Acta Palaeontologica Polonica
Vol. 34, No. 4 pp. 355—378; pls. 15—22 Warszawa, 1989

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AMMONITES AND STRATIGRAPHY OF THE KIMMERIDGIAN AT WIMANFJELLET, SASSENFJORDEN, SPITSBERGEN

WIERZBOWSKI, A.: Ammonites and stratigraphy of the Kimmeridgian at Wimanfjellet, Sassenfjorden, Spitsbergen. Acta Palaeont. Polonica, 34, 355—378, 1989 (issued 1990).

Five Kimmeridgian ammonite faunas occurring at well separated horizons have been recognized in the Janusfjellet Fm., at Wimanfjellet in Sassenfjorden. Together with other ammonite faunas described so far from the Kimmeridgian in Spitsbergen they are arranged into the faunistic sequence, and their correlations with the best known Arctic successions viz. in the East Greenland (Milne Land) and the northern Siberia (Kheta Basin) are discussed. The ammonites of Spitsbergen belong mostly to the family Cardioceratidae which indicates the affiliation of the area to the restricted Boreal Province. However, the faunas corresponding to the Rasenia cymodoce Zone (except its lowermost part) and the Aulacostephanoides mutabilis Zone show in Spitsbergen a marked increase in number of the Subboreal representatives of the Aulacostephanidae. The appearance of aulacostephanids of the Subboreal affinities reflects the faunal invasion from the south.

Key words: biostratigraphy, biogeography, ammonites, Upper Jurassic, Kimmeridgian, Boreal Realm.

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INTRODUCTION

The paper is the third of the planned series dealing with successive ammonite faunas of the Jurassic in the Sassenfjorden (cf. Wierzbowski *et al.* 1981, Kopik and Wierzbowski 1988). The presently studied Kimmeridgian ammonites come from the two sections north of Wimanfjellet (fig. 1). These ammonites have been discovered in the monotonous sequence of the black shales with dolomite and siderite concretions belonging to the Janusfjellet Formation, from about 38 meters up to 80 meters above the Brentskardhaugen Bed (fig. 2).

It should be remembered that the Brentskardhaugen Bed represents the well known regional marker unit occurring at the base of the Janusfjellet Formation in vast areas of the central Spitsbergen. This highly condensed bed has yielded the Toarcian and the Aalenian ammonites from the phosphatic nodules (Wierzbowski *et al.* 1981, Bäckström and Nagy 1985, and the earlier papers cited therein). On the other hand, the ammonites of Late Bathonian and Callovian ages have been reported at Janusfjellet and Wimanfjellet in the Sassenfjorden, from about 4 meters up to 12 meters above the Brentskardhaugen Bed (Kopik and Wierzbowski 1988), whereas the ammonites of Oxfordian age remain still poorly known in this area (cf. Yershova 1983). However, taking into account the data presented, one may suggest that the Oxfordian faunas should occur somewhere between 12 meters and 38 meters above the Brentskardhaugen Bed.

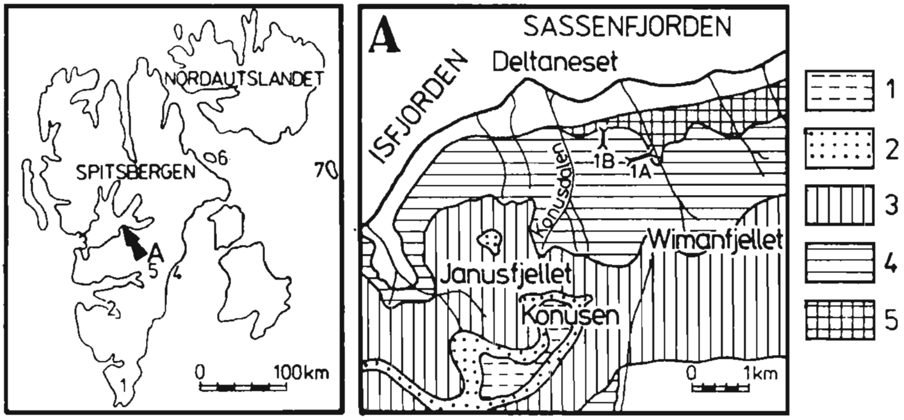


Fig. 1. Geological map of the Sassenfjorden area (after Major and Nagy 1972) showing the position of the studied sections 1A and 1B. *1* Basilika Formation-Sarkofagen Formation (Tertiary), *2* Firkanten Formation (Tertiary), *3* Helvetiafjellet Formation-Carolinafjellet Formation (Cretaceous), *4* Janusfjellet Formation (Jurassic-Lower Cretaceous), *5* Tschermakfjellet Formation-De Geerdalen Formation (Upper Triassic-Lower Jurassic). Numbers in the map of Svalbard denote the geographic names used in the text: *1* Sörkapp Land, *2* Van Keulenfjorden, *3* Festungsprofile, *4* Agardhbukta, *5* Oppdalen, *6* Wilhelmoya, *7* Kong Karls Land.

The present collection of the Kimmeridgian ammonites consists of 106 specimens, and it is housed at the Museum of Geological Faculty of the Warsaw University (IGPUW). The following abbreviations are used in description and figures (figs 3—6): D-shell diameter in mm, Wh-whorl height (in D$^{0}/_{0}$), Ud-umbilicus diameter (in D$^{0}/_{0}$), nPR-number of primary ribs per whorl.

Acknowledgements. — The material studied was collected in 1979 by the paleontological group of the Polish Spitsbergen Expedition which was supported by the Institute of Geophysics, Polish Academy of Sciences. The author expresses his thanks to Professor Gertruda Biernat, the leader of the group, as well as to the members of the group — and especially to Dr. Cyprian Kulicki (Institute of Paleobiology, Polish Academy of Sciences) — for their help and good companionship in the field. Thanks to the courtesy of the late Professor Tøve Birkelund the author had the opportunity to compare the material studied with the ammonites from East Greenland deposited in the Geological Museum of the University of Copenhagen. The author is also indebted to Professor John H. Callomon (University College London) for the discussion on the ammonites in question. Thanks are also due to Dr. Bożena Łącka (Institute of Geological Sciences, Polish Academy of Sciences) for mineralogical characteristics of the carbonate concretions.

The study was supported by the Polish Academy of Sciences.

AMMONITE FAUNAS IN THE SECTIONS IN SASSENFJORDEN

The Kimmeridgian ammonites collected in the sections north of Wimanfjellet occur only in some parts of the sequence being separated by the intervals in which ammonites are absent or have not been discovered. This allowed to distinguish several ammonite faunas designated with names of the taxa, and independently with the following numbers: 1a, 1b, 2, 3, 4 (fig. 2, cf. also Wierzbowski 1988). The ammonites belong mostly to the genus *Amoeboceras* found in all the faunas studied, and to the genus *Rasenia* represented only in fauna 3.

The particular faunas are as a rule composed of one, and maximally of two morphologically homogenous members (fig. 3—6), each of them corresponding to the separate population or biospecies in the terms of "horizontal classification" (Callomon 1985, Dzik 1985). The vertical succession of the populations and/or species of *Amoeboceras*, represents the main lineage of that genus which appears, with minor exceptions, monophyletic (Callomon 1985).

The succeding ammonite faunas may be also treated in stratigraphical terms as characterizing the stratigraphical horizons (fig. 2) which enables in the lack of the zonal subdivision, the detailed correlations of the Kimmeridgian within the Boreal Province (cf. Birkelund and Callomon 1985).

The oldest ammonite fauna (*fauna 1a*, fig. 2) occurs in the small dolomite concretions within 11 meters interval of the black shales, but mostly in its upper part, in the section 1A, from 37.5 m to 48.5 m above the Brentskardhaugen Bed. It is composed entirely of *Amoeboceras* (*Amoebites*) *subkitchini* Spath as emended recently by Birkelund and Callomon (1985). Of 21 specimens found in the indicated interval only 10 are better preserved and more complete which makes their specific identification possible (pl. 15: 2—6). However, also the rest of the specimens, as far as their preservation allows, do not differ substantially from the former ones, and is referred to as *A.* (*A.*) cf. *subkitchini* Spath (pl. 15: 1). The ammonites have fairly densely ribbed inner whorls with mostly single ribs, and occassionally scattered biplicate ribs. On the outer whorl beginning with the diameter of 30—40 mm, there appear the elongated ventrolateral nodes, which become gradually separated from the ribs. Then, on the younger part of the whorl the ventrolateral nodes become spaced independantly of the ribs. At the diameter of about 70 mm, in

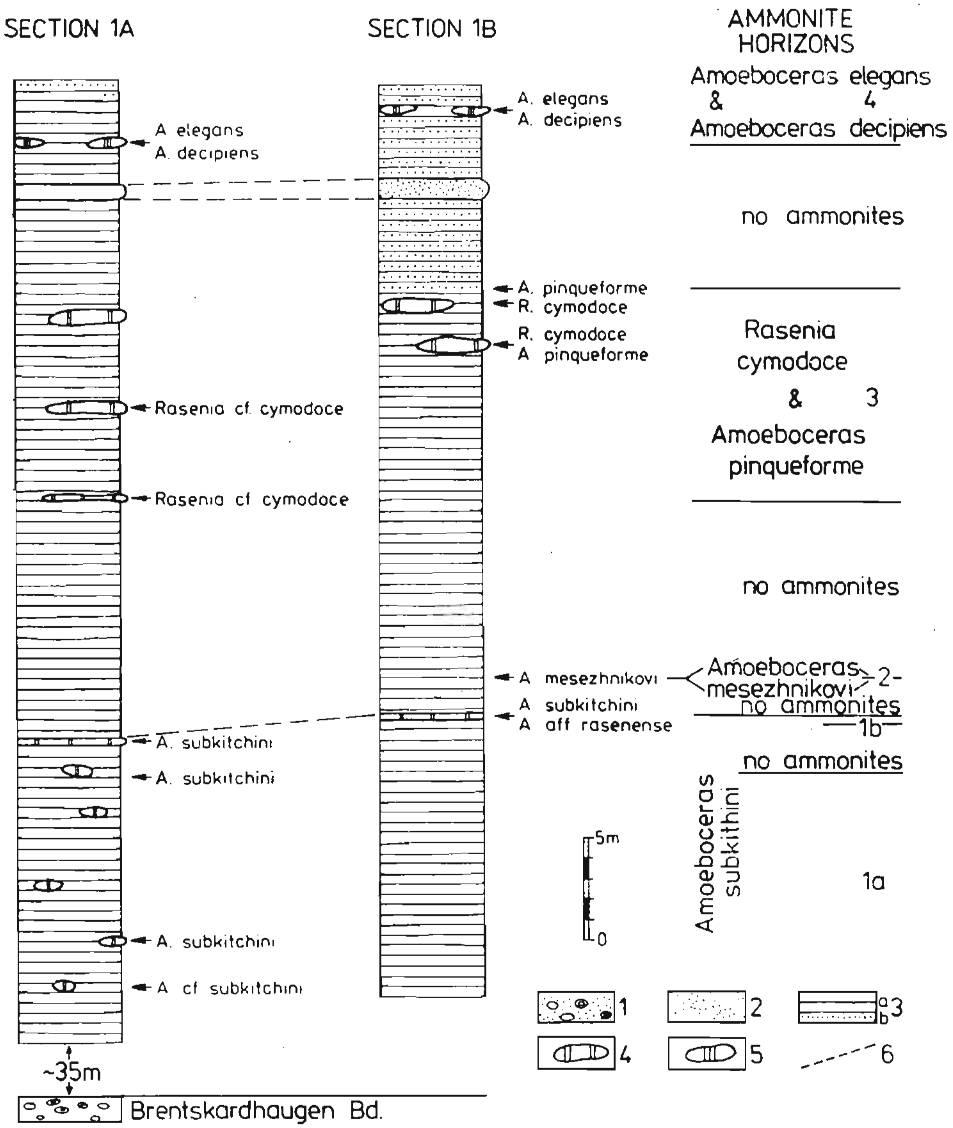


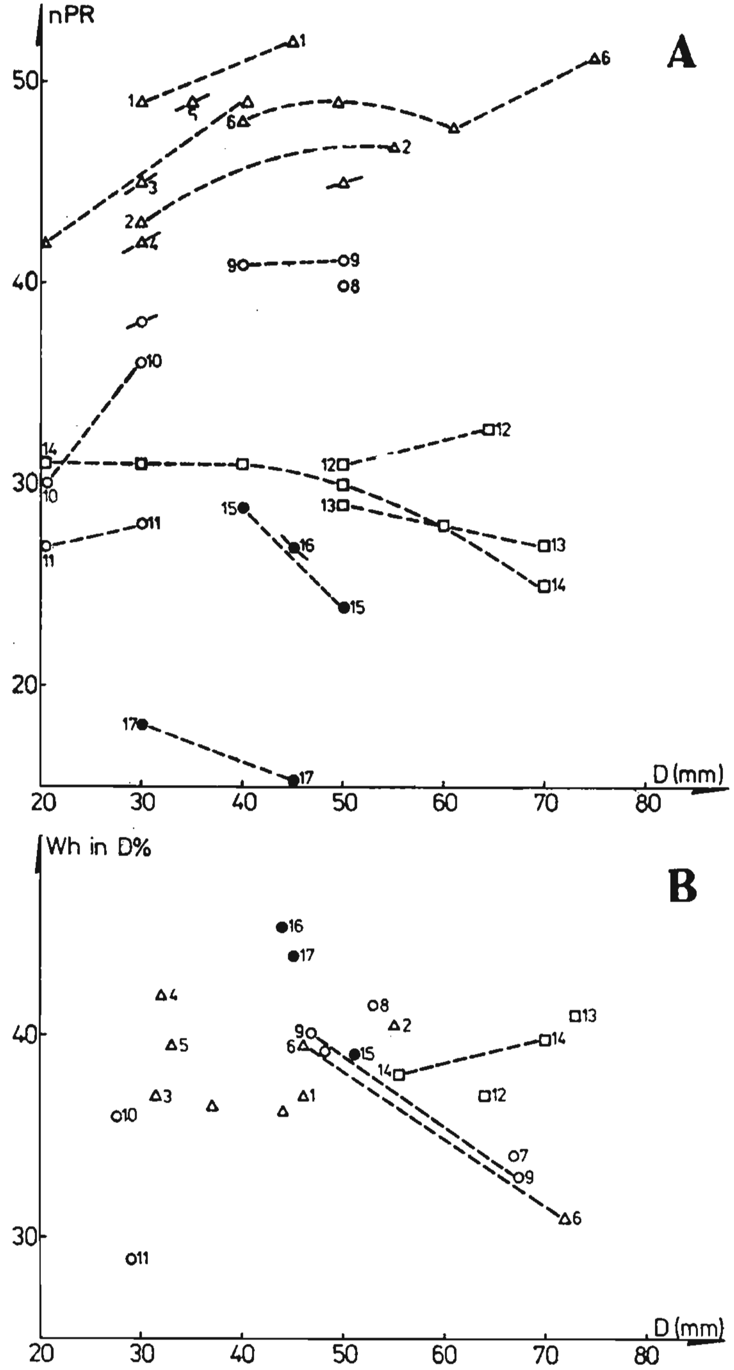
Fig. 2. Ammonite distribution in the studied sections 1A and 1B of the Janusfjellet Fm. at Wimanfjellet in Sassenfjorden: distingushed ammonite faunas and horizons are indicated. *1* conglomerate with phosphatic nodules, *2* sandstone, *3ab* shale and silty/sandy shale, *4* dolomite concretion, *5* siderite concretion, *6* lithostratigraphic correlations.

the fully grown macroconchs (pl. 15: 6), the ribs become weaker and more crowded.

The second ammonite fauna (*fauna 1b*, fig. 2) occurs in the narrow interval of the succession corresponding to the dolomite layer/concretions zone of about 0.4 m thick, and its close proximity, about 50 m above the Brentskardhaugen Bed. Out of 16 specimens found there, 10 belong undoubtedly to *Amoeboceras* (*Amoebites*) *subkitchini* Spath (pl. 15: 8; pl. 16: 1—3, 6, 7), and the further 5, fragmentarily preserved specimens, are also likely to belong to the species (pl. 15: 7). The ammonite fauna is generally close to the fauna 1a, showing the same morphological variability of the umbilical width, the whorl height, (fig. 3) and the secondary to primary ribs ratio. The differences are in somewhat less dense ribbing noticed in a few better preserved specimens (fig. 3), as well as in the coarser ribbing especially well observed on the last whorl of some macroconchs of the fauna 1b, (pl. 15: 8, pl. 16: 6, 7). The fauna studied contains also some small, possibly fully grown, specimens having the aperture with ventral rostrum, which may be interpreted as microconchs of *A.* (*A.*) *subkitchini* (see pl. 16: 2—3; also Birkelund and Callomon 1985: 22, pl. 3: 4, 7—9, 11). They are close to the microconch-species *Amoeboceras* (*Amoebites*) *rasenense* Spath (cf. Spath 1935: pl. 1: 6ab) differing in a finer ribbing (Birkelund and Callomon 1985).

A unique specimen (pl. 15: 9) found in the layer which provided specimens of *A. subkitchini*-*A.* cf. *subkitchini*, i.e. fauna 1b, differs in a common occurrence of the biplicate ribs as well as in the thickening of ribs at mid-height of whorls. The specimen seems to be similar to *Amoeboceras rasenense* Spath and it referred to as *A.* aff. *rasenense*, but also to some other related forms as *A. pingueforme* Mesezhnikov and *A. mesezhnikovi* Sykes et Surlyk.

The next ammonite fauna (*fauna 2*, fig. 2) was discovered in the dark shales — about 2 m above the dolomite horizon, in the section 1B, and about 52 m above the Brentskardhaugen Bed. The fauna is very poor and contains two specimens (pl. 16: 4—5) belonging to *Amoeboceras* (*Amoebites*) *mesezhnikovi* Sykes et Surlyk. It should be remembered that the name *Amoeboceras* (*Amoebites*) *simplex* Mesezhnikov et Romm, 1973, as the junior primary homonym of *Amoeboceras* (*Prionodoceras*) *simplex* Spath, 1935, has been replaced with the new name *Amoeboceras* (*Amoebites*) *mesezhnikovi* Sykes et Surlyk, 1976 (see Mesezhnikov and Romm 1973: 45; Sykes and Surlyk 1976: 431; *cf.* also Mesezhnikov 1984: 94). The studied specimens match very well the two illustrated specimens of the type-series (cf. Mesezhnikov and Romm 1973: pl. 4: 3 — paratype and 4 — holotype). The specimens studied are of about 70 mm in diameters, moderately involute; the ribbing is rather sparse, especially on the last whorl (fig. 3). The ribs are strong, prorsiradiate, single and biplicate, thickening up to the elongated nodes in the midheight of whorl, as well as in the ventrolateral area. On the last whorl the primaries are separated from the secondaries; the secondary/primary ribs ratio usually exceeds 1.0, even at larger diameter. The development of the secondary ribs partly transformed into weak ventrolateral nodes at larger diameter, but still in number exceeding the primary ribs, are the main features differing *A. mesezhnikovi* from *A. subkitchini.*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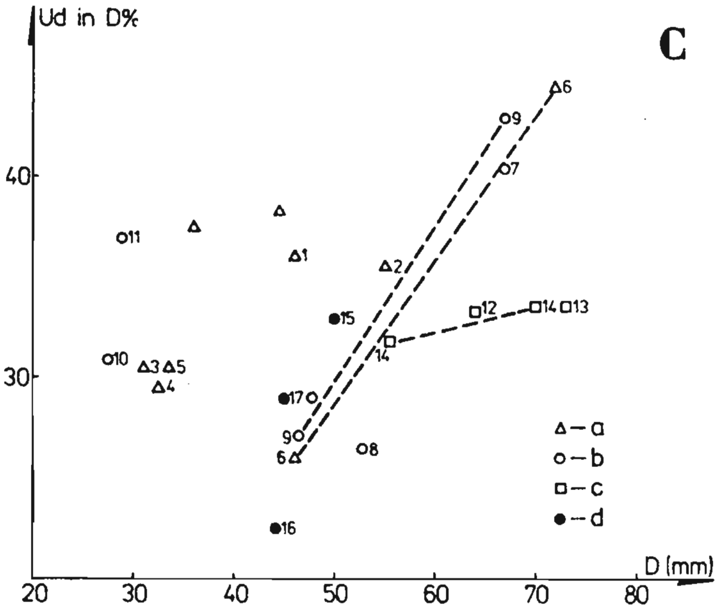

Fig. 3. *Amoeboceras subkitchini* Spath—*Amoeboceras mesezhnikovi* Sykes and Surlyk—*Amoeboceras pingueforme* Mesezhnikov; diagrams showing the relations between: *A* number of primary ribs per whorl and shell diameter, *B* whorl height (in percentage of shell diameter) and shell diameter, *C* umbilicus diameter (in percentage of shell diameter) and shell diameter; *a*—*A. subkitchini* (fauna 1a), *b*—*A. subkitchini* (fauna 1b) *c*—*A. mesezhnikovi* (fauna 2), *d*—*A. pingueforme* (fauna 3). Illustrated specimens: *A. subkitchini*: *1* IGPUW/A23/105 (pl. 15: 1), *2* IGPUW/A23/102 (pl. 15: 2), *3* IGPUW/A23/101 (pl. 15: 3), *4* IGPUW/A23/100 (pl. 15: 4), *5* IGPUW/A23/98 (pl. 15: 5), *6* IGPUW/A23/96 (pl. 15: 6), *7* IGPUW/A23/89 (pl. 15: 8), *8* IGPUW/A23/87 (pl. 16: 1), *9* IGPUW/A23/86 (pl. 16: 7), *10* IGPUW/A23/93 (pl. 16: 2), *11* IGPUW/A23/94 (pl. 16: 3). *A. mesezhnikovi*: *12* holotype (Mesezhnikov and Romm 1973: pl. 4: 4), *13* IGPUW/A23/48 (pl. 16: 4), *14* IGPUW/A23/46 (pl. 16: 5). *A. pingueforme*: *15* holotype (Mesezhnikov 1976: pl. 21: 5), *16* IGPUW/A23/47 pl. 17: 1), *17* IGPUW/A23/106 (pl. 17: 2).

Still younger ammonite fauna (*fauna 3*, fig. 2) was collected mostly from the dark dolomite concretions grouped in the four levels within the dark shales from 61.5 m to 71 m above the Brentskardhaugen Bed. The two higher levels known from the section 1B yielded 15 specimens of the genus *Rasenia* (pl. 17: 3—6; pl. 18; pl. 19: 1, 2): fourteen of them are 70—100 mm in diameters and show the rasenid triplicate ribbing pattern with bullate primaries and 3—4 secondaries per one primary; the latter, tend to obliterate at about 80—90 mm diameter (pl. 17: 6); moreover, two specimens (pl. 19: 1—2) about 40 mm and 80 mm in diameter are microconchs with biplicate ribbing appearing on the last whorl. The secondary ribs on the inner whorls are generally weakly exposed at the umbilical margin, but there also occur a few specimens (pl. 17: 5) where the roots of the secondaries are well visible in the umbilicus. The specimens are evolute (Ud=41—51%, but 43—48.5% at 60—90 mm diameters:

see fig. 4). Taking into account several features of the specimens studied including those in the diagrams (fig. 4) it is obvious that all of them represent a uniform biospecific assemblage which may be easily ascribed to *Rasenia cymodoce* (d'Orb.) as revised recently by Birkelund and Callomon (1985). It should be remembered however that there occurs a continuous variation, *int. al.* in ornamentation, ranging from the dominant forms with moderately strong primaries and poorly exposed secondaries in the umbilicus typical of *R. cymodoce*, up to the specimens with strong bullate primaries and better exposed secondaries being morphologically somewhat similar to *Rasenia evoluta* Spath. The variation consequently cannot be considered as valid taxonomically.

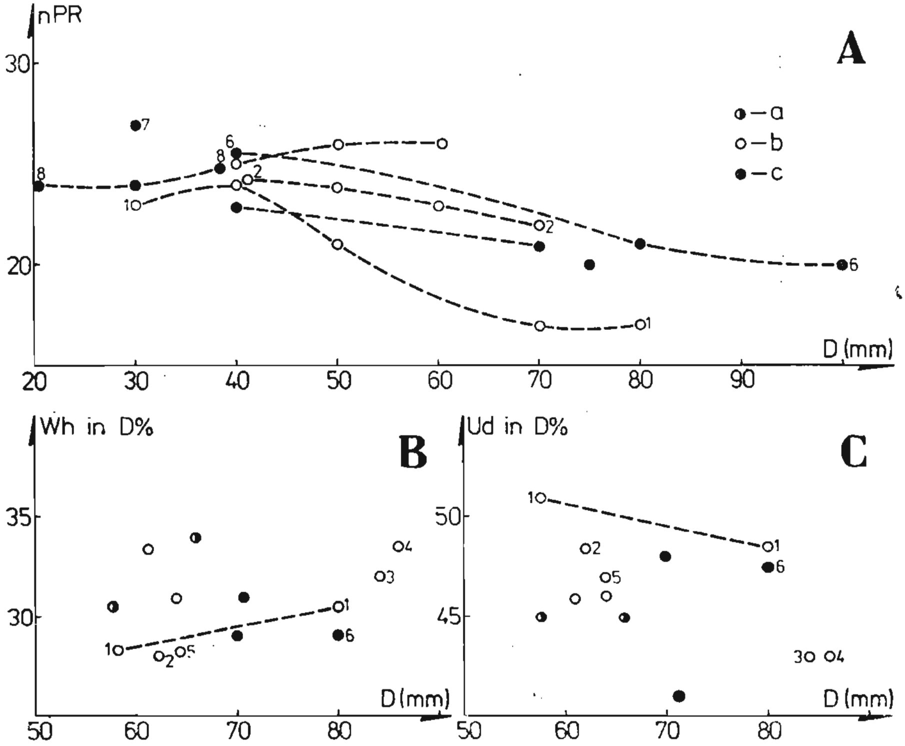

Fig. 4. *Rasenia cymodoce* (d'Orbigny): diagrams showing the relations between: *A* number of primary ribs per whorl and shell diameter, *B* whorl height (in percentage of shell diameter) and shell diameter, *C* umbilicus diameter (in percentage of shell diameter) and shell diameter; *a* — *R.* cf. *cymodoce* (specimens found between 61 m and 66 m above the Brentskardhaugen Bed), *b* — *R. cymodoce* (68 m, ditto), *c* — *R. cymodoce* (71 m, ditto). Illustrated specimens: *1* IGPUW/A23/1 (pl. 17: 5), *2* IGPUW/A23/3 (pl. 18: 2), *3* IGPUW/A23/4 (pl. 18: 3), *4* IGPUW/A23/9 (pl. 17: 4), *5* IGPUW/A23/11 (pl. 17: 3), *6* IGPUW/A23/6 (pl. 18: 4), *7* IGPUW/A23/8 (pl. 18: 1), *8* IGPUW/A23/14 (pl. 19: 2).

When compared with the macroconchs usually ascribed to *Rasenia cymodoce* (d'Orb.), the specimens having a triplicate ribbing are generally smaller; this may be due to immaturity (the sutures are, however, not visible), but some of the specimens may in fact represent the microconchs. It should be remembered that the microconchs of the species show the marked differences in end-size, as well as in appearance or absence of the biplicate ribbing on the outer whorl (pl. 19: 1, 2; *cf.* Surlyk *et al.* 1973: pl. 1: 9; Birkelund and Callomon 1985: 35—36, pl. 18: 3—6).

The ammonites found in the two lower levels of concretions in the section 1A (fig. 2) are generally poorly preserved, but all of them belong to the genus *Rasenia.* As far as the preservation state allows to judge, the specimens seem similar to those from the higher levels. Therefore, they are likely to be related to *Rasenia cymodoce* (d'Orb.).

Together with the discussed specimens of *Rasenia* the fauna 3 contains also sparse representatives of *Amoeboceras.* The two better preserved specimens found in the third, as well as slightly above the fourth concretion level in the section 1B (fig. 2) are about 40—50 mm in size, moderately involute (Ud equals 22.5% and 29%, respectively). The ribbing is from moderately dense to loosely spaced with dominating biplicate ribs, but sometimes also with scattered single ribs (pl. 17: 1, 2; fig. 3). Some thickenning of ribs appears in the midheight of whorls, and in the ventrolateral area. The specimens studied seem to be close to *Amoeboceras* (*Amoebites*) *pingueforme* Mesezhnikov (see Mesezhnikov *in*: Sachs *et al.* 1969: 99—101, pl. 21: 5; Mesezhnikov 1984: 93—94, pl. 1: 4) and show the similar variability in the density of ribbing. Also a fragmentary and not illustrated specimen found in the section 1B in the rubble, a few meters below the two levels of concretions, seems to be related to the species discussed.

The red siderite concretions occurring within the silty — to sandy shales, about 2 m and 3 m above the top of glauconitic sandstone bed in the sections 1A and 1B respectively, yielded numerous ammonites assigned to *Amoeboceras* (*Amoebites*) *elegans* Spath and *Amoeboceras* (*Hoplocardioceras*) *decipiens* Spath (pl. 19: 3—6; pl. 20—22). The specimens of the two species occur together and can be found even on a single slab. However, the specimens of *A. elegans* are much more common (56 specimens) and markedly outnumber those of *A. decipiens* (7 specimens). The species represent the youngest Kimmeridgian ammonite fauna (*fauna* 4, fig. 2) occurring from about 78 m to 80 m above the Brentskardhaugen Bed in the sections studied. Since the species have been recently discussed in details by Birkelund and Callomon (1985), only their most important characteristics, based on the material studied, are given below.

The biggest and fully grown specimen of *A. elegans* attains 140 mm in diameter (pl. 21: 3), but the most common specimens are from 40 mm to 90 mm in size. Some of them may be immature, but as the sutures are usually not visible, and the specimens are often incomplete, it is difficult to state the real variability in the end size of shells. The specimens are generally moderately involute up to about 70 mm in diameter, then

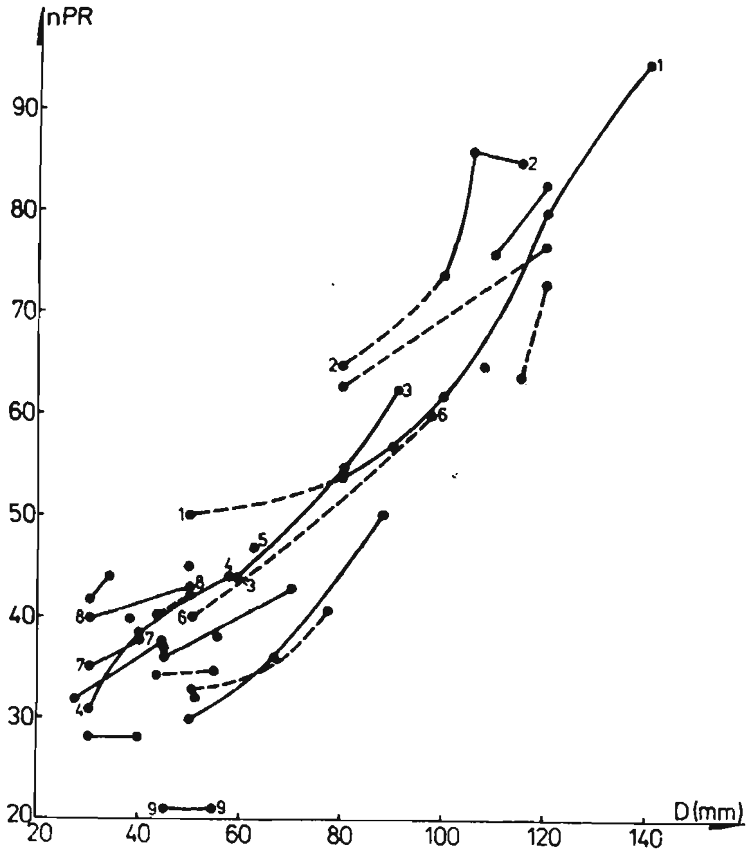

Fig. 5. *Amoeboceras elegans* Spath: diagram showing the relation between number of primary ribs per whorl and shell diameter. Illustrated specimens: *1* IGPUW/A23/26 (pl. 21: 3), *2* IGPUW/A23/27(pl. 22: 6), *3* IGPUW/A23/30 (pl. 21: 1), *4* IGPUW/A23/32 (pl. 22: 5), *5* IGPUW/A23/33 (pl. 20: 1), *6* IGPUW/A23/39 (pl. 21: 2), *7* IGPUW/A23/49 (pl. 20: 2), *8* IGPUW/A23/52 (pl. 22: 4), *9* IGPUW/A23/54 (pl. 22: 2).

weakly involute, or even close to evolute (fig. 6). The ribbing is moderately dense on the inner whorls (about 30 to 45 primaries per whorl at 50 mm diameter) and very dense at bigger diameters (about 60 to 95 primaries per whorl at 100—140 mm diameter, see fig. 5); some crowdings of ribs may be noticed in the narrow zones at different diameters (from about 60 mm up to 136 mm) which do not necessarily correspond to the last peristome (pl. 20: 1, pl. 21: 3, pl. 22: 6). The ventrolateral nodes or clavi fusing the ribs in the looped pairs are more or less strongly developed; extremely heavy clavi are observed in the specimens showing somewhat less dense ribbing and corresponding to *Amoeboceras pseudacanthophorum* Spath (Spath 1935: 35, pl. 5: 7—8; see also this paper pl. 22: 1—4) which is but a coarsely ribbed variant of *A. elegans* (see Birkelund and Callomon 1985).

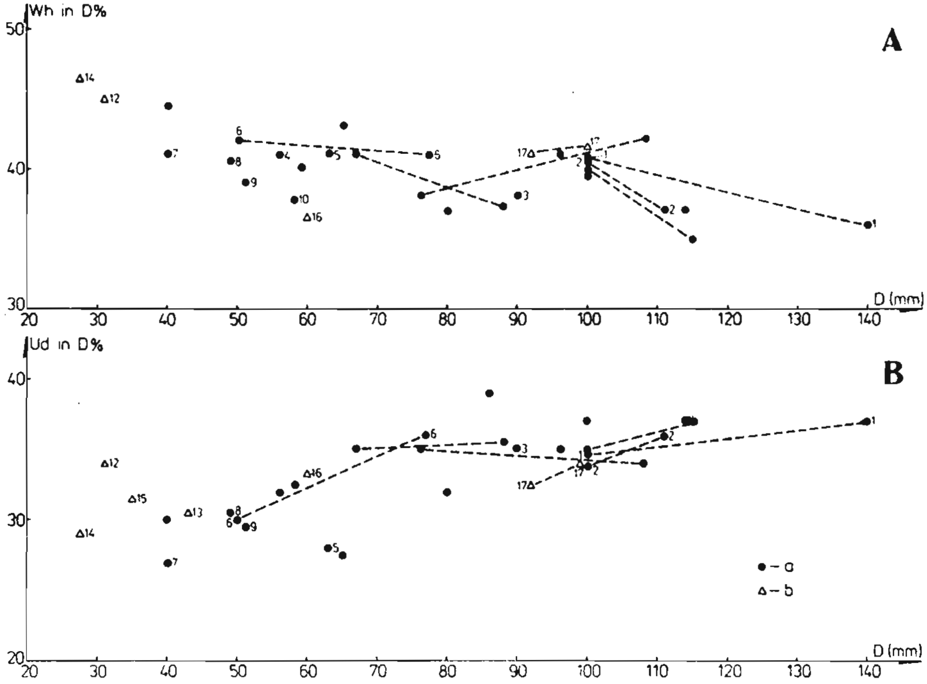

Fig. 6. *Amoeboceras elegans* Spath — *A. decipiens* Spath: diagrams showing the relations between: *A* whorl height (in percentage of shell diameter) and shell diameter, and *B* umbilicus diameter (in percentage of shell diameter) and shell diameter; fauna 4: *a* — *A. elegans*, *b* — *A. decipiens*. Illustrated specimens: *A. elegans*: *10* IGPUW/A23/84 (pl. 22: 3), other specimens as in fig. 5. *A. decipiens*: *12* IGPUW/A23/20 (pl. 19: 3), *13* IGPUW/A23/21 (pl. 19: 4), *14* IGPUW/A23/22 (pl. 19: 5), *15* IGPUW/A23/25 (pl. 19: 6), *16* IGPUW/A23/24 (pl. 20: 5), *17* IGPUW/A23/44 (pl. 20: 3).

The largest fully grown specimen of *A. decipiens* is 110 mm in diameter (pl. 20: 3), the other specimens, possibly not fully grown are 30—60 mm in size. The coiling is close to that of *A. elegans* (see fig. 6). The ribbing shows characteristic three rows of nodes (outer with spines) which disappear at about 60 mm diameter (pl. 20: 3—5). The ratio of ventrolateral to lateral nodes is 1.5 to 2 at 30—40 mm diameters (3 specimens). The last part of the body chamber in the largest specimens is covered with dense flexuous ribs accentuated at the ventral side.

BIOSTRATIGRAPHIC IMPORTANCE OF THE EARLIER AMMONITE FINDINGS IN SPITSBERGEN

Among a fairly big number of the Kimmeridgian ammonites described so far from Spitsbergen, there exist some which are better preserved and/or more precisely located in the sections and thus contribute to the construction of the detailed biostratigraphic succession recognized only partly in Sassenfjorden (see fig. 7).

The ammonites occurring in the lower part of the Kimmeridgian in the various parts of Spitsbergen were usually referred to as *Amoeboceras kitchini* (Salfeld) and as *A.* cf./aff. *kitchini* (Salfeld). However, the relation of the ammonites, at least some of them, to that species in doubtful (cf. recent revision of the species by Birkelund and Callomon 1985); it seems more likely that the ammonites in question should be placed within the widely understood *Amoeboceras subkitchini* Spath (*op. cit.*: 19—23). The following ammonites described from Spitsbergen may represent the latter species:

Cardioceras cf. *kitchini* Salfeld from the Festungsprofile in the western coast, described by Sokolov and Bodylevsky (1931: pl. 7: 1; pl. 8: 3).

Amoeboceras cf. *kitchini* (Salfeld) from Myklegardfjellet at Agardhbukta described by Wierzbowski (*in*: Birkenmajer *et al.* 1982: pl. 37: 3—4; cf. Birkelund and Callomon 1985: 19); the ammonites have been found 73.5 m above the Brentskardhaugen Bed together with *Rasenia cymodoce* (d'Orb.) (= *R. evoluta* Spath *in*: Birkenmajer *et al.* 1982: pl. 37: 8; *cf.* Birkelund and Callomon 1985: 35).

Amoeboceras kitchini (Salfeld) and *A.* aff. *pulchrum* Mesezhnikov et Romm from the Van Keulenfjorden illustrated by Yershova (1983: pl. 8: 1—2; pl. 12: 1—2, 5; pl. 13: 4).

The discussed ammonites, comparable to *A. subkitchini*, are known to occur in the lower part of the Kimmeridgian up to the layers containing *Rasenia cymodoce*. Thus, when compared with succession studied from Sassenfjorden, the total range of these ammonites covers the interval corresponding to horizons with faunas 1a, 1b, and 2, and possibly the part of the horizon with fauna 3 (figs. 2, 7). Such a wide vertical range of the ammonites referred to *A. subkitchini*, along with dominating monophyletic development of *Amoeboceras* lineage (*cf.* Callomon 1985), somewhat obscures the form's in question relationship to *A. mesezhnikovi* from fauna 2 in Sassenfjorden. However, as the full diversity of the fauna 2 is still not known due to a very limited number of the specimens available, the horizontal variation from *A. mesezhnikovi* to *A. subkitchini* morphotypes within a one biospecies may be taken into account here.

Still higher in the Kimmeridgian succession of Spitsbergen there appear the ammonite faunas in which the representatives of the family Aulacostephanidae play an important role. The fauna described by Yershova (1983) from the Oppdalen, south of Sassenfjorden, seems to be the oldest. It is composed of *Zonovia* sp. (*op. cit.*: pl. 10: 1—5; pl. 11: 1—3) being in fact very close to *Rasenia cymodoce* (d'Orb.), and of *Amoeboceras pingueforme* Mesezhnikov (*op. cit.*: pl. 9: 1—5). The fauna in question probably corresponds to fauna 3 from the Sassenfjorden (figs. 2, 7).

In the Myklegardfjellet at Agardhbukta, immediately above *Rasenia cymodoce* (d'Orb.) (= *Rasenia evoluta* as described by Wierzbowski in: Birkenmajer *et al.*: 1982: pl. 37: 8), the ammonite referred to as *Amoebo-*

ceras (*Amoebites*) cf. *salfeldi* Spath has been found (op. cit.: pl. 37: 5). It reveals coarse ornamentation including the development of the fully looped ribs with clavi, and it seems very close to *Amoeboceras* (*Amoebites*) *kitchini* Salfeld as recently revised by Birkelund and Callomon (1985: 20—22, fig. 6). This suggests that the ammonites similar to *Amoeboceras kitchini* do occur somewhere in proximity of the horizon with fauna 3 (*R. cymodoce* — *A. pingueforme*). Similar observation has been made by Pchelina (1967) and Yershova (1983) who reported the occurrence of *Amoeboceras kitchini* — *A.* cf. *kitchini* together with *Rasenia* from various parts of Spitsbergen, as well as by Rawson (*in*: Smith *et al.* 1976) who has found *Amoeboceras kitchini* with *Rasenia*? in Kong Karls Land in the eastern Svalbard. However, as far as Spitsbergen is concerned, the detailed stratigraphical position of *A. kitchini*, especially when compared with that of *Amoeboceras pingueforme* remains still somewhat obscure. The problem may be partly clarified if one takes into account the probable close affinity of the two species. In fact, both of them show similar type of coiling, and the common occurrence of biplicate ribs on the inner whorls, differing in development of the strong nodes and clavi in the outer whorl of *A. kitchini* (Birkelund and Callomon 1985: fig. 6), and in retaining of biplicate ribbing in the outer whorl of *A. pingueforme* (Mesezhnikov *in*: Sachs *et al.* 1969: pl. 21: 5). There are also known some specimens of *A. pingueforme* from fauna 3 in Spitsbergen which show well developed nodes and heavy ribbing on the outer whorl reminding to some degree those of *A. kitchini* (Yershova 1983: pl. 9: 1, but not pl. 9: 4 possibly erronously referred there to *A. kitchini*; see also pl. 17: 2 in the present paper). The material gathered suggests that the relation between the two species is probably phyletic and that *A. pingueforme*, dominating in fauna 3, is likely to precede the wide asemblage of *A. kitchini* related forms. This corresponds to observations from England and East Greenland where *A. kitchini* occurs commonly together with last representatives of the genus *Rasenia* or even a little higher (Callomon and Birkelund 1985: 23).

Also the younger ammonite fauna occurs with ammonites of the family Aulacostephanidae. It includes the specimens referred to as *Rasenia* sp. indet. cf./aff. *groenlandica* Ravn by Frebold (1930: pl. 9: 3—4 and pl. 22: 2) from Sörkapp Land in southern Spitsbergen and from Wilhelmøya in Svalbard. The ammonites seem to be similar to *Rasenia borealis* Spath, but as they are more evolute "may well be more closely related to *Xenostephanus*" (Birkelund and Callomon 1985: 39—40). Very close or even conspecific are ammonites referred to as *Zonovia* cf. *ranbyensis* Arkell et Callomon by Yershova (1983: pl. 15: 1—4) from Agardhdalen in eastern Spitsbergen. All these ammonites indicates possibly the single *Xenostephanus* fauna and a corresponding horizon. The same horizon is also recognized in the Kongs Karls Land from where *Aulacostephanus* (*Xeno-*

stephanus) together with *Amoeboceras kitchini* (Salfeld) have been reported by Rawson (*in*: Smith *et al.* 1976).

The indicated ammonite horizons with Aulacostephanidae viz. the older one with *Rasenia cymodoce*, and the younger with *Xenostephanus* denote the only interval of the Kimmeridgian succession where the aulacostephanids occur together with ammonites of the genus *Amoeboceras* (*cf.* also Parker 1967: 500—501). The youngest Kimmeridgian ammonite faunas of Spitsbergen are almost completely devoid of aulacostephanids (except a few poorly preserved and fragmentary specimens, see *Aulacostephanus* in Yershova 1983: pl. 15: 5) and very rich in *Amoeboceras* representatives.

The higher part of the faunal succession contains the ammonites referred usually to as *Amoeboceras* (*Euprionoceras*) *sokolovi* Bodylevsky. The representatives of the type-series of the species described from the Festungsprofile (Sokolov and Bodylevsky 1931: pl. 6: 1—2, pl. 9: 1) are poorly preserved, however, and thus the relation between the species in question and the other *Amoeboceras* species appears somewhat disputable. Nevertheless, it seems highly probable that *A. sokolovi* is close or conspecific with *Amoeboceras* (*Euprionoceras*) *kochi* Spath, 1935, and the name *sokolovi* should even have priority (Birkelund and Callomon 1985: 27). *A. sokolovi* occurs, according to Pchelina (1967), in the Sörkapp Land clearly above the beds with *Rasenia*, as well as together (or close to *Zonovia* sp. (= ?*Xenostephanus*) in the Festungsprofile and in the Sörkapp Land (Yershova 1983).

There are also references indicating the occurrence of *A. sokolovi* and/or *A. kochi* still in younger beds together with *Amoeboceras* (*Hoplocardioceras*) *decipiens* Spath or even above it (see Yershova 1983). The actual data from the Sassenfjorden (fig. 2), however, do not confirm such stratigraphical interpretation. The illustrated ammonites attributed to *A. sokolovi* coming from these younger beds are either poorly preserved and difficult for unequivocal palaeontological interpretation, or (Yershova 1938: pl. 13: 1) bear strong ventrolateral nodes resembling strongly *Amoeboceras* (*Amoebites*) *elegans* Spath.

The youngest ammonite fauna consists of *A. decipiens* and *A. elegans* as proved in Sassenfjorden in this paper (fig. 2). The two illustrated specimens of *A. decipiens* from the Agardhbukta area (Yershova 1983: pl. 14: 1—2), as well as some others referred to that species and reported from various parts of Spitsbergen (*op. cit.*: 23) seem to belong also to the fauna in question. It is worth noting that *Amoeboceras* (*Hoplocardioceras*) sp. indet. has been found together with *Streblites* sp. in the Sörkapp Land (Yershova 1983).

BIOSTRATIGRAPHIC CORRELATIONS WITH EAST GREENLAND AND NORTHERN SIBERIA

The succession of the Kimmeridgian ammonite faunas of the Milne Land in East Greenland recognized recently by Callomon and Birkelund (1985) may be treated as representative for the western part of the Boreal Province. The ten faunal horizons (with faunas 14—23) distinguished there can be rather precisely located within the framework of the standard NW European Subboreal zonation, from the Pictonia baylei Zone, up to the Aulacostephanus autissiodorensis Zone (Birkelund and Callomon 1985; herein fig. 7) Hence, the correlation of the faunal horizons from Spitsbergen with those of East Greenland becomes a matter of some importance.

The oldest Kimmeridgian ammonite fauna from Milne Land (fauna 14 with *Pictonia* aff. *normandiana* and *Amoeboceras bayi*) corresponding partly to the Subboreal Pictonia baylei Zone, has not been recognized in Spitsbergen. The two lowermost faunal horizons in the Kimmeridgian of Spitsbergen (with faunas 1a and 1b composed entirely of *Amoeboceras subkitchini*: fig. 7) can be correlated with that containing the fauna 15 from Milne Land (with *Rasenia inconstans* and *Amoeboceras subkitchini*) and probably with occurring there somewhat younger beds devoid of ammonites. The first occurrence of *Rasenia cymodoce* in Spitsbergen has been stated above the poorly defined fauna 2 with *Amoeboceras mesezhnikovi* in Sassenfjorden, and immediately above *Amoeboceras subkitchini* in the Aghardbukta area. The abrupt arrival of *R. cymodoce* in Spitsbergen reflects the northward invasion of this Subboreal ammonite being more or less contemporaneous, or slightly younger, when compared with appearance of *R. cymodoce* in East Greenland where the occurrence of Subboreal ammonites in the succession is much more continous. Hence, the base of the horizon with ammonite fauna 3 (*Rasenia cymodoce* and *Amoeboceras pingueforme*) in Spitsbergen should be traced within, or just immediately above, the horizon with fauna 17 (*Rasenia cymodoce-Amoeboceras* aff. *subkitchini*) of Milne Land. Such stratigraphical correlations indicate that the horizons with faunas 1a, 1b, 2 and 3 from Spitsbergen correspond generally to the lower part of the Rasenia cymodoce Zone of the Subboreal zonal scheme (fig. 7). The appearance of the species *Amoeboceras kitchini* (Salfeld) or closely allied forms in proximity of, and above the horizon with fauna 3 in Spitsbergen, suggests the upper Rasenia cymodoce Zone (*cf.* Birkelund and Callomon 1985: 15, 23) which is also in good agreement with correlations given above.

The faunal horizon with *Xenostephanus* and (?) allied forms close to *Rasenia borealis* stated in some places in Spitsbergen (but beyond the Sassenfjorden), and in the neighbouring areas of Svalbard seems to correlate approximatively with horizon characterized by fauna 19 (with *Rasenia borealis* and *Amoeboceras* cf. *beaugrandi*) from Milne Land. It

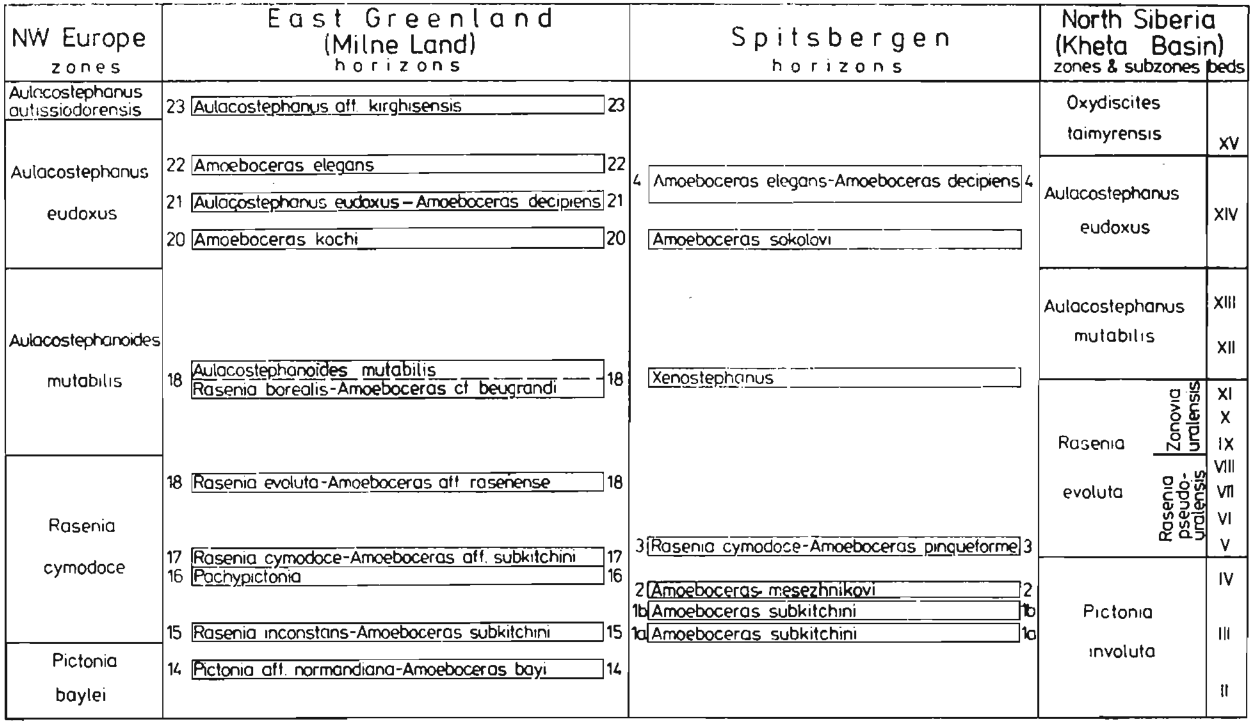

Fig. 7. Correlation of the Kimmeridgian ammonite zones and horizons in the Boreal Realm: the succession of Milne Land (after Birkelund and Callomon 1985), Kheta Basin (after Mesezhnikov 1984), Spitsbergen (this paper, *cf* fig. 2, and the data from older published materials).

indicates the lower Aulacostephanoides mutabilis Zone in the Subboreal zonal scheme (fig. 7).

It is probable that the occurrence of *Amoeboceras sokolovi* marks still younger horizon in Spitsbergen. The species, if really synonymous with *Amoeboceras kochi* Spath, suggests the correlation of the horizon in question with the one containing *A. kochi* in Milne Land (horizon with fauna 20) of Birkelund and Callomon (1985).

The correlation of the youngest faunal horizon (ammonite fauna 4 with *Amoeboceras elegans* and *A. decipiens*) recognized in the Sassenfjorden area in Spitsbergen with those from East Greenland is somewhat troublesome. In Milne Land there have been recognized two horizons containing the indicated ammonites: lower one (21) with *Aulacostephanus eudoxus* and *Amoeboceras decipiens*, and the upper one (22) with *Amoeboceras elegans*. On the other hand, the overlapping of stratigraphical ranges of *A. elegans* and *A. decipiens* has been stated, except Spitsbergen, in Franz Josef Land (Schulgina 1960, cf. Birkelund and Callomon 1985) and in the Nordkapp Basin in the southern Barents Sea, where *A. decipiens* occurs also above *A. elegans* (Wierzbowski and Århus 1990). All these differences in stratigraphical ranges of the two species seem to be of a local significance and related to the environmental factors. Hence, the two horizons from the Milne Land probably have only a minor correlation value and they may roughly correspond to the one with fauna 4 from Sassenfjorden in Spitsbergen.

Of the Siberian sections representative for the eastern part of the Boreal province, those of the Boyarka River in the Kheta Basin of northeastern Siberia seem the most important. The detailed studies (Sachs *et al.* 1969, Mesezhnikov 1984) have revealed here a succession of several ammonite faunas which, being well located in the succeeding beds (from II to XVI), gave considerable support to zonation of the Kimmeridgian in northern Siberia. This zonal scheme somewhat differs from the one worked out in NW Europe, and some questions arise as to stratigraphic correlations of the two schemes (*cf.* Birkelund and Callomon 1985). Thus, the comparison of the succession of the ammonite faunas in Spitsbergen with that in the Kheta Basin in Siberia may also be of some general stratigraphical interest.

In the succession recognized at Boyarka River, *Amoeboceras pingueforme* is known to occur in bed IV representing the uppermost part of the Pictonia involuta Zone, and in bed V of the lowermost part of the Rasenia pseudouralensis Subzone of the Rasenia evoluta Zone (= Rasenia borealis Zone, as previously distinguished by Sachs *et al.* 1969). On the other hand, *A. mesezhnikovi* is reported in the same succession approx. from the same beds, i.e. the lowermost part of the Rasenia evoluta Zone (Mesezhnikov 1984), and from the Pictonia involuta Zone (*cf.* Mesezhnikov and Romm

1973). The Pictonia involuta Zone in the same area contains, among other ammonites of the genus *Amoeboceras*, a number of closely related, if not synonymous species (*A. pulchrum* Mesezhnikov et Romm, *A. spathi* Schulgina, *A. subkitchini* Spath) while the ammonites related to *A. kitchini* (Salfeld) are absent. The latter one (together with related *A. salfeldi* Spath) appears in the lowermost part of the Rasenia evoluta Zone (Sachs *et al.* 1969, Mesezhnikov 1984).

It should be remembered that in the sections studied in Sassenfjorden, Spitsbergen, *A. pingueforme* and *A. mesezhnikovi* are known to occur in the horizons with fauna 2 and 3, but a single specimen similar to the species discussed has been found in the horizon with fauna 1b (pl. 15: 9; *cf.* fig. 2). Moreover, the first ammonites similar to *A. kitchini* seem to appear somewhere in proximity of fauna 3, and *A. subkitchini* overdominates in faunas 1a and 1b. The comparison of the given data suggests that the boundary between the Siberian Pictonia involuta Zone and the Rasenia evoluta Zone should be possibly placed in the Spitsbergen succession somewhere close to the horizon with fauna 3 (?within it or even at its base). Such stratigraphical interpretation of the boundary corresponds well with the correlation given by Birkelund and Callomon (1985) who placed the upper boundary of the Siberian Pictonia involuta Zone in the middle of the widely understood NW European Rasenia cymodoce Zone.

Still younger beds in the Boyarka sections (V—XI) yielded ammonites of the genus *Rasenia*, as well as of the *Zonovia — Xenostephanus* group (Sachs *et al.* 1969). The latter become especially common in beds IX—XI attributed to the Zonovia uralensis Subzone of the Rasenia evoluta Zone (Mesezhnikov 1984). The stratigraphical distribution of the ammonites of the genera *Rasenia* and *Xenostephanus* has been recognized in England (Birkelund *et al.* 1983) where the first *Xenostephanus*-like ammonites appear in the uppermost part of the Rasenia cymodoce Zone. The typical representatives of the genus *Xenostephanus*, however, are known to occur there in the lower Aulacostephanoides mutabilis Zone, well above *Rasenia s.s.* On the other hand, the ammonites in the Boyarka sections, being very close to the typical British *Xenostephanus*, coexist over some range with ammonites which retained all the characteristics of typical *Rasenia*. This makes it difficult to correlate the Subboreal and Siberian zonal schemes, and the problem cannot be resolved here. It may only be suggested that some beds from the Boyarka sections, probably from the base of the Zonovia uralensis Subzone, are in fact younger than the upper part of the Rasenia cymodoce Zone, and may correspond to the lower part of the Aulacostephanoides mutabilis Zone from NW Europe (*cf.* Birkelund and Callomon 1985, see also Birkelund *et al.* 1983).

Beds XII and XIII of the Boyarka sections yielded *Aulacostephanoides mutabilis* (Sowerby) as well as some species of *Xenostephanus* and of *Amoeboceras*, as *A.* cf. *kitchini* (Salfeld). The fauna indicates undoubtedly the Aulacostephanus mutabilis Zone (Sachs *et al.* 1969, Mesezhnikov 1984). A poorly defined *Xenostephanus* horizon from Spitsbergen would probably correspond to this part of the Siberian succession (fig. 7).

Bed XIV in the Boyarka sections has been found to contain: *Aulacostephanus* (*Aulacostephanoceras*) *pseudolinealis* Mesezhnikov, *A.* (*A.*) cf. *eudoxus* (d'Orbigny) as well as *Amoeboceras* (*Euprionoceras*) *sokolovi* Bodylevsky and *A.* (*E.*) *kochi* Spath (Sachs *et al.* 1969, Mesezhnikov 1984). The latter two are characteristic of the *A. sokolovi* horizon from Spitsbergen (probably corresponding to the *A. kochi* horizon from East Greenland, see fig. 7). The presence of the species of *Aulacostephanus* mentioned above, indicates that the horizon in question may be correlated with some parts of the Aulacostephanus eudoxus Zone.

The youngest ammonite fauna in the Boyarka sections comes from bed XV. Here occur (Sachs *et al.* 1969; Mesezhnikov 1984): *Oxydiscites* (= *Streblites*) cf. *taimyrensis* Mesezhnikov together with not illustrated representatives of *Amoeboceras*, including *A.* (*Nannocardioceras*) sp. and alleged *A.* (*Euprionoceras*) *sokolovi* Bodylevsky. The fauna is attributed to the Siberian Oxydiscites (or Streblites) taimyrensis Zone which seems to corresponds approximately to the Aulacostephanus autissiodorensis Zone (Mesezhnikov 1984, 1988) and may also be to the uppermost part of the Aulacostephanus eudoxus Zone from the NW European zonal scheme (Birkelund and Callomon 1985). The Spitsbergen horizon with fauna 4 (*A. elegans*-*A. decipiens*) is older than the Oxydiscites taimyrensis Zone, but it should be remembered that the horizon itself has not been recognized in the Boyarka sections. On the other hand, the Oxydiscites taimyrensis Zone has not been distinguished in Spitsbergen so far. It is only the occurrence of *Streblites* sp. together with *Amoeboceras* (*Hoplocardioceras*) sp. indet. in Sörkapp Land (Yershova 1983) which may suggest the presence of the Zone in question.

When comparing the ammonite faunas from Spitsbergen with those from East Greenland and northern Siberia some general remarks on the biogeography of the Boreal Realm during Kimmeridgian can be made. Spitsbergen and some other neighbouring areas, e.g. Franz Josef Land, northern Greenland, Nordkapp Basin of the southern Barents Sea, where the dominance of ammonites of *Amoeboceras* has been stated (Schulgina 1960, Mesezhnikov and Schulgina 1982, Wierzbowski and Århus 1990) were strongly confined to the restricted Boreal Province. On the other hand, East Grenland, as well as the Kheta Basin in Siberia revealed stronger Subboreal influences as evidenced there by a higher frequency of the representatives of the family Aulacostephanidae. The biogeographical situation, however, changed somewhat with time as it is prooved by an abrupt appearance in Spitsbergen of the aulacostephanids during the Rasenia cymodoce Chron and in Aulacostephanoides mutabilis Chron. Moreover, this strong invasion of the Subboreal fauna towards the north has also been recognized in the Kheta Basin and in the Taimyr in northern Siberia where the corresponding ammonite spectra for the Rasenia evoluta (= Rasenia borealis) Zone, and for the Aulacostephanus mutabilis Zone show the dominance of aulacostephanids over cardioceratids; on the contrary, the spectra for the Pictonia involuta Zone and the Aulacostephanus eudoxus Zone in the same area reveal the dominance of cardioceratids over aulacostephanids (Mesezhnikov 1984: fig. 23b). It has also been found out that the same invasion of the Subboreal fauna occurred towards the south where, in the Aquitaine Basin, *Rasenia cymodoce* appears abruptly over the succession of the faunas of the Submediterranean origin (Hantzpergue 1979, Hantzpergue and Debrand-Passard 1980; *cf.* Birkelund *et. al.* 1983).

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ANDRZEJ WIERZBOWSKI

AMONITY I STRATYGRAFIA KIMERYDU OKOLIC WIMANFJELLET W SASSENFJORDEN, SPITSBERGEN

Streszczenie

Opisano cztery zespoły amonitów zebrane z konkrecji i przeławiceń dolomitowych i syderytowych wśród łupków należących do formacji Janusfjellet, odsłoniętych w okolicach Wimanfjellet w Sassenfjorden na Spitsbergenie. Przedstawione obserwacje oraz analiza danych ze starszych prac geologicznych pozwoliły uzyskać generalny obraz następstwa amonitów w kimerydzie Spitsbergenu (fig. 1—2, 7).

Dwa najstarsze zespoły amonitów w Sassenfjorden złożone są niemal wyłącznie z przedstawicieli gatunku *Amoeboceras* (*Amoebites*) *subkitchini* Spath. Zespoły te reprezentują dwie następujące po sobie populacje. Między populacjami zaznaczają się istotne różnice w rozkładzie cech morfologicznych, m.in. w wyrazistości i gęstości urzeźbienia (fig. 3; pl. 15: 1—8, pl. 16: 1—3, 6—7). Młodszy zespół w Sassenfjorden reprezentują okazy *Amoeboceras* (*Amoebites*) *mesezhnikovi* Sykes et Surlyk. Zebrane amonity są tu jednak nieliczne co utrudnia określenie zmienności gatunkowej (fig. 3; pl. 16: 4—5). Generalne podobieństwo *A.* (*A.*) *mesezhnikovi* do *A.* (*A.*) *subkitchini* zdaje się wskazywać jednakże iż gatunki te stanowią jeden etap filogenetycznego rozwoju podrodzaju *Amoebites.* W kolejnym zespole amonitów w Sassenfjorden stwierdzono obecność *Rasenia cymodoce* (d'Orbigny) oraz *Amoeboceras* (*Amoebites*) *pingueforme* Mesezhnikov (fig. 3—4; pl. 17, pl. 18, pl. 19: 1—2). Ten ostatni gatunek jest zbliżony morfologicznie zarówno do poprzedzającego go stratygraficznie gatunku, *A.* (*A.*) *mesezhnikovi*, jak też następującego później *Amoeboceras* (*Amoebites*) *kitchini* (Salfed). Omawiane gatunki podrodzaju *Amoebites* reprezentują zatem najprawdopodobniej jedną monofiletyczną linię rozwojową (por. Callomon 1985).

Dwa młodsze zespoły amonitów na Spitsbergenie wydzielone zostały w oparciu o analizę starszych prac. Należą tu: zespół z *Xenostephanus* oraz zespół z *Amoeboceras* (*Euprionoceras*) *sokolovi* Bodylevsky, wymieniane z różnych części Spitsbergenu, lecz nieudokumentowane w Sassenfjorden.

Najmłodszy stwierdzony dotąd zespół amonitów w Sassenfjorden reprezentują współwystępujące razem *Amoeboceras* (*Amoebites*) *elegans* Spath oraz *Amoeboceras* (*Hoplocardioceras*) *decipiens* Spath (fig. 5—6; pl. 19: 3—6, pl. 20—22).

W dalszej części pracy (fig. 7) przedstawiono korelację poszczególnych horyzontów faunistycznych na Spitsbergenie zawierających omawiane zespoły amonitów, z horyzontami oraz poziomami amonitowymi wyróżnionymi we Wschodniej Grenlandii (Birkelund i Callomon 1985) oraz w północnej Syberii, w basenie rzeki Chety (Sachs i in. 1969, Mesezhnikov 1984). Korelacja ta umożliwiła jednocześnie wzajemne porównanie podziałów amonitowych Wschodniej Grenlandii i północnej Syberii, a także nawiązanie do standardowego podziału kimerydu północno-zachodniej Europy. Należy tu zaznaczyć, że przedstawiona uprzednio przez Birkelund i Callomon

(1985) korelacja podziałów amonitowych ze Wschodniej Grenlandii i Syberii znalazła potwierdzenie w niniejszej pracy.

Analiza zespołów amonitowych pozwoliła także na określenie pozycji biogeograficznej Spitsbergenu w kimerydzie. Dominacja amonitów z rodziny Cardioceratidae (rodzaju *Amoeboceras*) pokazuje, że obszar ten pozostawał pod silnym wpływem prowincji borealnej. Jednakże pojawienie się dość licznych przedstawicieli rodziny Aulacostephanidae w dobie *Rasenia cymodoce* oraz w dobie *Aulacostephanoides mutabilis* wskazuje na wyraźniejsze w tym czasie wpływy prowincji subborealnej. Wspomniana inwazja amonitów subborealnych ku północy została stwierdzona w innych częściach prowincji borealnej, m.in. w północnej Syberii (por. Mesezhnikov 1984). Na uwagę zasługuje pojawienie się amonitów subborealnych także w tym samym czasie na obszarach odpowiadających prowincji submedyterańskiej — w basenie akwitańskim (Hantzpergue 1979, Hantzpergue i Debrand-Passard 1980).

Praca została wykonana w ramach programu CPBP 03.03 Polskiej Akademii Nauk.

EXPLANATION OF PLATES 15—22

All figures in natural size; photographs: S. Kolanowski

Plate 15

1, 7. *Amoeboceras* (*Amoebites*) cf. *subkitchini* Spath: section 1A, *1* specimen IGPUW/A23/105, 37.5 m above the Brentskardhaugen Bed, fauna 1a; *7* IGPUW/ /A23/95, about 50 m above the Brentskardhaugen Bed, fauna 1b.

2—6, 8. *Amoeboceras* (*Amoebites*) *subkitchini* Spath: *2—6* from section 1A, fauna 1a, *2* specimen IGPUW/A23/102, about 48 m above the Brentskardhaugen Bed, *3—6* specimens IGPUW/A23/101, 100, 98 and 96, respectively, about 40 m above Brentskardhaugen Bed, *6* nearly complete macroconch; *8* macroconch from section 1B, about 50 m above the Brentskardhaugen Bed, fauna 1b, IGPUW/ /A23/89.

9. *Amoeboceras* (*Amoebites*) aff. *rasenense* Spath: section 1B, about 50 m above the Brentskardhaugen Bed, fauna 1b, IGPUW/A23/92.

Plate 16

1, 6, 7. *Amoeboceras* (*Amoebites*) *subkitchini* Spath: macroconchs, section 1B, about 50 m above the Brentskardhaugen Bed, fauna 1b, specimens IGPUW/A23/87, 88 and 86, respectively.

2, 3. *Amoeboceras* (*Amoebites*) *subkitchini* Spath: nearly complete adult microconchs, about 50 m above the Brentskardhaugen Bed, fauna 1b; *2* specimen IGPUW/ /A23/93 from section 1B, *3* IGPUW/A23/94 from section 1A.

4, 5. *Amoeboceras* (*Amoebites*) *mesezhnikovi* Sykes et Surlyk: macroconchs, section 1B, about 52 m above the Brentskardhaugen Bed, fauna 2, specimens IGPUW/ /A23/48 and 46, respectively.

Plate 17

1, 2. *Amoeboceras* (*Amoebites*) *pingueforme* Mesezhnikov: section 1B, 68 m (*1* specimen IGPUW/A23/47) and 71 m (*2* IGPUW/A23/106) above the Brentskardhaugen Bed, fauna 3.

3—6. *Rasenia cymodoce* (d'Orbigny): *6* macroconch; section 1B, about 68 m above the Brentskardhaugen Bed, fauna 3, specimens IGPUW/A23/11, 9, 1 and 10, respectively.

Plate 18

1—4. *Rasenia cymodoce* (d'Orbigny): section 1B, 68 m (*2*, *3* specimens IGPUW/A23/3 and 4, respectively), and 70 m above the Brentskardhaugen Bed (*1* and *4* specimens IGPUW/A23/8 and 6, respectively), fauna 3.

Plate 19

1, 2. *Rasenia cymodoce* (d'Orbigny): adult microconchs, note the difference in end size, section 1B, 68 m (*1* specimen IGPUW/A23/13) and 70 m (*2* specimen IGPUW/A23/14) above the Brentskardhaugen Bed, fauna 3.

3—6. *Amoeboceras* (*Hoplocardioceras*) *decipiens* Spath: section 1A, 78.5 m above the Brentskardhaugen Bed (*3*, *4* specimens IGPUW/A23/20 and 21); section 1B, about 80 m above the Brentskardhaugen Bed (*5*, *6* specimens IGPUW/A23/22 and 25, respectively), fauna 4.

Plate 20

1, 2. *Amoeboceras* (*Amoebites*) *elegans* Spath: section 1A, about 78.5 m above the Brentskardhaugen Bed (*1* specimen IGPUW/A23/33); section 1B, about 80 m above the Brentskardhaugen Bed (*2* IGPUW/A23/49), fauna 4.

3—5. *Amoeboceras* (*Haplocardioceras*) *decipiens* Spath: *3* completely adult macroconch; section 1B, about 80 m above the Brentskardhaugen Bed, fauna 4, specimens IGPUW/A23/44, 23, 24, respectively.

Plate 21

1—3. *Amoeboceras* (*Amoebites*) *elegans* Spath: *3* completely adult macroconch; section 1B, about 80 m above the Brentskardhaugen Bed, fauna 4, specimens IGPUW/A23/30, 39, 26, respectively.

Plate 22

1—6. *Amoeboceras* (*Amoebites*) *elegans* Spath: *1—4* with heavy ribbing of the "*pseudoacanthophorum*" type; section 1A, about 78.5 m above the Bretskardhaugen Bed (*1* and *5* specimens IGPUW/A23/73 and 32, respectively); section 1B, about 80 m above the Brentskardhaugen Bed (*2—4*, *6* specimens IGPUW//A23/54, 84, 52, 27, respectively), fauna 4.


1


3


4


2


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7


9


6


8


1


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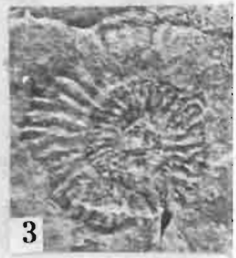
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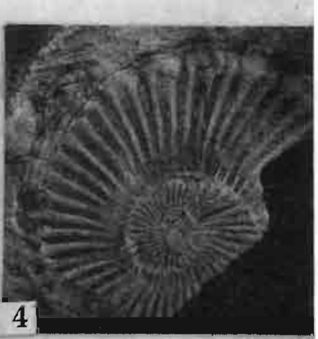

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