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BIOSTRATIGRAPHY OF THE VALANGINIAN IN SVERDRUP BASIN, DISTRICT OF FRANKLIN

EDWIN KEMPER



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BIOSTRATIGRAPHY OF THE VALANGINIAN IN SVERDRUP BASIN, DISTRICT OF FRANKLIN

Abstract

A sequence of Valanginian rocks was studied in the part of the depocentre of the Sverdrup Basin, now occupied by Amund Ringnes and Ellef Ringnes islands. The about 500 m thick Valanginian sequence is represented mostly by the upper part of the Deer Bay Formation.

Bed by bed collecting of fossils resulted in an improvement of our knowledge of the succession of ammonite species in the report area. Only high-boreal to arctic species occur in the lower part of the particularly thick (about 300 m) lower Valanginian. The upward faunal sequence is: **Temnoptychites**, **Thorsteinssonoceras**, **Polyptychites** (**Siberiptychites** n. subgenus) ex gr. **stubendorffi**. In the younger lower Valanginian these faunas are replaced by those consisting of true **Polyptychites**. The latter faunas originating in the more temperate regions of the Boreal Realm consist of **P. keyserlingi** fauna below and **P. spheroidalis** fauna at the top. These beds also contain new, very large **Polyptychites** species. The lower part of overlying lower upper Valanginian beds contains a new **Prodichotomites** species which is then replaced by representatives of **Homolomites**. No ammonites have been found in the topmost beds of Deer Bay Formation which only yielded a late Valanginian **Buchia** fauna.

Résumé

On a étudié une succession de roches du Valanginien, dans le secteur de la région axiale du bassin de Sverdrup, actuellement occupé par les îles Amund Ringnes et Ellef Ringnes. La succession valanginienne, d'environ 500 mètres d'épaisseur, est principalement représentée par la partie supérieure de la formation de Deer Bay.

En recueillant lit par lit les fossiles, nous avons élargi nos connaissances sur les successions d'espèces d'ammonites, qui caractérisent la région étudiée. A la base des couches du Valanginien inférieur, qui sont particulièrement épaisses (environ 300 mètres), on n'a rencontré que des espèces subarctiques à arctiques. De bas en haut, la succession faunique est: **Temnoptychites**, **Thorsteinssonoceras**, **Polyptychites** (**Siberiptychites**, sous-genre nouveau), ex gr. **stubendorffi**. Dans les couches les plus récentes du Valanginien inférieur, ces faunes sont remplacées par celles contenant de vrais **Polyptychites**. Ces dernières, qui se sont constituées dans les régions plus tempérées du domaine boréal, contiennent la faune à **P. spheroidalis** au sommet, et au-dessous, la faune à **P. keyserlingi**. Ces couches contiennent aussi de nouvelles espèces de **Polyptychites** de très grande taille. La partie inférieure de lits sus-jacents de la base du Valanginien supérieur contient une nouvelle espèce de **Prodichotomites**, qui fait ensuite place à des représentants de **Homolomites**. On n'a pas rencontré d'ammonites dans les lits du sommet de la formation de Deer Bay, mais uniquement une faune à **Buchia** du Valanginien supérieur.

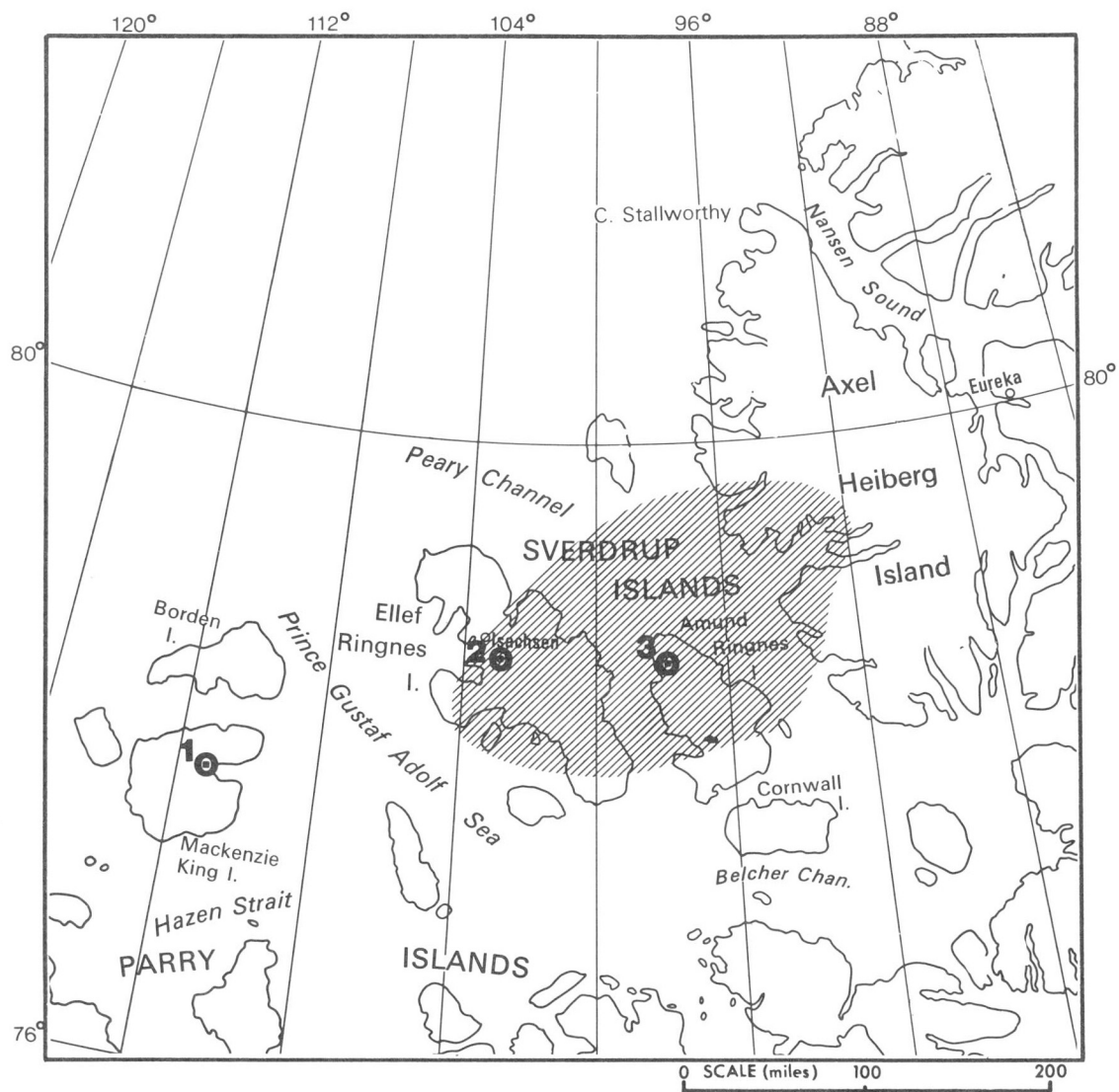


Figure 1. Sketch map of Sverdrup Basin.

BIOSTRATIGRAPHY OF THE VALANGINIAN IN SVERDRUP BASIN, DISTRICT OF FRANKLIN

INTRODUCTION

The conclusions presented in this paper are based on field work carried out in 1974 and 1976. This field work, which was financed by the Ministerium für Forschung und Technologie der Bundesrepublik Deutschland, was carried out under the title of a joint project with J.A. Jeletzky, Geological Survey of Canada, and was concerned with the comparative paleontology and biostratigraphy of the Valanginian of Sverdrup Basin and northwestern Germany. The accommodation, transportation, and field assistants were provided by the geological parties of the Geological Survey of Canada headed by H.R. Balkwill.

The objective of the author's research was the study of the paleontology and stratigraphy of the Valanginian rocks of Sverdrup Basin which is represented largely by the upper part of the Deer Bay Formation. The first results have been published by Kemper (1975) and Kemper and Schmitz (1975).

The study of the biostratigraphically most important Polytychitinae taxa collected from the Valanginian rocks of report area by the writer and other workers is now nearing completion (Kemper and Jeletzky, in prep.). The same applies to the study of early Valanginian Craspeditidae taxa collected in the report area (Jeletzky, in prep.) and the predominantly closely allied Polytychitinae taxa of northwestern Germany (Kemper, in prep.). Some of the still unpublished, principal conclusions reached in the above mentioned papers by J.A. Jeletzky and the writer will be summarized below in a preliminary form since they are relevant to the subject of this paper.

The author thanks all above mentioned organizations and persons who either have made the project possible or helped to carry it through. Special thanks are due to J.A. Jeletzky, Geological Survey of Canada, for manifold help during the field and office phases of the project. In particular he has identified *Buchia* material collected by the writer, translated this manuscript into English, and critically read and edited it. The identification and biostratigraphic evaluation of all other fossil material collected by the author and others was done jointly with J.A. Jeletzky under the terms of the above mentioned joint project.

The 1976 field work was restricted almost exclusively to the central part of Sverdrup Basin and particularly to Amund Ringnes and Ellef Ringnes islands. Earlier work (Kemper, 1975) indicated that the complete sequences of the upper Deer Bay Formation could be expected only in this part of the area which is characterized by good exposures (see Fig. 1). The work on Mackenzie King Island proved to be unproductive and was abandoned because of poor exposures and scarcity of fossils. However, an important discovery of *Astieriptychites* was made in this western marginal area of Sverdrup Basin and the coordinates of this fossil locality are cited below together with those of the sections measured on Amund Ringnes and Ellef Ringnes islands; they are:

1. Mackenzie King Island (Ke 76/1), unnamed hills in the northern part of the island, latitude 77°54'N, longitude 111°09'W.

2. Ellef Ringnes Island (Ke 76/3), unnamed hills and ravines situated about 13 km (8 miles) southwest of the Isachsen Weather Station, latitude 78°43'N, longitude 103°00'W.

3. Amund Ringnes Island, unnamed hills and ravines in the northern part of the island between latitudes 78°38'20" and 78°38'35"N and longitudes 97°56' and 97°52'W.

Field work of the 1976 season resulted in the clarification of some previously unsolved problems, in particular that of the general succession of the Valanginian ammonite faunas. However, thick sequences of unfossiliferous beds continue to separate some of the beds containing diagnostic fossils. Future discoveries in other parts of the region, therefore, may necessitate some additions and corrections of the faunal succession proposed in this paper, particularly where the time ranges and overlaps of the diagnostic taxa are concerned.

GENERAL REMARKS ABOUT THE STRATIGRAPHY, DELIMITATION AND SUBDIVISION OF THE VALANGINIAN

The stratotype of the Valanginian stage is situated in Switzerland, that is, in an area which formed part of the Tethyan Realm in the Early Cretaceous. However, it is possible to recognize with relative ease the approximate equivalents of the Valanginian in the Boreal Biotic Realm (Jeletzky, 1973, Saks and Shulgina, 1974). This is facilitated by repeated northward and southward migrations of elements of the Valanginian faunas which permit the correlation of its Tethyan and Boreal biofacies. The depositional basin of Lower Saxony in northwestern Germany is a key area for the purpose of such correlation for the following reasons. First, it exhibits a relatively thick, continuous sequence of the Valanginian. Second, it was the evolutionary centre of the ammonite subfamily Polytychitinae (Kemper and Jeletzky, in prep.; Kemper, in prep.) which provides a number of Valanginian index fossils ranging all the way from northwestern Europe to Arctic Canada. Third, the presence of fairly numerous southern faunal elements in the Lower Saxonian basin permits the correlation of the individual evolutionary phases of its Polytychitinae with the zonal sequence of the Tethyan Valanginian.

In addition to Tethyan diagnostic faunas and the Polytychitinae of the Lower Saxonian basin, the Valanginian Stage contains yet another important group of ammonites — the Craspeditidae — which evolved in the eastern part of the Boreal Realm (i.e. largely on the territory of the present day USSR). The representatives of this family dominated the high boreal and arctic seas in the Berriasian and early Valanginian. In the course of their evolution, the Craspeditidae commonly gave rise to forms convergent with the representatives of the Polytychitinae. These forms have been confused in the past with the true Polytychitinae. These misidentifications were the principal reason for strongly divergent subdivisions of the Valanginian in different boreal regions which have little in common. The misinterpretation of *Homolomites* species (e.g. of *H. bojarkensis* Shulgina and *H. petschorenensis* (Bogoslavsky)), in particular, had complicated the long-range correlation of the upper Valanginian rocks. A major result of J.A. Jeletzky's research (several papers,

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particularly Jeletzky, 1965) is that it is now possible to differentiate the homoeomorph forms of Polyptychitinae and Craspeditidae on the basis of distinctive morphology of their suture lines. This research opened the way toward a reliable subdivision and correlation of the Valanginian of the boreal regions.

Generally, differences in faunal successions and resulting difficulties in comparing Valanginian successions of different boreal and arctic regions are caused by:

1. The repeated dislodging and replacement of faunas consisting of representatives of one of the above mentioned ammonite families (or subfamilies) by the invading representatives of another family (or subfamily). This process may consist either in the replacement of Craspeditidae by the Polyptychitinae or Polyptychitinae by Craspeditidae.
2. Contemporaneously with this process of faunal replacement, the invading faunas developed new endemic species in their newly acquired habitat areas. These vicarious species may differ considerably from their closest allies in the original evolutionary centres; and
3. Some of the waves of faunal migrations are synchronous in all arctic regions (e.g. the ammonite faunas of the late Valanginian transgression). However, the other waves are heterochronous from one region to another. For example, the oldest known representatives of Polyptychitinae which stand closest to the root of the subfamily are so far known only from northwestern Germany. Only the younger, more advanced Polyptychitinae species had reached the Russian Platform and Siberia. These species are cited as *Polyptychites keyserlingi* (Neumayr and Uhlig), *P. polytychus* (Keyserling) and *P. michalskii* (Bogoslovsky) by the Russian authors. So far as is known, only representatives of the latest evolutionary phase of the subgenus *Polyptychites* sensu stricto immediately preceding its transmutation into *Dichotomites* (*Prodichotomites*) penetrated into the Sverdrup Basin.

The above-discussed recognition (Kemper, in prep.; Kemper and Jeletzky, in prep.) of the progressively later appearance of representatives of the genus *Polyptychites* sensu stricto in different boreal and arctic depositional basins is important for the subdivision of the boreal Valanginian. Its subdivision into lower, middle, and upper Valanginian, as practised until now by Jeletzky (1973) for Arctic Canada, does not appear to be advisable any longer. This subdivision was based on the idea of the presence of thick and paleontologically distinctive "Polyptychites-beds" representing the middle Valanginian. In the writer's opinion, the recognition of a considerably earlier appearance of *Polyptychites* sensu stricto in northwestern Germany (see Fig. 2) invalidates this idea. On the one hand, it would leave little room for the lower Valanginian in the Middle European region and, on the other, it reveals that the beds containing *Polyptychites* sensu stricto in Sverdrup Basin comprise only a small part of the Valanginian sequence. The writer recommends, therefore, that the same bipartite subdivision of the Valanginian used by the majority of workers in Europe be used also for the Valanginian of the Sverdrup Basin.

The lower limit of the Valanginian is best defined by the first appearance of *Platylenticeras* (and *Pseudogammaria*) following Kemper (1971, 1976). In the boreal-arctic regions, this boundary coincides approximately with the first appearance of *Buchia keyserlingi* (Lahusen) (see

Jeletzky, 1973, Fig. 3), but is not placed uniformly because of the absence of the diagnostic genus *Platylenticeras*. The Russian workers (e.g. Saks and Shulgina, 1974, p. 556, Table 1) assign the beds with *Tollia tolli* Pavlov to the late Berriasian and begin the Valanginian with the next younger zone of *Neotollia klimovskiensis* which underlies the beds with *Temnoptychites*. In Sverdrup Basin, *Tollia* sensu stricto ranges up into the beds containing *Temnoptychites* and *Neotollia* appears to be absent. Therefore, Jeletzky (1973, Fig. 3) placed the lower boundary of the Valanginian immediately beneath the beds containing *Tollia tolli* sensu lato. The boundary beds between Berriasian and Valanginian in the central part of Sverdrup Basin, unfortunately, are so poorly fossiliferous that it is not possible to contribute to the solution of this problem at this stage of the writer's research.

The boundary between the lower and upper Valanginian is defined by an interprovincial, easily recognizable biostratigraphic event. This event consists of the transmutation of the *Polyptychites* sensu stricto into the subgenus *Prodichotomites* of the genus *Dichotomites* and in the emergence of the genus *Dichotomites* sensu lato (Kemper, 1976, p. 35). The interregional correlation of the upper Valanginian rocks, however, is complicated by the fact that the subgenus *Dichotomites* sensu stricto is restricted to the southern part of the Boreal Realm and is replaced in the high boreal to arctic depositional basins by vicarious evolutionary lineages of *Prodichotomites* (see Kemper, 1975, p. 248). In these high boreal to arctic basins, the representatives of *Prodichotomites* soon become replaced by species of the craspeditid genus *Homolomites* which are, however, relatively common only in the marginal areas of southwestern Sverdrup Basin. These *Homolomites* forms also do not range up into the upper part of the upper Valanginian of the basin.

During the late late Valanginian, the number of ammonites decreased markedly in many parts of the world. In Europe these beds contain few ammonites and mainly representatives of the genus *Olcostephanus* (= "Astieria"). In the high boreal to arctic basins, as for example in the Sverdrup Basin, the ammonites appear to be absent completely. Therefore, it is impossible to recognize the exact position of the upper boundary of the Valanginian as defined in the Tethyan Realm (e.g. Jeletzky, 1973, Fig. 3) in these boreal basins. Even the placement of this boundary in the depositional basins of northwestern Germany and eastern England remains uncertain. Where the upper upper Valanginian rocks devoid of ammonites in the higher latitudes are concerned, the position of this boundary is one of the so far insoluble problems of correlation.

THE VALANGINIAN SEQUENCE AND ZONATION IN THE DEPOCENTRE OF SVERDRUP BASIN

As indicated in Figure 3, the sequence of Volgian-Berriasian-Valanginian stages is represented largely by the argillaceous rocks of the Deer Bay Formation (see also Kemper, 1975, p. 246). The greater part of the Deer Bay Formation, comprising about two thirds of its thickness, belongs to the Valanginian. On Amund Ringnes Island the succession, considered and described herein as the standard profile of the Valanginian of the depocentre, of the Sverdrup Basin, is more than 400 m (1312 ft.) thick.

The equivalents of the Berriasian parts of Deer Bay Formation are absent either entirely, or for the most part, in the eastern marginal parts of Sverdrup Basin (Kemper, 1975, p. 248, Fig. 2). There, the Volgian Stage or the

Volgian/Berriasian boundary beds are overlapped directly either by the Berriasian/Valanginian boundary beds or by the lower Valanginian beds. The data now available suggest the presence of similar transgressive relationships also in the southwestern part of Sverdrup Basin.

It is not known whether or not the Berriasian part of the Deer Bay Formation is completely developed in the central part of the Sverdrup Basin because of the scarcity of fossils here. Because uplifts are known in the marginal parts of the basin in the Berriasian, the Berriasian subsidence of its central parts is assumed to have been either minor or sporadic. That is why the thickness of the Berriasian beds in the depocentre is insignificant in comparison with that of the Valanginian.

Following the period of slight downwarp in the Berriasian, subsidence increased in the early Valanginian. This is indicated by the presence now of about 300 m (900 ft.) of lower Valanginian strata. The upper Valanginian, in contrast, is considerably thinner. It was not possible to determine accurately the thickness of the upper Valanginian because of the problematic nature of its upper boundary within the Isachsen Formation (Kemper, 1975, p. 251). However, this thickness is probably not more than 200 m (656 ft.).

The lithology and mineralogical peculiarities (e.g. the euhedral aggregates) of the Valanginian sequence of Sverdrup Basin have been discussed elsewhere (e.g. Kemper, 1975; Kemper and Schmitz, 1975). The following descriptions of the Valanginian profile of Amund Ringnes Island and of that of the upper Valanginian of Ellef Ringnes Island, therefore, are concerned mainly with the zonal succession of that stage. The thicknesses indicated in Figure 3 are the values beneath the base of the spheroidally weathering sandstone of the lower Isachsen Formation, whereas the numerical values enclosed in brackets are the numbers of the fossil collections listed in the text below.

On Amund Ringnes Island, the first euhedral aggregates occur at the 405 m (1329 ft.) level in unfossiliferous dark shale. Because of their stratigraphic position, these beds are interpreted tentatively as the lower lower Valanginian corresponding to the beds containing *Temnoptychites troelseni* n. sp. (Jeletzky, in prep.) (equals *Tollia-Temnoptychites* beds of Sec. 4; Kemper, 1975, Fig. 2) in the Reptile Creek section.

The oldest determinable fauna (20) consists of a community of *Buchia keyserlingi*. This horizon can be recognized easily because of the presence of exceptionally large solitary crystals or simple twin crystals belonging to the group of euhedral aggregates described by Kemper and Schmitz (1975). It belongs, presumably, to the next younger lower Valanginian zone, the index fossil of which – *Temnoptychites kemperi* n. sp. (Jeletzky, in prep.) – occurs frequently above the 380 m (1247 ft.) level (19) (GSC 93757). According to the latest identifications by Jeletzky (in prep.), *T. kemperi* n. sp. is associated with rare specimens of *T. borealis* Bodylevsky and *Tollia* n. sp. aff. *T. subtilis* Voronets, 1962. The first, rare representatives of *Thorsteinssonoceras* ex gr. *ellesmerense* Jeletzky were found (in the float) in this fauna in 1976.

A large number of specimens of *Thorsteinssonoceras ellesmerense* Jeletzky were found in a concretionary bed at the 360 m (1181 ft.) level (GSC 93756); these display the already known (see Jeletzky, 1965) great infraspecific variability. This bed forms part of a sequence of closely spaced bands of clay ironstone concretions which are recognizable on aerial photographs as a clearly expressed double band.

This sequence of beds contains euhedral aggregates up to the 350 m (1148 ft.) level, except in some subordinate beds. It is overlain by a 40 m (131 ft.) thick unit consisting of dark to blackish grey shale which splits into thin, small plates. This shale evidently contained inclusions of pyrite and marcasite prior to weathering as indicated by the characteristic pitted surface observed during the examination in the field. This feature results from leaching by acidic solutions. This "uniform shale sequence" is prominently expressed on aerial photographs as a continuous wide band. It is completely devoid of euhedral aggregates and fossils and, therefore, it is impossible to assign it to any of the recognized paleontological zones. The "uniform shale sequence" forms a distinctive lithological unit of the lower Valanginian situated immediately above the *Thorsteinssonoceras*-bearing concretions and extending over the whole basin. This unit is well exposed in the Blackwelder Mountains on Ellesmere Island and in the area of Buchanan Lake on Axel Heiberg Island.

The "uniform shale sequence" is overlain by a shale unit, about 60 m (197 ft.) thick, which is characterized by the common presence of euhedral aggregates, and which contains several yellow-weathering beds of clay ironstone. However, it is devoid of clay ironstone concretions, and no fossils have been found in it. The immediately overlying part of the profile centred at the 250 m (820 ft.) level (15-17) did yield, in contrast, a relatively abundant fauna of ammonites consisting of *Polyptychites* (*Siberiptychites*) *stubendorffi* (Schmidt) and *P. (S.) densicosta* Pavlow. The need for a subgeneric separation of these high arctic species from *Polyptychites* sensu stricto was recognized during a joint study by Kemper and Jeletzky (in prep.). It is expressed herein in their assignment to *Siberiptychites* Kemper and Jeletzky subgen. nov. which is characterized by the combined presence of frequent constrictions and the third auxiliary lobe in the external suture line. *Ammonites stubendorffi* Schmidt 1872 is designated as the type species of *Siberiptychites*.

Siberiptychites was found also in the bands of concretions between 220 and 230 m (722-755 ft.). The representatives of the subgenus are much less well preserved in this interval but they are represented mostly by broad *Cadoceras*-shaped shells. These shells resemble those of *Euryptychites* but the evidence now available suggests their being the cadoform terminal representatives of the *Polyptychites* (*Siberiptychites*) ex gr. *stubendorffi*. The *Siberiptychites* lineage apparently evolved in the same direction as the *Temnoptychites*-*Thorsteinssonoceras* lineage of Craspeditidae (Jeletzky, in prep.) which also terminated with broad *Cadoceras*-like forms (e.g. *Thorsteinssonoceras ellesmerense*). The *Siberiptychites*-bearing shale unit discussed herein contains euhedral aggregates at the 242 and 244 m (794 and 801 ft.) levels only.

The grey shale which immediately overlies the *Siberiptychites*-bearing shale is about 140 m (459 ft.) thick and includes thick units rich in euhedral aggregates at the 140 to 160 m (459-525 ft.) and at the 190 to 200 m (623-656 ft.) levels. This grey shale has yielded only typical representatives of *Buchia keyserlingi* (11-13) and belemnites (10). Because of the absence of representatives of the subgenus *Siberiptychites*, which is assumed to be extinct by that time, it seems best to assign the unit to the zone of *Polyptychites* (*Polyptychites*) *keyserlingi* in spite of the absence of any index fossils (Fig. 3). This problem is discussed in a greater detail below.

In the writer's opinion, the previously discussed ammonite taxa were undoubtedly high boreal to arctic

forms, since they are prevalent also in the corresponding beds in northern Siberia, in Novaya Zemlya, and in Spitzbergen (Jeletzky, in prep.). The absence of ammonite taxa, including representatives of *Polyptychites* sensu stricto, of the more southern boreal regions in the lower three quarters of the Valanginian beds of Sverdrup Basin indicates the existence of arctic climatic conditions there in the early Valanginian. This agrees well with similar inferences made by Kemper and Schmitz (1975) on the basis of a mass occurrence of euhedral aggregates in the same beds.

The succession of ammonite taxa in the lower Valanginian of Sverdrup Basin is particularly evident because of an unusually great thickness of these beds there. It is impossible to make definitive external comparisons of this sequence because of the exclusively generalized character of corresponding data published in the Russian literature (e.g. Voronets, 1962, Fig. 3; Saks and Shulgina, 1974, p. 556). The coexistence of *Polyptychites* (*Siberiptychites*) ex gr. *stübendorffi* with *Temnoptychites* species in northern Siberia claimed by Saks and Shulgina (loc. cit.) contradicts the sequence of ammonite taxa observed on Amund Ringnes Island. This contradiction must reflect either different concepts of taxa employed by the Russian workers or the condensation of index fossils of two or more adjacent zones in thin beds of their more attenuated sequences.

Some of the Valanginian ammonite genera cited in the Russian literature appear to be restricted to the shallow-water facies of the marginal areas of Sverdrup Basin. This applies, for example, to the genus *Astieriptychites* Bodylevsky which now has been recognized there.

An exceptionally well preserved specimen of *Astieriptychites* found in the lower part of the Upper shale member of the Mould Bay Formation on Mackenzie King Island (see Fig. 1) permitted the interpretation of poorly preserved material of the genus previously found in the profiles of Station Creek, north of Eureka Weather Station on Ellesmere Island. On Mackenzie King Island, the *Astieriptychites* is associated with a fauna of large-size *Buchia keyserlingi sibirica* (Sokolov).

No representatives of *Polyptychites keyserlingi* (Neumayr and Uhlig) have been found in the course of the bed-by-bed collecting carried out by the writer in 1974 and 1976. However, the presence of rocks equivalent to the *Polyptychites keyserlingi* zone of northwestern Germany (Fig. 2) in the Deer Bay Formation is indicated by the earlier find of two specimens of *P. keyserlingi* (Jeletzky, 1973, p. 64, 68, Pl. 1, fig. 2, Pl. 3, figs. 2a, 2b) on Amund Ringnes Island whose stratigraphic position is known only approximately. According to the latest identifications of Kemper and Jeletzky (in prep.), other diagnostic ammonites found together and presumably associated with apparently late representatives of *P. keyserlingi* at GSC locality 82695 are *P. sphaeroidalis* Koenen and *P. n. sp. aff. lamplugi* Pavlow. Other preliminary identifications of ammonites from this fossil locality made by Jeletzky (unpublished intradepartmental fossil report in 1969; and 1973, p. 68) are withdrawn herewith. This *Polyptychites keyserlingi* fauna appears to be entirely younger than the *Polyptychites* (*Siberiptychites*) ex gr. *stübendorffi* fauna, contrary to the suggestion of Jeletzky (1973, p. 68, Fig. 3).

The character of the ammonite fauna in Sverdrup Basin changes completely beginning with the *Polyptychites keyserlingi* zone. This drastic faunal change was studied particularly in the approximately 130 m (426 ft.) of topmost lower Valanginian beds (7-9) on Amund Ringnes Island. These are believed to correspond to the *Polyptychites sphaeroidalis* zone of the Lower Saxonian basin and,

therefore, to overlies immediately the beds of the Deer Bay Formation containing *P. keyserlingi* (Fig. 2).

The beds of the Deer Bay Formation comprising *Polyptychites keyserlingi* and *Polyptychites sphaeroidalis* zones combined are characterized by an apparently sudden appearance of an ammonite fauna that had obviously migrated to Arctic Canada all the way from the European part of the Boreal Realm. This is indicated by the close affinity of some of the known species to the well-known mid-European and specifically Lower Saxonian species. The evolutionary level of this ammonite fauna corresponds to that of the deeper level of Hollwede profile in the Lower Saxonian basin. This level, unfortunately, was never observed either elsewhere in northwestern Germany or in any other part of the world with the exception of northern Siberia (Pavlow, 1914). The discovery of this fauna on Amund Ringnes Island is, therefore, of outstanding biostratigraphical importance.

The presently much better known ammonite fauna of the *Sphaeroidalis* Zone (Fig. 2) is late early Valanginian in age and has features clearly indicating its transitional character to the late Valanginian faunas. No definitively identifiable representative of *Dichotomites* (*Prodichotomites*) *hollwedensis* n. sp. (Kemper, in prep.; Kemper and Jeletzky, in prep.) which is the index species of the lowermost upper Valanginian in the Lower Saxonian basin (Fig. 2), was found in place by the writer. However, a previously collected specimen from GSC locality 85023 (stratigraphic position not precise) was determined as *D. (P.) aff. hollwedensis* n. sp. by Kemper and Jeletzky (in prep.).

The ammonite fauna of the *Sphaeroidalis* Zone from Amund Ringnes Island is characterized by exceptionally large dimensions of almost all species contained in it. This agrees well with the general evolutionary trend of *Polyptychites* sensu stricto which results in the appearance of larger and larger shells in the course of its phylogenesis traced in the Lower Saxonian Basin (Kemper, in prep.; Kemper and Jeletzky, in prep.). However, the specimens comprising the *P. sphaeroidalis* fauna on Amund Ringnes Island are considerably larger than the largest representatives of the same or the most closely allied species found in middle Europe.

The presently known species of the Canadian *P. sphaeroidalis* fauna belong to two different species groups of the subgenus *Polyptychites* sensu stricto. The species which belong to the "more typical" *Polyptychites*, characterized by a relatively coarse ribbing habit beginning on the early growth stages, are represented first of all by *P. (P.) sphaeroidalis* Koenen itself and its huge subspecies, *P. (P.) sphaeroidalis tschekanowskii* Pavlow. However, this species group is represented also by the huge new species *P. (P.) balkwilli* n. sp. (Kemper and Jeletzky, in prep.). It should be noted in this connection that the previously mentioned Canadian representatives of *P. (P.) keyserlingi* (Neumayr and Uhlig) (evidently the youngest representatives of that species) and *P. (P.) n. sp. aff. lamplugi* Pavlow tentatively assigned to the next older *Polyptychites* (*Polyptychites*) *keyserlingi* zone (Fig. 2) also belong to this species group.

So far as is known, the second species group of *Polyptychites* sensu stricto of the Canadian *Sphaeroidalis* Zone is represented only by little known, especially large forms with very fine ribbed inner whorls and coarse, widely spaced bullae on the outer whorls. The Lower Saxonian species *P. (P.) orbitatus* Koenen, which is represented by a closely related form on Amund Ringnes Island, belongs to this species group. However, the species group is represented here also by a number of

other, morphologically extremely variable forms. In *P. (P.) canadensis* n. sp. (see Kemper and Jeletzky, in prep. for this and all other new species mentioned below), the finely ribbed growth stage extends only to the shell diameter of about 5 cm and its umbilicus is shallow and stepladder-like. However, in *P. (P.) sverdrupi* n. sp., the growth stages up to the shell diameter of about 10 cm remain finely and closely ribbed. This fine and dense sculpture evidently represents a new, proterogenetically evolving morphological feature which appears late in the evolutionary history of *Polyptychites* sensu stricto. This feature arose independently from the fine sculpture of such older *Polyptychites* sensu stricto as *P. (P.) ascendens* Koenen or *P. (P.) multicostatus* Koenen. Of the previously described Russian species, *P. (P.) tscherskii* Pavlov (1914, p. 33, Pl. IV, fig. 2) seems to belong to the late species group of *Polyptychites* sensu stricto discussed here. Everything known about this group which immigrated to the Sverdrup Basin from the European part of the Boreal Realm indicates that its Canadian representatives developed independently from and in another direction than their mid-European ancestors.

The *Dichotomites* (*Prodichotomites*?) *tozeri* n. sp. Kemper and Jeletzky (in prep.), which is diagnostic of the beds immediately overlying those with the *Polyptychites* (*Polyptychites*) *sphaeroidalis* fauna (Fig. 2), is that early late Valanginian form described and figured by Jeletzky (1973, p. 72, Pl. 1, fig. 1, Pl. 2, fig. 1, Pl. 3, fig. 1) under the name of *Polyptychites* (*Dichotomites*) aff. *bidichotomus* (Leymerie). As pointed out by Kemper and Jeletzky (in prep.), *D. (P.?) tozeri* is more likely an earliest late Valanginian offspring of the late representatives of *Polyptychites* sensu stricto discussed above than a new mid-European immigrant into the Sverdrup Basin. It should be stressed again in this connection that *Dichotomites* sensu stricto is restricted to the southern part of the Boreal Realm and is replaced by the vicarious subgenus *Prodichotomites* in its high boreal and arctic parts.

The vertical distribution of Craspeditidae in the latest early and early late Valanginian of the Sverdrup Basin is remarkable. In the Sphaeroidalis Zone, the above mentioned, prevalent representatives of Polyptychitinae are accompanied by a large craspeditid which will be described as *Virgatoptychites*? *thorsteinsoni* n. sp. by Jeletzky (in prep.). Large representatives of *Homolosomes*, which become sculptureless in the middle and late growth stages, also occur in the Sverdrup Basin. These *Homolosomes* forms, which occur in the lower upper Valanginian rocks of many regions of the world (see Jeletzky, 1973, p. 70-73, Fig. 3) because of the widespread marine transgression characteristic of that time, are represented in the Sverdrup Basin by *Homolosomes* aff. *quatsinoensis* (Whiteaves). This species occurs at the 105 and 98 m (344 and 321 ft.) levels (5, 6; see Fig. 3). It is accompanied by *Dichotomites* (*Prodichotomites*?) *tozeri* n. sp. at first but ranges up higher than the latter species and is the only ammonite known to occur in highest ammonite-bearing Valanginian beds of Sverdrup Basin (Fig. 2). Even *Dichotomites* aff. *quatsinoensis* (Whiteaves) is not known to range up into the uppermost beds of the Deer Bay Formation.

The argillaceous upper Valanginian of the report area includes one more unit containing euhedral aggregates between the 80 and 90 m (262 and 295 ft.) levels. Still higher parts of the Valanginian sequence of Amund Ringnes Island are characterized by the presence of "cannon ball" concretions. The concretions in this unit, which is barely 20 m (65 ft.) thick, are widespread at this level in northern and central parts of the basin where they

are commonly filled with small *Buchia* specimens. These concretions, however, are not present at the same level on Ellef Ringnes Island and accordingly are assumed to be absent also in the southwestern part of the basin.

The above described enrichment of the Valanginian faunas of Sverdrup Basin by migrants from elsewhere is noticeable also in bivalves, which are represented almost exclusively by *Buchias*. The lower Valanginian is characterized by the exclusive presence of typical representatives and morphological variants (e.g. *B. keyserlingi sibirica*) of *Buchia keyserlingi* (Lahusen). Similar *Buchia* associations may still occur in the lower half of the upper Valanginian. However, there they are accompanied by other *Buchia* forms and commonly are replaced by the latter (Fig. 2). For example, representatives of one of the *Buchia* associations of the Sphaeroidalis Zone commonly were found to exhibit affinities with *Buchia uncitoides* and *Buchia sublaevis*. Furthermore, *Buchia crassicolis* becomes prominent in beds containing *Homolosomes* aff. *quatsinoensis* (5). From the 50 m (164 ft.) level in the Deer Bay Formation and stratigraphically upward to the level high in the sandstone of the Isachsen Formation, the rich *Buchia* fauna is dominated by *Buchia* ex gr. *inflata-sublaevis* while lacking completely *Buchia keyserlingi* (0, 1a, 1b). Jeletzky (1973, p. 67, 68, Figs. 2, 3) has noted that this widespread, long-ranging fauna also contains variable ratios of *Buchia bulloides* (Lahusen).

The deeper levels of upper Valanginian strata on Ellef Ringnes Island yielded a richer *Buchia* fauna than other parts of Sverdrup Basin. This appears to be caused by the influence of shallower and presumably warmer water. In this area, the most significant *Buchia* faunas were found in beds with numerous bands of clay ironstone concretions designated herein as the "banded sequence". These beds stand out clearly on aerial photographs as a banded part of the Deer Bay Formation. The lowermost bed (-4) contains numerous faunal components of southern affinities, as for example *Homolosomes* cf. *quatsinoensis*, huge phylloceratids, and huge lytoceratids. These forms are associated with *Dichotomites* (*Prodichotomites*?) *tozeri* n. sp. which becomes more common in the collections made higher at levels -2 to -4 inclusive. In this area, the earliest known populations of *Buchia crassicolis* (Keyserling) consist exclusively of its subspecies *solida*.

Homolosomes specimens and especially *Buchias* are abundant in the upper part (beds +1 to +7) of this banded unit. According to the identifications of J.A. Jeletzky, this *Buchia* fauna includes many representatives of the *Buchia bulloides* species group and transitional forms between this group and *B. n. sp.* aff. *inflata* Jeletzky.

However, it includes also forms transitional to *B. crassicolis*. The typical representatives of *B. crassicolis* become common in the uppermost beds (+7) of the unit. The beds confined between the 40 to 55 m (131-147 ft.) levels (M1-M4) are rich in large *Buchia* (*B. cf. bulloides* and *B. crassicolis solida*) contained in thin arenaceous interbeds. The higher upper Valanginian of the area discussed here contains thin, arenaceous beds. This facies commonly contains worm burrows (sand tubes) and other trace fossils but is devoid of the previously mentioned "cannon ball" concretions.

The uppermost beds of the Deer Bay Formation do not contain ammonites either on Amund Ringnes Island or on Ellef Ringnes Island. Therefore, one can only speculate about the stratigraphic position of the Valanginian/Hauterivian boundary. Even the boundary between the Deer Bay and Isachsen formations is arbitrary because of the gradual upward increase of sand. In this paper, the boundary was drawn at the base of the

lowermost platy sandstone on Ellef Ringnes Island and at the base of the first pure spheroidal sandstone (which is here characterized by a spherical appearance of weathered surfaces) on Amund Ringnes Island. The basal sandstone beds, definitely including the *Buchia*-bearing platy sandstones (?a lagoonal facies), are marine in origin. Several argillaceous interbeds are present stratigraphically above the measured profile on Amund Ringnes Island. However, they are unfossiliferous.

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