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The *Amoeboceras* faunas in the Middle Oxfordian – lowermost Kimmeridgian, Submediterranean succession, and their correlation value

ABSTRACT: The *Amoeboceras* faunas occurring at certain, but well documented biostratigraphically levels of the Submediterranean succession provide arguments for closer correlation of the Submediterranean zonal scheme with the Boreal and Subboreal ones. The conclusions are: (1) The boundary between the Boreal Tenuiserratum and Glosense Zones, *i.e.* the boundary between the Boreal Middle and Upper Oxfordian is recognized within the lower part of the Wartae Subzone of the Submediterranean Transversarium Zone, (2) The upper part of the Submediterranean Transversarium Zone correlates mostly with the upper part of the Boreal Glosense Zone, (3) The uppermost part of the Submediterranean Bifurcatus Zone correlates with the upper part of the Boreal Regulare Zone, (4) The lower part of the Submediterranean Bimammatum Zone correlates with the lower part of the Boreal Rosenkrantzi Zone, (5) The lowermost part of the Submediterranean Planula Zone correlates partly at least with the upper part of the Boreal Rosenkrantzi Zone, (6) The major part of the Submediterranean Planula Zone correlates with the lower part of the Subboreal Baylei Zone, (7) The lower part of the Submediterranean Platynota Zone correlates with the upper part of the Subboreal Baylei Zone. The conclusions (6) and (7) indicate, moreover, that the boundary between the Oxfordian and Kimmeridgian is actually drawn higher in the Submediterranean zonal scheme (*i.e.* between the Planula and Platynota Zones), than in the Subboreal (*i.e.* between the Pseudocordata and Baylei Zones) and Boreal ones (*i.e.* between the Rosenkrantzi and Bauhini Zones).

INTRODUCTION

The faunal provincialism developed within the ammonite faunas of Europe during the Middle and Late Oxfordian, as well as Early Kimmeridgian, results in necessity of setting up of a separate zonal schemes based on different groups of ammonites (Text-fig. 1). Zonal schemes for the Submediterranean and Mediterranean provinces are based on ammonites of the families Perisphinctidae, Ataxioceratidae, and Aspidoceratidae, as well as occurring there very commonly representatives of the Haplocerataceae (*see e.g.* CARIOU & *al.* 1971, BROCHWICZ-LEWIŃSKI 1976, ATROPS 1982, CALLOMON 1988, CARIOU & MELÉNDEZ 1990; *cf. also* MATYJA & WIERZBOWSKI 1993). On the other hand, the zonal scheme for the Subboreal Province is based on the ammonites of the family Aulacostephanidae, such as *Decipia, Ringsteadia, Pictonia,* and *Rasenia* (*see* ARKELL 1956, SYKES & CALLOMON 1979, BIRKELUND & *al.* 1983, BIRKELUND & CALLOMON 1985), whereas that for the Boreal Province is worked out on the basis of the ammonites of the family Cardioceratidae, mostly of the genus *Amoeboceras* (*see* SYKES & CALLOMON 1979, WIERZBOWSKI & SMELROR 1993).

The precise stratigraphic correlation of the zonal schemes presents long standing problems discussed also in last years. The occurrence of Boreal ammonites of the genus *Amoeboceras* in the Submediterranean succession is thus of great interest as it provides important arguments for a closer correlation

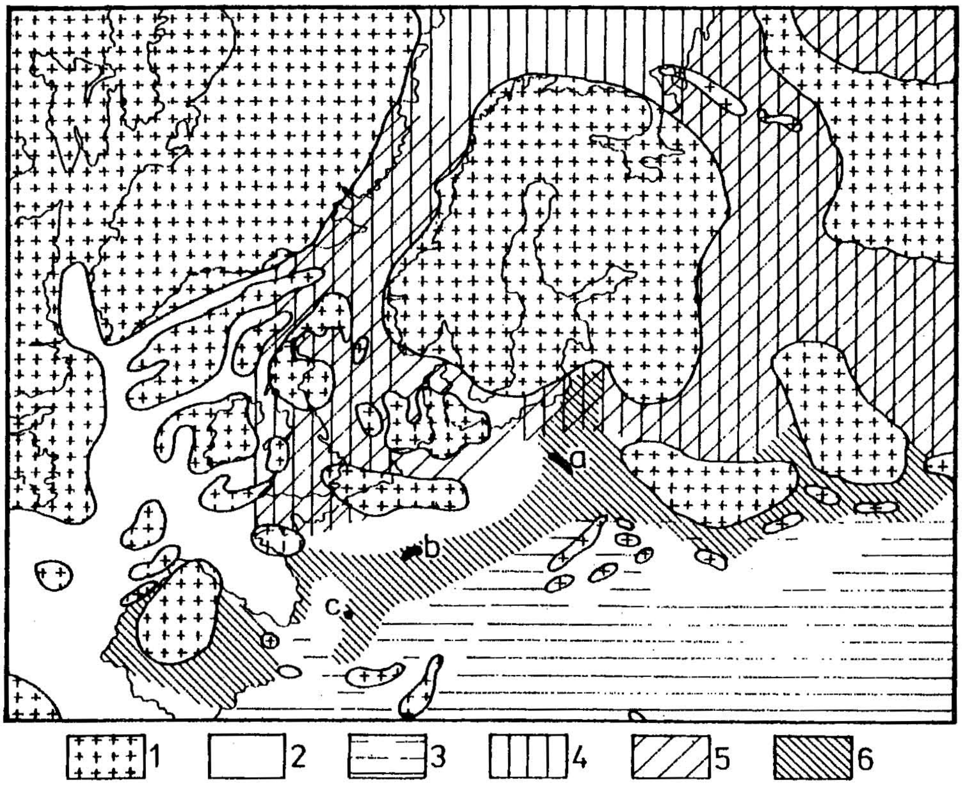

Fig. 1. Middle Oxfordian — lowermost Kimmeridgian paleogeography (*after* ZIEGLER 1987, simplified and modified) and distribution of ammonites indicative of particular bioprovinces

PALEOGEOGRAPHY: 1 — Land areas, 2 — epicratonic seas, 3 — deep-water areas

BIOGEOGRAPHY: 4 — Common occurrence of Cardioceratidae, 5 — common occurrence of Aulacostephanidae, 6 — common occurrence of Perisphinctidae, Ataxioceratidae, Aspidoceratidae and Haploceratacea

The areas of study are indicated: **a** — Polish Jura Chain, **b** — Swiss Jura Mts, **c** — Mt. Crussol (southern France) of the Submediterranean zonal scheme with the Boreal and Subboreal ones (*cf.* SYKES & CALLOMON 1979, MATYJA & WIERZBOWSKI 1988, 1993; WIERZBOWSKI 1991). These ammonites occur in the succession at some levels of which the most important are the "*Amoeboceras* layers": they represent short time invasions of the Boreal faunas into the Submediterranean Province, and yield a large number of specimens of the genus *Amoeboceras* making possible their closer paleontological study (MATYJA & WIERZBOWSKI 1988; *see also* ATROPS 1982).

The *Amoeboceras* faunas from the Submediterranean succession described in the present paper come from southern France (Mt. Crussol), northern Switzerland (Jura Mts), and adjoining parts of southern Germany, and Central Poland (Polish Jura Chain: Częstochowa Upland and Wieluń Upland). Some of these faunas were either described, or partly discussed, previously (MATYJA & WIERZBOWSKI 1988, 1993; ATROPS & GYGI 1990; *cf. also* ATROPS & *al.* 1992). The materials are deposited in the Museum of the Faculty of Geology, University of Warsaw, in the Geological Department, Lyon-*I* University, in the *Naturhistorisches Museum Basel* and in the *Geologisches Institut der Eidgenosischen Technischen Hochschule*, Zurich.

AMOEBOCERAS FAUNAS IN THE SUBMEDITERRANEAN AMMONITE SUCCESSION

The oldest ammonite of the genus *Amoeboceras* has been discovered together with the last representatives of the genus *Cardioceras* (*Cawtoniceras* or *Maltoniceras*) in the lower part of the Wartae Subzone of the Transversarium Zone, in the Niegowonice section in the Częstochowa Upland in Central Poland (MATYJA & WIERZBOWSKI 1993; *cf.* MATYJA & WIERZBOWSKI 1991, 1992a; ATROPS & *al.* 1992). This ammonite was ascribed originally to the *Amoeboceras glosense* group, and possibly to the species *Amoeboceras transitorium* SPATH. A more detailed examination of the opposite side of this specimen (Pl. 1, Fig. 1) has shown, however, that the secondary ribs are evenly projected on the ventrolateral shoulders, what indicates, together with a strong ribbing, that the specimen can be actually safely attributed to the species *Amoeboceras transitorium* SPATH..

A somewhat younger *Amoeboceras* fauna is represented by three specimens coming from bed *32* of the Chalch quarry at Hoelderbank in Switzerland (Pl. 1, Figs 2-4). Other ammonites found in the same bed indicate the Transversarium Zone, but below its upper part as it is proved by occurrence in younger beds of the same section of *Taramelliceras colleti* (LEE) in bed *35*, and *Larcheria schilli* (OPPEL) in bed *42* (GYGI & *al.* 1979, Fig. 3; *cf. also* GYGI 1990). Thus, the discussed *Amoeboceras* specimens occur possibly in the Luciaeformis Subzone of CARIOU & MELÉNDEZ (1990), and are but slightly younger than *Amoeboceras transitorium* from the Niegowonice section. The discussed *Amoe-*

boceras specimens are not fully grown and not complete: the smallest of them measures 26 mm in diameter and is wholly septate (Pl. 1, Fig. 2), whereas two larger specimens (Pl. 1, Figs 3-4) are 48 mm and 33 mm in diameters, and show the body-chambers partly preserved (the diameters at last sutures are 35 mm and 25 mm, respectively). The strength and density of ribbing are variable. Strongly ribbed specimens show widely spaced ribs (about 28-31 primaries per whorl at 20-30 mm diameters), whereas those showing a weaker ribbing pattern are more densely ribbed (36-38 primaries at 20-30 mm diameters). The secondary to primary ribs ratio equals 1.7 to 1.5 at 20-30 mm diameters. The secondary ribs show a turn forward from the furcation point, and then a second turn forward at the ventral side. This angular appearance of secondaries is typical of *Amoeboceras glosense* (BIGOT & BRASIL), and the specimens studied are assigned to that species. However, the angular appearance of secondary ribs is not very strongly expressed, which may suggest that these specimens possibly represent early forms of *Amoeboceras glosense.* On the other hand, this feature indicates that the specimens studied cannot be compared with any older species of the genus *Amoeboceras,* such as *Amoeboceras ilovaiskii* and/or *Amoeboceras transitorium* (cf. ATROPS & *al.* 1992).

A still younger specimen is an *Amoeboceras* found in bed *8* of the cement-works quarry in Oberehrendingen in Switzerland (Pl. 1, Fig. 5). The same bed has yielded also (GYGI 1977) *Subdiscosphinctes lucingae* (FAVRE) and *S. kreutzi* (SIEMIRADZKI); whereas the underlying bed *7*, as well as overlying bed *10* have yielded some specimens of *Larcheria schilli* (OPPEL). Thus, the level at which *Amoeboceras* specimen occurs, corresponds to the Schilli Subzone, *i.e.* to the upper part of the Transversarium Zone (CARIOU & MELÉNDEZ 1990).

The discussed specimen is small, having only 25 mm in diameter. It appears to be mature, as the last sutures at 17 mm diameter are crowded, but the body-chamber is partly preserved. The inner whorls are mostly damaged. The ribbing, well visible on the outer whorl, is strong with rather weak lateral tubercles. The umbilicus is narrow and equals about 26% of the specimen diameter. The characteristic angular secondary ribs indicate a close relation of the specimen with *Amoeboceras glosense,* and especially with its small-sized specimens, mostly microconchs illustrated by SYKES & CALLOMON (1979, Pl. 116, Figs 6-9).

The next ammonite fauna is represented by *Amoeboceras ovale* (QUENSTEDT) and related forms (Text-fig. 2). The typical specimens of this microconch species have been discovered in big numbers in the "*Amoeboceras* layer" in the Semimammatum horizon of the Hypselum Subzone, *i.e.* in the lowermost part of the Bimammatum Zone, in several sections in Central Poland, mostly in the Częstochowa Upland (MATYJA & WIERZBOWSKI 1988, and the earlier papers cited therein). More recently (MATYJA & WIERZBOWSKI 1991, 1992b, 1993; ATROPS & *al.* 1992), some specimens of *A. ovale* have been found also in the upper part of the Grossouvrei Subzone of the Bifurcatus Zone, in the Syborowa Góra section of Central Poland. The same section has yielded a few larger specimens: fragmentary ones from the Grossouvrei Subzone which seem to be close to the species *Amoeboceras freboldi* Spath and *Amoeboceras marstonense* Spath, and a single typical *Amoeboceras rosenkrantzi* Spath from a lower part of the Semimammatum horizon. The indicated larger forms are

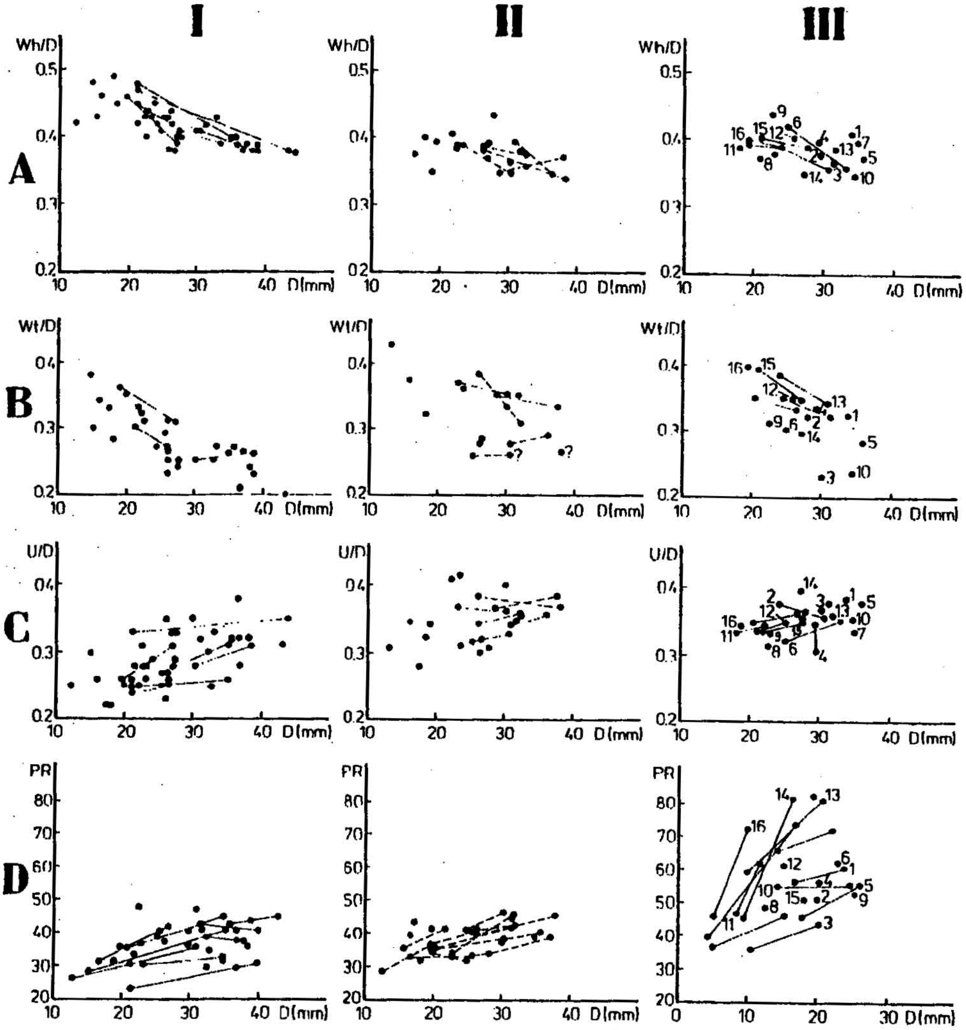

Fig. 2. Diagrams showing relations of morphologic features in some studied *Amoeboceras* specimens

A — Whorl height (*Wh*) in percentage of shell diameter against shell diameter (*D*); B — whorl thickness (*Wt*) in percentage of shell diameter against shell diameter (*D*); C — umbilicus diameter (*U*) in percentage of shell diameter against shell diameter (*D*); D — number of primary ribs per whorl (*PR*) against shell diameter (*D*)

I — Biospecies *Amoeboceras ovale* (Quenstedt) from the "*Amoeboceras* layer", Semimammatum horizon, Bimammatum Zone, Częstochowa Upland, Poland; II — Biospecies *Amoeboceras praebauhini* (Salfeld) from the "*Amoeboceras* layer", lowermost Planula Zone, Raciszyn (Poland); III — Biospecies of *Amoeboceras* from the *Amoeboceras* horizon of Mt. Crussol (France) and beds with *Amoeboceras* from Schaffhausen (Switzerland)

Numbers correspond to figure numbers in Plate 2 macroconchs, and they represent possibly the stratigraphically successive counterparts of a more "conservative" microconch species *Amoeboceras ovale* (QUENSTEDT).

Some fairly typical specimens of *A. ovale* coming from sections of France and Switzerland and illustrated in the present paper are but briefly commented below. A single specimen (Pl. 1, Fig. 10) is coming from the Hypselum Subzone in Mt. Crussol section of southern France. Another specimen (Pl. 1, Fig. 9) comes from bed *6* of the Mellikon quarry section in Switzerland (GYGI 1969, Pl. 17). As the latter specimen has been found together with *Ringsteadia* similar to *Ringsteadia pseudoyo* SALFELD, and below *Epipeltoceras* cf. *bimammatum* (QUENSTEDT), their stratigraphic position must be the Bimammatum Zone (GYGI 1969, GYGI & PERSOZ 1986), and the most possibly the Hypselum Subzone (*cf.* WIERZBOWSKI 1991).

It should be remembered that a few microconchs coming from the Siblingen area in Switzerland show a marked resemblance to *Amoeboceras ovale*, but their inner whorls are smooth (Pl. 1, Figs 7-8). The smooth inner whorls are typical of the *Amoeboceras serratum* group, and the specimens discussed can be interpreted as intermediate between microconchs of *Amoeboceras serratum* and *A. ovale*. The biostratigraphic position of these specimens in

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PLATE 1

Amoeboceras faunas, Transversarium to Planula Zones

1 — *Amoeboceras transitorium* SPATH; Transversarium Zone, Wartae Subzone, Niegowonice section, bed *17*; Specimen No. IGPUW/A/27/5

2-4 — *Amoeboceras glosense* (BIGOT & BRASIL); Transversarium Zone, Luciaeformis Subzone, Holderbank, Chalch quarry, bed *32*; Specimen Nos J 27912, J 27678, J 27679

5 — *Amoeboceras* cf. *glosense* (BIGOT & BRASIL); Transversarium Zone, Schilli Subzone, Oberehredingen, cement-work quarry, bed *8*; Specimen No. J 25336

6-8 — *Amoeboceras serratum* (SOWERBY) — *Amoeboceras ovale* (QUENSTEDT) intermediate forms: **6** — upper part of Bifurcatus Zone, Moenthal, Specimen No. J 31456; **7** — Siblingen, Specimen No. J 27636; **8** — Siblingen, Specimen No. J 26275

9-13 — *Amoeboceras ovale* (QUENSTEDT); Bimammatum Zone, Hypselum Subzone: **9** — Mellikon quarry, bed *6*, Specimen No. J 25608; **10** — Mt. Crussol, bed *28*, Specimen No. SF 28; **11-12** — Jaroszów (Częstochowa Upland), Specimens Nos IGPUW/A/27/32, IGPUW/A/27/435; **13** — Biskupice (Częstochowa Upland), Specimen No. IGPUW/A/27/222

14 — *Amoeboceras tuberculatoalternans* (NIKITIN), Bimammatum Zone, Hornbuck; Specimen No. J 31462

15-17 — Full range of variants of *Amoeboceras praebauhini* (SALFELD) biospecies including morphospecies (*cf.* MATYJA & WIERZBOWSKI 1988, Pl. 2): **15** — *A. bauhini*, Specimen No. IGPUW/A/27/34; **16** — *A. praebauhini*, Specimen No. IGPUW/A/27/35; **17** — *A.* aff. *lineatum*, Specimen No. IGPUW/A/27/39; all from the lowermost Planula Zone, Raciszyn, "*Amoeboceras* layer"

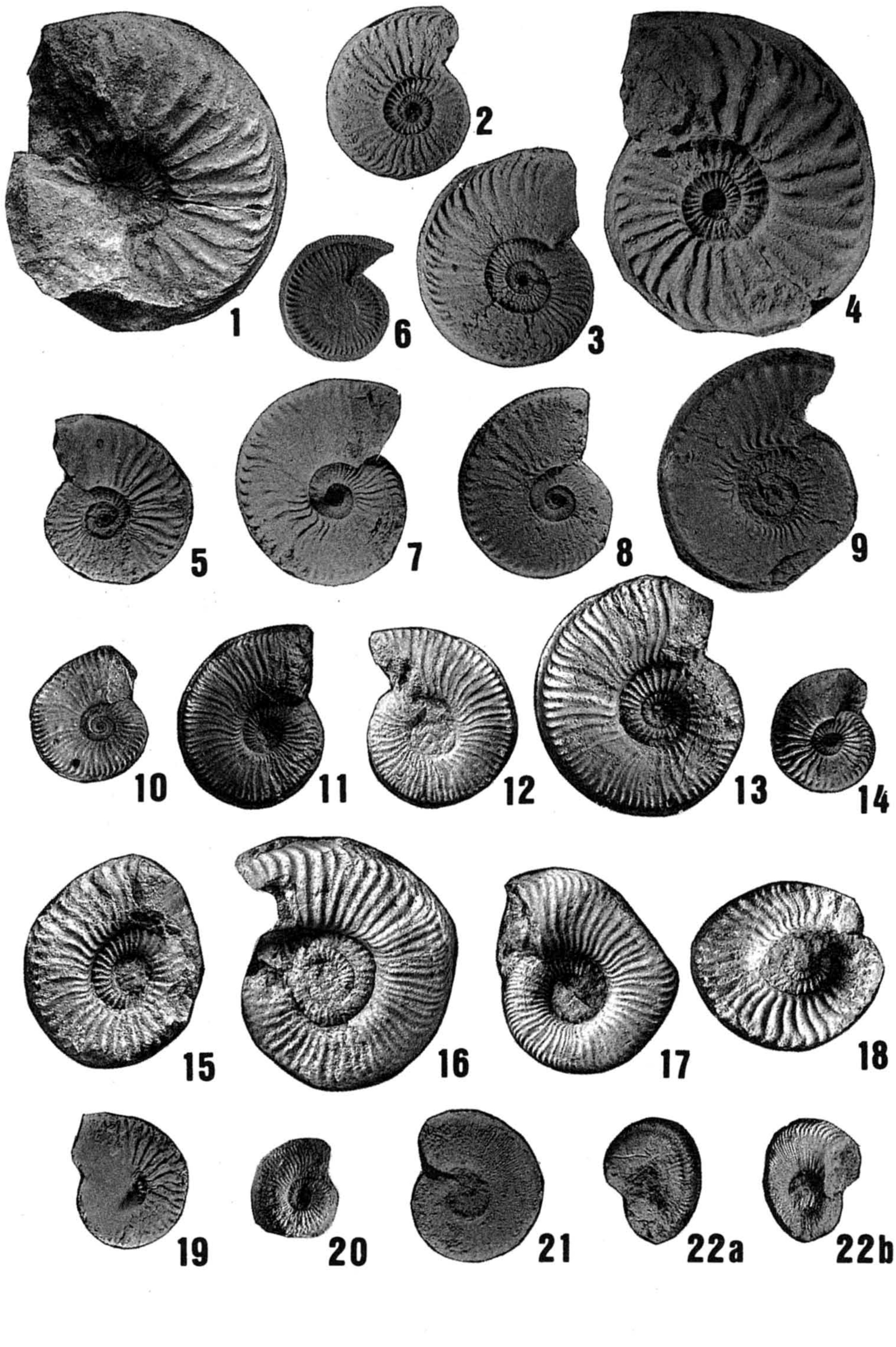
18 — *Amoeboceras bauhini* (OPPEL); lower/middle Planula Zone, Antonie, Specimen No. W 52 Dz/1

19 — *Amoeboceras bauhini* (OPPEL); Planula Zone, Galar Subzone, Summerhalde (Schaffhausen), bed *9*; Specimen No. J 26540

20-21 — *Amoeboceras lineatum* (QUENSTEDT); Planula Zone, Galar Subzone, Summerhalde (Schaffhausen): **20** — bed *10*, Specimen No. J 26564; **21** — bed *9*, Specimen No. J 26543

22a-22b — *Amoeboceras* cf. *lineatum* (QUENSTEDT); uppermost Planula Zone, Pilica; Specimen No. IGPUW/A/27/ 328

All specimens in natural size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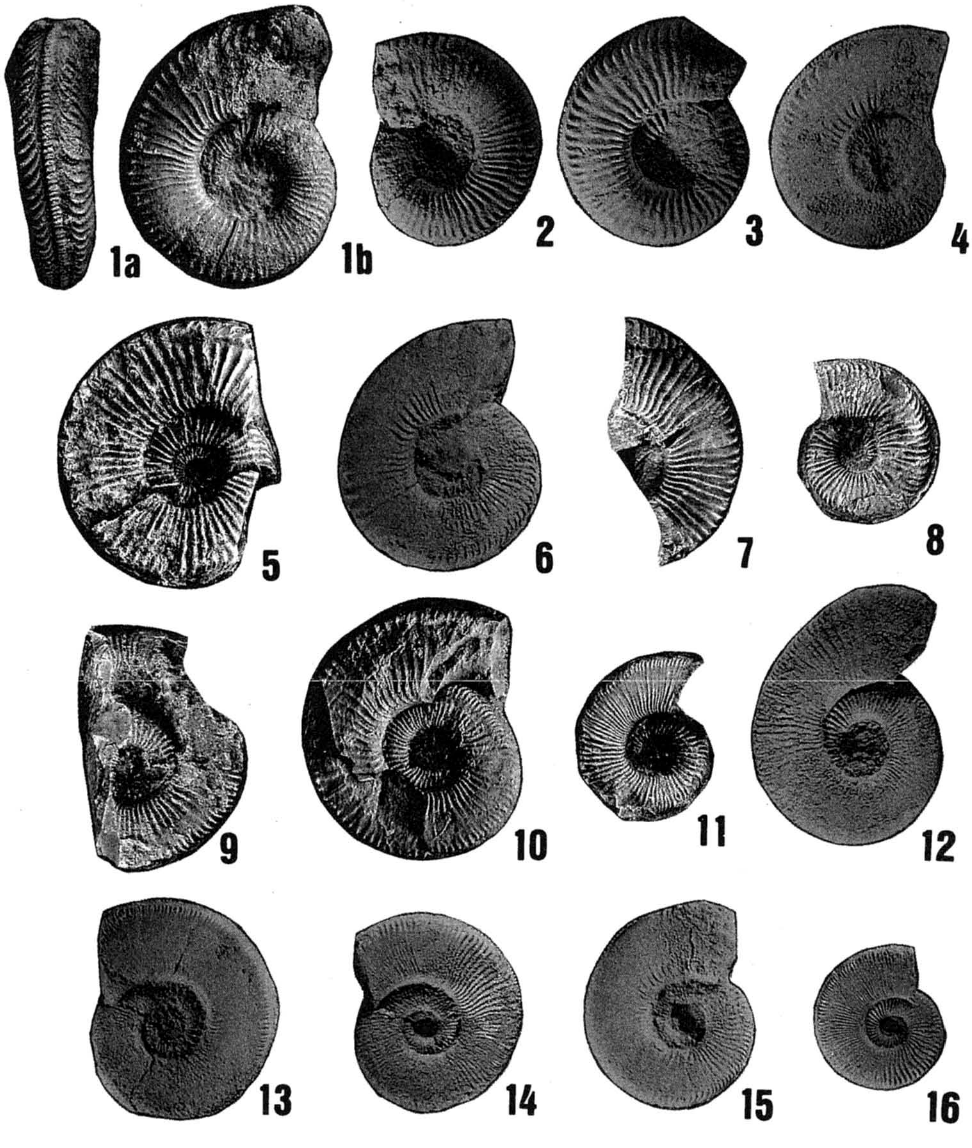
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the Siblingen area cannot be precisely recognized but it has to be somewhere inbetween the Bimammatum Zone and the Bifurcatus Zone (*cf.* GYGI 1969). It is worth noting, moreover, the occurrence possibly in the upper part of the Bifurcatus Zone of the Moenthal section in Switzerland of a very similar specimen (Pl. 1, Fig. 6) compared by GYGI & PERSOZ (1986, p. 407) with *Amoeboceras serratum* (SOWERBY).

A single *Amoeboceras* specimen is well localized in the upper part of the Bimammatum Zone. It comes from bed *12* of the Hornbuck section in southern Germany together (*see* GYGI 1969, Fig. 2) with *Epipeltoceras bimammatum* (QUENSTEDT). This specimen (Pl. 1, Fig. 14) is small, about 20 mm in diameter; the diameter at the last suture is about 12 mm. It is involute (whorl height and umbilical width are 44.5%, and 27.7% of the specimen diameter, respectively). The whorl section is somewhat depressed, pentagonal in outline. The primaries are strongly prorsiradiate, and end in lateral tubercles slightly above the whorl mid-height. The smooth spiral band separates the primary and secondary ribs on the body chamber. The secondaries are somewhat rursiradiate; they are accentuated at the ventrolateral shoulder. The keel is low, crenulated, and flanked by shallow, smooth sulci.

All the features indicate a close relation between the specimen studied and these of the type-series of the species *Amoeboceras tuberculatoalternans* (NIKITIN), recently discussed by MESEZHNIKOV & *al.* (1989, pp. 81-85, Pl. 24, Figs 13-17). It can be thus safely attributed to this very species.

Still younger fauna represented by large number of specimens comes from the "*Amoeboceras* layer" in the lowermost part of the Planula Zone in the Raciszyn section of the Wieluń Upland in Central Poland (MATYJA & WIERZBOWSKI 1988, WIERZBOWSKI 1992; *cf.* ATROPS & *al.* 1992). The fauna consists of the single biospecies *Amoeboceras praebauhini* (SALFELD) which shows a wide, but nevertheless continuous spectrum of variability (Text-fig. 2), ranging from forms close to *Amoeboceras bauhini* (OPPEL) up to forms similar to *Amoeboceras lineatum* (QUENSTEDT). When compared with older *Amoeboceras* faunas, the one discussed shows a different type of the ventral side with more coarsely

PLATE 2

Amoeboceras fauna, Platynota Zone, Orthosphinctes Subzone

1-6 — Specimens of group **A** similar to more coarsely ribbed *Amoeboceras bayi* BIRKELUND & CALLOMON: **1a-1b** — Summerhalde (Schaffhausen), bed *20-21*, Specimen No. SUM 20-22; **2-3** — Summerhalde (Schaffhausen), bed *20*, Specimens Nos J 26696 and J 26713; **4** — Summerhalde (Schaffhausen), bed *21*, Specimen No.J 26760; **5** — Mt. Crussol, bed *114*, Specimen No. 226990; **6** — Summerhalde (Schaffhausen), bed *20*, Specimen No. J 26690

7-10 — Specimens of group **B** similar to more densely ribbed *Amoeboceras bayi* BIRKELUND & CALLOMON and *Amoeboceras cricki* (SALFELD); Mt. Crussol, bed *114*; Specimens Nos 227006, 227005, 227002, 186678

11-16 — Specimens of group **C** similar to *Amoeboceras ernesti* (FISCHER): **11** — Mt. Crussol, bed *114*, Specimen No. 227004; **12** — Summerhalde (Schaffhausen), bed *21*, Specimen No. J 26759; **13-16** — Summerhalde (Schaffhausen), bed *20*, Specimens Nos J 26683, J 26681, J 26682 and J 26511

All specimens in natural size

crenulated keel, and a poor development, or nearly absence of the ventral sulci (*cf.* MATYJA & WIERZBOWSKI 1988, Pl. 2).

A few specimens of the genus *Amoeboceras* have been found in the sections at Antonie and Lelity of the Wieluń Upland in Central Poland, in beds somewhat younger than the discussed "*Amoeboceras* layer". These specimens (WIERZBOWSKI 1978, Pl. 2, Fig. 15; *see also* Pl. 1, Fig. 18 herein) belong to *Amoeboceras bauhini* (OPPEL), and are closely comparable with the type of the species. They occur in lower/middle parts of the Planula Zone, as indicated by their coexistence with *Idoceras minutum* DIETERICH (*see* WIERZBOWSKI 1987; *cf.* ATROPS & *al.* 1992).

The species *Amoeboceras bauhini* (OPPEL) is abundant in the upper part of the Planula Zone, *i.e.* in the Galar Subzone, especially in southern Germany, in the Swabian Alb (BIRKELUND & CALLOMON 1985, p.15, Pl. 9, Figs 8-12). A single specimen of the same species (Pl. 1, Fig. 19) comes from the Galar Subzone near Schaffhausen, northern Switzerland (bed *9* of the section: GYGI 1990, p. 69; *cf. also* GYGI 1969, Pl. 16). This specimen is small, about 20 mm in diameter, but well characterized by its quadrate section, evolute coiling, and sharp, sparse ribs which are curved backwards at the point of furcation, about two thirds of the whorl height. The Galar Subzone of the same section at Schaffhausen (beds *9*, *10* and *17*) has yielded also three specimens which may be ascribed to the species *Amoeboceras lineatum* (QUENSTEDT). These specimens (Pl. 1, Figs 20-21) show lenticulate whorl section, as well as single and biplicate ribbing which changes from fairly dense on inner whorls (about 40 primaries per whorl at 15 mm diameter), up to extremely dense on the outer whorl (about 70 primaries per half a whorl at 23 mm diameter). The primaries are prorsiradiate, the furcation point is high, and the short secondaries are rectiradiate or slightly prorsiradiate. The keel is crenulated, and the lateral sulci are poorly marked.

Three specimens from the uppermost part of the Planula Zone of the Częstochowa Upland in Central Poland are small and deformed. They show however dense, single and biplicate ribbing continuing up to the crenulated keel through poorly marked ventral sulci (Pl. 1, Fig. 22). The specimens are referred to as *Amoeboceras* cf. *lineatum* (QUENSTEDT).

The youngest *Amoeboceras* fauna comes from the lowermost part of the Orthosphinctes Subzone representing the lower part of the Platynota Zone (ATROPS 1982, ATROPS & GYGI 1990; *see also* ATROPS & *al.* 1992): it comes from bed *114* of Mt. Crussol section in southern France (*Amoeboceras* horizon of ATROPS 1982, Tab. 46, and Figs 63-64), as well as from beds *20-21* of the Summerhalde section at Schaffhausen in northern Switzerland (GYGI 1990, p. 69; *cf. also* GYGI 1969, Tab. 16). The material consists of 21 fairly complete specimens (6 from Mt. Crussol section, 15 from Summerhalde section). The specimens are from 20 mm to about 35 mm in diameters with body chambers preserved (the diameters at last sutures are between 10 mm and 27 mm). The peristome is nowhere preserved, but some specimens are undoubtedly fully grown, as shown by crowding of their sutures and uncoiling of the umbilical seam (Pl. 2, Fig. 12). The specimens display a wide variation of the sculpture on the last whorl, and may be divided into three groups as follows (*see also* Text-fig. 2 *and* Pl. 2, Figs 1-16):

A. Specimens (Pl. 2, Figs 1-6) showing rather sparse, strong ribbing; the primary ribs are rectiradiate, and separated from secondary ribs by a marked smooth spiral band located high on the whorl side; the secondary ribs are short and strongly accentuated; specimens show subrectangular whorl section; ventral side is tabulate with coarsely crenulated keel bordered by shallow sulci;

B. Specimens (Pl. 2, Figs 7-10) showing fairly dense rectiradiate, straight to somewhat flexuous ribbing; a smooth spiral band on the whorl side is either poorly developed or absent; the secondary ribs are somewhat accentuated; specimens show subrectangular whorl section; ventral side is flattened with crenulated keel bordered by poorly marked sulci.

C. Specimens (Pl. 2, Figs 11-16) very finely and densely ribbed, but only on the outer whorl (number of primary ribs attains there up to 80; Text-fig. 2); the ribbing may however increase and/or decrease in density in a single specimen in some sectors of the whorl; the last half-whorl becomes partly smooth (or with vestigial striations) in some specimens, but the primary ribs close the umbilicus, and the secondary ribs at the ventral side are usually persisting (Pl. 2, Figs 13 and 15); specimens show subrectangular to suboval whorl section; ventral side is flattened with finely crenulated keel borderd, by poorly marked ventral sulci.

The classification of these specimens depends on the approach accepted. On purely morphological grounds the particular groups of specimens may be easily attributed to different morphospecies. The specimens of the group (A) are very similar to more coarsely ribbed forms of *Amoeboceras* (*Amoebites*) *bayi* BIRKELUND & CALLOMON; it deals *e.g.* with some specimens figured here (Pl. 2, Figs 2-3) which are very close to that presented by BIRKELUND & CALLOMON (1985, Pl. 1, Fig. 6); also a single specimen illustrated herein (Pl. 2, Fig. 6), which shows some looping of secondary ribs, is similar to that illustrated by BIRKELUND & CALLOMON (1985, Pl. 1, Fig. 7). The specimens of the group (B) seem to be similar to some more densely ribbed variants of *Amoeboceras* (*Amoebites*) *bayi* BIRKELUND & CALLOMON (*see* BIRKELUND & CALLOMON 1985, Pl. 1, Figs 11-12), but also to *Amoeboceras cricki* (SALFELD); *see* SALFELD (1915, Pl. 19, Figs 2a-c; *cf. also* WRIGHT 1989, Fig. 4C-F). The specimens of the group (C) can be compared with *Amoeboceras ernesti* (FISCHER) as well as the two closely related "species" *Amoeboceras haizmanni* (FISCHER) and *Amoeboceras fraasi* (FISCHER); *see* FISCHER (1913, Pl. 5, Figs 16-18; *cf. also* BIRKELUND & CALLOMON 1985, pp. 18-19).

The continuous variability observed in specimens of the fauna studied (Text-fig. 2; Pl. 2, Figs 1-16), as well as their occurrence in a narrow stratigraphic interval, suggest that the discussed groups could be treated merely as variants of a single biospecies. Of the names available, the name *Amoeboceras cricki* (SALFELD) would be the most appropriate as it corresponds to an intermediate morphotype. However, from the stratigraphic point of view it is possibly better for the time being to use the names *Amoeboceras bayi* BIRKELUND & CALLOMON and *Amoeboceras ernesti* (FISCHER) for the extreme morphologies, as they correspond to forms whose stratigraphic and geographic positions in the Boreal/Subboreal and the Submediterranean successions/areas are well known.

BIOSTRATIGRAPHIC CORRELATION

The last fauna of *Cardioceras* (*Cawtoniceras* or *Maltoniceras*) occurring together with *Amoeboceras transitorium* SPATH in the lower part of the Wartae Subzone of the Transversarium Zone, indicates the boundary between the Blakei Subzone of the Tenuiserratum Zone, and the Ilovaiskii Subzone of the Glosense Zone, *i.e.* the boundary between Boreal Middle and Upper Oxfordian (Text-fig. 3; MATYJA & WIERZBOWSKI, 1993; ATROPS & *al.* 1992; *cf. also* SYKES & CALLOMON 1979). Because the Submediterranean Middle Oxfordian consists of the Plicatilis and the Transversarium Zones (CARIOU & *al.* 1971), and sometimes also of the Bifurcatus Zone (*e.g.* CARIOU & MELÉNDEZ 1990), the findings discussed indicate that the boundary of the Middle and Upper Oxfordian in the Boreal zonal scheme runs markedly lower than the boundary of these two substages in the Submediterranean zonal scheme (MATYJA & WIERZBOWSKI 1993).

Still younger in the Submediterranean succession are *Amoeboceras glosense* (BIGOT & BRASIL) and *A.* cf. *glosense* (BIGOT & BRASIL) discovered in the Luciaeformis and Schilli Subzones of the upper Transversarium Zone. The species *A. glosense* characterizes the Glosense Zone of the Boreal zonal scheme, occurring mostly in the upper part of this zone, in the Glosense Subzone (SYKES & CALLOMON 1979). Thus, the upper part of the Submediterranean Transversarium Zone would be correlated mostly with the upper part of the Boreal Glosense Zone (Text-fig. 3; *cf. also* ATROPS & *al.* 1992). The occurrence of a specimen showing considerable resemblence to *Amoeboceras nunningtonense* WRIGHT in the Schilli Subzone of north-western France at Poitiers (SYKES & CALLOMON 1979, p. 872) is in good accordance with the correlation presented.

The next well characterized, and abundant *Amoeboceras* fauna occurs in the Submediterranean succession in the upper part of the Grossouvrei Subzone of the Bifurcatus Zone, as well as in the lower part of the Bimammatum Zone, mostly in the Semimammatum horizon. It is represented by numerous specimens of the microconch species *Amoeboceras ovale* (QUENSTEDT), well corresponding to the microconchs of such Boreal ammonites as *Amoeboceras freboldi* SPATH, *A. marstonense* SPATH, and *A. rosenkrantzi* SPATH (*see* MATYJA & WIERZBOWSKI 1988, 1993; *see also* Pl. 1, Figs 11-13 herein). Moreover, rare macroconchs of the Boreal species have been found in this stratigraphic interval (MATYJA & WIERZBOWSKI 1993): a few *Amoeboceras freboldi* or *A. marstonense* in the upper part of the Grossouvrei Subzone, and a single *A. rosenkrantzi* in the Semimammatum horizon. The data given indicate that the upper part of the Grossouvrei Subzone, *i.e.* the uppermost part of the Submediterranean Bifurcatus Zone, corresponds to the upper part of the Boreal Regulare Zone, whereas the lower part of the Submediterranean Bimammatum Zone corresponds to the lower part of the Boreal Rosenkrantzi Zone (MATYJA & WIERZBOWSKI 1993). The data also suggest that the lower boundary of the Pseudocordata Zone of the Subboreal zonal scheme should be drawn somewhat below the base

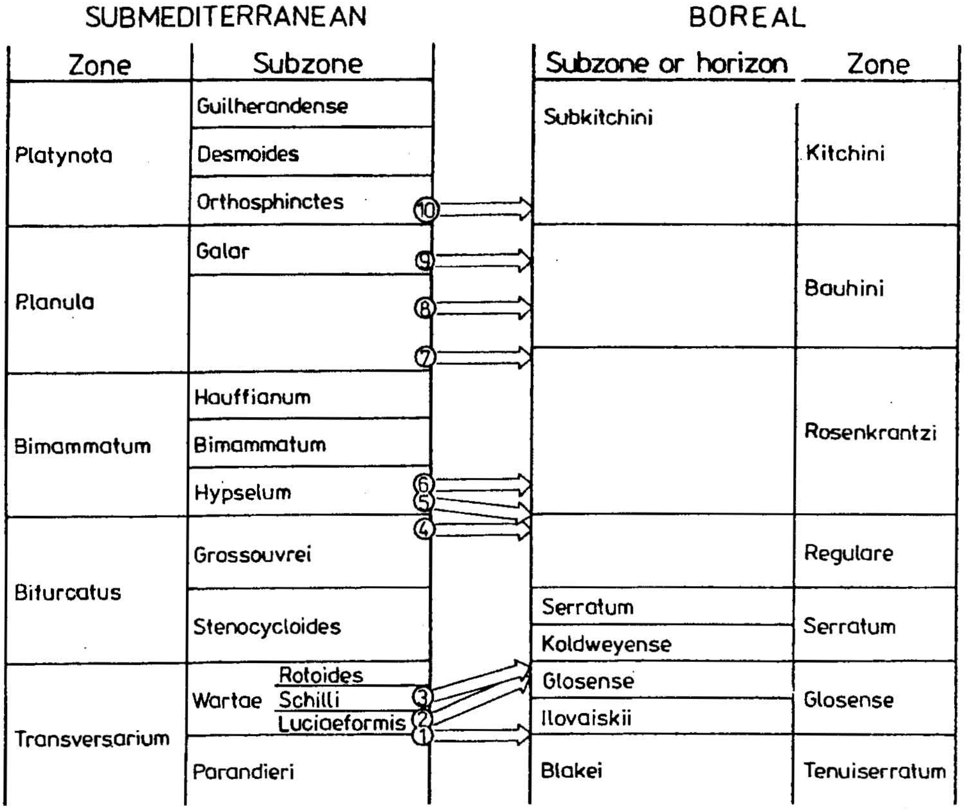

Fig. 3. Correlation of the Submediterranean and the Boreal zonal schemes

Numbers *1-10* indicate the stratigraphic position of particular cardioceratid faunas discussed in the text

1 — *Cardioceras (Cawtoniceras* and/or *Maltoniceras)* followed by *Amoeboceras transitorium* SPATH from Niegowonice section (Poland),
2 — *Amoeboceras glosense* (BIGOT & BRASIL) from Holderbank (Switzerland),
3 — *Amoeboceras* cf. *glosense* (BIGOT & BRASIL) from Oberehredingen (Switzerland),
4 — *Amoeboceras ovale* (QUENSTEDT), *Amoeboceras freboldi* SPATH and/or *Amoeboceras marstonense* SPATH from Syborowa Góra (Poland),
5 — *Amoeboceras rosenkrantzi* SPATH from Syborowa Góra (Poland),
6 — *Amoeboceras ovale* (QUENSTEDT) from Syborowa Góra (Poland),
7 — *Amoeboceras praebauhini* (SALFELD) from Raciszyn (Poland),
8 — *Amoeboceras bauhini* (OPPEL) from Antonie (Poland),
9 — *Amoeboceras bauhini* (OPPEL) and *Amoeboceras lineatum* (QUENSTEDT) from Schaffhausen (Switzerland),
10 — *Amoeboceras bayi* (BIRKELUND & CALLOMON), *Amoeboceras cricki* (SALFELD), and *Amoeboceras ernesti* (FISCHER) from Schaffhausen (Switzerland) and Mt. Crussol (France)

of the Bimammatum Zone, within the Grossouvrei Subzone of the Bifurcatus Zone of the Submediterranean zonal scheme (WIERZBOWSKI 1991, MATYJA & WIERZBOWSKI 1993; see Text-fig.3). On the other hand, the older part of the Bifurcatus Zone represents an interval of the Submediterranean succession in which *Amoeboceras* are very poorly known. It possibly corresponds to the Serratum Zone, and to the lower part of the Regulare Zone of the Boreal subdivision. The occurrence of an intermediate form between *Amoeboceras serratum* (SOWERBY) and *A. ovale* (QUENSTEDT) in the upper part of the Bifurcatus Zone is in favor of such a correlation.

A single specimen of *Amoeboceras tuberculatoalternans* (NIKITIN) discovered in the upper part of the Bimammatum Zone is of smaller correletion value. In fact, the stratigraphic range of the species in the Boreal/Subboreal successions is wide but not very well recognized (*cf.* MESEZHNIKOV & *al.* 1979). The species seems to range up to the boundary of the Rosenkrantzi and the Bauhini Zone, *i.e.* to the boundary of the Oxfordian and Kimmeridgian in the Boreal subdivision (*cf.* SYKES & CALLOMON 1979, Pl. 121, Fig. 7; BIRKELUND & CALLOMON 1985, p. 16; WIERZBOWSKI & SMELROR 1993).

The younger fauna coming from the "*Amoeboceras* layer" in the lowermost part of the Planula Zone consists (*see* MATYJA & WIERZBOWSKI 1988, WIERZBOWSKI 1992) of the single biospecies *Amoeboceras praebauhini* (SALFELD). The forms close to typical representatives of *A. praebauhini* occur with *Amoeboceras rosenkrantzi* SPATH in the upper part of the Rosenkrantzi Zone in the cores from the southwestern Barents Sea (WIERZBOWSKI & SMELROR 1993). This indicates that the lowermost part of the Submediterranean Planula Zone correlates, partly at least, with the upper part of the Boreal Rosenkrantzi Zone. It is also worth noting the occurrence, in the lower part of the Planula Zone, of ammonites of the genus *Ringsteadia* similar to *R. evoluta* SALFELD (*see* WIERZBOWSKI 1970). The latter species is typical of the upper part of the Subboreal Pseudocordata Zone what indicates that the lower part of the Planula Zone correlates actually also with the upper Pseudocordata Zone (WIERZBOWSKI 1991; *cf. also* SYKES & CALLOMON 1979).

Still younger *Amoeboceras* faunas occurring in the Submediterranean Planula Zone range from the lower/middle parts of this zone to the Galar Subzone of the upper Planula Zone. Of the two species discovered here, *Amoeboceras bauhini* (OPPEL) and *A. lineatum* (QUENSTEDT), the former is especially important for the biostratigraphic correlation. It is recently regarded as indicative of the lower part of the Subboreal Baylei Zone, as well as of the corresponding Boreal Bauhini Zone, *i.e.* the lowermost Kimmeridgian in the Subboreal and Boreal zonal schemes (*see* BIRKELUND & CALLOMON 1985, WRIGHT 1989, WIERZBOWSKI & SMELROR 1993). The data given indicate that the boundary of the Oxfordian and Kimmeridgian in Subboreal/Boreal schemes would run somewhere in the lower/middle parts of the Planula Zone of the Submediterranean zonal scheme. As the boundary of the Oxfordian and Kimmeridgian in the Submediterranean zonal scheme has been hitherto placed commonly between the Planula and the Platynota Zones, it is actually drawn too high when compared with this boundary in the Subboreal/Boreal schemes (Text-fig. 3; MATYJA & WIERZBOWSKI 1988, WIERZBOWSKI 1991; *cf. also* SYKES & CALLOMON 1979).

The youngest *Amoeboceras* fauna has been discovered in the Orthosphinctes Subzone of the Platynota Zone, *i.e.* in the lowermost part of the Submediterranean Kimmeridgian (*cf.* ATROPS 1982, ATROPS & GYGI 1990). This fauna shows a wide spectrum of variability, but only some groups of specimens are of higher stratigraphic value and can be compared with the species of the Subboreal/Boreal successions. The most important are specimens which bear a close resemblance to *Amoeboceras (Amoebites) bayi* BIRKELUND & CALLOMON. The species *A. bayi* occurs in the upper part of the Baylei Zone of the Subboreal zonation (BIRKELUND & CALLOMON 1985, WRIGHT 1989), and in the lowermost part of the Kitchini Zone of Boreal zonation (WIERZBOWSKI & SMELROR 1993; *cf. also* WIERZBOWSKI & ÅRHUS 1990). Some other specimens of the fauna studied seem to be similar to *Amoeboceras (Amoebites) cricki* (SALFELD). The stratigraphic position of this species in the Subboreal/Boreal successions is generally poorly known (BIRKELUND & CALLOMON 1985); it is however worth noting the occurrence of the specimens attributed to this very species in the upper part of the Baylei Zone, and in the Cymodoce Zone of the Lower Kimmeridgian at Staffin in Skye (WRIGHT 1989). The third group of specimens of the fauna studied from the Platynota Zone compared with *Amoeboceras ernesti* (FISCHER) has no good counterparts in the ammonites from the Subboreal/Boreal successions. A few specimens of similar type have been found only in East Greenland in the same locality as the type of *A. bayi*, but without precise location in a thick bed which yielded ammonites ranging in age from the Pseudocordata Zone to the Baylei Zone (BIRKELUND & CALLOMON 1985, pp. 18-19; Pl. 6, Figs 9-10).

The presented stratigraphic data dealing with the *Amoeboceras* fauna from the lower part of the Platynota Zone indicate that this part of the Submediterranean succession correlates with the upper part of the Baylei Zone, as well as with the lowermost part of the Kitchini Zone of the Boreal/Subboreal successions. This correlation confirms the different position of the boundary between Oxfordian and Kimmeridgian in the Submediterranean and Subboreal/Boreal zonal scheme (*see* Text-fig. 3).

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