VOLUMINA JURASSICA, 2010, VIII: 5–48

The Middle Oxfordian to lowermost Kimmeridgian ammonite succession at Mikhalenino (Kostroma District) of the Russian Platform, and its stratigraphical and palaeobiogeographical importance

Ewa GŁOWNIAK[1], Dmitry N. KISELEV[2], Mikhail ROGOV[3], Andrzej WIERZBOWSKI[1], John K. WRIGHT[4]

Key words: ammonites, biostratigraphy, Boreal zonation, Subboreal zonation, Submediterranean zonation, correlation, Oxfordian/ Kimmeridgian boundary.

Abstract. The Mikhalenino section on the Russian Platform has yielded numerous ammonites from the Middle and Upper Oxfordian and lowermost Kimmeridgian, collected bed by bed. The ammonites belong mostly to the Boreal family Cardioceratidae, but also to the Subboreal family Aulacostephanidae; additionally at some levels there were collected various Submediterranean ammonites (Perisphinctidae, Oppeliidae and Aspidoceratidae). The co-occurrence of ammonites representative of different faunal provinces makes possible recognition of the Boreal, Subboreal, and partly also Submediterranean standard zonations. In consequence, it is possible to make a close correlation between these zonal schemes.

The Oxfordian/Kimmeridgian boundary at the Pseudocordata/Baylei zonal boundary of the Subboreal zonal scheme corresponds precisely to the Rosenkrantzi/Bauhini zonal boundary. This boundary of the stages defined well faunistically in the Flodigarry section (Isle of Skye, Scotland) and proposed as a candidate for the uniform Oxfordian/Kimmeridgian boundary, can be also recognized in the Russian section studied. The boundary can be traced in the Mikhalenino section using the same criteria as used at Staffin: the appearance of the first representatives of *Pictonia* [M]–*Prorasenia* [m] (Subboreal), and the first appearance of *Amoeboceras* (*Plasmatites*) (Boreal). This indicates the large correlation potential of the boundary defined in this way. The research on the Mikhalenino section has provided the new palaeontological findings described in this study. These include the first discovery in the territory of the Russian Platform of ammonites of the genera/subgenera *Decipia*, *Vineta* and *Pomerania* (*Pachypictonia*). Two new species: *Decipia* (?) *kostromensis* sp. nov., and *Pictonia mesezhnikovi* n. sp. are described.

INTRODUCTION

The Oxfordian and lowermost Kimmeridgian deposits which crop out along the Unzha River of the Kostroma District, about 500 km north-east of Moscow, although generally of small thickness, are stratigraphically among the most complete of the Russian Platform, and thus are especially important for wider correlations and palaeobiogeography. These deposits have been studied for more than 120 years (Nikitin, 1884; Ivanov, 1909; Zhirmunskyj, 1914; Sokolov, 1929; Spijarski, 1932; Krom, 1933; Gerasimov, 1972), and the results of these investigations were of major importance for the general foundation of the Oxfordian and Kimmeridgian stratigraphy of the whole Russian Platform. The detailed succession of ammonites of the Boreal family Cardioceratidae in the Middle and Upper Oxfordian (as well as the lowermost Kimmeridgian according to the stratigraphical interpretation in the present study) has been recognized only recently by Mesezhnikov *et al.* (1986, 1989), and Mesezhnikov and Kalacheva (1989). These studies resulted

[1] Institute of Geology, University of Warsaw, ul. Żwirki i Wigury 93, 02-089 Warszawa, Poland; e-mail: glowniak_ek@uw.edu.pl, andrzej.wierzbowski@uw.edu.pl

[2] Geographical Department, Yaroslavl State Pedagogical University, Kotoroslnaya nab. 46, Yaroslavl 150000, Russia; e-mail: dnkiselev@mail.ru

[3] Geological Institute of Russian Academy of Sciences, Pyshevskii Lane 7, Moscow 109017, Russia; e-mail: russianjurassic@gmail.com

[4] Department of Geology, Royal Holloway, Egham, Surrey, TW20 OEX, UK; e-mail: j.wright@es.rhul.ac.uk

in the recognition of the succession as a key one for elaboration of the Upper Oxfordian–Lower Kimmeridgian Boreal ammonite zonal scheme and the relevant foraminiferal zonal scheme for the Russian Platform (Mesezhnikov *et al.*, 1989; Grigelis, 1982). The other ammonite groups (Perisphinctidae and Aulacostephanidae), although reported previously in the interval studied, have not been described in detail so far. The co-occurrence of ammonites belonging to families of Boreal (Cardioceratidae), Subboreal (Aulacostephanidae) and Submediterranean (mostly Perisphinctidae) affinity in the succession studied is of great importance for correlation of the different zonal schemes recognized in particular ammonite provinces of Europe.

The best sections of the Oxfordian to lowermost Kimmeridgian deposits are afforded by the banks of the Unzha River, the left tributary of the Volga (Fig. 1). These sections, described by Mesezhnikov *et al.* (1986, 1989) and subsequently discussed by Hantzpergue *et al.* (1998a, b), are situated close to the town of Makariev. The section studied by the present authors is located on the right bank of the Unzha River, about 15 kilometers to the north of Makariev, near the village of Mikhalenino. The section was recognized for the first time by Rogov and Kiselev (2007; but note also the earlier description of some gastropods from the section by Guzhov, 2004), and demonstrated during a field-trip for the participants of the International Kimmeridgian W.G. Meeting in Russia in June 2007. The results presented in this paper are based on the field-work carried at Mikhalenino during this field-meeting, as well as on the previous studies of Rogov and Kiselev (2007) on the same section. The section has been revisited by the authors in June 2010 when supplementary field work was carried aut. The stratigraphical distribution of ostracods and foraminifers in the Mikhalenino section using the ammonite stratigraphy of the current study has been recently presented by Tesakova and Guzhov (2009) and by Ustinova (2009a, b).

THE DETAILS OF THE SECTION STUDIED: LITHOLOGY AND AMMONITES

The deposits are exposed in the steep bank of the Unzha river valley, and are flat lying. Slumping often obscures the succession, and the state of the section can vary from year to year. The full succession exposed in 2006 from Middle Oxfordian to lowermost Kimmeridgian consisted of 10.25 m of dark silty and shaly clays (beds 1 to 29 according to Rogov, Kiselev, 2007). The section studied in 2007 by the authors showed well-exposed deposits from bed 1 upwards to bed 21 covering the interval from the Middle Oxfordian to the lowermost Kimmeridgian (about 5 meters in thickness) with the interval corresponding to beds 22–27 of Rogov and Kiselev (2007) obscured, and the topmost part

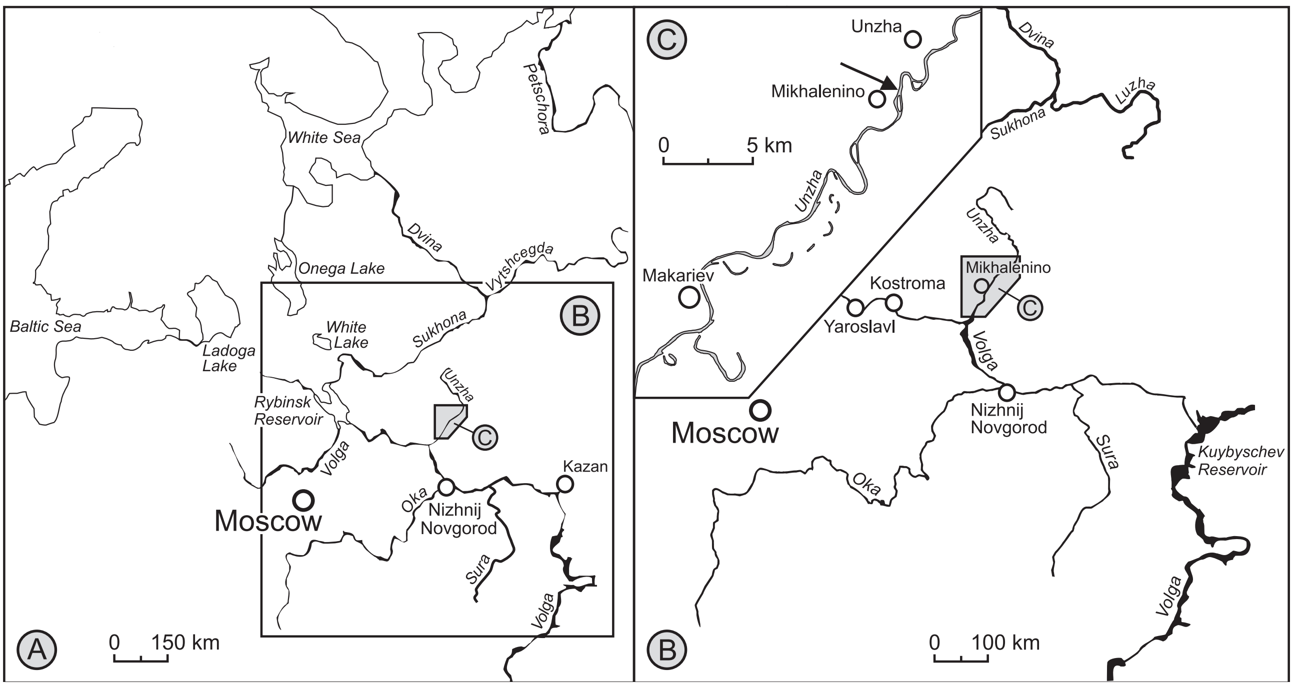


Fig. 1. Locality map of the Mikhalenino section as well as other localities discussed in the text (B–C), and their position in northern Europe (A)

of the section (beds 28–29 of the Lower Kimmeridgian) exposed to about 1.9 m in thickness. The ammonites were collected carefully bed by bed. The following lithologies and ammonites have been recognized in the section studied (Figs 2–4).

Bed 1: grey-greenish silty clays, bioturbated, containing ammonites: *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden, *C.* (*Plasmatoceras*) ex gr. *popilaniense* Boden, *C.* (*Scoticardioceras*) *laevigatum* Boden; 0.2–0.3 m (base not visible).

Bed 2: grey-greenish silty clays, bioturbated, containing ammonites: *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden, *C.* (*Plasmatoceras*) cf. *tenuicostatum* (Nikitin), *C.* (*Scoticardioceras*) *laevigatum* Boden, *C.* (*Vertebriceras*) cf. *rachis* Buckman; 0.28–0.30 m.

Bed 3: grey silty clays, bioturbated near the top, containing ammonites: *Cardioceras* (*Cawtoniceras*) *cawtonense* (Blake et Huddleston) (Pl. 2: 4–4a), *Perisphinctes* (*Otosphinctes*) cf. *arkelli* Głowniak (Pl. 2: 1, 2), *P.* (*Kranaosphinctes*) sp., *Euaspidoceras* sp. and *Taramelliceras* cf. *dentostriatum* (Quenstedt) (Pl. 2: 5), *Taramelliceras* sp. and *Glochiceras* sp.; 0.28–0.30 m.

Bed 4: grey silty clays, bioturbated in the upper part of the bed, with glauconite, containing ammonites: *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel), *C.* (*Subvertebriceras*) sp.; 0.25 m.

Bed 5: grey, locally greenish silty clays with glauconite, containing ammonites: *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel), *C.* (*Cawtoniceras*) cf. *blakei* Spath, *C.* (*Subvertebriceras*) sp. (Pl. 2: 3); 0.15–0.17 m.

Bed 6: grey silty clays containing ammonites: *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel) (Pl. 2: 6), *C.* (*Miticardioceras*) sp., *C.* (*Cawtoniceras*) *blakei* Spath; 0.25 m.

Bed 7: grey to black, highly bioturbated clays containing ammonites: *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel), *C.* (*Cawtoniceras*) *blakei* Spath; 0.08 m.

Bed 8: is a fossiliferous horizon of bituminous oil shales with *Chondrites*, with ammonites: *Decipia* (?) *kostromensis* sp. nov. (Pl. 2: 8, 9), *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz (Pl. 1: 2–5; Pl. 3: 1a, b), *P.* (*D.*) *luciae* de Riaz, *P.* (*D.*) *luciaeformis* Enay (Pl. 1: 1), *Amoeboceras* (*Amoeboceras*) *ilovaiskii* (Sokolov) (Pl. 2: 10; Pl. 3: 2–4), *A.* cf. *ilovaiskii* (Sokolov), *Amoeboceras* (*A.*) *transitorium* Spath (Pl. 2: 7), *A.* cf. *transitorium* Spath; 0.13 m.

Bed 9: grey silty clays with ammonites: *Amoeboceras* (*Amoeboceras*) *ilovaiskii* (Sokolov) (Pl. 3: 5), *A.* cf. *ilovaiskii* (Sokolov), *A.* cf. *transitorium* Spath; 0.12 m.

Bed 10: grey clays with ammonites: *Amoeboceras glosense* (Bigot et Brasil) (Pl. 4: 1); 0.27 m.

Ammonites found in a loose block in the rubble coming from beds 9–10 (but without precise location) include: *Decipia* cf. *decipiens* (Sowerby) (Pl. 3: 7) and *Amoeboceras* (*A.*) *ilovaiskii* (Sokolov) (Pl. 3: 6).

Beds 11–12: light grey-greenish silty clays, highly bioturbated (*Chondrites*) in the lowest part (0.07 m), followed by a non-bioturbated interval (0.06 m) – together representing bed 11, whereas more highly bioturbated interval (*Chondrites*) in the upper part (0.17 m) is recognized as bed 12; the ammonites from bed 11 include *Perisphinctes* (*Perisphinctes*) sp. (Pl. 8: 1); the ammonites from bed 12 include: *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatoides* Enay (Pl. 4: 12, 13), *P.* (*D.*) cf. *wartae* Bukowski, *P.* (*D.*) sp. juv., *Amoeboceras nunningtonense* Wright (Pl. 4: 2), *A.* cf. *nunningtonense* Wright; total thickness of beds 11–12 equals 0.30 m.

Bed 13: light grey-greenish highly bioturbated silty clays with common phosphorites at the top; ammonites: *Perisphinctes* (*Dichotomoceras*) sp. juv., *P*. (*Dichotomoceras*) cf. *bifurcatoides*, *Amoeboceras glosense* (Bigot et Brasil), found within the bed, and *Amoeboceras koldeweyense* Sykes et Callomon (Pl. 4: 3), found at its top and directly below the base of bed 14; 0.07–0.09 m.

Bed 14: grey, silty, shaly clays that become green 0.03 m below the top and contain abundant belemnite rostra; ammonites: *Ringsteadia* sp., and *Amoeboceras* ex gr. *regulare* Spath from the middle part of the bed, and *Ringsteadia* sp., *Perisphinctes* (*Perisphinctes*) sp. (Pl. 6: 2a, b), *Amoeboceras pectinatum* Mesezhnikov (Pl. 4: 4) coming from the uppermost part of the bed; 0.21–0.23 m.

Bed 15: light grey silty clays, bioturbated in the lower part (*Chondrites*); at the top thin green glauconitic intercalations and small phosphorite nodules; ammonites from the lowermost part of the bed (up to 0.07 m above the base) include: *Amoeboceras regulare* Spath, and *Ringsteadia* sp. (Pl. 4: 14); still higher in the bed – *Amoeboceras rosenkrantzi* Spath (Pl. 4: 5); 0.30 m.

Bed 16: grey silty shaly clays, bioturbated in the lower part of the bed, containing ammonites: *Microbiplices microbiplex* (Quenstedt) (Pl. 4: 16), *M.* cf. *anglicus* Arkell (Pl. 4: 15), *Ringsteadia* sp., *Amoeboceras* sp. cf. *marstonense* Spath; 0.13 m.

Bed 17: dark grey massive clays, heavily bioturbated (*Chondrites*); in the middle, a horizon rich in ammonite shells, belemnites, and glauconite, 0.15 m in thickness; ammonites from lowermost part of the bed include: *Microbiplices*/*Prorasenia* trans. form (Pl. 4: 17), ?*Microbiplices* sp., *Ringsteadia* sp., *Amoeboceras tuberculatoalternans* (Nikitin) (Pl. 4: 8); from

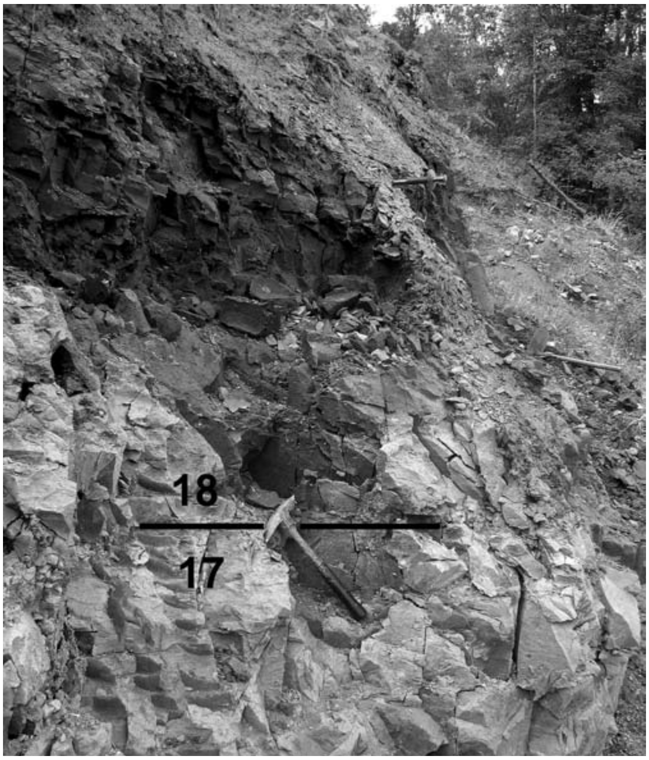


Fig. 2. Massive clay beds at the boundary of beds 17 and 18 (indicated by a hammer) of the Mikhalenino section

the middle part of the bed come: *Pictonia* sp. (Pl. 4: 18), *Amoeboceras* (*Plasmatites*) cf. *lineatum* (Quenstedt), *A.* (*P.*) aff. *bauhini* (Oppel) (Pl. 4: 6), *Amoeboceras* cf. *rosenkrantzi* Spath and *Amoeboceras schulginae* Meseznikov (Pl. 4: 7); whereas from the topmost 0.1 m of the bed come – *Amoeboceras* (*Plasmatites*) *bauhini* (Oppel) (Pl. 4: 9–11) and *Prorasenia* sp. (Pl. 4: 19); a large specimen of *Vineta* (*V. jaekeli* Dohm) (Pl. 5: 13; Pl. 8: 2) was found, moreover, at the top of the bed. Rogov and Kiselev (2007, pl. 4: 1, 2) recorded a large *Ringsteadia* referred by them to as *R.* cf. *anglica*, but which is *R. brandesi* Salfeld (Pl. 6: 1a, b; see also Wright, 2010), probably from the lower part of bed 17; 0.4 m.

Bed 18: dark grey silty clays, bioturbated towards the top, and with numerous belemnite rostra and phosphorites; ammonites from lowermost part of the bed include: *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt) (Pl. 5: 2), *Prorasenia* sp. (Pl. 5: 9); in the higher part of the bed (down to 0.1 m from the top) were found moreover: *Amoboceras* (*Plasmatites*) *bauhini* (Oppel), *A.* (*P.*) *praebauhini* (Salfeld) (Pl. 5: 1); 0.19 m.

Bed 19: black to dark grey silty clays, bioturbated (*Chondrites*) and with marked concentrations of fossils (especially ammonites and belemnites) at 0.10, 0.20 and 0.30 m above the base of the bed; phosphorites at the base and about 0.20–0.25 m upwards; ammonites collected in the middle and upper parts of the bed include: *Vineta* sp. (Pl. 5: 11, 12), *Prorasenia* sp., *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt) (Pl. 5: 3, 4), *Amoeboceras* aff. *schulginae* Mesezhnikov (Pl. 5: 5); a large specimen of *Pictonia mesezhnikovi* sp. nov. (Pl. 5: 14; Pl. 7: 2) has been found, moreover, 0.2 m below the top of the bed. Rogov and Kiselev (2007) reported from this bed a large specimen of *Pachypictonia* which is *Pomerania* (*Pachypictonia*) *peltata* (Schneid) (Pl. 7: 1), as well as *Pictonia* sp.; 0.57 m.

Bed 20: dark grey shaly clays; 0.1 m.

Bed 21: grey silty clays with pyrite nodules containing ammonites: *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt) – in the lowermost part of the bed, up to 0.15 m above its base; and *Amoeboceras* (*Amoebites*) cf. *bayi* Birkelund et Callomon – directly above, at 0.25–0.30 m above the base (Rogov, Kiselev, 2007); a large *Pomerania* (*Pachypictonia*) *peltata* (Schneid) found, moreover, in the lower part of the bed; 0.65 m.

Beds 22–24: dark grey and grey clays bioturbated with small pyrite nodules (bed 22) and phosphorites (beds 23 and 24) representing part of the interval of the section not exposed in June 2007; ammonites reported by Rogov and Kiselev (2007) included infrequent representatives of *Prorasenia*; total thickness of the deposits equals 2.20 m: bed 22 – 0.65 m, bed 23 – 0.65 m, bed 24 – 0.9 m (Rogov, Kiselev, 2007).

Bed 25: grey clays with numerous lenses of shell detritus, and levels of phosphorites recognized at 0.1, 0.4 and 0.75 m above the base of the bed, with ammonites (Rogov, Kiselev, 2007): *Amoeboceras* (*Amoebites*) *bayi* Birkelund et Callomon and *Prorasenia* sp.; thickness of the bed is about 1 m.

Bed 26: dark grey clays with pyrite nodules and phosphorites at the top, containing ammonites (Rogov, Kiselev, 2007): *Amoeboceras* (*Amoebites*) *bayi* Birkelund et Callomon, *Prorasenia* sp., and a single specimen of *Aspidoceras* sp. (Pl. 5: 15) and *Laevaptychus* sp.; 0.3–0.4 m.

Bed 27: level with grey calcareous septarian concretion with *Pomerania* (*Pachypictonia*) sp., *Prorasenia* sp. and *Amoeboceras* (*Amoebites*) sp.; 0.1–0.3 m.

Beds 28–29: grey and dark grey clays without phosphorites below (bed 28 – thickness 0.75–0.80 m) and with phosphorites above (bed 29 – thickness 1.1 m) containing ammonites *Amoeboceras* (*Amoebites*) *bayi* Birkelund et Callomon (Pl. 5: 6–8), *Amoeboceras* cf. *cricki* (Salfeld) and *Prorasenia* sp. (Pl. 5: 10), as well as the first representatives of the genus *Rasenia* (*R.* cf. *inconstans* Spath) (Pl. 5: 16, 17) as reported by Rogov and Kiselev (2007) both from beds 28 and 29.

AMMONITE STRATIGRAPHY

The section at Mikhalenino has yielded ammonites of the families Cardioceratidae, Aulacostephanidae and Perisphinctidae (as well as Oppeliidae and Aspidoceratidae). The succession of ammonites of each of these families is stratigraphically interpreted below in terms of the standard ammonite zones and subzones typical of the separate subdivisions corresponding to particular ammonite provinces – the Boreal, Subboreal and Submediterranean ones.

BOREAL SUCCESSION

The Boreal succession is characterized by ammonites of the family Cardioceratidae – the genus *Cardioceras* phylogenetically followed by the genus *Amoeboceras.* The section at Mikhalenino yielded abundant ammonites of this family in the whole interval studied (Figs 3, 4). Some additional information is also given below on the succession of these ammonites in the neighbouring section at Makariev according to the description of Mesezhnikov *et al.* (1986, 1989); see also some ammonites of the section illustrated by Rotkyte (1987): its correlation with the Mikhalenino section, and in a few cases the palaeontological reinterpretation of some ammonites from the Makariev section are also discussed below.

The fauna of *Cardioceras* in the Mikhalenino section comes from beds 1–7. An older fauna consists of *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden, representatives of the *Cardioceras* (*Plasmatoceras*) *tenuicostatum* group – like *C.* (*P.*) *tenuicostatum* (Nikitin) and *C.* (*P.*) ex gr. *popilaniense* Boden, as well as of *Cardioceras* (*Scoticardioceras*) *laevigatum* Boden found in beds 1 and 2, and *Cardioceras* (*Vertebriceras*) cf. *rachis* Buckman found in bed 2. This fauna is indicative of the Tenuicostatum Subzone of Salfeld (1914) – roughly (?partly) equivalent to the Vertebrale Subzone – the lower subzone of the Densiplicatum Zone of Sykes and Callomon (1979). From bed 3 comes only *Cardioceras* (*Cawtoniceras*) *cawtonense* (Blake et Huddleston), but without any representatives of *Plasmatoceras* and *C.* (*S.*) *densiplicatum*, which indicates either the upper part of the Densiplicatum Zone – the Maltonense Subzone or already the Tenuiserratum Zone (*cf.* Sykes, Callomon, 1979).

A younger *Cardioceras* fauna consists of *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel) found in beds 4–7, as well as *Cardioceras* (*Cawtoniceras*) *blakei* Spath found in beds 5–7; additionally *Cardioceras* (*Subvertebriceras*) occurs in beds 4–5. These ammonites are indicative of the Tenuiserratum Zone of the uppermost Middle Oxfordian.

The total thickness of the Middle Oxfordian deposits cropping out in the Mikhalenino section is about 1.5 to 1.7 m: with the Densiplicatum Zone attaining at least (base not exposed): 0.48–0.60 m or even 0.76–0.90 m (if bed 3 is included in this zone), and the Tenuiserratum Zone: about 0.73–0.77 m in thickness (or even 1.0–1.05 m if bed 3 is included in the zone). Similar faunas with *Cardioceras* (*Subvertebriceras*) *densiplicatum* and *C.* (*Plasmatoceras*) indicative of the Densiplicatum Zone, as well as one consisting of *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel) and *C.* (*Subvertebriceras*) *zenaidae* Ilovaisky indicating the Tenuiserratum Zone, have been recognized by Mesezhnikov *et al.* (1986, 1989: beds 4*a*, 5*б*) in the Makariev section where the corresponding deposits attain about 2.5 and 0.5 m in thickness, respectively.

The oldest fauna of *Amoeboceras* consisting of *Amoeboceras ilovaiskii* (Sokolov) – *A.* cf. *ilovaiskii* (Sokolov) and *A. transitorium* Spath – *A.* cf. *transitorium* Spath was found in beds 8–9 of the Mikhalenino section. The fauna is indicative of the lowermost Upper Oxfordian – the lower part of the Glosense Zone – the Ilovaiskii Subzone (*cf.* Sykes, Callomon, 1979). The deposits of the subzone attain only 0.25 m in thickness, and are developed in its lower part as black “oil shales” (bed 8), followed by grey silty clays. The same fauna containing *Amoeboceras ilovaiskii* has been recognized also in the Makariev section where it occurs also in “dark bituminous shales”, about 0.2–0.4 m in thickness (Mesezhnikov *et al.*, 1986, 1989: bed 5) showing a high organic content (ranging up to 11–19% TOC after Hantzpergue *et al.*, 1998b; and 10.4–15.5% after Bushnev *et al.*, 2006).

A younger *Amoeboceras* fauna consisting of *Amoeboceras glosense* (Bigot et Brasil) and *A. nunningtonense* Wright was found in beds 10–13 in the Mikhalenino section. It is indicative of the upper part of the Glosense Zone – the Glosense Subzone (*cf*. Sykes, Callomon, 1979). The deposits of the subzone attain about 0.65 m.

Previously, the Glosense Subzone was not unequivocally recognized in the Makariev section. Here, deposits attaining about 0.50 m in thickness, containing *A. ilovaiskii*, but also *A.* cf. *damoni* Spath and *A.* cf. *glosense* (Bigot et Brasil), and even *A.* cf. *koldeweyense* Sykes et Callomon, have been attributed (Mesezhnikov *et al.*, 1986, 1989: beds 6*a*, *б)* to an upper part of the Amoeboceras alternoides Zone correlated with the upper part of the Glosense Zone – *i.e.* with the Glosense Subzone (Mesezhnikov *et al.*, 1986, 1989); on the other hand, according to Hantzpergue *et al.* (1998a, b), the Glosense Subzone itself “was not clearly identified” in the Makariev section. It should be remembered, however, that of the reported faunal assemblage from the Makariev section, the ammonites illustrated (Mesezhnikov *et al.*, 1986,

1989) include, in addition to undoubted representatives of *A. ilovaiskii*, specimens which represent *A. glosense* (as for example the specimen referred to as *Amoeboceras alternoides* by Mesezhnikov *et al.*, 1989: pl. 15: 3). These data indicate that the deposits in question in the Makariev section may be in fact easily attributed to the Glosense Subzone.

Bed 13 of the Mikhalenino section, 0.07–0.09 m in thickness, yielded *Amoeboceras koldeweyense* Sykes et Callomon found at the top of the bed, and indicative of the lower part of the Serratum Zone – the Koldeweyense Subzone (Sykes, Callomon, 1979). Similar deposits were recognized in the Makariev section (Mesezhnikov *et al.*, 1986, 1989: bed 6*в* about 0.15–0.20 m in thickness) yielding ammonites of the lower part of the Serratum Zone, *i.a. Amoeboceras koldeweyense* Sykes et Callomon (see Mesezhnikov *et al.*, 1989, pl. 10: 7).

A younger fauna of *Amoeboceras* was found in the upper 0.1 metre of bed 14 of the Mikhalenino section. It consists of densely ribbed non-tuberculate specimens (Pl. 4: 4), revealing a marked similarity to *Amoeboceras pectinatum* Mesezhnikov (see Mesezhnikov, 1967, pp. 124, 125, pl. 4: 2, 4). The stratigraphical range of this form is limited according to Mesezhnikov (1967) to his Ravni Zone which corresponds both to the Regulare Zone and the Rosenkrantzi Zone of the standard Boreal subdivision (*cf*. Matyja *et al.*, 2006). There occur small specimens, moreover, which can be attributed to the *Amoeboceras regulare* group, although their affiliation to particular species is difficult. These indicate that the upper part of bed 14 in the Mikhalenino section corresponds already to the Regulare Zone, whereas the lower part of bed 14, which does not yield any identifiable ammonites, could correspond to the Regulare Zone and/or upper part of the Serratum Zone. The Regulare Zone continues upwards in the Mikhalenino section where in a lower part of bed 15 (0.07 m from the base) has been found *Amoeboceras regulare* Spath. Because the higher part of bed 15 yielded already *Amoeboceras rosenkrantzi* Spath indicative of the Rosenkrantzi Zone of the Boreal uppermost Oxfordian, the total thickness of the Regulare Zone in the Mikhalenino section ranges over at least 0.17 m, but it may be somewhat larger covering at least partly a lower part of bed 14 – about 0.11–0.13 m in thickness. In any case the interval from the top of bed 13 up to the lower part of bed 15, about 0.30 m thick, rich in phosphorites, shows a stratigraphically highly condensed fragment of the sequence corresponding to the Regulare Zone, and presumably to the upper part of the Serratum Zone.

The ammonite fauna occurring in beds 6*г*–7*б* of the Makariev section of Mesezhnikov *et al.* (1986, 1989), about 0.35–0.40 m in thickness, directly above the fauna with *A. koldeweyense*, consists of such forms as *A.* cf. *tuberculatoalternans* (Nikitin), *A.* cf. *ovale* (Quenstedt) and *A.* ex gr. *serratum* (Sowerby). This fauna was placed in the Serratum Zone both by Mesezhnikov *et al.* (1986, 1989) and Hantzpergue *et al.* (1998a, b). It should be noted, however, that the specimen illustrated from bed 6*г* of the Makariev section by Mesezhnikov *et al.* (1989, pl. 18: 7) and referred to as *Amoeboceras serratum* (Sowerby) does not belong to this species, but seems very close to *Amoeboceras pectinatum* Mesezhnikov. On the other hand, both *A. ovale* and *A. tuberculatoalternans* are typical of the Regulare to Rosenkrantzi zones, and not of the Serratum Zone (*e.g*. Atrops *et al.*, 1993). Thus, it seems highly probable that the deposits in question from the Makariev section do not correspond to the Serratum Zone, but to the Regulare and Rosenkrantzi zones.

The ammonite fauna of the Rosenkrantzi Zone of the uppermost Boreal Oxfordian consists in the Mikhalenino section of *Amoeboceras rosenkrantzi* Spath from upper part of bed 15, *Amoeboceras* cf. *marstonense* Spath from bed 16, and *Amoeboceras tuberculatoalternans* (Nikitin) from lower part of bed 17. The Rosenkrantzi Zone attains at least about 0.4 m in thickness, and its top is marked in the middle part of bed 17 by the first occurrence of small-sized *Amoeboceras* of the subgenus *Plasmatites* indicative already of the Bauhini Zone of the lowermost Kimmeridgian (see Matyja *et al.*, 2006; Wierzbowski *et al.*, 2006). The total thickness of the Upper Oxfordian deposits is about 1.70 m.

The upper boundary of the Rosenkrantzi Zone in the Makariev section runs at the base of bed 7*в*, which has yielded the first representative of *Plasmatites* (*cf*. Mesezhnikov *et al.*, 1986, 1989). Here, the total thickness of the Upper Oxfordian deposits is about 1.4 m.

The Bauhini Zone of the lowermost Kimmeridgian is well represented in the Mikhalenino section. The oldest ammonites characteristic of this zone, *Amoeboceras* (*Plasmatites*) cf. *lineatum* (Quenstedt), *A.* (*P.*) aff. *bauhini* (Oppel), *A.* cf. *rosenkrantzi* Spath and *A. schulginae* Mesezhnikov, were found in the middle part of bed 17, which shows sedimentological features of condensation. This part of the section, which is only about 0.15 cm in thickness, corresponds to the lowest part of the Bauhini Zone and is characterized by the co-occurrence of the first *Plasmatites* with the last representatives of large *Amoeboceras* such as *A. rosenkrantzi* and *A. schulginae* (see Matyja *et al.*, 2006; Wierzbowski *et al.*, 2006).

Various representatives of the subgenus *Plasmatites* representing closely allied forms such as *Amoeboceras* (*Plasmatites*) *bauhini* (Oppel) (Pl. 4: 9–11) – including the closely related *A. gerassimovi* Kalacheva et Mesezhnikov (see palaeontological part herein), *A.* (*P.*) *praebauhini* (Salfeld) and *A.* (*P.*) *lineatum* (Quenstedt) – are known from younger beds of the Mikhalenino section (from the upper part of bed 17, through beds 18 and 19, up to bed 21 – presumably its lower part only). These ammonites are associated

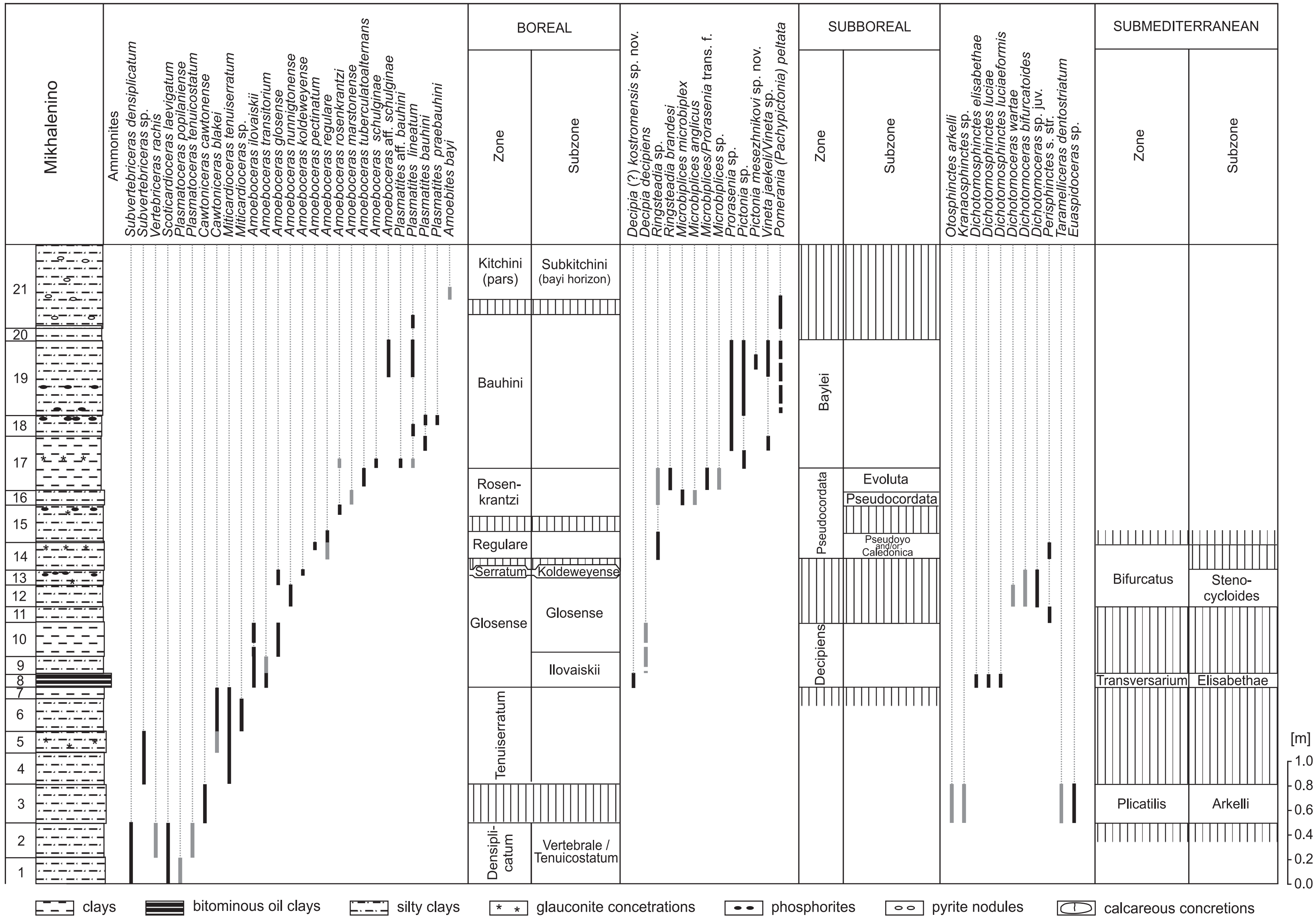


Fig. 3. Ammonite distribution in beds 1–21 of the Mikhalenino section and its chronostratigraphic interpretation

Ammonite distribution – grey bars are referred to *cf.* species; **chronostratigraphy** – striped parts indicate the interval of uncertain correlation; continuous lines indicate precise stratigraphical range, hatched lines indicate approximate stratigraphical range with *Amoeboceras* aff. *schulginae* Mesezhnikov found in the middle–upper parts of bed 19: the latter corresponds to the form *A.* aff. *schulginae* described from the Bauhini Zone of Scotland and other Boreal localities (see Wierzbowski, Smelror, 1993; Matyja *et al.*, 2006). The whole assemblage studied, consisting of *Plasmatites* and *A.* aff. *schulginae*, is thus typical of the middle–upper parts of the Bauhini Zone (see Matyja *et al.*, 2006), attaining about 1 m in thickness.

From bed 21 – presumably its upper part – came small--sized *Amoeboceras* (*Amoebites*) cf. *bayi* Birkelund et Callomon. The same ammonite fauna consisting of *Amoeboceras* (*Amoebites*) *bayi* is known from younger deposits – beds 25–26 (Rogov, Kiselev, 2007) and beds 28–29. All these deposits, about 6 m in thickness, represent the lowermost part of the Kitchini Zone – the Subkitchini Subzone – the *bayi* horizon (Wierzbowski, Smelror, 1993; Wierzbowski *et al.*, 2002; Matyja *et al.*, 2006; see also Birkelund, Callomon, 1985). It is worth stressing the marked increase in thickness of the deposits of the faunal horizon discussed when compared with the thickness of older deposits in the section (see Fig. 4).

In their measured section of these deposits at Makariev, Mesezhnikov *et al.* (1986, 1989) list several beds (7*в–з* of total thickness about 1.1 m) yielding ammonites of the subgenus *Plasmatites* such as *A.* (*P.*) *lineatum* (Quenstedt) and *A. gerassimovi* Kalacheva et Mesezhnikov – closely related to *A.* (*P.*) *bauhini* (Oppel) (see also palaeontological part herein). Here also belongs specimen referred to as *Amoebocearas* (*Plasmatites*) cf. *crenulatus* Buckman by Rotkyte (1987, pp. 51, 52, pl. 15: 3a–b). These deposits were attributed by Mesezhnikov *et al.* (1986, 1989) and Mesezhnikov and Kalacheva (1989) to the lower and middle parts of the Amoeboceras ravni Zone. It should be remembered that the Amoeboceras ravni Zone, as originally distinguished in Siberian sections, was characterized (Mesezhnikov, 1967) by the occurrence of such ammonites as *Amoeboceras regulare*, *A. leucum*, *A. freboldi*, *A. schulginae* and *A. pectinatum*, an assemblage which thus correlates mostly with those characteristic of the Regulare Zone plus the Rosenkrantzi Zone of the standard Boreal subdivision (Matyja *et al.*, 2006). Because ammonites of the subgenus *Plasmatites* are clearly younger, they cannot be treated as indicative either of the lower–middle part of the Amoeboceras ravni Zone (Mesezhnikov *et al.*, 1989), nor of the Regulare and Rosenkrantzi zones (Hantzpergue *et al.*, 1998a, b), but of the Bauhini Zone (Matyja *et al.*, 2006, p. 399).

The ammonite assemblage in the uppermost part of the Makariev section can be subdivided into two ammonite faunas (*cf.* Mesezhnikov *et al.*, 1986, 1989): an older one containing, beside ammonites of the subgenus *Plasmatites*, other representatives of *Amoeboceras* (beds 7*в–д*), and a younger one containing only representatives of the subgenus *Plasmatites* (beds 7*е–з*). The former fauna contains, according to Mesezhnikov *et al.* (1986, 1989), such species as *Amoeboceras* ex gr. *serratum* (Sowerby), *A. leucum* Spath, *A. freboldi* and *A. tuberculatoalternans* (Nikitin). These taxa differ markedly in their stratigraphical ranges, and their co-occurrence in the same beds is difficult to accept without a marked stratigraphical reworking/condensation which seem rather unlikely. Unfortunately, only some of these forms have been illustrated: *Amoeboceras tuberculatoalternans* (Nikitin) from bed 7*д* (Mesezhnikov *et al.*, 1989, pl. 24: 6, 7), and a specimen referred to as *Amoeboceras freboldi* Spath from bed 7*д* (Mesezhnikov *et al.*, 1989, pl. 23: 4; see also Rotkyte, 1987, pl. 13: 6) – but belonging in fact to *Amoeboceras rosenkrantzi* Spath. The co-occurrence of ammonites of the subgenus *Plasmatites* with *Amoeboceras tuberculatoalternans* and *A. rosenkrantzi* indicates the lowermost part of the Bauhini Zone (*cf.* Matyja *et al.*, 2006), and such a stratigraphical interpretation is presented herein of this older ammonite fauna from the Makariev section. The younger fauna, consisting entirely of representatives of the subgenus *Plasmatites*, indicates a higher part of the Bauhini Zone.

The youngest deposits of the Makariev section, resting directly on the deposits with the *Plasmatites* fauna, yielded ammonites of the subgenus *Amoebites* (Mesezhnikov *et al.*, 1986, 1989) indicative already of the Lower Kimmeridgian Kitchini Zone.

SUBBOREAL SUCCESSION

The Subboreal succession is characterized by ammonites of the family Aulacostephanidae, the genera *Decipia*, *Ringsteadia* and *Pictonia*. Here also belong such forms as *Vineta* and *Pomerania* (Figs 3, 4).

The oldest aulacostephanid fauna, unexpectedly discovered in the Mikhalenino section, consists of *Decipia* (?) *kostromensis* sp. nov. found in bed 8 (Pl. 2: 8, 9) and a single specimen referred to as *Decipia* cf. *decipiens* (Sowerby) (Pl. 3: 7), found in the rubble but coming almost surely from the stratigraphical interval from bed 9 to bed 10 (specimens described in the palaeontological part of this study). These are the first specimens of the genus recognized from the Russian Platform, and are thus important for palaeobiogeographic considerations. Moreover, the new species D. (?) *kostromensis* sp. nov. shows, in comparison with other species of *Decipia* known so far, a more perisphinctoidal appearance, being possibly the oldest known representative of the Aulacostephanidae, important for phylogeny. Ammonites of the genus *Decipia* indicate the Decipiens Zone of an older usage in Northwest Europe (*e.g.* Arkell, 1957), which, however, "as a stratigraphical entity has turned out to be synonymous, more or less with the Cautisnigrae Zone" (*e.g.* Sykes, Callomon, 1979).

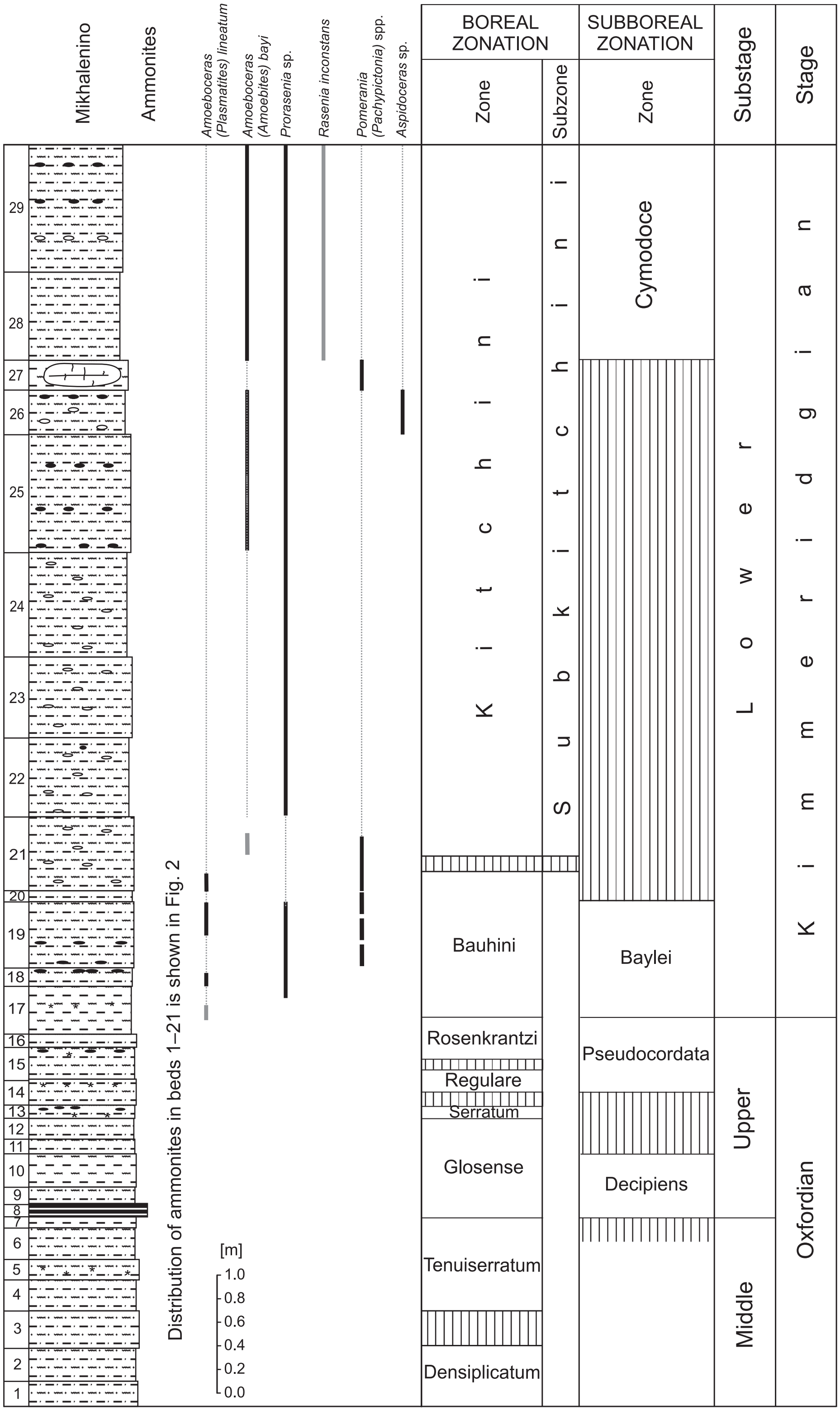


Fig. 4. Chronostratigraphic interpretation of the Mikhalenino section

Beds 1–21 after that shown in Fig. 3; ammonite distribution in beds 22–29 and its chronostratigraphic interpretation is shown in the figure. For explanations see Fig. 3

The oldest specimens of *Ringsteadia* have been found from the middle part of bed 14 to lowermost part of bed 15 directly above its base. These are young specimens and fragments of a larger individual, all of which are difficult for unequivocal attribution to any particular species, but which show similarity to early representatives of the genus, and are thus indicative of a lower part of the Pseudocordata Zone (?Caledonica–Pseudoyo subzones).

Slightly younger ammonite faunas are represented mostly by *Microbiplices* – the microconch counterpart of the genus *Ringsteadia*. These microconchs represented by *Microbiplices microbiplex* (Quenstedt) and *M.* cf. *anglicus* Arkell have been found in bed 16 where they co-occur with poorly preserved ammonites of the genus *Ringsteadia* difficult for precise identification. It should be remembered that *Microbiplices microbiplex* appears in the Pseudoyo Subzone and continues into Pseudocordata Subzone of the Pseudocordata Zone, whereas *M. anglicus* is known from the Pseudocordata Subzone (see Matyja *et al.*, 2006; *cf.* also Wright, 2003): thus, the co-occurrence of these forms is indicative of the Pseudocordata Subzone, and such a stratigraphical interpretation of bed 16 in the Mikhalenino section is presented herein.

Microconch forms transitional between *Microbiplices* and *Prorasenia* define well the uppermost part of the Pseudocordata Zone – the Evoluta Subzone (see Matyja *et al.*, 2006). Such ammonites together with fragments of a large *Ringsteadia* have been found in the lower part of bed 17. A large specimen of *Ringsteadia brandesi* Salfeld referred to bed 17 (*cf.* Rogov, Kiselev, 2007; see also Wright, 2010) comes possibly from that level. Because the middle part of bed 17 yielded already the first ammonites of the genus *Pictonia* indicative of the lowermost Kimmeridgian Baylei Zone, the boundary between the Pseudocordata and Baylei zones, *i.e.* the boundary between the Oxfordian and Kimmeridgian, should be drawn between the lower and middle part of bed 17 of the Mikhalenino section.

The middle part of bed 17 yielded the first representatives of the genus *Pictonia* indicative of the Baylei Zone of the Lower Kimmeridgian (Matyja *et al.*, 2006). These ammonites have been found also in younger beds up to the top of bed 19 indicating the stratigraphical range of the Baylei Zone. A well preserved, large ammonite of the genus *Pictonia* was found in bed 19, about 0.2 m below its top. It is recognized as the new species – *Pictonia mesezhnikovi* sp. nov. (Pl. 5: 14; Pl. 7: 2). Almost the whole of the interval corresponding to the Baylei Zone in the Mikhalenino section also yielded ammonites of the genus *Prorasenia* representing the microconch of *Pictonia.*

Special attention should be paid to other representatives of the family Aulacostephanidae in the Mikhalenino section. The topmost part of bed 17 yielded a large ammonite very comparable with *Vineta jaekeli* Dohm (Pl. 5: 13; Pl. 8: 2a, b). Specimens which can be referred to the genus *Vineta* have been found also in the middle and upper parts of bed 19 (see palaeontological description of specimens and discussion on systematic position of the genus in the chapter on systematic palaeontology). It should be remembered that the genus *Vineta*, with type species *V. jaekeli*, was created by Dohm (1925) for large involute ammonites, smooth on the outer whorls, whose systematic position and stratigraphical occurrence remained for long time unclear. They occurred, after Dohm (*op. cit.*), in the sections of West Pomerania (now northwestern Poland), directly below ammonites referred by him to the genus *Pictonia*, but successively placed after the revision by Arkell (1937) into a new genus *Pomerania.* According to Schweigert and Callomon (1997), a representative of the genus *Vineta* – *V. streichensis* (Oppel) occurs in the *bauhini* horizon in southern Germany, which corresponds to a part of the Subboreal Baylei Zone. All specimens of *Vineta* were found within the Baylei Zone in the section studied at Mikhalenino.

An ammonite referred to as *Ringsteadia* cf. *frequens* Salfeld was reported (but not illustrated) by Hantzpergue *et al*. (1998a, b) together with *Amoeboceras* (*Plasmatites*), from deposits of the Makariev section corresponding to the beds yielding ammonites of the genera *Pictonia* and *Vineta* in the Mikhalenino section. That ammonite has been treated (Hantzpergue *et al.*, 1998a, b) as indicative of the Pseudocordata Zone of the uppermost Oxfordian, but it seems more likely that it belongs in fact to the genus *Vineta* known from the Baylei Zone (see chapter on systematic palaeontology herein).

Ammonites identified as *Pomerania* (*Pachypictonia*), found in beds 19–21 and 27 of the Mikhalenino section (Pl. 7: 1), were reported for the first time from the Russian Platform by Rogov and Kiselev (2007). These ammonites are known from Central Europe (Poland, Germany) in deposits yielding Submediterranean ammonites, which generally correlate with the Baylei Zone and a lower part of the Cymodoce Zone of the Subboreal Kimmeridgian (*cf.* Geyer, 1961; Kutek, 1968). Occasionally, a single horizon with these ammonites has been also recognized in a lower part of the Cymodoce Zone in East Greenland (Birkelund, Callomon, 1985).

Beds 22 to 27 of the section yielded ammonites of the genus *Prorasenia* which allow only for general correlation with the Baylei Zone and/or the Cymodoce Zone of the Subboreal zonal scheme. The occurrence in beds 28–29 of ammonites of the genus *Rasenia* (*R.* cf. *inconstans* Spath) indicates the lower part of the Cymodoce Zone (*cf.* Birkelund, Callomon, 1985).

SUBMEDITERRANEAN SUCCESSION

The Submediterranean succession is characterized by the ammonites of the family Perisphinctidae and additionally some Aspidoceratidae and Oppeliidae (Fig. 3). The Perisphinctidae constitute *c.* 50% of the total number of specimens (about 40) collected in the Densiplicatum Zone to Glosense Zone interval, but they show a patchy distribution in the section, being especially common in bed 8, but occurring also in bed 3 and in 11–14.

Bed 3 yielded fragments of large-sized *Otosphinctes* of the species *Perisphinctes* (*Otosphinctes*) cf. *arkelli* Głowniak (2 lappeted fragments of adult body chambers, Pl. 2: 1, 2) and two unidentifiable fragments of the middle whorls of *Perisphinctes* (*Kranaosphinctes*) sp. In addition from this bed came also *Taramelliceras* cf. *dentostriatum* (Questedt) and *Euaspidoceras* sp. The perisphinctid elements of the assemblage indicate the Arkelli Subzone of the Plicatilis Zone (*cf*. Głowniak, 2000, 2002).

Beds 4–7 are devoid of any representatives of the Perisphinctidae.

Bed 8 contains abundant ammonites, usually adult and complete, but all of them crushed and flattened. The bed yielded ammonites of the *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* group as distinguished by Głowniak (in: Głowniak, A. Wierzbowski, 2007), such as: *P*. (*D*.) *elisabethae* de Riaz (7 specimens), *P*. (*D*.) *luciae* de Riaz (2 specimens) and *P*. (*D*.) *luciaeformis* Enay (1 specimen) (Pl. 1: 1–5; Pl. 3: 1; *cf*. palaeontological description). The perisphinctid assemblage indicates the Elisabethae Subzone of the Transversarium Zone.

Beds 9–10 did not yield any representatives of the Perisphinctidae.

From bed 11 came an immature specimen of *Perisphinctes* (*Perisphinctes*) sp. (Pl. 8: 1; *cf*. palaeontological description). The state of preservation does not allow more precise specific identification of the specimen and its exact subzonal/zonal affiliation.

Bed 12 yielded some *Dichotomoceras*: *Perisphinctes* (*Dichotomoceras*) cf. *wartae* Bukowski accompanied by *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatoides* Enay (2 middle-size juvenile specimens of each species). The co-occurrences of the two species is diagnostic of the lowermost part of the Stenocycloides Subzone of the Bifurcatus Zone as recognized by Głowniak (2006a: fig. 3; 2006c).

Bed 13 yielded *Perisphinctes* (*Dichotomoceras*) sp. juv., and *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatoides* Enay which suggests that this bed belongs to the higher part of the Stenocycloides Subzone.

From the top of bed 14 came a single specimen of *Perisphinctes* (*Perisphinctes*) sp. (Pl. 6: 2a, b; *cf*. palaeontological description).

Higher up in the section no ammonites of the family Perisphinctidae have been collected.

The next level marked by the appearance of Submediterranean ammonites lies close the top of the section where bed 26 yielded *Aspidoceras* sp. and *Laevaptychus* – often joined with ammonites of the family Aspidoceratidae.

CORRELATION BETWEEN ZONAL SCHEMES

CORRELATION BETWEEN THE BOREAL AND SUBBOREAL ZONAL SCHEMES

The Mikhalenino section of the Russian Platform shows a fairly complete Boreal and Subboreal ammonite succession from the Upper Oxfordian and lowermost Kimmeridgian. Boreal ammonites dominate markedly here over Subboreal ones (of the 120 specimens collected from the stratigraphical interval from the Regulare Zone to the lowermost part of the Kitchini Zone, about 75% comprise the Boreal Cardioceratidae and about 25% the Subboreal Aulacostephanidae). This is a similar situation to that in East Greenland and in the cores from the Norwegian Sea offshore Norway (Birkelund, Callomon, 1985; A. Wierzbowski *et al.*, 2002). In the coeval deposits of the Staffin Bay section, Scotland, both families are represented by nearly equal numbers of specimens (Matyja *et al.*, 2006). It should be remembered that the general succession of ammonites in the stratigraphical interval discussed is similar in all these areas, which makes possible the distinction also in the Mikhalenino section of the standard Subboreal and Boreal ammonite zones and subzones (Figs 3–5).

The occurrence of ammonites of the genus *Decipia* in the Mikhalenino section (Fig. 3) makes correlation possible between the Subboreal Decipiens Zone (now Cautisnigrae Zone following Sykes, Callomon, 1979), and at least some parts of the Boreal Glosense Zone (Ilovaiskii Subzone plus possibly Glosense Subzone). Such a correlation was presented already by Arkell (1946) who correlated the Russian fauna with "*Amoeboceras pseudocaelatum* Spath" = *Amoeboceras ilovaiskii* (Sokolov) (*cf.* Sykes, Callomon, 1979) with the Decipiens Zone of Northwest Europe. It corresponds well to the stratigraphical relation between these zones in the English sections, where the genus *Decipia* occurs in deposits corresponding to the Boreal Glosense Zone (*e.g.* Wright, 1972, 1996; Wright, Powell, 2008). The correlation of the Russian succession studied with the ammonite zones based on the Perisphinctidae of the Northwest European subdivision (*cf.* Sykes, Callomon, 1979) is not discussed in the present study.

An early representative of the ammonite genus *Ringsteadia* co-occurs with ammonites of the *Amoeboceras regulare* group in the Mikhalenino section, which indicates that the lower part of the Subboreal Pseudocordata Zone should be correlated with some parts of the Boreal Regulare Zone. The same correlation between these units has been recognized in the Staffin Bay section in Skye, Scotland (Matyja *et al.*, 2006).

The middle part of the Subboreal Pseudocordata Zone – the Pseudocordata Subzone as recognized in the section studied by the co-occurrence of *Microbiplices microbiplex* (Quenstedt) and *M.* cf. *anglicus* Arkell – correlates with some part of the Boreal Rosenkrantzi Zone (excluding its upper part). At least the upper part of the Subboreal Pseudocordata Zone – the Evoluta Subzone (as recognized in the section studied by the co-occurrence of *Ringsteadia brandesi* Salfeld, and forms transitional between *Microbiplices* and *Prorasenia*) – correlates with the upper part of the Boreal Rosenkrantzi Zone (see Figs 3, 5; *cf.* Matyja *et al.*, 2006).

The boundary between the Oxfordian and Kimmeridgian in the Subboreal zonal scheme corresponds to the boundary between the Pseudocordata and Baylei zones. This boundary was distinguished recently by the International Subcommission of Jurassic Stratigraphy of the International Union of Geological Sciences as the only candidate for the uniform boundary of the stages with a well defined candidate for the Global Boundary Stratotype Section and Point (GSSP) in the Flodigarry section, Staffin Bay (Isle of Skye, Scotland) (A. Wierzbowski *et al.*, 2006; A. Wierzbowski, 2007, 2008).

The Oxfordian/Kimmeridgian boundary is proposed in the Subboreal succession at the first occurrence of representatives of the genus *Pictonia* (*P. flodigarriensis* Matyja, Wierzbowski et Wright) and its microconch counterpart – *Prorasenia*, according to Matyja *et al.* (2006). The co-occurrence of the ammonites *Pictonia* and *Prorasenia* is in

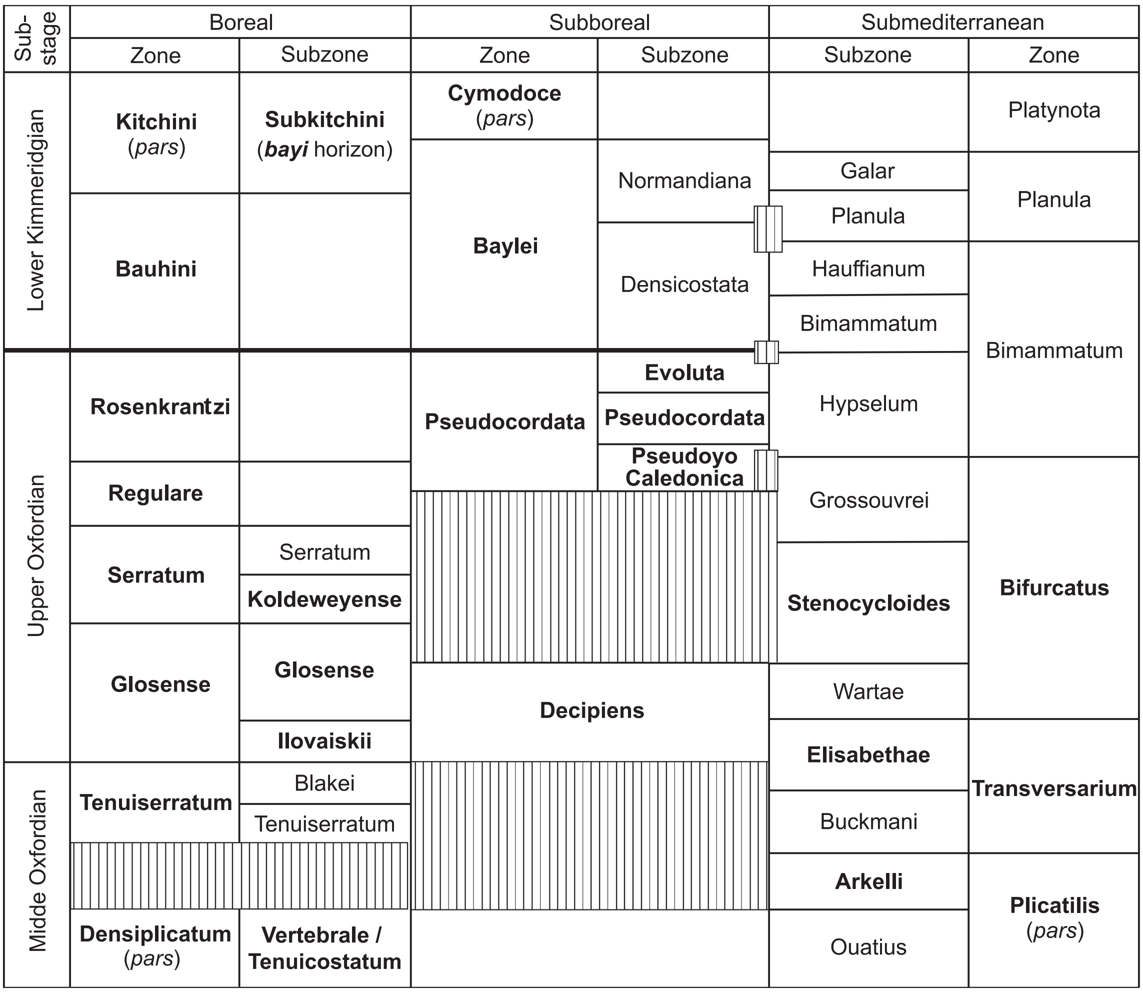


Fig. 5. Correlation of the Boreal, Subboreal and Submediterranean zonal schemes as based on Matyja *et al.* (2006) confirmed and supplemented with new data from the Mikhalenino section

The names of ammonite zones and subzones recognized in the section studied are given in bold letters the middle-upper part of bed 17 in the Mikhalenino section. In the same level at Mikhalenino there occur moreover Boreal ammonites indicative of the lowermost part of the Boreal Bauhini Zone – such as the first representatives of *Amoeboceras* (*Plasmatites*), and last representatives of older *Amoeboceras* species – like *A. schulginae* Mesezhnikov, and *A. rosenkrantzi* Spath. Such an assemblage was recognized for the first time in the Flodigarry section, Staffin Bay (Isle of Skye, Scotland) where it marks the *flodigarriensis* horizon – the lowermost ammonite horizon of the Baylei Zone, and independently, an informal horizon representing the lowermost part of the Bauhini Zone (Matyja *et al.*, 2006). The data indicate that in the Mikhalenino section, just as in the Flodigarry section, the base of the Subboreal Baylei Zone corresponds to the base of the Boreal Bauhini Zone (Figs 3–5). The same boundary may be placed close to beds 7*в–г* of the Makariev section (*cf.* Mesezhnikov *et al.*, 1986, 1989) located close to Mikhalenino on the Unzha River (see chapter on stratigraphy herein presenting a revision of some of the ammonite determinations from the Makariev section). The recognition of the boundary in question on the Russian Platform, about 2700 km to the east of the Flodigarry section, shows its large correlation potential (A. Wierzbowski *et al.*, 2008).

The Subboreal Baylei Zone ranges in the Mikhalenino section from the middle part of bed 17 up to bed 19 (at least) corresponding to the stratigraphical range of the genus *Pictonia*. It should be remembered, however, that the Russian representatives of the genus *Pictonia* differ in some features from Northwest European representatives of the genus, which makes it difficult to recognize particular Northwest European *Pictonia* faunistic horizons in the Russian sections (*cf.* palaeontological part of the study). The stratigraphical range of the ammonites *Amoeboceras* (*Plasmatites*) spp. covers also the interval from the middle part of bed 17 up to bed 21, indicating the Boreal Bauhini Zone. Because the top of the Bauhini Zone has to be placed within bed 21 which yielded the last representatives of *Amoeboceras* (*Plasmatites*) as well as the first representatives of *Amoeboceras* (*Amoebites*) indicative already of the Kitchini Zone – the Subkitchini Subzone (*cf.* A. Wierzbowski, Smelror, 1993; A. Wierzbowski *et al.*, 2002), the whole Boreal Bauhini Zone could correlate with a large part of the Subboreal Baylei Zone – which is generally consistent with results obtained in the Flodigarry section, Staffin Bay (Isle of Skye, Scotland; *cf.* Matyja *et al.*, 2006). The lowermost part of the Subkitchini Subzone of the Kitchini Zone, the *bayi* horizon as recognized in the section studied from bed 21 to bed 29, possibly correlates in its lower part still with the Baylei Zone (*cf.* Matyja *et al.*, 2006), but undoubtedly corresponds in its upper part (beds 28–29) to the lower part of the Subboreal Cymodoce Zone.

CORRELATION WITH THE SUBMEDITERRANEAN ZONAL SCHEME

The Arkelli Subzone, the topmost Subzone of the Plicatilis Zone in the Submediterranean Middle Oxfordian, was identified in bed 3 (Fig. 3). The Subzone correlates either with the upper part of the Boreal Densiplicatum Zone – the Maltonense Subzone, or with lower part of the Tenuiserratum Zone. The correlation as presented herein is substantiated by the co-occurrence of the large *Otosphinctes* and *Kranaosphinctes* with rare cardioceratid species of the subgenus *Cawtoniceras* – *e.g. C.* (*C.*) *cawtonense* (Blake et Huddleston). *Cardioceras* (*Miticardioceras*) sp. is still absent in this assemblage. A fact worthy of note is, however, that the index species of the Maltonense Subzone, *Cardioceras* (*Maltoniceras*) *maltonense* (Young et Bird) has been found hitherto neither in the Arkelli Subzone in the Polish sections – where the Subzone has been defined (Głowniak, 2000, 2002; Matyja, Głowniak, 2003) – nor in the Russian section of Mikhalenino.

The Arkelli Subzone should be correlated with the lower part of the Antecedens Subzone of the Plicatilis Zone in the Submediterranean zonation as shown by Głowniak (2006b). Such a correlation finds partial confirmation in the Mikhalenino section: cardioceratid species become rare in bed 3, while the index species *Perisphinctes* (*Dichotomosphinctes*) *antecedens* Salfeld of Callomon's (1964) Antecedens Subzone is still absent.

The ammonite assemblage under consideration is relevant for the correlation of the Arkelli Subzone across the European provinces. During the Arkelli Chron there occurred the *Platysphinctes* event (Głowniak, 2000), referred to as the Mediterranean Spread by Głowniak (2006b). It consisted of the prompt northward spread of various genera of Mediterranean affinity, *e.g. Neumannia*, *Gregoryceras*, *Taramelliceras* as well as *Platysphinctes* – the latter being the guide and index species of the event. In the stratigraphic interval where the event occurs, there is a distinctive fall in the number of cardioceratid ammonites recognized in the various sections (*e.g.* Matyja, Głowniak, 2003: fig. 2). In addition, an isotope anomaly – *i.e.* the maximum positive excursion of $\delta^{14}C$ – has been recognized in the *Platysphinctes* event-horizon by H. Wierzbowski (2002, 2004). The correlation value of this event has been recently claimed by Głowniak (2006b) and Głowniak and H. Wierzbowski (2007). Although the event has not been recognized with certainty on the Russian Platform, the current studies in the Mikhalenino section have yielded some preliminary evidence that it affected also this part of Europe. Thus the authors have indicating the first occurrence in this subzone in the Middle Oxfordian of the Mikhalenino section some taxa of Mediterranean affinity, *e.g. Taramelliceras* and *Euaspidoceras* combined with a reduction in number of the cardioceratid ammonites. Otherwise, in the underlying beds 1–2 in Mikhalenino, cardioceratid ammonites are numerous. They are diagnostic of the Tenuicostatum Subzone of the Densiplicatum Zone. Further studies on the possible occurrence of the *Platysphinctes* event in Russian sections are in progress *(cf.* chapter “Palaeobiogeography”).

No evidence has been found for the presence in the section at Mikhalenino of the Buckmani Subzone, the basal Subzone of the Transversarium Zone of the Submediterranean Middle Oxfordian, and thus the lower boundary of the Transversarium Zone has not been accurately located there. Beds 4–7 did not yield any ammonites of the family Perisphinctidae. Otherwise, bed 4 yielded the first *Cardioceras* (*Miticardioceras*) sp. which indicates the Boreal Tenuiserratum Zone. The available perisphinctid ammonite material does not allow any more precise correlation of the lower boundaries of the Transversarium and Tenuiserratum zones in the section studied. Further studies are required for more detailed correlation.

The Elisabethae Subzone, the upper Subzone of the Transversarium Zone as defined by Głowniak (2002), has been identified in bed 8. The cardioceratid ammonites co-occurring with *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* group in bed 8, in particular *Amoeboceras ilovaiskii* (Sokolov) and *Amoeboceras transitorium* Spath, allow correlation of the Elisabethae Subzone – but in fact probably only its upper part – with the Ilovaiskii Subzone, the basal Subzone of the Boreal Upper Oxfordian Glosense Zone (Fig. 3). This conclusion is in accordance with earlier data obtained from other Submediterranean sections (Atrops *et al*., 1993; Matyja, A. Wierzbowski, 1994). For instance Niegowonice Quarry (Central Poland) yielded *A. transitorium* Spath with species of the *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* group in the uppermost part of the Elisabethae Subzone (*cf.* Głowniak, 2005: fig. 1; 2006a). This demonstrates that the lower boundary of the Ilovaiskii Subzone and the Glosense Zone lies somewhere in the upper part of the Elisabethae Subzone of the Transversarium Zone (Fig. 5).

The occurrence of the oldest aulacostephanid species *Decipia* (?) *kostromensis* sp. nov. in the assemblage of the Elisabethae Subzone in the Mikhalenino section is of special importance for the correlation with the Subboreal Decipiens Zone.

No evidence has been found in the Mikhalenino section for the presence of the Wartae Subzone, the basal Subzone of the Bifurcatus Zone of the Submediterranean Upper Oxfordian (as proposed by Głowniak, 2005), as beds 9–11 did not provided any diagnostic perisphinctid species. A single occurrence of *Perisphinctes* (*Perisphinctes*) sp. in bed 11 does not allow recognition of its subzonal affilliation. The boundary between the Elisabethae/Wartae subzones, and thus the lower boundary of the Upper Oxfordian Bifurcatus Zone, has not been precisely located in the section. The perisphinctid assemblage of the Bifurcatus Zone recognized in beds 12–13 is not the earliest one of this zone. It indicates the Stenocycloides Subzone of the Bifurcatus Zone, and bed 12 correlates with the lower part of the subzone. The evidence from the Mikhalenino section allows only a rough correlation of the lower Bifurcatus Zone with the Boreal zonation, showing that the lower boundary of the Wartae Subzone (and thus of the Bifurcatus Zone) is situated somewhere in the upper Ilovaiskii or lower Glosense Subzones of the Glosense Zone (Fig. 5). The Stenocycloides Subzone correlates with the Glosense Subzone – most probably only with its upper part – and perhaps with the Koldeweyense Subzone, the lower Subzone of the Serratum Zone (Figs 3, 5). Higher up there is a sedimentary discontinuity in this section obscuring precise correlations. The *Perisphinctes* (*Perisphinctes*) sp. found in bed 14 suggests the higher part of the Bifurcatus Zone, which may correspond already to the Grossouvrei Subzone of the Bifurcatus Zone of the Submediterranean zonation.

The occurrence of the aulacostephanid genera *Vineta* and *Pomerania* (*Pachypictonia*) in the Mikhalenino section studied is also of correlation value because both these forms are known from the Submediterranean succession. Representatives of the genus *Vineta* – *V. streichensis* (Oppel) are known from the Hauffianum Subzone of the Bimammatum Zone in southern Germany (Schweigert, Callomon, 1997), and very similar involute forms originally attributed to the genus *Ringsteadia* but belonging in fact to the genus *Vineta* – such as *V. submediterranea* (Wierzbowski) – appear already in the Bimammatum Subzone of the Bimammatum Zone and continue upwards into the Planula Zone (A. Wierzbowski, 1978; Matyja, A. Wierzbowski, 1997). Because ammonites of the genus *Vineta* occur in the Subboreal Baylei Zone (possibly except its uppermost part), and in the Boreal Bauhini Zone in the Mikhalenino section, it results from the aforegoing that the two zones correspond to the stratigraphical interval from the Bimammatum Subzone or from the Hauffianum Subzone of the Bimammatum Zone up to nearly the top of the Planula Zone of the Submediterranean zonal scheme.

Pomerania (*Pachypictonia*) occurs in the Submediterranean succession possibly already in the uppermost part of the Planula Zone (in the Galar Subzone) and mostly in the Platynota Zone and the Hypselocyclum Zone (Schneid, 1940; Geyer, 1961; Kutek, 1968). These ammonites have been found in beds 19, 21 and 27 in the Mikhalenino section *i.e.* from the upper part of the Bauhini Zone to the lower part of the Kitchini Zone of the Boreal zonal scheme.

In spite of the poor preservation of the Submediterranean ammonites collected so far from bed 26 (*Aspidoceras* sp.), further records of these ammonites could be useful in correlation with the Submediterranean succession (*cf.* Rogov, Efimov, 2002).

PALAEOBIOGEOGRAPHY

The ammonites of the Mikhalenino section are mostly of Boreal affinity (Cardioceratidae) with a marked and steady admixture of Subboreal forms (Aulacostephanidae). There occur in some levels, moreover, ammonites of Submediterranean/Mediterranean origin (Perisphinctidae, Oppeliidae, Aspidoceratidae) which indicate temporary Tethyan influences. These periodic changes in Boreal/Subboreal or Tethyan influence shown in the Mikhalenino section, may be compared with those recognized in other areas of the Boreal/Subboreal and Submediterranean provinces in Europe (Figs 3, 5; see also discussion below).

Whereas the lower part of the Middle Oxfordian Densiplicatum Zone shows overdominance of Boreal ammonites in the section studied, the upper part of the Zone/lower part of the overlying Tenuiserratum Zone yields already abundant ammonites of Tethyan affinity – such as *Perisphinctes* (*Kranaosphinctes*, *Otosphinctes*), *Taramelliceras* and *Euaspidoceras*. This stratigraphical interval corresponds to the Arkelli Subzone of the Plicatilis Zone of the Submediterranean zonation (*cf.* chapter on correlation). It should be remembered that a strong migration of Tethyan ammonites into the area of Central Russia (the so-called Middle Russian Sea) at the turn of the Densiplicatum and Tenuiserratum zones of the Middle Oxfordian has been indicated by Rogov *et al.* (2006). A rich assemblage of Submediterranean/Mediterranean ammonites was reported by Rogov (2001) from deposits of this stratigraphical interval from the Russian Platform (Riasan and Belogrod areas); it consists of representatives of *Perisphinctes*, *Gregoryceras*, *Neoprionoceras* and *Glochiceras* (Rogov, 2003).

Submediterranean ammonites of the family Perisphinctidae occur abundantly also in the Ilovaiskii Subzone of the Glosense Zone of the Boreal zonation (lowermost Upper Oxfordian). Those found in bed 8 of the Mikhalenino section indicate the Elisabethae Subzone of the Transversarium Zone. Still younger deposits of the upper part of the Glosense Zone, the lower part of the Serratum Zone, and possibly even of the Regulare Zone, yielded ammonites of the genus *Perisphinctes* indicative mostly of the Stenocycloides Subzone of the Bifurcatus Zone of the Submediterranean zonation. The same stratigraphical interval from the Ilovaiskii Subzone up to the Serratum Zone and possibly lower Regulare Zone, yielded in the neigbouring section at Makariev planktonic foraminifera of the genus *Globuligerina* (see Azbel, 1989), recently also recognized in the Mikhalenino section (Ustinova, 2009a, b). The flood of planktonic foraminifera was clearly a response to sea level change and/or to changes in water mass movements which could correlate with the free connection with the Tethys.

The stratigraphical interval from the Regulare Zone through the Rosenkrantzi and Bauhini zones up to the lowermost part of the Kitchini Zone in the Mikhalenino section is practically devoid of Submediterranean ammonites, and represents an interval of strong Boreal influences. The same pattern can be recognized also in some northern areas of the Submediterranean Province which show a consistent northerly increase in the number of Boreal ammonites of the genus *Amoeboceras* (see *e.g.* Matyja, A. Wierzbowski, 1998: fig. 4): the phenomenon is noted in these areas from the upper part of the Bifurcatus Zone (corresponding to the upper part of the Regulare Zone, *cf.* Matyja *et al.*, 2006; see also Figs 2, 3) up to the lowermost part of the Platynota Zone (corresponding to the basal part of the Kitchini Zone – the lower part of the *bayi* horizon). A reversal of this tendency appears in the uppermost part of the section at Mikhalenino where in the upper part of the *bayi* horizon appear once more ammonites of Submediterranean affinity (*Aspidoceras* sp.). This may be correlated with the almost total disappearance of Boreal ammonites of the genus *Amoeboceras* in large areas of the Submediterranean Province observed in the bulk of the Platynota Zone (*e.g.* Matyja, A. Wierzbowski, 1998).

The Subboreal ammonites found in the Mikhalenino section present a mixture of Subboreal aulacostephanids typical of Northwest European areas – such as *Decipia* and *Ringsteadia*, and other forms indigenous to central and eastern European areas like *Vineta* and *Pomerania* (*Pachypictonia*). The latter were first described from the area of Pomerania, northwestern Poland (see Dohm, 1925), which constitutes a fragment of the eastern part of the Subboreal Province (*cf.* Sykes, Callomon, 1979), but the same ammonites are also known from northeastern parts of the Submediterranean Province – from central Poland and southern Germany. Their occurrence alongside other endemic ammonites has been the basis of the distinction of the German-Polish Subprovince of the Submediterranean Province showing stronger overlapping of Submediterranean and Subboreal faunas (Matyja, A. Wierzbowski, 1995). It should be remembered also that the ammonites of the genus *Pictonia* occurring in the Mikhalenino section differ in some features from typical representatives of the genus known from Northwest Europe (*cf.* paleontological section of this study). This can be regarded as another example illustrating the faunal differences which exist within the Aulacostephanidae in particular parts of the Subboreal Province.

SYSTEMATIC PALAEONTOLOGY

The following abbreviations are used in the description of ammonites: D – diameter of specimen in mm (Df – diameter of phragmocone; Dm – maximal diameter of the specimen), Wh – whorl height as percentages of D; Ud – umbilical diameter as percentages of D; Wb – whorl breadth as percentages of D; PR – number of primary ribs per whorl (or half a whorl – when indicated).

The specimens are housed in the Museum of the Faculty of Geology of the University of Warsaw (collection no. MWG UW ZI/41), in the Yaroslav State Pedagogical University (collection no. YSPU/M), and in the Geological Institute of the Russian Academy of Sciences in Moscow (collection no. GIN/MK).

Family **Cardioceratidae** Siemiradzki, 1891

Genus *Amoeboceras* Hyatt, 1900

Type species: *Amoeboceras alternans* von Buch, 1831.

Of the numerous forms of the genus occurring in the deposits studied at Mikhalenino the bulk has been discussed and described elsewhere (see *e.g.* Sykes, Callomon, 1979; Mesezhnikov *et al.*, 1989; Matyja *et al.*, 2006). Hence, two species only are described here: the poorly known *Amoeboceras pectinatum* Mesezhnikov, 1968, and the stratigraphically important *A.* (*Plasmatites*) *bauhini* (Oppel, 1863), the latter to make clear its relation with the very similar form *Amoeboceras* (*Amoeboceras*) *gerassimovi* Kalacheva et Mesezhnikov, 1989, described from sections on the Russian Platform (Mesezhnikov *et al.*, 1989).

Amoeboceras pectinatum Mesezhnikov, 1967

(Pl. 4: 4)

1967 *Amoeboceras* (*Prionodoceras*) *pectinatum* Mesezhnikov; Mesezhnikov, pp. 124, 125, pl. 4: 2 (holotype) and 4; text-fig. 5.

1989 *Amoeboceras* (*Prionodoceras*) *serratum* (Sowerby); Mesezhnikov *et al.*, pp. 104–106, pl. 18: 7 (only).

Material. — One specimen no. ZI/41/042 coming from the uppermost part of bed 14 in the Mikhalenino section.

Description. — The specimen is about 30 mm in diameter (at D = 29 mm, Wh = 38, Ud = 35). The ribbing is dense (on the outer whorl PR = 25 per half of whorl; on the inner whorl PR = about 20 per half a whorl). The primary ribs are thin, slightly prorsiradiate to rectiradiate, but incline backwards above the middle of the whorl height. The furcation point is high, and some ribs are simple. Tubercles are absent.

Discussion. — The specimen referred to as *A. serratum* (Sowerby) by Mesezhnikov *et al.* (1989: pl. 18: 7) from the Makariev section differs from typical representatives of the species (*cf.* Sykes, Callomon, 1979) in having generally more dense and thin ribbing and shorter secondary ribs which appear higher on the whorl side. All these features indicate the affinity of the specimen in question with *A. pectinatum*. The species *A. pectinatum* belongs to the *Amoeboceras regulare* group, and shows similarity to the more finely ribbed flexuous forms of *Amoeboceras freboldi* Spath (see Sykes, Callomon, 1979, p. 885).

Subgenus *Plasmatites* Buckman, 1925

Type species: *Plasmatites crenulatus* Buckman, 1925.

Amoeboceras (*Plasmatites*) *bauhini* (Oppel, 1863)

(Pl. 4: 9–11)

1997 *Amoeboceras bauhini* (Oppel); Schweigert, Callomon, pp. 5, 6, pl. 1: 1–26; pl. 2: 2; text-fig. 2a–k (with given synonymy).
moreover *int. al.*

1989 *Amoeboceras* (*Amoeboceras*) *gerassimovi* Kalacheva et Mesezhnikov; Mesezhnikov *et al.*, 1989, pp. 85, 86, pl. 26: 3–8.

Material. — Ten specimens (including illustrated nos ZI/41/50,52,53) coming from beds 17 (upper part) and bed 18.

Description. — The specimens attain about 26 mm in maximum diameter, and some of them show a final peristome marked by uncoiling, and the appearance of faint crowded ribs. The coiling is involute (at D = 17–25 mm, Wh = 39.6–44.0, Ud = 24.2–32.0). The ribbing is rather sparse (PR = 23–27). The primary ribs characteristically curve backwards, and finish about two-thirds of the whorl height with a small tubercle; the secondary ribs are short and tuberculate (the number of secondary ribs per primary is about 1.6–1.7), and are separated from the primaries by a more or less well developed smooth spiral band. The keel is raised and crenulated; it is bordered by nearly smooth lateral bands.

Discussion. — Variation in the species can be seen in the density of ribbing, the development of a smooth spiral band on the whorl side, and the more or less accentuated continuation of the secondary ribs onto the keel. These features can vary within a single faunal assemblage, for example that from the *bauhini* horizon in Plettenberg (southern Germany) or that from the *densicostatum* horizon in South Ferriby (England) (see Schweigert, Callomon, 1997). The new species *Amoeboceras gerassimovi* Kalacheva et Mesezhnikov, distinguished on the basis of specimens collected from the section at Makariev (Mesezhnikov *et al.*, 1989), is possibly only another variant of the widely variable *A. bauhini*. *A. gerassimovi* was originally distinguished from *A. bauhini* by its smooth ventral side (see Mesezhnikov *et al.*, 1989), but specimens showing this feature occur also in other faunal assemblages where they constitute a part of the wider population of *A. bauhini*: see *e.g.* specimens from the Staffin Bay section, Isle of Skye, Scotland, interpreted as *A. bauhini* by Sykes and Callomon (1979: pl. 121: 4, 5) but subsequently placed into the synonymy of *A. gerassimovi* by Mesezhnikov *et al.* (1989: pl. 26: 7, 8).

Family **Aulacostephanidae** Spath, 1924

The ammonites of the family Aulacostephanidae represented by *Decipia* [M, m], *Ringsteadia* [mostly M] – *Microbiplices* [m], as well as *Pictonia* [M] and *Rasenia* [M] – *Prorasenia* [m] formed during the Late Oxfordian and earliest Kimmeridgian a smoothly evolving lineage well recognized in Northwest European areas and in Greenland (see Birkelund, Callomon, 1985; Matyja *et al.*, 2006; Wright, 2010). Similar ammonites of the genera *Decipia* and *Ringsteadia* occur also in areas of central and eastern Europe, as, for example, in the section studied at Mikhalenino, where they can be interpreted as elements of the same phylogenetical lineage. Nevertheless, in this section there have been found other representatives of the family – such as special representatives of the genus *Pictonia*, as well as the genera *Vineta* and *Pomerania* (*Pachypictonia*), occurring in deposits corresponding to the Baylei Zone (and possibly also to the lowermost part of the Cymodoce Zone), which are practically unknown from the sections of Northwest Europe; on the other hand the bulk of these ammonites have been reported from lowermost Kimmeridgian deposits in central and eastern Europe.

Genus *Decipia* Arkell, 1937

Type species: *Ammonites decipiens* Sowerby, 1821.

Decipia cf. *decipiens* (Sowerby, 1821)
(Pl. 3: 7)

cf. 1937 *Decipia decipiens* (J. Sowerby); Arkell, p. 44, pl. F: 1–4.
cf. 1944 *Decipia decipiens* (J. Sowerby); Arkell, pp. 370–373, pl. 78: 7; text-figs 132–133.
cf. 1996 *Decipia decipiens* (Sowerby, 1821); Wright, pp. 456–458, pl. 6: 3; pl. 7: 1–4; text-fig. 5.

Material. — One specimen no. ZI/41/064 from the rubble (of beds 9–10) of the Mikhalenino section.

Description. — This is an incomplete external cast of a specimen approximately 95 mm in diameter. The outer whorl is a fragmentarily preserved body chamber (without the final peristome). The specimen was probably nearly mature. The coiling of the whorls is nearly weakly involute on the inner whorls and weakly involute on the outer whorl (approximate ratios of Wh and Ud are 33 and 44, respectively at D = *c.* 45 mm; 31 and 36 respectively at D = *c.* 95 mm). The primary ribs are thicker than the secondary ribs. They are prorsiradiate and moderately densely spaced. PR is about 19 per half a whorl at D = *c.* 45 mm and remains almost constant up to D = 95 mm. The ribs usually trifurcate. Some bifurcating ribs occasionally occur on the inner whorls only. The secondary ribs arise indistinctly from the primary rib. The division points are somewhat obscure. There is one wide, shallow constriction on the last half of the outer whorl.

Discussion. — The species differs from *Decipia lintonensis* Arkell and *D. ravenswykensis* Wright in having thinner and sharper primary ribs (*cf.* Wright, 1996).

Decipia (?) *kostromensis* sp. nov.
(Pl. 2: 8–9)

Type material: Two specimens: holotype no. ZI/41/012, figured in Pl. 2: 8; and paratype no. ZI/41/065, in Pl. 2: 9.
Type area and locality: Mikhalenino section (bed 8) on the Unzha River in Kostroma District.
Type horizon: Upper Oxfordian, Glosense Zone, Ilovaiskii Subzone (lowermost part); Transversarium Zone, Elisabethae Subzone (uppermost part).
Etymology: Named after Kostroma Town, the capital of Kostroma District.
Diagnosis: Lappetted middle-sized microconchs; bifurcating ribs predominate on the inner-medium whorls, trifurcations on the adult body chamber; primary ribs moderately sharp, prorsiradiate; point of rib division somewhat obscured; rib number changes insignificantly with growth (*c.* 50 per whorl); coiling weakly involute to moderately evolute.

Description. — The specimens are badly crushed and flattened. The test is partially preserved. The holotype (Pl. 2: 8) is a mature lappetted specimen (D = 90 mm, Df = 55 mm). The body chamber is one whorl long. The coiling is weakly involute on the inner whorl and moderately evolute on the outer whorl (the ratio Wh and Ud is 38 and 40, respectively, at D = 55 mm; 37 and 42 respectively at D = 80 mm). The primary ribs are moderately sharp, prorsiradiate. They mostly bifurcate on the phragmocone and on the first half of the body chamber. On the last half whorl of the body chamber they divide almost exclusively into three secondary ribs. The division point is somewhat obscured. The secondary ribs arise indistinctly from the primary ribs, and some of them have the aspect of intercalatory ribs. The rib number per whorl increases but little with growth. PR is 46 per whorl at D = 30 mm, and 50 per whorl at D = 90 mm.

The paratype (Pl. 2: 9) is an immature specimen with a juvenile peristome, D = 60 mm. The beginning of the body chamber is unrecognizable. The coiling of the whorls is weakly involute (the ratio Wh and Ud is 35 and 36, respectively, at D = 60 mm). The primary ribs bifurcate, and the secondary ribs are irregularly accompanied by intercalatory ribs on the outer whorl. The primary ribs are thin and moderately sharp. PR is 46 per whorl at D = 60 mm. The constrictions are shallow. They number 2 on the outer whorl.

Discussion. — The specimens studied show affinity to the genus *Decipia* in shell size, prorsiradiate ribbing and the presence of trifurcations. They differ from typical representatives of the genus (*e.g. Decipia decipiens*) in the appearance of bifurcating ribs, which predominate on the juvenile and middle whorls, and trifurcations, which are limited basically to the adult body chamber; in primary ribs which are but little obscured at the division point, and in the character of the primary ribs which are as strong as the secondaries. The new species *kostromensis* is tentatively attributed herein to the genus *Decipia*. The characters mentioned, particularly the predominance of bifurcating ribs on the early–middle whorls, with trifurcations appearing in the later stage of shell ontogeny–suggest its affinity to some early Middle Oxfordian perisphinctids, for instance the macroconchiate genus *Liosphinctes* Buckman (*cf.* Głowniak, 2002). *Decipia* (?) *kostromensis* sp. nov. shows an intermediate character between the early Middle Oxfordian perisphinctids and the Late Oxfordian aulacostephanids.

Genus *Ringsteadia* Salfeld, 1913 and genus *Microbiplices* Arkell, 1936

Type species: *Ammonites pseudocordatus* Blake et Huddleston, 1877 and *Ammonites microbiplex* Quenstedt, 1887–1888.

These are ammonites of corresponding macro- and microconchs for which separate morphogeneric names are often retained (*cf.* Matyja *et al.*, 2006; Wright, 2010). Because these ammonites have been reported rather rarely from the Russian Platform, mostly from its southern – Peri-Caspian and Peri--Uralian parts (Mesezhnikov *et al.*, 1989), but also rarely from its central part, where in addition their occurrence has been poorly documented (*e.g.* Davithachvili, 1926; Gerasimov, 1972), some comments on particular occurrences of representatives of these groups in the Mikhalenino section are given.

The oldest specimens referred to as *Ringsteadia* sp. come from the middle part of bed 14 up to the lowermost part of bed 15 in the Mikhalenino section. The specimen found in bed 14 represents a whorl fragment about 30 mm in height showing irregular ribbing somewhat similar to that of early representatives of *Ringsteadia* such as *R. caledonica* Sykes et Callomon (*cf.* Sykes, Callomon, 1979). The other specimen (Pl. 4: 14) from the lowermost part of bed 15 in the Mikhalenino section is small, attaining only 37 mm in diameter. The coiling is moderately involute (at D = 37 mm, Wh = 43, Ud = 32), and the ribbing is fairly dense consisting of prorsiradiate primaries (PR = 17 per half a whorl) which bifurcate just below the middle of the whorl height, with some intercalated secondary ribs. There are some irregularities in the ribbing marked by the joining of neighbouring ribs at the umbilicus (2, 3 on the last half whorl), as well as changes in the density of ribbing observed in particular sectors of the last whorl in areas bordered by well developed constrictions. The secondary ribs are initially rectiradiate and curve slightly forward on the ventral side. Such a style of ribbing is observed in early representatives of the genus *Ringsteadia*, such as *R. pseudoyo* Salfeld.

A large specimen of *Ringsteadia brandesi* Salfeld from bed 17 attains about 110 mm in diameter (Pl. 6: 1a, b). It shows involute coiling and coarse ribbing with well developed constrictions. The whorl section is oval with a rounded ventral side.

The specimen of *Microbiplices microbiplex* (Quenstedt) (Pl. 4: 16) from bed 16, is not complete and is somewhat deformed; it attains about 35 mm in diameter, and is weakly evolute (Ud = 39); on the inner whorls the ribbing is dense, on the outer whorl the ribs become more distant and are regularly biplicate.

The specimen referred to as *Microbiplices* cf. *anglicus* Arkell (Pl. 4: 15) from bed 16, is about 35 mm in diameter, and it shows markedly evolute coiling (Ud = 48.5), and strong, rather distant ribbing on the inner whorls (PR = 18).

The specimen about 30 mm in diameter referred to as *Microbiplices/Prorasenia* transitional form (Pl. 4: 17) from the lower part of bed 17, shows a fragment of the penultimate whorl covered with moderate thick primary ribs of the *Microbiplices* type, whereas swollen distant triplicate ribs typical of *Prorasenia* are developed at the beginning of the last whorl; coarse, regularly biplicating ribs occupy a major part of the last whorl; the peristome is not preserved. The specimen shows much similarity to microconchs of intermediate character between *Microbiplices* and *Prorasenia*, described from Staffin Bay, Scotland by Matyja *et al.* (2006, p. 403, fig. 4f–h).

Genus *Pictonia* Bayle, 1878 and genus *Prorasenia* Schindewolf, 1925

Type species: *Pictonia baylei* Salfeld, 1913 and *Prorasenia quenstedti* Schindewolf, 1925.

As was the case with *Ringsteadia – Microbiplices*, in the description of *Pictonia* and *Prorasenia*, separate morphogeneric names are retained for corresponding macro- and microconchs (*cf.* Matyja *et al.*, 2006; Wright, 2010). The comments on the specimens collected in the section are given below.

The character of the ribbing of the specimens studied referred herein to the genus *Pictonia* shows some special features not encountered in Northwest European representatives of the genus. These are: sparsely placed trifurcating ribs occurring at a fairly small diameter, and short primary ribs (Pl. 4: 18; Pl. 5: 14). This type of ribbing is close to that of the inner whorls of representatives of the genus *Pomerania* (see *e.g.* Geyer, 1961), which show, however, quite a different ornamentation of the outer whorls, consisting of strong, swollen, wedge- shaped primaries. A different group within the genus *Pictonia* is represented also by ammonites described by Mesezhnikov (1969) from Siberian sections: the main features encountered in the Siberian species such as strong development of the secondary ribbing and rather early fading of the primary ribs differentiate them markedly both from Northwest European, as well as from the Russian Platform representatives described herein.

None of the specimens of *Prorasenia* gathered in the Mikhalenino section can be unequivocally identified at the species level. The specimens are not complete and are often compressed which makes detailed measurements and recognition of the whorl section impossible (Pl. 4: 19; Pl. 5: 9). Hantzpergue *et al.* (1998a, b) identified "*Desmosphinctes*" = *Prorasenia* cf. *mniovnikense* (Nikitin) in the Baylei Zone of the neighbouring Makariev section. This is a very close form to *Prorasenia bowerbanki* Spath, differing mostly in its much wider whorl section (*cf.* Mesezhnikov, 1984) and evolute coiling of the outer whorl (at D = 34–40 mm, Wh = 28–29, Wb = 35–38, Ud = 42–44; see Nikitin, 1884).

Pictonia mesezhnikovi sp. nov.

(Pl. 5: 14; Pl. 7: 2)

Type material: — Holotype (specimen no. ZI/41/031) figured in Pl. 5: 14: representing the inner whorls of a large specimen the collection of whose outer whorls was not possible (see field photo Pl. 7: 2).

Type area and locality: Mikhalenino section (bed 19, upper part) at the Unzha River in Kostroma District.

Type horizon: Lower Kimmeridgian, Baylei Zone (Subboreal) and Bauhini Zone (Boreal).

Etymology: In honour of outstanding late Russian geologist and palaeontologist Professor M.S. Mesezhnikov student of Russian Boreal ammonites.

Diagnosis: Large ammonite, evolute to weakly involute on inner whorls, covered with short, distant and strong primary ribs splitting about mid height of whorl into 2–3 strongly developed secondaries. Constrictions well marked. Ribbing disappears at about 95 mm diameter, and outer whorls smooth, showing evolute coiling.

Description. — The innermost whorls are only preserved as small fragments covered with strong, distant ribs. On the remaining inner whorls representing the phragmocone (Pl. 5: 14) the coiling is weakly evolute, and later weakly involute (at D = 90 mm, Wh = 36, Ud = 35, Wb = 31). The whorl section is high oval. The primary ribs are short, rather distant and bold (PR = 26 at D = 90 mm) splitting below the middle of the whorl height into 2–3 somewhat less strongly developed secondary ribs with intercalatories in between (the secondary/primary rib ratio is about 3.2–3.6 at D = 60–80 mm). The secondary ribs disappear at about 95 mm diameter, and the primary ribs somewhat later. The constrictions on the inner – middle whorls are well marked, but not very deep, bordered in front by flared ribs. The outer whorls are smooth. Their coiling as calculated from the photograph taken in the field (Pl. 7: 2) is evolute (at D about 240 mm: Wh *c.* 33, and Ud *c.* 40; at D about 380 mm: Wh *c.* 36, and Ud *c.* 44). The maximum diameter of the specimen as measured in the field reached about 400 mm.

Discussion. — The specimen shows some similarity to *Pictonia normandiana* (Tornquist) – see Tornquist (1896: pl. 5: 1; pl. 6: 2) and Hantzpergue (1989: pp. 224–229, pl. 25: a–c referred to *P. thurmanni*, but preferably retained in *P. normandiana*; see Schweigert, Callomon, 1997). It differs, however, in its shorter primary ribs, somewhat more involute coiling and in attaining a larger diameter.

As indicated above, the specimen studied shows some similarity to the inner whorls of *Pomerania.* It is especially close to some more densely ribbed *Pomerania* species as *e.g. Pomerania* (*Pachypictonia*) *albinea* (Oppel) (see *e.g.* Oppel, 1862–1863: pl. 50: 3a, b; Schneid, 1940: pl. 6: 3; see also Geyer, 1961).

Pictonia sp.

(Pl. 4: 18)

Material. — The oldest specimen (no. ZI/41/035) of *Pictonia* coming from the middle part of bed 17.

Description. — This small specimen is 28 mm in diameter. The ribbing of the innermost whorls up to 10 mm diameter is dense, but soon afterwards it becomes much stronger and irregular. The primary ribs (PR = 25) are distant, and mostly trifurcate with a number of intercalatory ribs. Constrictions are numerous (4 on the last whorl), well marked and bordered by strongly accentuated single ribs. Although well preserved, this interesting form is too small to be unequivocally related to a particular species. A similar specimen approximately 35 mm in diameter with coarse primary ribbing and dense secondary ribbing was collected by one of the authors (J.K.W.) from a similar horizon in the Makariev section.

Discussion. — These small specimens belong to the same group of species as the large specimen of *Pictonia mesezhnikovi* described above.

Genus *Vineta* Dohm, 1925

Type species: *Vineta jaekeli* Dohm, 1925.

Vineta is a poorly know genus generally treated in the past either as younger synonym of *Ringsteadia* (*e.g.* Arkell *et al.*, 1957) or as a subgenus of *Ringsteadia* characterized by its more involute coiling (Geyer, 1961). The stratigraphical position of the representatives of *Vineta* which occur in younger deposits than typical Northwest European *Ringsteadia*, and the difference in their morphology both indicate, however, that the two taxa should be treated separately (Schweigert, Callomon, 1997; *cf.* Głowniak, A. Wierzbowski, 2007).

Vineta jaekeli Dohm, 1925

(Pl. 5: 13; Pl. 8: 2a, b)

1925 *Vineta jaekeli* Dohm; Dohm, pp. 33, 34, pl. 4: 1, 4–5 (lectotype); pl. 3: 2; pl. 10: 5, 8–9.

1988 *Ringsteadia* (*Vineta*) *jaekeli* (Dohm); Malinowska, p. 343, pl. 151: 4 (lectotype, not holotype as erronously indicated therein).

Material. — One large specimen (no. ZI/41/032) from top of bed 17 of the Mikhalenino section, photographed in the field (Pl. 8: 2a), and of which the middle and inner whorls only were collected (Pl. 5: 13; pl. 8: 2b).

Description. — The specimen studied attains 390 mm in maximum diameter: Wh = 34, Ud = 32. On the middle whorl at D = 100 mm, Wh = 40, Ud = 31, Wb = 33. The coiling thus is markedly involute on the inner and middle whorls but becomes successively more evolute on the outer whorl. The whorl section shows the maximum thickness in its lower part, becoming narrower towards the ventral side, which is rounded. Ribbing is visible only on the inner and middle whorls and is generally rather weak. The ribbing of the innermost whorls (Pl. 8: 2b) consists of dense, thin primary ribs which are prorsiradiate (PR = 25 per half a whorl at D = 25 mm), and much stronger secondary ribs appearing about the mid-height of the whorl and showing a rectiradiate or even weakly rursiradiate course (the primary/secondary ribs ratio equals about 2.0 at D = 20 mm). On the middle whorl, the secondary ribs are fairly numerous and rather strong, but the primary ribs are very weakly developed and almost imperceptible (Pl. 5: 13). On the outer whorl the ribbing disappears, but some faint striae are visible at the peristome (Pl. 5: 2a). The peristome is simple. The body chamber of this large specimen is about one whorl long.

Discussion. — The specimen described shows a marked similarity to the species *Vineta jaekeli* Dohm. According to Dohm (1925, pp. 33, 34, pl. 4: 1, 4, 5 – this specimen designated here the lectotype of *V. jaekeli*) both the outer and the inner whorls of *Vineta* are smooth. However, this is possibly partly the result of poor preservation, but also of generally weak ornamentation, better developed in the dorsolateral part of the inner and middle whorls.

Vineta spp
(Pl. 5: 11, 12)

Material. — Other specimens referred to the genus *Vineta* in the Mikhalenino section come from the middle and upper parts of bed 19, and represent the inner whorls as well as a fragment of a larger whorl. A small specimen (Pl. 5: 11) representing the inner whorls is involute (at D = 32, Wh = 34, Ud = 30) and fairly densely ribbed (PR = 15 at D = 30 mm); the ribs are mostly biplicate. The narrow constrictions (3 on the last whorl) are bordered by accentuated single ribs. The specimen shows similarity both to the inner whorls of *Vineta*, but also to early representatives of the genus *Pictonia* – such as *P. flodigarriensis* and *P. densicostata* (*cf.* Matyja *et al.*, 2006). A fragment of a large whorl, about 33 mm in height (Pl. 5: 12), shows rather dense ribbing; the primary ribs are visible in the lower part of the whorl but disappear higher on the whorl side; the secondary ribs are strongly developed and numerous (the secondary/primary ribs ratio equals 3.5); the coiling of the complete specimen was clearly markedly involute.

Discussion. — Two specimens referred to as *Ringsteadia cuneata* (Trautschold) from the collection of P.A. Gerasimov (*cf.* Gerasimov, 1972, p. 36) of the Russian Platform (Kostroma District) were illustrated by Kimchashvili *et al.* (1958, pl. 38: 4–5); they represent the inner whorls of phragmocones, about 25 and 35 mm in diameter, respectively. Both the involute coiling and the character of the ribbing indicate their close affinity to the genus *Vineta.* It should be remembered that the species *Ammonites cuneatus* was established by Trautschold (1861, pp. 83, 84, pl. 8: 2a–c) on the basis of a fragment of a large completely smooth whorl, showing involute coiling and a high-oval cross-section tapering towards the venter. In the Russian literature this species is traditionally referred to the genus *Ringsteadia* (*e.g.* Gerasimov, 1972), but its affinity to the genus *Vineta* seems probable.

Considering the phylogenetical affinity of the genus *Vineta*, one has to take into account the weak ornamentatation of the inner whorls, which are covered with dense, S-shaped ribbing and show the presence of strong constrictions (*cf.* also Schweigert, Callomon, 1997, p. 24). Such ribbing with well developed constrictions is recognized also in early representatives of the genus *Pictonia* such as *Pictonia flodigarriensis* Matyja, Wierzbowski et Wright, and even in many specimens of *P. densicostata* Buckman (see Matyja *et al.*, 2006). Another feature in common between *Vineta* and *Pictonia* is the strong development of secondary ribs. The main differences are strongly involute coiling, and the presence of more regular ribbing of the middle whorls in representatives of *Vineta*.

According to Schweigert and Callomon (1997, p. 45) the species *Vineta jaekeli* is very close to the youngest representative of British *Ringsteadia* – the species *Ringsteadia evoluta* Salfeld occurring in the uppermost part of the Pseudocordata Zone of the uppermost Oxfordian. The inner whorls of typical *R. evoluta* morphospecies show very coarse ribbing, however, rather different from those of *Vineta* and early *Pictonia* (*cf.* Matyja *et al.*, 2006). On the other hand, some forms are known from the uppermost Pseudocordata Zone, which are more involute and show more dense ribbing than *R. evoluta*. Such different morphospecies belonging to the group of *Ringsteadia pseudoyo* Salfeld (see Salfeld, 1917; see also Wright, 2010) can be easily recognized as possible forerunners of both *Vineta* and *Pictonia.* It may be suggested, that the specimen (not illustrated) referred to as *Ringsteadia* cf. *frequens* Salfeld by Hantzpergue *et al.* (1998a, b), and coming from deposits of the lowermost Kimmeridgian (bed 7*e* of the Makariev section after Mesezhnikov *et al.*, 1989; fauna Mk 8d of Hantzpergue *et al.*, 1998a, b; see also chapter on stratigraphy), could also belong to the genus *Vineta.*

Genus *Pomerania* Arkell, 1937

Type species: *Decipia* (*Pomerania*) *dohmi* Arkell, 1937.

This genus includes both the forms of the true *Pomerania* type – close to *Pomerania* (*Pomerania*) *dohmi* Arkell, and corresponding to the bulk of the ammonites described by Dohm (1925) as *Pictonia*, as well as the specimens of the *Pachypictonia* type described by Schneid (1940). The two groups of ammonites are closely related and grouped in the same genus but in separate subgenera (Geyer, 1961; Kutek, 1968). The main differences are the more evolute coiling, and the somewhat less dense ribbing of the representatives of the nominative subgenus. The specimens found in the Mikhalenino section belong to the subgenus *Pachypictonia.*

Subgenus *Pachypictonia* Schneid, 1940

Type species: *Pictonia indicatoria* Schneid, 1940.

Pomerania (*Pachypictonia*) *peltata* (Schneid, 1940)
(Pl. 7: 1)

1940 *Pictonia peltata* Schneid; Schneid, pp. 96, 97, pl. 11: 2.
1961 *Pomerania* (*Pachypictonia*) *peltata* (Schneid); Geyer pp. 120, 121 (with given synonymy).
2007 *Pictonia* (*Pachypictonia*) cf. *consobrina* Schneid; Rogov, Kiselev, pl. 4: 3.

Material. — Two large specimens attaining about 280 mm in final diameters found in bed 19 (no. YSPU/M19; Pl. 7: 1) and bed 21.

Description. — The coiling is evolute (in the specimen from bed 19 at D = 282.5 mm, Wh = 26, Ud = 44; in the specimen from bed 21 at D = 260 mm, Wh = 26, Ud = 46). The ribbing is very coarse both on the inner and middle whorls (PR = about 16) with strongly developed cuneiform ribs on the outer whorl (PR = about 13). The sparse ribbing both on the inner/middle and outer whorls, as well as the type of ornamentation and coiling, indicate close affinity of the specimens studied with *Pomerania* (*Pachypictonia*) *peltata* (Schneid).

Discussion. — This is the only species of *Pachypictonia* showing such distant ribbing both on the inner/middle and outer whorls (*cf.* Geyer, 1961, text-fig. 143). The closely related species *P. dacquei* (Wegele) and *P. consobrina* (Schneid), although similar in many features, show more dense ribbing especially on the inner and middle whorls (Geyer, 1961). The present finding is the first documented occurrence of the genus *Pomerania* (*Pachypictonia*) from the Russian Platform (see Rogov, Kiselev, 2007). Mesezhnikov (1967) reported (but without any description and illustration) the ammonites "*Pomerania* sp. indet." from northern Siberia.

Family **Perisphinctidae** Steinmann, 1890

Genus *Perisphinctes* Waagen, 1869

Subgenus *Perisphinctes* Waagen, 1869

Type species: *Ammonites variocostatus* (Buckland, 1836) [M].

Perisphinctes (*Perisphinctes*) spp
(Pl. 6: 2a, b; Pl. 8: 1)

Material. — 1 specimen no. ZI/41/014, from the bed 11, and 1 specimen no. YSPU/ M14–8 from bed 14.

Description. — The specimen from bed 11 (Pl. 8: 1) is an incomplete phragmocone with a small portion of the body chamber. D is approximately 200 mm. The inner whorls are crushed flat and distorted (they are not shown on the photograph). They are moderately evolute and fairly densely ribbed. The ribs on the outer whorl are moderately thick and bifurcating. They become somewhat thicker on the body chamber and divide into 3 secondary ribs. The latter ones are much less distinct than the primaries. The specimen can not be precisely assigned to any species due to its incompleteness.

The specimen from bed 14 (Pl. 6: 2a, b) is an incomplete phragmocone with D approximately 170 mm or somewhat greater. The whorl section is flat sided with a gently rounded venter on the penultimate whorl, but subrectangular on the outer whorl. The specimen is moderately densely ribbed. The primary ribs bifurcate. The secondary ribs of the penultimate whorl are as distinct as the primary ribs. They follow the direction of the primaries on the side of the venter. Occasional zig-zag ribs occur. They end as simple ribs on the whorl side. There are 3 simple ribs on the whorl side. On the outer whorl the primary ribs strengthen at the ventrolateral margin. The secondary ribs pass straight across the venter. They are less distinct than the primaries. There are 3 constrictions on the outer whorl. The specimen resembles *P.* (*P.*) *variocostatus* (Buckland) (see *e.g.* Arkell, 1947, pl. 76: 1–4), but its preservation does not allow for its unequivocal assignation.

Subgenus *Dichotomosphinctes* Buckman, 1926

Type species: *Perisphinctes antecedens* Salfeld, 1914 [m].

Perisphinctes (*Dichotomosphinctes*) *elisabethae* de Riaz group

The group as distinguished by Głowniak (in: Głowniak, A. Wierzbowski, 2007) joins four nominal species (*elisabethae, luciae, luciaeformis* and *crotalinus*) which co-occur and merge by transients within single horizons in the Polish Middle Oxfordian (Elisabethae Subzone, Transversarium Zone). The group encompasses microconchs which presumably belong to a single variable biospecies.

Perisphinctes (*Dichotomosphinctes*) *elisabethae* de Riaz, 1898

(Pl. 1: 2–5; Pl. 3: 1a, b; Fig. 6; Tab. 1)

1898 *Perisphinctes elisabethae* sp. nov.; de Riaz, p. 22; pl. 12: 4a–b, pl. 12: 5 (lectotype).
1966 *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz; Enay, p. 490, pl. 30: 4–5 (topotypes); pl. 31: 2–4, 5 (lectotype), 6 (topotype); text-fig. 150.
2001 *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz; Gygi, p. 72, p. 127, figs 106–107, 178–180a, 181–182 (with given synonymy).
2007 *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz; Głowniak, A. Wierzbowski, pp. 83–85, figs 44–45, tab. 25.

Material. — Eight specimens nos ZI/41/001, 003–4, 006–7, 013a, 013b, 015, from bed 8.

Description. — The specimens are usually mature and complete; all of them crushed flat. When excavated from the section all of them had test, which is still partially preserved. Body chambers exist in all specimens and occupy *c.* 1 whorl. The peristome is simple, constricted, flexuous (*e.g.* Pl. 1: 2). The ribs become approximated near the peristome in some specimens and/or their body chambers are constricted, with 2–3 constrictions appearing usually on its second half of the body chamber (*e.g.* Pl. 1: 2–4). The characters previously mentioned indicate that the specimens are fully grown. The shell diameter of the mature specimens varies from 50–70 mm to 120–140 mm (Tab. 1).

The shells are moderately evolute in terms of the coiling of the whorls. They are densely ribbed already at a small diameter (45–55 ribs per whorl at D = 30 mm). The rib-density curves are usually convex upward (Fig. 6). They rise up near the maximum diameter due to the final approximation of ribs.

Tabela 1

***Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz, 1898**

No. of specimen	D_m	D_f
ZI/41/001	140	70
ZI/41/003	120	60
ZI/41/004	70	30
ZI/41/006	50	25
ZI/41/007	*c.* 50	*c.* 25
ZI/41/013a	60	30
ZI/41/013b	70	35
ZI/41/015	*c.* 90	?

D_m (maximal diameter) and D_f (diameter of phragmocone) when underlined indicate shell and phragmocone diameters, respectively, of fully grown specimens

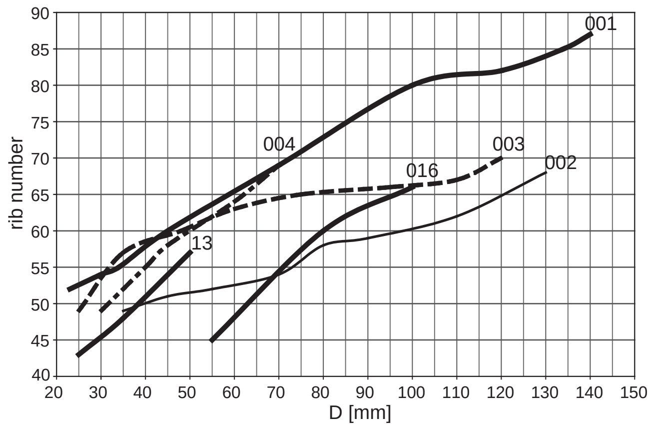


Fig. 6. Rib density curves of *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz, 1898 (specimens numbers: ZI/41/001, 003, 004, 013)

For comparison purposes the rib density curve of *P.* (*D.*) *luciaeformis* Enay, 1966 (ZI/41/002) and *P.* (*D.*) *luciae* de Riaz, 1898 (no ZI/41/016) from the studied collection of Mikhalenino are drawn as well. All the specimens come from a single bed 8 in the Mikhalenino section

Discussion. — The presence of adult specimens with a relatively small shell diameter (*e.g.* Pl. 1: 2, 4) is a remarkable character of the assemblage studied. Large-sized specimens in the collection studied (*e.g.* Pl. 1: 3) are comparable in shell diameter with Polish specimens of this species collected by the author (E.G.) from the Submediterranean sections of central Poland, the largest of which attain D = 150–160 mm.

Stratigraphical position. — Guide and index species of the Submediterranean Elisabethae Subzone of the Transversarium Zone.

Perisphinctes (*Dichotomosphinctes*) *luciae* de Riaz, 1898

(Fig. 6)

1898 *Perisphinctes luciae* sp. nov.; de Riaz, p. 36, pl. 10: 5 (lectotype).
2001 *Perisphinctes* (*Dichotomosphinctes*) *luciae* de Riaz; Gygi, p. 125, figs 174–175, pl. 69.
2007 *Perisphinctes* (*Dichotomosphinctes*) cf. *luciae* de Riaz; Głowniak, A. Wierzbowski, pp. 85–87, text-figs 46–47.

Material. — Two specimens nos ZI/41/016, 023 from bed 8.

Description. — Both specimens are crushed flat, with nearly complete body chambers. The test is partially preserved. Dm is *c*. 100 mm (no. ZI/41/023) and *c*. 110 mm (no. ZI/41/016). The specimens are fully grown or nearly fully grown. In specimen no. ZI/41/023 there are 3 constrictions on the final quarter of whorl of the body chamber which indicates the cessation of growth. The coiling of the whorls is moderately evolute. The primary ribs often bifurcate, with occasional simple ribs. The specimens are moderately densely ribbed on the inner and middle whorls. The rib number per whorl increases *c*. 20 ribs between 50 and 80 mm diameter (Fig. 6).

Stratigraphical position. – Submediterranean Elisabethae Subzone of the Transversarium Zone.

Perisphinctes (*Dichotomosphinctes*) *luciaeformis* Enay, 1966
(Pl. 1: 1; Fig. 6)

1966 *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* n. sp.; Enay, p. 496, pl. 32: 2a, b (holotype), pl. 32: 1, 3, text-fig. 152.
1989 *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* Enay; Meléndez, p. 301, pl. 45: 1–2, pl. 46: 1–4, pl. 47: 2–4, text-fig. 61.
2001 *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* Enay; Gygi, p. 74, p. 122, figs 110–112, 170–171; tabs 41, 67.

Material. — Two specimen no. ZI/41/002 from bed 8.

Description. — The specimen is crushed flat, with the test partially preserved. The specimen is fully grown, with Dm *c*.130 mm and Df *c*. 70 mm. The body chamber is one whorl long. The peristome is simple, constricted (Pl. 1: 1), and the specimen is moderately evolute, fairly densely ribbed on the inner whorls but moderately densely ribbed on the middle and outer whorls. The rib-density curve gently rises up (Fig. 6).

Stratigraphical position. — This is the index species of the Luciaeformis Subzone of the Transversarium Zone in the standard Submediterranean Middle Oxfordian zonation. It is one of the guide forms of the Elisabethae Subzone (Transversarium Zone) in the Submediterranean zonation of Central Europe (*cf*. A. Wierzbowski *et al*., 2006).

Acknowledgements. The Faculty of Geology of the University of Warsaw supported the stay in Russia of Ewa Głowniak and Andrzej Wierzbowski. The study was supported also by the Polish Ministry of Science and Higher Education (grant no. N N307 036537). The authors are grateful to the editorial referees: Svetlana V. Meledina and Bronisław A. Matyja for critical review of the text.

REFERENCES

ARKELL W.J., 1937, 1944 — A monograph on the ammonites of the English Corallian Beds. *Palaeontographical Society Monograph*, part **3**: 43–68; part **10**: 269–378.

ARKELL W.J., 1946 — Standard of the European Jurassic. *Bulletin of the Geological Society of America*, **57**: 1–34.

ARKELL W.J., 1947 — The geology of Oxford. University Press, Oxford.

ARKELL W.J., 1957 — Introduction to Mesozoic Ammonoidea. *In*: Treatise on invertebrate paleontology (ed. R.C. Moore). Part L. Mollusca 4: L81–L129. Kansas University Press, Lawrance, Kansas.

ARKELL W.J., KUMMEL B., WRIGHT C.W., 1957 — Systematic description. *In*: Treatise on invertebrate paleontology (ed. R.C. Moore). Part L. Mollusca 4: L129–L437. Kansas University Press, Lawrance, Kansas.

ATROPS F., GYGI R., MATYJA B.A., WIERZBOWSKI A., 1993 — The Amoeboceras faunas in the Middle Oxfordian – lowermost Kimmeridgian, Submediterranean succession, and their correlation value. *Acta Geologica Polonica*, **43**, 3/4: 213–227.

AZBEL A.Ya., 1989 — Foraminiferal zonation of the Middle and Upper Oxfordian of the Russian Platform. *In*: The Middle and Upper Oxfordian of the Russian Platform (ed. M.S. Mesezhnikov). Academy of Sciences of the USRR, Ministry of Geology of the USRR, Interdepartmental Stratigraphic Committee of the USRR, Transactions, 19: 44–62 [in Russian].

BIRKELUND T., CALLOMON J.H., 1985 — The Kimmeridgian ammonite faunas of Milne Land, central East Greenland. *Grønlands Geologiske Undersøgelse*, **153**: 1–56.

BUSHNEV D.A., SHCHEPETOVA E.V., LYYUROV S.V., 2006 — Organic geochemistry of Oxfordian carbon-rich sedimentary rocks of the Russian Plate. *Lithology and Mineral Resources*, **41**, 5: 475–488.

CALLOMON J.H., 1964 — Notes on the Callovian and Oxfordian Stages. *In*: Colloque du Jurassique, Luxembourg, 1962. *Comptes Rendus et Mémoires de Institut Grand Ducal, Section des sciences naturelles, physiques et mathématiques, Luxembourg*: 269–291.

DAVITHACHVILI L.C., 1926 — On the zoning of the Upper Oxfordian of the Middle Russia. *Bulletin de la Société des Naturalistes de Moscou, Section géologique*, **4**, 1/2: 282–293 [in Russian, with English sum.].

DOHM B., 1925 — Ueber den oberen Jura von Zarnglaff i.P. und seine Ammonitenfauna. *Abhandlungen der Geologischen Institut der Universität Greifswald*, **4**: 1–40.

ENAY R., 1966 — L'Oxfordien dans la moitié sud du Jura français. I: Étude stratigraphique. II: Contribution a la connaissance des Pèrisphinctidés. *Nouvelles Archives Muséum d'Historie Naturelle de Lyon*, **8**: 1–324 (I), 325–624 (II).

GEYER O.F., 1961 — Monographie der Perisphinctidae des unteren Unterkimeridgium (Weisser Jura γ, Badenerschichten) im süddeutschen Jura. *Palaeontographica*, **117**, 1–4: 1–157.

GERASIMOV P.A., 1972 — Yuzhna chast Moskovskoy sineklizy. *In*: Stratigraphyja SSSR, Yurskaya Sistema (ed. G.J. Krymgoltz): 27–51. Nedra, Moskva.

GŁOWNIAK E., 2000 — The Platysphinctes immigration event in the Middle Oxfordian of the Polish Jura Chain (Central Poland). *Acta Geologica Polonica*, **50**: 143–160.

GŁOWNIAK E., 2002 — The ammonites of the family Perisphinctidae from the Plicatilis Zone (lower Middle Oxfordian) of the Polish Jura Chain (Central Poland); their taxonomy, phylogeny and biostratigraphy. *Acta Geologica Polonica*, **52**: 307–364.

GŁOWNIAK E., 2005 — The Wartae Subzone – a proposal for the lower boundary of the unified Upper Oxfordian Substage in the Submediterranean Province. *International Subcommission on Jurassic Stratigraphy Newsletter*, **32**: 34–37.

GŁOWNIAK E., 2006a — Correlation of the zonal schemes at the Middle–Upper Oxfordian (Jurassic) boundary in the Submediterranean Province: Poland and Switzerland. *Acta Geologica Polonica*, **56**: 33–50.

GŁOWNIAK E., 2006b — The Platysphinctes immigration event: biostratigraphic and paleobiogeographic implications for the Middle Oxfordian (Late Jurassic) seas of Central Europe (NW Germany and Poland). *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, **241**: 155–201.

GŁOWNIAK E., 2006c — Stop B1.9 – Zawodzie Quarry ammonite succession (Middle to Upper Oxfordian, Upper Transversarium to Bifurcatus zones). *In*: Jurassic of Poland and adjacent Slovakian Carpathians (eds A. Wierzbowski *et al.*): 159–162. Field trip guidebook of 7th International Congress on the Jurassic System; Poland, Kraków, September 6–18.

GŁOWNIAK E., WIERZBOWSKI H., 2007 — Comment on “The Mid-Oxfordian (Late Jurassic) positive carbon-isotope excursion recognized from fossil wood in the British Isles” by C.R. Pearce, S.P. Hesselbo and A.L. Coe. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **248**: 247–251.

GŁOWNIAK E., WIERZBOWSKI A., 2007 — Taxonomical revision of the perisphinctid ammonites of the Upper Jurassic (Plicatilis to Planula Zones) described by Józef Siemiradzki (1891) from the Kraków Upland. *Volumina Jurassica*, **5**: 27–137.

GRIGELIS A.A. (ed.), 1982 — Biostratigraphy of the Upper Jurassic deposits of USSR by foraminifers. Vilnius, Mokslas [in Russian].

GUZHOV A.V., 2004 — Jurassic gastropods of European Russia (orders Cerithiiformes, Bucciniformes and Epitoniiformes). *Paleontological Journal*, *Supplement*, **38**, 5: 457–562.

GYGI R., 2001 — Perisphinctacean ammonites of the type Transversarium Zone (Middle Oxfordian, Late Jurassic) in northern Switzerland. *Schweizerische Paläontologische Abhandlungen*, **122**: 1–171.

HANTZPERGUE P., 1989 — Les ammonites kimméridgiennes du haut-fond d’Europe occidentale: biochronologie, systématique, evolution, paléobiogéografie. *Cahiers de Paléontologie*. Éditions du CNRS.

HANTZPERGUE P., BAUDIN F., MITTA V., OLFERIEV A., ZAKHAROV V.A., 1998a — Le Jurassique supérieur du basin de la Volga: biostratigraphie des faunes d’ammonites et corréraltion avec les zonationas standards européennes. *Compte Rendus de l’Académie des Sciences de Paris, Sciences de la Terre et des Planets*, **326**: 633–640.

HANTZPERGUE P., BAUDIN F., MITTA V., OLFERIEV A., ZAKHAROV V.A., 1998b — The Upper Jurassic of the Volga basin: ammonite biostratigraphy and occurrence of organic--carbon rich facies. Correlations between Boreal-Subboreal and Submediterranean provinces. *In*: Peri-Tethys Memoir 4: epicratonic basins of Peri-Tethyan platforms (eds S. Crasquoin-Solea, É. Barrier). *Mémoires du Muséum National d’Histoire Naturelle*, **179**: 9–33.

IVANOV A.P., 1909 — Geologicheskye opisanye phosphoritonosnykh otlozhenyij Kostromskoy gubernyij po reke Volgye k vostoku ot goroda Kineshmi y po rekakh Unzhe y Nee. *In*: Otchet po geologicheskomu isledovanyju phosphoritovykh zelezhenyi, vypusk 1, Kostromskaya gubernyja (reki Volga i Unzha) (ed. A.P. Ivanov). Moskva.

KIMCHASHVILI N.G., KAMYSHEVA-ELPATIEVSKAYA V.G., BODYLEVSKYJ V.I., DRUSHCHITZ V.V., SIBIRYAKOVA L.V., LUPPOV N.P., TROITSKAYA E.A, NIKOLAYEVA V.P., 1958 — Nadsemeystvo Perisphinctaceae. *In*: Osnovy Paleontologyj, Molluski – Golovonogye II (eds N.P. Luppo, V.V. Drushchitz): 85–96. Gosudavstvenoye Nauchno Teknicheskoye Izdatelstvo, Moskva.

KROM I.I., 1933 — Geologicheskyie stroyenye i usloviya slantzenosti srednevo techenya r. Unzhi v severo-vostochnoy chasti 71 listka. *Voprosy obschey geologyj*, **1933**: 3–25.

KUTEK J., 1968 — The Kimmeridgian and uppermost Oxfordian in the SW margin of the Holy Cross Mts. (Central Poland). Part I. Stratigraphy. *Acta Geologica Polonica*, **18**, 3: 494–584.

MATYJA B.A., GŁOWNIAK E., 2003 — Następstwo amonitów dolnego i środkowego oksfordu w profilu kamieniołomu w Ogrodzieńcu i ich znaczenie paleobiogeograficzne (Lower to Middle Oxfordian ammonite succession of the Ogrodzieniec Quarry and their palaeobiogeographical significance). *Tomy Jurajskie*, **1**: 53–58. Warszawa [in Polish].

MATYJA B.A., WIERZBOWSKI A., 1994 — On correlation of Submediterranean and Boreal ammonite zonations of the Middle and Upper Oxfordian: new data from Central Poland. *Géobios, Mémoire Spécial*, **17**: 351–358.

MATYJA B.A., WIERZBOWSKI A., 1995 — Biogeographic differentiation of the Oxfordian and Early Kimmeridgian ammonite faunas of Europe, and its stratigraphic consequences. *Acta Geologica Polonica*, **45**, 1/2: 1–8.

MATYJA B.A., WIERZBOWSKI A., 1997 — The quest for a unified Oxfordian/Kimmeridgian boundary: implications of the ammonite succession at the turn of the Bimammatum and Planula zones in the Wieluń Upland, Central Poland. *Acta Geologica Polonica*, **47**, 1/2: 77–105.

MATYJA B.A., WIERZBOWSKI A., 1998 — The stratigraphical and palaeogeographical importance of the Oxfordian and Lower Kimmeridgian succession in the Kcynia IG IV borehole. *Biuletyn Państwowego Instytutu Geologicznego*, **382**: 35–69 [in Polish, with English sum.].

MATYJA B.A., WIERZBOWSKI A., WRIGHT J.K., 2006 — The Sub-Boreal/Boreal ammonite succession at the Oxfordian/Kimmeridgian boundary at Flodigarry, Staffin Bay (Isle of Skye), Scotland. *Transactions of the Royal Society of Edinburgh, Earth Sciences*, **96**: 387–405.

MELÉNDEZ G., 1989 — El Oxfordiense en el sector central de la Cordillera Iberica (provincias de Zaragoza y Teruel). Institucion Fernando el Catholico, Instituto de Estudios Turolenses, Zaragoza-Teruel.

MESEZHNIKOV M.S., 1967 — A new ammonite zone of the Upper Oxfordian and the position of Oxfordian and Kimmeridgian boundary in northern Siberia. *In*: Problems of palaeontological substantiation of detailed stratigraphy of Siberia and Far East (ed. V.N. Saks): 110–130. Nauka, Leningrad [in Russian].

MESEZHNIKOV M.S., 1969 — Systematic descriptions. Kimmeridgian ammonites. *In*: Fundamental section of the Upper Jurassic of Kheta River Basin (ed. V.N. Saks): 99–124. Izdatelstvo Nauka, Leningrad [in Russian].

MESEZHNIKOV M.S., 1984 — Kimmeridgian and Volgian of the North of the USSR: 1–65. Nedra, Leningrad [in Russian].

MESEZHNIKOV M.S., KALACHEVA E.D., ROTKYTE L.M., 1986 — Raspredelenyje ammonitov v sredno-verhnyjeoksfordskih otlozhenyjah reki Unzhi. *In*: Yurskiye otlozhenyja Ruskoy Platformy:145–154. Ministerstvo Geologyj SSSR, VNIGRI, Leningrad.

MESEZHNIKOV M.S., AZBEL A.J., KALACHEVA E.D., ROTKYTE L.M., 1989 — The Middle and Upper Oxfordian of the Russian Platform. *Academy of Sciences of the USRR, Ministry of Geology of the USRR, Interdepartmental Stratigraphic Committee of the USRR, Transactions*, **19**: 1–183 [in Russian].

MESEZHNIKOV M.S., KALACHEVA E.D., 1989 — Zonalnoye podrozdelenyje borealnovo verkhnievo oksforda SSSR, 109–122. *In*: Stage and zonal scales of the Boreal Mesozoic of the USRR. *Academy of Sciences of the USRR, Siberian Branch, Transactions*, **722**: 108–122, 218.

NIKITIN S.N., 1884 — Die Cephalopodenfauna der Jurabildungen des Gouvernements Kostroma: 1–83. Kaiserlich Akademie der Wissenschften, St. Petersburg.

de RIAZ A., 1898 — Description des ammonites des couches *Peltoceras transversarium* (Oxfordien supérieur) de Trept (Isère), Lyon.

OPPEL A., 1862–1863 — Ueber jurassische Cephalopoden. *Palaeontologische Mittheilungen aus dem Museum des koeniglich bayerischen Staates*: 127–266. Stuttgart.

ROGOV M., 2001 — Ways of migrations and correlative potential of the Middle Oxfordian ammonites: new data from Russian Plate. Abstract volume: 181–182, International Conference on Paleobiogeography & Paleoecology. Piacenza & Castell'Arquato, Italy, May 31–June 2 2001.

ROGOV M.A., 2003 — Upper Jurassic Ochetoceratinae (Oppeliidae, Ammonoidea) of Central Russia. *Bulletin of the Society of Naturalists of Moscow, Series Geology*, **78**, 6: 38–52 [in Russian].

ROGOV M.A., EFIMOV V.M., 2002 — On the possibility to establish zones of Submediterranean ammonite scale in Lower Kimmeridgian of Russian Platform. *Bulletin of the Society of Naturalists of Moscow, Series Geology*, **77**, 1: 43–46 [in Russian].

ROGOV M.A., KISELEV D.N., 2007 — The Kimmeridgian of Russia and adjacent areas, its subdivision and correlations. Unpublished field-guide: 1–31. Geological Institute of Russian Academy of Sciences, Moscow.

ROGOV M., ZAKHAROV V., KISELEV D., 2006 — Molluscan migrations and biogeographical ecotone in the Middle Russian Sea. *Volumina Jurassica*, **4**: 132–134.

ROTKYTE L.M., 1987 — Amonity i zonalnaya stratigrafia verkhneyurskikh otlozhenij Pribaltiki: 1–118. Mokslas, Vilnius.

SALFELD H., 1914 — Die Gliederung des oberen Jura in Nordwesteuropa. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage Bd.*, **37**: 125–246.

SALFELD H., 1917 — Monographie der Gattung *Ringsteadia* (gen. nov.). *Palaeontographica*, **62**, 2: 69–84.

SCHNEID T., 1940 — Über Raseniiden, Ringsteadiiden und Pictoniiden des nördlichen Frankenjura. *Palaeontographica*, **91**, 3–6: 79–119.

SCHWEIGERT G., CALLOMON J.H., 1997 — Der *bauhini* Faunenhorizont und seine Bedeutung für die Korrelation zwischen tethyalem und subborealem Oberjura. *Stuttgarter Beiträge zur Naturkunde, Serie B* (*Geologie und Paläontologie*), **247**: 1–69.

SOKOLOV M.M., 1929 — Geologische Untersuchungen den Fluss Unja Entlang. *Izvestya asocyacyi nauchno-issled. institutov pri fiz.-mat. fakhulte M.G.U.*, **2**, 1: 5–31.

SPIJARSKI T.N., 1932 — The Upper Jurassic beds of the Unja River within the limits of Sheet 70. *Bulletins of the United Geological and Prospecting Service of USSR*, **69**: 1027–1037 [in Russian].

SYKES R.M., CALLOMON J.H., 1979 — The *Amoeboceras* zonation of the Boreal Upper Oxfordian. *Palaeontology*, **22**, 4: 839–903.

TESAKOVA E.M., GUZHOV A.V., 2009 — The Middle Oxfordian–Lower Kimmeridgian beds with ostracods from Mikhalenino section (Kostroma region) and their comparison with synchronous strata of the Western Europe. *In*: Jurassic System of Russia: problems of stratigraphy and palaeogeography (ed. V.A. Zakharov): 240–242. Third all-Russian Meeting, Saratov, Saratov State University, September 23–27, 2009. "Nauka" Saratov 2009 [in Russian].

TORNQUIST A., 1896 — Die degenerierten Perisphinctiden des Kimmeridge von Le Havre. *Abhandlungen der Schweizerischen Paläontologischen Gesellschaft*, **33**: 1–43.

TRAUTSCHOLD H., 1861 — Recherches géologiques aux environs de Moscou. Couche Jurassique de Mniovniki. *Bulletin de la Société Impériale des Naturalistes de Moscou*, **34**, 1: 64–94.

USTINOVA M.A., 2009a — Zonalnoye rozchlenienye oksfordskokimeridgzkikh otlozhenij po foraminiferam razreza Mikhalenino (Kostromskaya oblast), 36. *In*: Materyali sobranya sekcji MOIP "Paleostrat – 2009", 26–27.01.2009, Moskva [in Russian].

USTINOVA M.A., 2009b — Foraminiferal ranges in the Oxfordian–Kimmeridgian deposits of the Mikhalenino section (Kostroma region). *In*: Jurassic System of Russia: problems of stratigraphy and palaeogeography (ed. V.A. Zakharov): 246–248. Third all--Russian Meeting, Saratov, Saratov State University, September 23–27, 2009. “Nauka” Saratov 2009 [in Russian].

WIERZBOWSKI A., 1978 — Ammonites and stratigraphy of the Upper Oxfordian of the Wieluń Upland, Central Poland. *Acta Geologica Polonica*, **28**, 3: 299–333.

WIERZBOWSKI A., 2007 — Kimmeridgian Working Group. Report. *International Subcommission on Jurassic Stratigraphy Newsletter*, **34**, 2: 17–20.

WIERZBOWSKI A., 2008 — Kimmeridgian Working Group. Report. *International Subcommission on Jurassic Stratigraphy Newsletter*, **35**, 2: 14–19.

WIERZBOWSKI A., SMELROR M., 1993 — Ammonite succession in the Kimmeridgian of southwestern Barents Sea, and the *Amoeboceras* zonation of the Boreal Kimmeridgian. *Acta Geologica Polonica*, **43**, 3/4: 229–249.

WIERZBOWSKI A., COE A.L., HOUNSLOW M.W., MATYJA B.A., OGG J.G., PAGE K.N., WIERZBOWSKI H., WRIGHT J.K., 2006 — A potential stratotype for the Oxfordian/Kimmeridgian boundary: Staffin Bay, Isle of Skye. *Volumina Jurassica*, **4**: 17–34.

WIERZBOWSKI A., GŁOWNIAK E., KISELEV D., ROGOV M., WRIGHT J.K., 2008 — Correlation potential of the *flodigarriensis* horizon of proposed GSSP for the base of the Kimmeridgian (Staffin Bay, Isle of Skye, Scotland) in the light of new data from Russian and Polish sections. The 5th International Symposium of IGCP 506 on: marine and non-marine Jurassic: global correlation and major geological events, Tunisia(Hammamet), March 28–31, 2008. Abstract volume: 47–48.

WIERZBOWSKI A., SMELROR M., MØRK A., 2002 — Ammonites and dinoflagellate cysts in the Upper Oxfordian and Kimmeridgian of the northeastern Norwegian Sea (Nordland VII offshore area): biostratigraphical and biogeographical significance. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen*, **226**, 2: 145–164.

WIERZBOWSKI H., 2002 — Detailed oxygen and isotope stratigraphy of the Oxfordian in Central Poland. *Geologische Rundschau*, **91**: 304–314.

WIERZBOWSKI H., 2004 — Carbon and oxygen isotope composition of Oxfordian–Early Kimmeridgian belemnite rostra: palaeoenvironmental implications for Late Jurassic seas. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **203**: 153–168.

WRIGHT J.K., 1972 — The stratigraphy of the Yorkshire Corallian. *Proceedings of the Yorkshire Geological Society*, **39**, 2/12: 225–266.

WRIGHT J.K., 1996 — Perisphinctid ammonites of the Upper Calacareous Grit (Upper Oxfordian) of North Yorkshire. *Palaeontology*, **39**, 2: 433–469.

WRIGHT J.K., 2003 — New exposures of the Ampthill Clay near Swindon, Wiltshire, and their significance within the succession of Oxfordian/Kimmeridgian boundary beds in southern England. *Proceedings of the Geologists' Association*, **114**: 97–121.

WRIGHT J.K., 2010 — The Aulacostephanidae (Ammonoidea) of the Oxfordian/Kimmeridgian boundary beds (Upper Jurassic) of southern England. *Palaeontology*, **53**, 1: 11–52.

WRIGHT J.K., POWELL J.H., 2008 — Ammonites from the basal Ampthill Clay (Upper Jurassic) at Abingdon and Cumnor, Oxfordshire. *Proceedings of the Geologists' Association*, **119**: 161–173.

ZHIRMUNSKYJ A.M., 1914 — Baseyn nizhney Unzhi. *Ezhogodnik po geologyj i mineralogyj Rossyi*, **16**, 2–4: 67–77.

Plates

PLATE 1

Ammonites of the *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* group

Fig. 1. *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* Enay
ZI/41/002; bed 8; Transversarium Zone, Elisabethae Subzone

Fig. 2–5. *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz:
2 – ZI/41/006, 3 – ZI/41/003, 4 – ZI/41/004, 5 – ZI/41/007; bed 8; Transversarium Zone, Elisabethae Subzone

All specimens in natural size


1
2
4
3
5

PLATE 2

Fig. 1–2. *Perisphinctes* (*Otosphinctes*) cf. *arkelli* Głowniak
1 – ZI/41/011, 2 – ZI/41/010; bed 3; Plicatilis Zone, Arkelli Subzone

Fig. 3. *Cardioceras* (*Subvertebriceras*) sp.
ZI/41/075; bed 5; Tenuiserratum Zone

Fig. 4–4a. *Cardioceras* (*Cawtoniceras*) *cawtonense* (Blake et Huddleston)
4 – natural size, 4a – × 1.5; YSPU/M3-1; bed 3; Densiplicatum Zone or Tenuiserratum Zone

Fig. 5. *Taramelliceras* cf. *dentostriatum* (Quenstedt)
GIN/MK2480; bed 3; Densiplicatum Zone or Tenuiserratum Zone

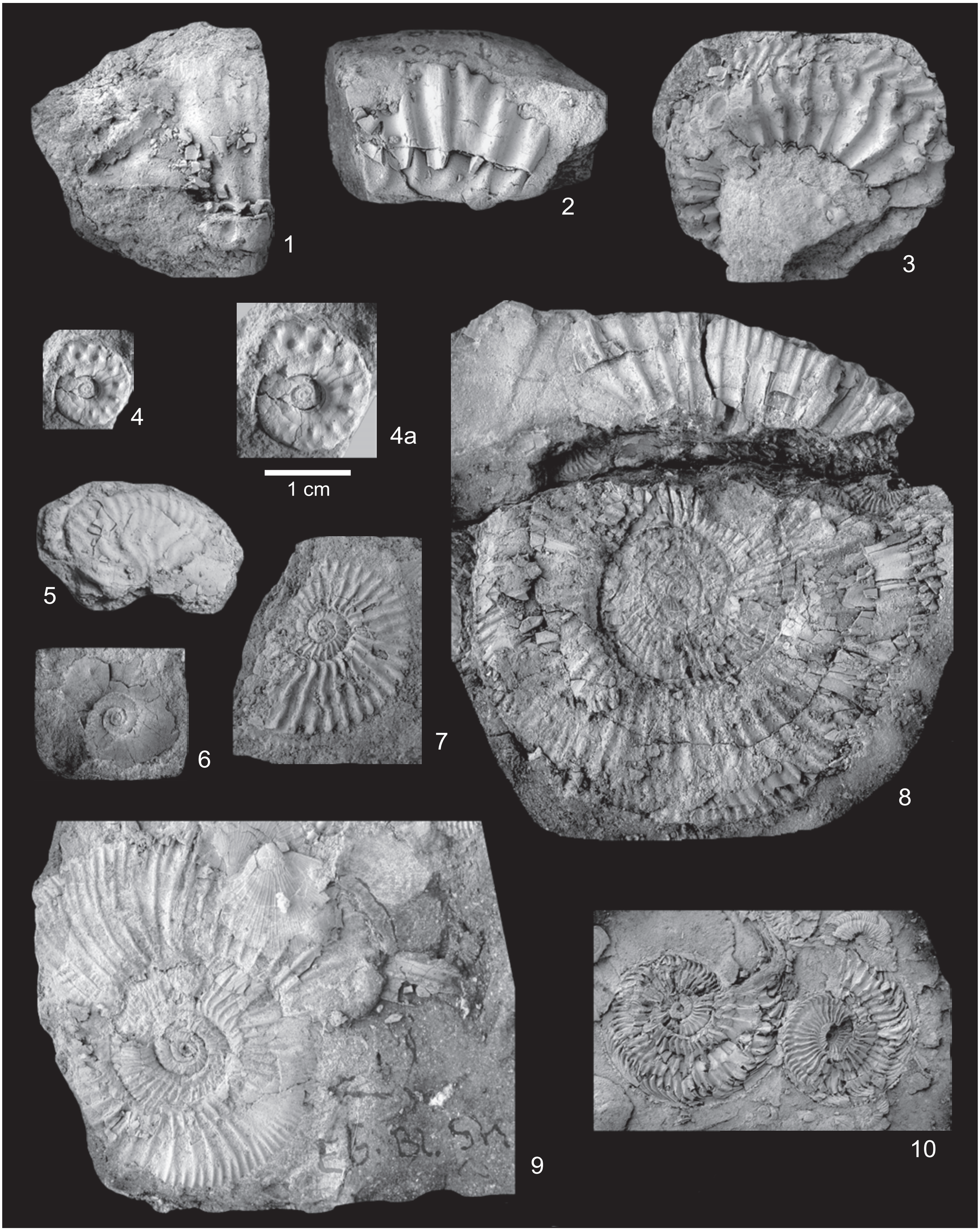
Fig. 6. *Cardioceras* (*Miticardioceras*) *tenuiserratum* (Oppel)
ZI/41/063; bed 6; Tenuiserratum Zone

Fig. 7. *Amoeboceras* (*Amoeboceras*) *transitorium* Spath
ZI/41/071; bed 8; Glosense Zone, Ilovaiskii Subzone

Fig. 8–9. *Decipia* (?) *kostromensis* sp. nov.
8 – holotype, ZI/41/012, 9 – paratype, ZI/41/065; bed 8; Decipiens Zone

Fig.10. *Amoeboceras* (*Amoeboceras*) *ilovaiskii* (Sokolov)
ZI/41/066; bed 8; Glosense Zone, Ilovaiskii Subzone

Except of Fig. 4a which is (×1.5), all specimens in natural size



Ewa GŁOWNIAK *et al.* — The Middle Oxfordian to lowermost Kimmeridgian ammonite succession at Mikhalenino (Kostroma District)...

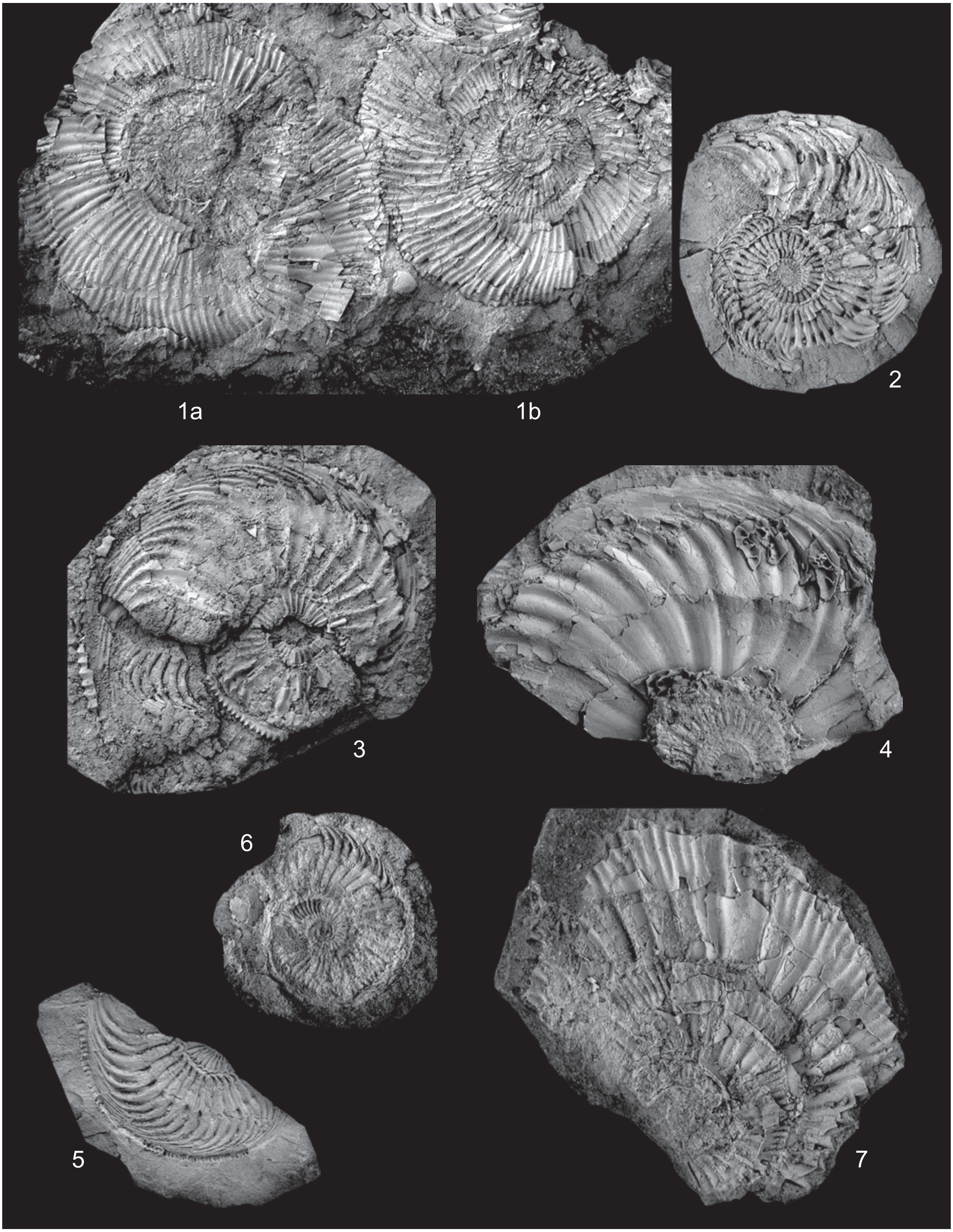
PLATE 3

Fig. 1. *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* de Riaz
ZI/41/013a, b; bed 8; Transversarium Zone, Elisabethae Subzone

Fig. 2–6. *Amoeboceras* (*Amoeboceras*) *ilovaiskii* (Sokolov)
2 –ZI/41/069, 3 – ZI/41/074, 4 – ZI/41/068, 5 – ZI/41/072; 2–5 – bed 9, Glosense Zone, Ilovaiskii Subzone;
6 – ZI/41/067, collected loose form beds 9–10, Glosense Zone, Ilovaiskii or Glosense Subzone

Fig. 7. *Decipia* cf. *decipiens* (Sowerby)
ZI/41/064; collected loose from beds 9–10; Decipiens Zone

All specimens in natural size



Ewa GŁOWNIAK *et al.* — The Middle Oxfordian to lowermost Kimmeridgian ammonite succession at Mikhalenino (Kostroma District)...

PLATE 4

Fig. 1. *Amoeboceras glosense* (Bigot et Brasil)
ZI/41/073; bed 10; Glosense Zone, Glosense Subzone

Fig. 2. *Amoeboceras nunningtonense* Wright
ZI/41/070; bed 12; Glosense Zone, Glosense Subzone

Fig. 3. *Amoeboceras koldeweyense* Sykes et Callomon
ZI/41/041; bed 13 – topmost part; Serratum Zone, Koldeweyense Subzone

Fig. 4. *Amoeboceras pectinatum* Mesezhnikov
ZI/41/042; bed 14, uppermost part; Regulare Zone

Fig. 5. *Amoeboceras rosenkrantzi* Spath
ZI/41/055; bed 15; Rosenkrantzi Zone

Fig. 6. *Amoeboceras* (*Plasmatites*) aff. *bauhini* (Oppel)
ZI/41/029; bed 17 – middle part; Bauhini Zone

Fig. 7. *Amoeboceras schulginae* Mesezhnikov
ZI/41/034; bed 17 – middle part; Bauhini Zone

Fig. 8. *Amoeboceras tuberculatoalternans* (Nikitin)
ZI/41/036; bed 17 – lowermost part; Pseudocordata Zone, Evoluta Subzone

Figs 9–11. *Amoeboceras* (*Plasmatites*) *bauhini* (Oppel)
9 – ZI/41/050, 10 – ZI/41/052, 11 – ZI/41/053; bed 17 – uppermost part; Bauhini Zone

Figs 12–13. *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatoides* Enay
12 – ZI/41/005, 13 – ZI/41/008; bed 12; Bifurcatus Zone, Stenocycloides Subzone

Fig. 14. *Ringsteadia* sp.
ZI/41/038; bed 15; Pseudocordata Zone, ?Caledonica or Pseudoyo Subzone

Fig. 15. *Microbiplices* cf. *anglicus* Arkell
ZI/41/030; bed 16; Pseudocordata Zone, Pseudocordata Subzone

Fig. 16. *Microbiplices microbiplex* (Quenstedt)
ZI/41/039; bed 16; Pseudocordata Zone, Pseudocordata Subzone

Fig. 17. *Microbiplices*/Prorasenia trans. form
ZI/41/037; bed 17 – lowermost part; Pseudocordata Zone, Evoluta Subzone

Fig. 18. *Pictonia* sp.
ZI/41/035; bed 17 – middle part; Baylei Zone

Fig. 19. *Prorasenia* sp.
ZI/41/051; bed 17 – uppermost part; Baylei Zone

All specimens in natural size

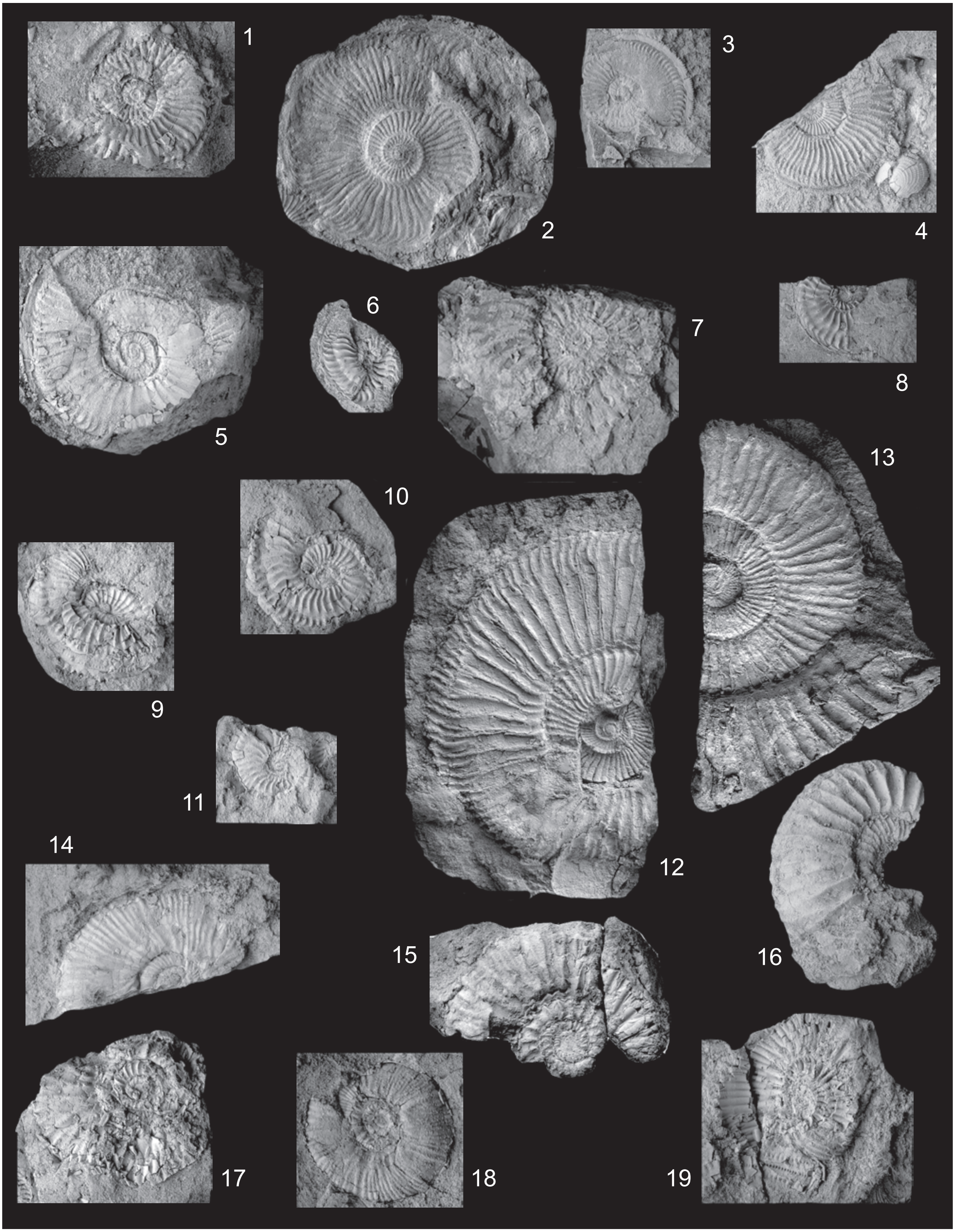

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

PLATE 5

Fig. 1. *Amoeboceras* (*Plasmatites*) *praebauhini* (Salfeld)
ZI/41/026; bed 18 – upper part; Bauhini Zone

Figs 2–4. *Amoeboceras* (*Plasmatites*) *lineatum* (Quenstedt)
2 – ZI/41/028, bed 18 – lowermost part; 3 – ZI/41/033, bed 19; 4 – ZI/41/040, bed 19; Bauhini Zone

Fig. 5. *Amoeboceras* (*Amoeboceras*) aff. *schulginae* Mesezhnikov
ZI/41/045; bed 19; Bauhini Zone

Figs 6–8. *Amoeboceras* (*Amoebites*) *bayi* Birkelund et Callomon
6 – ZI/41/043, 7 – ZI/41/044, 8 – ZI/41/054; beds 28–29; Kitchini Zone, Subkitchini Subzone

Figs 9–10. *Prorasenia* sp.
9 – ZI/41/027, bed 18 – lowermost part, Baylei Zone; 10 – ZI/41/049, bed 28–29, Cymodoce Zone (along with *Amoeboceras* cf. *cricki* (Salfeld))

Figs 11–12. *Vineta* sp.
11 – ZI/41/046, 12 – ZI/41/048; bed 19; Baylei Zone

Fig. 13. *Vineta jaekeli* Dohm (only the middle whorls of the specimen which is fully illustrated in Pl. 8: 2a)
ZI/41/032; bed 17 – topmost part; Baylei Zone

Fig. 14. *Pictonia mesezhnikovi* sp. nov. (inner whorls of the specimen which is fully illustrated in Pl. 7: 2)
holotype, ZI/41/031; bed 19 – upper part; Baylei Zone

Fig. 15. *Aspidoceras* sp.
GIN/MK2477; bed 26; Baylei Zone or Cymodoce Zone

Figs 16–17. *Rasenia* cf. *inconstans* Spath
16 a – ventral view, b – lateral view, YSPU/M28–11, bed 28; 17 a – ventral view, b – lateral view, YSPU/M29–13, bed 29; Cymodoce Zone

All specimens in natural size

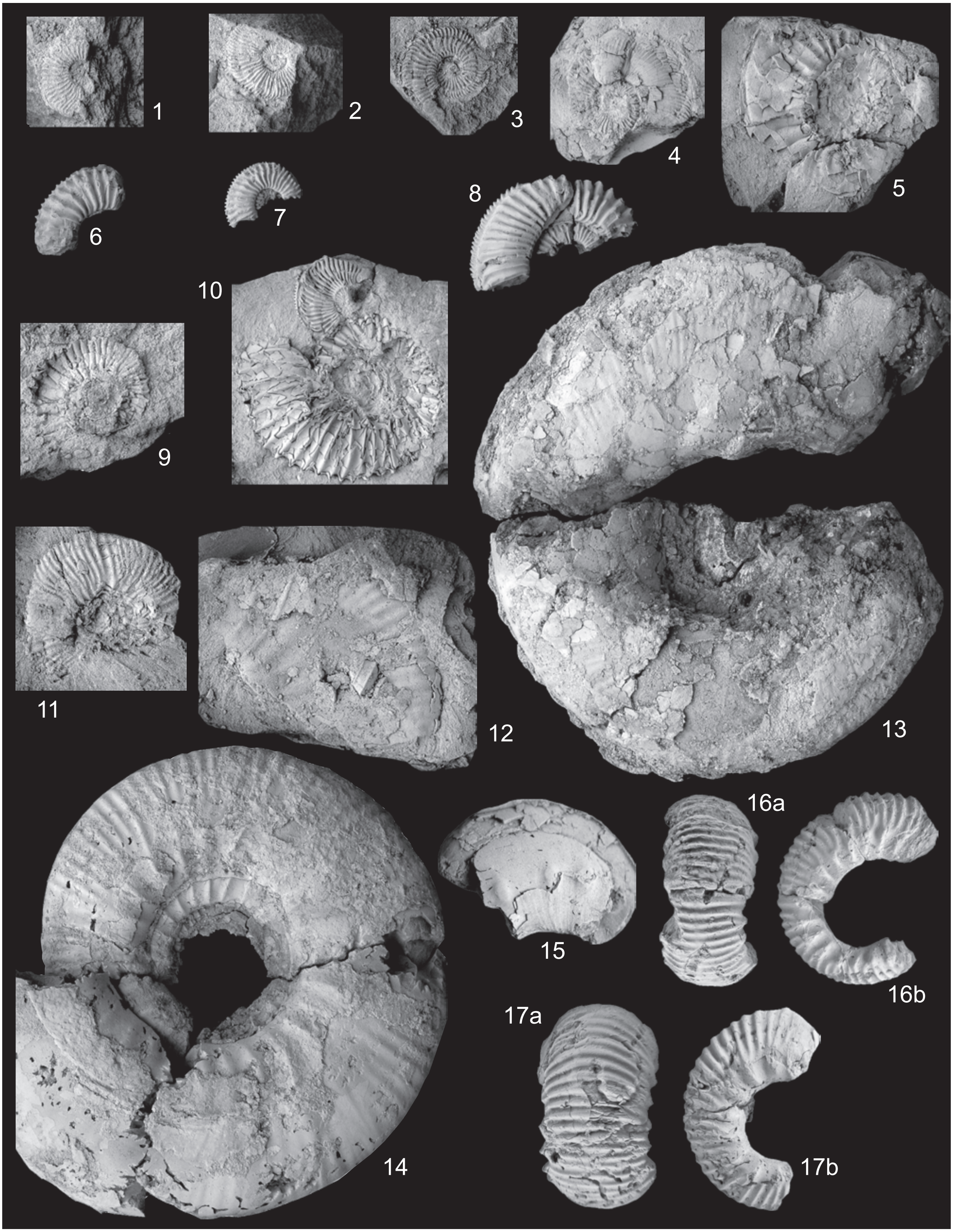

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16a
16b
17a
17b

PLATE 6

Fig. 1. *Ringsteadia brandesi* Salfeld
1a – lateral view, 1b – ventral view; YSPU/M17–3; bed 17 – probably lower part; Pseudocordata Zone, Evoluta Subzone; 1b – × 0.75

Fig. 2. *Perisphinctes* (*Perisphinctes*) sp.
YSPU/M14–8; bed 14; Bifurcatus Zone

Except Fig. 2b, which is reduced (× 0.75), all figures in natural size

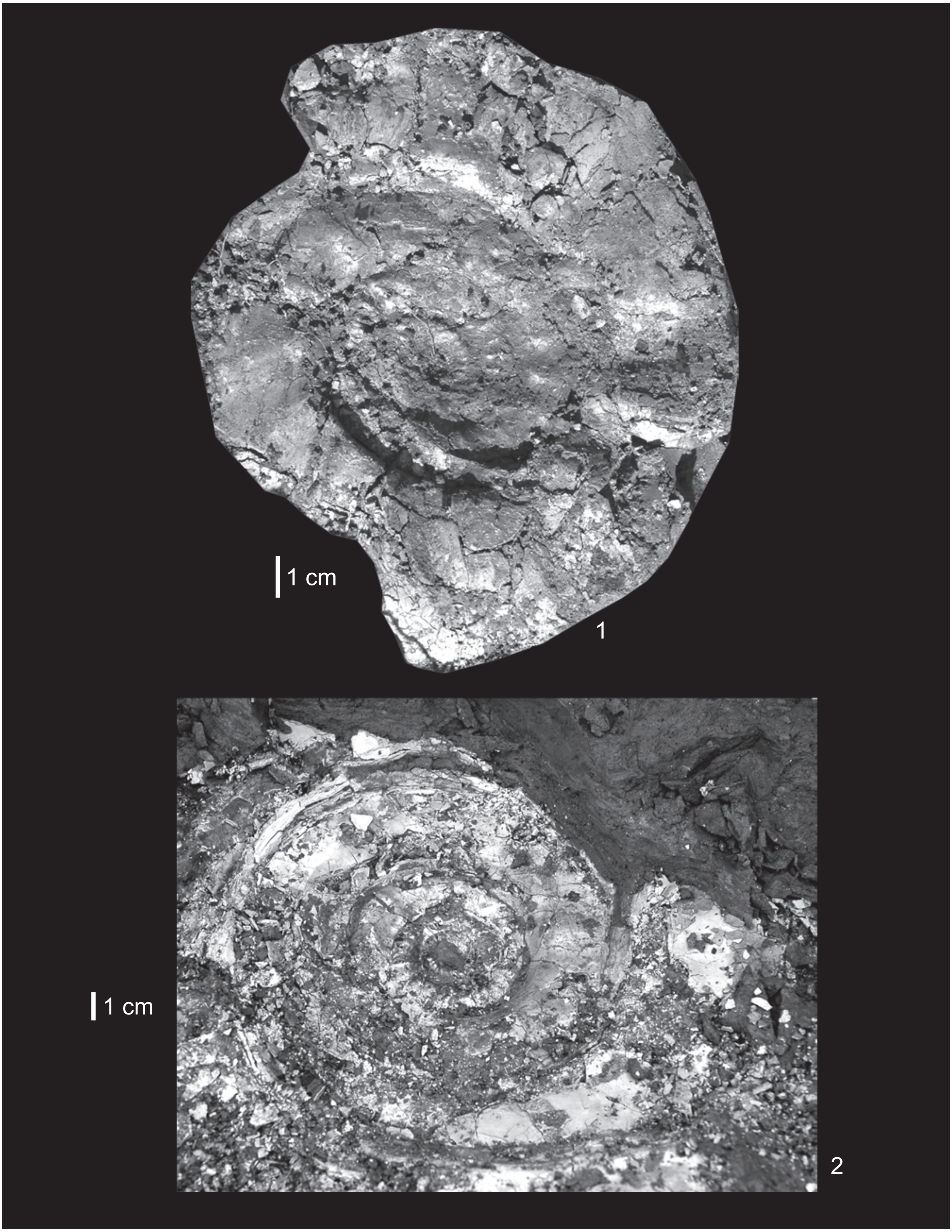

1a
1b
2b
2a
1 cm

PLATE 7

Fig. 1. *Pomerania* (*Pachypictonia*) *peltata* (Schneid)
YSPU/M19; bed 19; Baylei Zone; × 0.75

Fig. 2. *Pictonia mesezhnikovi* sp. nov.
Photograph taken in the field of the specimen (without an outer whorl) whose inner whorls (ZI/43/031, holotype) are illustrated herein in Pl. 5: 14; bed 19 – upper part; Baylei Zone; × 0.5

Fig. 1 reduced ×0.75; Fig. 2 ; × 0.5



Ewa GŁOWNIAK *et al.* — The Middle Oxfordian to lowermost Kimmeridgian ammonite succession at Mikhalenino (Kostroma District)...

PLATE 8

Fig. 1. *Perisphinctes* (*Perisphinctes*) sp.
ZI/41/014; bed 11; Transversarium or Bifurcatus Zone

Fig. 2. *Vineta jaekeli* Dohm (cf. also Pl. 5: 13)
2a – photograph taken in the field (the complete specimen is not in the collection, but its inner whorls represent specimen no. ZI/41/032 illustrated in Pl. 5: 13), bed 17 – topmost part, Baylei Zone; 2b – the innermost whorls of specimen ZI/41/032

Fig. 1 natural size; Fig. 2a reduced × 0.33; Fig. 2b enlarged × 2


2a
1
3 cm
2b
0,5 cm