel. *O. kellumi* is smaller, more strongly ribbed and has a weakly crenulated keel. The whorl section of *O. chinitnana* Imlay (1953b, p. 74, Pl. 26, figs. 3-6) is similar, but that species is much smaller when adult. The specimen figured as O. (O.) sp. by Imlay (1953b, p. 75, Pl. 26, figs. 1, 2) resembles the Porcupine River specimen in its feeble sculpture and slight inflation.

One specimen from Western Canada described as *Oxycerites* (Frebold, 1957, p. 54, Pl. 28, fig. 2) has a keel, but, besides lacking the slight ventrolateral shoulders, has stronger ribbing than *O. birkelundi*. Other specimens from Canada (Frebold, 1957, p. 54, Pl. 28, fig. 1a, b; Frebold and Tipper, 1973, Pl. 1, fig. 6) lack the keel.

Name. For T. Birkelund, for her contributions to Mesozoic paleontology and biostratigraphy.

Oxycerites sp.

Plate 35, figs. 7, 8; Plate 36, figs. 1-4

Material and occurrence. Two specimens (figured specimens GSC 68435, 68436) found loose below the section (GSC locs. C-95382, C-95374 respectively), both in boulders together with other ammonites, and in a rock type which indicates their probable source in or near Bed 60. *Ishmae* Zone.

Description. One specimen was large, but only the juvenile whorls are well preserved (Pl. 35, figs. 7, 8). The specimen was septate to at least a full whorl length beyond the size figured, that is, beyond a diameter of 7 cm. No ribs can be clearly seen at any growth stage, nor is there a very distinct keel or ventrolateral shoulder. At a diameter of 7 cm, there is a very faint suggestion of a spiral ridge about two fifths of the way up the flank. From this locus, the flanks converge toward the venter. At smaller growth stages there is a somewhat greater tendency for the flanks to be subparallel, sloping steeply toward the venter only on their outer part. The suture line of this specimen is shown in Figure 27. The umbilical edge is sharply rounded.

The juvenile whorls of another large specimen (Pl. 36, figs. 1-4) are conspicuously but weakly ornamented by moderately spaced falcoid ribs on the ventral half of the flank. In this and nearly every other characteristic, this specimen resembles the one described above and shown in

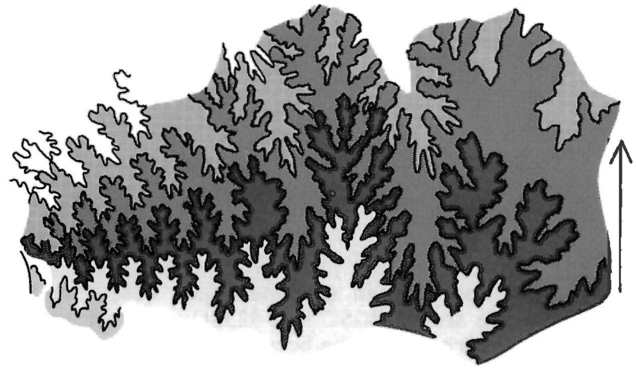

Figure 27. *Septal suture pattern of* ***Oxycerites*** *sp.; figured specimen GSC 68435, from GSC locality C-95382; whorl height 3.7 cm.*

Plate 35, figures 3, 4, 9, and 10. However, a very weak and poorly defined spiral ridge is present on both the juvenile and adult shell, the keel is less distinctly developed if it is present at all, and the flanks slope evenly toward the venter over most of their width. This specimen also is septate to its maximum preserved size.

Discussion. The specimens are not well enough preserved to compare in detail with other species. They are similar to the northwest European species of *Oxycerites* (see Arkell, 1951 for example), differing from associated *O. birkelundi* n. sp. and other Arctic forms, in the absence of a distinct keel, and ventrolateral shoulders.

Genus *Oecotraustes* Waagen, 1869

Oecotraustes(?) sp.

Plate 35, figures 1, 2, 6

Material and occurrence. One small specimen (figured specimen GSC 68432) in a loose boulder below the section (GSC loc. 92567) in which *Arctocephalites spathi* n. sp.(?) also occurs (*spathi* Zone); another small specimen (figured specimen GSC 68431) found loose below the section (GSC loc. 92473) in a yellow-weathering matrix, which may have been derived from the *spathi* Zone as well, or from any other zone as high as the *barnstoni* Zone. The presence of a specimen (unfigured) in Bed 62 (GSC loc. 92543) supports the latter suggestion.

Description. The umbilicus of one specimen (Pl. 35, fig. 6) is small but apparently not tiny. The umbilical edges are rounded. The umbilical third of each flank is nearly smooth, with fine, subradial threads that are the dorsal ends of the ribs. The ventral two thirds of the flank has coarse, falcoid ribs that are strongest along a poorly defined ventrolateral shoulder. A distinct ventral keel is present. The shell is highly compressed, thickest in the center of the flank. The maximum whorl height preserved is 9 mm.

The other specimen (Pl. 35, figs. 1, 2) is septate to its maximum preserved size – whorl height 1.1 cm, diameter 2.5 cm. The umbilicus is wide, and expands rapidly at the largest growth stage preserved. The umbilical edge is rounded, the walls vertical, the flanks are only very slightly convex, with maximum conch width around the umbilical edge. The lateral shell surface is not preserved, thus detailed ornamentation cannot be seen. Coarse ribs, curved foward at their ventral ends, ornament the ventral part of the flank, weakening rapidly dorsally. On the internal mould, the venter is sharply rounded, presumably the base of a distinct keel that is not preserved. Weak, ventrally inclined thread-like extensions of the ribs continue on the narrow, nearly smooth space between the venter itself and the ventrolateral shoulder formed by the strengthened ribs.

The suture pattern of this specimen is figured (Fig. 28). It is characteristic of the family Oppeliidae.

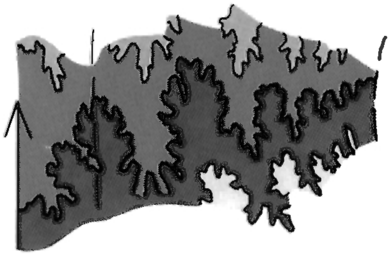

Figure 28. *Septal suture pattern of* ***Oecotraustes*** *sp.; figured specimen GSC 68431, from GSC locality 92473; whorl height 11 cm.*

Discussion. One specimen has been described from *Arcticoceras* beds of East Greenland where it was considered (Birkelund et al., 1971) to possibly be a microconch dimorph of associated *Oxycerites.* Neither the Yukon nor the Greenland specimens are sufficiently well preserved to compare precisely.

Subfamily HECTICOCERATINAE Spath, 1925

Genus *Prohecticoceras* Spath, 1928

Prohecticoceras(?) sp.

Plate 35, figure 5

Material and occurrence. One small specimen (figured specimen GSC 68433) found in a boulder loose below the section (GSC loc. 92570). The boulder also contains many juvenile cadoceratinae in a dense matrix suggesting derivation from about the level of the *ishmae* Zone or just below it.

Description. The maximum whorl height is 9 mm, corresponding to a radius of about 11 mm. The specimen is entirely septate. It is planulate, widest about one third to one half of the way up the flank. The flank is convex, with a gently rounded umbilical edge and a sloping umbilical wall. The umbilicus is fairly wide.

The ribs are falcate, changing orientation sharply along a locus about two fifths of the whorl height, and strongest along the ventrolateral edge where they form a weak shoulder. The ribs are weak (the outer shell surface is not preserved), strongest on the ventral half of the flank, and are finely spaced. The flanks merge gradually with the narrow ventrolateral slope, adjacent to a narrow, distinct keel. The umbilical edge is gently rounded. The suture line is shown in Figure 29.

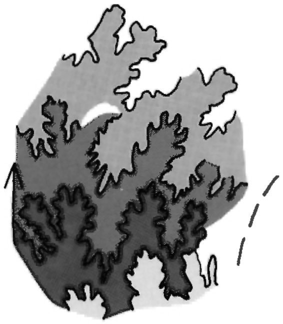

Figure 29. *Septal suture pattern of* ***Prohecticoceras(?)*** *sp.; figured specimen GSC 68433, from GSC locality 92570; whorl height 0.8 cm.*

Discussion. Although the presence of falcate ribs suggests the assignment of this specimen to *Prohecticoceras*, the narrow keeled venter is not characteristic of the genus. The falcate ribs and rounded umbilical margins distinguish this specimen from previously described *Oxycerites*.

Superfamily PERISPHINCTACEAE Steinmann, 1890

Family PERISPHINCTIDAE Steinmann, 1890

Cobbanites Imlay (=*Leptosphinctes* according to Westermann, 1980, thereby constituting a younger extension of the range of that genus than is known in Europe) and other genera that are widely represented in the Western Interior, British Columbia, and southern Alaska, have not been reported in arctic Canada or arctic Alaska, where only a few perisphinctids are known.

Genus *Choffatia* Siemiradzki, 1898

Only a few fragments, either found together with *Arcticoceras ishmae* (Keyserling) or probably derived from beds with *A. ishmae*, are thought to possibly represent the genus at Salmon Cache Canyon. Elsewhere in North America, *Choffatia* has been reported from southern Alaska (Imlay, 1953b) in the lower part of the lowest zone with *Cadoceras*, i.e. the *Iniskinites intermedius* Subzone of the *Cadoceras catostoma* Zone and at a similar level in Oregon (Imlay, 1964, 1980, 1981), and with *Arcticoceras* in northern Alaska (Imlay, 1976). The genus is widespread in non-Boreal regions, and ranges throughout the Upper Bathonian (e.g. Hahn, 1969) through Middle Callovian (Arkell et al., 1957).

Choffatia(?) sp.

Plate 36, figures 9-11

Material and occurrence. One poorly preserved, entirely septate specimen (figured specimen GSC 68439) collected loose below the section (GSC loc. 92561) in a rock type that suggests its occurrence in the beds with *Arcticoceras ishmae*. Another crushed, small fragment of a whorl (figured specimen GSC 68440; from GSC loc. 92564) was also found loose in a boulder, together with *Arcticoceras ishmae* (Keyserling) and *Arctocephalites*(?) *belli*. Yet another, poorly preserved, unfigured fragment was collected from a loose boulder (GSC loc. C-95372) with *Oxycerites*, which has been found most commonly with *Arcticoceras ishmae*.

Description. The smallest whorl in the largest specimen seen (Pl. 36, figs. 9, 10) is 1.2 cm wide. Widely spaced, weak, primary ribs can be seen on the ventrolateral part of the flank; umbilical parts are not exposed. Fine secondaries, approximately three times as numerous as the primaries, pass straight across the venter.

At an intermediate growth stage (whorl height 2.5 cm approx.; width 2.3 cm), only weak, somewhat irregular, poorly preserved primary ribbing of the flank can be seen. The venter is very poorly preserved but appears to be smooth.

The largest whorl preserved is 3 cm high and about 3.3 cm wide, and is apparently smooth. The suture pattern of this largest whorl is shown in Figure 30. The whorl height of another fragment (Pl. 36, fig. 11) is approximately 3.7 cm; the whorl has strong, undivided, widely spaced ribs.

Discussion. The material is not sufficiently well preserved to compare meaningfully with other described specimens.

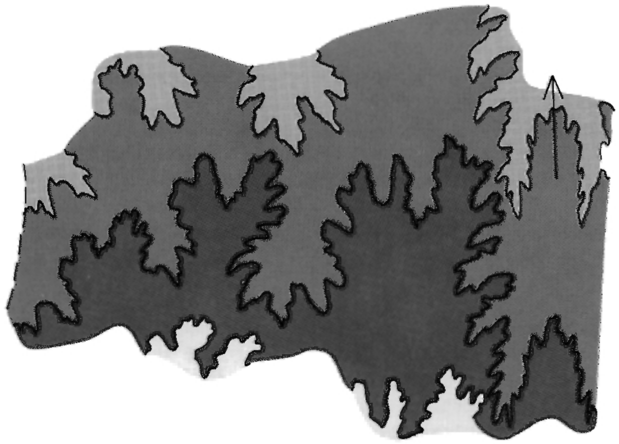

Figure 30. *Septal suture pattern of* ***Choffatia(?)*** *sp.; figured specimen GSC 68439, from GSC locality 92561; whorl height 3 cm.*

Suborder *PHYLLOCERATINA* Arkell, 1950

Superfamily PHYLLOCERATACEAE Zittel, 1884

Family PHYLLOCERATIDAE Zittel, 1884

The writer follows the classification of Joly (1975), who, in the most recent comprehensive treatment of family Phylloceratidae, has given criteria for recognition of the most common Jurassic genera and their ranges. In particular, he considered Early Jurassic species of *Partschiceras*, including its genotype, to belong to *Phylloceras*, and he erected *Adabofoloceras* to accommodate those Middle Jurassic species that are nonlirate, but have well developed ribs on the venter and ventral parts of the flank. Other important works on the genera of phylloceratids are by Besnosov (1958) and Gasanov (1961), who assigned two of the species mentioned here, *Phylloceras kunthi* Neumayr and *P. kudernatschi* von Hauer, to a new genus, *Pseudophylloceras*.

Phylloceratids are uncommon in the Boreal Middle Jurassic generally, the Salmon Cache Canyon locality being unusual in having them in abundance, variety and large size, undoubtedly an indication of its southern connections. In addition to the poorly preserved specimens from this locality, Frebold (1961) described *Zetoceras thorsteinssoni* from Bajocian beds of the Canadian Arctic Archipelago. Phylloceratids occur throughout the *Arctocephalites* beds in Siberia (Meledina, 1973) but only one has been described (Voronetz, 1962) and their biostratigraphic potential has not been evaluated.

One Arctic species, *P.*(?) *subatlas* Voronetz (1962) differs from others in the fine, reticulate ornamentation reported, which is not shown on Voronetz's figures, however. Two poorly preserved Bajocian specimens were figured by Efimova et al. (1968).

In Bathonian beds of western North America, Imlay (1953b, 1962) described one species of *Holcophylloceras* associated with *Cranocephalites* in southern Alaska, several other species from younger Bathonian or Lower Callovian beds (Imlay, 1975), and other phylloceratids from Upper Bajocian beds (Imlay, 1982).

Several occurrences of "*Phylloceras*" in Western Canada were noted by Frebold (1957, p. 23, 30, 32). *Phylloceras (Partschiceras) grantzi* Imlay was identified in the lowest beds with *Kepplerites* and *Cadoceras*(?) in the Queen Charlotte Islands (Frebold, 1979; Tipper and Cameron, 1980). *Phylloceras (Macrophylloceras) grossicostatum* Imlay occurs in Lower Callovian beds of central British Columbia (Tipper and Richards, 1976, p. 67), and *Phylloceras (Partschiceras) pacificum* Frebold and Tipper (1975) in higher Callovian beds. *Phylloceras* and *Calliphylloceras* have been listed from eastern Oregon (Imlay, 1964, 1981).

Subfamily PHYLLOCERATINAE Zittel, 1884

Genus *Phylloceras* Suess, 1865

Certain Bathonian and Callovian species have been reported from many localities around the world (see Joly, 1975, for example) and many of the northern Yukon specimens are similar to the most widespread of them, particularly *P. kunthi* Neumayr and *P. kudernatschi* (von Hauer). The association of bunching of the lirae with compression of the shell is reversed in the northern Yukon specimens that are compared with those species, however. *P. billingsi* (Meek) is apparently endemic, unusual in its inflation.

Phylloceras sp. aff. *P. kudernatschi* (von Hauer)

Plate 37, figures 1-7, 16-23, 26; Plate 38, figures 1, 2

aff. *Phylloceras kudernatschi* (von Hauer). Joly, 1975, p. 151-160, Pl. 2, figs. 8, 11; Pl. 3, figs. 1, 4, 6, 7-9; Pl. 4, figs. 1-4, 6-8; Pl. 5, fig. 2; Pl. 39, figs. 4-8; Pl. 40, fig. 5; Pl. 42, figs. 9, 11; Pl. 43, figs. 6, 11, 14, 16, 18.

?*Phylloceras* sp. indet. Frebold, 1961, p. 6, Pl. V, fig. 3.

Material and occurrence. A large fragment (figured specimen GSC 68457) from GSC locality C-95357 (Bed 32); many small specimens (including figured specimens GSC 68443, 68444, 68451) from GSC locality 92532 (Bed 42); two (including figured specimen GSC 68449) from GSC locality C-95362 (Bed 46). *Amundseni* and *frami* Zones.

Many specimens occur loose below the section, some alone (e.g. figured specimens GSC 68453 from GSC loc. 92546, GSC 68455 from GSC loc. C-95369, and others from GSC locs. 92473 and 92520), one with *Arctocephalites*(?) *freboldi*, probably from the *amundseni* Zone, and others associated with faunas and matrix that indicate their probable source in Bed 62 (*barnstoni* Zone) (e.g. figured specimen GSC 68442 from GSC loc. 92473x; figured specimen GSC 68441 from GSC loc. C-95383; GSC 68450 from GSC loc. C-95370; figured specimen GSC 68452 from GSC loc. 92561).

Description. The largest fragment figured (Pl. 38, figs. 1, 2) is also stratigraphically the lowest that was found in place (Bed 32). It is septate. The whorl height is 6.5 cm; maximum width, about halfway up the flank, is about 5 cm. The venter bears regularly spaced weak ribs that fade rapidly dorsally. The ventrolateral parts of the flank bear more coarsely spaced ribs with fine lirae between them. The suture pattern cannot be seen clearly.

A very similar fragment (Pl. 37, figs. 20, 21) was found in Bed 42. The ribs in the flank are proportionately more widely spaced, the specimen is smaller, and the fine ventral ribs cannot be seen clearly. The other specimens from the same bed are juveniles (Pl. 37, figs. 5, 6) and bear fine lirae and incipient, very weak, lateral folds. All are smooth on the internal mould.

Another specimen (Pl. 37, figs. 16, 17) from Bed 46 is entirely septate, 6 cm in diameter, and 2.5 cm wide where it appears to flare out at its preserved end. It also is finely lirate with incipient lateral folds.

The best preserved specimen (Pl. 37, figs. 18, 19) was found in a loose boulder together with *Cadoceras barnstoni* and *Iniskinites*, indicating its source in or near Bed 62. At the smallest growth stage seen, with a whorl height of 2.2 cm and a width of 1.2 cm (maximum halfway up the flank), only fine lirae can be seen. Little of the outer shell surface is preserved. At larger growth stages, the lateral folds are well developed, as are fine ribs across the venter. The whorl height at the largest, still septate, growth stage preserved, is 5.2 cm (diameter 8.2 cm).

Discussion. All of the specimens described here are allied by their compressed cross-section, the width becoming gradually narrower ventrally from a locus about halfway up the flank. The narrow venter of the present species contrasts with that of *P. billingsi* and *P.* sp. aff. *P. kunthi*, as do the fine lirae that cover the ventral part of the outer shell surface wherever it can be seen, and the bunching of these lirae into gentle folds on the mid part of the flank. These last characters ally this species most closely with *P. kudernatschi* (von Hauer), which is most commonly more inflated, however. The strength of the lateral folds is as highly variable in the northern Yukon material as it is in the many specimens assigned to *P. kudernatschi* and named forms of it by Joly (1975).

One specimen from approximately equivalent beds in southern Alaska figured by Imlay (1953b; Pl. 25, figs. 12, 13) as *P. (Macrophylloceras) grossicostatum* Imlay is similar, but the lateral folds in that species develop into strong ribs that remain strong as they cross the venter at large growth stages.

Phylloceras billingsi (Meek)

Plate 37, figures 8-11

Ammonites billingsi Meek, 1859, p. 184, 185, Pl. 2, figs. 4, 5, 6.

Material and occurrence. One specimen (figured specimen GSC 68445) from GSC locality 92543 (Bed 62); others below the section in loose boulders in which other ammonites (including figured specimen GSC 68653 from GSC loc. 92553) as well as the rock type, indicate the source as Bed 62; figured specimen GSC 68446 from GSC locality 92473x, and others from GSC locality C-95369. The holotype described by Meek (1859), like most specimens found by the writer, occurs in a boulder together with *Cadoceras barnstoni* (Meek), and is presumed to come from Bed 62 of the Salmon Cache Canyon locality (see under *Cadoceras barnstoni*). These represent the *barnstoni* Zone. Another specimen (unfigured) was found in a loose boulder (GSC loc. 92552) together with *Loucheuxia bartletti* n. sp. and *Iniskinites* sp., and is thought to come from the *ishmae* Zone.

Description. The specimens are small, not exceeding 3.8 cm in diameter, but still septate at their oralmost preserved ends. They are moderately inflated, the greatest thickness occurring about halfway up the flank. The external surface of the present material is not preserved but Meek (1859, p. 185) reported "very faint traces of radiating costae, which arch a little in crossing the dorsum". Fine lirae, and intersecting, weak, spiral striae are present on an intermediate shell layer, as seen in Plate 38, figure 11.

The suture pattern (Fig. 31) is characteristic, with a triphyllic first lateral, and diphyllic second lateral saddle.

*Figure 31. Septal suture pattern of **Phylloceras billingsi** (Meek); figured specimen GSC 68653, from GSC locality 92553; whorl height 2 cm.*

Discussion. *P. billingsi* is more inflated than any of the other Bathonian and Callovian *Phylloceras* species from northern Yukon or elsewhere.

Phylloceras sp. aff. *P. kunthi* Neumayr

Plate 37, figures 12-15

aff. *Phylloceras kunthi* Neumayr, 1971, p. 312-313; Table XII, Fig. 6; Table XIII, Fig. 1.

aff. *Phylloceras kunthi* Neumayr. Joly, 1975, p. 162-165, Pl. 3, fig. 2, Pl. 39, fig. 9.

Material and occurrence. One small fragment (figured specimen GSC 68448) from GSC locality C-86398 (Bed 21), two (including figured specimen GSC 68447) from GSC locality C-86394 (Bed 28), one specimen and another fragment from GSC locality C-95357 (Bed 32).

Description. The largest fragment is 4.7 cm in maximum diameter; all are entirely septate. The species is moderately compressed and involute, with a maximum width about halfway up the flank. The ornamentation is not well preserved but seems to consist entirely of fine, thread-like lirae, radial or inclined gently forward.

The suture pattern, with typical diphyllic first and second lateral lobes, is shown in Figure 31.

Discussion. The characteristic bunching of lirae into ribs that is typical of *P.* sp. aff. *P. kudernatschi* and many other species is apparently lacking in this species, and it is slightly more inflated than *P.* sp. aff. *P. kudernatschi*. The lack of bunching of the lirae allies it with the widespread, contemporary species *P. kunthi*, as illustrated by Joly (1975) but the cross-section appears to be slightly more inflated. Another very similar but slightly older (Aalenian-Bajocian) species, first described in Europe, has also been identified in Argentina – *P.* cf. *P. trifoliatum* Neumayr (Westermann and Riccardi, 1982).

Genus *Adabofoloceras* Joly, 1975

Joly (1975) erected *Adabofoloceras* to accommodate many of the Middle Jurassic species previously assigned to *Partschiceras*, after recognizing the synonymy of the genotype of that genus, Lower Jurassic *P. monestieri* Briestroffer, with *Phylloceras*.

Adabofoloceras(?) sp.

Plate 37, figures 24, 25

Material and occurrence. One large whorl fragment (figured specimen GSC 68454) found loose below the section (GSC loc. C-95369) preserved in a matrix, suggesting its origin in the beds with *Arcticoceras ishmae*. *Ishmae* Zone.

Description. The whorl fragment is septate, 7 cm wide and at least as high. It is more inflated than the other phylloceratids described here, perhaps subquadrate in outline. It has very strong, coarsely spaced ribs preserved only on the ventrolateral edge, where they appear to be strengthened, weakening again across the venter. The ribs are very weakly reflected on the internal mould.

Another large fragment (unfigured, GSC loc. 92473) is still septate at a whorl height exceeding 10 cm. The first and second lateral saddle are diphyllic. The weak but regular folds are strongest along the ventrolateral part of the shell, and are not represented on the internal mould.

Discussion. This fragment is not sufficient to add to our knowledge of the genus, except probably to further document its stratigraphic and geographic range, and the large size it can attain.

Subfamily CALLIPHYLLOCERATINAE Spath, 1927

Genus *Calliphylloceras* Spath, 1927

Calliphylloceras sp.

Plate 38, figures 8-10

Material and occurrence. Several specimens found loose below the section may represent the genus. Only the best preserved (figured specimen GSC 68460) from GSC locality 92473 is figured. It occurs alone, in a yellow-weathering matrix, like those in the section that contain *Cadoceras barnstoni* (Meek) on the one hand, or those of the lower beds of the *spathi* Zone on the other. None can be assigned confidently to any particular horizon.

Description. The best preserved fragment has a whorl height of 4 cm, and is still septate at that size. It is moderately inflated, widest at about one third of the way up the flank, narrowing to the venter. The constrictions are nearly straight, curving slightly forward, and slightly projected over the venter. They do not appear to be reflected in the external sculpture. The suture line is figured (Fig. 32).

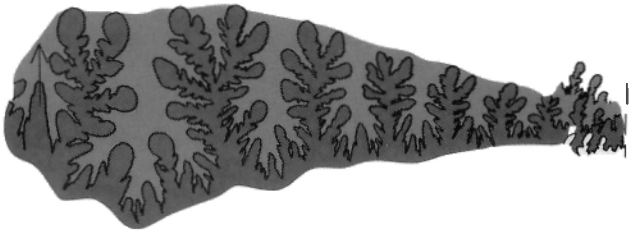

Figure 32. Septal suture pattern of ***Calliphylloceras*** *sp.; figured specimen GSC 68460, from GSC locality 92473; whorl height 4 cm.*

The largest specimen seen that is probably a *Calliphylloceras* is still septate at a whorl height of 7 cm, at which size it still shows evidence of rapid expansion. There appears to be considerable difference in cross-section from one specimen to another.

Discussion. Too little of the specimen is preserved to compare in detail with previously described species. There appear to be no significant differences from *Calliphylloceras freibrocki* (Imlay) from equivalent and older beds in southern Alaska (Imlay, 1953b, 1975, 1982) or from *C. heterophylloides* (Oppel) or *C. disputabile* (Zittel) from equivalent beds of Europe, Africa and southern Asia (e.g. Joly, 1975).

Genus *Holcophylloceras* Spath, 1927

Holcophylloceras sp.

Plate 3, figure 10; Plate 37, figures 27, 28;
Plate 38, figures 3-7

Material and occurrence. One small fragment (figured specimen GSC 68462) from GSC locality 92525 (Bed 22); one (figured specimen GSC 68456) from GSC locality 92527 (Bed 24); and another specimen (unfigured) from GSC locality C-95368 (Bed 45). *Porcupinensis* and *amundseni* Zones. Others occur loose below the section, some (e.g. figured specimens GSC 68458 and 68459) from GSC localities C-95383 and 92520, respectively, the matrix of which suggests derivation from Bed 62 (*barnstoni* Zone), and others that cannot be confidently traced to their source horizon.

Description. The poorly preserved fragment (Pl. 3, fig. 10) from Bed 22 is figured only because of its association with another ammonite. This is the stratigraphically lowest appearance of *Holcophylloceras* in the section. Only the inner whorls of the specimen from Bed 24 (Pl. 37, figs. 27, 28) are preserved, with maximum whorl height of 1 cm, and diameter of about 1.9 cm. Sigmoid constrictions are seen on the internal mould. Incipient ventral flanges are present. The only other (unfigured) specimen found in-place is poorly preserved, but has a similar, compressed cross-section, and is septate to its maximum preserved diameter of 6 cm.

The loose material indicates that some large specimens are present. The best preserved large one (Pl. 38, figs. 5-7) has weak, finely spaced ribbing near the venter, diphyllic first lateral saddles, sigmoid constrictions and ventral flares.

Another loose specimen (Pl. 38, figs. 3, 4) also has sigmoid constrictions on the internal mould and ventral flares. Its cross-section is similar in appearance. The external shell surface is not well preserved.

Discussion. The specimen figured (Imlay, 1962), from older beds of southern Alaska, is not well enough preserved to meaningfully compare with the present specimens.

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PLATES

All figured specimens are actual size unless otherwise stated.

All the type specimens, with prefix 'GSC', are stored in the Type Collection of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario.

The localities from which the specimens come bear different numbers, prefixed by 'GSC locality' or 'GSC loc.'.

All specimens illustrated, except Plate 16, figures 1 and 2, come from the Middle Boreal Bathonian through Lower Callovian section at Salmon Cache Canyon, Porcupine River, northern Yukon.

PLATE 1

Figures 1-17. *Arctocephalites spathi* n.sp.

1-3. Lateral (with and without crushed body chamber) and ventral views of holotype GSC 68261 from GSC locality 92523 (Bed 6 and base of Bed 7). *Spathi* Zone. A terminal constriction (not shown) is present on the internal mould near the aperture, near the position shown by the arrow. No septae can be seen; shell is filled with sediment.

4-8. Lateral, ventral (with and without body chamber) and cross-sectional views of partial paratype GSC 68262 from same locality as figure 1. No septae can be seen; shell is filled with sediment.

9-12. Lateral and ventral views of fragmentary paratype GSC 68263 from GSC locality 92522 (Bed 2) and lateral and cross-sectional views of an inner whorl fragment. *Spathi* Zone. Internal structure crystalline; possibly entirely septate.

13. Lateral view of fragmentary paratype GSC 68264 from same locality as figure 1, showing pronounced terminal constriction on internal mould (arrow).

14, 15. Lateral and ventral views of paratype GSC 68265 from GSC locality 92520 (loose below section). The ribs are not as strongly curved as is typical of the species. X marks position of last septum.

16, 17. Lateral and ventral views of figured specimen GSC 68266 from GSC locality 92520 (loose below section). X marks position of last septum.


1


2


3


4


5


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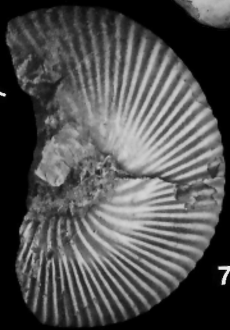
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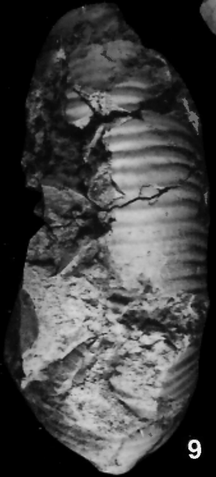
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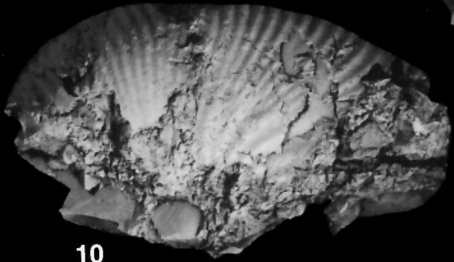
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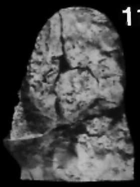
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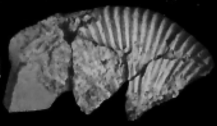
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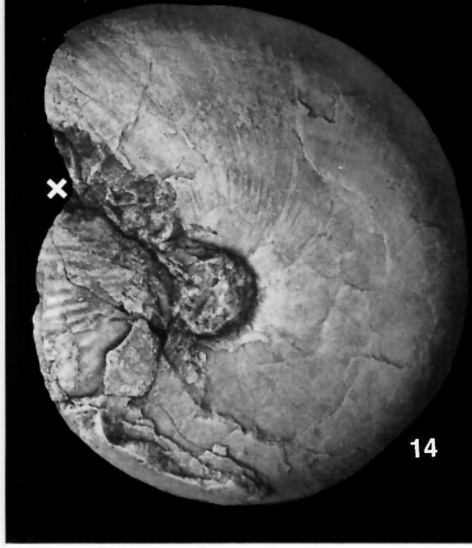
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PLATE 2

Figures 1-10. *Arctocephalites spathi* n. sp.

1, 2. Lateral and cross-sectional views of paratype GSC 68267 from GSC locality 92484 (Bed 14). *Spathi* Zone. Position of apertural constriction shown by arrow. X marks position of last septum.

3, 4. Lateral and ventral views of plaster cast of figured specimen GSC 15110 from GSC locality 35638 (Bed 7, approx.), described by Frebold (1961, p. 11, 12) as *A.* sp. cf. *A. ornatus* Spath. *Spathi* Zone. Location of apertural constriction shown by arrow.

5, 6. Ventral and lateral views of plaster cast of figured specimen GSC 15107 from GSC locality 35635 (Bed 2 approx.) described by Frebold (1961, p. 12) as *Arctocephalites*? sp. indet. *Spathi* Zone.

7-10. Ventral and lateral views, with and without outer whorl, of figured specimen GSC 68269 from GSC locality 92520 (loose below section). X marks position of last septum.


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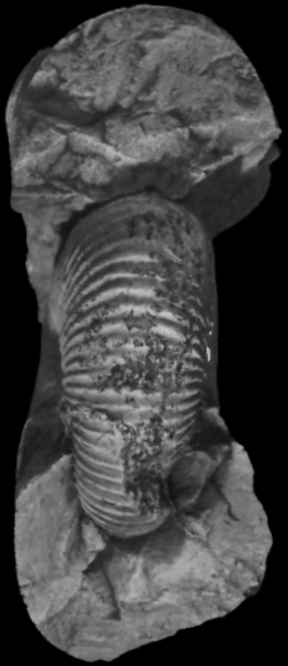
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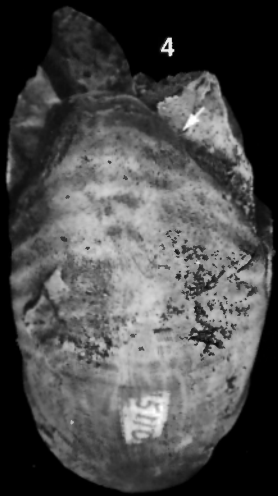
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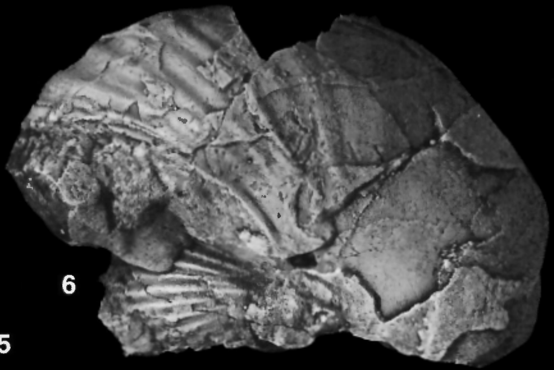
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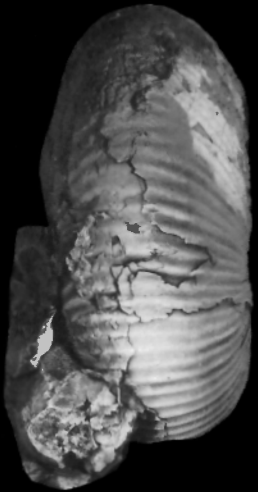
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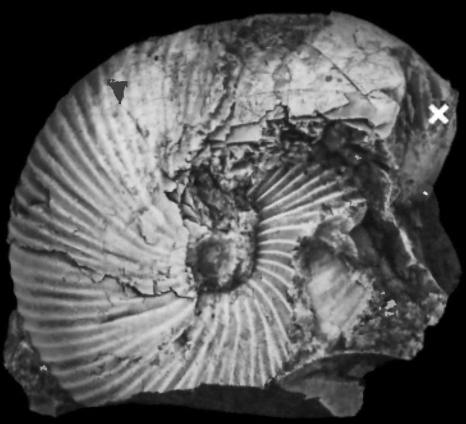
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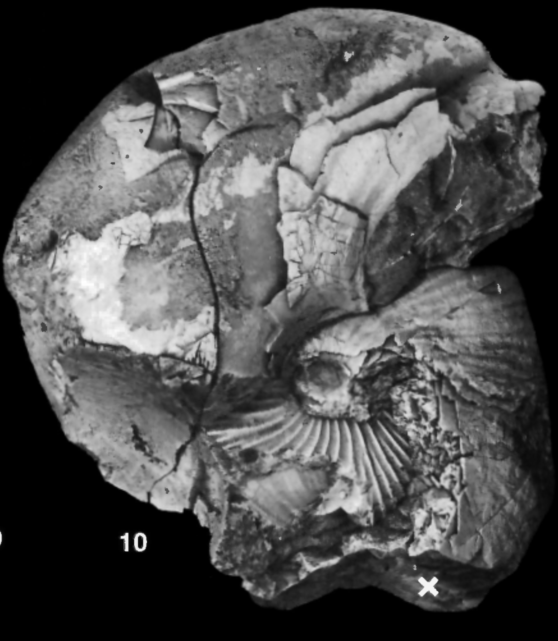
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PLATE 3

Figures 1-6. *Arctocephalites ellipticus* Spath(?)

1-3. Lateral, ventral, and cross-sectional views of fragmentary figured specimen GSC 68270 from GSC locality 92523 (Bed 6 and base of Bed 7). *Spathi* Zone. Specimen is entirely septate.

4-6. Lateral (body and intermediate whorls) and cross-sectional views of fragmentary figured specimen GSC 68271 from GSC locality 92520 (loose below section). Location of apertural constriction shown by arrow; intermediate whorl is entirely septate.

Figures 7-10. *Arctocephalites* sp. A aff. *A. sphaericus* Spath

7-9. Ventral, lateral, and cross-sectional views of fragmentary figured specimen GSC 68272 from GSC locality 92523 (Bed 6 and base of Bed 7). *Spathi* Zone. X marks position of last septum.

10. Lateral view of fragment, figured specimen GSC 68273 from GSC locality 92525 (Bed 22), and a fragment of *Holcophylloceras* sp. (figured specimen GSC 68462). *Porcupinensis* Zone. No septae can be seen.

Figures 11-20, 22. *Arctocephalites porcupinensis* n. sp.

11, 12. Lateral and ventral views of holotype GSC 68274 from GSC locality 92525 (Bed 22). *Porcupinensis* Zone. The entire whorl illustrated is nonseptate.

13, 14. Ventral and lateral views of fragmentary paratype GSC 68275 from GSC locality 92527 (Bed 24). *Porcupinensis* Zone. No septae can be seen.

15, 16. Lateral and ventral views of paratype GSC 68276 from same locality as figure 13. The figured whorl is nonseptate.

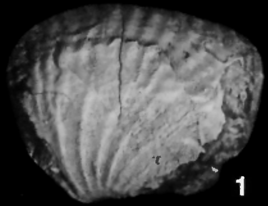
17-20. Lateral and ventral views of paratype GSC 68277 from same locality as figure 11. Location of terminal constriction shown by arrow. X marks approximate position of last septum.

22. Lateral view of broken paratype GSC 68279 from same locality as figure 13. Location of terminal constriction shown by arrow. No septae can be seen.

Figure 21. *Arctocephalites porcupinensis* n. sp.(?).

Lateral view of latex cast of fragmentary figured specimen GSC 68278 from GSC locality C-86392 (Bed 20). *Porcupinensis* Zone.

PLATE 3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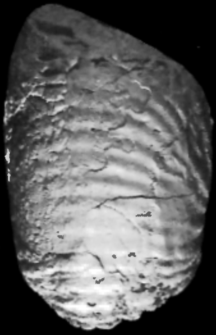
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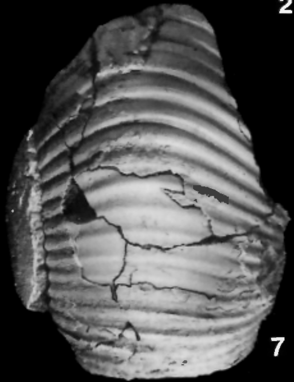
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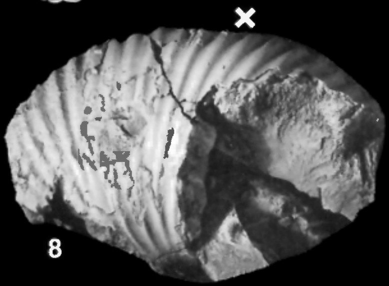
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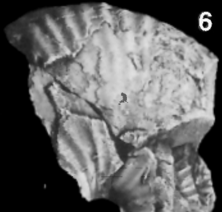
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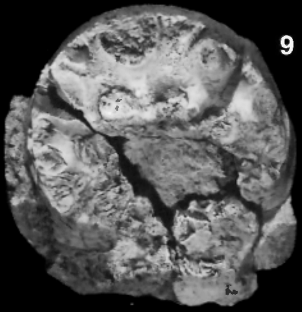
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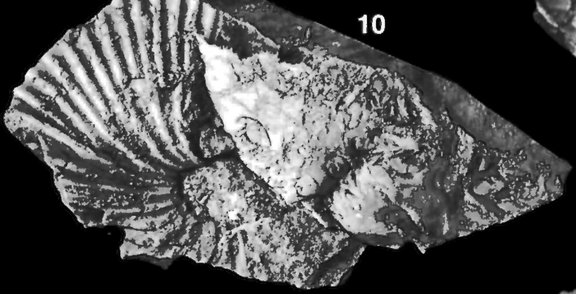
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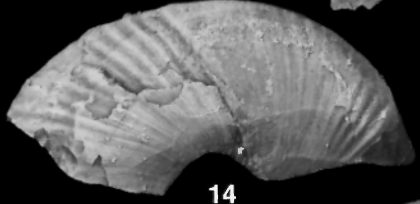
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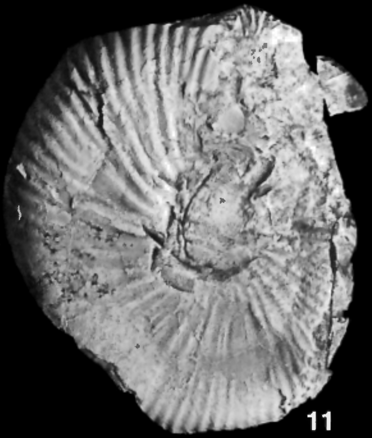
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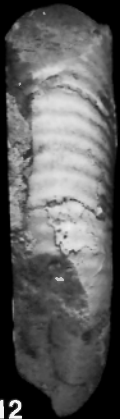
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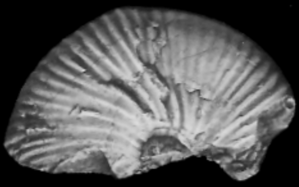
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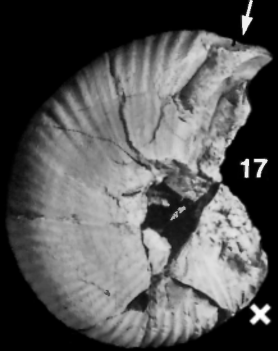
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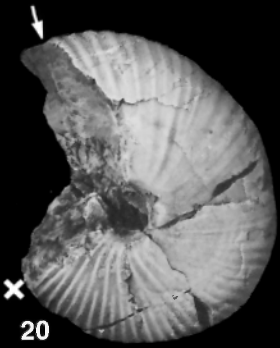
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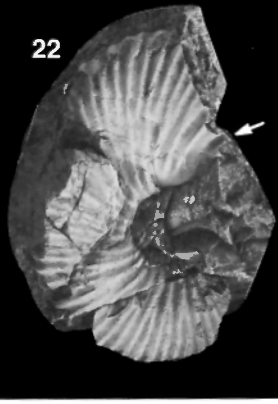
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PLATE 4

Figures 1, 2. *Arctocephalites porcupinensis* n. sp.

1, 2. Lateral and ventral views of figured specimen GSC 68280 from GSC locality C-95357 (Bed 32). *Amundseni* Zone. Apertural constriction is probably present in position indicated by arrow. X marks approximate position of last septum.

Figures 3-6. *Arctocephalites* sp. B aff. *A. sphaericus* Spath

3-6. Lateral and ventral views (with and without outer whorl) of figured specimen GSC 68281 from GSC locality 92520 (loose below section). X marks position of last septum.

Figures 7-9. *Arctocephalites callomoni* Frebold

7-9. Ventral and lateral views (with and without outer whorl) of hypotype GSC 68282 from GSC locality C-86390 (Bed 16). *Porcupinensis* Zone. X marks approximate position of last septum.


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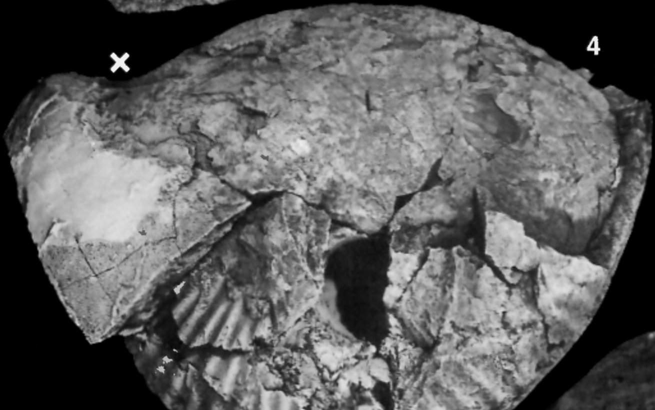
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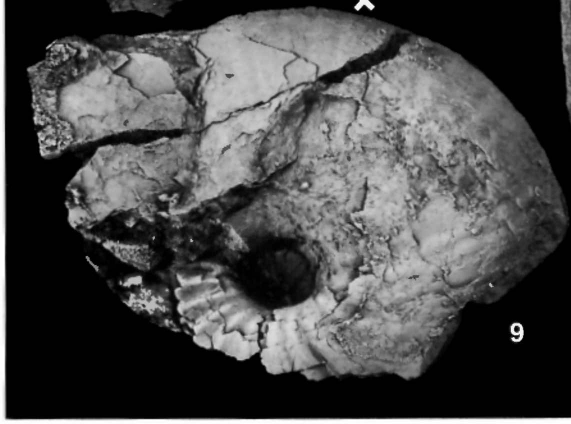
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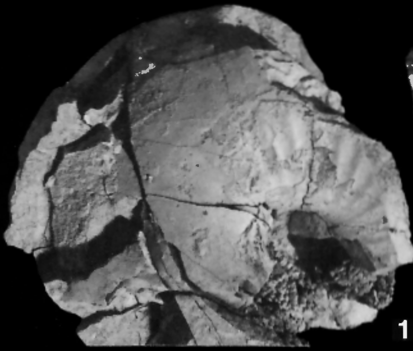
PLATE 5

Figures 1-13. *Arctocephalites callomoni* Frebold

1, 2.	Lateral and ventral views of fragmentary hypotype GSC 68283 from GSC locality C-86396 (Bed 31). *Amundseni* Zone. Whorl illustrated is nonseptate.
3-5.	Lateral and ventral views of juvenile hypotype GSC 68284 from GSC locality C-86395 (Bed 30). *Amundseni* Zone.
6-9.	Lateral and ventral views (with and without outer whorls) of hypotype GSC 68285 from GSC locality C-95369 (loose below section). X marks position of last septum.
10-13.	Lateral and ventral views (with and without outer whorls) of hypotype GSC 68286 from GSC locality C-95372 (loose below section). X marks position of last septum.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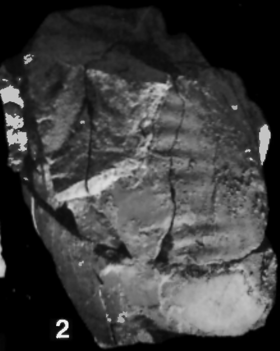
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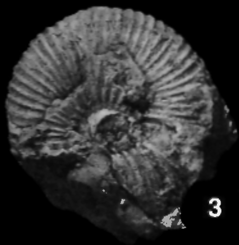
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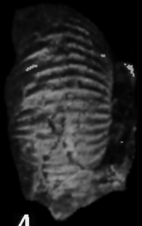
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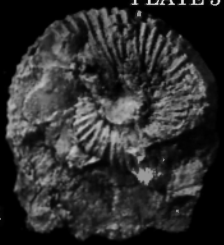
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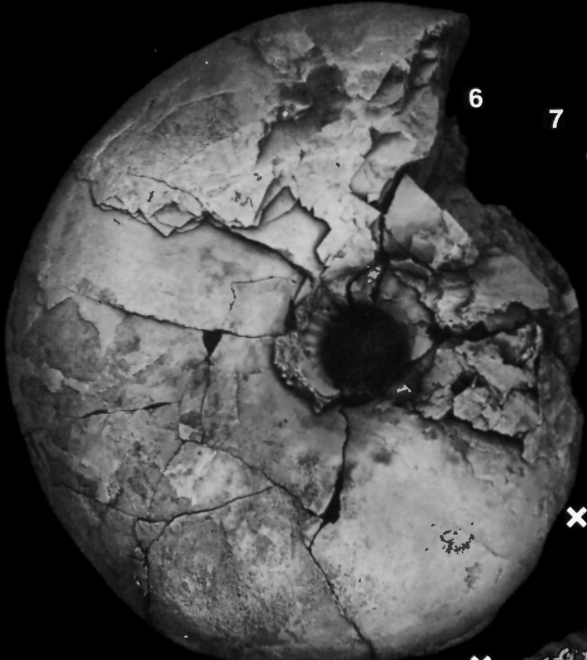
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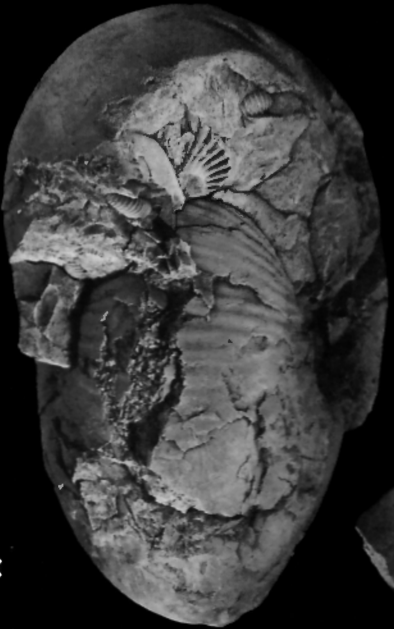
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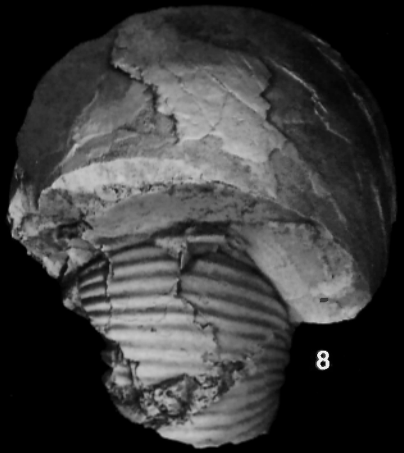
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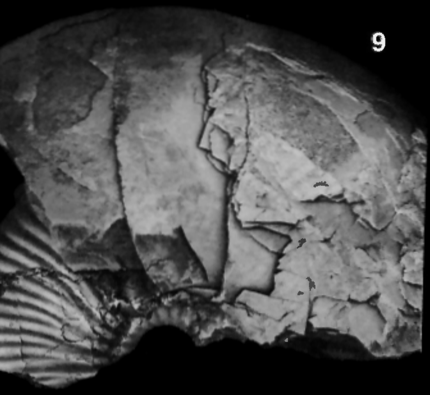
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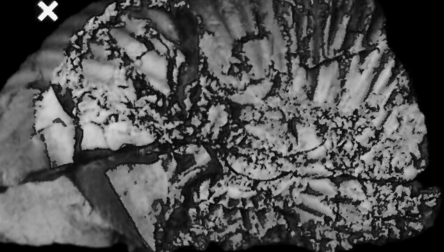
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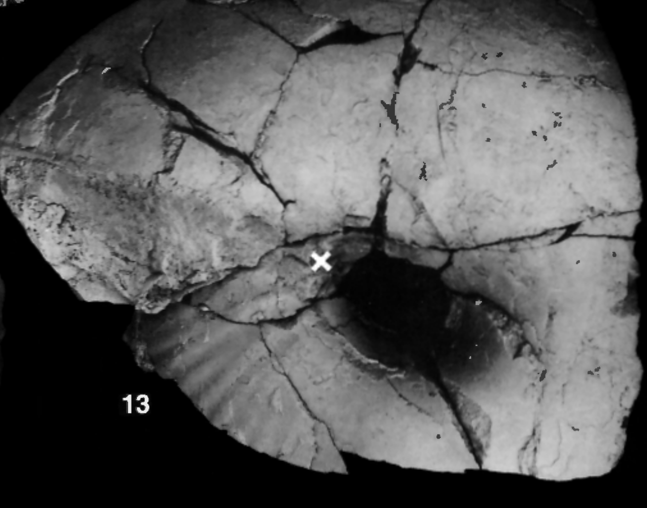
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PLATE 6

Figures 1-5. *Arctocephalites callomoni* Frebold

1-3. Lateral, ventral and cross-sectional views of hypotype GSC 68287 from GSC locality 92520 (loose below section). Whorl fragment shown is entirely septate.

4, 5. Lateral and ventral views of hypotype GSC 68288 from GSC locality C-95369 (loose below section). X marks position of last septum.

Figures 6-14. *Arctocephalites* sp. A aff. *A. nudus* Spath

6, 7. Lateral and cross-sectional views of figured specimen GSC 68289 from GSC locality 92525 (Bed 22). *Porcupinensis* Zone. Whorl shown is nonseptate.

8, 9. Lateral and ventral views of figured specimen GSC 68290 from GSC locality C-86394 (Bed 28). *Amundseni* Zone. Location of terminal constriction shown by arrow. X marks approximate position of last septum.

10, 11. Lateral and ventral views of figured specimen GSC 68291 from GSC locality C-86393 (Bed 26). *Amundseni* Zone. No septae can be seen.

12, 13. Lateral and ventral views of figured specimen GSC 68292 from same locality as figure 10. X marks position of last septum.

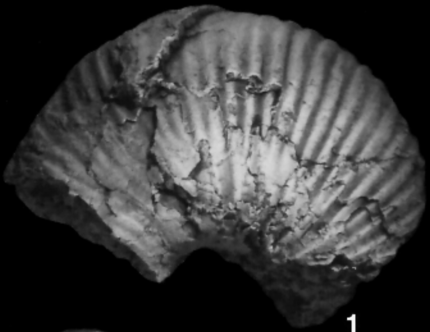
14. Lateral view of fragmentary figured specimen GSC 68293 from same locality as figure 6. No septae can be seen.

Figures 15-18. *Arctocephalites* sp. B aff. *A. nudus* Spath

15, 16. Lateral and ventral views of figured specimen GSC 68294 from GSC locality 92527 (Bed 24) showing also impacted lateral mould of a ribbed portion of another specimen of the same species. *Porcupinensis* Zone. Terminal constriction indicated by arrow. X marks position of last septum.

17, 18. Ventral and lateral views of figured specimen GSC 68295 from same locality as figure 15. X marks position of last septum.

PLATE 6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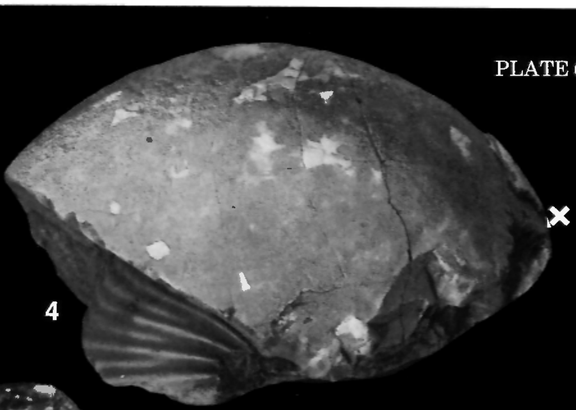
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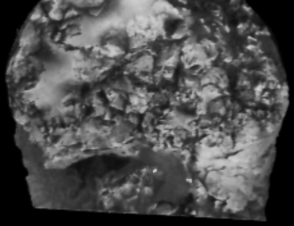
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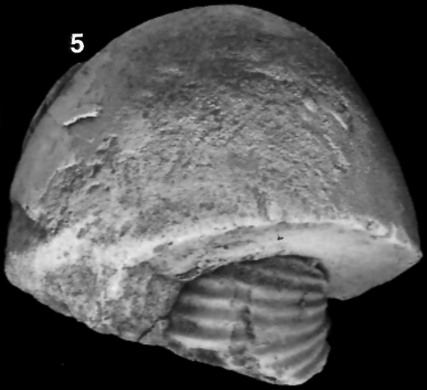
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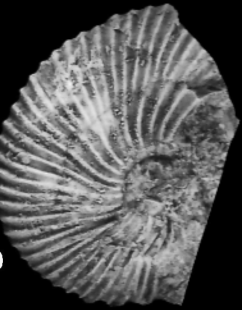
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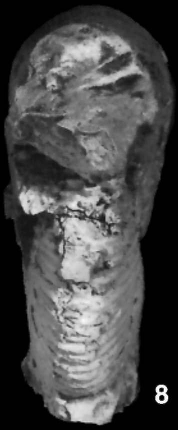
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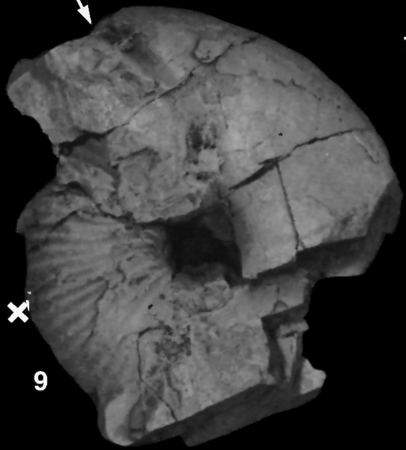
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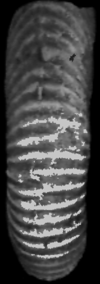
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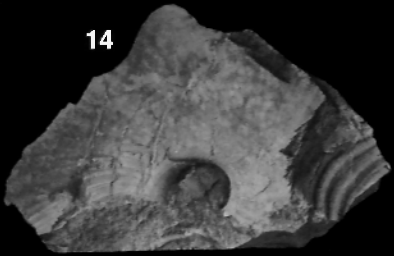
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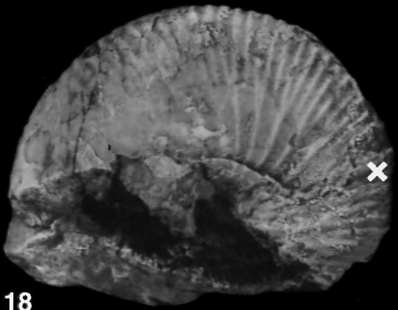
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PLATE 7

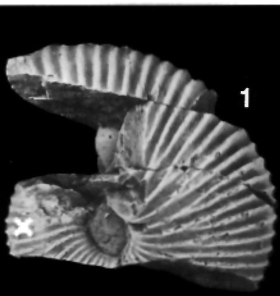
Figures 1-12. *Arctocephalites arcticus* (Whitfield)

1-3.	Lateral, cross-sectional, and ventral views of hypotype GSC 68296 from GSC locality 92527 (Bed 24). *Porcupinensis* Zone. X marks position of last septum.
4, 5.	Lateral and ventral (near peristome) views of part of body chamber, hypotype GSC 68297, from same locality as figure 1. Location of terminal constriction shown by arrow. Whorl fragment is entirely nonseptate.
6, 7.	Lateral and ventral views of hypotype GSC 68298 from same locality as figure 1. X marks position of last septum.
8, 9.	Lateral and ventral views of hypotype GSC 68299 from same locality as figure 1. The whorl height is exaggerated by distortion due to crushing. No septae can be seen.
10.	Lateral view of hypotype GSC 68300 from GSC locality 92530 (loose at level of Bed 30), transitional to *A. praeishmae* n. sp. by its small size and the weak, forward curvation of the ribs. *Amundseni* Zone. X marks position of last septum.
11, 12.	Lateral and oral views of hypotype GSC 68301 from GSC locality 92531 (Bed 32). *Amundseni* Zone. X marks position of last septum.

Figures 13-16. *Arctocephalites praeishmae* n. sp.

13, 14.	Lateral and ventral views of crushed paratype GSC 68302 from GSC locality 92531 (Bed 32). *Amundseni* Zone. Arrow shows position of apertural constriction. No septae can be seen.
15, 16.	Lateral and ventral views of paratype GSC 68303 from GSC locality 92529 (Bed 28). *Amundseni* Zone. X marks position of last septum.

PLATE 7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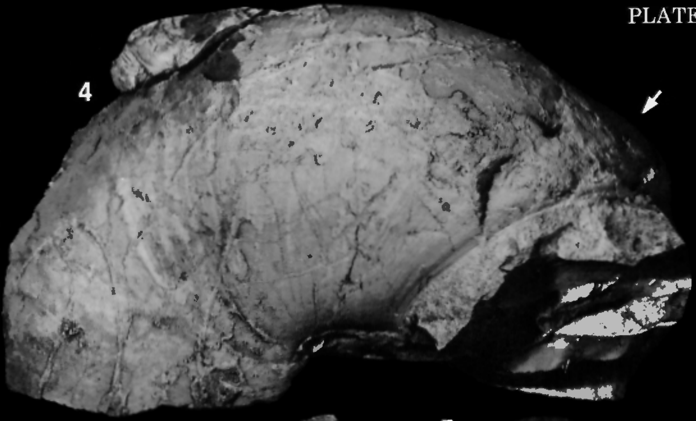
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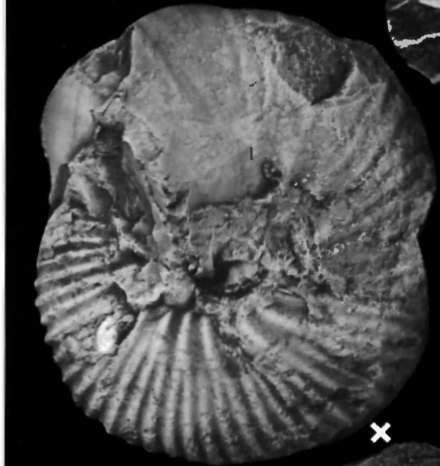
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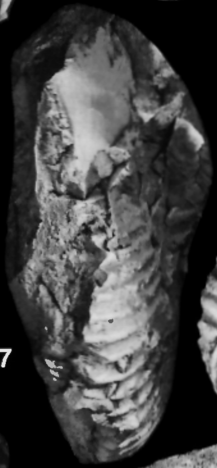
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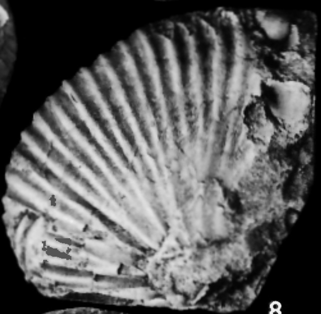
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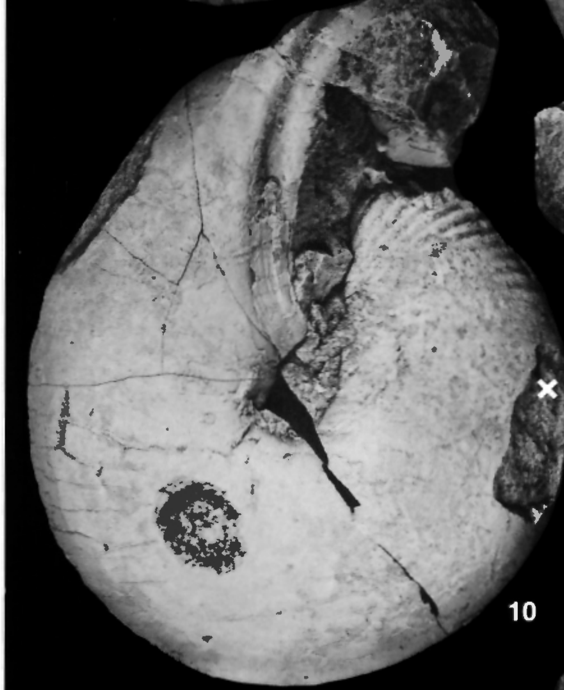
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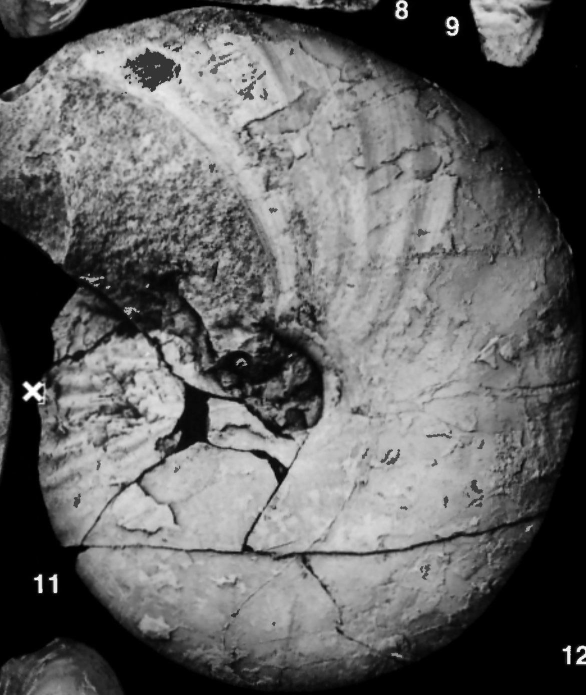
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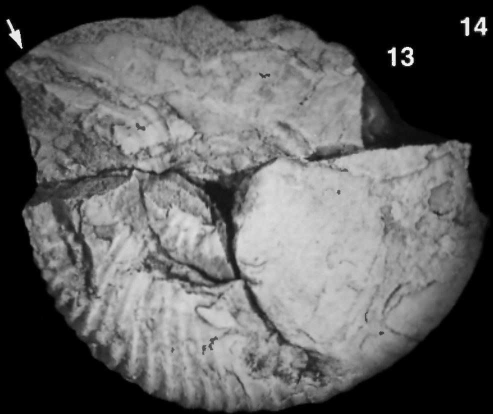
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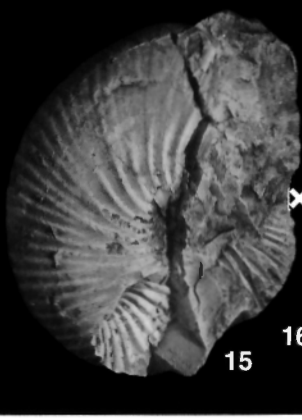
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PLATE 8

Figures 1-4. *Arctocephalites arcticus* (Whitfield)

1, 2. Lateral and ventral views of hypotype GSC 68304 from GSC locality C-86396 (Bed 30). *Amundseni* Zone. Position of apertural constriction shown by arrows. X marks position of last septum.

3, 4. Lateral and ventral views of hypotype GSC 68305 from GSC locality 92520 (loose below section). Broken end of shell marks position of last septum.

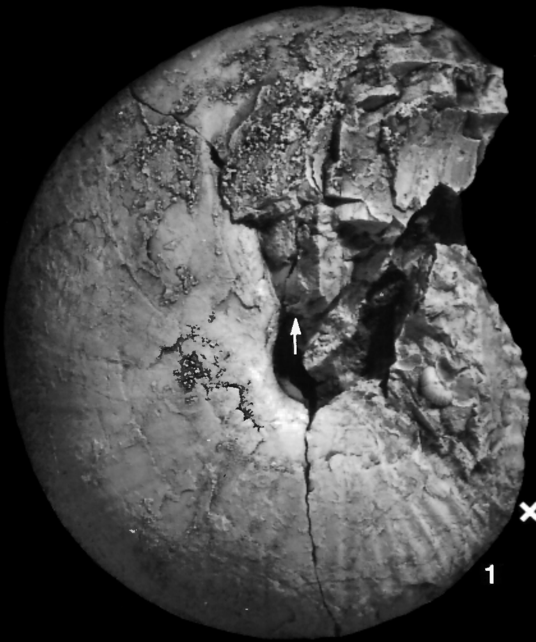
Figures 5-12. *Arctocephalites praeishmae* n. sp.

5, 6. Lateral and ventral views of holotype GSC 68306 from GSC locality 92458 (Bed 34). *Amundseni* Zone. X marks position of last septum.

7, 8. Lateral and ventral views of paratype GSC 68307 from GSC locality C-86394 (Bed 28). *Amundseni* Zone. X marks position of last septum.

9, 10. Lateral and ventral views of paratype GSC 68308 from GSC locality C-86396 (Bed 31). *Amundseni* Zone. X marks position of last septum.

11, 12. Lateral and ventral views of paratype GSC 68309 from same locality as figure 9. Entire whorl nonseptate; arrow marks position of a possible apertural constriction.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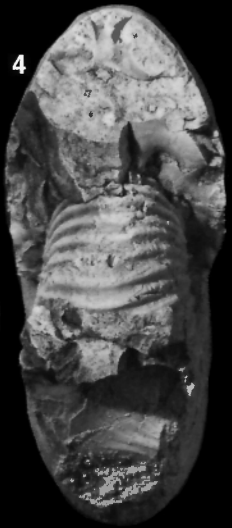
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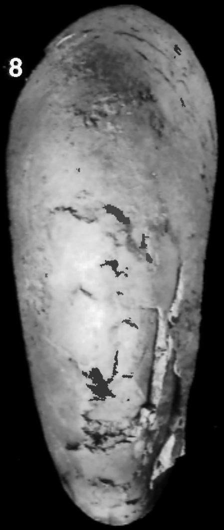
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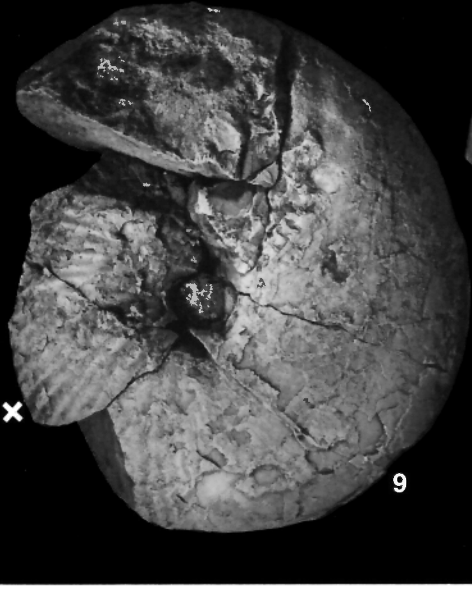
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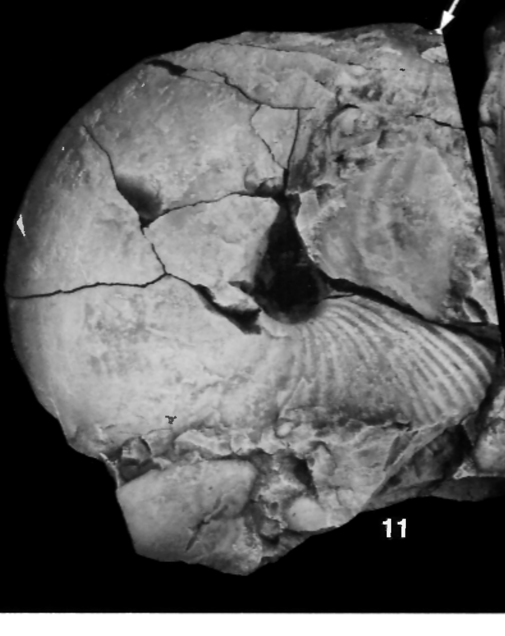
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PLATE 9

Figures 1, 2. *Arctocephalites amundseni* n. sp.

1, 2. Lateral and ventral views of paratype GSC 68310 from GSC locality C-86395 (Bed 30). *Amundseni* Zone. X marks position of last septum.

Figures 3, 4. *Arctocephalites amundseni* n. sp.(?).

3, 4. Ventral and lateral views of figured specimen GSC 68311 from GSC locality C-95358 (Bed 36). *Amundseni* Zone. X marks position of last septum.

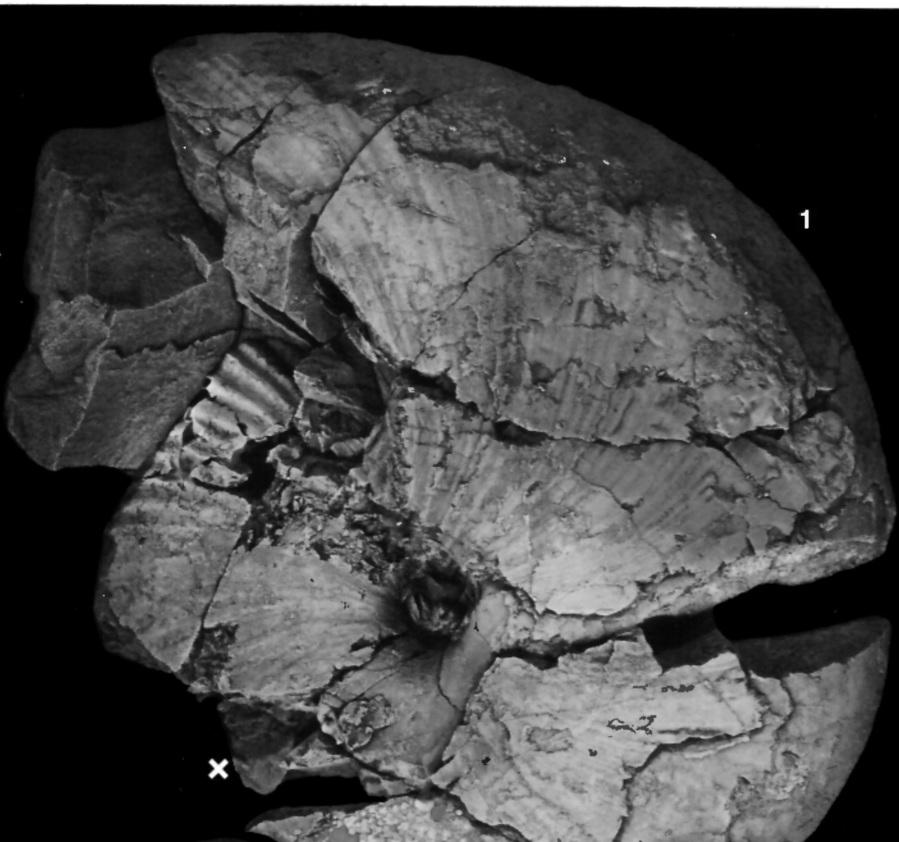
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PLATE 10

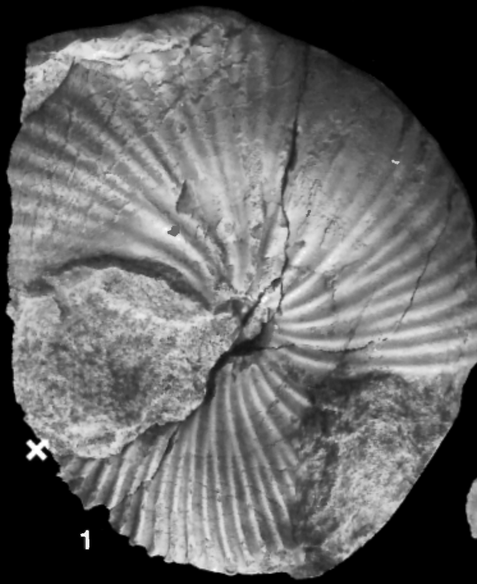
Figures 1-8. *Arctocephalites kigilakhensis* Voronetz

1. Lateral view of crushed hypotype GSC 68312 from GSC locality C-95357 (Bed 32). *Amundseni* Zone. X marks approximate position of last septum.

2-4. Lateral (with and without outer whorl) and ventral views of hypotype GSC 68313 from same locality as figure 1. X marks approximate position of last septum.

5-7. Lateral (with and without outer whorl) and ventral views of hypotype GSC 68314 from same locality as figure 1. X marks approximate position of last septum.

8. Lateral view of hypotype GSC 68315 from GSC locality 92529 (Bed 28), showing apertural constriction. *Amundseni* Zone. X marks approximate position of last septum.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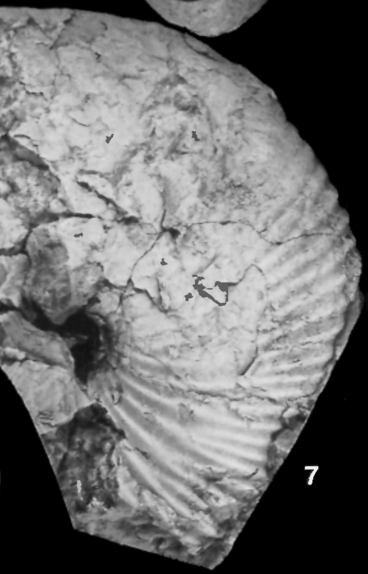
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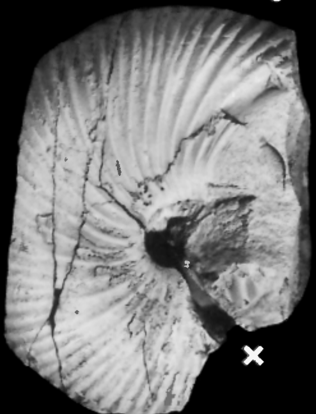
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PLATE 11

Figures 1-12. *Arctocephalites kigilakhensis* Voronetz

1-4. Lateral and ventral views (with and without outer whorls) of hypotype GSC 68316 from GSC locality C-86396 (Bed 31). *Amundseni* Zone. X marks approximate position of last septum. Corresponding points of figures 1 and 4, rotated with respect to each other, shown by circle.

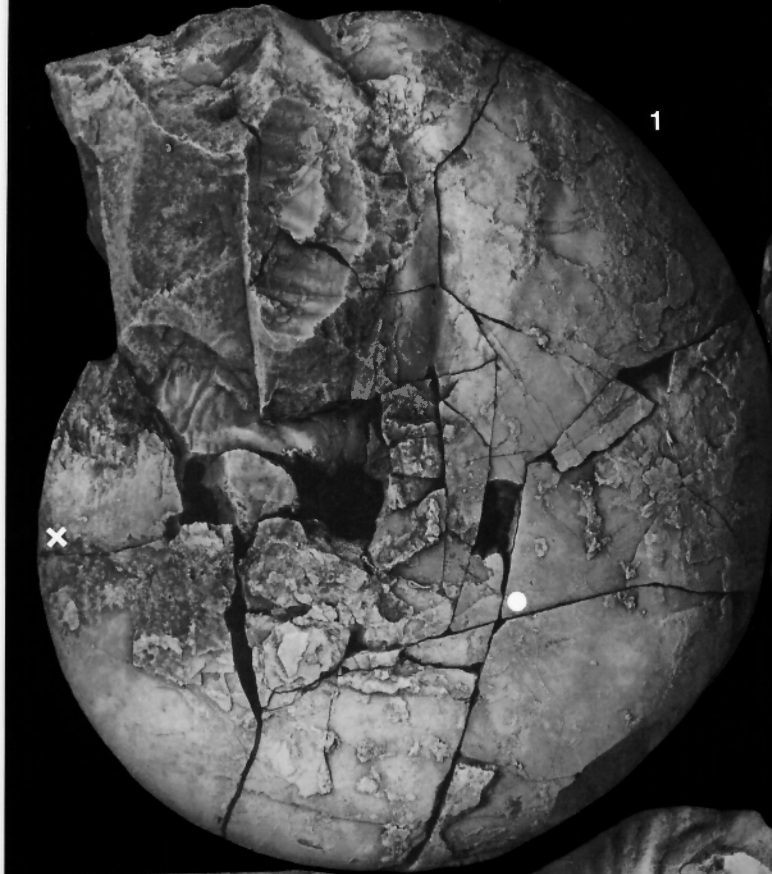
5, 6. Lateral and ventral views of fragmentary hypotype GSC 68317 from GSC locality 92473 (loose below section). Fragment is entirely nonseptate.

7, 8. Ventral and lateral views of fragmentary hypotype GSC 68318 from GSC locality 35619 (Bed 40). *Amundseni* Zone. X marks approximate position of last septum.

9. Lateral view of hypotype GSC 68319 from same locality as figure 7. No septae can be seen.

10. Lateral view of latex cast of hypotype GSC 68320 from GSC locality 92532 (Bed 42). *Amundseni* Zone. No septae can be seen.

11, 12. Ventral and lateral views of hypotype GSC 68321 from same locality as figure 10. Fragment is entirely septate.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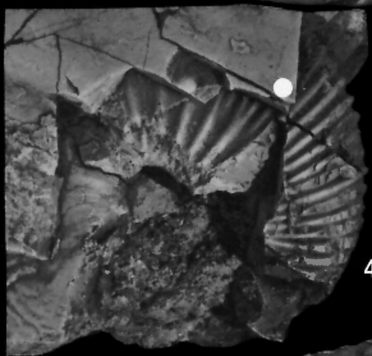
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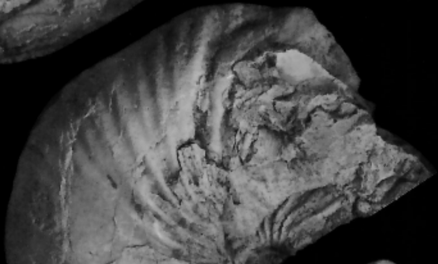
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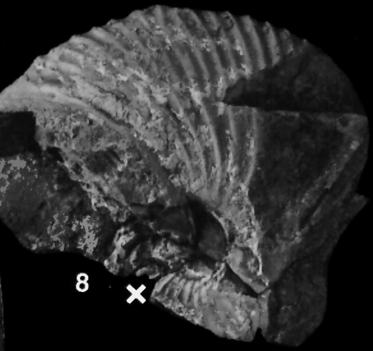
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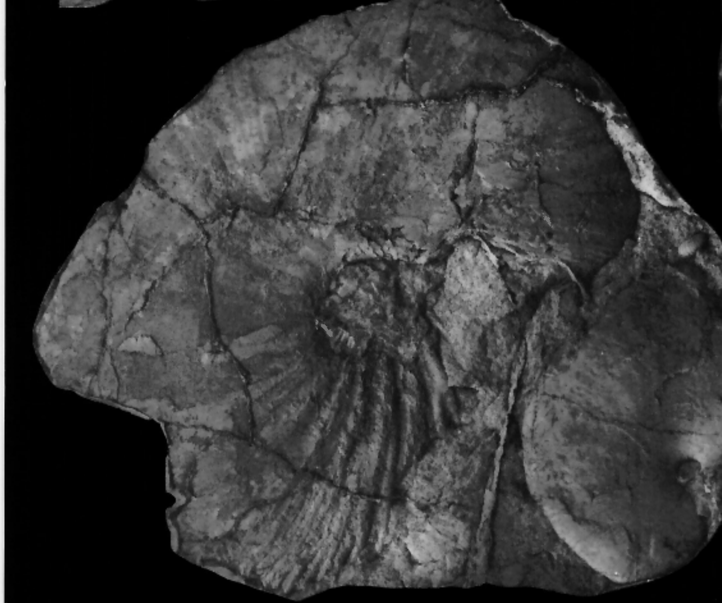
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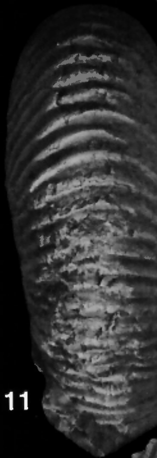
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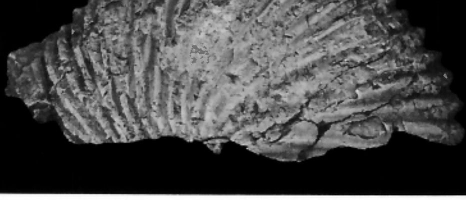
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PLATE 12

Figures 1-4. *Arctocephalites kigilakhensis* Voronetz

1, 2. Ventral and lateral views of hypotype GSC 68322 from GSC locality 35692 (loose below section). Fragment is entirely nonseptate. Note uncoiling.

3, 4. Ventral and lateral views of hypotype GSC 68323 from GSC locality 92520 (loose below section). Arrow points to apertural constriction. X marks position of last septum.

Figures 5, 6. *Arctocephalites amundseni* n. sp.

5, 6. Lateral and ventral views of holotype GSC 68324 from GSC locality C-86394 (Bed 28). *Amundseni* Zone. X marks position of last septum.

Figures 7-10. *Arctocephalites frami* n. sp.

7, 8. Lateral and ventral views of paratype GSC 68325 from GSC locality C-95363 (Bed 47). *Frami* Zone. X marks probable position of last septum.

9, 10. Lateral and ventral views of paratype GSC 68326 from GSC locality 92473 (loose below section). X marks possible position of last septum.


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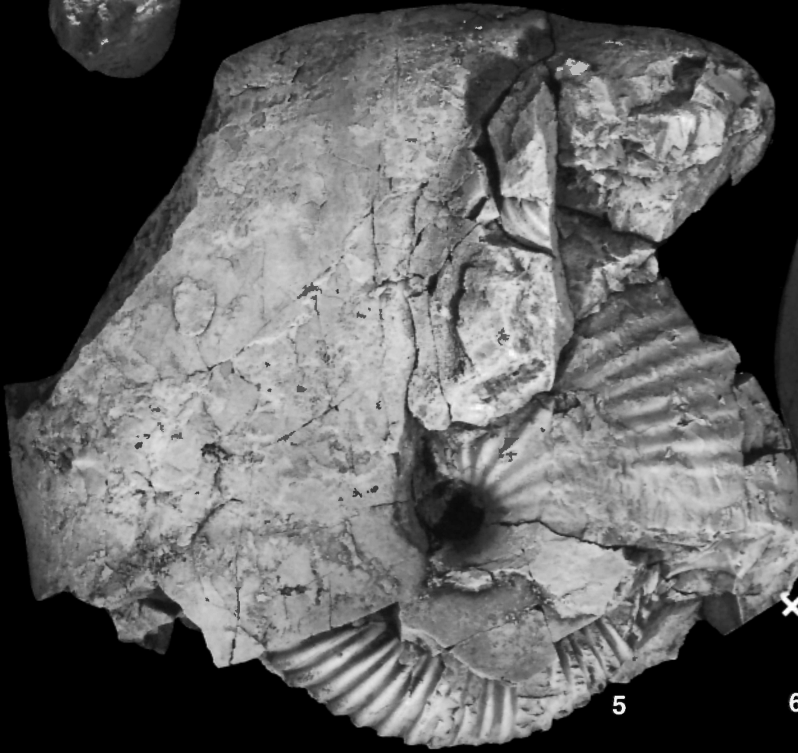
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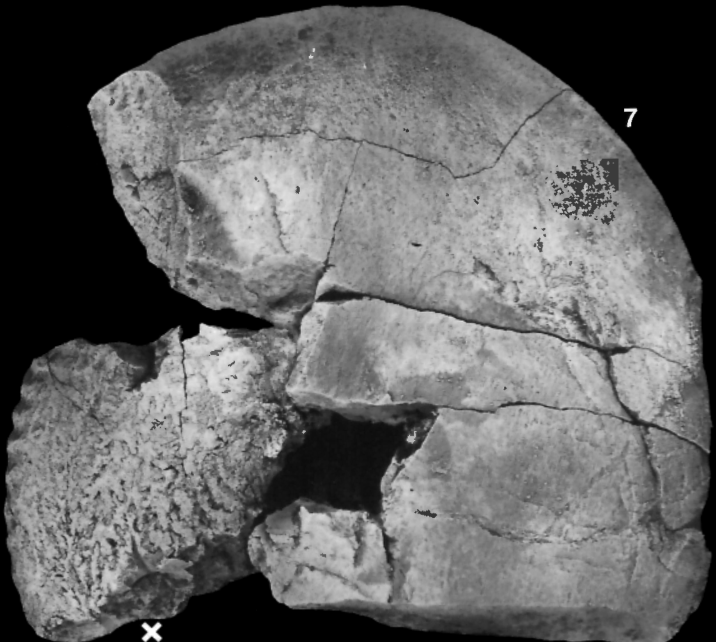
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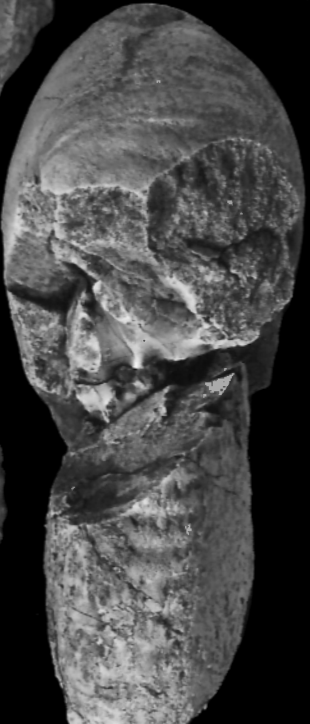
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PLATE 13

Figures 1-11. *Arctocephalites frami* n. sp.

1-4. Lateral (with and without body chamber fragment; circles indicate same point on figures 2 and 3, which are rotated with respect to each other), and ventral views of holotype GSC 68327 from GSC locality 92536 (Bed 47). *Frami* Zone. X marks probable position of last septum.

5-7. Lateral (with and without crushed body chamber) and cross-sectional views of paratype GSC 68328 from GSC locality 92535 (Bed 46). *Frami* Zone. Outer whorl nonseptate; inner whorl shown entirely septate.

8, 9. Lateral and ventral views of fragmentary paratype GSC 68329 from GSC locality C-95369 (loose below section). Whorl figured is entirely nonseptate.

10, 11. Lateral and ventral views of paratype GSC 68330 from GSC locality 35631 (beds 47-50). *Frami* Zone. X marks position of last septum.

PLATE 13


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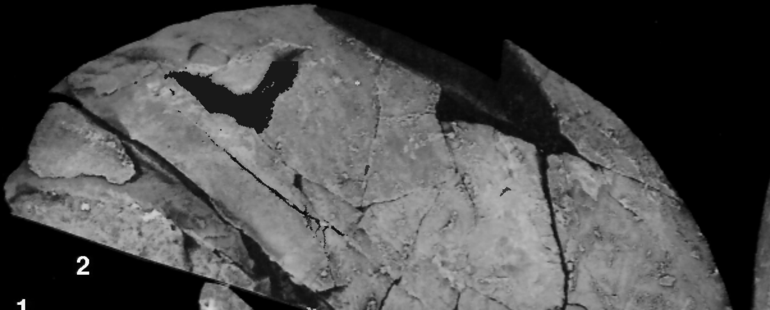
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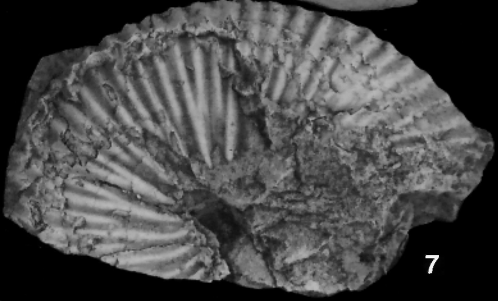
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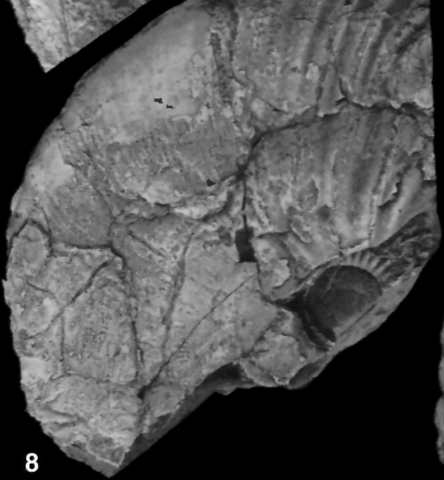
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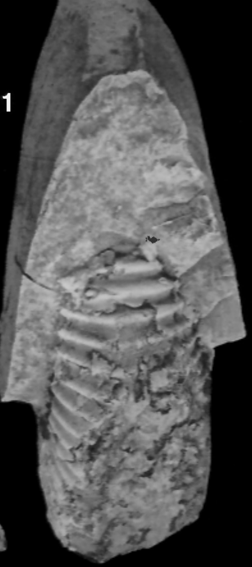
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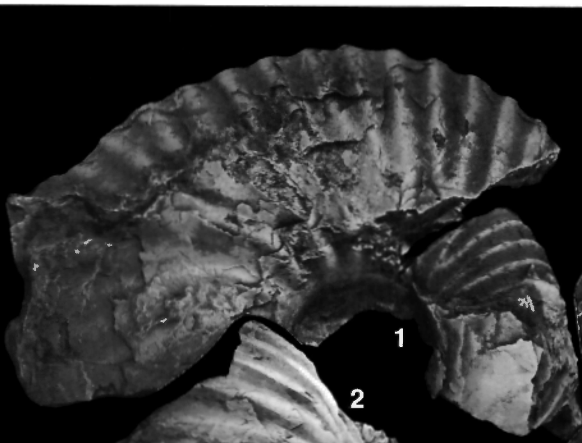
PLATE 14

Figures 1-9. *Arctocephalites* sp. A

1-4. Lateral and ventral views of intermediate and outer whorls of figured specimen GSC 68331 from GSC locality 92561 (loose below section). X marks approximate position of last septum.

5-7. Ventral, lateral and cross-sectional views of fragmentary figured specimen GSC 68332 from GSC locality 92473 (loose below section). Whorl illustrated is entirely nonseptate.

8, 9. Ventral and lateral views of fragmentary figured specimen GSC 68333 from GSC locality 92546 (loose below section). Whorl illustrated is entirely septate.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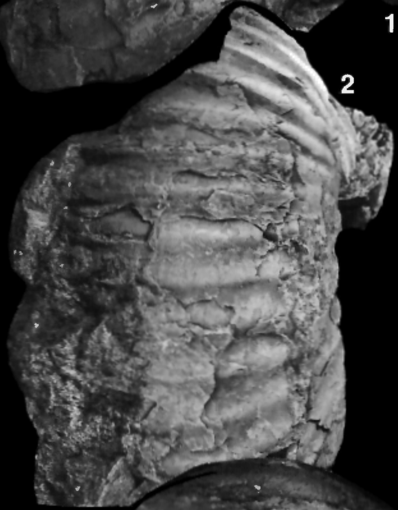
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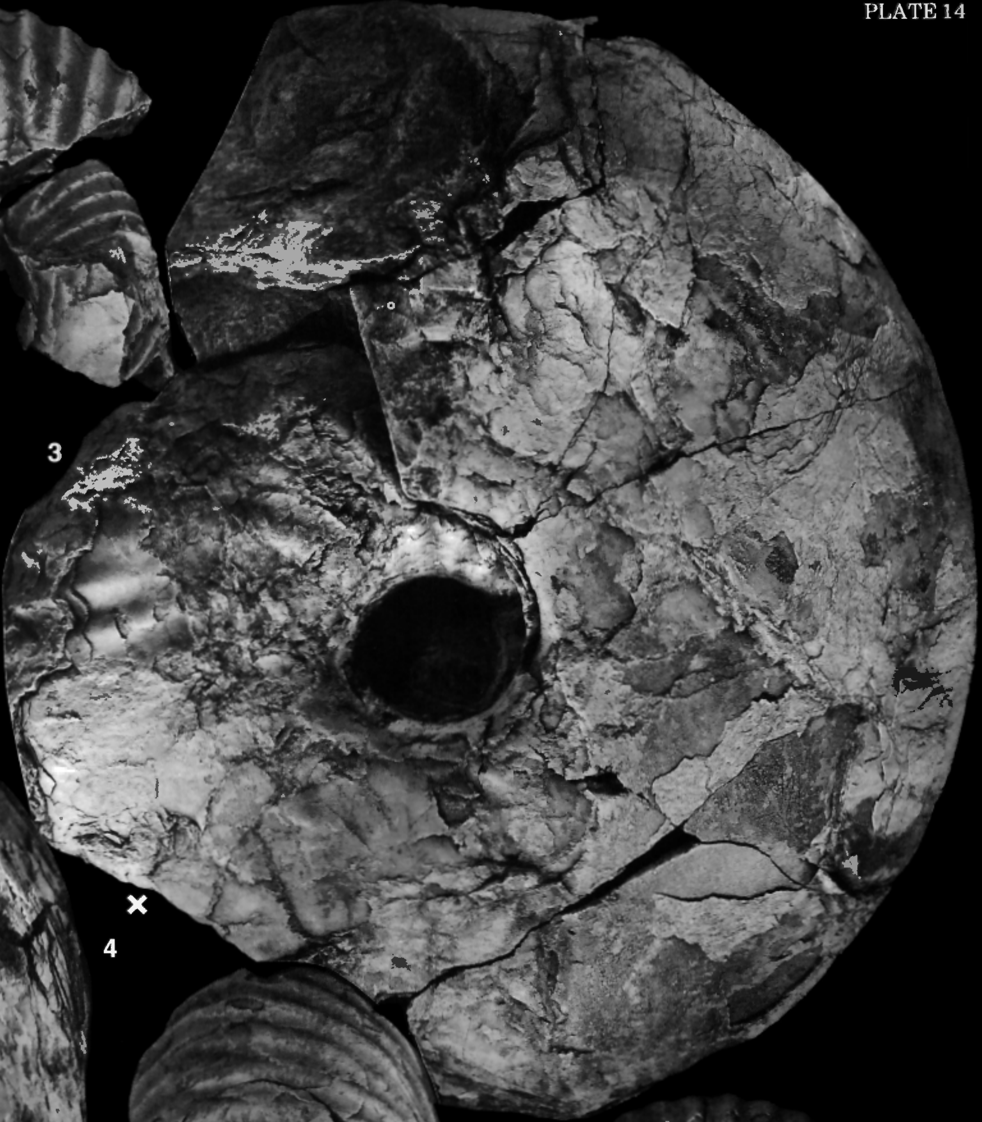
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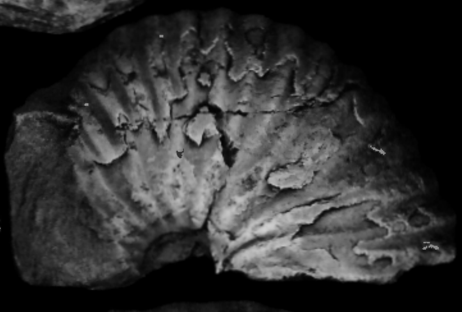
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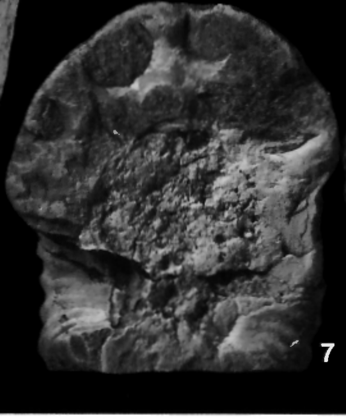
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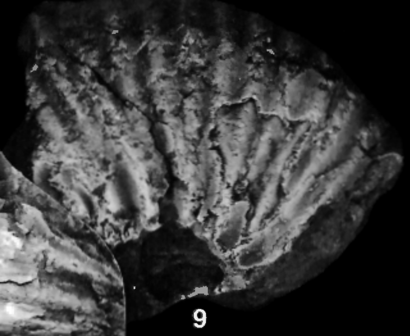
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PLATE 15

Figures 1-4. ***Arctocephalites*** **sp. B**

1-4. Lateral and ventral views of intermediate and outer whorls of figured specimen GSC 68334 from GSC locality 35616 (Bed 36, 37 or 38). *Amundseni* Zone.

Figures 5, 6. ***Arctocephalites*** **sp. B(?)**

5, 6. Lateral and ventral views of figured specimen GSC 68335 from GSC locality C-95372 (loose below section). Fragment is entirely septate.

Figures 7-9. ***Arctocephalites*** **sp. A**

7. Ventral fragment, figured specimen GSC 68336 from GSC locality 35619 (Bed 40). *Amundseni* Zone.

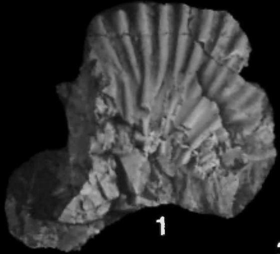
8, 9. Lateral and ventral views of figured specimen GSC 68337 from GSC locality 92520 (loose below section). X marks position of last septum.

Figure 10. ***Arctocephalites*** **sp. C**

10. Lateral view of latex cast of small fragment, GSC 68338 from GSC locality 92532 (Bed 42). *Amundseni* Zone.

Figures 11, 12. ***Arctocephalites*** **sp. D**

11, 12. Ventral and lateral views of figured specimen GSC 68339 from GSC locality C-86396 (Bed 31). *Amundseni* Zone. X marks approximate position of last septum.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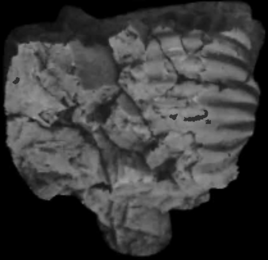
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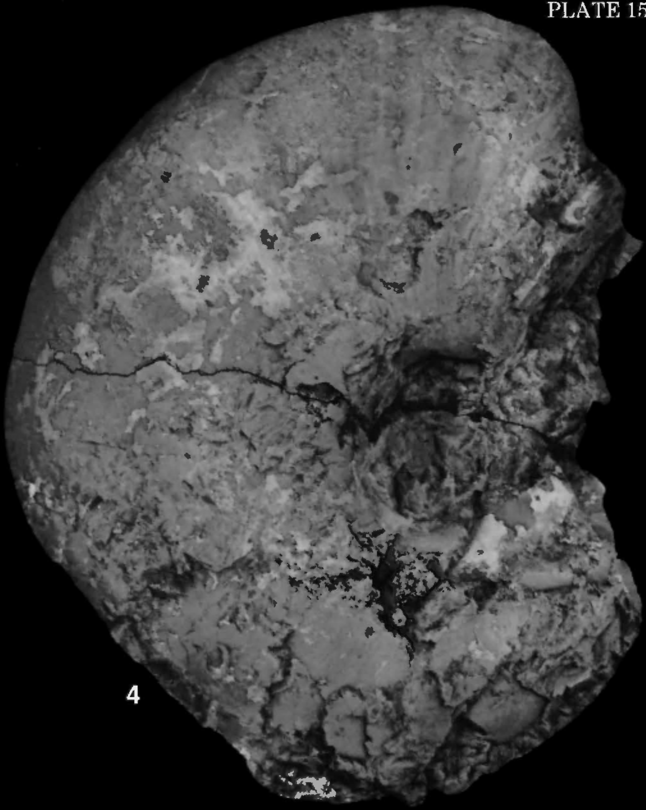
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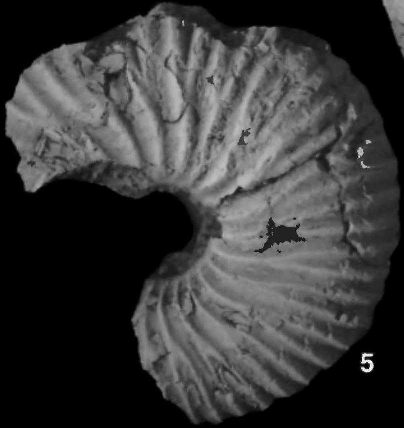
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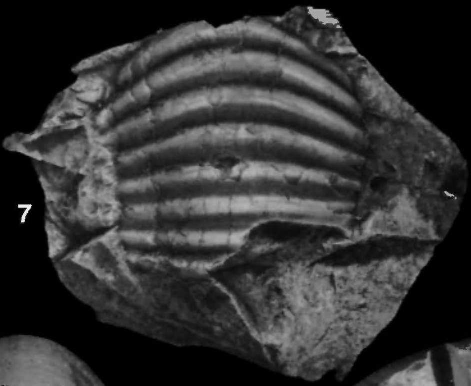
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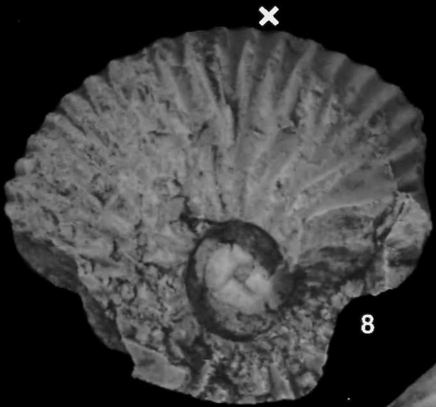

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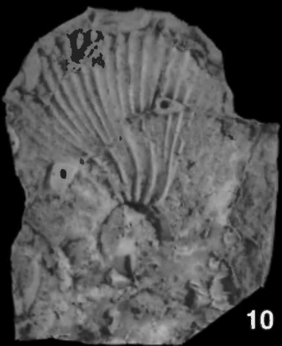
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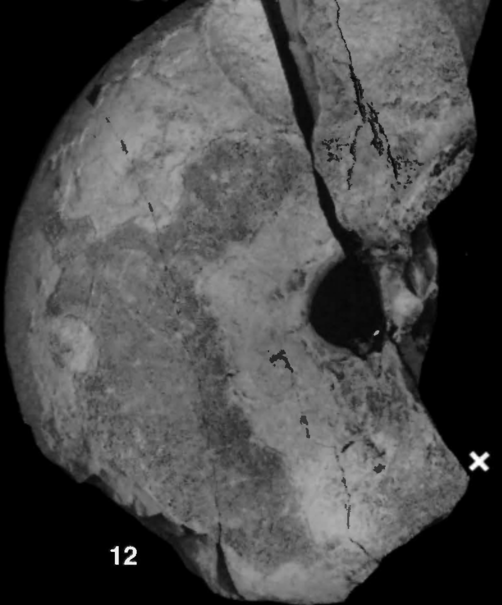

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PLATE 16

Figures 1-4. *Arctocephalites*(?) *freboldi* (Spath)

1, 2. Lateral and ventral views of plaster cast of holotype MMH 9257 of *Cadoceras freboldi* Spath (1932, p. 65, Pl. 18, fig. 2a, b); supplied by T. Birkelund, showing previously unfigured outer whorl.

3, 4. Lateral and ventral views of hypotype GSC 68340 from GSC locality C-86395 (Bed 30). *Amundseni* Zone. X marks position of last septum.

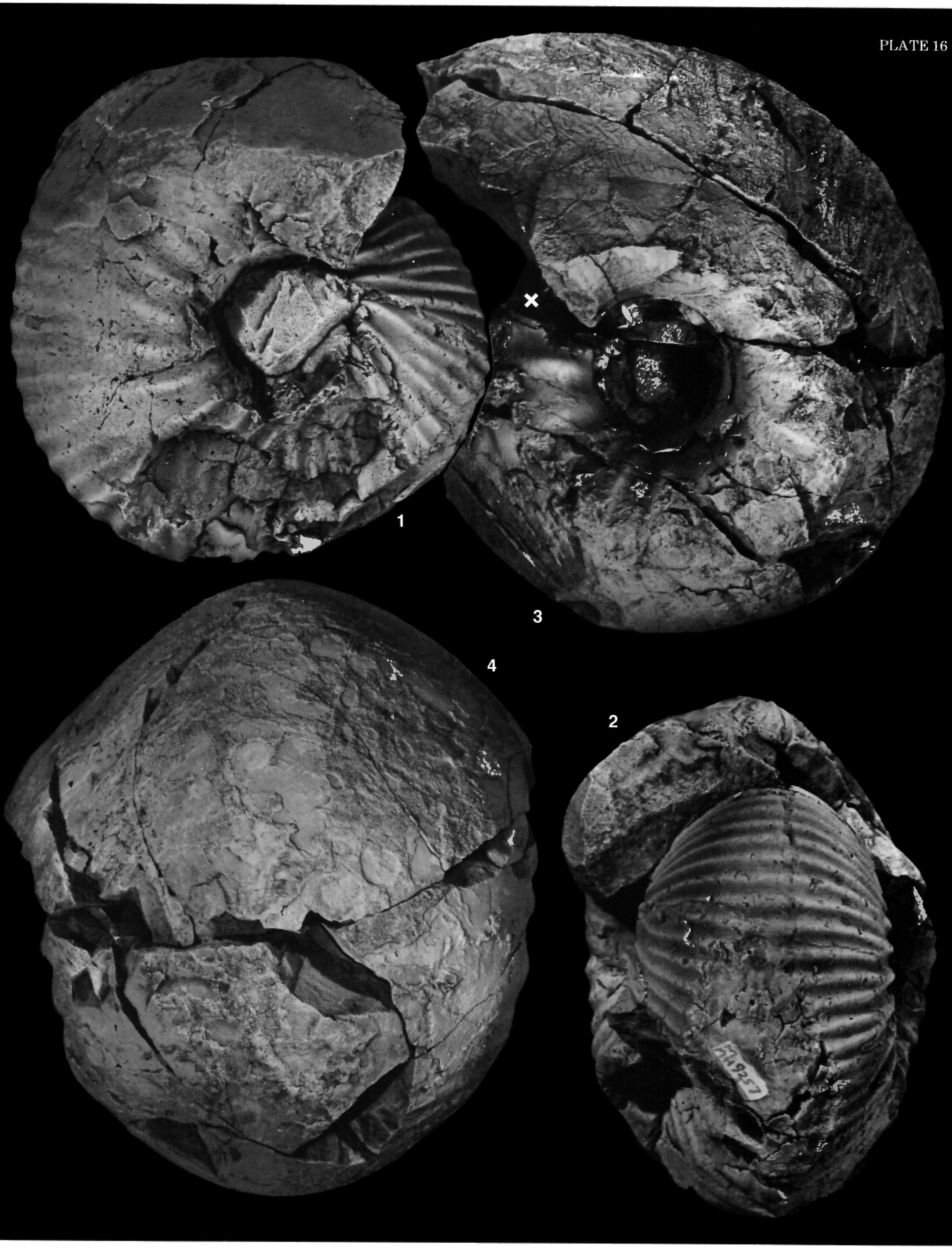
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PLATE 17

Figures 1-3. *Arctocephalites*(?) ***belli*** n. sp.

1-3. Cross-sectional, lateral, and ventral views of holotype GSC 68341 from GSC locality 92564 (loose below section). X marks position of last septum.

Figures 4-6. *Arctocephalites*(?) sp. aff. *A.*(?) *freboldi* (Spath).

4-6. Lateral view of latex cast of large whorl fragment, and lateral and ventral views of intermediate whorl, figured specimen GSC 68342 from GSC locality C-95365 (Bed 53). *Harlandi* Zone.


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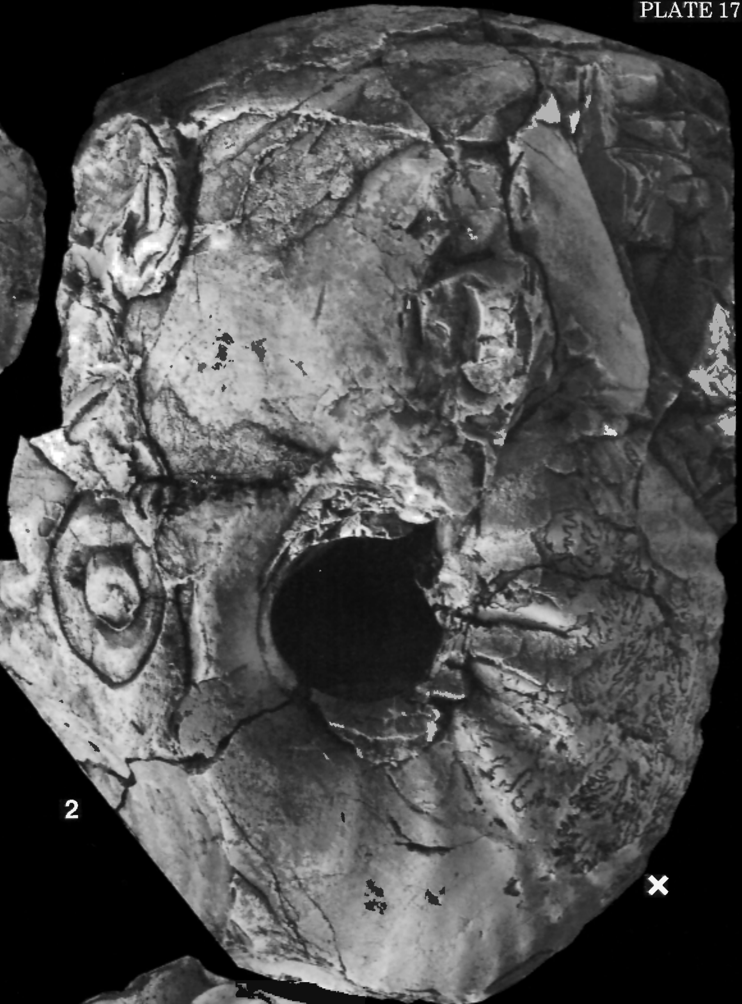
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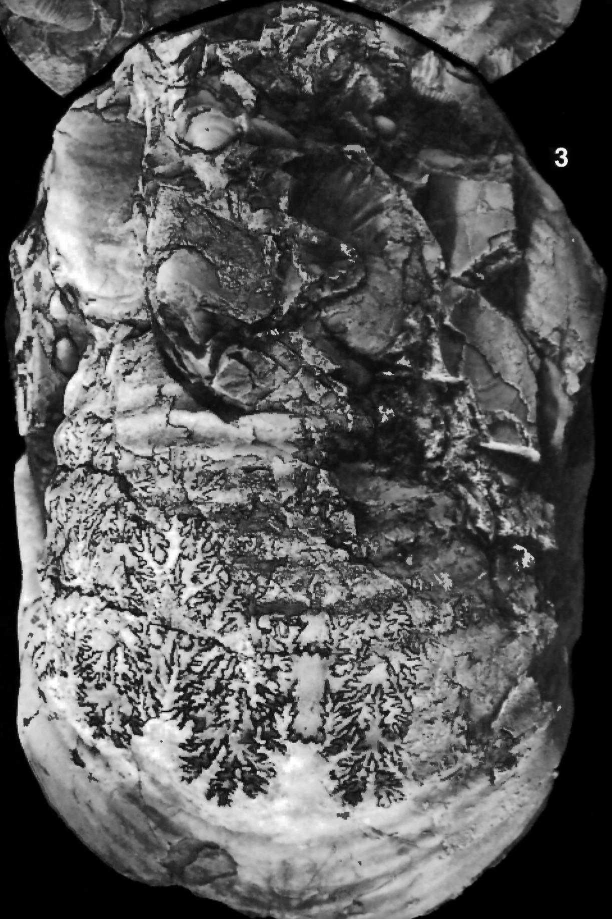
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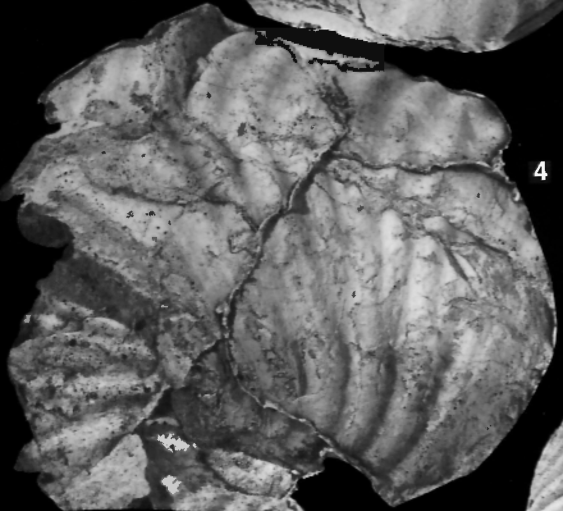
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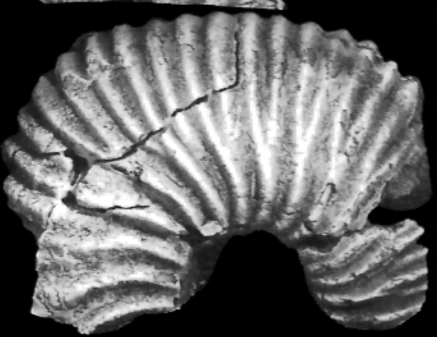
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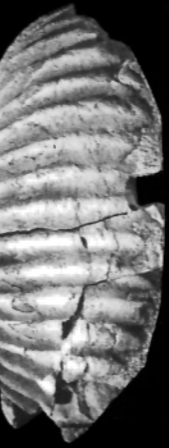
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PLATE 18

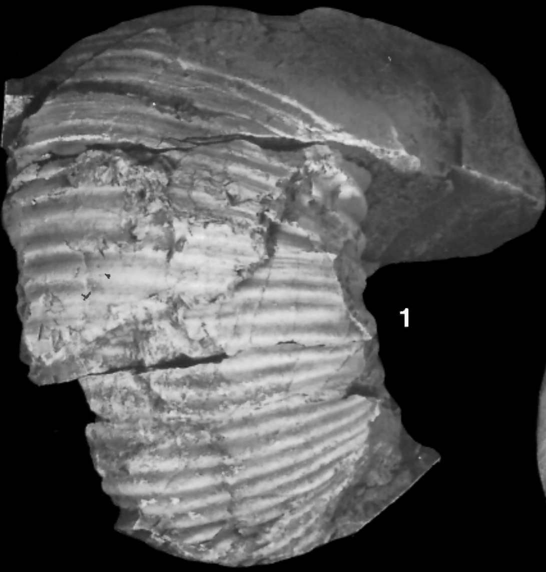
Figures 1-5. *Arctocephalites*(?) sp. aff. *A.*(?) *crassum* (Madsen)

1-3. Ventral and oblique views of intermediate whorls, and cross-sectional views of complete, crushed, figured specimen GSC 68343 from GSC locality C-86393 (Bed 26). *Amundseni* Zone. The subquadrate cross-section of the outer whorl is suggested in figure 2.

4, 5. Lateral and ventral views of figured specimen GSC 68344 from GSC locality 92525 (Bed 22). *Porcupinensis* Zone.

Figures 6, 7. *Arctocephalites*(?) *belli* n. sp.

6, 7. Lateral and ventral views of paratype GSC 68345 from GSC locality C-95362 (Bed 46). *Frami* Zone.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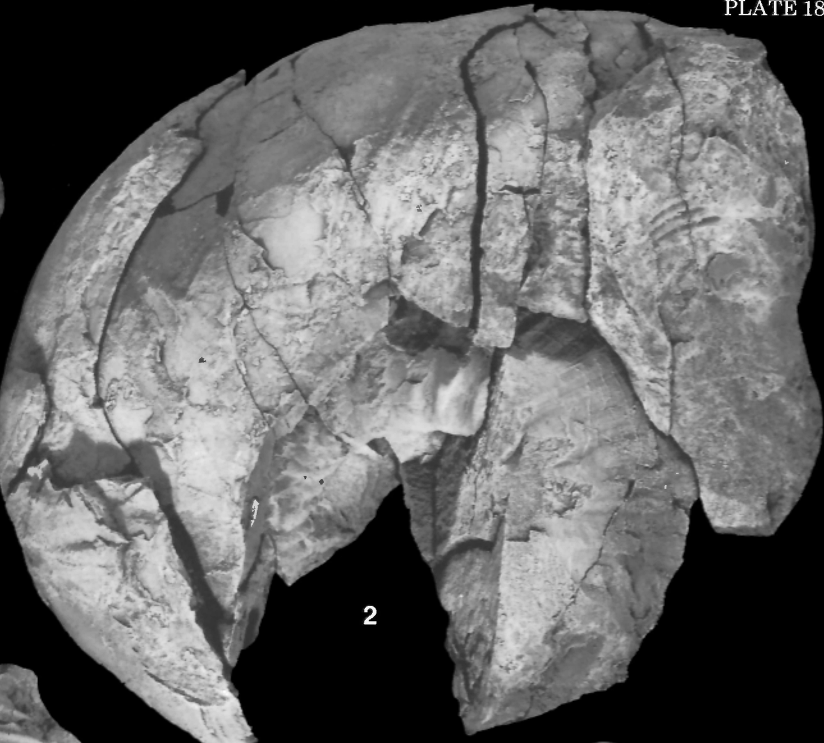
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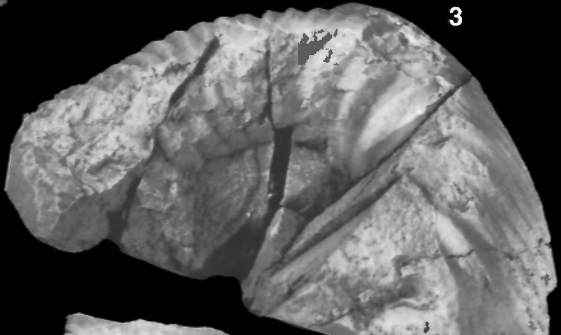
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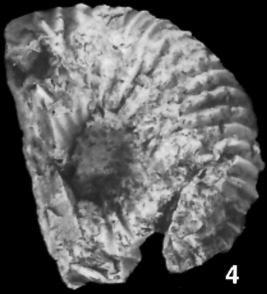
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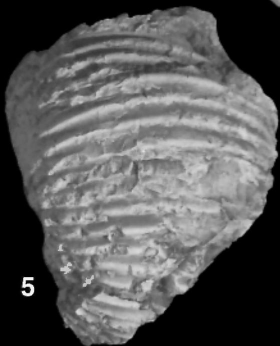
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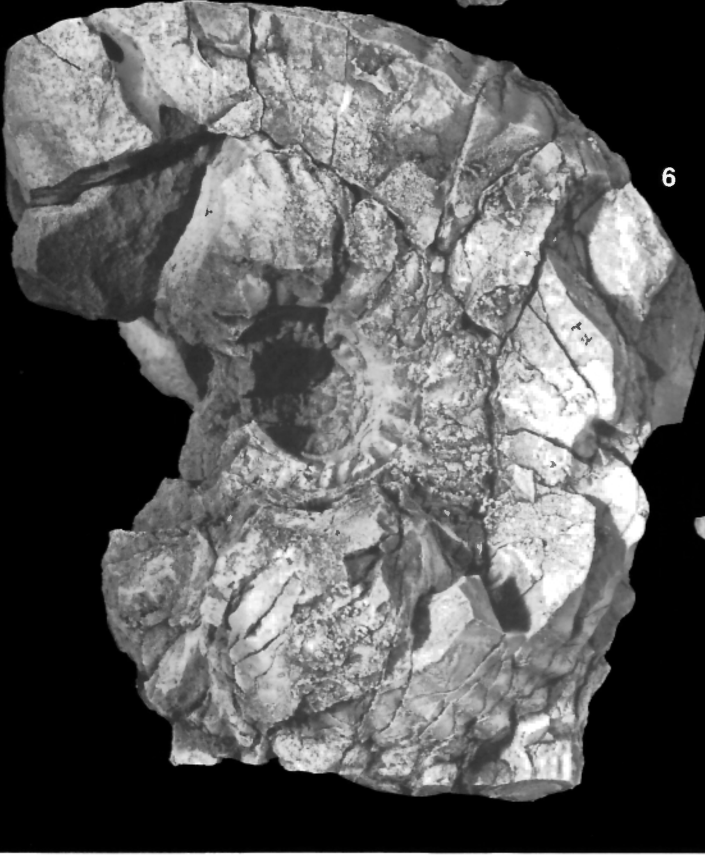
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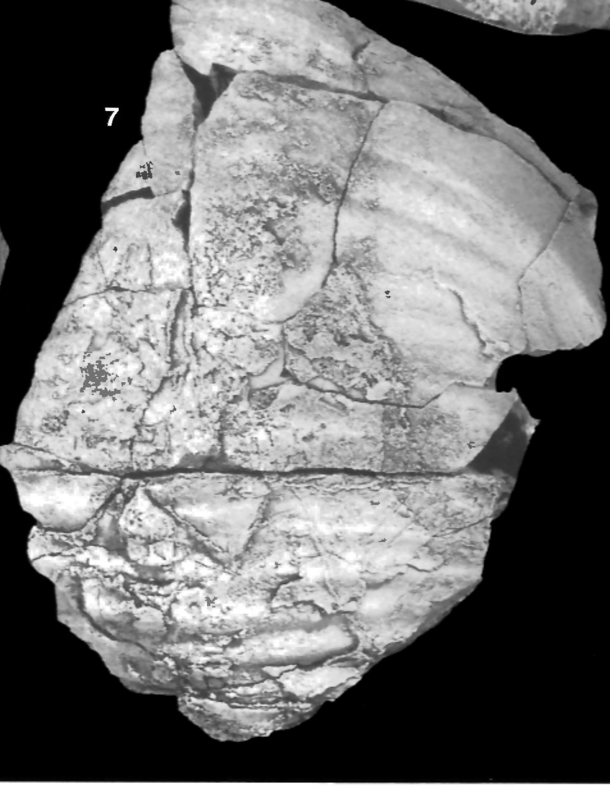
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PLATE 19

Figures 1, 2, 5-8. *Arcticoceras harlandi* Rawson

1, 2.	Ventral and lateral views of figured specimen GSC 68346 from GSC locality C-95365 (Bed 53). *Harlandi* Zone. Specimen is entirely septate.
5, 6.	Lateral and ventral views of figured specimen GSC 68347 from GSC locality 92473 (loose below section). Specimen is entirely septate.
7, 8.	Lateral and ventral views of figured specimen GSC 68349 from GSC locality C-95365 (Bed 53). *Harlandi* Zone.

Figures 3, 4. *Arctocephalites*(?) *belli* n. sp.

3, 4.	Ventral views of apertural part of body chamber, and of preceding whorl fragment, paratype GSC 68348 from GSC locality C-95362 (Bed 46). *Frami* Zone.

Figures 9, 10. *Arctocephalites*(?) sp. E

9, 10.	Lateral and ventral views of figured specimen GSC 68350 from GSC locality C-95364 (Bed 48). Unnamed Zone. X marks approximate position of last septum.


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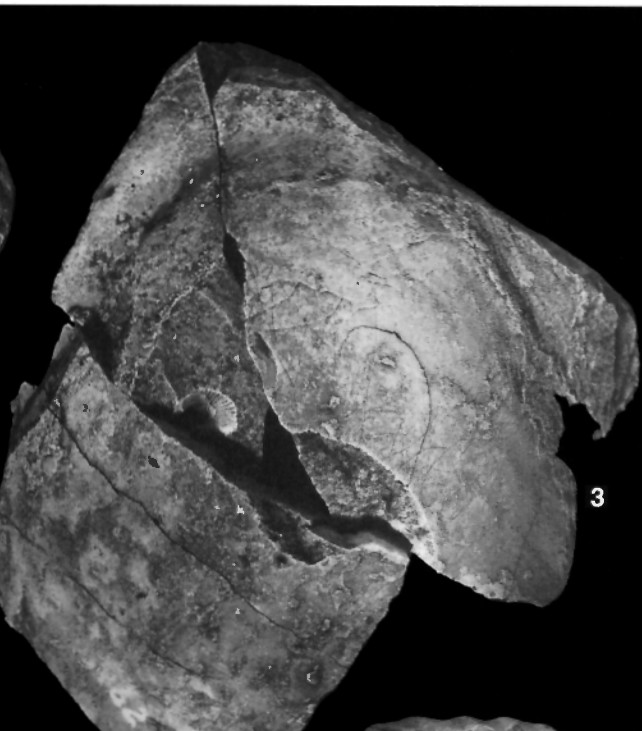
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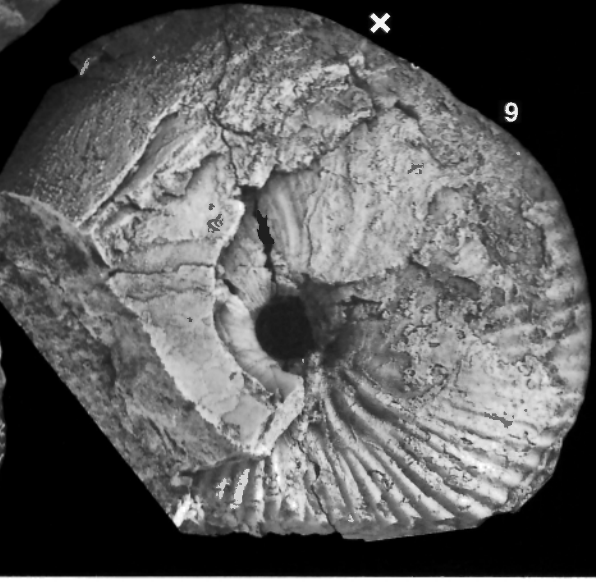
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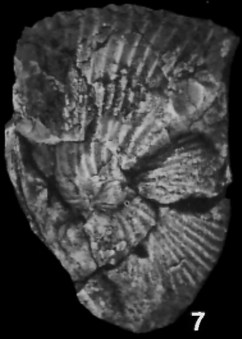
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PLATE 20

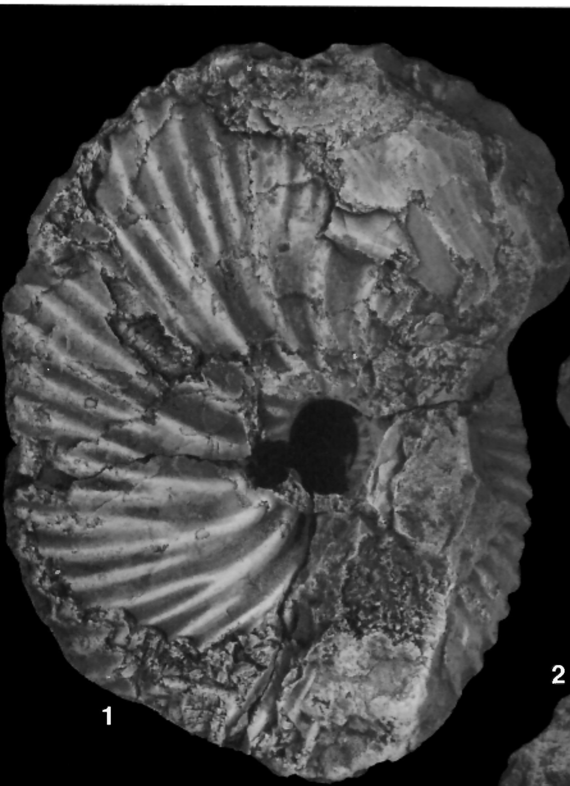
Figures 1-4. *Arcticoceras harlandi* Rawson

1, 2. Lateral and ventral views of figured specimen GSC 68351 from GSC locality 92520 (loose below section). Specimen is entirely septate.

3, 4. Lateral and ventral views of figured specimen GSC 68352 from GSC locality 92520 (loose below section). Specimen is entirely nonseptate.

Figures 5-8. *Arcticoceras ishmae* (Keyserling)

5-8. Ventral and lateral (figures 5 and 7 at aperture showing apertural constriction) views of hypotype GSC 68353 from GSC locality 92540 (Bed 60). *Ishmae* Zone. Entire whorl illustrated is nonseptate.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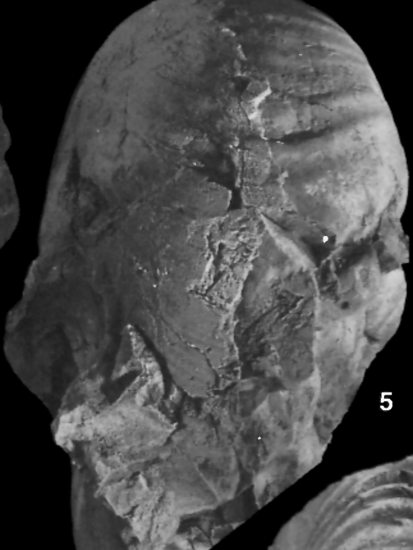
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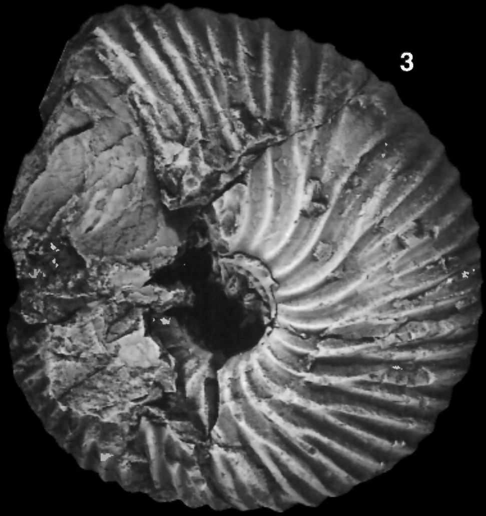
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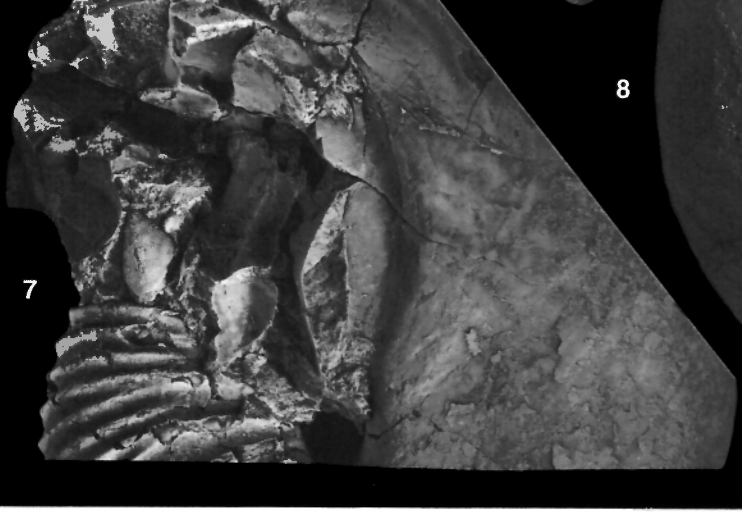
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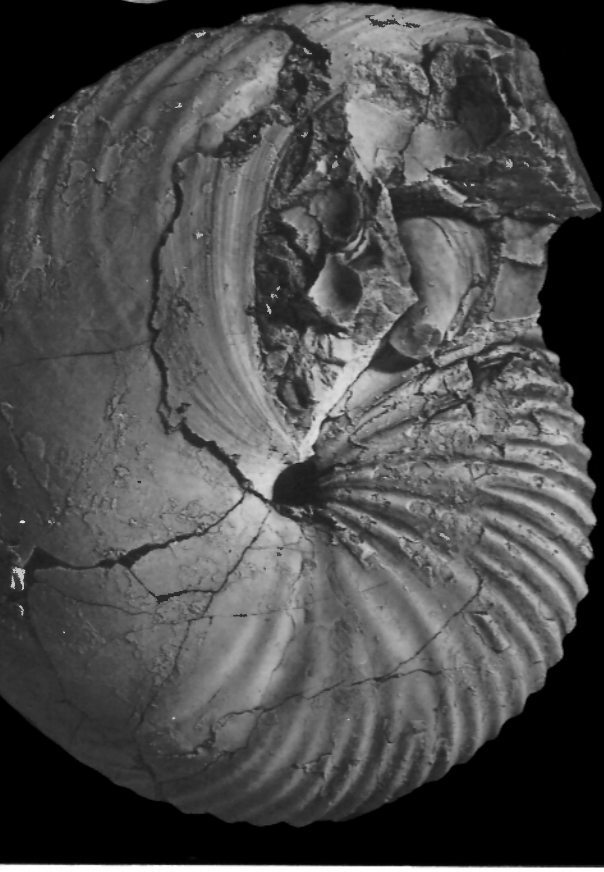
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PLATE 21

Figures 1-5. *Arcticoceras ishmae* (Keyserling)

1, 2. Ventral and lateral views of hypotype GSC 68354 from GSC locality 92556 (loose below section). X marks approximate position of last septum.

3. Lateral view of figured specimen GSC 68355 from GSC locality 92564 (loose below section). Specimen is entirely septate.

4, 5. Ventral and lateral views of figured specimen GSC 68356 from GSC locality 92554 (loose below section). X marks approximate position of last septum.

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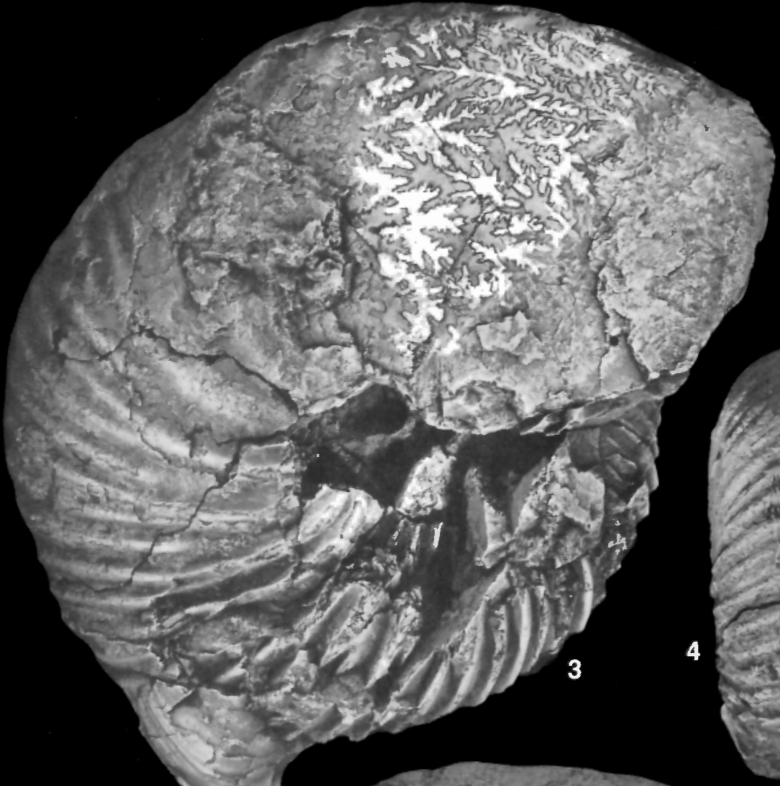

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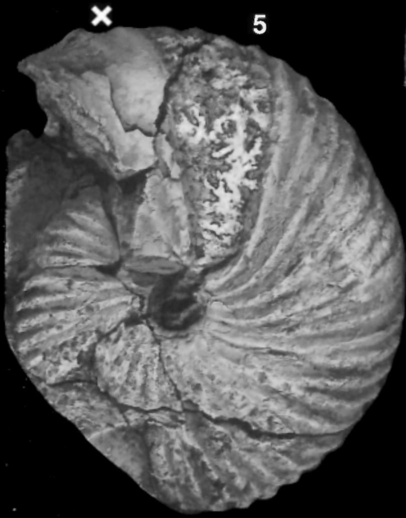

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PLATE 22

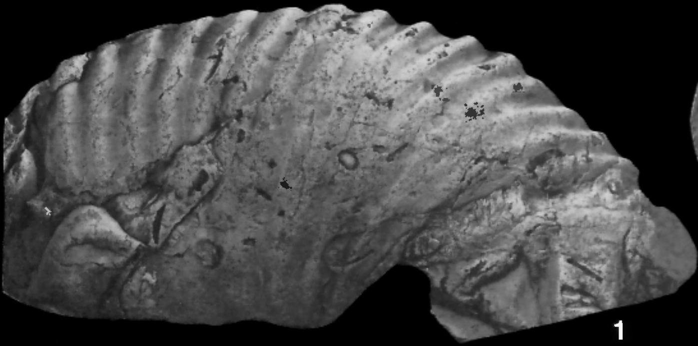
Figures 1-7. *Arcticoceras ishmae* (Keyserling)

1.	Lateral view of figured specimen GSC 68357 from GSC locality 92473 (loose below section). Whorl fragment is entirely nonseptate.
2, 3.	Ventral and lateral views of figured specimen GSC 68358 from GSC locality 92520 (loose below section). Specimen is entirely septate.
4, 5.	Lateral and ventral views of fragmentary figured specimen GSC 68359 from GSC locality 92473 (loose below section).
6, 7.	Lateral and ventral views of fragmentary figured specimen GSC 68360 from GSC locality C-95369 (loose below section). Specimen is nonseptate.

Figures 8-13. *Arcticoceras* spp. indet.

8, 9.	Ventral and lateral views of figured specimen GSC 68361 from GSC locality 92520 (loose below section). Specimen is entirely septate.
10, 11.	Lateral and ventral views of figured specimen GSC 68362 from GSC locality C-95362 (Bed 46). *Frami* Zone. Specimen is septate.
12, 13.	Ventral and lateral views of figured specimen GSC 68363 from GSC locality C-95369 (loose below section). Outer whorl illustrated is nonseptate.

PLATE 22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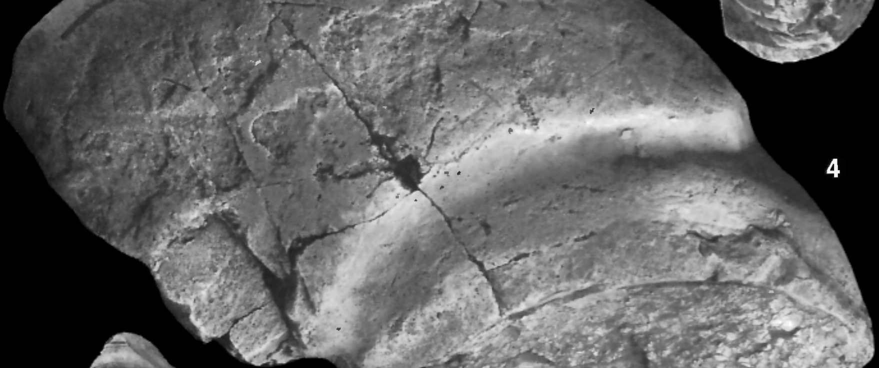
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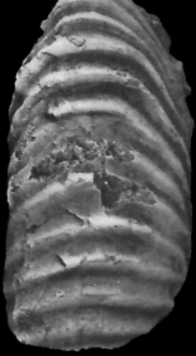
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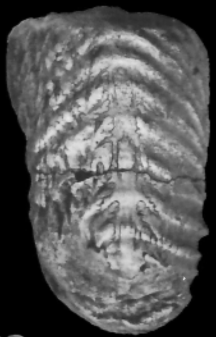
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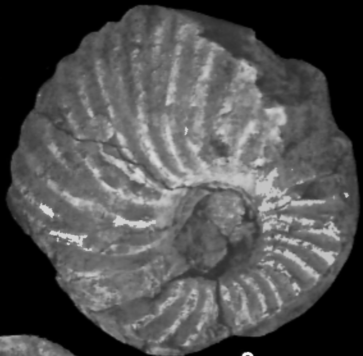
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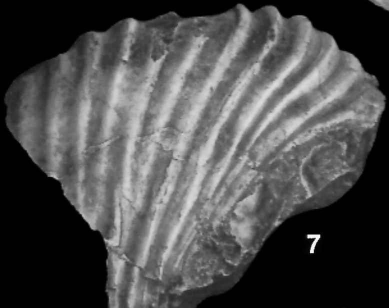
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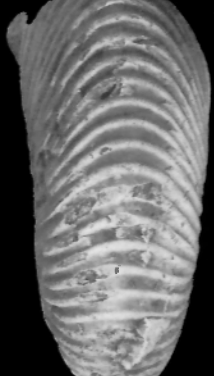
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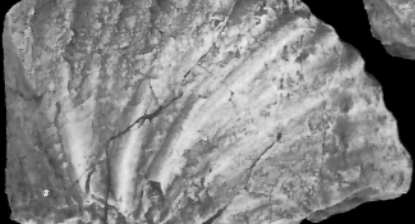
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PLATE 23

Figures 1-4. *Arcticoceras* spp. indet.

1, 2. Lateral and ventral views of figured specimen GSC 68364 from GSC locality C-95372 (loose below section). X marks approximate position of last septum.

3, 4. Ventral and lateral views of figured specimen GSC 68365 from GSC locality C-95372 (loose below section). X marks approximate position of last septum.

Figures 9, 10. *Kepplerites*(?) sp. D

9, 10. Lateral view of entire specimen and of a fragment of an intermediate whorl, figured specimen GSC 68366 from GSC locality 92540 (Bed 60). *Ishmae* Zone. Ventral view shown in Plate 32, figure 1. Outer whorl illustrated is nonseptate.

Figures 5, 6. "*Costacadoceras*" sp. indet. A

5, 6. Ventral and lateral views of figured specimen GSC 68268 from GSC locality 92534 (Bed 44). *Amundseni* Zone. Outer whorl illustrated is nonseptate.

Figures 7, 8. "*Costacadoceras*" sp. indet. B

7, 8. Ventral and lateral views of figured specimen GSC 68651 from GSC locality 92537 (Bed 51). Unnamed Zone.


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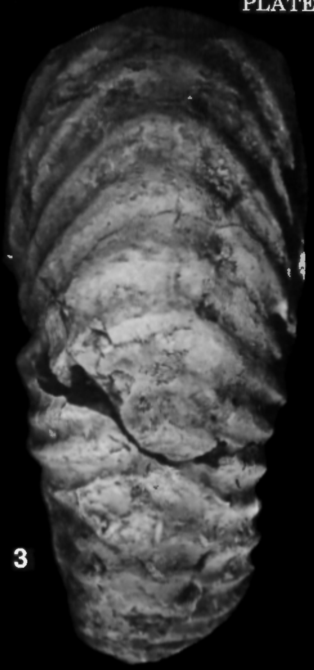
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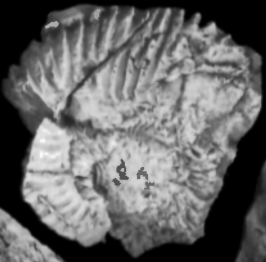
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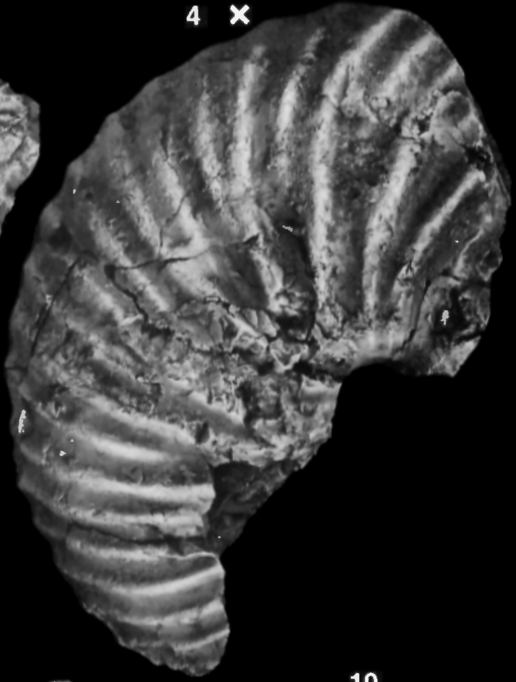
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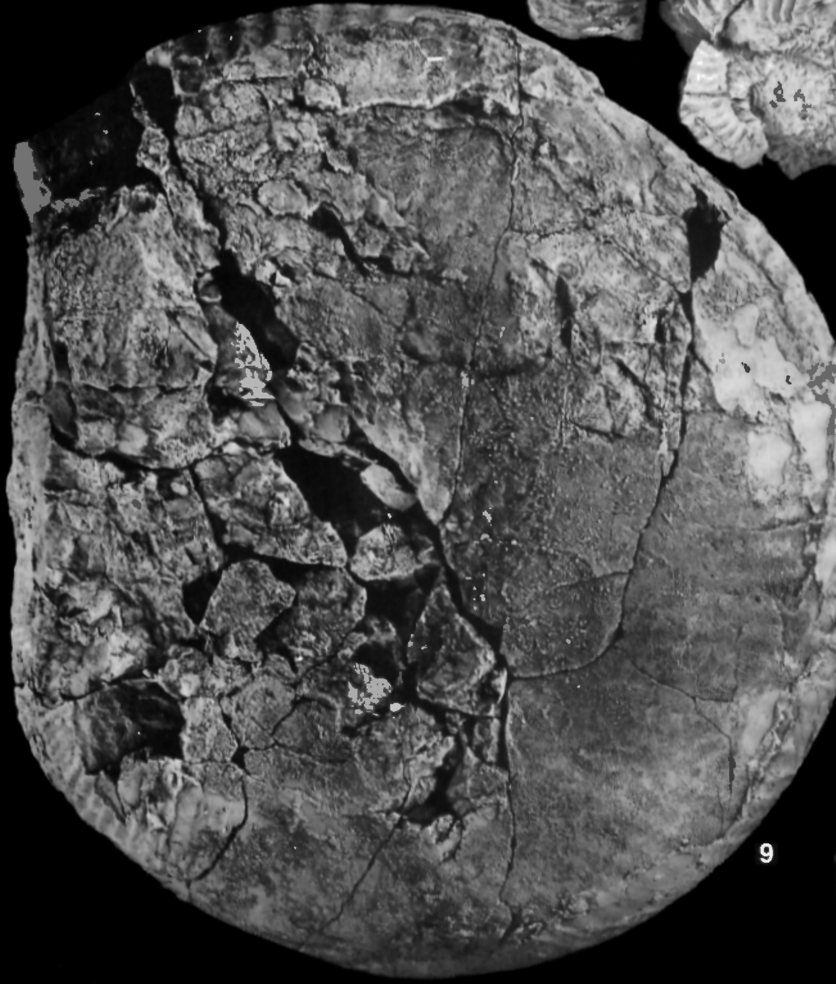
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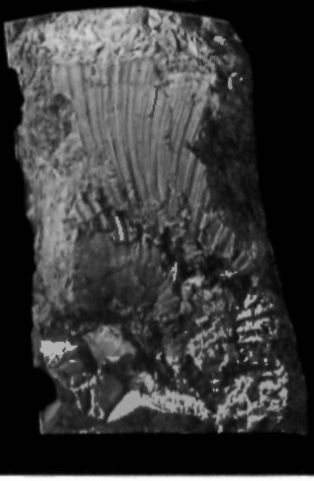
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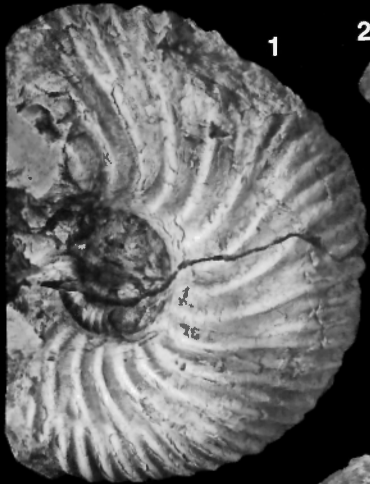
PLATE 24

Figures 1-18. *Cadoceras barnstoni* (Meek)

1, 2.	Lateral and ventral views of figured specimen GSC 68382 from GSC locality 92543 (Bed 62). *Barnstoni* Zone. Outer whorl illustrated is entirely septate.
3-5.	Lateral, ventral and cross-sectional views of figured specimen GSC 68383 from same locality as figure 1. Outer whorl illustrated is entirely septate.
6, 7.	Lateral view of natural cast, and latex cast (x3; umbilical detail) of figured specimen GSC 68384 from same locality as figure 1. Outer whorl illustrated is entirely septate.
8, 9.	Ventral and lateral views of fragmentary figured specimen GSC 68385 from same locality as figure 1. Specimen is entirely septate.
10, 11.	Lateral and ventral views of figured specimen GSC 68386 from same locality as figure 1.
12, 13.	Lateral and ventral views of figured specimen GSC 68387 from GSC locality 92553 (loose below section). Cross-section shown in Plate 26, figure 5. X marks approximate position of last septum.
14-16.	Lateral, cross-sectional, and ventral views of crushed figured specimen GSC 68388 from same locality as figure 1.
17, 18.	Ventral and lateral views of figured specimen GSC 68389 from same locality as figure 1. Specimen is entirely septate.

PLATE 24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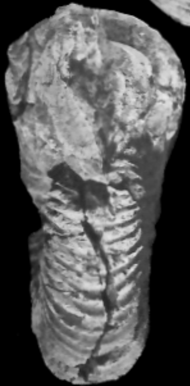
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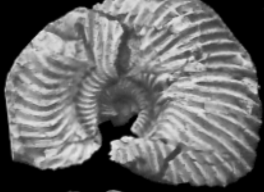
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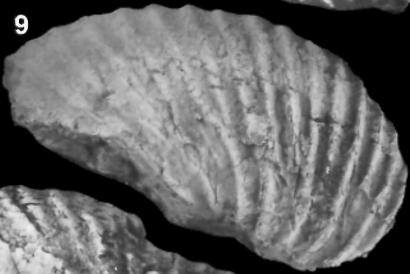
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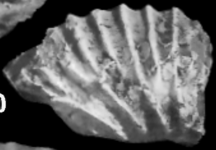
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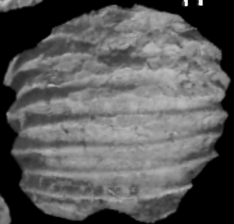
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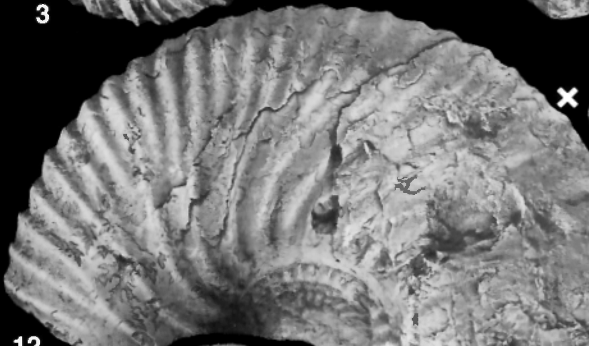
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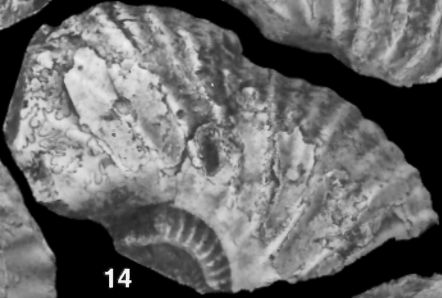
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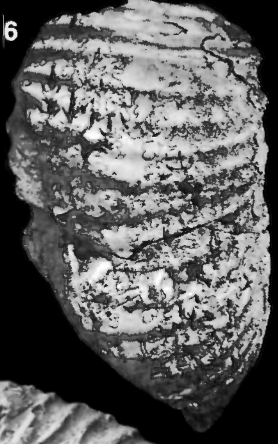
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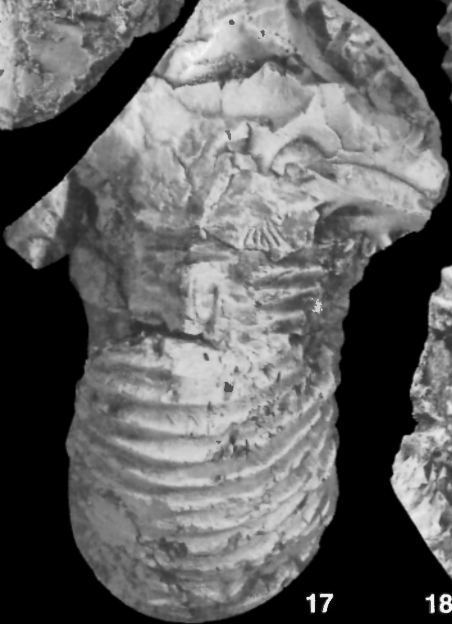
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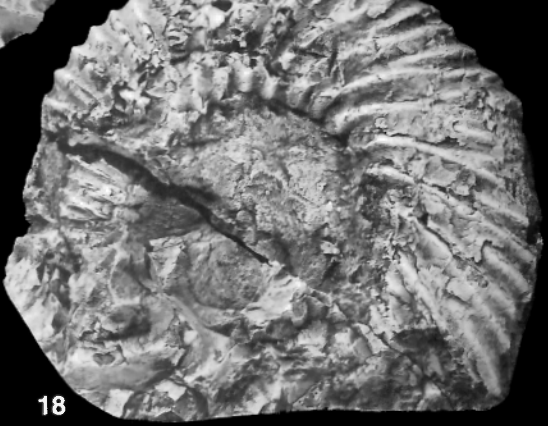
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PLATE 25

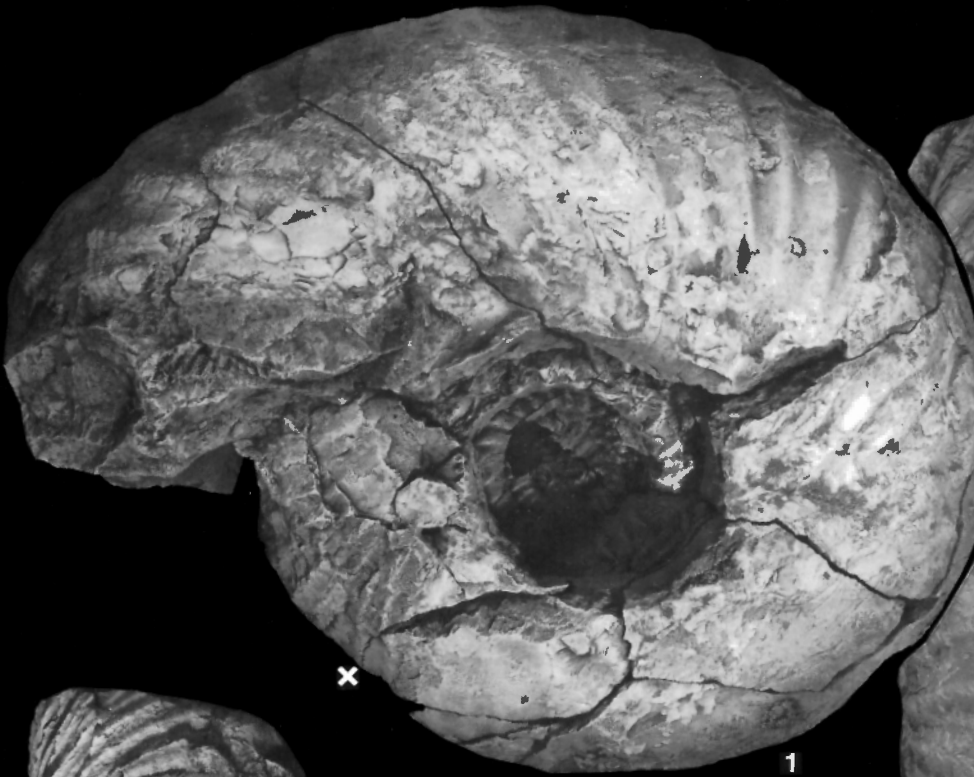
Figures 1-8. *Cadoceras barnstoni* (Meek)

1, 2. Lateral and ventral views of figured specimen GSC 68390 from GSC locality C-95369 (loose below section). X marks approximate position of last septum.

3, 4. Ventral and lateral views of figured specimen GSC 68391 from GSC locality 92568 (loose below section). Specimen is entirely septate.

5, 6. Ventral and lateral views of figured specimen GSC 68392 from GSC locality 92473 (loose below section). X marks position of last septum.

7, 8. Lateral and ventral views of figured specimen GSC 68393 from same locality as figure 5. Specimen is entirely septate.



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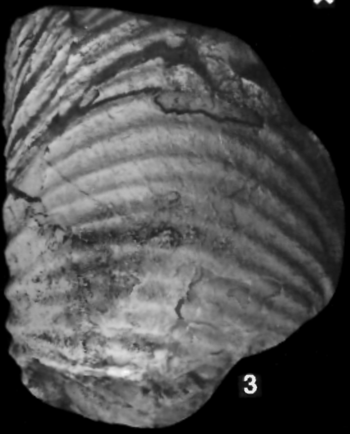

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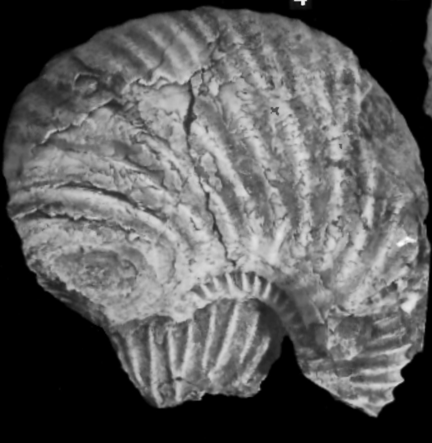

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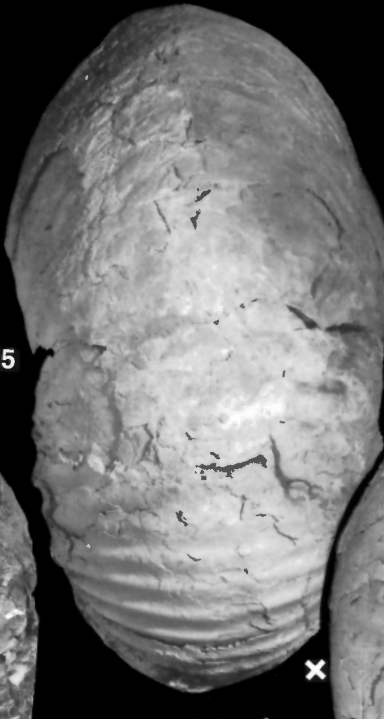

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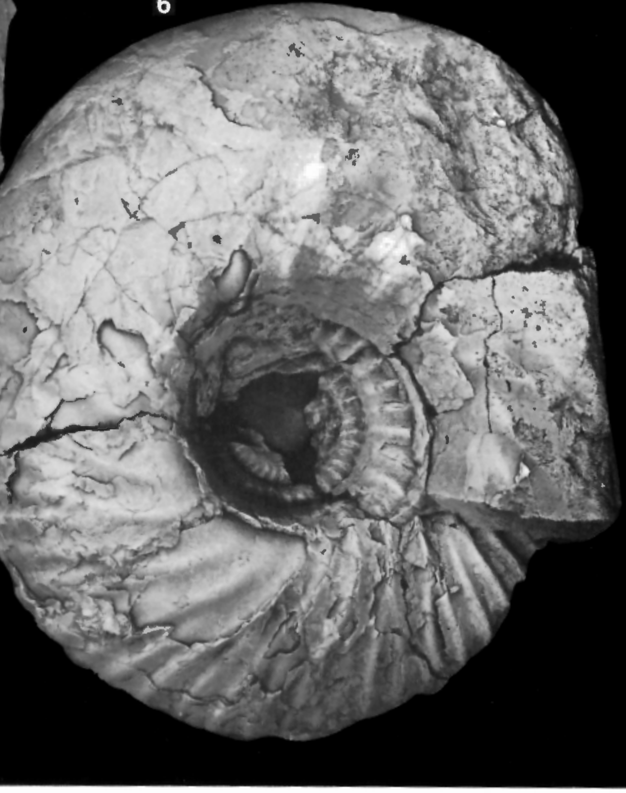

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PLATE 26

Figures 1-8. *Cadoceras barnstoni* (Meek)

1. Cross-sectional view of figured specimen GSC 68394 from GSC locality C-95369 (loose below section).

2. Cross-sectional views of figured specimen GSC 68395 from GSC locality 92473 (loose below section).

3, 4. Lateral and ventral views of figured specimen GSC 68396 from GSC locality 92473 (loose below section).

5. Cross-sectional view of specimen shown in Plate 24, figures 11, 12.

6. Cross-sectional view of figured specimen GSC 68397 from GSC locality 92568 (loose below section).

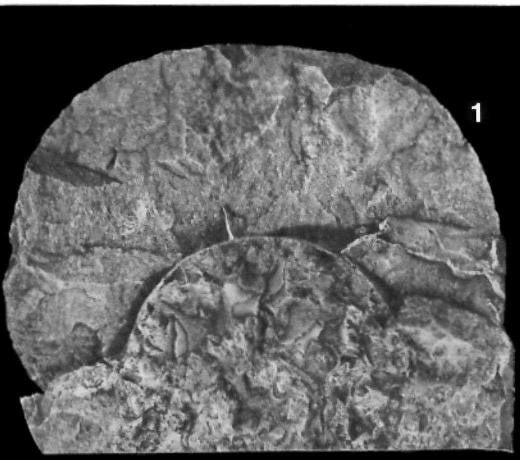
7, 8. Lateral and cross-sectional views of figured specimen GSC 68398 from GSC locality 92543 .(Bed 62). *Barnstoni* Zone.

Figures 9-11. *Cadoceras* sp.

9-11. Ventral, lateral and cross-sectional views of figured specimen GSC 68399 from GSC locality 92520 (loose below section).

Figure 12. *Cadoceras bodylevskyi* Frebold

12. Umbilical detail of specimen shown in Plate 27, figures 4-6.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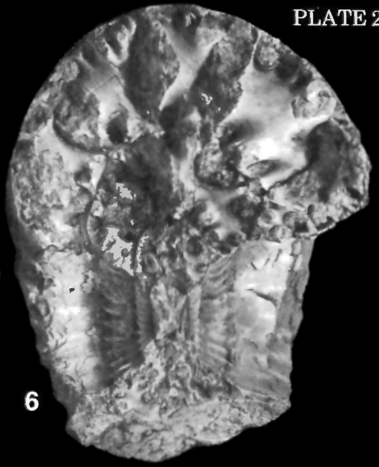
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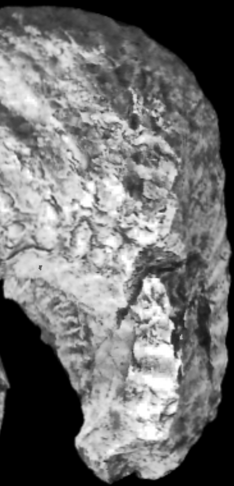
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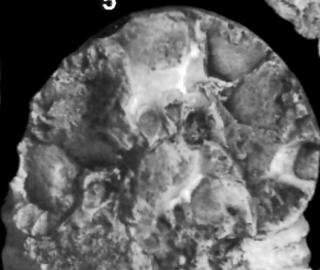
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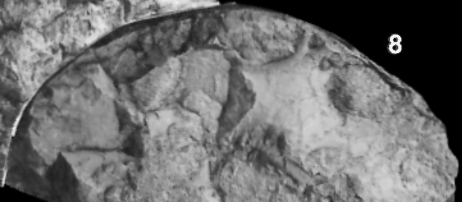
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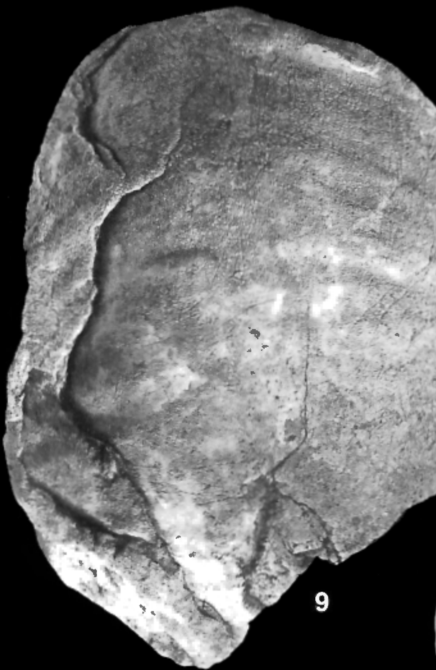
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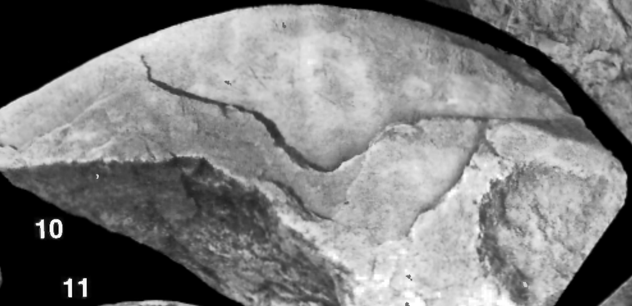
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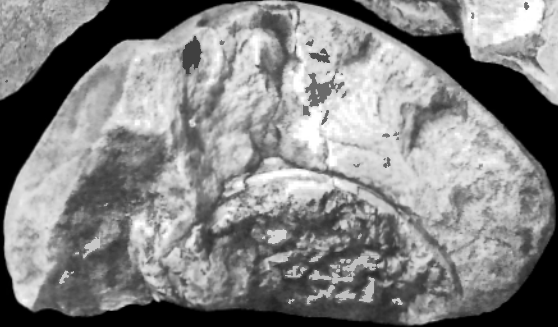
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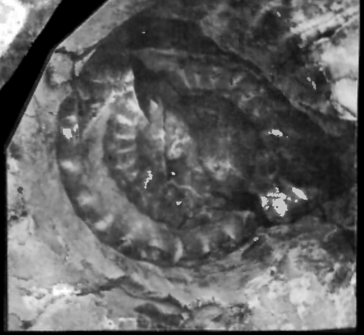
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PLATE 27

Figure 1. *Cadoceras variabile* Spath

Lateral view of figured specimen GSC 68400 from GSC locality 92561 (loose below section). X marks approximate position of last septum.

Figures 2-6. *Cadoceras bodylevskyi* Frebold

2, 3. Lateral and ventral views of figured specimen GSC 68401 from GSC locality C-95367 (Bed 68c). *Bodylevskyi* Zone. No septae can be seen.

4-6. Lateral and ventral views of figured specimen GSC 68402 from GSC locality 92544 (Bed 68c). *Bodylevskyi* Zone. Umbilical detail shown in Plate 26, figure 12. X marks position of last septum.

PLATE 27

PLATE 28

Figures 1-9. *Cadoceras bodylevskyi* Frebold

1, 2. Ventral and lateral views of figured specimen GSC 68403 from GSC locality C-95367 (Bed 68c). *Bodylevskyi* Zone. X marks position of last septum.

3-5. Lateral, cross-sectional, and ventral views of figured specimen GSC 68404 from same locality as figure 1. X marks approximate position of last septum.

6, 7. Lateral and ventral views of figured specimen GSC 68405 from GSC locality 92544 (Bed 68c). *Bodylevskyi* Zone. X marks approximate position of last septum.

8, 9. Ventral and lateral views of figured specimen GSC 68406 from same locality as figure 1. X marks approximate position of last septum.

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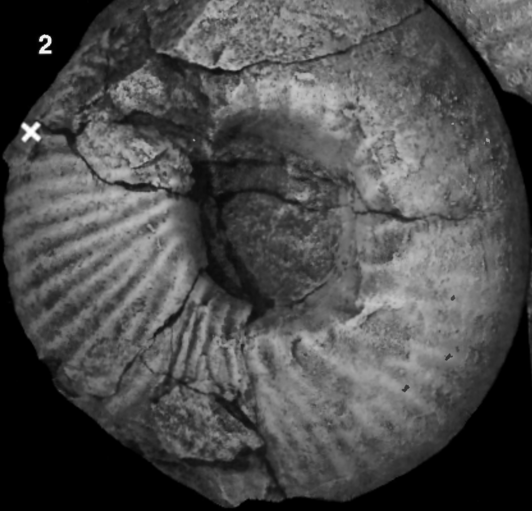

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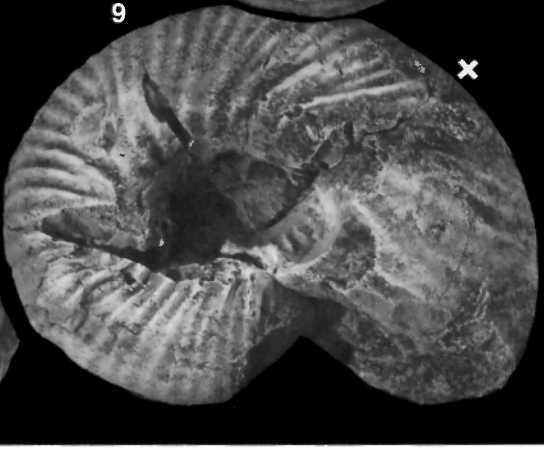

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PLATE 29

Figures 1-6. *Paracadoceras* sp.

1, 2. Lateral and ventral views of figured specimen GSC 68407 from GSC locality 92561 (loose below section). X marks approximate position of last septum.

3, 4. Lateral and ventral views of figured specimen GSC 68408 from same boulder as figure 1. Specimen is entirely septate.

5, 6. Lateral views of outer and intermediate (latex cast) whorl fragments, figured specimen GSC 68409 from GSC locality C-95372 (loose below section). Outer whorl fragment illustrated is nonseptate.

Figures 7-19. *Iniskinites* spp.

7, 8. Lateral and ventral views of figured specimen GSC 68410 from GSC locality 92551 (loose below section). Specimen is entirely septate.

9, 10. Lateral and ventral views of figured specimen GSC 68411 from GSC locality 92561 (loose below section). Specimen is entirely septate.

11, 12. Lateral and ventral views of figured specimen GSC 68412 from GSC locality C-95369 (loose below section). Specimen is entirely septate.

13, 14. Lateral and ventral views of figured specimen GSC 68413 from GSC locality 92473 (loose below section). X marks approximate position of last septum.

15. Lateral views of figured specimen GSC 68414 from GSC locality 92473 (loose below section) (x2). X marks approximate position of last septum.

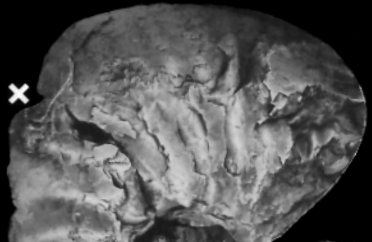
16, 17. Ventral and lateral views of figured specimen GSC 68415 from GSC locality C-95370 (loose below section). Specimen is entirely septate.

18, 19. Lateral and ventral views of figured specimen GSC 68416 from GSC locality C-95369 (loose below section). Specimen is entirely nonseptate.

Figures 20-24. *Cadomites* sp.

20-23. Lateral and ventral views of outer and intermediate whorls of figured specimen GSC 68417 from GSC locality C-95365 (Bed 53). *Harlandi* Zone. X marks approximate position of last septum.

24. Lateral view, latex cast of figured specimen GSC 68418 from GSC locality C-95369 (loose below section).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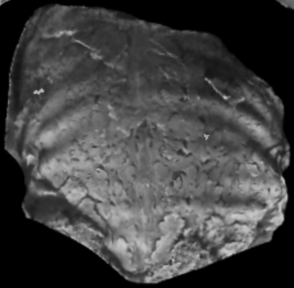
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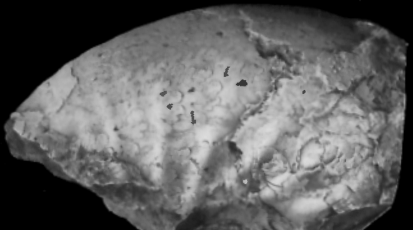
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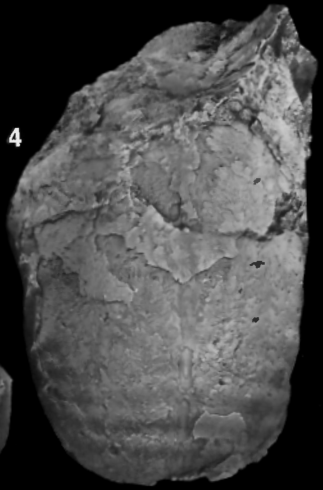
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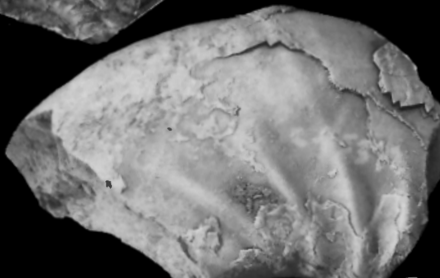
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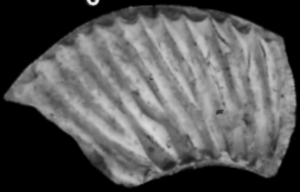
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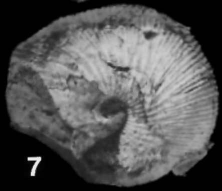
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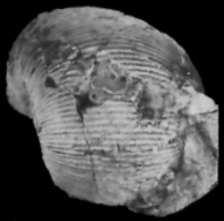
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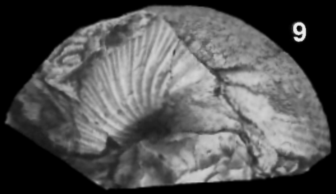
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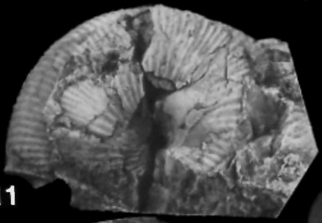
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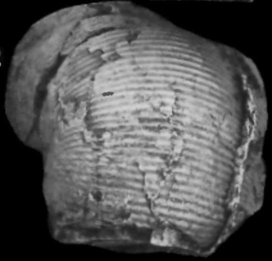
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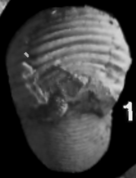
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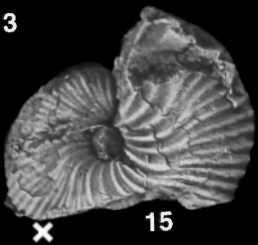
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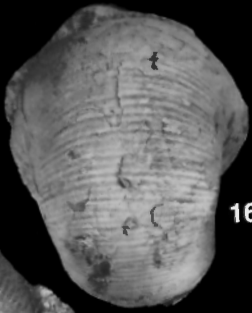
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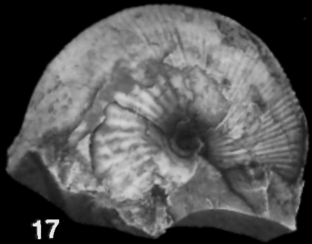
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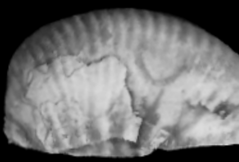
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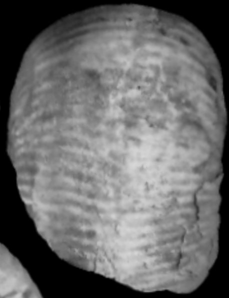
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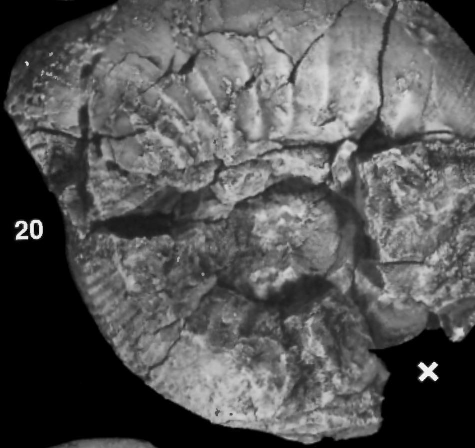
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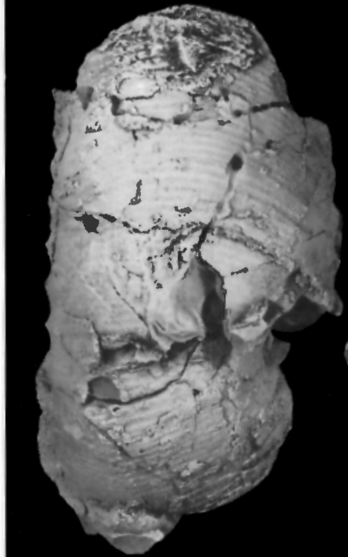
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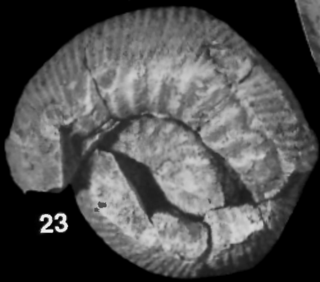
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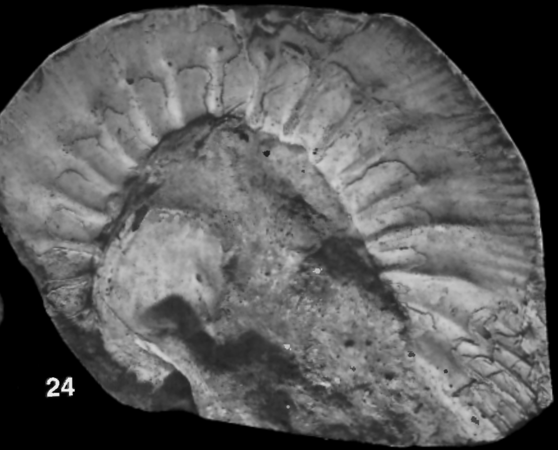
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PLATE 30

Figures 1-10, 16. *Kepplerites* sp. aff. *K. rosenkrantzi* Spath

1-3. Lateral, ventral and cross-sectional views of figured specimen GSC 68419 from GSC locality 92551 (loose below section). Specimen is entirely septate.

4, 5. Lateral and ventral views of figured specimen GSC 68420 from GSC locality C-86389 (loose below section). X marks approximate position of last septum.

6, 7. Lateral and ventral views of figured specimen GSC 68421 from GSC locality 92551 (loose below section) (x2). Specimen is entirely septate.

8-10. Ventral and lateral views (with and without outer whorl fragment) of figured specimen GSC 68422 from GSC locality 92543 (Bed 62). *Barnstoni* Zone. Outer whorl illustrated is septate.

16. Ventral view of small fragment of inner whorl, figured specimen GSC 68423 from same locality as figure 8.

Figures 11-15. *Kepplerites* sp. A

11-15. Lateral (with and without outer whorl), ventral and cross-sectional views of figured specimen GSC 68424 from GSC locality 92473 (loose below section). Outer whorl illustrated is nonseptate.

Figures 17-21. *Kepplerites* sp. B

17-19. Cross-sectional (with partial mould of inner whorl), ventral and lateral views of figured specimen GSC 68425 from GSC locality 92543 (Bed 62). *Barnstoni* Zone. Specimen is entirely septate.

20, 21. Lateral and ventral views of figured specimen GSC 68426 from GSC locality C-95372 (loose below section). Outer whorl illustrated is nonseptate.

PLATE 30

PLATE 31

Figures 1-7. *Iniskinites* spp.

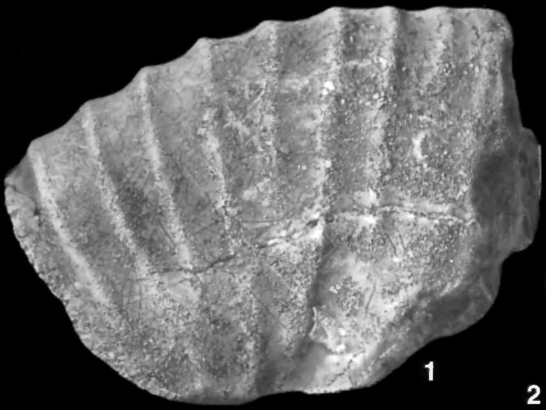
1-3. Lateral, ventral and dorsal views of figured specimen GSC 68427 from GSC locality 92473 (loose below section). Whorl fragment illustrated is nonseptate.

4, 5. Lateral and ventral views of figured specimen GSC 68428 from GSC locality 92554 (loose below section). Arrow shows apertural constriction preserved low on flank.

6, 7. Ventral and lateral views of figured specimen GSC 68429 from GSC locality C-95372 (loose below section). Whorl fragment illustrated is nonseptate.

Figures 8-10. *Kepplerites* (?) sp. C

8-10. Lateral (with and without outer whorl parts) and ventral views of figured specimen GSC 68430 from GSC locality C-95372 (loose below section).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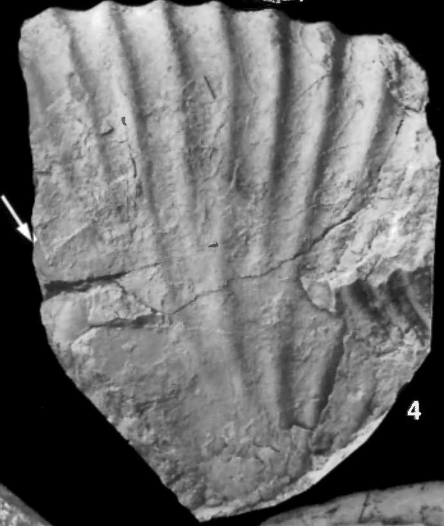
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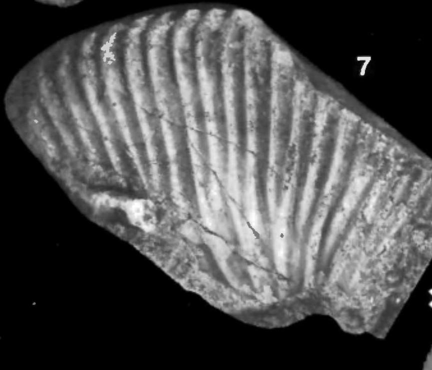
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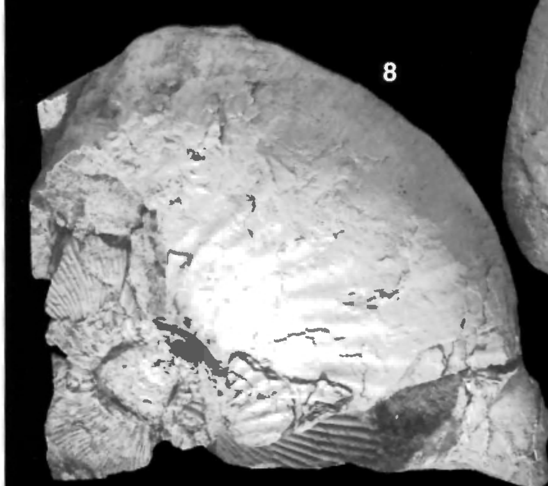
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PLATE 32

Figure 1. *Kepplerites*(?) sp. D

1. Ventral view of same specimen as in Plate 23, figures 9, 10.

Figures 2, 3. Genus et sp. indet. A

2, 3. Ventral and lateral views of figured specimen GSC 68367 from GSC locality C-95364 (Bed 48). Unnamed Zone. Specimen is entirely septate.

Figures 4, 5. *Loucheuxia*(?) sp.

4, 5. Ventral and lateral views of figured specimen GSC 68368 from GSC locality C-95381 (loose below section). X marks position of last septum.

Figures 6-9. *Loucheuxia bartletti* n. sp.

6, 7. Lateral and ventral views of holotype GSC 68369 from GSC locality C-95372 (loose below section). X marks position of last septum.

8, 9. Lateral and ventral views of paratype GSC 68370 from GSC locality 92554 (loose below section).

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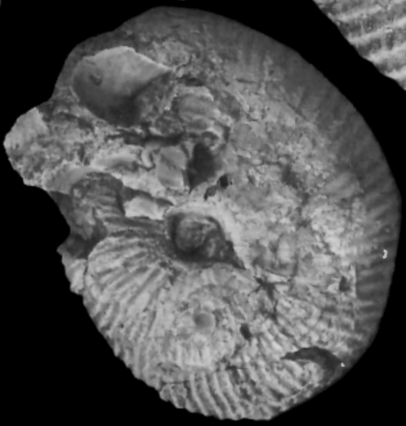

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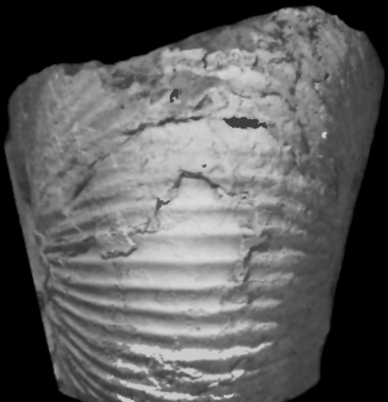

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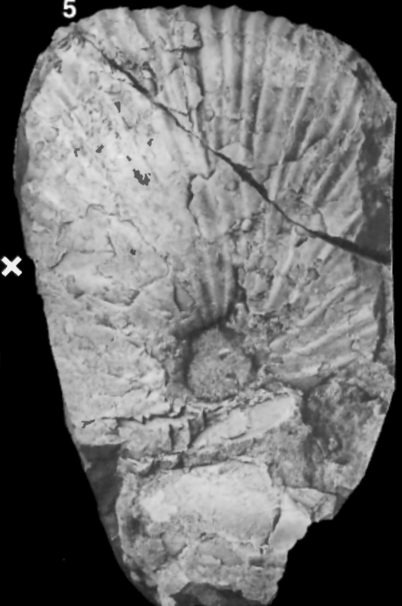

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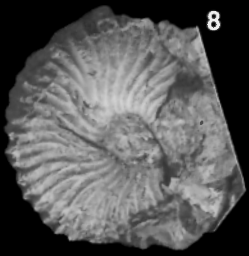

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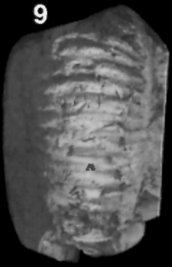


PLATE 33

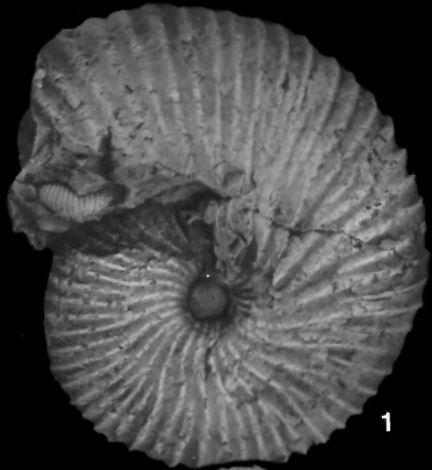
Figures 1-10. *Loucheuxia bartletti* n. sp.

1-4. Lateral and ventral views of intermediate and outer whorls of paratype GSC 68371 from GSC locality 92552 (loose below section). X marks position of last septum.

5, 6. Lateral and ventral views of paratype GSC 68372 from GSC locality C-95372 (loose below section). Specimen is entirely septate.

7, 8. Lateral and ventral views of paratype GSC 68373 from GSC locality 92473x (loose below section). Specimen is entirely septate.

9, 10. Ventral and lateral views of paratype GSC 68374 from GSC locality C-95374 (loose below section). Reverse side seen in Plate 34, figure 1. Specimen is entirely septate.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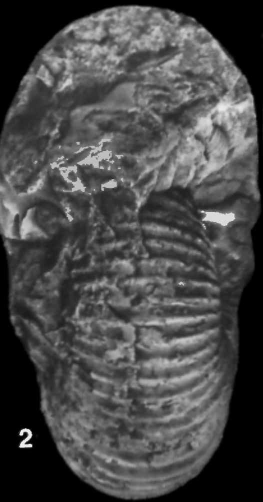
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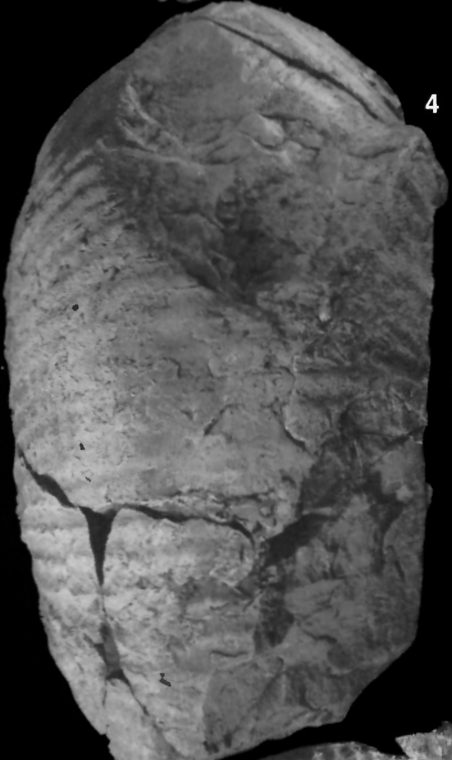
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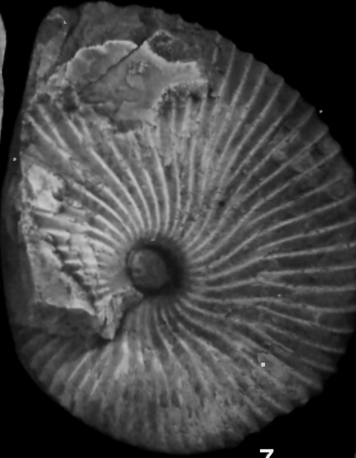
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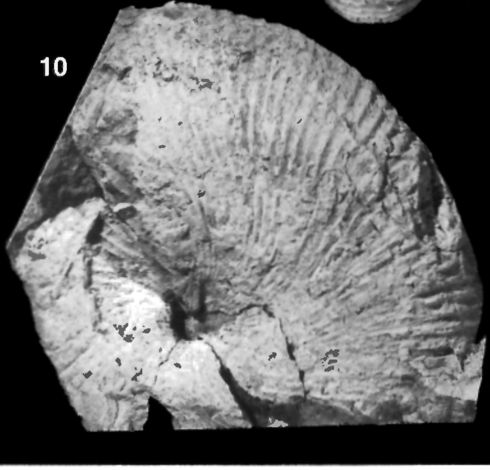
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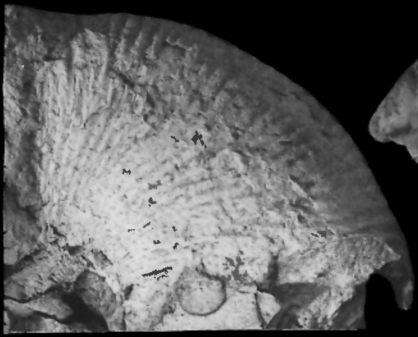
PLATE 34

Figures 1-6, 10, 15-19. *Loucheuxia bartletti* n. sp.

1.	Lateral view of same specimen shown in Plate 33, figures 9, 10.
2-6.	Lateral, cross-sectional, and ventral views (with and without outer whorl), paratype GSC 68375 from GSC locality 92552 (loose below section). Specimen is entirely septate.
10.	Lateral view of latex cast of paratype GSC 68377 from GSC locality C-95375 (loose below section).
15-17.	Ventral and lateral views of paratype GSC 68380 from GSC locality 92552 (loose below section). Specimen is entirely septate.
18, 19.	Lateral and ventral views of paratype GSC 68381 from GSC locality C-95375 (loose below section). Specimen is entirely septate.

Figures 7-9, 11-14. *Loucheuxia*(?) sp.

7-9.	Lateral, ventral and cross-sectional views of figured specimen GSC 68376 from GSC locality 92553 (loose below section). Specimen is entirely septate.
11, 12.	Ventral and lateral views of figured specimen GSC 68378 from GSC locality C-95383 (loose below section).
13, 14.	Lateral and ventral views of figured specimen GSC 68379 from GSC locality C-95383 (loose below section). Specimen is entirely septate.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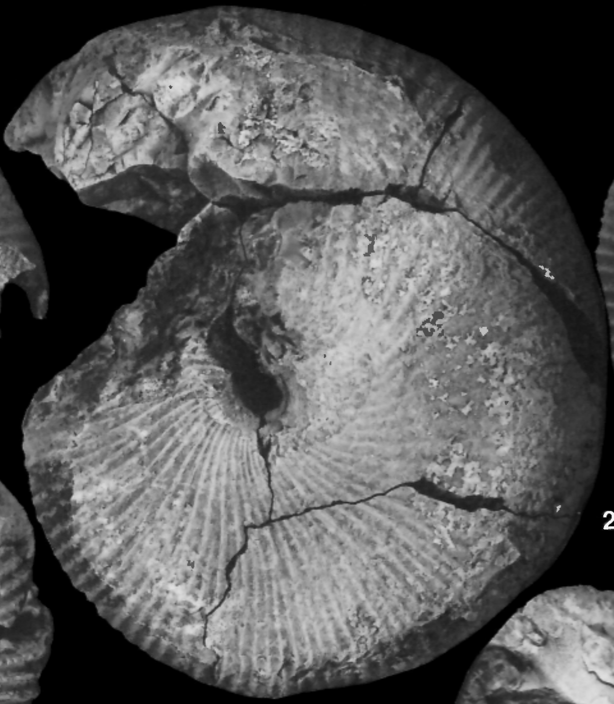
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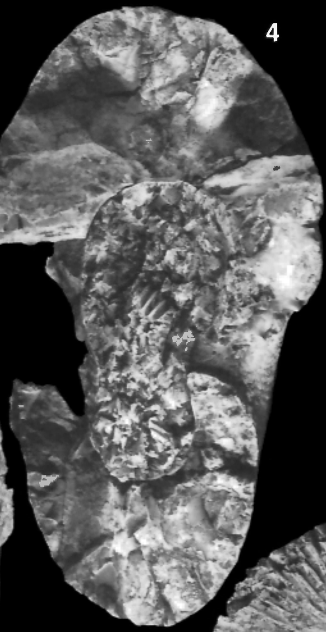
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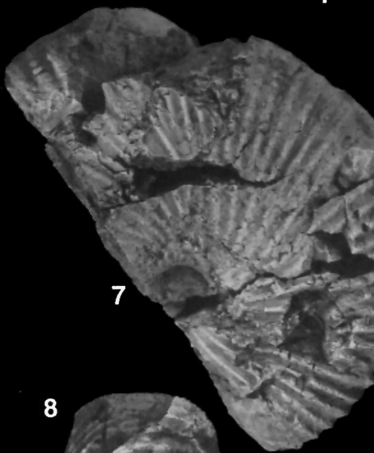
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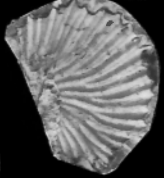
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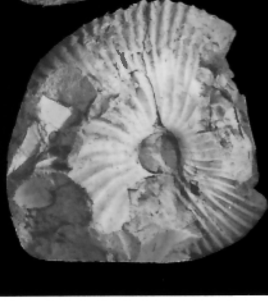
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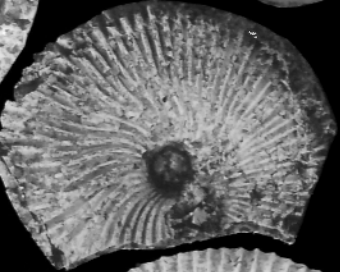
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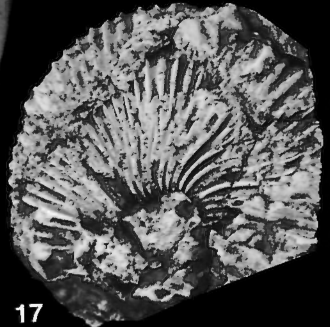
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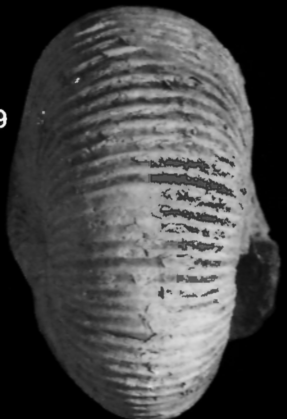
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PLATE 35

Figures 1, 2, 6. *Oecotraustes*(?) sp.

1, 2. Lateral and ventral views of figured specimen GSC 68431 from GSC locality 92473 (loose below section). Specimen is entirely septate.

6. Lateral view of external mould of figured specimen GSC 68432 from GSC locality 92567 (loose below section).

Figure 5. *Prohecticoceras*(?) sp.

5. Lateral view of figured specimen GSC 68433 from GSC locality 92570 (loose below section). Specimen is entirely septate.

Figures 3, 4, 9, 10. *Oxycerites birkelundi* n. sp.

3, 4, 9, 10. Ventral, lateral (with and without outer whorl) and cross-sectional views of holotype GSC 68434 from GSC locality 92554 (loose below section). Specimen is entirely septate.

Figures 7, 8. *Oxycerites* sp.

7, 8. Lateral and ventral views of internal whorls of figured specimen GSC 68435 from GSC locality C-95382 (loose below section). Outer whorls not shown. Specimen is entirely septate.


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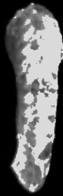
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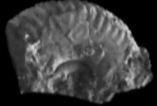
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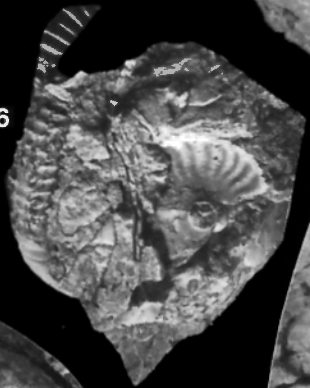
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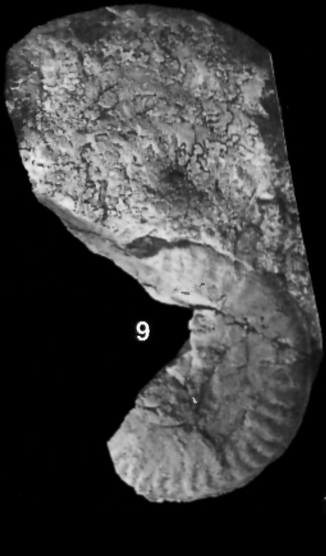
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PLATE 36

Figures 1-4. *Oxycerites* sp.

1-4. Cross-sectional, ventral and lateral (with and without outer whorl fragments), figured specimen GSC 68436 from GSC locality C-95374 (loose below section). Specimen is entirely septate.

Figures 5, 6. *Oxycerites birkelundi* n. sp.

5, 6. Ventral and lateral views of paratype GSC 68437 from GSC locality C-95354 (loose below section). Specimen is entirely septate.

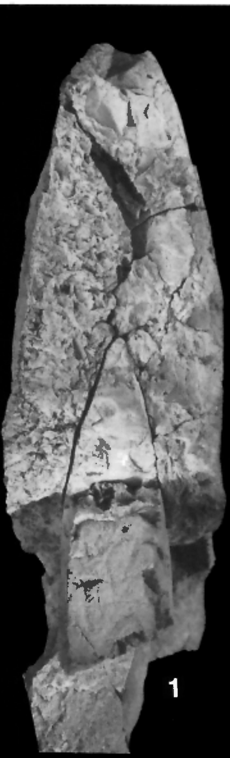
Figures 7, 8. *Parareineckeia* sp.

7, 8. Lateral and ventral (without outer whorl) views of figured specimen GSC 68438 from GSC locality 92520 (loose below section).

Figures 9-11. *Choffatia*(?) sp.

9, 10. Ventral and lateral views of figured specimen GSC 68439 from GSC locality 92561 (loose below section). Specimen is entirely septate.

11. Lateral view of crushed fragment, figured specimen GSC 68440 from GSC locality 92564 (loose below section). Specimen is entirely septate.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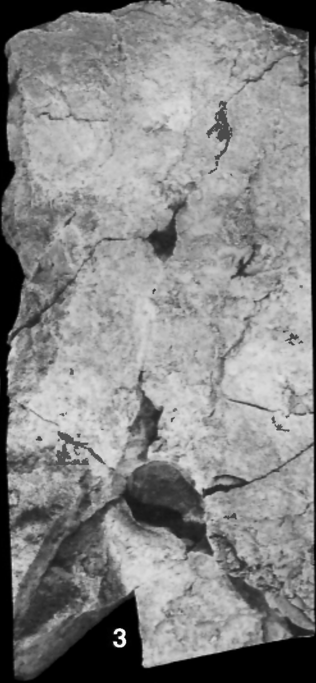
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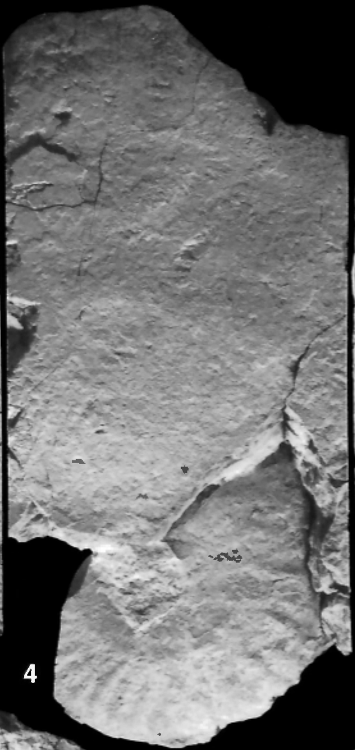
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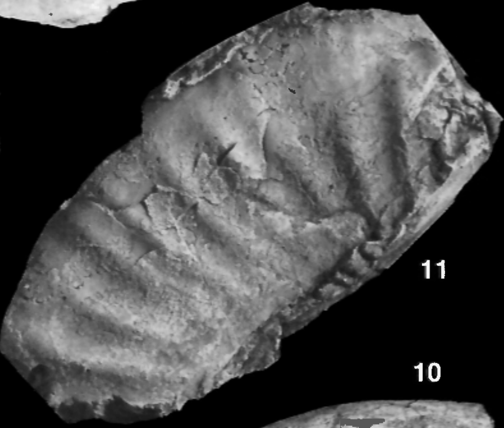
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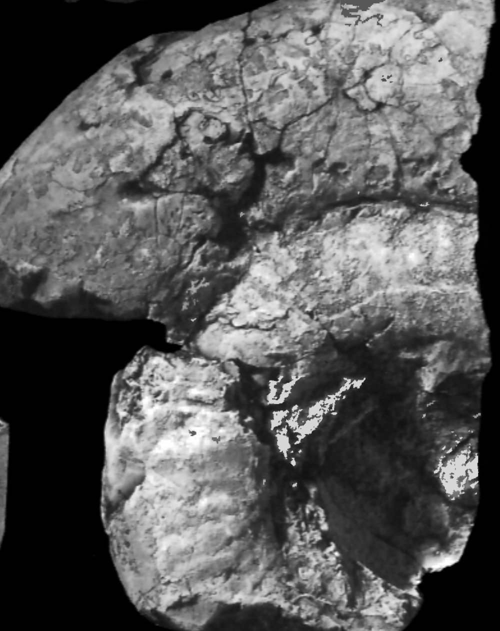

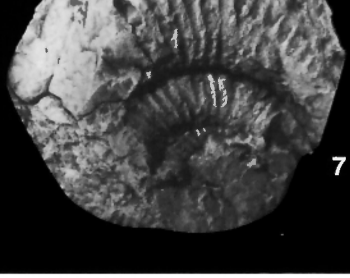
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PLATE 37

All specimens are entirely septate

Figures 1-7, 16-23, 26. ***Phylloceras*** sp. aff. ***P. kudernatschi*** (von Hauer)

1, 2.	Lateral and ventral views of figured specimen GSC 68441 from GSC locality C-95383 (loose below section).
3, 4.	Lateral and ventral views of figured specimen GSC 68442 from GSC locality 92473x (loose below section).
5, 6.	Lateral and ventral views of figured specimen GSC 68443 from GSC locality 92532 (Bed 42). ***Amundseni*** Zone.
7.	Lateral view of figured specimen GSC 68444 from same locality as figure 5.
16, 17.	Lateral and ventral views of figured specimen GSC 68449 from GSC locality C-95362 (Bed 46). ***Frami*** Zone.
18, 19.	Lateral and ventral views of figured specimen GSC 68450 from GSC locality C-95370 (loose below section).
20, 21.	Lateral and ventral views of figured specimen GSC 68451 from GSC locality 92532 (Bed 42). ***Amundseni*** Zone.
22.	Lateral view of figured specimen GSC 68452 from GSC locality 92561 (loose below section).
23.	Lateral view of figured specimen GSC 68453 from GSC locality 92546 (loose below section).
26.	Cross-section of figured specimen GSC 68455 from GSC locality C-95369 (loose below section).

Figures 8-11. ***Phylloceras billingsi*** (Meek)

8, 9.	Lateral and ventral views of figured specimen GSC 68445 from GSC locality 92543 (Bed 62). ***Barnstoni*** Zone.
10, 11.	Lateral and ventral views of figured specimen GSC 68446 from GSC locality 92473x (loose below section).

Figures 12-15. ***Phylloceras*** sp. aff. ***P. kunthi*** Neumayr

12, 13.	Lateral and ventral views of figured specimen GSC 68447 from GSC locality C-86394 (Bed 28). ***Amundseni*** Zone.
14, 15.	Ventral and lateral views of figured specimen GSC 68448 from GSC locality C-86398 (Bed 21). ***Porcupinensis*** Zone.

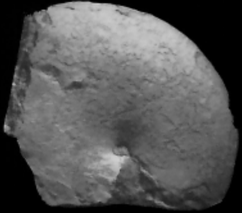
Figures 24, 25. ***Adabofoloceras***(?) sp.

24, 25.	Lateral and ventral views of figured specimen GSC 68454 from GSC locality C-95369 (loose below section).

Figures 27, 28. ***Holcophylloceras*** sp.

27, 28.	Ventral and lateral views of figured specimen GSC 68456 from GSC locality 92527 (Bed 24). ***Porcupinensis*** Zone. (x2).

PLATE 37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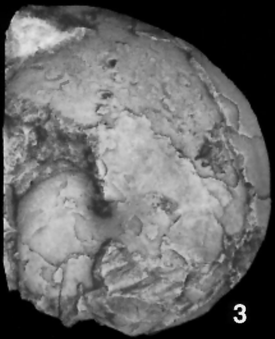
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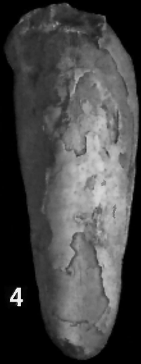
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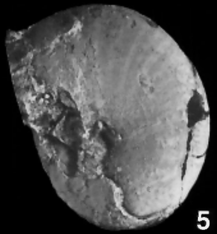
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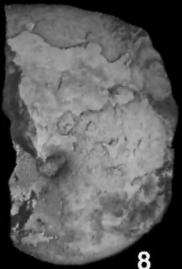
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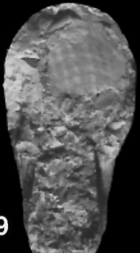
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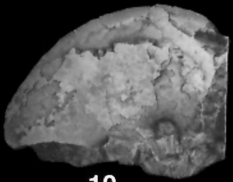
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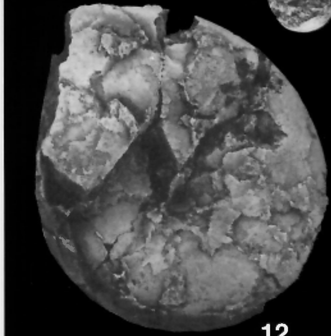
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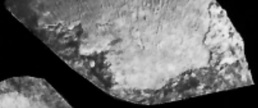
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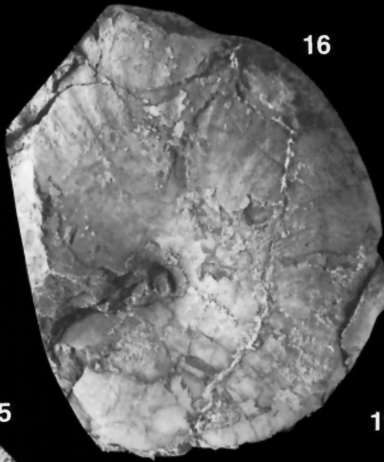
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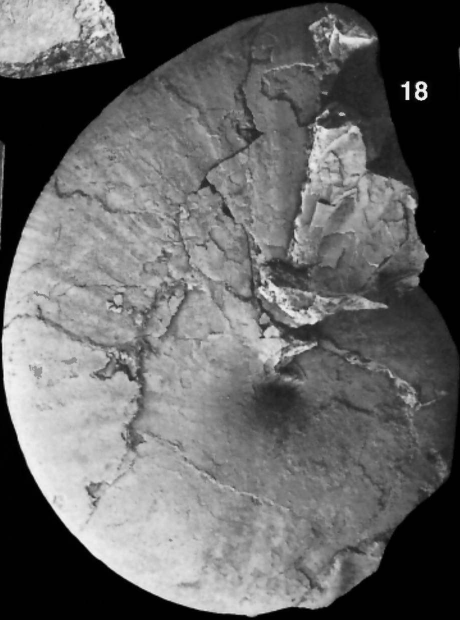
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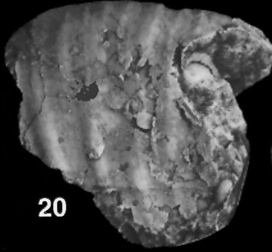
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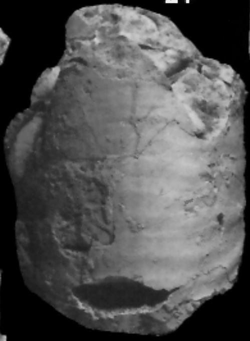
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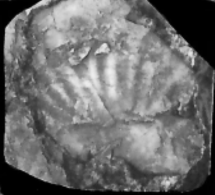
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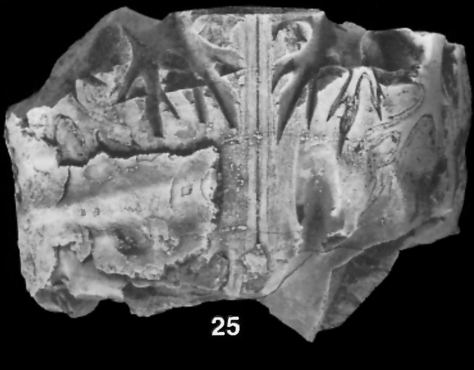
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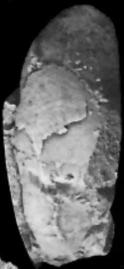
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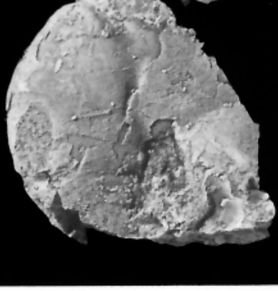
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PLATE 38

Figures 1, 2. *Phylloceras* sp. aff. *P. kudernatschi* (von Hauer)

1, 2.	Lateral and ventral views of figured specimen GSC 68457 from GSC locality C-95357 (Bed 32). *Amundseni* Zone. Specimen is entirely septate.

Figures 3-7. *Holcophylloceras* sp.

3, 4.	Ventral and lateral views of figured specimen GSC 68458 from GSC locality C-95383 (loose below section). Specimen is entirely septate.
5-7.	Cross-sectional (showing lateral mould of part of intermediate whorl), lateral, and ventral views of figured specimen GSC 68459 from GSC locality 92520 (loose below section). Specimen is entirely septate.

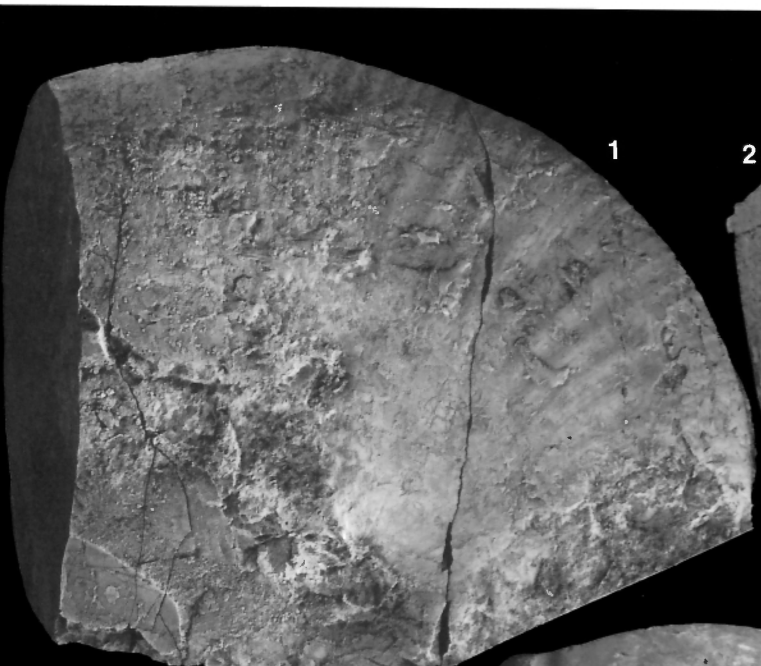
Figures 8-10. *Calliphylloceras* sp.

8-10.	Lateral and ventral views of figured specimen GSC 68460 from GSC locality 92473 (loose below section). Specimen is entirely septate.

Figures 11, 12. Genus et species indet. B

11, 12.	Ventral and lateral views of figured specimen GSC 68461 from GSC locality C-95372 (loose below section). Whorl illustrated is entirely nonseptate.

PLATE 38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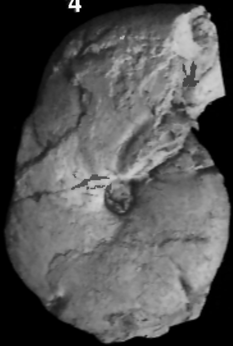
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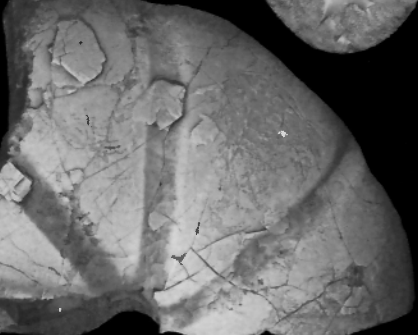
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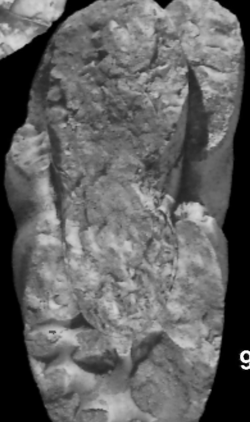
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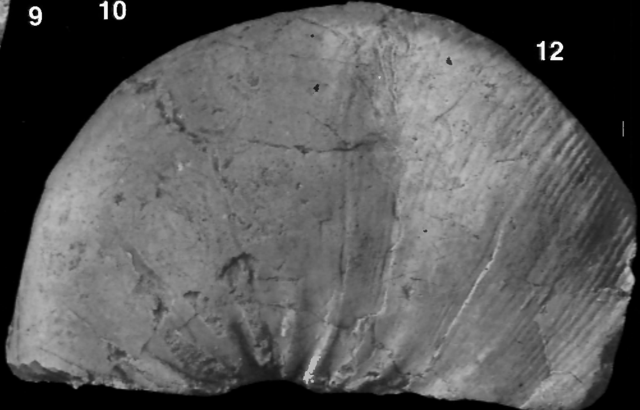
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