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JENÖ NAGY

Ammonite faunas and stratigraphy of Lower Cretaceous (Albian) rocks in southern Spitsbergen

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Abstract

The upper part of the Lower Cretaceous (Aptian and Albian) in Spitsbergen is represented by the marine Carolinefjellet Formation, which consists chiefly of shales, siltstones, and sandstones. In this paper five members are recognized within the formation, and a brief lithological description is given for each member. The two uppermost members, Zillerberget and Schönrockfjellet, are defined as new.

The age relationships within the Carolinefjellet Formation are elucidated by means of the recognized ammonite faunas. In the lower part of the formation occurs the Tropaeum fauna, which is of Upper Aptian age. In the middle part of the formation occur four successive ammonite faunas, which are correlated with the following parts of the Albian of Western Europe. 1) Freboldiceras fauna: – lower part of Lower Albian. 2) Arcthoplites fauna: – middle part of Lower Albian. 3) Otohoplites fauna: – upper part of Lower Albian. 4) Hoplites fauna: – lower part of Middle Albian.

In the upper part of the Carolinefjellet Formation a few species of *Dimorphoplites, Euhoplites,* and *Gastroplites* have been found. These species are considered to belong to the middle or upper part of Middle Albian.

The paleogeographical conditions in Spitsbergen in Aptian and Albian times are briefly discussed. It is suggested that the sandy sediments which compose the Langstakken Member have been supplied to the Albian sea from land areas situated in the north-eastern and eastern parts of the Barents shelf.

The ammonite faunas recorded from the Albian of Spitsbergen contain faunal elements known from Western Europe and north-western North America. These relationships indicate that in Albian time Spitsbergen was connected both with Western Europe and north-western North America by sea areas through which migration of ammonites was possible.

The top of the Carolinefjellet Formation is truncated by a disconformity and is overlain by Tertiary strata. This disconformity arose in consequence of the pre-Tertiary uplift of the Spitsbergen area, and represents a considerable hiatus. The regional thickness variation of the formation indicates that the pre-Tertiary uplift and the subsequent denudation were largest in the north and north-west and decreased in intensity to the south-east. This interpretation is also supported by the age relations within the formation as they are shown by means of the ammonite faunas.

Thirty-three Albian ammonite species from 38 fossil localities are described. The families represented are: *Tetragonitidae, Desmoceratidae, Leymeriellidae,* and *Hoplitidae.* Of the recorded species, 8 are identified with previously described species, while the following 4 are new: *Hoplites (H.) svalbardensis, Freboldiceras remotum, Arcthoplites birkenmajeri,* and *Gastroplites subquadratus.* Furthermore, 7 species are compared to previously described species, 11 species are determined only as to generic level, while for 3 species the generic determination is uncertain.

Preface

The material for the following account was obtained during five summer seasons in Spitsbergen in the years 1961–1965. The field work was carried out on expeditions organized by Norsk Polarinstitutt. In addition to the material I have collected on these expeditions, I have in this paper incorporated stratigraphical information and treated ammonites collected by Professor K. BIRKENMAJER (Polish Academy of Sciences), geologist E. NYSÆTHER (University of Bergen), and geologist T. S. WINSNES (Norsk Polarinstitutt). I am very grateful to each of these persons for their contributions, which will be further specified on a later page.

The present study was commenced at the Institute of Geology, University of Oslo, and later continued at Norsk Polarinstitutt where the larger part of the work has been carried out. I wish to thank Professor L. STØRMER, University of Oslo, for his advice and helpfulness. Thanks are also due to the staff of Norsk Polarinstitutt, in particular to the geologists B. FLOOD, H. MAJOR, and T. S. WINSNES for discussions and for their personal kindness.

In 1966 Norsk Polarinstitutt enabled me to take a trip to London, where I visited the Geological Survey and Museum, and the British Museum (Natural History). I wish to express my gratitude to Dr. R. CASEY for giving me access to the rich collections of Albian ammonites in the Geological Survey and Museum, for gifts of publications and plaster casts of ammonites, and for his instructive advice and helpful suggestions with which he has promoted my study. I should also like to thank Dr. E. J. WHITE for giving me the opportunity to study the collections of Albian ammonites in the British Museum (Natural History).

Special thanks are given to the following persons for their assistance in the preparation of the manuscript: Mr. P. G. MAURTVEDT, who prepared the photographs for Plates 1–9; Messrs. R. ANDERSSON, M. GALÅEN, J. MELSOM, and E. WHIST for the final drafting of the text-figures and the illustrations on Plates 10–12; Cand. mag. P. HAGEVOLD for great help with the language of the English manuscript and for translation of the English abstract into Russian; Mr. T. R. WESTALL for correcting the English text; Miss S. ØVERLAND for typing the manuscript.

This study was in 1968 submitted as a thesis for the degree of Cand. real. at the University of Oslo. The present paper is a translated version of that thesis with some modifications.

I. Introduction

The regional background

The lower Cretaceous sequence in Spitsbergen is widely exposed in the main Mesozoic-Tertiary trough, which occupies the larger part of the central and southern region of the island. This structure (called the Spitsbergen trough) contains a thick sedimentary succession composed of marine and continental deposits which were formed during late Paleozoic, Mesozoic and Tertiary times. On the steeply sloping western flank of the trough the sediments were strongly folded during the Tertiary diastrophism, while in the central part of the structure the beds lie more or less horizontally. On the gently sloping eastern flank of the trough the beds dip slightly to the south-west or west. The Lower Cretaceous sequence is extensively exposed on the flanks of the trough; in the central part of the trough the Lower Cretaceous is covered by Tertiary strata. A comprehensive review of the geology of Spitsbergen is given by ORVIN (1940).

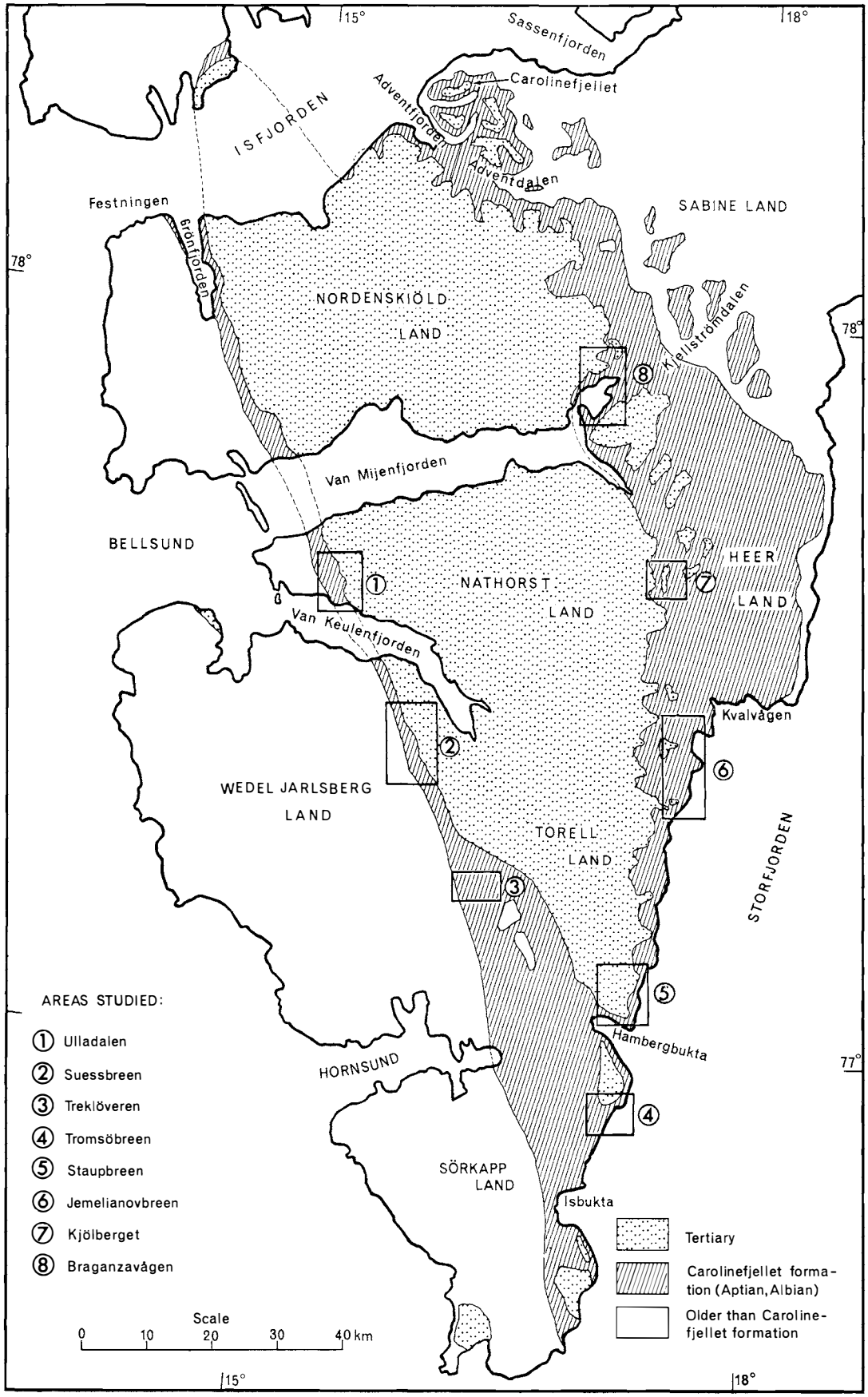
The present paper deals with the Carolinefjellet Formation, which represents the upper part of the Lower Cretaceous in Spitsbergen. The formation is marine and consists predominantly of shales, siltstones, and sandstones; its regional distribution is shown in Fig. 1. The lower part of the formation belongs to the Aptian, while its middle and upper parts are of Albian age.

The rock unit lying below the Carolinefjellet Formation is the Helvetiafjellet Formation. This unit consists of continental deposits (mainly sandstones), and is considered to be of Barremian age (PARKER 1967).

The Carolinefjellet Formation is overlain disconformably by the Tertiary Firkanten Formation. The disconformity between these two units arose in consequence of pre-Tertiary earth movements and represents a considerable hiatus in the succession. The pre-Tertiary earth movements in Spitsbergen have essentially consisted in an uplift of the region, and the denudation which followed this uplift removed a considerable part of the earlier deposited sedimentary succession. The denudation is considered to have been most intense in the northern and north-western areas of the island.

The investigated sections and fossil localities

This paper is based on stratigraphical observations and ammonites collected chiefly from the middle and upper parts of the Carolinefjellet Formation in the southern part of Spitsbergen. The field work has mainly been limited to 8 areas,


15°
18°
Sassenfjorden
Carolinefjellet
ISFJORDEN
Adventfjorden
Adventdalen
Festningen
Grönfjorden
SABINE LAND
78°
NORDENSKIÖLD LAND
Kjellströmdalen
Van Mijenfjorden
BELLSUND
HEER LAND
NATHORST LAND
Van Keulenfjorden
Kvalvågen
WEDEL JARLSBERG LAND
TORELL LAND
STORFJORDEN
HORNSUND
Hambergbukta
77°
SÖRKAPP LAND
Isbukta
AREAS STUDIED:
① Ulladalen
② Suessbreen
③ Treklöveren
④ Tromsöbreen
⑤ Staupbreen
⑥ Jemelianovbreen
⑦ Kjölberget
⑧ Braganzavågen
Scale
0 10 20 30 40 km
Tertiary
Carolinefjellet formation (Aptian, Albian)
Older than Carolinefjellet formation

the location of which is indicated in Fig. 1. From these areas, 9 stratigraphical sections are presented (Pl. 12, sections 1–9), and the ammonite faunas of 38 fossil localities are described (Pl. 11). The geographical positions of the sections and fossil localities are shown on the detail maps on Plate 10. Of the investigated fossil localities 26 are situated within the sections reproduced on Plate 12, where the stratigraphical positions of these localities are indicated. The remaining 12 localities are situated in places where continuous stratigraphical sections have not been measured. Information on the stratigraphical positions of these localities is given on Plate 11. A summary including all the fossil localities with information on their geographical and stratigraphical positions is given in Table 1.

Table 1

List of fossil localities studied, with key references to sections (Pl. 12) and maps (Pl. 10) on which their positions are indicated.

Area	Fossil locality No.	Place name within the area	References	
			Section Pl. 12, No.	Map Pl. 10, Fig.
Ulladalen	1, 2	Svedenborgfjellet	1	1
	3, 4, 5	Dalmøya	2	
	6	Ulladalen	–	
Suessbreen	7, 8, 9, 10, 11	Zillerberget	3	2
	12	Basilika	–	
	13	Neumayerberget	–	
	14	Langryggen	–	
Trekløveren	15	Blåklettane	–	3
	16	Trekløveren	–	
Tromsøbreen	17	Havkollen	–	4
Staupbreen	18, 19	Kovalskifjella	–	5
	20	Stellingfjellet	–	
Jemelianovbreen	21, 22, 23	Schönrockfjellet	4	6
	24	Kostinskifjellet	5	
	25, 26	Utnibba	–	
Kjølberget	27, 28, 29	Kjølberget	6	7
Braganzavågen	30, 31, 32, 33	Snøvola	7	8
	34, 35, 36	Liljevalchfjellet	8	
	37, 38	Trollstedet	9	

←

Fig. 1. *Key map showing the distribution of the Carolinefjellet Formation in Spitsbergen. The investigated sections and fossil localities are situated within the areas* 1–8. *These areas are reproduced on a larger scale in Plate* 10, *fig.* 1–8. [*Details of outcrops are based on:* ORVIN (1940); T. S. WINSNES (*map in preparation*); *the writer's own field observations.*]

In the field I have used partly tape and partly aneroid barometer for measuring of thicknesses. Of the sections reproduced on Plate 12, Nos. 1–6 have been measured by aneroid barometer, while Nos. 7–9 have been measured by tape. On the locality maps on Plate 10 the contact between the Carolinefjellet Formation and the Tertiary Firkanten Formation is indicated in order to give a better picture of the positions of sections and fossil localities in the field. The position of the contact is marked partly on the basis of field observations, and partly by means of aerial photographs.

At 22 of the fossil localities investigated, the ammonites have been found *in situ*. At the remaining 16 fossil localities, the ammonites have been collected from the scree on rather steep mountain slopes (with inclinations usually of 30–40°). It is supposed that the ammonites found at these 16 fossil localities are derived from beds which lie stratigraphically higher in the formation than the respective fossil localities. This assumption is reasonable as the loose material on the slopes moves downwards, and the strata in the investigated areas are only slightly tilted or lie practically horizontally.

In addition to the material collected during my own field work, I have in this paper included the following unpublished material: 1) ammonites and stratigraphical observations from the Tromsøbreen and Trekløveren areas, collected by K. BIRKENMAJER; 2) one ammonite from locality 5 found by E. NYSÆTHER; 3) stratigraphical observations from the southern part of Heer Land carried out by T. S. WINSNES.

II. Historical review

Subdivision and nomenclature of the Carolinefjellet Formation

The major lithostratigraphical units within the Jurassic and Cretaceous sequence of Spitsbergen were already recognized by NATHORST (1910a) in his comprehensive description of the geology of Spitsbergen. For sediments within the Carolinefjellet Formation, NATHORST in this work introduced the term Dentalien beds, which alludes to the fossil content of these deposits. The name Dentalien beds was later changed into Ditrupa beds by STOLLEY (1912), after his investigations had shown that the name-giving fossil belongs to the genus *Ditrupa*.

The name Carolinefjellet Formation, which is used in the present paper, was originally proposed by H. MAJOR in connection with the geological map "Adventdalen" 1:100,000 (in preparation at Norsk Polarinstitutt). Definitions of the formation were subsequently published by PARKER (1966 and 1967).

Based on field work around Kjellströmdalen HAGERMAN (1925) introduced a subdivision of the Carolinefjellet Formation into three lithostratigraphical units (in ascending order): Lower Lamina sandstone, Cretaceous shale, and Upper Lamina sandstone. HAGERMAN worked in the area in 1924 as a member of a Swedish expedition.

On the north side of Kjellströmdalen the Carolinefjellet Formation was investigated anew by PARKER (1967) on expeditions from the Cambridge University. He followed HAGERMAN in subdividing the formation into three units, but he introduced the new names Dalkjegla Member, Innkjegla Member, and Langstakken Member for respectively Lower Lamina sandstone, Cretaceous shale, and Upper Lamina sandstone. (See Fig. 2.)

Previous reports on Albian ammonites

The possible occurrence of Albian rocks in Spitsbergen was first suggested by POMPECKJ (in NATHORST 1910b). The material examined by POMPECKJ was collected in the Bellsund area by NATHORST's expedition in 1898 and consisted mainly of pelecypods but contained also a few ammonites. Of particular interest in this collection is an ammonite found on Firkanten, on the northern coast of Van Keulenfjorden. According to POMPECKJ, this ammonite was very like *Arcthoplites jachromensis* (NIKITIN 1888) from the Albian of Central Russia. The age of the ammonite, however, could not be determined more definitely than "?Portlandian (-Lower Cretaceous)" owing to its poor preservation.

The next paper containing information on the Albian of Spitsbergen was published by SPATH (1921). His material was collected by CONWAY's expedition in 1896 from various parts of the Mesozoic in the Isfjorden area. The occurrence of Albian beds in this area was assumed by SPATH on the basis of ammonites collected from Breinosa in Adventdalen. From this locality he recorded the following species:

Sonneratia ? sp. cf. *"Hoplites" jachromensis* (NIKITIN)
Sonneratia ? sp. cf. *latisulcata,* SINZOW
Sonneratia ? (*Hoplites?*) spp. ind.
Cleoniceras ? cf. *bicurvatoides* SINZOW sp.

The ammonites mentioned from Breinosa were poorly preserved, and SPATH referred them only with some doubt to the Albian. Moreover, in this paper SPATH suggested the possible occurrence of Albian rocks in the Storfjorden area on the basis of a fragmentary ammonite found on the northern coast of Kvalvågen.

A large collection of Mesozoic fossils from Spitsbergen and Novaya Zemlya was examined and described by FREBOLD (1930). This material had mainly been collected after the turn of the century, chiefly by Norwegian and Swedish expeditions. From four localities on the coast of Van Mijenfjorden FREBOLD described *Hoplites* (*Sonneratia ?*) cf. *jachromensis* NIKITIN, and by this demonstrated the occurrence of Albian rocks in the area.

Jurassic and Cretaceous fossils from the Festningen section and from other places around Isfjorden and Bellsund were described by SOKOLOV & BODYLEVSKY (1931). From the Albian in Van Mijenfjorden these authors have also recorded *Sonneratia* (*?*) cf. *jachromensis* NIKITIN in accordance with FREBOLD (1930).

SPATH's (1921) assumption of the occurrence of Albian strata in the Storfjorden area was later supported by WEIR (in TYRRELL 1933). From the northern coast of Kvalvågen WEIR recorded an ammonite ("Hoplites") which he supposed to be of Albian age. The material examined by WEIR was collected by TYRRELL in 1919 and 1920.

The Mesozoic sequence and its faunas in the Isfjorden and Van Keulenfjorden areas have been discussed in two papers by PČELINA (1965a, 1965b). The papers are based on field investigations made by Russian expeditions in the years 1962–64. In the Festningen section PČELINA (1965a) has proved the presence of Albian beds by find of *Arcthoplites jachromensis* (NIKITIN) and *Sanmartinoceras* sp. (? *S.pusillum* RAVN). From the Van Keulenfjorden area PČELINA (1965b) has reported the occurrence of *Arcthoplites jachromensis* and *Arcthoplites* sp. in the middle part of the Carolinefjellet Formation. From the same area, but from the upper part of the formation, she has mentioned the following ammonites:

Cleoniceras sp. (aff. *sablei* IMLAY)
Beudanticeras aff. *glabrum* WHITEAVES
Freboldiceras ? sp.
Sonneratia sp.

New information on the stratigraphy of the Mesozoic in the southern and eastern parts of Spitsbergen are given by PČELINA (1967). The material presented in this publication was collected in 1965 and 1966 by Russian expeditions. Among the Albian fossils recorded in the paper, the following ammonites are of particular interest:

Beudanticeras sp. (aff. *multiconstrictum* IMLAY)
Leymeriella aff. *tardefurcata* (LEYM.)
Cleoniceras (*Neosaynella* ?) sp.
Hoplites sp. (ex gr. *dentatus* SOW.)
Otohoplites sp.
Dimorphoplites sp.
Freboldiceras sp. *indet.*
Arcthoplites cf. *jachromensis* (NIK.)

The faunal succession in the whole Jurassic and Cretaceous sequence of Spitsbergen was discussed by PARKER (1967). Within the Carolinefjellet Formation he has recognized three main ammonite faunas (in ascending order): the Tropaeum fauna, the Arcthoplites fauna, and the Cleoniceras fauna.

III. Stratigraphical part

Lithostratigraphy of the Carolinefjellet Formation

The following account of the lithostratigraphy is limited mainly to the southern part of Spitsbergen. In this region the Carolinefjellet Formation is subdivided into five members as shown in Fig. 2. The lower three members, with type sections in the Kjellströmdalen area, have been named by PARKER (1967). The upper two members – the Zillerberget and the Schönrockfjellet – are proposed in the present paper.

The lithological descriptions given in this chapter are based solely on field observations. A closer sedimentological study of samples in laboratory has not been made for the purpose of this paper.

1. THE DALKJEGLA MEMBER

The Dalkjegla Member is marine and rests conformably on the Helvetiafjellet Formation, which is made up of non-marine strata. The member consists mainly of fine-grained, grey-green sandstone alternating with grey shale and siltstone. The sandstone is laminated to thin-bedded, and splits into even plates by weathering. The siltstone and shale weather into small, angular bits. On some horizons ripple marks are common on the bedding surfaces of sandstone. Fossils occur rather sparsely; at a few localities shells of pelecypods, tubes of *Ditrupa,* and different types of tracks and borrows after benthonic animals have been found.

In its type section at Kjellströmdalen the Dalkjegla Member is 131 m thick (PARKER 1967). In the Suessbreen area and in southern Heer Land its thickness is 96 and 57 m respectively. Outside these localities, the member is observed in the Ulladalen area, in western Torell Land, in the Tromsøbreen area, west of Grønfjorden, and around Adventfjorden. As it appears from these observations, the Dalkjegla Member has a large regional extension, which reaches from Isfjorden southwards to Sørkapp Land.

2. THE INNKJEGLA MEMBER

The lower and upper part of this member show obvious lithological differences. On the basis of this fact the member is here subdivided into two informally designated units: the Lower shale unit and the Upper shale-siltstone unit. The boundary between these divisions is gradational.

Kjellströmdalen area		Southern Spitsbergen
HAGERMAN 1925	PARKER 1967	This paper
		Schönrockfjellet member
		Zillerberget member
Upper Lamina sandstone	Langstakken member	Langstakken member
Cretaceous shale	Innkjegla member	Innkjegla member
Lower Lamina sandstone	Dalkjegla member	Dalkjegla member

Fig. 2. *Chart of the Carolinefjellet Formation showing the stratigraphical schemes of previous authors compared with the scheme used in the present paper.*

The Lower shale unit rests on the Dalkjegla Member, and consists mainly of grey shale with beds and lenses of clay-ironstone. In some horizons the clay-ironstone shows cone-in-cone structures, and occasionally contains fossilized driftwood. The thickness of the clay-ironstone beds is usually 20–50 cm. The shales contain scattered pebbles of chert and quartzite, calcareous concretions, and rosettes of calcite. The lower and middle part of the unit consist of pure, dark-grey shale without siltstone and sandstone. In the upper part of the unit, however, the shale has a lighter colour, and here also occur some bands of siltstone and silty shale. The thickness of the Lower shale unit is about 180 m at Kjellströmdalen, 110 m at Ulladalen, 100 m at Suessbreen, 210 m at Kvalvågen, and 250 m at Tromsøbreen.

The Upper shale-siltstone unit consists of shale and siltstone with beds of fine-grained, grey-green sandstone. The sandstone beds are rarely thicker than 50 cm, and they are usually distinctly laminated. Beds and lenses of clay-ironstone are also present in this unit, but they do not appear so frequently here as in the Lower shale unit. In the Braganzavågen area the sandstone beds increase in frequency and thickness towards the upper boundary of the Upper shale-siltstone unit, so that here is a gradational contact between this unit and the overlying Langstakken Member.

The Lower shale unit is generally poor in fossils, whereas the Upper shale-siltstone unit contains a comparatively rich fauna. The most common fossils are shells of pelecypods and tubes of *Ditrupa,* while ammonites occur rather scarcely.

The total thickness of the Innkjegla Member is 429 m in its type section at Kjellströmdalen (PARKER 1967). In the Ulladalen and Suessbreen areas the thickness of the member is 323 and 321 m respectively. In the southern part of Heer Land the member is 326 m thick.

3. THE LANGSTAKKEN MEMBER

This member consists of grey-green, fine-grained sandstone with thin horizons of grey siltstone and shale. The quantitative dominance of sandstone within the member is particularly obvious in the area around Kjellströmdalen. The sandstone has a distinct stratification and splits easily into slabs and plates along the bedding planes. At several localities the bedding planes bear well-preserved ripple marks. Fossils are rather uncommon in this member. Molds of pelecypods, tubes of *Ditrupa,* and a few poorly preserved ammonites have been found. With regard to its lithology this member shows a close similarity to the Dalkjegla Member.

The thickness of the Langstakken Member is 194 m on Trollstedet at Kjellströmdalen, 90 m in the southern part of Heer Land, 62 m on Dalmøya in the Ulladalen area, and 40 m on Zillerberget in the Suessbreen area. These observations indicate that the Langstakken Member decreases in thickness from Kjellströmdalen in southern direction to Kvalvågen, and in south-western direction to Zillerberget, as shown in Fig. 5. The explanation of this decrease in thickness must be that the sandstones which characterize the Langstakken Member pass laterally into shales and siltstones towards the south and south-west. This explanation is supported by the following observations: the boundaries of the member are locally gradational; the member contains less sandstone in relation to shale and siltstone in the Suessbreen area than at Kjellströmdalen (see Pl. 12, sections 3 and 9); in the southernmost area investigated, i. e. the Tromsøbreen area, this member cannot be recognized, as shown below.

The Carolinefjellet Formation begins also in the Tromsøbreen area with a sandstone sequence, which represents the Dalkjegla Member. This member is overlain by an about 250 m thick shale sequence, which is equivalent to the Lower shale unit of the Innkjegla Member (Fig. 5). This unit is succeeded by a c. 600 m thick sequence, which represents the remaining part of the Carolinefjellet Formation in this area and shows the following lithology: in general it consists of shale and siltstone with thin beds of sandstone; the sandstone beds occur scattered over the whole succession, but they do not constitute more than c. 10–20% of the total thickness. The stratigraphical position of this, c. 600 m thick, sequence indicates that it may be correlated with the following parts of the Carolinefjellet Formation farther north in Spitsbergen, namely: the Upper shale-siltstone unit of the Innkjegla Member, the Langstakken Member, the Zillerberget Member, and the Schönrockfjellet Member.

4. THE ZILLERBERGET MEMBER

This unit consists of grey shale and siltstone with beds of grey-green, fine-grained sandstone. The sandstone occurs in relatively small quantities, and is mainly limited to certain more or less persistent bands between the shale and siltstone. The thickness of these bands is commonly 5–20 cm, and rarely more than 50 cm. The sandstone is usually distinctly laminated and splits into thin plates by weathering. Lenses of clay-ironstone with red-brown weathering colour occur scattered over the whole member. The type section of the member is

situated on the western slope of Zillerberget in the Suessbreen area. In lithological respect, this member is more or less identical with the Upper shale-siltstone unit of the Innkjegla Member.

The most common fossils in the Zillerberget Member are pelecypods and *Ditrupa,* which in some beds occur in great quantities and occasionally form thin seams of coquina. Ammonites, gastropods, and echinoderms, however, are more sparsely represented. At several localities different types of tracks and borrows after benthonic organisms have been observed.

The base of the Zillerberget Member is defined as the change in lithology from the cliff-forming sandstones of the Langstakken Member to the softer shales and siltstones of the Zillerberget Member. In the terrain this contact is usually marked by a distinct topographical ledge.

In the Ulladalen, Suessbreen, Kjølberget, and Braganzavågen areas, the Zillerberget Member is overlain by the Tertiary Firkanten Formation. In these areas the upper boundary of the member is formed by the disconformity which follows the base of the Tertiary. This disconformity in several places is marked by a thin conglomerate (thickness often 20–40 cm).

In the Jemelianovbreen area and in the southern part of Heer Land, the Zillerberget Member is overlain by the Schönrockfjellet Member. In these areas the upper boundary of the Zillerberget Member is defined as the base of the lowest resistant sandstone bed of the Schönrockfjellet Member.

The Zillerberget Member is topographically marked by slopes which commonly have an inclination of 30–45° and are partly covered by scree. This feature contrasts with the steeper bluffs formed by the Langstakken Member (below), and the Schönrockfjellet Member or the Firkanten Formation (above).

The thickness of the Zillerberget Member shows an appreciable variation from area to area, as it appears from the sections on Plate 12 and from the following observations. The thickness of the member is: 334 m in the southern part of Heer Land; 210 m on Zillerberget in the Suessbreen area; 130 m on Dalmøya in the Ulladalen area; 87 m on Snøvola, and 28 m on Trollstedet, both in the Braganzavågen area. In the latter three areas the top of the member is limited by the disconformity, which was formed by the pre-Tertiary uplift of the Spitsbergen area. Consequently, these considerable differences in thickness must be explained, at least partly, by the pre-Tertiary uplift and the subsequent erosion, which are more closely discussed later in this chapter.

5. THE SCHÖNROCKFJELLET MEMBER

This unit consists of grey-green, fine-grained sandstone with dark-grey shale and siltstone. The sandstone has a strong quantitative dominance; it usually shows a distinct stratification, and splits easily into plates along the bedding planes. Fossils are comparatively rare; in a few places shells of pelecypods and stem fragments of crinoids have been found. The type section of the member is situated on the eastern slope of Schönrockfjellet, where the unit is 83 m thick. In lithological respect this unit is similar to the Dalkjegla and Langstakken

Members, which are the other two strongly sandy members of the Carolinefjellet Formation.

The Schönrockfjellet Member is topographically marked by relatively steep rock walls. The base of the unit is defined as the lowest resistant sandstone bed.

The Schönrockfjellet Member is overlain by the Tertiary Firkanten Formation, and the boundary between these units is formed by the disconformity that follows the base of the Tertiary. Also in this case the disconformity in several places is marked by a thin conglomerate.

Regionally, the Schönrockfjellet Member seems to be restricted to the south-eastern part of Spitsbergen, where it has been observed in the following places: southern part of Heer Land, the Jemelianovbreen area, Veteryggen, Bellingen, and Ommaneyfjellet.

Ammonite faunas and correlations

The ammonites from 34 of the investigated fossil localities are in the following grouped in four successive faunas. Each of these faunas is named after a characteristic genus. *To one and the same fauna are referred those ammonites which either on the basis of their occurrence in the rock sequence, or on the basis of their genetic affinities can be supposed to belong to the same restricted stratigraphical time interval.* A summary of the faunas is given on Plate 11.

The ammonites collected from the remaining four fossil localities are treated in a separate group in addition to the four faunas. This group comprises only a few species belonging to the genera *Dimorphoplites, Euhoplites,* and *Gastroplites.*

The faunal classification proposed here is of a preliminary character. The purpose of the classification is to give a practical survey of the ammonite sequence within the Carolinefjellet Formation on the basis of the material which is available at present. A faunal classification of this type may be useful until a formal subdivision into biostratigraphical zones can be introduced on the basis of more detailed observations and collections in the field.

The age relationships within the Carolinefjellet Formation are shown in the following by correlation of the recognized ammonite faunas with the Albian in southern England. A summary of this correlation is given in Fig. 3.

The Albian succession in southern England is studied in great detail, and the rich ammonite faunas occurring here, afford the basis of a refined subdivision of the Albian stage into zones and subzones. Other Albian sequences of great stratigraphical importance are described from northern Germany, from France, and from Switzerland. Information on the stratigraphy of the Albian in western Europe used in the present paper is obtained mainly from the following publications: Brinkmann (1937), Spath (1942 and 1943), Breistroffer (1947), and Casey (1961).

As previously mentioned, the lower part of the Carolinefjellet Formation belongs to the Aptian, whereas the middle and upper part of the formation is of Albian age. Before starting to discuss the Albian ammonite faunas, we shall therefore first review the Aptian ammonites.

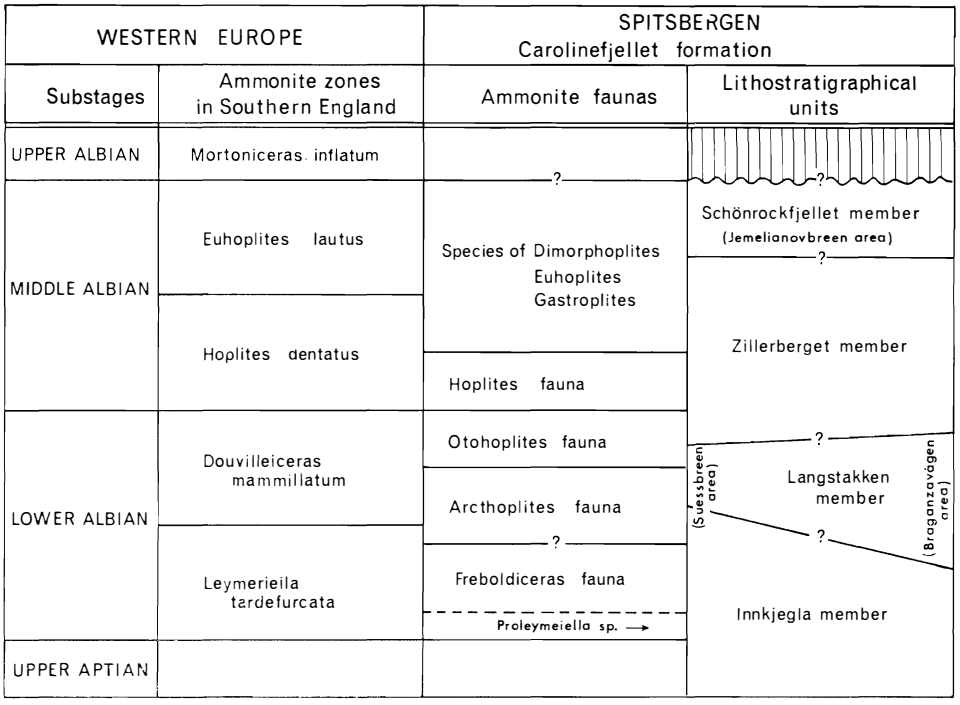


Fig. 3. *Correlation chart showing the age relationships within the middle and upper part of the Carolinefjellet Formation; the members of the formation are correlated with the Albian of southern England by means of the ammonite faunas.*

The only Aptian ammonite genus hitherto recognized in Spitsbergen is *Tropaeum*. From this region the genus was first recorded by STOLLEY (1912), who described *Tropaeum arcticum* (= *Crioceras arcticum* STOLLEY) from the Carolinefjellet Formation on the southern side of Sassenfjorden and western side of Adventfjorden. Later FREBOLD (1930) and SOKOLOV & BODYLEVSKY (1931) have described several poorly preserved specimens of *Tropaeum* from Festningsodden. The occurrence of *Tropaeum* in the Aptian at Kjellströmdalen is mentioned by PARKER (1967).

The collections of Norsk Polarinstitutt contain several well-preserved specimens of *T. arcticum*, which have not been described hitherto. These specimens have been collected on Havkollen in the Tromsøbreen area and on Storbullen at Kjellströmdalen, by K. BIRKENMAJER and T. S. WINSNES respectively. Both on Havkollen and Storbullen the specimens were found in the Lower shale unit of the Innkjegla Member. According to FREBOLD & STOLL (1937) the age of *T. arcticum* is Upper Aptian.

1. FREBOLDICERAS FAUNA

The characteristic and most common ammonites of this fauna are *Freboldiceras remotum* n. sp. and *Arcthoplites birkenmajeri* n. sp. The fauna occurs at seven localities, and its composition at these localities is shown in Table 2.

Table 2

Locality No.	7	8	14	15	17	26	38
Freboldiceras remotum n. sp.	+				+		+
Arcthoplites birkenmajeri n. sp.		+	+	+	+		+
Leymeriella (L.) germanica					+	+	
Eogaudryceras inaequale					+		
Freboldiceras singulare						+	
Grantziceras cf. *affine*	+					+	

Locality 17 in the Tromsøbreen area is of particular importance for the correlation of the Freboldiceras fauna with the Albian in western Europe, because *F.remotum* and *A.birkenmajeri* at this locality is associated with *L.(L.) germanica.* The evolution and stratigraphical distribution of the Leymeriellidae has been studied in detail by BRINKMANN (1937) in the Lower Albian sequence of northern Germany. These investigations show that *L.(L.) germanica* occurs in the middle part of the Leymeriella tardefurcata zone. Consequently, the presence of *L.(L.) germanica* at locality 17 indicates that the Freboldiceras fauna is approximately contemporaneous with the middle part of the Leymeriella tardefurcata zone. This correlation is supported by the presence of *Proleymeriella* sp. at locality 37, which is commented on below.

The genus *Proleymeriella* in western Europe occurs in the lower part of the Leymeriella tardefurcata zone, as shown by BRINKMANN (1937) and CASEY (1957). A corresponding age is here assumed for *Proleymeriella* sp. from locality 37. In the rock sequence, this locality is situated 64 m lower than locality 38. The last-mentioned locality contains Freboldiceras fauna represented by *F.remotum* and *A.birkenmajeri.* (See Plate 12, section 9.)

In the Suessbreen area the Freboldiceras fauna occurs in the upper part of the Innkjegla Member (at localities 7, 8, and 14), while in the Braganzavågen area, the same fauna is found in the lower part of the Langstakken Member (at locality 38). These observations suggest that the upper part of the Innkjegla Member in the Suessbreen area is contemporaneous with the lower part of the Langstakken Member in the Braganzavågen area, as indicated in Fig. 3. The correctness of this assumption will probably be confirmed by additional field work in these two areas.

Locality 26 in the Jemelianovbreen area contains *L. (L.) germanica, F. singulare,* and *G.* cf. *affine.* The fossils at this locality have been collected from the talus below the steep eastern slope of Utnibba, and the three species mentioned above were obtained from separate loose boulders. The occurrence of *L. (L.) germanica* indicates that beds of the same age as the middle part of the Leymeriella tardefurcata zone are present on the eastern slope of Utnibba, because the ammonites in all probability must have originated from this slope.

Locality 6 in the Ulladalen area contains *Grantziceras* cf. *glabrum.* This locality is situated c. 125 m below the upper boundary of the Innkjegla Member. The stratigraphical position of the locality suggests that this occurrence of *G.* cf. *glabrum* either belongs to the Freboldiceras fauna or is slightly older than this fauna.

2. ARCTHOPLITES FAUNA

This fauna is represented at locality 1, 2, 3, 9, and 25. At locality 2 occur *Arcthoplites jachromensis* and *Brewericeras* cf. *hulenense*, while at the remaining four localities only *A. jachromensis* is present.

The Arcthoplites fauna is considered to be of Lower Albian age, because the five localities where this fauna occurs are situated considerably lower in the rock sequence than those localities which contain *Otohoplites* or *Hoplites*. (See Pl. 11 and Pl. 12.) Both *Otohoplites* and *Hoplites* are well-known from southern England, where they occur in the upper part of the Lower Albian and in the lower part of the Middle Albian respectively.

Within Lower Albian the precise age of the Arcthoplites fauna is more difficult to determine. As a preliminary correlation it can be supposed that the fauna is younger than the middle part of the Leymeriella tardefurcata zone, but older than the upper part of the Douvilleiceras mammillatum zone. This correlation is based on the fact that the Arcthoplites fauna in the Ulladalen and Suessbreen areas occurs stratigraphically higher than the Freboldiceras fauna, but lower than the Otohoplites fauna. In the present paper the Freboldiceras fauna is correlated with the middle part of the Leymeriella tardefurcata zone, while the Otohoplites fauna is referred to the upper part of the Douvilleiceras mammillatum zone (Fig. 3).

At localities 1, 2, and 3 in the Ulladalen area, the ammonites have been collected from the bedrock while at locality 9 in the Suessbreen area they were obtained from the scree. All of these localities are situated in the upper part of the Innkjegla Member.

At locality 25 in the Jemelianovbreen area, the specimens of *A. jachromensis* have been collected from the talus below the steep eastern slope of Utnibba. Judging from aerial photographs, the lower part of this slope is composed of beds belonging to the middle or upper part of the Innkjegla Member.

3. OTOHOPLITES FAUNA

This fauna consists almost exclusively of species belonging to the genus *Otohoplites*. The fauna is recorded from seven localities, and its composition at these localities is shown in Table 3.

The Otohoplites fauna is correlated here with the upper part of the Douvilleiceras mammillatum zone. The genus *Otohoplites* is particularly well-known from

Table 3

Locality No.	4	16	30	31	34	35	36
Otohoplites guersanti	+						
O. cf. *guersanti*	+						
O. glyphus		+					
O. sp. A	+						
O. sp. B				+	+		
O. sp. C			+			+	+
(*Grycia sablei*)		+					
Grycia sp.					+		

southern England, but it is abundant also in northern France. From southern England altogether 14 species of *Otohoplites* have been described by CASEY (1965), and according to his investigations, these species occur in the upper part of the Douvilleiceras mammillatum zone.

In the Ulladalen and Braganzavågen areas the Otohoplites fauna is represented at localities 4, 30, 31, 34, 35, and 36. With the exception of No. 30, all these localites are situated in the lower part of the Zillerberget Member. The species at locality 30 has been obtained from a loose block found in the upper part of the Langstakken Member.

The ammonites collected from locality 16 in the Tromsøbreen area are *Otohoplites glyphus* and *Grycia sablei*. These two species have been found here separately in the talus, and there is no evidence to show that they have originated from the same stratigraphical horizon. It remains therefore uncertain whether these two species at locality 16 are stratigraphically contemporaneous. In this connection it is worth noticing that *G. sablei* at most localities where it occurs in Spitsbergen, is associated with the Middle Albian genus *Hoplites*.

4. HOPLITES FAUNA

This fauna is characterised by the genera *Hoplites* and *Grycia,* which at eight of the investigated localities occur associated. The most common species of the fauna are *Grycia sablei, Grycia whittingtoni,* and *Hoplites* (*H. svalbardensis*) n. sp. The fauna is recorded with certainty from ten localities, and its composition at these localities is shown in Table 4.

Table 4

Locality No.	10	11	12	13	21	22	23	24	27	28
Hoplites (*H.*) *svalbardensis* n. sp.	.....	.....	.....	+	+	.....	+	+	+	
Grycia sablei	+	+	+	.....	+	+	+	+	+	+
Grycia whittingtoni	+	.....	.....	.....	+	+	+	+	+	
Hoplites (*I.*) cf. *eodentatus*	.....	.....	.....	.....	.....	+				
Hoplites (*H.*) aff. *obtusus*	.....	.....	.....	.....	.....	.....	.....	.....	.....	+
Hoplites (*H.*) sp. A	.....	.....	+							
Hoplites (*H.*) sp. B	+									

The Hoplites fauna from Spitsbergen is in the following correlated with the lower part of the Hoplites dentatus zone. The fossil localities where this fauna is represented are situated in the lower part of the Zillerberget Member.

Hoplites and closely related genera are characteristic of the Middle Albian, and they are particularly abundant in the Gault in southern England.

In the present material the subgenus *Hoplites* (*Isohoplites*) is represented only by one specimen collected from locality 22 in the Jemelianovbreen area. In southern England and northern France this subgenus is widespread in the

Hoplites (I.) eodentatus subzone (CASEY 1961). This subzone represents the lowermost part of the Hoplites dentatus zone.

All species of the subgenus *H.* (*Hoplites*) occurring in the present material are characterized by a very shallow siphonal depression. By this feature, but also by their ribbing, these species show a close similarity to early representatives of *H.* (*Hoplites*) known from southern England. In southern England occur *H.* (*Hoplites*) with shallow siphonal depression [e. g. *H.* (*H.*) *obtusus, H.* (*H.*) *pseudodeluci,* and *H.* (*H.*) *devisensis*] in the lower part of the Hoplites dentatus zone, as it appears from SPATH (1942, p. 675).

To the Hoplites fauna belong probably also *Hoplites?* sp. C from locality 5, *Hoplites?* sp. D from locality 32, and *Hoplites?* sp. E from locality 33. The generic determination of these three forms is uncertain owing to the crushed and fragmentary nature of the material. They bear, however, a strong resemblance to *Hoplites*. The localities containing these three forms are situated in the lower part of the Zillerberget Member, in accordance with those localities where the genus *Hoplites* with certainty has been recognized.

5. SPECIES OF *DIMORPHOPLITES, EUHOPLITES,* AND *GASTROPLITES*

The recorded species of *Dimorphoplites, Euhoplites,* and *Gastroplites* have been collected from 4 fossil localities in the south-eastern region of Spitsbergen. These localities are situated in the upper part of the Carolinefjellet Formation and contain the following ammonites:

Locality 18: *Dimorphoplites* cf. *tethydis, Euhoplites* sp. A
» 19: *Gastroplites* sp. A
» 20: *Euhoplites* sp. B, *Gastroplites subquadratus* n. sp.
» 29: *Gastroplites* sp. B

At these four localities the ammonites have been collected from loose boulders on talus slopes. Where two species are recorded from the same locality, these species have been obtained from separate boulders.

The genera *Dimorphoplites* and *Euhoplites* are well-known from the Albian of Europe. They are particularly abundant in the Gault in southern England, where their stratigraphical distribution has been studied in detail by SPATH (1942) and MILBOURNE (1963). In England the oldest representatives of both *Dimorphoplites* and *Euhoplites* appear in the upper part of the Hoplites dentatus zone; the youngest species of *Dimorphoplites* occur in the uppermost part of the Euhoplites lautus zone, while the youngest species of *Euhoplites* are described from the Mortoniceras inflatum zone.

Euhoplites sp. A from locality 18 seems to be closely related to *Euhoplites subtuberculatus* SPATH, and is considered to be of about the same age as this species. *E. subtuberculatus* is described from southern England, where it occurs in the upper part of the Hoplites dentatus zone and in the lower part of the Euhoplites lautus zone (SPATH 1942, p. 677).

Euhoplites sp. B from locality 20 resembles *Euhoplites boloniensis* SPATH. A more detailed comparison of these two species, however, is impossible, because *Euhop-*

lites sp. B is represented only by one fragmentary specimen. In southern England *E. boloniensis* is recorded from the lower part of the Mortoniceras inflatum zone (SPATH 1942, p. 677).

The genus *Gastroplites* is best known from western Canada and northern Alaska. In Spitsbergen this genus has been found at localities 19, 20, and 29. The rocks, which in Canada and Alaska contain *Gastroplites,* are considered to be of Middle Albian age (REESIDE & COBBAN 1960; IMLAY 1961). From Europe only a single specimen of *Gastroplites* has been recorded. It was found at the top of the Middle Albian and is described by SPATH (1937).

Paleogeographical conclusions

THE APTIAN-ALBIAN SEA IN SPITSBERGEN

The distribution of land and sea on the Barents shelf during Jurassic and Cretaceous times has been reconstructed on paleogeographical maps by FREBOLD (1930, Pl. XXIX–XXXIII). For the upper part of the Lower Cretaceous these maps show the following picture: during the Aptian Svalbard was covered by the sea with the exception of a minor land area at Nordaustlandet; in Albian time the north-eastern and eastern areas of Svalbard (i. e. Barentsøya, Edgeøya, Nordaustlandet, and north-east Spitsbergen) were parts of an extensive eastern land mass, while the western and southern parts of Spitsbergen continued to be covered by sea.

In his next paper FREBOLD (1931) assumed the existence of an extensive land west of Svalbard in Aptian and Albian times. In his opinion, this land (the so-called Skandik) lay close to the present western coast of Spitsbergen.

A detailed paleogeographical reconstruction of the Aptian sea in Spitsbergen has been worked out by BIRKENMAJER (1966) on the basis of sedimentological investigations made in the Dalkjegla Member. According to this author the sediments deposited in the Aptian sea were derived from a land area which covered the north-eastern and eastern parts of the Svalbard archipelago. As mentioned above, FREBOLD (1931) assumed the existence of a land mass also west of Spitsbergen. BIRKENMAJER (1966) is of the opinion that this land supplied practically no clastic material to the Aptian-Albian sea.

The theory about the existence of land areas in the north-eastern and eastern parts of the Svalbard archipelago is supported by the distribution and thickness-variation of the Langstakken Member. This member consists mainly of sandstone, and its thickness is greatest at Kjellströmdalen. To the south and south-west from this area the member decreases in thickness, as shown by observations made in the Suessbreen area and in the southern part of Heer Land. (See Fig. 5 and Pl. 12). South of the two latter areas the Langstakken Member is wedging out gradually, and in the Tromsøbreen area this unit is, therefore, no longer recognizable. These relationships indicate that the clastic material which compose the Langstakken Member was transported to the Albian sea mainly from the north-east and east. Consequently, the source area of this material must have been situated within the present Barents shelf.

	SPITSBERGEN	WESTERN EUROPE (Southern England, France, Northern Germany)	TRANSCASPIA (Turkmenia, Mangyshlak)	EAST GREENLAND	ALASKA	CANADA (Arctic Archipelago Alberta, British Columbia)	OTHER AREAS
Group A	Eogaudryceras	+					North Africa Madagascar
	Proleymeriella	+					
	Leymeriella	+	+	+			Caucasus
	Hoplites	+	+	+			Caucasus Central Russia
	Euhoplites	+	+	+			
	Otohoplites	+	+				
	Dimorphoplites	+	+	+			Caucasus Central Russia
Group B	Grantziceras				+	+	
	Brewericeras			+	+	+	California
	Grycia				+	?	
	Freboldiceras				+	+	
	Arcthoplites			+	?	+	Central Russia
	Gastroplites	+		+	+	+	Western U.S.A.

Fig. 4. *Albian ammonite genera recorded from Spitsbergen and their occurrence in other regions. The genera are arranged in two groups (A and B) according to their geographical distribution outside Spitsbergen.*

FAUNAL COMPARISONS

The following discussion is concentrated on the Albian ammonite faunas in Spitsbergen and their relations to contemporaneous faunas from western Europe, East Greenland, Canada, and Alaska. Important information on the ammonite faunas occurring in the last four regions is obtained from the following papers: western Europe – SPATH 1942, BREISTROFFER 1947, CASEY 1961; East Greenland – DONOVAN 1957; western interior and arctic archipelago of Canada – JELETZKY 1964; Alaska – IMLAY 1960 and 1961. Information on Albian ammonites recorded from Russia is taken from LUPPOV & DRUŠČIC 1958.

The Albian ammonites recorded from Spitsbergen in the present paper, can be arranged in two groups on the basis of their regional distribution, as is shown in Fig. 4. Group A comprises 7 genera, which all are known from western Europe and most of them also from Transcaspia. From Alaska and Canada – to the writer's knowledge – none of these genera is recorded hitherto. Among the

species belonging to the genera listed in group A, the following are recognized with certainty both in Spitsbergen and in western Europe:

Eogaudryceras inaequale
Leymeriella (L.) germanica
Otohoplites guersanti
Otohoplites glyphus

Group B includes 6 genera, which all are known from the north-western regions of North America (Alaska, western interior and arctic archipelago of Canada). To the writer's knowledge, none of these genera are reported from western Europe, except *Gastroplites*. It must be emphasized, however, that in western Europe only a single specimen of *Gastroplites* is found to date. The genus is currently regarded as characteristic of North America where it is represented by several species. Among the species belonging to the genera listed in group B, the following are recognized with certainty both in Spitsbergen and in north-western North America:

Grycia whittingtoni
Grycia sablei
Freboldiceras singulare

As demonstrated above, the Albian ammonite faunas of Spitsbergen show close affinities with those of western Europe on the one hand, and those of north-western North America on the other. Faunal elements from these two regions are also recognizable in the Albian of East Greenland, as shown in Fig. 4 and in the following review.

From Albian rocks in East Greenland 10 ammonite genera are recorded with certainty. On the basis of their regional distribution, these genera can be grouped as follows: 5 of the genera are common in western Europe, but not recorded from north-western North America; 3 of the genera show arctic North American affinities; the remaining 2 genera (*Lytoceras* and *Puzosia*) must be regarded as cosmopolitan "open-sea" forms. Of the 10 genera mentioned here from East Greenland, altogether 7 are recorded from Spitsbergen.

It is now currently accepted that the Albian seas, which covered parts of England, France, and Germany, were in open communication with a sea area situated north of western Europe. This ancient "North Sea" is supposed to have extended northwards between Scandinavia and Greenland, and thus communicated with the Albian seas of Spitsbergen and East Greenland. The assumption of this sea-way explains readily the occurrence of western European faunal elements in the Albian of Spitsbergen and East Greenland.

Several paleogeographers (e. g. FREBOLD 1929, Pl. IV–VII; STILLE 1948; ARKELL 1956, p. 604) consider that the Arctic Ocean existed also during the Mesozoic, and its extent in this era was essentially the same as today. It is highly probable that this old "Arctic Ocean" was directly in communication with the Albian seas which covered parts of Spitsbergen, East Greenland, and north-western North America. The existence of these marine connections easily explains the fact that faunal elements characteristic of north-western North America occur in Spitsbergen and East Greenland.

A reasonable conclusion drawn from these relationships is that the sea area which in Albian time lay north of western Europe, was in open communication with the Arctic Ocean through the Spitsbergen–East Greenland area. The existence of this sea-way was previously assumed by FREBOLD (1935, Fig. 20). In Spitsbergen and East Greenland this sea-way has led to development of mixed ammonite faunas showing both western European and north-western North American affinities.

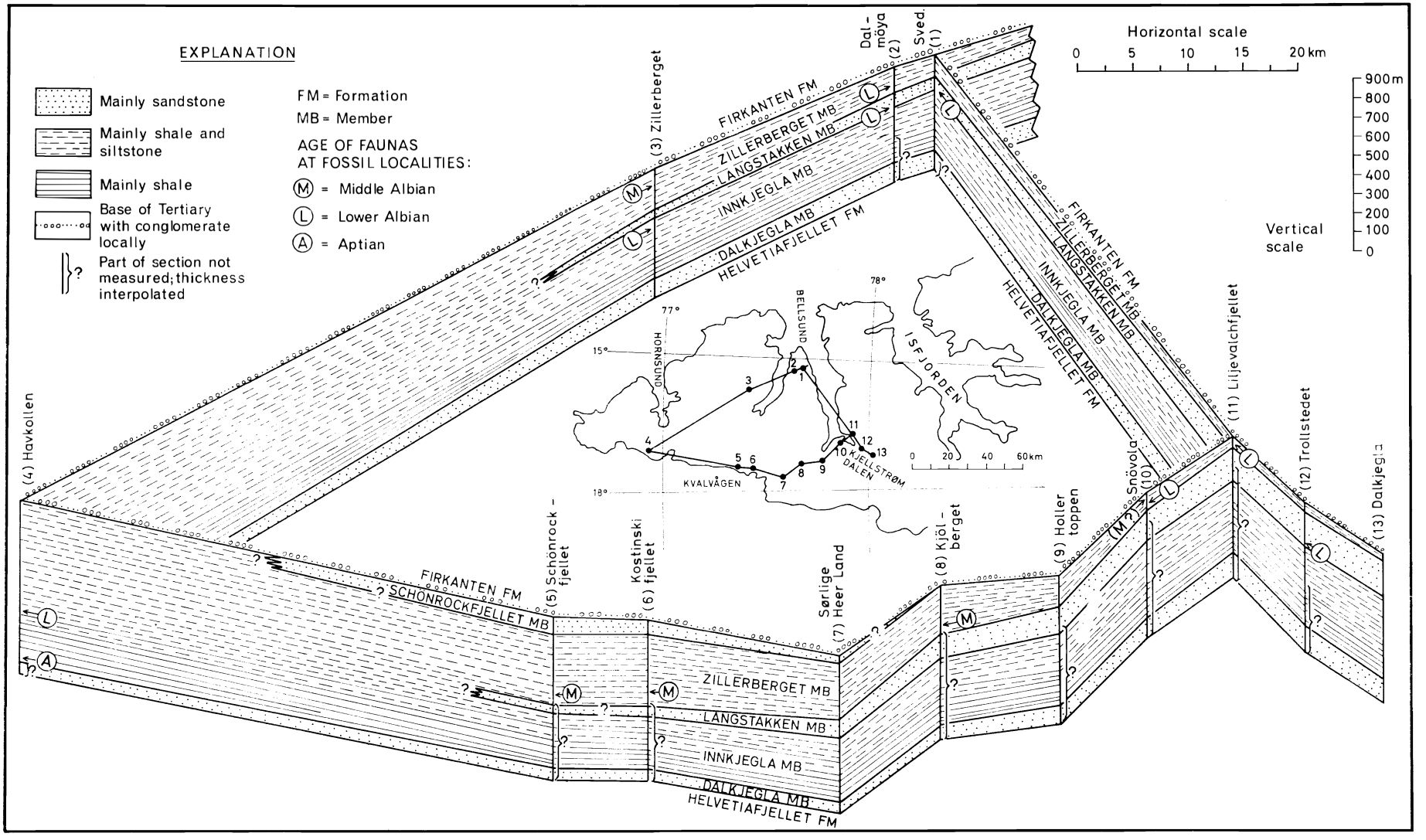
The pre-Tertiary earth movements

As already mentioned above (p. 7), the Carolinefjellet Formation is overlain by the Tertiary Firkanten Formation, and the boundary between these two units is marked by a disconformity. This disconformity is formed in consequence of pre-Tertiary earth movements and represents a considerable hiatus in the succession: the youngest stage of the Cretaceous recognized below this disconformity is the Albian, while the sediments overlying the disconformity are by RAVN (1922) assigned to Paleocene; Upper Cretaceous sediments are apparently missing in Spitsbergen.

According to ORVIN (1940), the pre-Tertiary earth movements in Spitsbergen have consisted only in an oblique rise of the region. The uplift was greatest in the northern parts of Spitsbergen, where the denudation has exposed Paleozoic rocks of different ages (ORVIN 1940, fig. 5). Farther to the south the elevation was of lesser extent, and therefore, in the central and southern parts of Spitsbergen the Paleozoic remained covered by Mesozoic sediments. This Mesozoic succession terminates with the Carolinefjellet Formation.

The Carolinefjellet Formation appears to be thinnest in the Isfjorden area, as shown by these two observations: at Festningsodden the formation is c. 180 m thick (HOEL & ORVIN 1937); on Carolinefjellet the thickness of the formation is 270 m (PARKER 1967). Farther south, at Van Keulenfjorden, the formation is considerably thicker than at Isfjorden: in the Ulladalen and Suessbreen areas the thickness of the formation is 520 and 667 m respectively. The greatest thicknesses of the Carolinefjellet Formation have been measured in the south-eastern part of Spitsbergen, where the thickness of this unit is: 768 m at Kjellströmdalen (PARKER 1967), 830 m in southern Heer Land, and more than 850 m at Tromsøbreen in Sørkapp Land.

From the thicknesses given above it is evident that the Carolinefjellet Formation is considerably thinner in the north and north-west than in the south-east. The differences in thickness are particularly conspicuous if the section at Festningsodden is compared with the sections at Storfjorden. These differences indicate that the pre-Tertiary uplift was greatest in the northern and north-western parts of Spitsbergen and decreased in magnitude towards the south-east, as has been suggested by ORVIN (1940). In consequence of this oblique rise of the region, the denudation has removed an appreciably larger part of the formation in the north and north-west than in the south-east. This interpretation is supported by the litho- and biostratigraphical relationships within the formation, as shown in the following paragraphs.


EXPLANATION
Mainly sandstone
Mainly shale and siltstone
Mainly shale
Base of Tertiary with conglomerate locally
Part of section not measured; thickness interpolated
FM = Formation
MB = Member
AGE OF FAUNAS AT FOSSIL LOCALITIES:
(M) = Middle Albian
(L) = Lower Albian
(A) = Aptian
Horizontal scale
0 5 10 15 20 km
Vertical scale
900 m
800
700
600
500
400
300
200
100
0
(1) Sved.
(2) Dal-möya
(3) Zillerberget
(4) Havkollen
(5) Schönrock-fjellet
(6) Kostinski fjellet
(7) Sørlige Heer Land
(8) Kjöl-berget
(9) Holler toppen
(10) Snövola
(11) Liljevalchfjellet
(12) Trollstedet
(13) Dalkjegla
FIRKANTEN FM
ZILLERBERGET MB
LANGSTAKKEN MB
INNKJEGLA MB
DALKJEGLA MB
HELVETIAFJELLET FM
SCHÖNROCKFJELLET MB
HORNSUND
BELLSUND
ISFJORDEN
KJELLSTRØMDALEN
KVALVÅGEN
77°
78°
15°
18°
0 20 40 60 km

At Festningsodden the Carolinefjellet Formation shows roughly the following stratigraphy (after HOEL & ORVIN 1937): the lower part of the formation is a c. 55 m thick sequence consisting mainly of sandstone with some shale; above these sediments there is a c. 125 m thick sequence composed chiefly of shale and marl; these beds are overlain disconformably by the Tertiary basal conglomerate. In the present paper the lower 55 m of the formation is correlated with the Dalkjegla Member, whereas the upper 125 m is correlated with the Lower shale-siltstone unit of the Innkjegla Member. If these correlations are correct, only the lower part of the Carolinefjellet Formation is present at Festningsodden. The remaining part of the formation is considered to have been removed by erosion before the deposition of the Tertiary commenced.

In the Braganzavågen, Ulladalen, Suessbreen, and Kjølberget areas the Tertiary rests directly on the Zillerberget Member. Consequently, the Carolinefjellet Formation in these areas is considerably more complete than at Isfjorden. The Zillerberget Member shows a marked increase in thickness from Kjellströmdalen to Suessbreen, and particularly to southern Heer Land (see Fig. 5 and Pl. 12).

The Schönrockfjellet Member (which is the youngest member of the Carolinefjellet Formation) is preserved only in the south-eastern part of Spitsbergen, where the pre-Tertiary denudation is considered to have been least intensive. The member is recognized in southern Heer Land, in the Jemelianovbreen area, and on the mountains just south of the Jemelianovbreen area.

The stratigraphical position of the ammonite faunas within the Carolinefjellet Formation also indicate that the erosion has removed a considerably larger part of this unit in the north and north-west than in the south-east. This is illustrated by Fig. 5, which shows that the Middle Albian Hoplites fauna at Kvalvågen occurs considerably deeper below the upper boundary of the formation than the Lower Albian faunas near Bellsund and Kjellströmdalen. This relationship is demonstrated by the following examples: on Schönrockfjellet at Kvalvågen, the Hoplites fauna (Middle Albian) is found 402 and 372 m below the upper boundary of the Carolinefjellet Formation; on Dalmøya near Bellsund, the Arcthoplites fauna (Lower Albian) occurs 202 m below the upper boundary, while the Otohoplites fauna (Lower Albian) occurs 86 m below the upper boundary; on Liljevalchfjellet at Kjellströmdalen the Otohoplites fauna (Lower Albian) is found 30 and 45 m below the upper boundary.

←

Fig. 5. *Normal panel diagram showing the lateral variation of members within the Carolinefjellet Formation. The age relationships within the formation are indicated by some of the investigated fossil localities.*

IV. Paleontological part

Material and methods

The preservation of the ammonites described in the present paper varies considerably; at some of the fossil localities the ammonites are strongly deformed by compression, while at other localities they are only slightly crushed or not deformed at all. Most of the specimens at hand are internal molds, commonly with attached fragments of the shell wall. On the surface of the internal molds the sutures are usually well-preserved. A few of the specimens are represented only by external molds.

On some internal molds large parts of the sutures were satisfactory for study without preparation. In most cases, however, preparatory work has been necessary before a more detailed examination of the sutures was possible. During the preparation dilute hydrochloric acid has been used in order to remove parts of the shell wall and to make the sutures clearly visible.

The sutures shown in this paper have been drawn by the following method: A piece of transparent cellulose tape was attached to the surface of the internal mold, and the suture was traced in Indian ink on the tape. The tracing was then mounted between two object glasses, and enlarged by means of a photographic enlarger. The magnified suture was then redrawn and, where necessary, corrected by comparing with the original on the internal mold.

The whorl sections have been drawn by this method: The specimen was cut on a lapidary wheel at the cross section selected. The section was then ground with fine carborundum powder until a smooth surface, showing the outline of the inner whorls, was obtained. After grinding, a piece of transparent cellulose tape was attached to the surface of the section, and the outline of the whorls was traced on the tape. The tracing was mounted between two larger object glasses before the final drawing was made. The whorl section of rare and more important specimens was obtained from sectioned plaster casts.

The methods described above for drawing of sutures and whorl sections are mainly in accordance with the procedures described by CASEY (1960, p. XXXIV).

In the drawings reproduced on the following pages, reconstructed parts of the sutures and whorl sections are indicated by dotted lines. On the sutures the middle of the venter is marked by a straight line with an arrow pointing adorally; the umbilical seam is marked by a dashed arc, whereas the middle of the dorsum is indicated by a straight line.

Six of the recorded species are represented by material suitable for detailed measurements, and for these species dimensions are tabulated in the systematic descriptions. According to common practice the following dimensions are given in the tables: diameter, whorl height, whorl width, and umbilical diameter. The

diameter is given in millimetres, whereas the other three dimensions are expressed both in millimetres and in percentages of the diameter. The measurements are taken at the standard points as shown by CASEY (1960, text-fig. A).

Some of the ammonites were first photographed without colouring, but the pictures thus obtained were not satisfactory, in particular those taken of dark specimens. Subsequently it was tried to colour the ammonites with light-grey poster paint ("gouache"), and it was also attempted to whiten the fossils with ammonium chloride. Poster paint proved to be the most advantageous in practice, and the ammonites figured on the plates were, therefore, coloured light-grey with this paint before being photographed. (Exceptions to this are the specimens shown on Pl. 2, fig. 2 and Pl. 3, fig. 1, which are figured without colouring.) On the surface of fossils the poster paint forms a thin and opaque coating that may be removed by washing with soap and water.

Systematic descriptions

The ammonites discussed on the preceding pages, in this section are treated systematically. The classification followed corresponds to the "Treatise on Invertebrate Paleontology" (part L, Mollusca 4, Ammonoidea, – edited by R. C. MOORE 1957), with addition of three genera (*Grantziceras, Grycia,* and *Freboldiceras*), which have been proposed after the publishing of this part of the "Treatise". The morphological terminology employed in the following descriptions is largely in accordance with that used in the mentioned part of the "Treatise".

The specimens described and figured in the present paper are deposited in the Paleontological Museum of the University of Oslo. The registration numbers of the specimens (e.g. A32801) refer to the collections of this museum.

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Eogaudryceras inaequale BREISTROFFER 1947
Pl. 1, fig. 1; text-fig. 6a–c

1908 *Lytoceras* (*Gaudryceras*) *Aelus* D'ORBIGNY. – JACOB, pp. 14–16, pl. 1, fig. 15.
1947 *Eogaudryceras inaequale* n. sp. – BREISTROFFER, p. 74.

Material: – One incomplete specimen.

Description: – Inner whorls of phragmocone are wider than high, and their surface bears sharp, widely spaced, rib-like ridges. Outer whorls of phragmocone are subcircular in section, and their ornament consists of shallow constrictions and dense, fine striae. The umbilicus is funnel-shaped and moderately narrow. The suture has bifid lobes and saddles; first lateral lobe is slightly asymmetrical. The auxiliary elements of the suture show strong umbilical retraction.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32801	16 mm	6 mm 37,5%	8 mm 50%	7 mm 44%
»	26 »	12 » 46,0%	12 » 46 »	10 » 38 »

Remarks: – Both in whorl shape and ornament the Spitsbergen specimen agrees closely with *E. inaequale* from the Albian of France. The suture of the specimen is very similar to that of *Eogaudryceras shimizui* BREISTROFFER 1947 as figured by JACOB (1908, p. 15, figs. 2, 3) and CASEY (1960, text-fig. 2f, g).

Occurrence: – Locality 17, together with *Leymeriella* (*L.*) *germanica*.

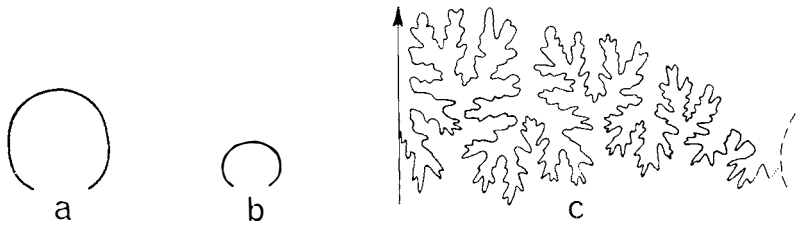

Fig. 6. *Eogaudryceras inaequale* BREISTROFFER. Whorl sections and suture line of A32801 from locality 17:
a–b. Sections through phragmocone (×1).
c. External suture (×3) at a whorl height of 13 mm.

Genus Grantziceras IMLAY 1960

Grantziceras cf. *affine*

Pl. 1, fig. 2; text-fig. 7b

cf. 1893 *Desmoceras affine* n. sp. – WHITEAVES, p. 113, pl. 8; pl. 11, figs. 1, 1a.
cf. 1967 *Grantziceras affine* (WHITEAVES). – JONES (*in* JONES & GRANTZ), p. 31, pl. 5, figs. 1–15; pl. 6, figs. 4–6; text-fig. 15.

Material: – Two incomplete internal molds; both are crushed laterally.

Description: – The shell is discoidal in outline with compressed whorl section and convex whorl sides. The umbilicus is narrow with sloping wall and rounded rim. The surface of the internal mold bears regularly spaced constrictions which have a slightly sinuous course on the whorl sides. These constrictions are asymmetrical; their adoral wall being steeper than their adapical wall. The ventral part of the whorl sides bears indistinct, rib-like undulations. The suture has deep, subsymmetrically trifid first lateral lobe; second lateral saddle is high and asymmetrically bifid.

Remarks: – Both in ornament and suture the present specimens are quite similar to *G. affine* from the Albian of Canada and Alaska. With regard to whorl shape, however, a detailed comparison is difficult to make, as both specimens from Spitsbergen are crushed laterally.

Occurrence: – Localities 7 and 26.

Grantziceras cf. *glabrum*

Text-fig. 7a

cf. 1889 *Placenticeras glabrum* n. sp. – WHITEAVES, p. 172, pl. 24, figs. 1, 1a, 1b.
cf. 1967 *Grantziceras glabrum* (WHITEAVES). – JONES (*in* JONES & GRANTZ), p. 33, pl. 6, figs. 1–3, 7–9; text-fig. 16.

Material: – Partially crushed fragment of a specimen with well-preserved suture.

Description: – This fragment has compressed whorl section with convex sides and rounded venter. Its suture consists of shallow lobes and broad saddles; first

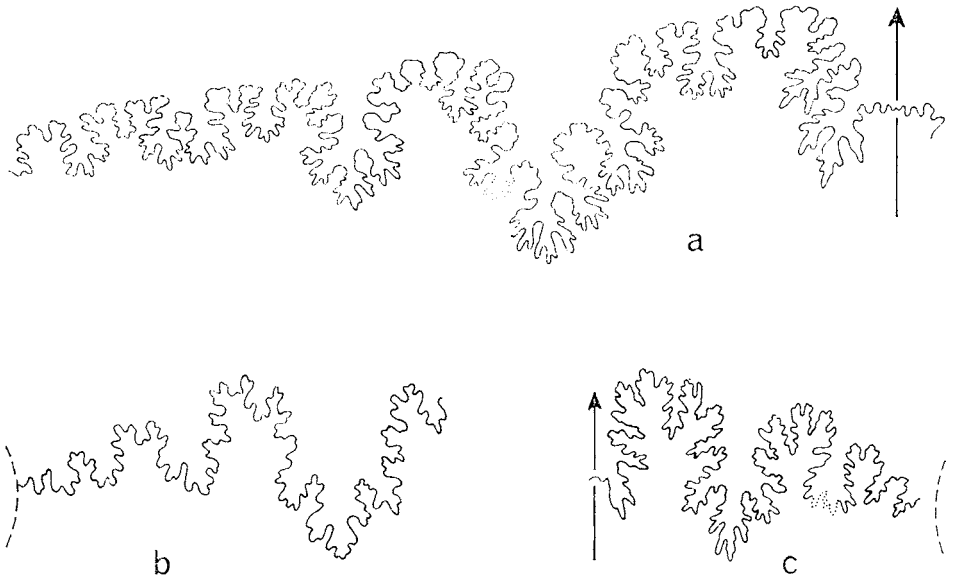

Fig. 7. Suture lines of *Grantziceras* and *Brewericeras*.
a. *Grantziceras* cf. *glabrum*. Part of the external suture (×2) of A32809 from locality 6.
b. *Grantziceras* cf. *affine*. Part of the external suture (×3) of A32808 from locality 7.
c. *Brewericeras* cf. *hulenense*. External suture (×3) of A32806 from locality 2.

lateral lobe is trifid and slightly asymmetrical. The adoral extremities of the saddles (the folioles) are distinctly enlarged and have an irregular, leaf-shaped outline. The fragment bears a single constriction.

Remarks: — The suture of *G.* cf. *glabrum* from Spitsbergen is closely similar to that of *G. glabrum* from the Albian of Alaska. Based mainly on Alaskan material, the suture of *G. glabrum* has been figured recently by IMLAY (1960, pl. 16, fig. 19) and by JONES (*in* JONES & GRANTZ, 1967, text-fig. 16).

Occurrence: — Locality 6.

Genus Brewericeras CASEY 1954

Brewericeras cf. ***hulenense***

Pl. 1, fig. 3; text-fig. 7c

cf. 1938 *Beudanticeras hulenense* n. sp. – ANDERSON, p. 190, pl. 44, figs. 3, 4.
cf. 1938 *Beudanticeras breweri* (GABB). – ANDERSON, p. 189, pl. 43, fig. 3; pl. 44, figs. 1, 2.
cf. 1965 *Brewericeras hulenense* (ANDERSON). – JONES *et al.* p. 16, pl. 8, figs. 1, 2, 4; pl. 9, 10; pl. 11, figs. 1–3, 13–14.

Material: — One specimen that is slightly deformed by lateral compression. Parts of its suture are well-preserved.

Description: — The whorls are higher than wide with flattened sides and rounded venter. The umbilicus is characterized by subvertical wall, angular rim, and a comparatively large diameter. Constrictions and ribs are apparently absent. The suture is moderately incised, having a high asymmetrically bifid first lateral-saddle and a deep subsymmetrically trifid first lateral lobe.

Remarks: — *B. hulenense* is widespread in the Pacific coast region of North America where it is characteristic of upper Lower Albian deposits. *B.* cf. *hulenense* from Spitsbergen has a general resemblance to this North American species, but differs from it by having a larger umbilical diameter. According to JONES *et al.* (1965, p. 19) *B. hulenense* from California has an umbilical diameter of 5.8 mm at a shell diameter of 40 mm. At the same shell diameter, *B.* cf. *hulenense* from Spitsbergen has an umbilical diameter of c. 12 mm. (It must be noticed, however, that the Spitsbergen specimen is crushed, and its dimensions can only be measured approximately.) Lobes and saddles of *B.* cf. *hulenense* seem to be generally more massive than those of *B. hulenense* from North America.

Occurrence: — Locality 2 together with *Arcthoplites jachromensis.*

Genus Proleymeriella BREISTROFFER 1947

Proleymeriella sp.

Pl. 1, fig. 4

Material: — One specimen represented by a half whorl of the body chamber. The fragment is preserved as a slightly crushed internal mold.

Description: — The umbilicus is comparatively wide, having a fairly steep wall and rounded rim. Half whorl of the body chamber bears about 23 rounded ribs and 5 narrow constrictions. The ribs commence weakly on the umbilical rim and gradually increase in strength towards the venter; they cross the venter and form chevrons on it. On the flanks both ribs and constrictions have a distinctly sigmoidal course. The ribs are closely spaced, and some of them show bifurcation at or below the mid-flank.

Remarks: — *Proleymeriella* sp. from Spitsbergen bears constrictions, and some of its ribs are bifurcated. In having these features, *Proleymeriella* sp. resembles first and foremost *Proleymeriella anterior* (BRINKMANN 1937) from the Lower Albian of northern Germany. The main differences between these two species are that *Proleymeriella* sp. has a more uniform ribbing, fewer constrictions, and more ribs than *P. anterior.*

Occurrence: — Locality 37.

Genus Leymeriella JACOB 1907

Leymeriella (Leymeriella) germanica CASEY 1957

Pl. 1, figs. 5–7

1937 *Leymeriella tardefurcata anterior* n. subsp. – BRINKMANN, p. 12, text-fig. 9 on p. 9.
1957 *Leymeriella* (*Leymeriella*) *germanica* nom. nov. – CASEY, p. 47.

Material: — Incomplete internal molds of five specimens. Some of them show well-preserved sutures.

Description: — The whorl section is subrectangular with greatest thickness just above the umbilical rim. The flanks are slightly convex and the venter is subtabulate. The umbilicus is shallow and comparatively wide, having a low, fairly steep wall and a rounded rim. The ribs commence on the umbilical rim and arch

gently forwards on the flanks. Near the umbilicus the ribs are thin and sharp, but increase gradually in breadth towards the venter. This expansion gives the ribs a wedge-like outline. The surface of the ribs bears a shallow sulcus, which is most distinct on the ventrolateral margin and disappears gradually towards the mid-flank. On the venter the ribs terminate in a more or less distinct, smooth siphonal band. The suture is characterized by a broad first lateral saddle and a deep, subsymmetrically trifid first lateral lobe.

Remarks: – *L.* (*L.*) *germanica* was first described by BRINKMANN (1937) from the Lower Albian (Leymeriella tardefurcata zone) of Northern Germany. The specimens from Spitsbergen agree well with BRINKMANN's original description of the species, both in shell form and ornament.

Occurrence: – Localities 17 and 26.

Genus Grycia IMLAY 1961

Type species: – *Cleoniceras* (*Grycia*) *sablei* IMLAY, by original designation (IMLAY 1961, p. 64).

Generic characters: – The shell is discoidal and involute with narrow umbilicus. Cross section of the phragmocone is lancetiform with narrowly arched venter; cross section of the adult body chamber is subelliptical. Some forms are smooth, whereas others bear ribbing of varying intensity. The ribs have a sigmoidal course on the flanks and show a gradual increase in strength towards the aperture. Their umbilical ends may be swollen, but do not form distinct tubercles. The suture consists of broad lobes and saddles; first lateral lobe is asymmetrically trifid.

Remarks: – *Grycia* has been described originally by IMLAY (1961, p. 64) as a subgenus of *Cleoniceras* PARONA & BONARELLI on the basis of fossil material from the Albian of northern Alaska. As shown in the following paragraphs, *Grycia* differs from *Cleoniceras* in some important morphological features. These differences are here considered sufficient to separate *Grycia* from *Cleoniceras* and to give it full generic status.

The genus *Cleoniceras,* as herein interpreted, comprises two subgenera: *C.* (*Cleoniceras*) and *C.* (*Neosaynella*) CASEY. The more strongly ribbed forms of *Grycia* have a general resemblance to *C.* (*Cleoniceras*), but differs from that subgenus mainly by the following features: distinct umbilical tubercles are absent in *Grycia* but are present in *C.* (*Cleoniceras*); the ribbing of *Grycia* increases in strength with increased diameter, whereas the ribbing in typical forms of *C.* (*Cleoniseras*) shows strong reduction at greater shell dimensions.

The smooth and slightly ribbed representatives of *Grycia* in general appearance are similar to the subgenus *C.* (*Neosaynella*). These forms of *Grycia* are distinguished from *C.* (*Neosaynella*) mainly by the venter of their inner whorls, which is convex, instead of tabulate.

The geographical distribution of *Grycia* seems to be restricted to the northern regions. The genus has been recorded hitherto from Alaska and Spitsbergen but also occurs probably in the Canadian Arctic Archipelago. *Cleoniceras*, on the contrary, seems to be a more southern genus. "Its geographical range extends

from S.–E. England, through France, Germany and Transcaspia to the N.–W. Province of India, and down to Madagascar" (CASEY 1966, p. 553).

The stratigraphical distribution of *Cleoniceras* and *Grycia* appears to be partly different. In southern England *Cleoniceras* reaches its acme in the Douvilleiceras mammillatum zone, and the genus disappears in the basal part of the Hoplites dentatus zone (CASEY 1966, p. 553). On the other hand, *Grycia* in Spitsbergen is abundant in beds that contain species of *Hoplites*. Based on the occurrence of *Hoplites,* these beds are here correlated with the lower part of the Hoplites dentatus zone in southern England.

Grycia sablei (IMLAY 1961)

Pl. 1, figs. 8–10; pl. 2, fig. 1; text-fig. 8c

1961 *Cleoniceras* (*Grycia*) *sablei* n. sp. – IMLAY, p. 64, pl. 20, figs. 13–20.

Material: – Internal molds of about 30 specimens and a few external molds. Most of the internal molds bear attached fragments of the shell wall. All specimens are more or less crushed laterally.

Description: – The shell is discoidal with gently convex flanks and narrowly arched venter. The umbilicus is narrow, having a steeply sloping wall and a rounded rim. The whorl section is compressed, and attains its greatest width in the area between the umbilical rim and mid-flank. The ornament consists of primary and secondary ribs, which have a sigmoidal course on the flanks and show a distinct increase in strength towards the aperture. The primary ribs commence on the umbilical rim, and most of them give rise to a secondary branch by bifurcation. In the adoral part of the body chamber, the points of bifurcation are situated on the mid-flank; more adapically the points of bifurcation are situated lower. At the umbilical rim the primary ribs are slightly swollen but do not form umbilical tubercles. The suture consists of broad, moderately incised lobes and saddles; first lateral lobe is asymmetrically trifid. The body chamber is about half a whorl in length.

Remarks: – At several localities in Spitsbergen *G. sablei* is associated with *G. whittingtoni*. These two species show a close similarity in shape and suture, but can be distinguished from each other by means of differences in ornament: Certain specimens of *G. whittingtoni* are smooth, and others bear low, rather obscure ribs in contrast to *G. sablei* that is distinctly ribbed. In *G. sablei* the primary ribs commence on the umbilical rim, and usually show well marked bifurcations. In *G. whittingtoni,* on the contrary, the ribs are mainly restricted to the outer half of the flanks, and they lack definite bifurcations.

Occurrence: – Localities 10–12, 16, 21–24, 27, and 28. At six of these localities *G. sablei* occurs together with species of *Hoplites*.

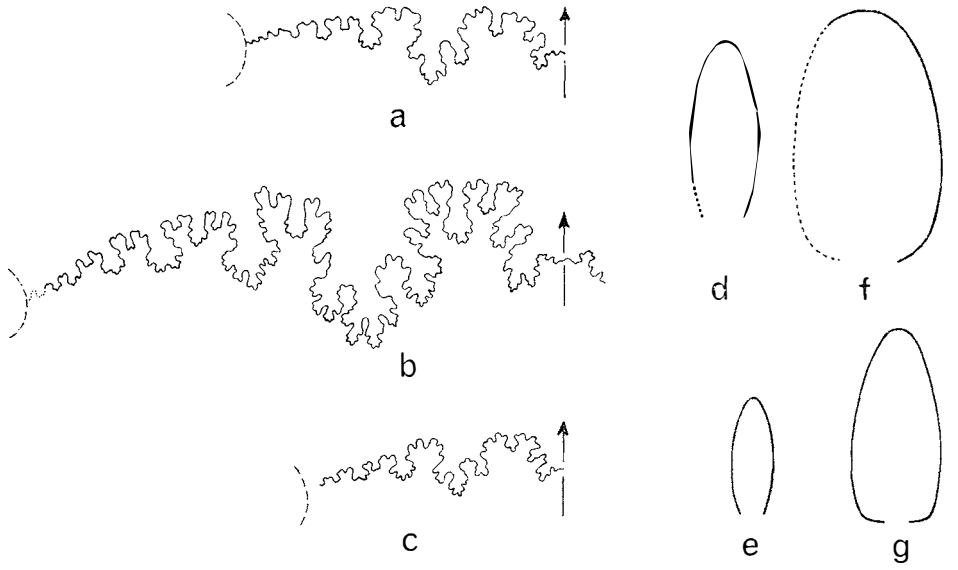

Fig. 8. Suture lines and whorl sections of *Grycia*.

a–b. *Grycia whittingtoni* (IMLAY). Sutures of two specimens from locality 23: a, external suture (×3) of A32804 at a whorl height of about 13 mm; b, external suture (×1.5) of A32805 at a whorl height of about 47 mm.

c. *Grycia sablei* (IMLAY). External suture (×3) of A32807 from locality 24, at a whorl height of about 10 mm.

d–g. *Grycia whittingtoni* (IMLAY). Whorl sections (×1) of three specimens: d, section through phragmocone of A32802 from locality 23 (slightly deformed); e, section through body chamber of A32803 from locality 23 (slightly deformed); section through body chamber (f) and phragmocone (g) of A32830 from locality 21.

Grycia whittingtoni (IMLAY 1961)

Pl. 2, figs. 2–4; text-fig. 8a,b,d–g

1961 *Cleoniceras* (*Neosaynella*)*? whittingtoni* n. sp. – IMLAY, p. 64, pl. 20, figs. 6–9.

Material: – Internal molds of 43 specimens, most of them with attached fragments of the shell wall. With a few exceptions, all molds are deformed by lateral compression.

Description: – The shell is discoidal with gently convex flanks. The umbilicus is narrow; it has a subvertical wall and a rounded rim. Cross-section of the phragmocone is lancetiform with narrowly arched venter, whereas the cross-section of the body chamber is subelliptical. The whorls are widest between the umbilical rim and the mid-flank. The shell is either smooth or ornamented with low ribs of sigmoidal course. These ribs are most distinct on the outer half of the flanks; they lack well-marked bifurcations and do not reach the umbilical rim. The suture consists of broad lobes and saddles which are moderately incised; first lateral lobe is asymmetrically trifid. The body chamber is about half a whorl in length.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32830	41 mm	22 mm 54%	11 mm 27%	5 mm 12%
»	62 »	32 » 52 »	18 » 29 »	9 » 15 »

Remarks: – This species has been described originally by IMLAY (1961) as *Cleoniceras (Neosaynella)? whittingtoni* from the Albian of northern Alaska. In the original description both the generic and subgeneric status of the species are considered uncertain because of insufficient preservation of the type material. The material now available from Spitsbergen shows that *C. (N.)? whittingtoni* is closely related to *Grycia sablei* (IMLAY), which is the type species of *Grycia*. On account of this clear affinity *C. (N.)? whittingtoni* is referred to the genus *Grycia* in the present paper.

Occurrence: – Localities 10, 21–24, and 27. At five of these localities *G. whittingtoni* is associated with species of *Hoplites*.

Grycia sp.
Pl. 1, fig. 11

Material: – Two slightly crushed internal molds.

Description: – The shell is discoidal with compressed whorl section and narrow umbilicus. The body chamber bears unbranched, sigmoidal ribs that are rather indistinct near the last suture but increase in strength towards the aperture. At the umbilical rim the ribs are low and thin but increase gradually in height and breadth upwards on the flanks; they cross the venter with strong forward projection. The body chamber is scaphitoid, and its length is approximately equivalent to that of a half whorl.

Remarks: – This form is assigned to the genus *Grycia,* particularly because its ribbing increases in strength towards the aperture, and the ribs lack umbilical tubercles. *Grycia* sp. differs from *Grycia sablei* mainly by its ribs, which are without distinct bifurcations. Another difference between these two species is that the ribs of *Grycia* sp. on the outer flanks and venter are higher and sharper than the ribs of *G. sablei.*

Occurrence: – Locality 34 together with *Otohoplites* sp. B.

Genus Hoplites NEUMAYR 1875
Subgenus Isohoplites CASEY 1954
Hoplites (Isohoplites) cf. ***eodentatus***
Pl. 2, fig. 5

cf. 1961 *Hoplites (Isohoplites) eodentatus* n. sp. – CASEY, p. 599, pl. 83, figs. 4a, 4b.

Material: – One internal mold representing the phragmocone and part of the body chamber. The specimen is somewhat crushed laterally.

Description: – The whorl section is subrectangular with slightly convex sides and subtabulate venter. The umbilicus has a sloping wall and a rounded rim. At a diameter of c. 30 mm the shell bears 19 umbilical bullae per whorl. From each umbilical bulla arise two ribs; occasionally a single rib arises freely on the lower flank. On the upper flank and ventral margin the ribs are strongly projected forwards; along the middle of the venter they are flattened and fail to cross the siphonal line. The free, ventral ends of the ribs are opposite on the two sides. The suture is hoplitid, with subsymmetrically trifid first lateral lobe.

Remarks: – On the venter of the present specimen the ribbing is distorted by crushing except for a small area, where the ribbing is well-preserved. In this area the ribs display the pattern characteristic of *Isohoplites*. In lateral view the specimen is similar to *H.* (*I.*) *eodentatus* from the Albian of southern England.

Occurrence: – Locality 22.

Subgenus Hoplites

Hoplites (Hoplites) svalbardensis n. sp.

Pl. 2, figs. 6–8; pl. 3, fig. 1; text-fig. 9a–c

Name: – This species is named after the Svalbard archipelago.

Holotype: – An essentially complete, but slightly deformed internal mold (A32841) from locality 23, collected by the author in 1962.

Material: – Internal molds of 20 specimens, some with attached fragments of the shell wall. The majority of the specimens are crushed laterally.

Description: – The whorls are higher than wide, with trapezoidal section that is widest at the umbilical bullae. The venter is subtabulate and lacks a distinct siphonal depression. The umbilical wall is subvertical at base, but rounds evenly into the gently convex flanks. At a diameter of 68 mm the shell bears 16–18 primary and 19–21 secondary ribs per whorl. The dorsal ends of the primary ribs are swollen, and form distinct umbilical bullae. On the lower flanks the ribs are more or less rectiradiate, whereas on the upper flanks and ventral margins they are projected strongly forwards. On the middle of the venter the ribbing is interrupted, and the free ends of the ribs alternate on opposite sides of the siphonal line. The suture has a deep, parallel-sided ventral lobe, a broad first lateral saddle, and a subsymmetrically trifid first lateral lobe. The body chamber is about half a whorl in length.

Remarks: – *Hoplites* (*H.*) *svalbardensis* has a comparatively simple ribbing and lacks a distinct siphonal depression. By these features it resembles early representatives of *Hoplites* known from the lower part of the Hoplites dentatus zone in southern England. Among these English forms *Hoplites* (*H.*) *pseudodeluci* Spath 1925 seems to be most similar to *H.* (*H.*) *svalbardensis*. The two species differ mainly in details of ribbing: The ribs of *H.* (*H.*) *svalbardensis* are more or less rectiradiate on the inner flanks, and project strongly forwards on the outer flanks and ventral margins. The ribs of *H.* (*H.*) *pseudodeluci,* on the contrary, have a more even, gently bowed course across the flanks from umbilicus to venter.

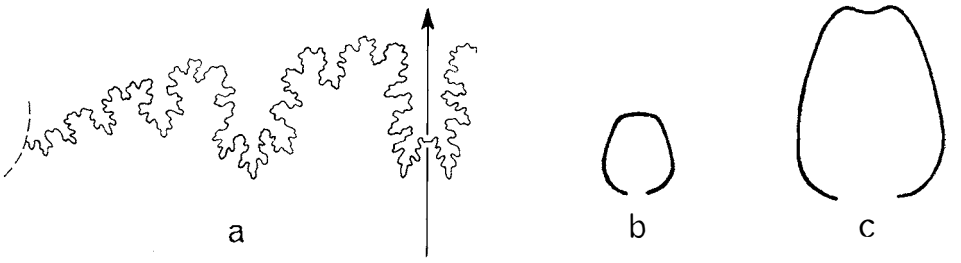

Fig. 9. Suture line and whorl sections of *Hoplites* (*Hoplites*) *svalbardensis* n. sp.
a. External suture (×3) of A32815 from locality 24, at a whorl height of about 14 mm.
b–c. Whorl sections (×1) of two specimens from locality 21: b, section through phragmocone of A32814; c, section through body chamber of A32813.

In some specimens of *H.* (*H.*) *svalbardensis* the primary ribs have a slightly sigmoidal course, which is most distinct on the body chamber. Such a specimen is shown on Plate 2, Fig. 7.

Occurrence: — Localities 13, 21, 23, 24, and 27.

Hoplites (Hoplites) aff. ***obtusus***

Pl. 4, fig. 2

aff. 1925 *Hoplites obtusus* n.sp. – SPATH, p. 123, pl. XI, fig. 15.

Material: — Two specimens preserved as internal molds, both are partly deformed by crushing.

Description: — The whorl section is trapezoidal with greatest thickness at the umbilical bullae. The venter is subtabulate, having a very shallow siphonal depression. The ornament consists of primary and secondary ribs, which cross the flanks with moderate forward projection. The dorsal ends of the primary ribs are swollen and form distinct umbilical bullae. On the middle of venter the ribbing is interrupted, and the free ends of the ribs alternate on opposite sides of the siphonal line.

Remarks: — The Spitsbergen specimens have essentially the same ornament as *Hoplites* (*H.*) *obtusus* from the Middle Albian of southern England. They seem to be similar to *H.* (*H.*) *obtusus* also in whorl shape. However, an adequate comparison with regard to whorl shape is difficult because the Spitsbergen specimens are partly deformed by crushing.

Occurrence: — Locality 28.

Hoplites (Hoplites) sp. A

Material: — Deformed fragment of a whorl preserved as internal mold.

Description: — The shell bears primary and secondary ribs, which commence at the umbilical bullae. On the outer flank and ventral margin the ribs are projected

forwards; on the middle of venter the ribbing is interrupted, and the free ends of the ribs alternate on opposite sides of the siphonal line. The venter is flattened and lacks a distinct siphonal depression.

Remarks: — The ornament of *Hoplites* (*H.*) sp. A is similar to that of *Hoplites* (*H.*) *svalbardensis* n. sp. The two species differ, however, in whorl shape; the whorls of *Hoplites* (*H.*) sp. A being thicker than those of *Hoplites* (*H.*) *svalbardensis*.

Occurrence: — Locality 12.

Hoplites (Hoplites) sp. B

Material: — Strongly deformed fragment of a whorl preserved as internal mold.

Remarks: — As the specimen is flattened by crushing, its original whorl shape cannot be determined with certainty. Its ribbing is comparatively well-preserved and resembles that of *Hoplites* (*H.*) *svalbardensis* n. sp.

Occurrence: — Locality 10.

Hoplites? sp. C

Material: — External mold which preserves the side of a specimen.

Remarks: — In this external mold the ribbing of the shell side is well preserved and resembles the ribbing of *Hoplites* (*H.*) *obtusus* SPATH 1925. As the ventral part of the mold is absent in the collection, the correct generic status of the specimen cannot be determined.

Occurrence: — Locality 5.

Hoplites? sp. D

Material: — Deformed fragment of a whorl preserved as internal mold.

Remarks: — The ribbing on the venter of this fragment is strongly disturbed by crushing. On the flanks the ribbing is somewhat better preserved and shows resemblance to the genus *Hoplites*; the ribs arise in pairs from the umbilical bullae, and in the ventrolateral area they are projected adorally.

Occurrence: — Locality 32.

Hoplites? sp. E

Material: — External mold which preserves the side of a specimen.

Remarks: — The specimen has high, prominent umbilical bullae, and from each bulla three prorsiradiate ribs arise. By these features the specimen resembles *Hoplites* (*H.*) *dorsetensis* SPATH (1925). The venter of the mold is not present in the collection.

Occurrence: — Locality 33.

Genus Euhoplites SPATH 1925

Euhoplites sp. A

Pl. 3, fig. 2

Material: – An internal mold of the body chamber and an external mold of the phragmocone; both are incomplete and belong to the same specimen.

Description: – The whorls are subhexagonal in section with greatest thickness at the lateral tubercles. The venter bears a shallow but distinct siphonal sulcus flanked by two rows of alternating clavi. Both the lateral tubercles and the ventral clavi are elevated to form blunt spines. On the body chamber the ribs are low and strongly prorsiradiate; they commence at the lateral tubercles and terminate at the ventral clavi.

Remarks: – On the body chamber of this specimen the lateral tubercles and ventral clavi are broken off from the internal mold, but their basal outlines are clearly visible. On the phragmocone of the specimen a few tubercles are preserved in their full length.

Euhoplites sp. A shows a strong similarity to *Euhoplites subtuberculatus* SPATH 1927, both in whorl shape and ornament. It is therefore reasonable to suppose that the two species are closely related to each other also genetically. In the English Gault *E. subtuberculatus* and its closer allies are characterized by relatively small shell dimensions; they are usually considerably smaller than *Euhoplites* sp. A from Spitsbergen. This difference in size may be ascribed to environmental factors, but the possibility of its genetic origin cannot be wholly precluded.

Occurrence: – Locality 18.

Euhoplites sp. B

Pl. 3, fig. 3; text-fig. 10a

Material: – Fragment of the ultimate and penultimate whorls of a specimen preserved as internal mold.

Description: – The specimen has a high, subvertical umbilical wall, rounded umbilical rim, and flattened whorl sides. The venter of the penultimate whorl bears a shallow siphonal sulcus bordered by two rows of alternating clavi. (The ventral part of the ultimate whorl is not preserved in the present specimen.) Ornamentation of the sides consists of prorsiradate ribs which arise from large, obtuse lateral tubercles. On the body chamber these tubercles are situated at the mid-flank, above a nearly smooth area which surrounds the umbilicus. The suture is characterized by deep, asymmetrically trifid first lateral lobe.

Remarks: – The specimen at hand is similar to *Euhoplites boloniensis* SPATH 1926 in its ornament, whorl shape, and large size. But nevertheless, the specimen is too fragmentary to be determined at the specific level.

Occurrence: – Locality 20.

Fig. 10. Suture lines of *Euhoplites* and *Otohoplites*.

a. *Euhoplites* sp. B. Part of the external suture (×2) of A32812 from locality 20.

b. *Otohoplites guersanti* (D'ORBIGNY). External suture (×3) of A32811 from locality 4, at a whorl height of about 26 mm.

c. *Otohoplites* cf. *guersanti*. First lateral lobe (×3) of A32810 from locality 4, at a whorl height of about 45 mm. (First lateral saddle to the right.)

Small arrows indicate points where the figured suture is truncated by the preceding suture.

Genus Otohoplites STEINMANN 1925
Otohoplites guersanti (D'ORBIGNY 1841)
Pl. 4, fig. 1; text-fig. 10b

1841 *Ammonites Guersanti* n. sp. – D'ORBIGNY, p. 235, pl. 67, figs. 1, 2, 4.

1965 *Otohoplites guersanti* (D'ORBIGNY). – CASEY, p. 505, pl. LXXXVI, fig. 4; text-figs. 190a–c, 191f, g.

Material: – Body chamber and phragmocone of two specimens. Both of them are preserved as external molds deformed by compression.

Description: – The whorls are subrectangular in section with gently convex sides and subtabulate venter. The umbilicus is narrow, its wall is subvertical, its rim is rounded but well defined. At a diameter of c. 75 mm the shell bears 14 umbilical bullae, 22 ribs, and 17 ventral clavi per whorl. The ribs arise singly or in pairs from the comma-shaped umbilical bullae; near the umbilicus they are low and narrow, but increase gradually in strength towards the venter. On the ventral margin the ribs terminate in the ear-shaped ventral clavi, which alternate

on opposite sides of the siphonal line. The suture has a deep, asymmetrically trifid first lateral lobe. The body chamber is about half a whorl in length.

Remarks: – As mentioned above, both specimens of *O. guersanti* from Spitsbergen are deformed by compression. Nevertheless, it can be asserted that their original whorl section is high and subrectangular, and closely resembles the whorl section of *O. guersanti* from the Lower Albian of France and England. The ornamentation of the specimens is only slightly affected by deformation and shows good agreement with the ornamentation of *O. guersanti.*

Occurrence: – Locality 4.

Otohoplites cf. ***guersanti***

Pl. 6, fig. 1; text-fig. 10c

cf. 1841 *Ammonites Guersanti* n. sp. – D'ORBIGNY, p. 235, pl. 67, figs. 1, 2, 4.
cf. 1965 *Otohoplites guersanti* (D'ORBIGNY). – CASEY, p. 505, pl. LXXXVI, fig. 4; text-figs. 190a–c, 191 f–g.

Material: – Three specimens preserved as internal molds with attached fragments of the shell wall. The specimens are crushed laterally.

Description: – The whorls are higher than wide and have gently convex sides. The umbilicus is narrow, with low, subvertical wall and definite but rounded rim. The venter of the phragmocone is subtabulate, whereas the venter of the body chamber is rounded. The ornament is mainly restricted to the phragmocone and consists of umbilical bullae, ribs, and ventral clavi. Near umbilicus the ribs are narrow, but increase gradually in width towards the venter. On the ventral margin the ribs terminate in the peripheral clavi, which alternate on opposite sides of the siphonal line. On the body chamber of adult specimens the ribs are reduced to broad radial ridges, whereas the ventral clavi and umbilical bullae have wholly disappeared. The suture has a deep, asymmetrically trifid first lateral lobe. The shell is comparatively large in size, the body chamber occupies about half a whorl.

Remarks: – All three specimens of *O.* cf. *guersanti* from Spitsbergen are deformed, and their ornament is partly disturbed by compression. In spite of this insufficient preservation, it can be demonstrated that the phragmocone of the specimens is closely similar to *O. guersanti* both in ribbing, tuberculation, and suture line.

The body chamber of *O.* cf. *guersanti* has a strongly reduced ornament, and it is considered to represent the final growth stage of the ammonite. On the other hand, the body chamber of *O. guersanti* in the final growth stage is not known with certainty; CASEY (1965, p. 508) mentions the occurrence of some large, smooth, outer whorl fragments of *Otohoplites* in the Albian of England, which according to him, could belong to *O. guersanti* or to *O. auritiformis.*

It is probable that *O.* cf. *guersanti* from Spitsbergen, by its nearly smooth body chamber, represents the final growth stage of *O. guersanti.* A more definite answer to this question is difficult to give until better preserved material is found.

Occurrence: – Locality 4, together with *O. guersanti.*

Otohoplites glyphus CASEY 1965
Pl. 5, fig. 1

1965 *Otohoplites glyphus* n. sp. - CASEY, p. 513, pl. LXXXV, fig. 1; text-fig. 191a, b.

Material: — One undeformed internal mold consisting of nearly complete body chamber and phragmocone.

Description: — The whorls are compressed, subrectangular in section, with gently convex sides and subtabulate venter. The umbilicus is comparatively narrow, its wall is sloping, and its rim is rounded. Ornamentation consists of comma-shaped umbilical bullae, narrow ribs, and low ventral clavi. At a diameter of 110 mm the shell bears 15 umbilical bullae per whorl. From each umbilical bulla arise two or three ribs, which terminate in the ventral clavi singly or in pairs. The ventral clavi alternate on opposite sides of the siphonal line.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32838	110 mm	55 mm 50%	31 mm 28%	21 mm 19%

Remarks: — The specimen described above has smaller umbilical diameter than the type specimen of *O. glyphus* figured by CASEY (1965). In other respects the two specimens show a general agreement.

Otohoplites sp. A
Pl. 4, fig. 3

Material: — One internal mold consisting of an almost complete body chamber and phragmocone. The specimen is crushed laterally.

Description: — The shell is discoidal in outline with comparatively narrow umbilicus and slightly convex whorl sides. Ornamentation consists of comma-shaped umbilical bullae, prominent ribbing, and large, subconical ventral clavi. At a diameter of c. 115 mm the shell bears 13 umbilical bullae per whorl. Each umbilical bulla gives rise to one or two ribs, which terminates in the ventral clavi. Near umbilicus the ribs are low and narrow, but show a strong increase in height and breadth towards the venter. The ventral clavi alternate on opposite sides of the siphonal line, and their alternation produces a marked zig-zag pattern on the venter.

Remarks: — The ornament of *Otohoplites* sp. A, particularly on the venter, closely resembles the ornament of *Otohoplites raulinianus* (D'ORBIGNY 1841) from the Lower Albian of France and England. A comparison with regard to the whorl shape is more difficult, because the Spitsbergen specimen is deformed by lateral compression. It seems, however, highly probable that the whorls of this specimen were higher than wide also before the deformation. If that be so,

the Spitsbergen specimen differs clearly from *O. raulinianus*, which (according to CASEY 1965, p. 494) has slightly larger whorl width than whorl height.

As a conclusion it is thought that *Otohoplites* sp. A represents a new species which is similar to *O. raulinianus* in its ornament, but differs from it in having a more compressed whorl section.

Occurrence: – Locality 4, together with *O. guersanti.*

Otohoplites sp. B
Pl. 5, fig. 2

Material: – Three internal molds consisting of incomplete body chamber and phragmocone. The specimens are crushed laterally.

Description: – The original whorl shape is apparently subrectangular with subtabulate venter and probably flattened sides. The umbilicus is comparatively narrow, having a steep wall and a well-marked rim. Ornamentation consists of comma-shaped umbilical bullae, narrow ribs, and low ear-like ventral clavi. The ribs are straight or gently sigmoidal; they arise from the umbilical bullae, or occasionally freely on the flanks, and run into the ventral clavi in pairs. The ventral clavi alternate on opposite sides of the siphonal line.

Remarks: – In its ornament *Otohoplites* sp. B shows considerable resemblance to *O. glyphus* CASEY 1965, and is supposed to be closely related to that species. With regard to shell form a satisfactory comparison is difficult, because all specimens of *Otohoplites* sp. B are markedly deformed by lateral compression.

Occurrence: – Localities 31 and 34.

Otohoplites sp. C
Pl. 5, fig. 3

Material: – Three specimens represented by fragments of the body chamber. The fragments are preserved as internal molds, and they are crushed laterally.

Description: – The original whorl shape is probably subrectangular; the umbilicus has a vertical wall and a subangular rim. Ornamentation consists of ventral clavi and distinctly sigmoidal ribs. The primary ribs commence on the umbilical rim; their dorsal ends are well-marked, but do not form umbilical bullae. The ventral clavi alternate on opposite sides of the siphonal line.

Remarks: – *Otohoplites* sp. C bears distinctly sigmoidal ribs and lacks umbilical bullae. By these features the species differs from other forms of *Otohoplites* herein described from Spitsbergen. Closer comparisons of the whorl shapes are difficult to make, owing to the crushed and fragmentary nature of the material.

Occurrence: – Localities 30, 35, and 36.

Genus Dimorphoplites SPATH 1925

Dimorphoplites cf. *tethydis*

Pl. 6, fig. 2

cf. 1878 *Hoplites tethydis* n. sp. – BAYLE, pl. LXXIV, figs. 1, 2.
cf. 1926 *Dimorphoplites tethydis* (BAYLE) – SPATH, p. 165, pl. XV, figs. 1a, b; text-figs. 47a, b.

Material: – One fragment of a body chamber preserved as internal mold.

Description: – The whorl section is subhexagonal with greatest thickness at the umbilical bullae. The umbilicus has a sloping wall rounding evenly into the flanks. The venter is subsulcate and bears two rows of alternating clavi the long axes of which are approximately parallel to the siphonal line. On the lower flanks the primary ribs form coarse umbilical bullae, with which the secondary ribs are indistinctly connected. On the ventral margin the ribs unite in pairs with the ventral clavi.

Remarks: – The present fragment closely resembles *Dimorphoplites tethydis* (BAYLE) both in ornament and whorl shape.

Occurrence: – Locality 18.

Genus Freboldiceras IMLAY 1959

Freboldiceras singulare IMLAY 1959

Pl. 6, fig. 3; text-fig. 11c

1959 *Freboldiceras singulare* n. sp. – IMLAY, p. 182, pl. 30, figs. 1–7.
1960 *Freboldiceras singulare* IMLAY. – IMLAY, p. 102, pl. 14, figs. 8–17.
1967 *Freboldiceras singulare* IMLAY. – JONES (*in* JONES & GRANTZ), p. 37, pl. 7, figs. 1–25; text-fig. 18.

Material: – Two comparatively small specimens. One of them is an internal mold with attached fragments of the shell wall; the other is an external mold.

Description: – The whorl section is compressed and subelliptical with greatest thickness at the umbilical rim. The umbilicus is moderately wide; its wall is subvertical, and its rim is evenly rounded. Ornamentation consists of ribs, distinct striae, and a few shallow constrictions. Secondary ribs are absent from the outer whorls of the present specimens. The primary ribs are high and well-marked on the inner parts of the flanks, but show a gradual flattening towards the venter. The suture has a broad, asymmetrically bifid first lateral saddle, and a subsymmetrically trifid first lateral lobe.

Remarks: – Both specimens of *F. singulare* from Spitsbergen are comparatively small in size. Specimens of *F. singulare* of about the same size as these have, however, been figured from the Albian of Alaska by IMLAY (1960, pl. 14, fig. 9) and by JONES (*in* JONES & GRANTZ 1967, pl. 7, figs. 7–9 and 18–20). The Spitsbergen specimens agree fairly well with the Alaskan specimens mentioned, both in shell form and ornament.

Occurrence: – Locality 26.

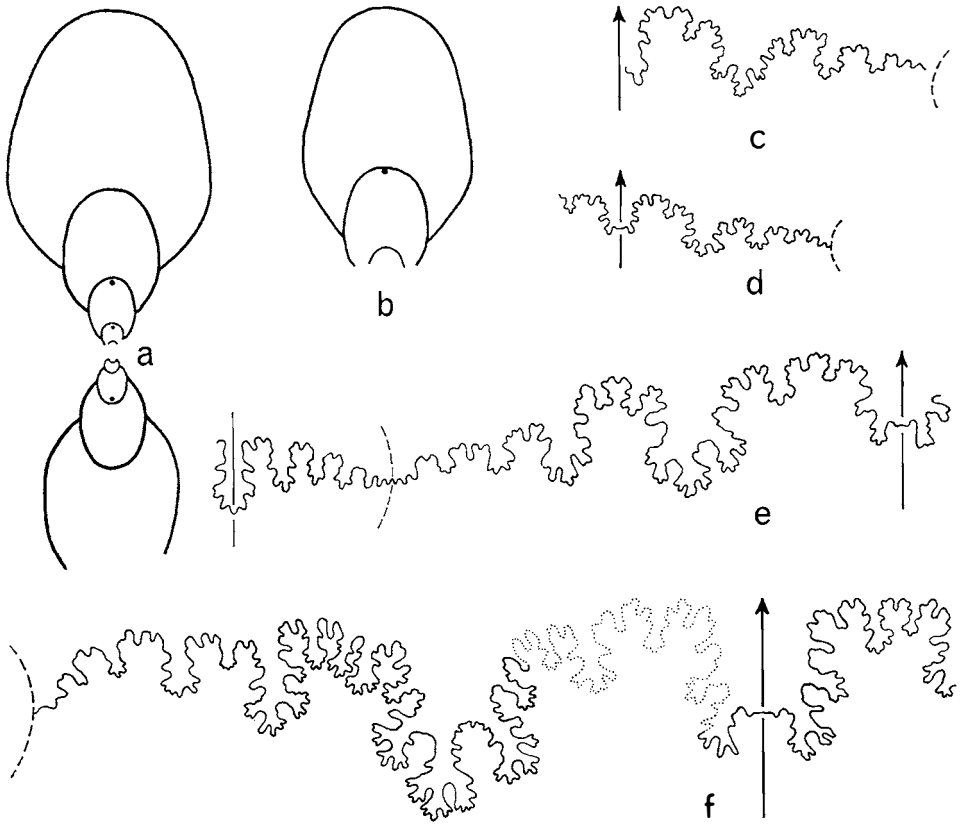

Fig. 11. Whorl sections and suture lines of *Freboldiceras*.

a–b. *Freboldiceras remotum* n. sp. Whorl sections (×1) of two specimens from locality 17: a, section through phragmocone of A32822; b, section through phragmocone of A32821.

c. *Freboldiceras singulare* IMLAY. External suture (×3) of A32823 from locality 26, at a whorl height of about 11 mm.

d–f. *Freboldiceras remotum* n. sp. Suture lines of two specimens from locality 17: d, external suture (×3) of A32820 at a whorl height of 8 mm; e, external and internal suture (×3) of A32820 at a whorl height of 18 mm; f, external suture (×2) of A32819 at a whorl height of 40 mm.

Freboldiceras remotum n. sp.

Pl. 6, figs. 4, 5; pl. 7, figs. 1–4; text-fig. 11a, b, d–f

Name: – The name ***remotum*** alludes to the geographical occurrence of this species.

Holotype: – An internal mold of a phragmocone (A32849) from locality 17, collected by K. BIRKENMAJER in 1962.

Material: – Internal molds of 48 specimens. The majority of these internal molds are undeformed and bear parts of the shell wall.

Description: – The whorl section is compressed and subelliptical with greatest thickness at the umbilical rim. The umbilicus is moderately wide and has a sloping wall and an evenly rounded rim. Ornamentation consists of primary and secondary

ribs, striae, and a few constrictions. The primary ribs commence on the umbilical rim and have a gently sigmoidal course on the flanks. From one primary rib arise one or two secondary ribs; the points of furcation are situated above the mid-flank. Some of the secondary ribs are only indistinctly connected with the primary ribs. On the inner parts of the flanks, the ribs are strongly developed; on the outer flanks they show a marked decrease in strength towards the periphery; on the venter the ribs are rounded and indistinct, and show a moderate forward projection.

At a diameter of 12 mm the shell is still smooth, but with continued increase in size the ribbing develops gradually. Already at a diameter of 20 mm both the primary and secondary ribs are well-developed, and they persist without marked reduction until the diameter reaches c. 50 mm. At a diameter of c. 50 mm, the ribs begin to efface gradually, but this effacement is restricted only to the ventral part of the whorls. When the diameter is larger than 70 mm, the venter of the whorls is smooth, secondary ribs are absent, and the primary ribs are restricted to the whorl sides.

The external suture consists of broad saddles and comparatively shallow lobes; first lateral lobe is subsymmetrically trifid.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32846	34 mm	15 mm 44%	11 mm 32%	10 mm 29%
A32851	41 »	18 » 44 »	14 » 34 »	11 » 27 »
A32848	48 »	22 » 46 »	16 » 33 »	13 » 27 »
A32849*	56 »	26 » 46 »	18 » 32 »	13 » 23 »
A32861	70 »	30 » 43 »	21 » 30 »	18 » 26 »
A32862	77 »	32 » 42 »	24 » 31 »	23 » 30 »

(* Holotype)

Remarks: — This species is assigned to the genus *Freboldiceras* because its whorl section is subelliptical both in the young and in the adult growth stage, and because its ribs are strongly flattened on the venter. The species is closely similar to *F. singulare* IMLAY, which is the type species of *Freboldiceras,* but resembles also *Arcthoplites birkenmajeri* n. sp. described below.

Both *F. singulare* and *F. remotum* display a reduction in ribbing during the ontogeny, but the two species show marked differences in this respect: The secondary ribs of *F. singulare* are strongly effaced already at a diameter of c. 28 mm, as it appears from the illustrations given by JONES (*in* JONES & GRANTZ 1967, pl. 7, figs. 7–15). On the contrary, the secondary ribs of *F. remotum* remain well-developed until a diameter of c. 50 mm. The body chamber of *F. singulare* lacks both primary and secondary ribs in the adult stage, as shown by IMLAY (1960, pl. 14, fig. 14). The body chamber of *F. remotum,* on the other hand, bears distinct primary ribs, also when the specimen has reached the adult growth stage.

In general appearance *F. remotum* is also similar to *Subarcthoplites talkeetnanus* (IMLAY 1960). It is distinguished from that species mainly by its ribs, which are less sigmoidal, more reduced in strength on the venter, and bifurcate higher up on the flanks.

The collection at hand contains some specimens which are intermediate in morphology between *F. remotum* and *A. birkenmajeri*. Consequently, the proper taxonomic position of these specimens is difficult to determine.

Occurrence: – Localities 7, 17, and 38. At locality 17 this species occurs together with *Leymeriella* (*L.*) *germanica*.

Genus Arcthoplites SPATH 1925

Arcthoplites jachromensis (NIKITIN 1888)

Pl. 8, fig. 1

1888 *Hoplites jachromensis* n. sp. – NIKITIN, p. 57, pl. IV, figs. 1–7.
1925 *Arcthoplites jachromensis* (NIKITIN) - SPATH, p. 76.
1965 *Arcthoplites jachromensis* (NIKITIN) – CASEY, p. 471, text-fig. 177.

Material: – More or less complete internal molds of 11 specimens. The majority of them are crushed laterally.

Description: – The whorl section is subelliptical in the young, and subrectangular in the adult stage. The umbilicus is moderately wide; its wall is steeply inclined but rounds evenly into the flanks. At a diameter of 50 mm the shell bears 18 primary ribs per whorl. The primary ribs commence on the umbilical rim, and most of them give rise to a secondary branch by bifurcation. The points of bifurcation are situated within the outer half of the whorl sides. Both on the sides and on the venter the ribs are high and sharpened; they cross the venter with marked forward projection.

Remarks: – Most specimens of *A. jachromensis* from Spitsbergen are flattened by crushing, and their original whorl shape is therefore not obtainable in detail. The ribbing of these specimens, however, is mainly well-preserved and shows a good agreement with undeformed specimens of *A. jachromensis*.

Occurrence: – Localities 1, 2, 3, 9, and 25.

Arcthoplites birkenmajeri n.sp.

Pl. 8, figs. 2–6; pl. 9, fig. 1; text-fig. 12a–e

Name: – The species is named in honour of Professor KRZYSZTOF BIRKENMAJER, who collected most of the type material.

Holotype: – An almost complete internal mold (A32860) from locality 17, collected by K. BIRKENMAJER in 1962.

Material: – Internal molds of 40 specimens. The majority of these molds are undeformed and bear parts of the shell wall.

Description: – The body chamber is subrectangular in section with greatest thickness at the umbilical rim; the section of the phragmocone is subelliptical.

The umbilicus is moderately wide; its wall is gently inclined and rounds evenly into the flanks. The primary ribs start on the umbilical rim and cross the flanks with a slightly sigmoidal course. From one primary rib usually arises a secondary rib by more or less distinct bifurcation; the points of bifurcation are situated within the outer half of the whorl sides. On the lower and middle parts of the sides the ribs are high and sharpened, whereas on the venter they are low and rounded. The ribs pass over the venter with marked forward projection.

The body chamber bears one or two broad constrictions. The suture is comparatively simple. Its external part consists of broad saddles and shallow lobes; first lateral lobe is subsymmetrically trifid.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32816	30 mm	12 mm 40%	10 mm 33%	10 mm 33%
A32863	38 »	15 » 39 »	13 » 34 »	13 » 34 »
A32829	48 »	17 » 35 »	16 » 33 »	18 » 37 »
A32864	55 »	20 » 36 »	18 » 33 »	20 » 36 »
A32860*	59 »	22 » 37 »	19 » 32 »	22 » 37 »

(* Holotype)

Remarks: – This species is considered to be intermediate between the genera *Freboldiceras* and *Arcthoplites*. It is herein assigned to *Arcthoplites,* because its ribs on the venter are generally well-marked, and because its whorl section in the adult stage is usually subrectangular. In these features the species resembles first and foremost *A. jachromensis* (NIKITIN 1888), which is the type species of *Arcthoplites*.

In some specimens of *A. birkenmajeri* the body chamber is subelliptical in section with only slightly flattened venter. These specimens are difficult to distinguish from *Freboldiceras remotum* n. sp., and they represent transitions connecting the latter species with *A. birkenmajeri*. One of these specimens is shown on Plate 8, fig. 5.

Most specimens of *A. birkenmajeri* differ clearly from *F. remotum* by their body chamber, which is subrectangular in section instead of subelliptical. Furthermore, the venter of *A. birkenmajeri* is generally more distinctly ribbed, its umbilicus is wider, and its whorls are lower than those of *F. remotum*. (Compare the measurements listed for the species.)

A. birkenmajeri is distinguished from *A. jachromensis* mainly by its ribs, which on the venter are low and rounded instead of being high and sharpened.

Occurrence: – Localities 8, 14, 15, 17, and 38. At locality 17 this species occurs together with *Leymeriella* (*L.*) *germanica*.

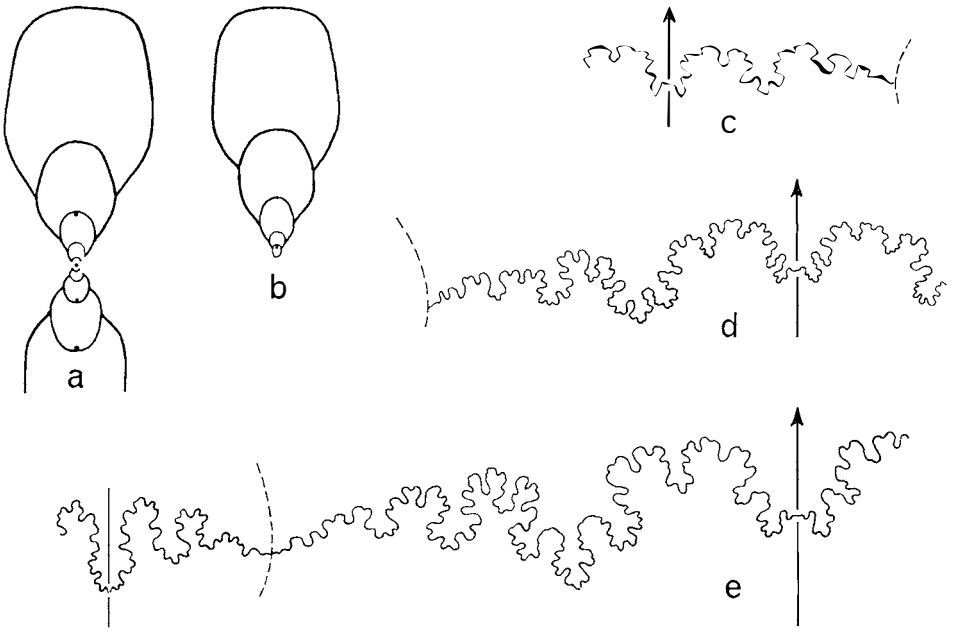

Fig. 12. Whorl sections and suture lines of *Arcthoplites birkenmajeri* n. sp.
a–b. Whorl sections (×1) of two specimens from locality 17: a, section through body chamber and phragmocone of A32817; b, section through body chamber and phragmocone of A32818.
c–e. Suture lines (×3) of three specimens from locality 17: c, external suture of A32816 at a whorl height of 8 mm; d, external suture of A32829 at a whorl height of 13 mm; e, external and internal suture of A32828 at a whorl height of 18 mm.

Genus Gastroplites McLEARN 1930

Gastroplites subquadratus n. sp.

Pl. 9, fig. 2; text-fig. 13b–d

Name: – The name *subquadratus* alludes to the almost quadrate whorl section of the species in the adult stage.

Holotype: – A nearly complete internal mold (A32827) from locality 20, collected by the author in 1963. The holotype is the only known specimen of this species.

Description: – The shell is involute with deep umbilicus, which has a steeply inclined wall and an abruptly rounded rim. The whorl section is trapezoidal in the young, and subquadrate in the adult stage. At a diameter of 49 mm the shell bears 10 short, raised rib-stems, which commence on the umbilical rim. From one rib-stem arise two or three ribs, which show a gradual increase in strength towards the venter. On the venter the ribs are broader and higher than on the flanks, and have a straight course. The body chamber occupies three fourths of the last whorl. In the adoral part of the body chamber the ribs are strongly prorsiradiate when crossing the flanks. The suture consists of simplified lobes and saddles; first lateral lobe is irregularly trifid with subparallel sides.

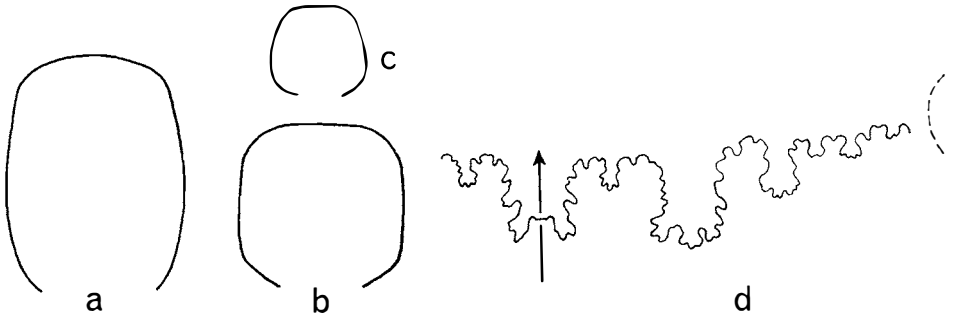

Fig. 13. Whorl sections and suture line of *Gastroplites*.

a. *Gastroplites* sp. A. Section through body chamber (×1) of A32826 from locality 19.

b–d. *Gastroplites subquadratus* n. sp. Holotype, A32827, from locality 20: b, section through body chamber (×1); c, section through phragmocone (×1); d, external suture (×3) at a whorl height of 12 mm.

Measurements:

No.	Diameter	Whorl height	Whorl width	Umbilical diameter
A32827	47 mm	22 mm 47%	22 mm 47%	10 mm 21%
»	37 »	17 » 46 »	17 » 46 »	9 » 24 »

Remarks: – *Gastroplites* is particularly well-known from Canada and Alaska, but it has been recorded also from East Greenland and England. The genus has been treated in several papers, e.g. McLEARN (1931; 1933), SPATH (1937), and REESIDE & COBBAN (1960, p. 54–56).

Gastroplites subquadratus from Spitsbergen shows some resemblance to *Gastroplites canadensis* (WHITEAVES 1892), but it has greater whorl width and narrower umbilicus. Furthermore, the ribs of *G. subquadratus* are straight on the venter instead of being gently arched as those of *G. canadensis*.

The suture of *G. subquadratus* is simplified as is the case with the suture of *Gastroplites cantianus* SPATH 1937 from the English Gault. The first lateral lobe of *G. cantianus*, however, is considerably broader and more asymmetrical than that of *G. subquadratus*.

Occurrence: – Locality 20.

Gastroplites sp. A

Pl. 9, fig. 3; text-fig. 13a

Material: – Fragment of the body chamber of a specimen preserved as internal mold.

Description: – The body chamber is higher than wide; its cross-section is subrectangular with gently convex flanks and venter. The ribs begin weakly near the umbilicus, but show a strong increase in breadth towards the venter. By this

expansion the ribs get a wedge-like outline on the flanks. On the venter the ribs are prominent and have a bowed course; the bows are concave adorally.

Remarks: – The whorl section of *Gastroplites* sp. A is similar to that of *Gastroplites canadensis* (Whiteaves 1892) from the Albian of western Canada. The ribs of *Gastroplites* sp. A, however, are much broader on the outer flank and on the venter than those of the Canadian species.

Occurrence: – Locality 19.

Gastroplites sp. B

Pl. 9, fig. 4

Material: – One incomplete internal mold of a body chamber. The specimen is somewhat flattened by crushing.

Description: – The body chamber is higher than wide, with slightly convex sides and flat venter; its original cross-section is apparently subrectangular. The ribs commence weakly near the umbilicus and show a gradual increase in strength towards the venter. They cross the venter in a straight line, or probably in a gently convex arc.

Remarks: – *Gastroplites* sp. B shows some resemblance to *Gastroplites kingi* McLearn 1931 from the Albian of western Canada.

Occurrence: – Locality 29.

Аннотация

Верхняя часть нижнего мела (апт и альб) на Шпицбергене представлена морской Каролинефьеллетской (Carolinefjellet) формацией, состоящей, главным образом, из аргиллитов, алевролитов и песчаников. В настоящей работе выделены пять пачек внутри формации и дано краткое литологическое описание каждой пачки. Две верхних пачки Циллербергетская (Zillerberget) и Шёнрокфьеллетская (Schönrockfjellet), описаны впервые.

Возрастные отношения внутри Каролинефьеллетской формации освещены при помощи обнаруженных в ней аммонитовых фаун. В нижней ее части встречается фауна Tropaeum, являющаяся по возрасту верхнеаптской. В середине формации присутствуют четыре последовательных аммонитовых фауны, которые коррелированы с следующими частями западноевропейского альба: 1) фауной Freboldiceras – нижняя часть нижнего альба; 2) фауной Arcthoplites – средняя часть нижнего альба; 3) фауной Otohoplites – верхняя часть нижнего альба; 4) фауной Hoplites – нижняя часть среднего альба.

В верхней части Каролинефьеллетской формации обнаружено несколько видов родов Dimorphoplites, Euhoplites и Gastroplites. Эти виды отнесены к средней или верхней частям среднего альба.

Шпицбергенские палеогеографические условия в аптское и альбское времена кратко обсуждаются. Предполагается, что песчаные осадки, составляющие лангстаккенскую (Langstakken) пачку, внесены в альбское море с территорий суши, расположенных в северо-восточной и восточной частях Баренцового шельфа.

Аммонитовые фауны, полученные из шпицбергенского альба, содержат фаунистические элементы, известные в Западной Европе и северо-западной части Северной Америки. Эти отношения указывают на то, что Шпицберген в альбское время был связан как с Западной Европой, так и с северо-западной частью Северной Америки акваториями, через которые была возможной миграция аммонитов.

Верхняя часть Каролинефьеллетской формации ограничена несогласием, наложенным третичными слоями, возникшим в результате дотретичного поднятия шпицбергенской области и представляющим собой значительный пробел. Региональная вариация мощности формации указывает на то, что дотретичное поднятие и последующая денудация были наибольшими на севере и северо-западе и уменьшались по интенсивности на юго-восток. Эта интерпретация поддерживается также внутриформационными возрастными отношениями, как они выражаются аммонитовыми фаунами.

Описаны 33 альбских аммонитовых вида, происходящих из 38 местностей, где были найдены ископаемые. Представлены семейства: Tetragonitidae, Desmoceratidae, Leymeriellidae и Hoplitidae. Восемь из описанных видов отождествлены с прежде известными видами, тогда как новыми являются четыре: Hoplites (H.) svalbardensis, Freboldiceras remotum, Arcthoplites birkenmajeri и Gastroplites subquadratus. Кроме того, семь видов приравнены к прежде описанным видам, одиннадцать видов определены только по родовому уровню, а три вида — ненадежного родового определения.

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PLATES 1—12

The ammonites are reproduced in natural size, except Plate 1, figs. 5–7.

PLATE 1

Fig. 1a–b. *Eogaudryceras inaequale* BREISTROFFER . . . . . (p. 32)
Lateral views of A32801 from locality 17:
a. Incomplete internal mold of phragmocone.
b. Silopren cast from natural mold of phragmocone.

Fig. 2. *Grantziceras* cf. *affine* . . . . . (p. 33)
Lateral view of A32825 from locality 26.

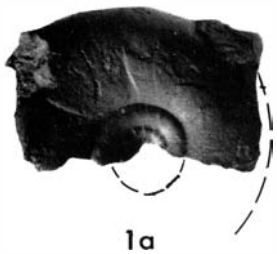
Fig. 3. *Brewericeras* cf. *hulenense* . . . . . (p. 34)
Lateral view of A32806 from locality 2.

Fig. 4. *Proleymeriella* sp. . . . . (p. 35)
Lateral view of A32824 from locality 37.

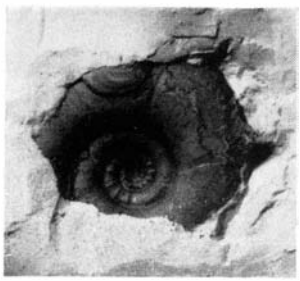
Fig. 5–7. *Leymeriella* (*L.*) *germanica* CASEY . . . . . (p. 35)
Three specimens from locality 17:
5a–b. ×2. Lateral (a) and ventral (b) views of A32837.
6a–b. ×2. Ventral (a) and lateral (b) views of A32836.
7. ×2. Lateral view of A32835.

Fig. 8–10. *Grycia sablei* (IMLAY) . . . . . (p. 37)
8. Lateral view of A32833 from locality 24.
9. Lateral view of A32832 from locality 16.
10. Lateral view of A32831 from locality 24.

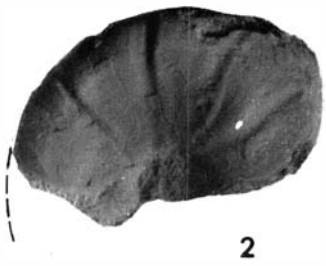
Fig. 11. *Grycia* sp. . . . . (p. 39)
Lateral view of A32843 from locality 34.



1a



1b



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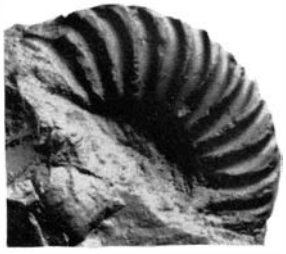
3

4

5a

5b

6a



6b

7

8

9

10

11

PLATE 2

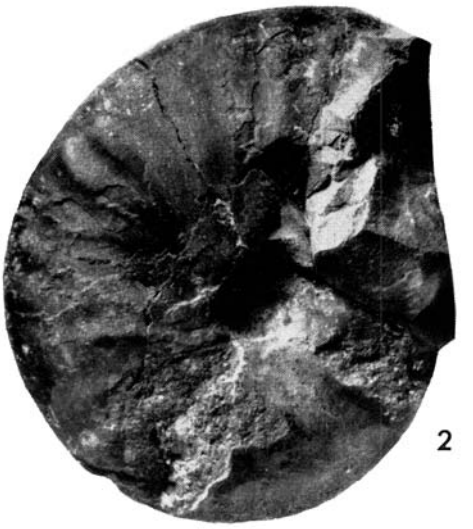
Fig. 1. *Grycia sablei* (IMLAY) ..... (p. 37)
Lateral view of A32834 from locality 21.

Fig. 2–4. *Grycia whittingtoni* (IMLAY) ..... (p. 38)
2. Lateral view of A32830 from locality 21.
3. Lateral view of A32844 from locality 24.
4. Lateral view of A32845 from locality 24.

Fig. 5a–b. *Hoplites* (*I.*) cf. *eodentatus* ..... (p. 39)
Lateral (a) and ventral (b) views of A32842 from locality 22.

Fig. 6–8. *Hoplites* (*H.*) *svalbardensis* n. sp. ..... (p. 40)
6. Lateral view of A32839 from locality 24.
7a–b. Ventral (a) and lateral (b) views of A32814 from locality 21.
8. Lateral view of A32815 from locality 24.

1



2

3

4

5a

5b

6

7a

7b

8

PLATE 3

Fig. 1a–b. *Hoplites* (*H.*) *svalbardensis* n. sp. ..... (p. 40)
Ventral (a) and lateral (b) views of the holotype, A32841 from locality 23.

Fig. 2a–c. *Euhoplites* sp. A. ..... (p. 43)
Lateral (a, c) and ventral (b) views of A32865 from locality 18:

a–b. Incomplete internal mold of body chamber. The basal outline of the ventral and lateral tubercles are well-marked.

c. Silopren cast from natural mold of phragmocone showing spine-like lateral tubercles.

Fig. 3. *Euhoplites* sp. B. ..... (p. 43)
Lateral view of A32812 from locality 20.

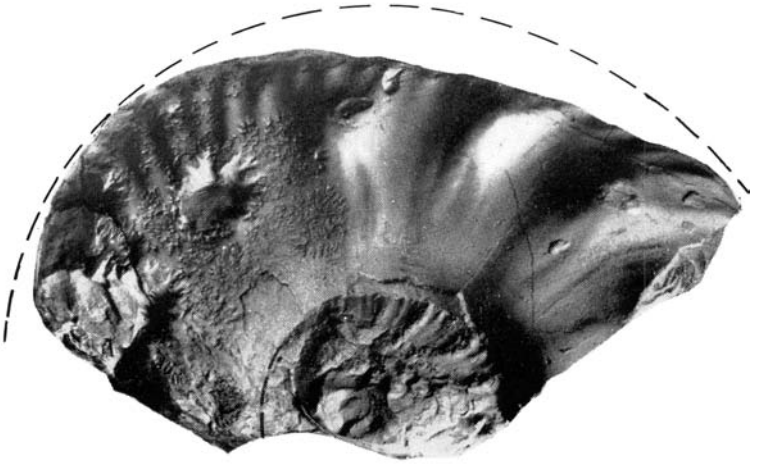
1a

1b

2a

2c

2b



3

PLATE 4

Fig. 1a–b. *Otohoplites guersanti* (D'ORBIGNY) ..... (p. 44)
Lateral (a) and ventral (b) views of A32811 from locality 4.

Fig. 2a–b. *Hoplites* (*H.*) aff. *obtusus* ..... (p. 41)
Lateral (a) and ventral (b) views of A32840 from locality 28.

Fig. 3a–b. *Otohoplites* sp. A. ..... (p. 46)
Ventral (a) and lateral (b) views of A32855 from locality 4.

1a

1b

2a

2b

3a

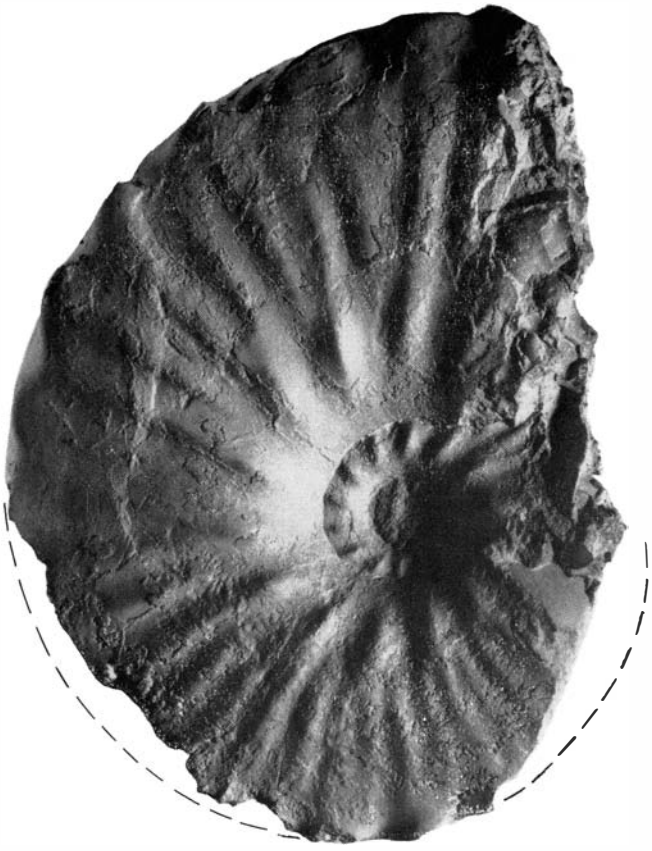
3b

PLATE 5

Fig. 1a–b. *Otohoplites glyphus* CASEY ..... (p. 46)
Lateral (a) and ventral (b) views of A32838 from locality 16

Fig. 2a–b. *Otohoplites* sp. B. ..... (p. 47)
Lateral (a) and ventral (b) views of A32865 from locality 34.

Fig. 3. *Otohoplites* sp. C. ..... (p. 47)
Lateral view of A32853 from locality 36.



1a

1b

2a

2b

3

PLATE 6

Fig. 1. *Otohoplites* cf. *guersanti* ..... (p. 45)
Lateral view of A32810 from locality 4.

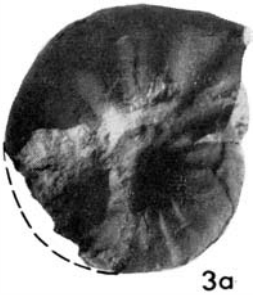
Fig. 2a–c. *Dimorphoplites* cf. *tethydis* ..... (p. 48)
Lateral (a), ventral (b), and frontal (c) views of A32852 from locality 18.

Fig. 3a–b. *Freboldiceras singulare* IMLAY ..... (p. 48)
Lateral (a) and frontal (b) views of A32823 from locality 26.

Fig. 4–5. *Freboldiceras remotum* n. sp. ..... (p. 49)
Two specimens from locality 17:
4a–b. Lateral (a) and ventral (b) views of A32851.
5a–b. Lateral (a) and ventral (b) views of A32846.

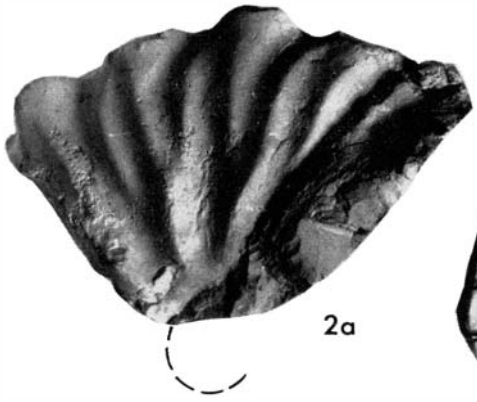
1

2b



3a

3b



2a

2c

4a

4b

5a

5b

PLATE 7

Fig. 1–4. *Freboldiceras remotum* n. sp. ..... (p. 49)

Four specimens from locality 17:

1a–b. Lateral (a) and ventral (b) views of A32848.

2a–b. Lateral (a) and ventral (b) views of A32850.

3a–b. Lateral (a) and ventral (b) views of the holotype, A32849.

4a–b. Lateral (a) and ventral (b) views of A32819.

1a

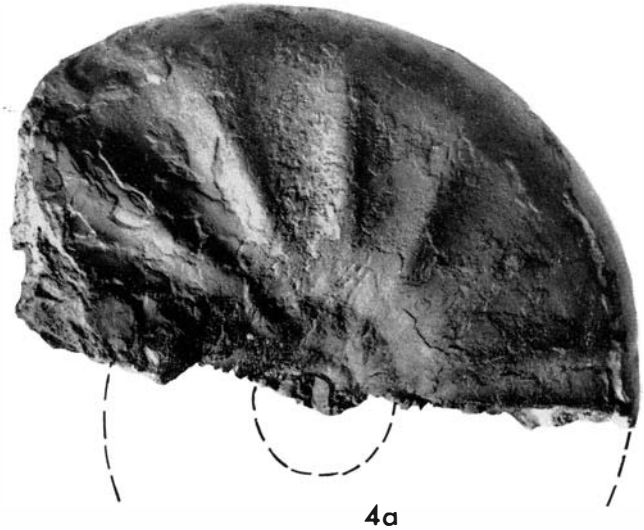
1b

2a

3a

3b

2b



4a

4b

PLATE 8

Fig. 1a–b. *Arcthoplites jachromensis* (NIKITIN) ..... (p. 51)
Lateral (a) and ventral (b) views of A32857 from locality 1.

Fig. 2–6. *Arcthoplites birkenmajeri* n. sp. ..... (p. 51)
Five specimens from locality 17:

2a–b. Lateral (a) and ventral (b) views of A32829.

3a–b. Lateral (a) and ventral (b) views of the holotype, A32860.

4a–b. Lateral (a) and ventral (b) views of A32816.

5a–b. Lateral (a) and ventral (b) views of A32859. Specimen intermediate between this species and *Freboldiceras remotum* n. sp.

6a–b. Lateral (a) and ventral (b) views of A32858.

1a

1b

2a

2b

3a

3b

4a

4b

5a

5b

6a

6b

PLATE 9

Fig. 1a–b. *Arcthoplites birkenmajeri* n. sp. ..... (p. 51)
Lateral (a) and ventral (b) views of A32847 from locality 17.

Fig. 2a–d. *Gastroplites subquadratus* n. sp. ..... (p. 53)
Lateral (a, b) and ventral (c, d) views of the holotype, A32827 from locality 20.

Fig. 3a–b. *Gastroplites* sp. A. ..... (p. 54)
Lateral (a) and ventral (b) views of A32826 from locality 19.

Fig. 4a–b. *Gastroplites* sp. B. ..... (p. 55)
Lateral (a) and ventral (b) views of A32856 from locality 29.

1a

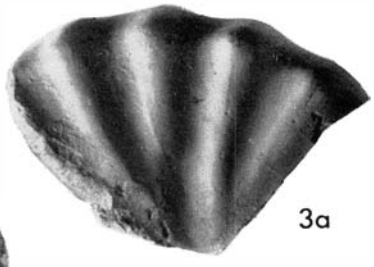
1b

2a

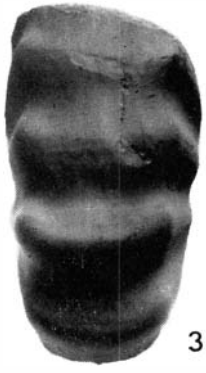
2b

2c

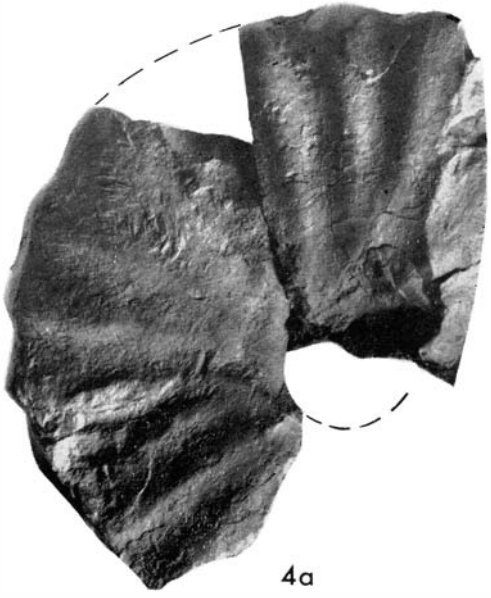
2d



3a



3b



4a

4b

A.W. BRØGGERS BOKTRYKKERI A/S - OSLO