The succession of ammonites of the genus *Amoeboceras* in the Upper Oxfordian – Kimmeridgian of the Nordvik section in northern Siberia

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ABSTRACT: A collection of ammonites of the genus *Amoeboceras* located carefully in the section of Nordvik Peninsula in northern Siberia has enabled recognition of the standard Boreal ammonite zones of the Upper Oxfordian and Kimmeridgian. The recognition of the standard *Amoeboceras* zones, well known in NW Europe and the Barents Sea area, in northern Siberia indicates the uniform character of the Late Oxfordian and Kimmeridgian ammonite faunas across the whole Boreal Province. Some comments on the occurrence of Boreal oppeliids of the genus *Suboxydiscites* in the studied section are also given.

INTRODUCTION

The Urduck-Khaia Cape of the Nordvik Peninsula situated on the Laptiev Sea, east of Taimyr Peninsula (Fig. 1), provides one of the most fossiliferous Jurassic/Lower Cretaceous successions of northern Siberia. The Mesozoic deposits of the area were discovered at the beginning of XX century, but more detailed studies were undertaken by Russian geologists from the sixties to the eighties of that century. Oxfordian and Kimmeridgian deposits were recognized by Voronetz (1962) on the basis of cardioceratids. Considering her ammonite illustrations the specimen referred to as *Amoeboceras alternans* (von Buch) found at the base of the Upper Oxfordian (Voronetz 1962, pl. 30: 6) seems, however, a late *Cardioceras*, possibly transitional to *Amoeboceras*, indicative of the uppermost Middle Oxfordian. Those occurring higher in the section are true Kimmeridgian ammonites: these can be revised as follows: the specimen of *Amoeboceras* ex gr. *kitchini* (Salfeld) in Voronetz (1962, pl. 29: 1, only) is typical of *Amoeboceras subkitchini* Spath, and the specimen of *Amoeboceras* (*Euprionoceras* ?) cf. *aldingeri* Spath (see Voronetz pl. 29: 3) is possibly *Amoeboceras* (*Euprionoceras*) *kochi* Spath; the latter comes from the interval in the section where a specimen of *Amoeboceras* cf. *elegans* Spath has been also recorded (Voronetz 1962, p. 17). The position of the specimens in the section (*cf.* Voronetz 1962, p. 17) generally corresponds to the ammonite succession as interpreted in the present study (see Fig. 2). Extensive field work in the Nordvik

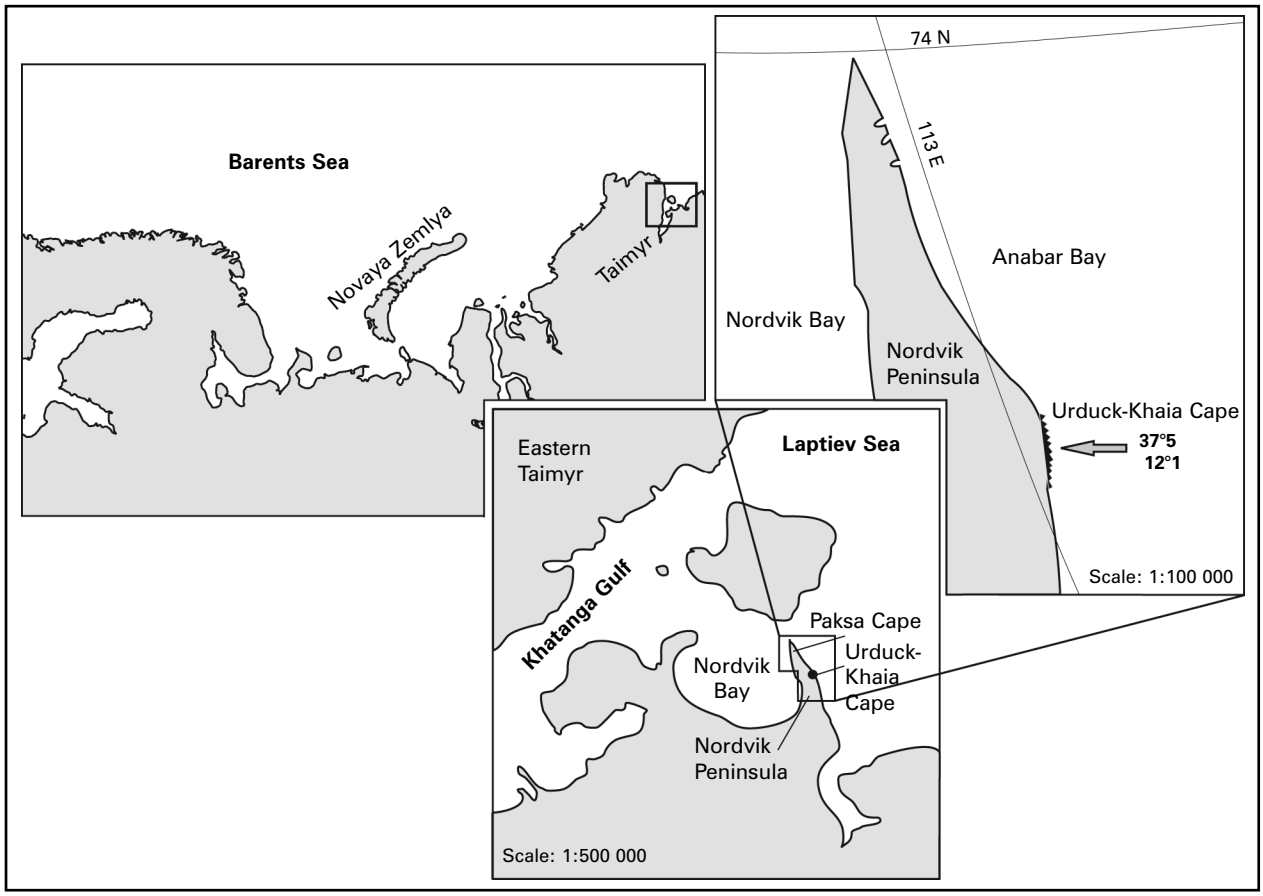


Fig. 1 Location map of the Nordvik section at Urduck-Khaia Cape.

Peninsula was carried out from 1958 by geologists of the Institute of Arctic Geology in Leningrad and the Institute of Geology and Geophysics in Novosibirsk under the leadership of V. N. Sachs. These resulted in a detailed description of the section – its lithology, fauna and biostratigraphy, providing especially new stratigraphical information on the uppermost Jurassic and Lower Cretaceous deposits (*e. g.* Sachs *et al.* 1963; Basov *et al.* 1970). The only new information on the Upper Oxfordian ammonites of the Nordvik Peninsula is that of Mesezhnikov (1989, p. 68) who recorded the occurrence of numerous specimens of *Amoeboceras transitorium* Spath occurring at single level in the section. The common occurrence of this species at the base of the Upper Oxfordian in the present section studied is confirmed herein. The Kimmeridgian deposits of the Nordvik section yielded also Boreal bivalves of the genus *Buchia* which make possible recognition of the two buchiid zones (Zakharov *et al.* 1983): the *Buchia concentrica* zone and the *Buchia tenuistriata* zone.

THE AMMONITE SUCCESSION AND ITS STRATIGRAPHICAL INTERPRETATION

The general succession of the Oxfordian and Kimmeridgian deposits of the Urduck-Khaia Cape was elaborated by Zakharov *et al.* (1983): these authors distinguished 7 beds in the interval studied – these range (Fig. 2) from silty clays (beds 1, 3, 5, 7) and clays (upper part of bed 6) to clayey siltstones (lower part of bed 6) and glauconitic silty clayey sandstones (bed 2). Calcareous concretions occur at some levels, either loosely dispersed in the clays (*e.g.* within bed 5), or forming prominent levels (bed 4, and at the base of bed 7). The collection of Upper Oxfordian and Kimmeridgian ammonites consisting of about 60 specimens is carefully located by the present authors in the 25 meter thick section of shales and siltstones with numerous levels of carbonate concretions. The four main reference levels, such as the principal concretion levels denoted as 2A (bed 4) and 2G (base of bed 7), the boundary between the silty

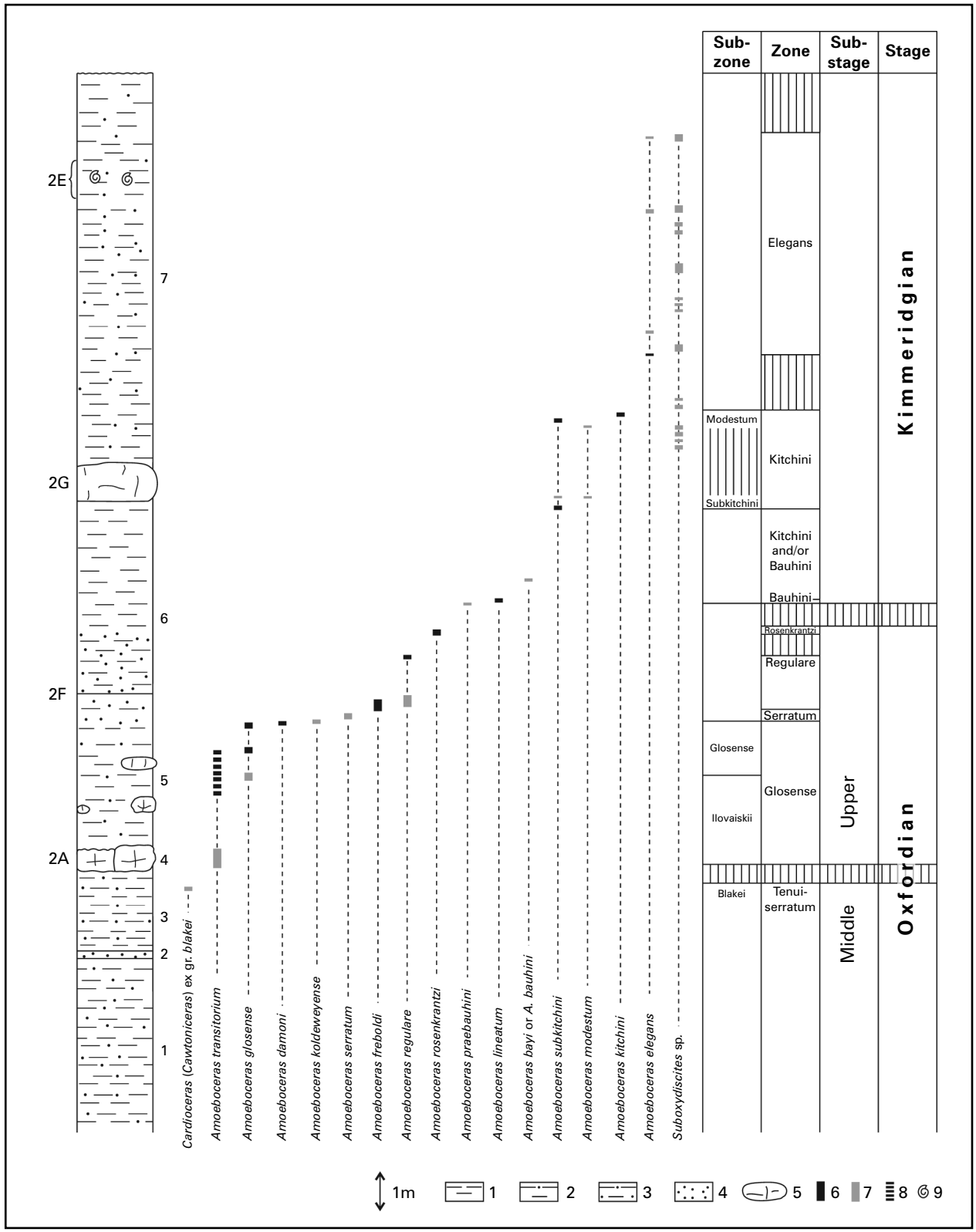
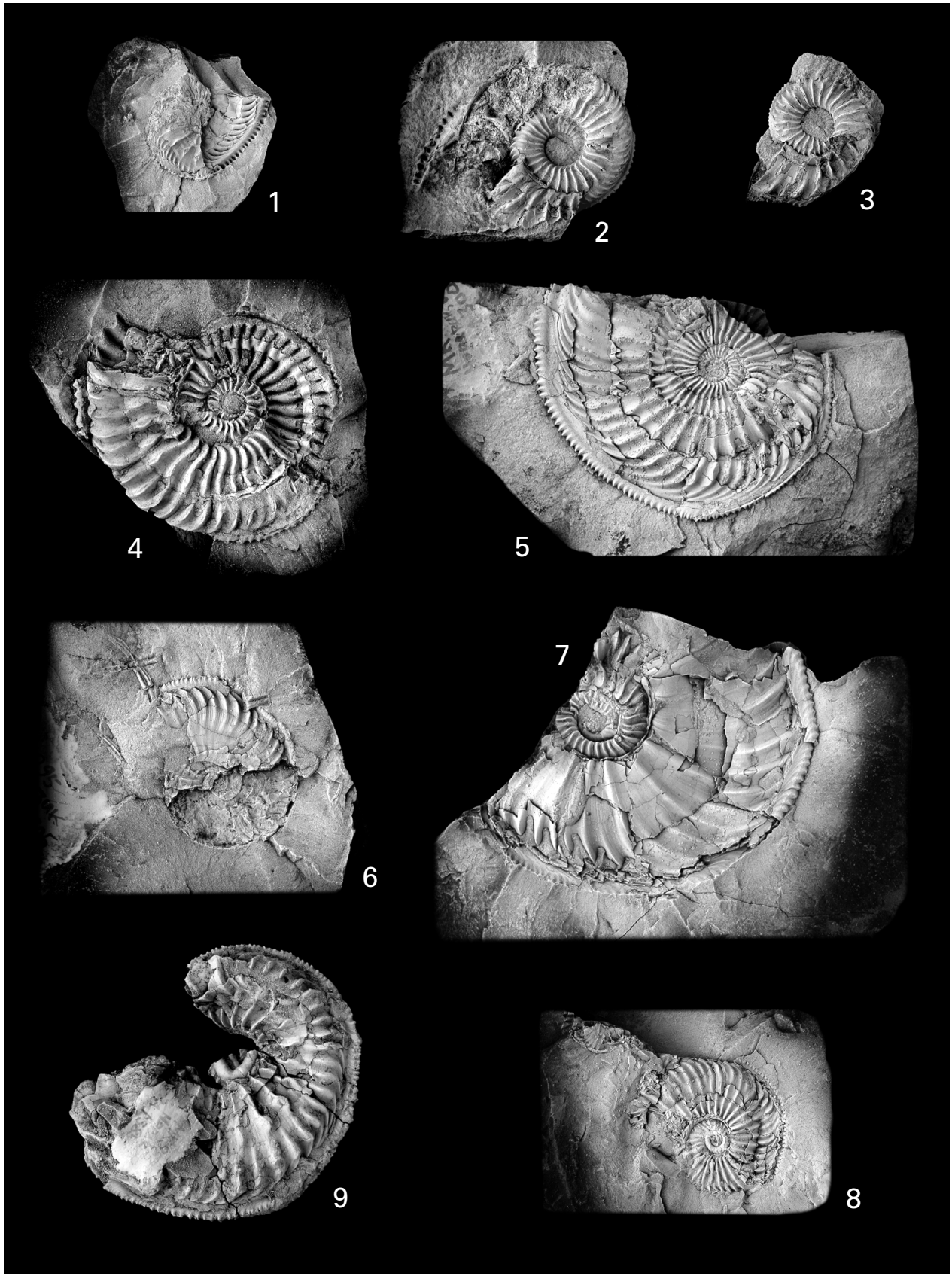


Fig. 2 Ammonite distribution in the Nordvik section, and its chronostratigraphical interpretation; 1 – clays, 2 – silty clays, 3 – clayey siltstones, 4 – silty clayey sandstones, 5 – calcareous concretions, 6 – precise range of the specimens referred to the species, 7 – precise range of the specimens referred to as cf. or ex gr. species, 8 – approximate range of specimens referred to the species, 9 – bed with numerous *Amoeboceras* used as correlation level 2E.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clays and overlying greenish clayey siltstones (2F), and the top of the silty clay layer with numerous *Amoeboceras* (2E), are useful in precise location of the ammonites in the section studied (see Fig. 2).

The lowest part of the section yielded ammonites of the genus *Cardioceras* which were not studied in detail. The lowermost part of bed 3 contains badly preserved ammonites of the genus *Cardioceras* possibly of the Densiplicatum Zone. The youngest *Cardioceras* fauna is represented by *Cardioceras* (*Cawtoniceras*) ex gr. *blakei* Spath found 0.47 m below the concretion level 2A (Pl. 1: 1), and indicative of the Blakei Subzone of the Tenuiserratum Zone of the uppermost part of the Middle Oxfordian.

The oldest ammonite fauna of the genus *Amoeboceras* consists of two specimens about 30 mm in diameter found in concretion level 2A (Pl. 1: 2-3). The specimens are very similar to small-sized specimens described by Arkell (1937, pl. 3: 7, 10, 12) as *Amoeboceras* aff. *pseudocaelatum*, and according to Sykes and Callomon (1979) represent microconchs of *Amoeboceras transitorium* Spath. Although not completely preserved, the specimens studied may be referred to as *A.* cf. *transitorium.* Another larger specimen about 50 mm in diameter was found in the rubble but its position in the section may be deduced as corresponding to the interval between 150 cm to about 250 cm above the concretion level 2A. The specimen (Pl. 1: 4) shows strong ribbing with markedly developed lateral tubercles, although the forward projection of the secondaries at the ventral side is poorly visible due to deformation of that part of the shell. It is comparable with representatives of *Amoeboceras transitorium* Spath (see *e.g.* Sykes and Callomon 1979, pl. 114: 1-4; Wright 1996, fig. 5A-G) and can be safely attributed to this species. The discussed assemblage of ammonites is indicative of the Ilovaiskii Subzone – the lower subzone of the Glosense Zone representing the lowermost part of the Upper Oxfordian (Sykes and Callomon 1979).

A still younger *Amoeboceras* fauna consists of a few specimens attaining from about 25 mm to about 50 mm in diameter and showing prorsiradiate ribbing with poorly developed lateral tubercles and a marked forward sweep of the secondary ribs at the ventral side. These features show a close relation of the specimens discussed with *Amoeboceras glosense* (Bigot et Brasil). The oldest specimens occur already at about 180 cm above the concretion level 2A (*A.* cf. *glosense*), but better preserved and larger specimens (Pl. 1: 5) were found from about 255-260 cm to 320 cm above the level. The ribbing on the outer whorl in some specimens (Pl. 1: 5) becomes more projected reminiscent that of *Amoeboceras ilovaiskii* (see also Sykes and Callomon 1979).

The slightly younger large specimen (about 70 mm in diameter) found at 325 cm above the concretion level 2A is generally similar to *A. glosense* but it shows more distant and stronger ribbing which shows on the inner whorls a slight backward course (Pl. 1: 7). The specimen may be easily placed in *Amoeboceras damoni* Spath being *e.g.* very close to the large specimen illustrated by Arkell (1948, text-fig. 136), and placed in the synonymy of the species in question by Sykes and Callomon (1979, p. 874). Another single fragmentarily preserved specimen about 25 mm in diameter found 325 cm above concretion level 2A shows delicate ornamentation strongly accentuated at the umbilicus and close to the ventral side, but very feeble in the middle part of whorl. Although poorly preserved, the specimen (Pl. 1: 6) can be referred to as *Amoeboceras* cf. *koldeweyense* Sykes and Callomon (see Sykes and Callomon 1979, pp 876-877). The discussed assemblage of ammonites consisting of *A. damoni* and *A.* cf. *koldeweyense* is indicative of the lower part of the Serratum Zone – the Koldeweyense Subzone.

Four small incomplete specimens from about 20 mm to about 30 mm in diameter were found from 335 to 355 cm above concretion level 2A. The innermost whorls where visible are smooth; these are followed by strong rectiradiate primaries splitting high on the whorl side into short prorsiradiate secondaries. The furcation point is

Plate 1

1 – *Cardioceras* (*Cawtoniceras*) ex gr. *blakei* Spath; VGM-1129-12/BP-09581; 47 cm below 2A; 2-3 – *Amoeboceras* cf. *transitorium* Spath; VGM-1129-29/BP-09598; level 2A; 4 – *Amoeboceras transitorium* Spath; VGM-1129-27/BP-09596; 150-250 cm above 2A; 5 – *Amoeboceras glosense* (Bigot, Brasil); VGM-1129-34/BP-09603; 300 cm above 2A; 6 – *Amoeboceras* cf. *koldeweyense* Sykes, Callomon; VGM-1129-32/BP-09601; 325 cm above 2A; scale x1,5; 7 – *Amoeboceras damoni* Spath; VGM-1129-06/BP-09575; 325 cm above 2A; 8 – *Amoeboceras* cf. *serratum* (Sowerby); VGM-1129-05/BP-09574; 350 cm above 2A; 9 – *Amoeboceras freboldi* Spath; VGM-1129-35/BP-09604; 385 cm above 2A. All specimens in natural size unless specified otherwise.

accentuated with tubercles; weaker tubercles appear also at the umbilicus, and at the ventrolateral side of the whorl. The features indicate close affinity of the specimens in question (see Pl. 1: 8) with *Amoeboceras serratum* (Sowerby). The species is indicative of the Serratum Zone of the Upper Oxfordian (Sykes and Callomon 1979).

A younger ammonite assemblage consist of two different forms: (1) heavily ribbed specimens from 40-60 mm in diameter showing markedly developed lateral tubercles, and blunt, flattened ribbing (Pl. 1: 9) – these specimens found from 360 to 385 cm above the concretion level 2A can be safely attributed to the species *Amoeboceras freboldi* Spath; (2) more densely ribbed specimens from about 30 mm to 55 mm in diameter. The ribbing is sharp and rectiradiate, the secondary ribs appear at about the mid-height of the whorl to 2/3 of whorl height, the tubercles are very weak and almost absent. These specimens found from 365 to 390 cm above concretion level 2A, and from 100 cm to 105 cm above the base of the greenish clayey siltstone (level 2F) can be referred to as *Amoeboceras regulare* Spath (Pl. 2: 1) and *A.* cf. *regulare* Spath. The common occurrence of *A. regulare* and *A. freboldi* and the lack of representatives of ammonites of the *A. serratum* group is indicative of the Regulare Zone of the Upper Oxfordian (Sykes and Callomon 1979).

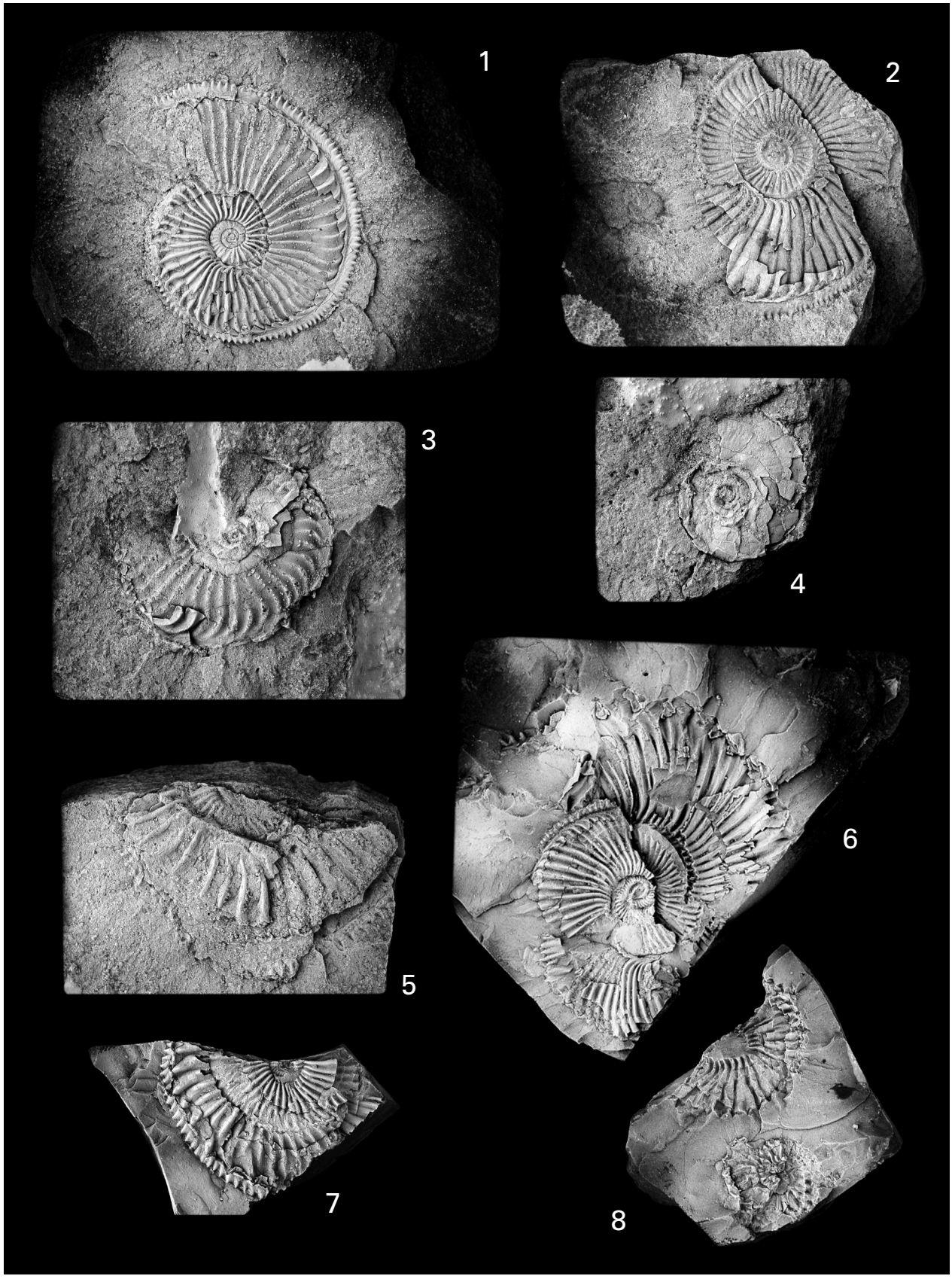
Two ammonites found at 160 cm and 165 cm above the base of the greenish clayey siltstones (level 2F) about 45 mm and 50 mm in diameter show dense somewhat prorsiradiate primaries, and long rectiradiate and even slightly rursiradiate secondaries; the secondaries at the ventrolateral shoulders are stronger accentuated. The features indicate the close relation of the specimens in question to *Amoeboceras rosenkrantzi* Spath (Pl. 2: 2). Also a specimen found 138 cm above the level discussed shows flexuous ribbing with markedly rursiradiate secondary ribs which indicate its affinity with the *A. rosenkrantzi* group. The occurrence of *A. rosenkrantzi* below the appearance of *Plasmatites* is indicative of the Rosenkranztzi Zone of the uppermost Upper Oxfordian (Matyja *et al.* 2006; see also Sykes and Callomon 1979).

The two ammonites found at 245 cm and 250 cm above the base of the greenish clayey siltstone (level 2F) are small, attaining only about 22 mm and 15 mm in their diameter, respectively. That found at the lower level is fairly strongly ribbed with flexuous ribs and with a smooth spiral band in the middle of the whorl side. The secondaries at the ventral side show a marked forward sweep and are continuous onto the keel – the specimen (Pl. 2: 3) may be referred to as *Amoeboceras* (*Plasmatites*) cf. *praebauhini* (Salfeld). The specimen found above (Pl. 2: 4) is covered by very dense, delicate ribbing and it is referred to as *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt). The occurrence of representatives of the subgenus *Plasmatites* is indicative of the Bauhini Zone of the lowermost Kimmeridgian (Matyja *et al.* 2006; for illustration of *Plasmatites* see also *e.g.* Matyja and Wierzbowski 1988; Atrops *et al.* 1993). The data indicate that the Oxfordian/Kimmeridgian boundary in the section studied runs within the 80 cm interval between 165 cm and 245 cm above the base of the greenish clayey siltstone (level 2F).

A poorly preserved specimen, about 25 mm in diameter, was found 305 cm above level 2F; it shows strong flexuous primary ribs which curve markedly backwards and end with a lateral tubercle well above the middle of whorl side; the short secondary ribs appear very high on the whorl side but the ventrolateral part of whorl is not visible. The specimen although poorly preserved (Pl. 2: 5) can be attributed to the group of small sized, strongly ribbed species – such as *Amoeboceras* (*Amoebites*) *bayi* Birkelund et Callomon, or its direct forerunner *Amoeboceras* (*Plasmatites*) *bauhini* (Oppel) – cf. *e.g.* Birkelund et Callomon (1985). Its occurrence indicates the presence of the Bauhini Zone or even the lowermost part of the Kitchini Zone of the lowermost Kimmeridgian (Wierzbowski and Smelror 1993; Matyja *et al.* 2006).

Plate 2

1 – *Amoeboceras regulare* Spath; VGM-1129-01/BP-09570; 103 cm above 2F; 2 – *Amoeboceras rosenkrantzi* Spath; VGM-1129-13/BP-09582; 160 cm above 2F; 3 – *Amoeboceras* (*Plasmatites*) cf. *praebauhini* (Salfeld); VGM-1129-47/BP-09616; 245 cm above 2F; scale x2; 4 – *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt); VGM-1129-19/BP-09588; 250 cm above 2F; scale x2; 5 – *Amoeboceras bayi* Birkelund et Callomon or *Amoeboceras bauhini* (Oppel); VGM-1129-10/BP-09579; 305 cm above 2F; scale x2; 6-7 – *Amoeboceras* (*Amoebites*) *subkitchini* Spath; VGM-1129-16/BP-09585 and VGM-1129-17/BP-09686; 20 cm and 30 cm below 2G; 8 – *Amoeboceras* (*Amoebites*) *kitchini* (Salfeld); VGM-1129-15/BP-09584; 110 cm above 2G; All the specimens in natural size unless specified otherwise.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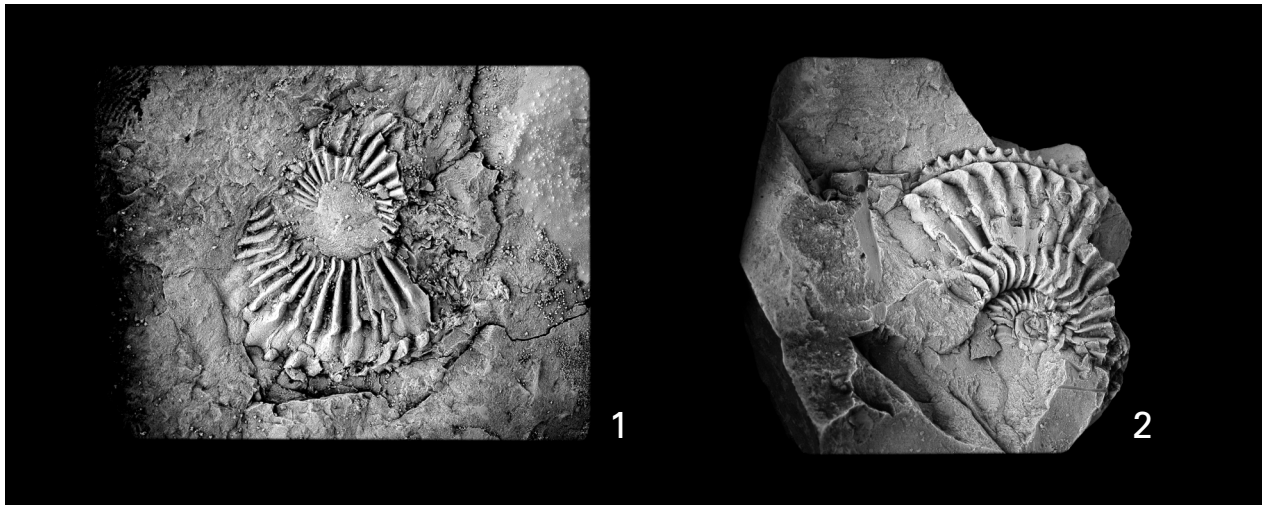

Fig. 3. 1 – *Amoeboceras* (*Hoplocardioceras*) *elegans* Spath; VGM-1129-37/BP-09606; 270 cm above 2G; 2 – *Amoeboceras* (*Hoplocardioceras*) cf. *elegans* Spath; VGM-1129-20/BP-09589; 60 cm below 2E. All the specimens x 1,7.

A younger ammonite assemblage has been discovered about 20-30 cm below concretion level 2G. The specimens (Pl. 2: 6-7) are representatives of *Amoeboceras* (*Amoebites*) *subkitchini* Spath with well developed ventrolateral nodes, and fairly large final sizes (up to about 60 mm in diameter) which are typical features of the species (Birkelund and Callomon 1985; Wierzbowski and Smelror 1993). Some of the specimens show a somewhat narrower umbilicus, being similar to *Amoeboceras* (*Amoebites*) *alticarinatum* Mesehnikov and Romm (*cf.* Mesezhnikov and Romm 1973, p. 42-43, pl. 3: 4-5) which is, however, treated as a form "very closely related if not identical to *A. subkitchini*" (Birkelund and Callomon, 1985, p. 22). The occurrence of the specimens in question indicates the lower part of the Kitchini Zone – the Subkitchini Subzone (Wierzbowski *et al.* 2002). Very close specimens occur also higher in the section from 5 cm below the concretion level 2G up to 110 cm above the level. Beside typical representatives of the species known up to 110 cm above the concretion level 2G (although some of them differ slightly from typical specimens of the species in having a somewhat narrower umbilicus), there occur also specimens showing fairly dense ribbing which is a typical feature of *A. subkitchini*, but showing rather common biplicate ribs similar to specimens of the younger species *Amoeboceras* (*Amoebites*) *modestum* Mesezhnikov et Romm (see Mesezhnikov and Romm 1973). The specimens may be treated as representative for the higher part of the Kitchini Zone (Wierzbowski *et al.* 2002).

Three specimens attaining about 30 mm in diameter were found from 110 cm to 120 cm above concretion level 2G. The specimens are very coarsely ribbed (Pl. 2: 8), showing strong ventrolateral nodes on the last whorl. They show close similarity to the lectotype of the species *Amoeboceras* (*Amoebites*) *kitchini* Salfeld and can be safely placed in that species. The occurrence of *A. kitchini* is indicative of the upper part of the Kitchini Zone – the Modestum Subzone (Wierzbowski *et al.* 2002; see also Wierzbowski and Smelror 1993).

The youngest *Amoeboceras* of the section occur from 270 cm above the concretion level G up to about 50 cm above the silty clay layer 2E. All the better preserved specimens show strong ornamentation with ventrolateral nodes, but lateral nodes are usually also well developed (Fig. 3: 1-2). These specimens represent mostly *Amoeboceras* (*Hoplocardioceras*) *elegans* Spath/*A.* cf. *elegans* Spath – the species showing close affinity to *A.* (*Hoplocardioceras*) *decipiens* Spath and occurring in the same beds in the Boreal Province (Wierzbowski 1989; Wierzbowski and Smelror 1993). Both are characteristic of the Elegans Zone – the highest *Amoeboceras* zone of the Boreal Kimmeridgian (Wierzbowski and Smelror 1993).

CONCLUSIONS

The specimens of *Amoeboceras* studied, from the Nordvik section in northern Siberia, enable recognition of the standard Boreal ammonite zones

(and some of the subzones) of the Upper Oxfordian and Kimmeridgian (Fig. 2). Those of the Upper Oxfordian (*cf*. Sykes and Callomon 1979) include: the Glosense Zone (with the Ilovaiskii Subzone below and the Glosense Subzone above), the Serratum Zone (with the Koldeweyense Subzone), the Regulare Zone, and the Rosenkrantzi Zone. The Kimmeridgian ammonite zones (*cf*. Wierzbowski and Smelror 1993; Wierzbowski *et al*. 2002) include: the Bauhini Zone, the Kitchini Zone (with the Subkitchini Subzone below, and the Modestum Subzone above), and the Elegans Zone. The Kochi Zone is the only standard zone of the Kimmeridgian not recognized in the material studied, but the interval possibly corresponding to this zone has not yielded recognizable ammonites; it should be remembered, however, that the specimen referred to as *Amoeboceras* (?*Euprionoceras*) cf. *aldingeri* Spath by Voronetz (1962, pl. 29: 3), and coming possibly from the interval in question in the Nordvik section, is possibly *Amoeboceras* (*Euprionoceras*) *kochi* Spath, and may be indicative of the Kochi Zone. The recognition of the standard *Amoeboceras* zones (and many of the subzones) in northern Siberia well known in NW Europe, Greenland, and the Barents Sea area indicates the uniform character of Late Oxfordian to Kimmeridgian ammonite faunas in the Boreal Province. The same stratigraphical interpretation of the Middle and Upper Oxfordian cardioceratid faunas in the East Taimyr section was given also by Aleynikov and Meledina (1993).

The section studied has also yielded representatives of the Boreal branch of the oppeliid family – the genus *Suboxydiscites*. These ammonites, although poorly preserved, appear for the first time 40 cm above concretion level 2G, and continue upwards ranging throught level 2E. They appear thus for the first time in the upper part of the Kitchini Zone of the Kimmeridgian and continue up into the Elegans Zone (Rogov and Wierzbowski 2006). In the section studied at Nordvik *Suboxydiscites* is represented both by microconchs and macroconchs. A detailed description will be presented elsewhere.

The ammonites of the genus *Suboxydiscites* represent a group of oppeliids of southern roots (*Ochetoceras*, see Poulton *et al*. 1988; see also Rogov 2001) that colonized the Boreal Province during the Kimmeridgian. The oldest representatives of the genus known so far have been reported from the horizon with Boreal *Amoeboceras bauhini* in the Hauffianum Subzone of the Bimammatum Zone of the Submediterranean Succession in southern Germany (Schweigert and Jantschke 2001), and it is an open question whether they are Boreal invaders, or just ancestors of the Boreal lineage of Submediterranean origin.

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