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# 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

ABSTRACT: The detailed biostratigraphic succession at the turn of the Bimammatum Zone and the Planula Zone in the Wieluń Upland, Central Poland, displays the five ammonite horizons, *viz.* the litocerum horizon and the broilii horizon in the Hauffianum Subzone of the Bimammatum Zone, and the minutum horizon, the proteron horizon, and the planula horizon, in the Planula Zone. The stratigraphic position of the *Amoeboceras* Layer (MATYJA & WIERZBOWSKI 1988) has been partly revised: it lies in the litocerum horizon of the Hauffianum Subzone of the Bimammatum Zone. The layer marks a short-time invasion of the Boreal/Subboreal ammonites into the Submediterranean Province, including such forms described previously as *Amoeboceras (Plasmatites) bauhini* (OPPEL), *A. (P.) praebauhini* (SALFELD), and *A. (P.) lineatum* (QUENSTEDT), as well as the recently discovered *Pictonia densicostata* BUCKMAN and *Prorasenia bowerbanki* SPATH. The presence of these ammonites, and especially of *P. densicostata,* shows that the lower boundary of the Subboreal Kimmeridgian corresponding to the base of the Baylei Zone, lies not higher than the litocerum horizon of the Hauffianum Subzone in the Submediterranean Succession; in fact, it may lie still lower, somewhere between an upper Bimammatum Subzone and a lower Hauffianum Subzone of the Bimammatum Zone. Precise location of the lower boundary of the Submediterranean Kimmeridgian, corresponding to the base of the Platynota Zone, is not possible in the Subboreal Succession; that boundary in the Boreal Succession lies at the base of the Kitchini Zone.

## INTRODUCTION

The increasing importance of carefully recognized ammonite successions for the different provinces in the Jurassic results from the necessity of defining the lower boundary stratotypes for the particular stages in such a way as to enable global correlation of the distinguished boundaries.

So far, however, only the Bajocian Stage has its lower boundary stratotype ratified by the International Commission on Stratigraphy (ICS) and the International Union of Geological Sciences (IUGS) at Cabo Mondego in Portugal.

The recognition of the uniform lower boundary for the Kimmeridgian Stage is one of the most troublesome problems. According to the Luxembourg recommendations (MAUBEUGE 1970), the lower boundary of the Kimmeridgian Stage has been drawn at the base of the Subboreal Baylei Zone, and at the base of the Submediterranean Platynota Zone. As these two boundaries appear to be diachronous, the recent biostratigraphic studies have concentrated on finding such a boundary which could be better recognized in different ammonite successions, and thus treated in future as the candidate for the stratotype of the lower boundary of the Kimmeridgian Stage. In the Submediterranean Province, the sections of potentially great interest for correlation are those which show, in addition to a continuous sequence of Submediterranean ammonites, the presence of Boreal/Subboreal ammonites

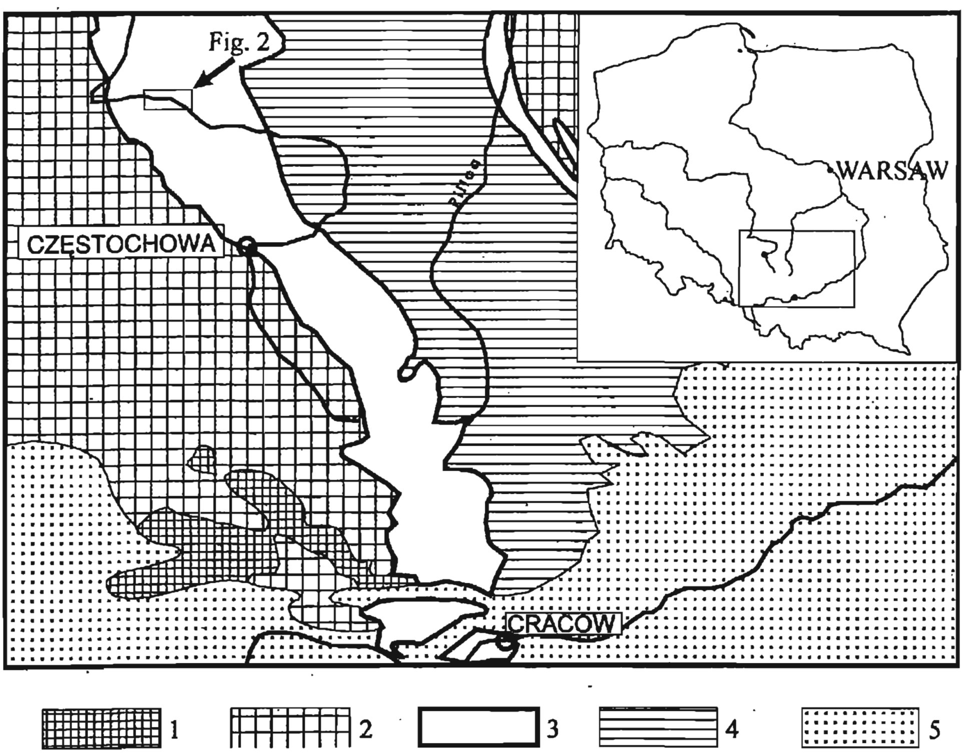



Fig. 1 Geologic map of Central Poland, to show location of the studied area

**1** — Paleozoic, **2** — Triassic through Middle Jurassic, **3** — Upper Jurassic, **4** — Cretaceous, **5** — Tertiary occurring at least at some levels. This is the case for a composite section from the Wieluń Upland in the Central Polish Uplands that spans the boundary between the Bimammatum and Planula Zones.

## DESCRIPTION OF THE SECTIONS AND NOTES ON AMMONITES

### DESCRIPTION OF THE SECTIONS

The sections studied are located along the Warta river valley both to the west of Działoszyn, at the villages of Raciszyn and Lisowice, and to the east of Działoszyn, at the village of Niwiska Dolne. The precise locations of the sections are referred to the index map at a scale of 1: 25 000 (Pj - sheet Pajęczno) and denoted by successive numbers. These localities, as formerly presented in the index-map by Wierzbowski (1978, Fig. 3),

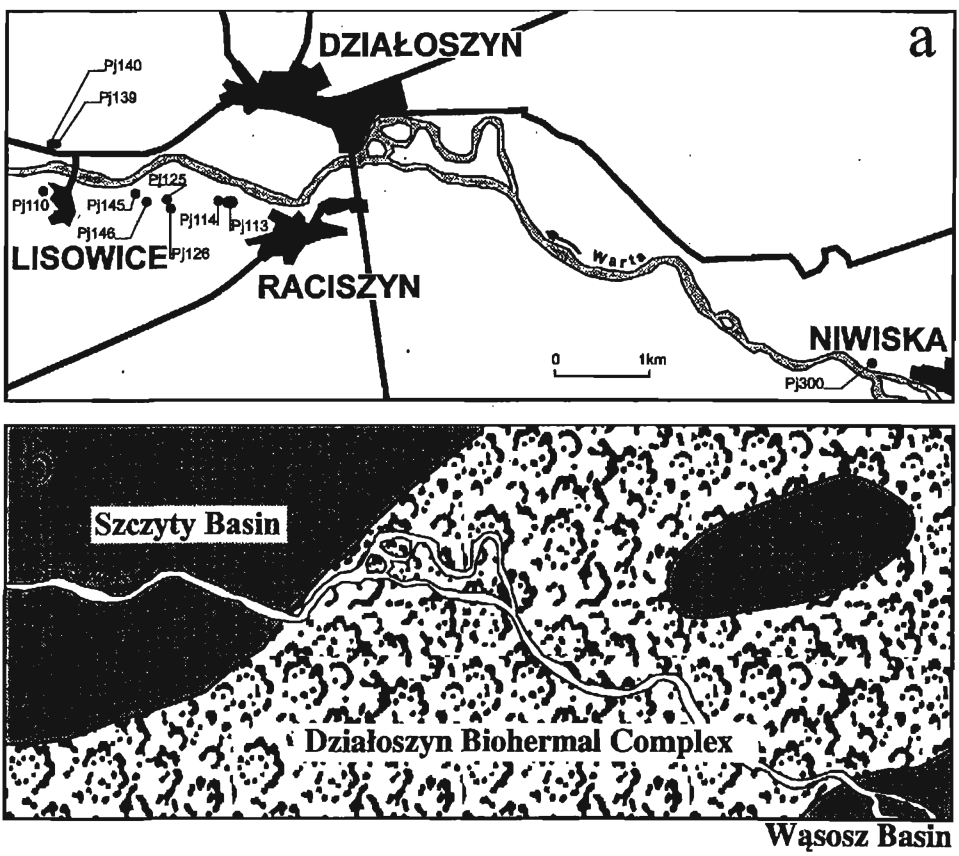



Fig. 2. Location map of the studied sections (**a**), and interpretation (**b**) of the Late Oxfordian paleogeography

were referred to the two map sheets at a scale of 1: 25 000 according to the older map scheme (Dz - sheet Działoszyn, Mi - sheet Mierzyce).

The sections studied are in the bedded limestones of the Niwiska Chalky Limestone Member, and the Wolbrom Limestone Member, north and south of the Działoszyn Biohermal Complex (Text-figs 1-2); all these units belong to the Częstochowa Sponge Limestones Formation (MATYJA & WIERZBOWSKI 1994).

The lithologies in the sections are micritic limestone of mudstone to wackstone type usually poor in benthic fossils, chalky (rarely dense) limestone of wackstone to packstone type containing benthic fossils (siliceous sponges, brachiopods, serpulids, and others), and marls. The ammonites in the sections are recorded bed by bed. The detailed paleontological comments on some ammonite findings indicated by numbers 1-17 in the description of the sections are given in the following subchapter.

The newly gathered collection of ammonites consists of 242 specimens. This collection is housed in the Museum of the Faculty of Geology, University of Warsaw (collection number IGPUW/A/33). The ammonites from older collections coming from the area of study which have been described earlier (WIERZBOWSKI 1970, 1978) are indicated also in the description of the sections, but sometimes with new taxonomic interpretation. These older collections denoted as IGPUW/A/08 and IGPUW/A/10 are also housed in the Museum of the Faculty of Geology, University of Warsaw.

**Raciszyn - Pj 113** (former 113 Dz)

Quarry with a lime-kiln on the left bank of the Warta river valley, west of the village of Raciszyn (coordinates: x - 22996, y - 96408). Exposed are bedded micritic limestones intergrading with biohermal bodies composed of massive limestones rich in siliceous sponges and cyanobacterian crusts (*see* WIERZBOWSKI 1992, Fig. 13).

Section (from the base):

**Unit 1**: Poorly-bedded to thick-bedded chalky limestones with cherts (exposed *ca.* 13.5 m): *Epipeltoceras bimammatum* (QUENSTEDT)[1] - Pl. 10, Fig. 5, about 6.5 - 11 m below the top of unit; *Ringsteadia submediterranea* WIERZBOWSKI - Pl. 5, Fig. 16; *Orthosphinctes (Pseudorthosphinctes) lisowicensis* WIERZBOWSKI, illustrated by WIERZBOWSKI (1978, Pl. 4, Fig. 2; Pl. 5, Fig. 1) as *Pomerania helvetica* (GEYER)[2].

**Unit 2**: Marly limestones (0.2 - 0.5 m): *Taramelliceras ( Taramelliceras) costatum* (QUENSTEDT)[3] - Pl. 4, Fig. 13.

**Unit 3**: Chalky limestones (0.6 m) with cherts: *Orthosphinctes (Pseudorthosphinctes) lisowicensis* WIERZBOWSKI, *Trimarginites arolicus* (OPPEL), *Taramelliceras (Metahaploceras) wenzeli* (OPPEL).

**Unit 4**: Alternating micritic limestones and marls (0.65 m.): *Taramelliceras*

*(Taramelliceras) hauffianum* (OPPEL) - Pl. 4, Fig. 11; *Taramelliceras (Metahaploceras) wenzeli* (OPPEL), illustrated by WIERZBOWSKI (1978, Pl. 2, Fig. 10); *Taramelliceras (Metahaploceras) litocerum* (OPPEL); *Ringsteadia* cf. *submediterranea* WIERZBOWSKI; *Ringsteadia limosa* (QUENSTEDT) illustrated by WIERZBOWSKI (1978, Pl. 3, Fig. 4); *Orthosphinctes (Orthosphinctes) tiziani* (OPPEL) - Pl. 6, Fig. 1; *Orthosphinctes (Pseudorthosphinctes) lisowicensis* WIERZBOWSKI, illustrated by WIERZBOWSKI (1978, Pl. 9, Figs 1-2).

**Unit 5**: Micritic limestones divisible into three beds (bed *5a* - 0.3 m, bed *5b* - 0.4 m, bed *5c* - 0.35 m) by thin marly intercalations; everywhere very common: *Taramelliceras (Metahaploceras) litocerum* (OPPEL), illustrated by WIERZBOWSKI (1978, Pl. 2, Figs 6-7); *Glochiceras (Coryceras) modestiforme* (OPPEL); rare *Ringsteadia* cf. *submediterranea* WIERZBOWSKI; moreover in bed *5b* which is the *Amoeboceras* Layer occur: *Amoeboceras (Plasmatites) bauhini* (OPPEL) - Pl. 5, Fig. 3 herein (*see also* MATYJA & WIERZBOWSKI 1988, Pl. 2, described as *Amoeboceras bauhini* msp; *and* ATROPS & *al.* 1993, Pl. 1, Fig. 15); *Amoeboceras (Plasmatites) praebauhini* (SALFELD), illustrated by MATYJA & WIERZBOWSKI (1988, Pl. 2 as *Amoeboceras praebauhini* msp), and ATROPS & *al.* (1993, Pl. 1, Fig. 16); *Amoeboceras (Plasmatites) lineatum* (QUENSTEDT) illustrated by: WIERZBOWSKI (1978, Pl. 2, Fig. 14), MATYJA & WIERZBOWSKI (1988, Pl. 2 as *Amoeboceras* aff. *lineatum* msp), and ATROPS & *al.* (1993, Pl. 1, Fig. 17); *Pictonia densicostata* BUCKMAN[4] - Pl. 5, Figs 7-8.

**Unit 6**: Hard limestones with cherts (1.1 m).

**Unit 7**: Micritic limestones with thin marly intercalations (0.7 m): *Taramelliceras (Metahaploceras) litocerum* (OPPEL), *Glochiceras (Coryceras) modestiforme* (OPPEL); without precise location (units 5-7) - *Passendorferia* sp. indet.[5]

The occurrence of *Idoceras* ex gr. *planula* (HEHL) in the youngest beds in this sectionas reported previously (WIERZBOWSKI 1992; *cf. also* WIERZBOWSKI 1978) is not confirmed by the recent collecting. The single specimen belonging to that species found in the rubble in this quarry most likely did not come from this location but had been transported from some other place, maybe with limestones used for lime-burning.

**Raciszyn - Pj 114** (former 114 Dz)

Quarry located west of the former one, on the left bank of the Warta river valley (coordinates: x - 22990, y - 96412).

Section (from the base):

**Unit 1**: Chalky limestones (exposed 0.6 m).

**Unit 2**: Alternating micritic limestones and marls (0.5 m): *Aspidoceras sesquinodosum* FONTANNES - Pl. 10, Fig. 4, *Orthosphinctes (Orthosphinctes) tiziani* (OPPEL), *Orthosphinctes (Pseudorthosphinctes) lisowicensis* WIERZBOWSKI - Pl. 6, Fig. 3; a few specimens of *Taramelliceras (Taramelliceras) hauffianum* (OPPEL) possibly come from this unit.

**Unit 3**: Micritic limestones (0.8 m); everywhere very common: *Taramelliceras (Metahaploceras) litocerum* (OPPEL), *Glochiceras (Coryceras) modestiforme* (OPPEL); in the lowermost part of the unit - *Taramelliceras (Taramelliceras)* cf. *hauffianum* (OPPEL); moreover from about 0.3 m to 0.7 m above the base occur: *Amoeboceras (Plasmatites) bauhini* (OPPEL), *Amoeboceras (Plasmatites) praebauhini* (SALFELD) - Pl. 5, Fig. 2, *Amoeboceras (Plasmatites) lineatum* (QUENSTEDT), *Pictonia densicostata* BUCKMAN - Pl. 5, Figs 6, 9, *Prorasenia bowerbanki* SPATH[6]; in the uppermost part - *Ringsteadia submediterranea* WIERZBOWSKI.

Not exposed part of the section - about 6.3 m.

**Unit 4**: Thick bedded chalky limestones - about 3 m.

**Unit 5**: Micritic limestones with thin marly intercalations (1.8 m): *Taramelliceras*

*(Metahaploceras) litocerum* (OPPEL), *Taramelliceras (Metahaploceras) wenzeli* (OPPEL) - Pl. 4, Fig. 7, *Orthosphinctes (Orthosphinctes)* cf. *tiziani* (OPPEL), *Passendorferia (Enayites)* sp.

**Raciszyn - Pj 125** (former 125 Dz) and **Pj 126** (former 126 Dz)

Two small quarries on the left bank of the Warta river valley where it joins the ravine running from the Kolonia Lisowice village (coordinates: x - 22926, y - 96414, and x - 22932, y - 96397, respectively).

Section (from the base):

**Unit 1**: Chalky limestones with cherts (0.7 m, base not exposed): *Ringsteadia* cf. *submediterranea* WIERZBOWSKI.

**Unit 2**: Alternating micritic limestones and marls (about 0.7 m); *Taramelliceras (Taramelliceras) costatum* (QUENSTEDT) found in the rubble possibly comes from units 1-2.

**Unit 3**: Thin bedded micritic limestones (1.06 m) divisible by thin marly intercalations into five beds (*3a* - 0.2 m, *3b* - 0.13 m, *3c* - 0.3 m, *3d* - 0.3 m, *3e* - 0.13 m), everywhere very common: *Taramelliceras (Metahaploceras) litocerum* (OPPEL), *Glochiceras (Coryceras ) modestiforme* (OPPEL); moreover: *Ochetoceras* cf. *marantianum* (D'ORBIGNY), *Trimarginites* sp., *Passendorferia* sp. indet., *Orthosphinctes (Pseudorthosphinctes) alternans* ENAY[7] - Pl. 7, *Orthosphinctes (Lithacosphinctes) evolutus* (QUENSTEDT) illustrated by WIERZBOWSKI (1978, Pl. 6, Fig. 2) as *Progeronia evoluta* (QUENSTEDT); in bed *3b* which is the *Amoeboceras* Layer occur: *Amoeboceras (Plasmatites) bauhini* (OPPEL), *Amoeboceras (Plasmatites) praebauhini* (SALFELD), *Amoeboceras (Plasmatites) lineatum* (QUENSTEDT), *Pictonia densicostata* BUCKMAN, *Prorasenia bowerbanki* SPATH; in bed *3d* occurs *Orthosphinctes (Praeataxioceras)* cf. *laufenensis* (SIEMIRADZKI).

Not exposed part of the section - about 0.5 m.

**Unit 4**: Chalky limestones with cherts divisible into three beds (*4a* - 0.3 m, *4b* - 1.4 m, *4c* -1.9 m); in bed *4c*, about 0.1 m above its base occurs *Prorasenia bowerbanki* SPATH - Pl. 5, Fig. 13; moreover in unit *4*, without precise position - *Prorasenia crenata* (QUENSTEDT).

**Lisowice - Pj 145** (former 145 Dz)

Quarry (Pl. 1, Fig. 1) on the left bank of the Warta river valley, east of the village of Lisowice (coordinates: x -22892, y - 96414).

Section (from the base):

**Unit 1**: Micritic limestones (base not exposed) divisible into two beds (*1a* - 0.3 m, *1b* - 0.3 m); everywhere very common: *Taramelliceras (Metahaploceras) litocerum* (OPPEL) - Pl. 4, Fig. 5, *Glochiceras (Coryceras) modestiforme* (OPPEL); moreover in bed *1a* which is the *Amoeboceras* Layer - *Amoeboceras (Plasmatites) bauhini* (OPPEL) - Pl. 5, Fig. 4, *Amoeboceras (Plasmatites) praebauhini* (SALFELD), *Amoeboceras (Plasmatites) lineatum* (QUENSTEDT) - Pl. 5, Fig. 1, *Pictonia densicostata* BUCKMAN - Pl. 5, Figs 10-11, *Prorasenia bowerbanki* SPATH - Pl. 5, Fig. 12; in bed *1b* occurs *Passendorferia* sp. indet.

**Unit 2**: Bedded chalky limestones (4.60 m) divisible into 6 beds (*2a* - 0.8 m, *2b* - 0.36 m, *2c* - 0.84 m, *2d* - 0.64 m, *2e* - 0.36 m, *2f* - 1.6 m): *Passendorferia* sp. indet. (without precise location).

**Unit 3**: Micritic limestones divisible into three beds (*3a* - 0.18 m, *3b* - 0.14 m, *3c* - 0.1m) by thin marly intercalations of which the lowest, at the base of the unit is the thickest (0.04 m) - the total thickness of the unit is 0.50 m: *Taramelliceras (Metahaploceras) litocerum*

(OPPEL): moreover in bed *3b* occur: *Taramelliceras* (*Metahaploceras*) *wenzeli* (OPPEL), *Ringsteadia* sp., *Orthosphinctes* sp.

**Unit 4**: Chalky limestones divisible into two beds (*4a* - 0.50 m, *4b* - 0.16 m): *Glochiceras* (*Coryceras*) *modestiforme* (OPPEL); moreover from bed *4b* comes *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE) - Pl. 4, Fig. 12.

**Unit 5**: Micritic limestones (about 2.5 m. in thickness), the lower part divisible into four beds (*5a* - 0.37 m, *5b* - 0.43 m, *5c* - 0.1 m, *5d* - 0.3 m), in the uppermost part the bedding planes are obscured due to weathering; about 1m below the top of the unit - *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE); about 2m above the base of the unit - *Glochiceras* (*Linulaticeras*) *lingulatum* (QUENSTEDT).

**Lisowice - Pj 146** (former 146 Dz)

Quarry on the left bank of the Warta river valley where it joins the ravine running from the village of Kolonia Lisowice (coordinates: x - 22909, y - 96413).

Section (from the base):

**Unit 1**: Micritic limestones poorly exposed, seen to about 0.2 m: *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Amoeboceras praebauhini* (SALFELD); this is the *Amoeboceras* Layer.

Not exposed part of the section - about 2.20 m.

**Unit 2**: Chalky limestones (1.9 m) divisible into five beds (*2a* - 0.6 m observed, *2b* - 0.46 m, *2c*- 0.12 m, *2d* - 0.32 m, *2e* - 0.4 m).

**Unit 3**: Micritic limestones (0.54 m) divisible into three beds (*3a* - 0.15 m, *3b* - 0.13 m, *3c* - 0.26 m), the ammonites come from bed *3a*: *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Taramelliceras* (*Taramelliceras*) cf. *broilii* (WEGELE), *Glochiceras* (*Lingulaticeras*) cf. *lingulatum* (QUENSTEDT), *Orthosphinctes* sp.

**Unit 4**: Chalky limestones divisible into two beds (*4a* - 1.93 m, *4b* - 0.25 m); ammonites in lower part of bed *4a*: *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE), and *Glochiceras* (*Lingulaticeras*) cf. *lingulatum* (QUENSTEDT) - about 0.3 m above its base; moreover, *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT) - about 0.6 m above the base.

**Unit 5**: Micritic limestones (0.31 m) underlain and overlain by thin marly intercalations about 0.02 m in thickness: *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Orthosphinctes* (*?Pseudorthosphinctes*) cf. *alternans* ENAY, *Ringsteadia limosa* (QUENSTEDT).

**Unit 6**: Micritic limestones (0.16 m) - *Passendorferia* (*Enayites*) sp.

**Unit 7**: Micritic limestones (0.6 m).

**Lisowice - Pj 140** (former 140 Dz) and **Pj 139** (former 139Dz)

Large abandoned quarry (Pl. 2, Fig. 1) on the right bank of the Warta river valley, north of the village of Lisowice (coordinates: x - 22809, y - 96468); the quarry in its eastern part, incorporates an old, formerly existing quarry (139 Dz, coordinates: x - 22830, y - 96462). The continuous section in the quarry is constructed by piecing together overlapping partial sections from the western part of the quarry (older units nos. 1-5; *see* Pl. 2, Fig. 2) and from its eastern part (younger units nos. 5-11; *see* Pl. 3, Figs 1 and 2).

## Section (from the base):

**Unit 1**: Chalky limestones with cherts (2.55 m) divisible into four beds ( *1a* - 1.2 m, base not exposed, *1b* - 0.47 m, *1c* - 0.5 m, *1d* - 0.38 m); bed *1a* yielded: *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT), *Glochiceras* (*Lingulaticeras*) cf. *nudatum* (OPPEL), *Orthosphinctes* (*Praeataxioceras*) *laufenensis* (SIEMIRADZKI)[8]; bed *1d* yielded: *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE), *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT); moreover, a few ammonites found in a rubble, and coming either from the uppermost part of unit *1*, or from the lowermost part of unit 2: *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE), *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT), *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT) - Pl. 4, Fig. 1, *Idoceras* (*Subnebrodites*) *minutum* DIETERICH - Pl. 9, Fig. 4.

**Unit 2**: Micritic limestones with marly intercalations (4.15 m); marly intercalations are thicker in the lower part of this unit (denoted as bed *2a*) about 0.75 m in thickness (from the base - 0.15 m - micritic limestones, 0.03 m - marls, 0.10 m - micritic limestones, 0.03 m - marls, 0.09 m - micritic limestones, 0.04 m - marls, 0.07 m - micritic limestones, 0.06 m - marls, 0.10 m - micritic limestones, 0.08 m - marls); in the middle and upper parts of the unit (denoted as bed *2b*) - 3.4 m in thickness, the limestone beds are about 0.2 m in thicknesses, and marly intercalations are very thin; the lower part of the unit (bed *2a*) yielded: *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE) - about 0.45-0.65 m above the base of the unit, *Idoceras* (*Subnebrodites*) *minutum* DIETERICH - 0.4 m above the base, and *Prorasenia crenata* (QUENSTEDT), *Amoeboceras bauhini* (OPPEL), and *Pictonia densicostata* BUCKMAN - Pl. 5, Fig. 5 - found without precise location; the middle and upper parts of the unit (bed *2b*) yielded: *Taramelliceras* (*Metahaploceras*) *lochense* (OPPEL) - Pl. 4 , Fig. 6, and *Passendorferia* (*Enayites*) cf. *wierzbowskii* MELENDEZ - about 0.85 m above the base of the unit, *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE) - 1.8 m above the base, *Glochiceras* (*Lingulaticeras*) cf. *lingulatum* (QUENSTEDT) - 2 m above the base, *Orthosphinctes laufenensis* (M.) (SIEMIRADZKI)[8] - Pl. 8, Fig. 2 - about 1.5-2.5 m above the base; moreover, the following ammonites come from unit *2* without precise location: *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT) - Pl. 4, Fig. 4, *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL), *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT), *Prorasenia crenata* (QUENSTEDT), *Ringsteadia* sp., *Passendorferia* (*Enayites*) *wierzbowskii* MELENDEZ[9], *Passendorferia* (*Enayites*) sp.

**Unit 3**: Chalky limestones (1.54 m).

**Unit 4**: Micritic limestones (0.44 m) divisible into two beds (*4a* - 0.14 m, *4b* - 0.3 m): *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) / *pseudowenzeli* (WEGELE)[10] - Pl. 4, Fig. 2.

**Unit 5**: Chalky limestones (1.3 m observed): *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) and *Passendorferia* (*Enayites*) *wierzbowskii* MELENDEZ - both 0.2 m above the base of the unit, *Passendorferia* (*Enayites*) sp. - about 0.4 m above the base; towards the east deposits corresponding to units *3-5* attain a thickness of at least 1.8 m; moreover, a few ammonites found in a rubble and coming from units *1-5*, such as *Prorasenia crenata* (QUENSTEDT) - Pl. 5, Fig. 15 and from the units *2-5*, such as *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE) - Pl. 4, Fig. 9.

**Unit 6**: Micritic limestones (0.35 m): *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT).

**Unit 7**: Chalky limestones, about 6.5 m in thickness, divisible into nine beds (*7a* - 0.8 m, *7b* - 0.6 m, *7c* - 0.75 m, *7d* - 0.8 m, *7e* - 0.5 m, *7f* - 1.1 m, *7g* - 0.25 m, *7h* - 0.9 m, *7i* - 0.8 m): *Idoceras* (*Subnebrodites*) *proteron* NITZOPOULOS - represented by two specimens, one found about 1.5 m above the base of the unit - Pl. 10, Fig. 1, and the other without precise location.

**Unit 8**: Micritic limestones (from 0.9 m to 0.3 m in thickness in the easternmost part of the quarry): *Taramelliceras (Metahaploceras)* cf. *pseudowenzeli* (WEGELE), *Taramelliceras (Metahaploceras) kobyi quenstedti* HÖLDER[11] - Pl. 4, Fig. 10, *Orthosphinctes (Orthosphinctes)* cf. *triplex* (QUENSTEDT), *Ringsteadia* sp., *Passendorferia (Enayites) wierzbowskii* MELENDEZ, *Physodoceras altenense* (D'ORBIGNY) - Pl. 10, Fig. 3.

**Unit 9**: Chalky limestones (2.81 m): *Taramelliceras (Metahaploceras) kobyi quenstedti* HÖLDER, *Orthosphinctes (Lithacosphinctes)* cf. *grandiplex* (QUENSTEDT), *Passendorferia (Enayites) wierzbowskii* MELENDEZ - Pl. 9, Fig. 2, all of them found in the lower 1.4 m thick part of the unit.

**Unit 10**: Micritic limestones (0.2 m).

**Unit 11**: Chalky limestones seen to about 3m; the lowermost part (to about 1m from the base) yielded - *Idoceras (Subnebrodites)* cf. *proteron* NITZOPOULOS, other ammonites found in the unit include: *Taramelliceras (Metahaploceras) kobyi quenstedti* HÖLDER, *Idoceras (Subnebrodites) planula* (HEHL) - Pl. 9, Fig. 6, *Idoceras (Subnebrodites) laxevolutum* (FONTANNES) illustrated by WIERZBOWSKI (1978, Pl. 2, Fig. 18), *Orthosphinctes (Lithacosphinctes)* aff. *evolutus* (QUENSTEDT) illustrated by WIERZBOWSKI (1978, Pl. 7, Fig. 2) as *Progeronia heidenheimense* (WEGELE)[12], *Prorasenia* aff. *quenstedti* SCHINDEWOLF illustrated by WIERZBOWSKI (1978, Pl. 3, Fig. 9)[13].

**Lisowice - Pj 110** (former 5 Mi)

Quarry ( Pl. 1, Fig. 2) in the village of Lisowice, on the left bank of the Warta river valley (coordinates: x - 22811, y - 96414).

Section (from the base):

**Unit 1**: Chalky limestones (4.1 m) divisible into four beds (*1a* - 0.42 m, base not exposed, *1b* - 0.94 m, *1c* - 0.81 m, *1d* - 1.93 m); the uppermost part of bed *1d* yielded, *Orthosphinctes (Lithacosphinctes) evolutus* (QUENSTEDT), *Idoceras (Subnebrodites) proteron* NITZOPOULOS - Pl. 10, Fig. 2, *Prorasenia crenata* (QUENSTEDT); moreover, other specimens of *Idoceras (Subnebrodites) proteron* NITZOPOULOS come from beds *1a* and *1c-1d*.

**Unit 2**: Micritic limestones (0.15 m), at the base thin (0.01 m) marly intercalation: *Taramelliceras (Metahaploceras) litocerum* (OPPEL).

**Unit 3**: Chalky limestones (1.95 m) divisible into two beds (*3a* - 0.9 m, *3b* - 1.05 m),

**Unit 4**: Micritic limestones (0.11 m).

**Unit 5**: Chalky limestones (1.92 m) divisible into four beds (*5a* - 0.48 m, *5b* - 0.33 m, including characteristic level of cherts 0.09 m in thickness at the top, *5c* - 0.68 m, *5d* - 0.33 m).

**Unit 6**: Micritic limestones with cherts (0.53 m): *Prorasenia bathyschista* (KOERNER).

**Unit 7**: Chalky limestones with cherts (5.6 m) divisible into six beds (*7a* - 0.47 m, *7b* - 0.54 m, *7c* - 0.5 m, *7d* - 0.3 m, *7e* - 0.76 m, *7f* - 3.0 m); *Taramelliceras (Metahaploceras) litocerum* (OPPEL)/ *pseudowenzeli* (WEGELE) from bed *7a*, *Idoceras (Subnebrodites) planula* (HEHL) - Pl. 9, Fig. 1 - from beds *7a*, *7c* and *7d*, and *Orthosphinctes (Orthosphinctes) triplex* (QUENSTEDT) - possibly from bed *7e*.

**Unit 8**: Micritic limestones (0.15 m).

**Unit 9**: Chalky limestones (1.9 m), the uppermost part (0.24 m) rich in micritic matrix; *Idoceras (Subnebrodites) planula* (HEHL), from the uppermost part of the unit, illustrated by WIERZBOWSKI (1978, Pl. 2, Fig. 19).

**Unit 10**: Shaly marls and marly limestones (1.46 m) with two thin (0.1 m in thickness) intercalations of hard micritic limestones (about 0.5 m, and 0.85 m above the base of the unit); *Idoceras (Subnebrodites) minutum* DIETERICH and *Idoceras (Subnebrodites)* sp.

**Unit 11**: Chalky limestones (2.0 m).

**Unit 12**: Micritic limestones (0.2 m).

**Unit 13**: Chalky limestones (0.8 m): *Idoceras* (*Subnebrodites*) cf. *laxevolutum* (FONTANNES), *Prorasenia* cf. *bathyschista* (KOERNER), *Ringsteadia flexuoides* (QUENSTEDT).

The specimens of *Orthosphinctes grandiplex* (QUENSTEDT)[14] - Pl. 8, Fig. 1, and *Idoceras* (*Subnebrodites*) *schroederi* (WEGELE) - Pl. 9, Fig. 3 - have been found in rubble; they come from units *3-13*; moreover one specimen of *Glochiceras* (*Coryceras*) *modestiforme* (OPPEL) comes from units *7-11*.

**Niwiska Dolne - Pj 300** (former 60 Dz)

Quarry on the right bank of the Warta river valley at the village of Niwiska Dolne (coordinates: x - 23648, y - 96240).

Section from the base:

**Unit 1**: Chalky limestones with cherts (about 6 m in thickness) divisible into four beds (*1a* - 2.0 m, base not exposed, *1b* - 1.9 m, *1c* - 0.55 m, *1d* - 1.6 m); ammonites: *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE) and *Orthosphinctes* (*Orthosphinctes*) *triplex* (QUENSTEDT)[15] - Pl. 6, Fig. 2, coming from the uppermost part of bed *1b*; *Prorasenia bathyschista* (KOERNER) - Pl. 5, Fig. 14, and *Ringsteadia* cf. *tenuiplexa* (QUENSTEDT)[16] - from bed *1c*; *Taramelliceras* (*Metahaploceras*) aff. *wenzeli* (OPPEL)[17] - Pl. 4, Fig. 3, *Idoceras* (*Subnebrodites*) *planula* (HEHL), and *Idoceras* (*Subnebrodites*) *planula* (HEHL) or *I.* (*S.*) *laxevolutum* (FONTANNES) from bed *1d*; moreover, *Idoceras* (*Subnebrodites*) *minutum* DIETERICH from lowermost part of bed *1d*, and *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE) - Pl. 4, Fig. 8, from uppermost part of bed *1d*; also a single specimen of *Orthosphinctes* (*Orthosphinctes*) *triplex* (QUENSTEDT) illustrated by WIERZBOWSKI (1978, Pl. 5, Fig. 3) and a few specimens of *Ringsteadia flexuoides* (QUENSTEDT) illustrated by WIERZBOWSKI (1970, Pl. 1, Fig. 1; Pl. 2, Figs 1-2), as well as a single specimen of *Orthosphinctes* (*Lithacosphinctes*) cf. *grandiplex* (QUENSTEDT) come from unit *1*, but without precise location.

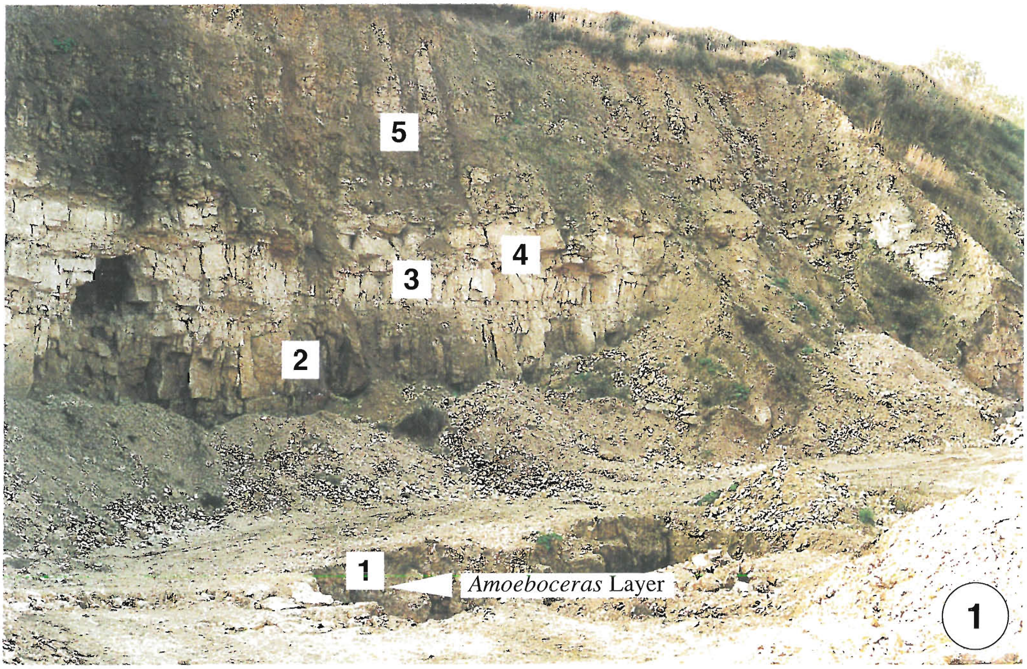
**Unit 2**: Alternating micritic limestones (the lowermost bed is only 0.45 m in thickness, but younger beds are much thinner - about 0.2 m in thickness) and marls (in thin layers - 0.05 m in thickness), the total section seen to 5.80 m; ammonites coming mostly from the lowermost limestone bed: *Taramelliceras* (*Metahaploceras*) cf. *pseudowenzeli* (WEGELE), *Taramelliceras* (*Metahaploceras*) aff. *wenzeli* (OPPEL), *Idoceras* (*Subnebrodites*) *minutum* DIETERICH - Pl. 9, Fig. 5; moreover, *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) found in rubble.

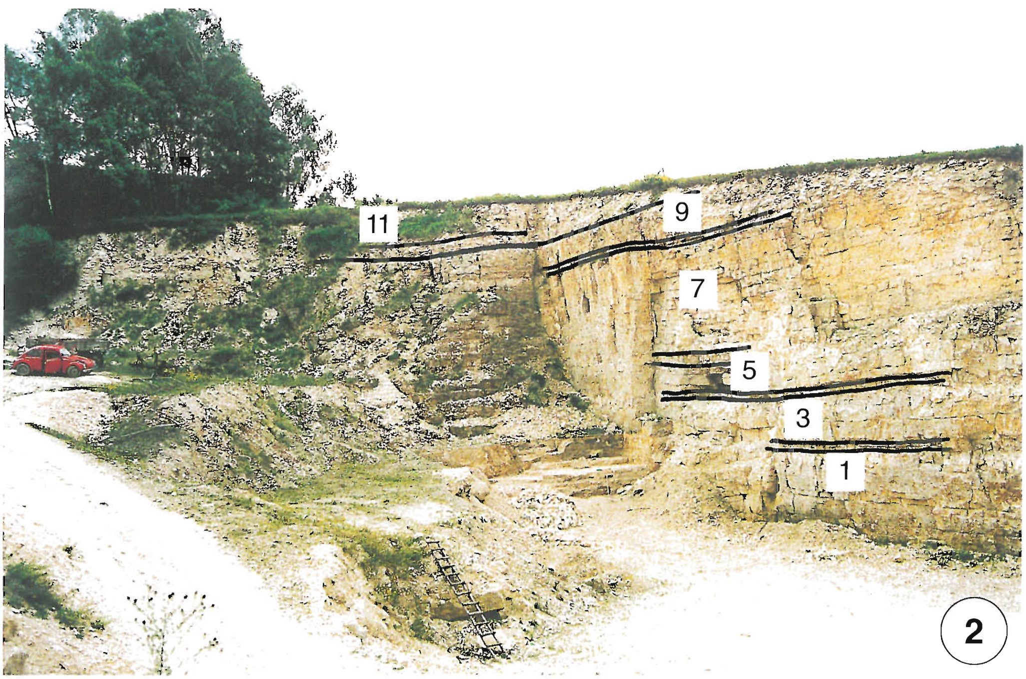
## NOTES ON AMMONITES

The detailed paleontological comments on some ammonite findings indicated in the description of the sections are given below.

The following abbreviations are used in paleontological comments on ammonites: **D** - diameter of specimen in mm, **Wh** - whorl height as percentages of D, **Ud** - umbilical diameter as percentages of D, **PR** - number of primary ribs per whorl, **SR/PR** - ratio of secondary to primary ribs (calculated for 5-10 primary ribs) at given diameter.

1) The specimen is crushed, about 30 mm in diameter, with rather wide umbilicus (Ud = 41%) showing strong simple ribs with heavy tubercles at the ventral margin; number of ribs (PR) equals 11 per half a whorl; whorl section is rectangular, ventral side is flattened. Although poorly preserved, it shows no differences from specimens of *Epipeltoceras bimammatum*



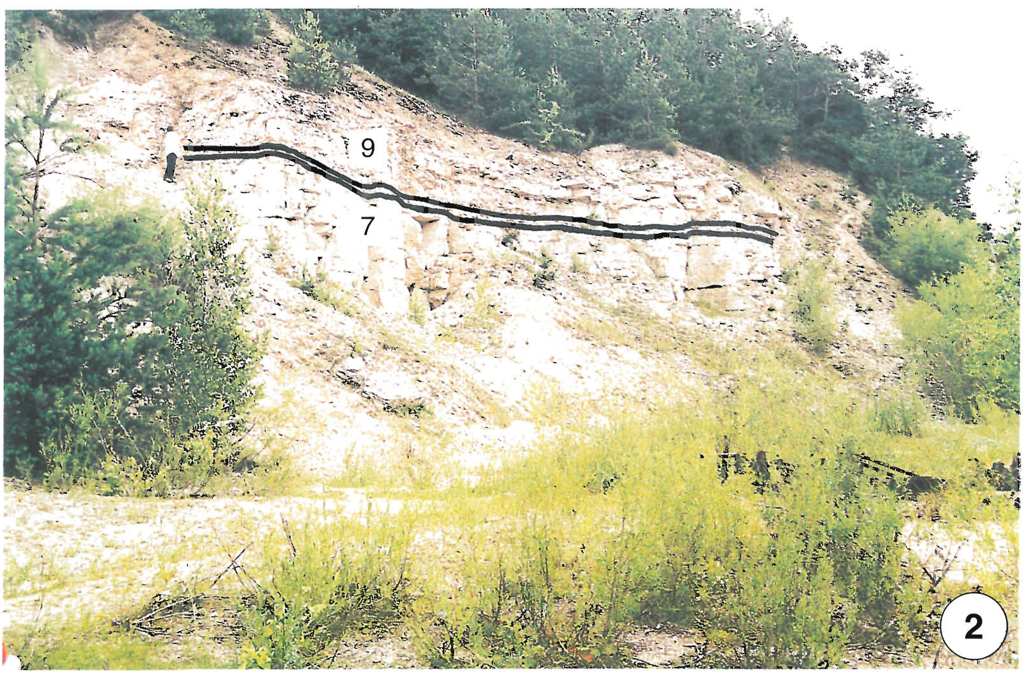

**1** — Quarry Pj 145 at village of Lisowice: indicated are the number of units and position of the *Amoeboceras* Layer (*cf*. Text-fig. 3)

**2** — Quarry Pj 110 at village of Lisowice: the number of units is indicated (*see* Text-fig. 3)



**1** — General view of the quarry Pj 140 at village of Lisowice: the partial sections presented in Pl. 2, Fig. 2 and Pl. 3 are indicated

**2** — Section in the western part of the quarry Pj 140: exposed are units *1* and *2*


**1** — Section in the eastern part of the quarry Pj 140; exposed are units *5-9*

**2** — Section in the eastern part of the quarry Pj 140; exposed are units *7-9*

(QUENSTEDT) from southern Germany and France (*see e.g.* ENAY 1962, 1966). Its occurrence in the proximity of sponge bioherm facies is also typical of the species. This is the first representative of this species found so far in Poland.

2) Ammonites found in these deposits and described previously as *Pomerania helvetica* (GEYER) by WIERZBOWSKI (1978, Pl. 4, Fig. 2; Pl. 5, Fig. 1) differ slightly from the type specimens of *Orthosphinctes (Pseudorthosphinctes) lisowicensis* WIERZBOWSKI (*see* WIERZBOWSKI 1978, Pl. 9, Figs 1-2) in being somewhat more involute. Rich, new material from the sections studied show that indicated specimens of "*Pomerania helvetica*" are merely variants of *O.* (*P.*) *lisowicensis*. The name *Pomerania* tentatively used by WIERZBOWSKI (1978) for some ammonites from the Bimammatum and Planula Zones should be replaced by other genus names, for which the taxonomic status is better understood, mostly by the name *Orthosphinctes*.

3) The specimen 73 mm in diameter with narrow umbilicus (Ud = 11%), marked ventrolateral tubercles which are initially rounded, and then slightly elongated at the end of the last whorl; ventral side with a row of rounded tubercles. Except the discussed specimen which is well located in the section, three additional closely comparable specimens of *Taramelliceras costatum* have been found in the quarries at Raciszyn but without precise location in the succession (Pj 113 - somewhere in between units *2* and *7*; and in Pj 125 and Pj 126 possibly from units *1*-*2*).

4) Eight specimens of *Pictonia densicostata* BUCKMAN have been found in four quarries (Pj 113, Pj 114, Pj 125, Pj 145) in a single horizon (*Amoeboceras* Layer) and in its close proximity. One specimen was found several metres higher in the sequence in the lowermost part of the Planula Zone, in the minutum horizon (quarry Pj 140, bed *2a*). Specimens are small, from about 30 to 50 mm in diameter, weakly evolute to weakly involute (Ud oscillates between 32 and 42%), rather densely and finely ribbed (at D = 30 mm, PR = 34 - 41) with fairly low number of secondary ribs (at D = 25 - 30 mm, SR/PR = 2.1 - 2.2). The primary and secondary ribs are never strongly differentiated when compared with those of the ammonite genus *Ringsteadia*, occurring in beds of similar age, where primaries are much more strongly developed than secondaries even in specimens with small diameters. The presence of strongly collared constrictions (about 3 per last whorl) is typical of the specimens studied. The specimens are close to, or conspecific with, *Pictonia densicostata* BUCKMAN, but generally of a smaller size. They may be compared, however, with immature forms or specimens representing inner whorls of the latter species (*see e.g.* BUCKMAN 1927, Pl. 716; *and* SPATH 1935, Pl. 8, Fig. 4a-b; *cf. also* BIRKELUND & CALLOMON 1985, p. 32).

5) The specimens are found close to, and somewhat above, the *Amoeboceras* Layer in three quarries (Pj 113, Pj 126, Pj 145). Medium-sized to large macroconchs (the biggest was described previously as *Pomerania* cf. *girardoti* ENAY - *see* WIERZBOWSKI 1978, Pl. 6, Fig. 1), characterized by dense radial ribbing on inner whorls; on outer whorl ornamentation consists of distant primary ribs with 2-3 secondary ribs per one primary, and finally of simple ribs. The specimens although attributed to the genus *Passendorferia* differ markedly from all the macroconchs of this genus known so far mostly from the Middle Oxfordian (*cf.* BROCHWICZ-LEWIŃSKI 1973, MELENDEZ 1989) by the presence of larger numbers of secondary ribs at larger diameters. Their taxonomic status and phylogenetical importance will be discussed elsewhere.

6) Five specimens assigned to this species come from a single horizon (*Amoeboceras* Layer) and its close proximity in three quarries ( Pj 114, Pj 125, Pj 145). These specimens show very evolute coiling (Ud = 43.5 to 48% on the last whorl), and fairly dense ribbing (about 23-30

PR at D = 30 mm). They are very close to the holotype of *Prorasenia bowerbanki* illustrated by SPATH (1935, Pl. 14, Fig. 5). Of other *Prorasenia* species recognized in the succession studied, *Prorasenia crenata* (QUENSTEDT) is similarly coiled but much more heavy ornamented, whereas *Prorasenia bathyschista* (KOERNER) is much less evolute.

7) The specimens assigned to *Orthosphinctes* (*Pseudorthosphinctes*) *alternans* ENAY (*see* Pl. 7; *see also* WIERZBOWSKI 1978, Pl. 8, Fig. 3) differ from *O.* (*P.*) *lisowicensis* in the more dense ribbing. The specimen described as *Pomerania helvetica* (GEYER) by WIERZBOWSKI (1978, Pl. 4, Fig. 1) comes from the same beds as the discussed specimens of *O.* ( *P.* ) *alternans*. It shows similar density of ribbing on inner whorls till 200 mm diameter, but the last whorl is mostly smooth, except for a few simple ribs close to the aperture. This latter feature indicates the presence of incipient "lithacosphinctoid" stadium which is fully developed in *Orthosphinctes* (*Lithacosphinctes*) *evolutus* (QUENSTEDT) occurring also in the same beds in the sections studied (*see* WIERZBOWSKI 1978, Pl. 6, Fig. 2).

8) Of the two specimens attributed to the species *Orthosphinctes laufenensis* (SIEMIRADZKI) from this quarry, the one coming from bed *1a* is the microconch with lappets, about 85 mm in diameter, whereas another specimen from bed *2b* is possibly the macroconch, about 138 mm in diameter. Both specimens show similar rib density at comparable diameters (PR = 54-56 at D = 50-70 mm), and similar rib index (SR/PR = 2.2 at D = 70-100 mm; in the macroconch SR/PR = 3.2 at the end of the shell). Their coiling is moderately evolute on the inner whorls (Ud = 42-43%) becoming markedly evolute on the outer whorl (Ud = 48% at the end of the shell in microconch and macroconch). When compared with the holotype of *Orthosphinctes laufenensis* (SIEMIRADZKI) illustrated by SIEMIRADZKI (1898, Pl. 26, Fig. 46), the studied specimens show somewhat more regular ribbing; this feature is, however, variable in specimens usually attributed to that very species (*see e.g.* specimens illustrated by KOERNER 1963). The species *Orthosphinctes laufenensis* (SIEMIRADZKI) has been recognized by ATROPS (1982) as the type species of the microconch subgenus *Praeataxioceras*, the macroconch counterpart of which was treated as "the group of *Orthosphinctes suevicus* (SIEMIRADZKI)". The microconchs of *Orthosphinctes laufenensis*, as well as the discussed specimen referred to as the macroconch of *O. laufenensis* (see Pl. 8, Fig. 2), differ from the holotype of *Orthosphinctes suevicus* (SIEMIRADZKI) illustrated by SIEMIRADZKI (1898, Pl. 24, Fig. 35) by their more densely ribbed inner whorls.

9) The specimen referred to as "?*Idoceras* ?*Nebrodites* (*Enayites*) aff. *gygii* BROCHWICZ-LEWIŃSKI & RÓŻAK" by WIERZBOWSKI (1978, p. 320, Text-fig. 4, Pl. 2, Fig. 17 ) was subsequently recognized (MELENDEZ 1989, pp. 164-165) as the holotype of the new species *Passendorferia* (*Enayites*) *wierzbowskii* MELENDEZ. The holotype was found in the quarry at Lisowice (Pj 140) between unit *6* and a lower part of unit *9*.

10) The specimen similar to *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) but showing poorly marked elongate ventrolateral tubercles, and thus morphologically intermediate between *T. litocerum* and *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE), and very close to, if not conspecific (*see* SCHAIRER 1983) with, "*Taramelliceras* (*Metahaploceras*) *ausfeldi* (WÜRTENBERGER)" *in* WEGELE (1929, Pl. 27, Fig. 9). The specimens of *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE) are known from younger beds of the succession studied.

11) Three specimens referred to as *Taramelliceras* (*Metahaploceras*) *kobyi quenstedti* HÖLDER come from units *8*, *9*, and *11* in the quarries at Lisowice (Pj 140 and Pj 139). The specimens are rather strongly ornamented showing well developed ventrolateral tubercles which are elongated on the whorl side and rounded at the venter; the umbilicus is rather nar-

row (Ud = 16% at D = 34 mm in smallest specimen, and Ud = 11-13% at D = 55-60 mm in larger ones - *see* Pl. 4, Fig.10). The primary ribs are distant (PR = 7-8 per half a whorl), the secondaries are numerous (SR/ PR = 3.0 - 4.0). The specimens are very close to the specimens of *T. kobyi quenstedti* illustrated and discussed by SCHAIRER (1972, 1983). The subspecies *Taramelliceras (Metahaploceras) kobyi wegelei* SCHAIRER differs in possessing a wider umbilicus, and the more numerous secondary ribs (*see* SCHAIRER 1972).

12) Large specimen, about 200 mm in diameter, showing sparsely placed primary ribs and compared originally (WIERZBOWSKI 1978, p. 325, Text-fig. 6, Pl. 7, Fig. 2) with *"Perisphinctes heidenheimensis"* of WEGELE (1929, Pl. 2, Fig. 1); it was subsequently placed with reservation in the synonymy of *Orthosphinctes (Lithacosphinctes) evolutus* (QUENSTEDT) by ATROPS (1982, pp. 125-126). When compared with the bulk of the specimens attributed to this latter species, the specimen in question differs in that it displays much more distant ribbing.

13) The specimen also resembles the holotype of the Boreal species *Prorasenia hardyi* SPATH (*cf.* SPATH 1935, Pl. 15, Fig. 5a-b; *see also* WIERZBOWSKI 1978, p. 320).

14) Fragmentary preserved specimen, about 150 mm in diameter, is very densely ribbed (PR equals about 40 per half a whorl at D = 140 mm). The ribs are fine, sharp, single and biplicate; some single ribs have the character of intercalatory ribs which join indistinctly primary ribs close to the umbilicus. The coiling is involute (Ud = 30% at D = 110-140 mm). These features resemble very much the inner whorls of a large specimen being the lectotype of *Orthosphinctes (Litacosphinctes) grandiplex* (QUENSTEDT) as illustrated originally by QUENSTEDT (1888, Pl. 102, Fig. 1; refigured by SCHLEGELMILCH 1994, p. 74, Pl. 27, Fig. 5; *see also* ATROPS 1982, pp. 87-92) and discussed by HANTZPERGUE (1989, pp. 87-92), who placed this species in the genus *Subdiscosphinctes*. The affinity of the species in question to the Middle Oxfordian representatives of *Subdiscosphinctes* seems doubtful. Two large but poorly preserved specimens in the collection studied can be referred to the species *O. (L.) grandiplex* with reservation. They come from quarries at Lisowice (Pj 140, unit *9*), and Niwiska Dole (Pj 300, unit *1*). The specimens show many fine secondary ribs at about 200 - 250 mm diameter (SR/PR = 5.0-7.0), and swollen distant primary ribs appearing at about 250-300 mm diameter.

15) Two specimens (Pl. 6, Fig. 2; *see also* WIERZBOWSKI 1978, Pl. 5, Fig. 3) from the quarry at Niwiska Dolne (Pj 300) showing moderately evolute coiling (Ud = 42.5-44% at D = 70 mm) and moderately dense ribbing (PR = 43-44 at 70-75 mm diameter). The ribbing is fairly irregular with rather common parabolic ribs. This last feature makes a comparison possible with *Orthosphinctes wemodingensis* (WEGELE) illustrated by WEGELE (1929, Pl. 3, Fig. 4) which, however, displays the parabolic ribs much more numerous. On the other hand, very close to the specimens studied is the lectotype of *Orthosphinctes (Orthosphinctes) triplex* (QUENSTEDT) as illustrated by QUENSTEDT (1887, Pl. 100, Fig. 9; *see* GEYER 1961, p. 33). The species is generally poorly known (*see* ATROPS 1982, p. 55), but as the studied specimens resemble the lectotype of *O. triplex* in nearly all respects, they are referred to this very species. The relation of *O. triplex* to other species of the genus *Orthosphinctes* from the Planula Zone needs further study. The single specimen from the Lisowice quarry (Pj 110, bed *7e*) is also close to the species in question.

16) This specimen is large but incomplete, showing part of a middle whorl with distant, thick primaries, and weaker secondaries (SR/PR = 3.0 at about 130 mm diameter), and a fragment of the outer whorl which is wide at the umbilicus with thick primaries, becoming smooth in the outer part of whorl and markedly tapering towards the venter. Such a section of the outer

whorl, and the presence of strong primaries makes a close comparison (*see* GEYER 1961) with some late representatives of the genus *Ringsteadia*. The overall affinity is especially with *Ringsteadia tenuiplexa* (QUENSTEDT), the species discussed in detail by GEYER (1961, p. 126) and WIERZBOWSKI (1970, pp. 278-279, Pl. 6). It is possible that the other specimen from the quarry at Niwiska Dolne (Pj 300) described as *Ringsteadia* cf. *limosa* (QUENSTEDT) by WIERZBOWSKI (1970, Pl. 4, Fig. 3; Pl. 5, Fig. 1) also belongs to the species *R. tenuiplexa*. This specimen shows similar whorl section of the outer whorl, but the ornamentation of inner whorls is obscured.

**17)** Two specimens with somewhat similar ribbing to that of *Taramelliceras* (*Metahaploceras*) *wenzeli* (OPPEL) but with elongated ventrolateral tubercles as in *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE). Moreover, the ventral side of the whorl shows a row of minute tubercles as in *Taramelliceras* (*Metahaploceras*) *tenuinodosum* (WEGELE). Some specimens attributed to *T.* (*M.*) *wenzeli* (OPPEL) by WEGELE (1929, Pl. 27, Figs 2-3), and treated now as representing an independent form (SCHAIRER 1983), have possibly small tubercles on the ventral side of whorls.

## SUBMEDITERRANEAN AMMONITE SUCCESSION IN THE WIELUŃ UPLAND, AND CORRELATION WITH OTHER SECTIONS OF THE SUBMEDITERRANEAN PROVINCE

The ammonites collected bed by bed in the sections studied are predominantly of Submediterranean character, permitting the recognition of the higher parts of the Bimammatum Zone and the lower parts of the Planula Zone, and making possible detailed biostratigraphic correlation with other sections in Europe belonging to the Submediterranean Province.

The oldest part of the sections exposed at Raciszyn (*see* Text-fig. 3) has yielded *Epipeltoceras bimammatum* (QUENSTEDT) indicative of the Bimammatum Subzone (*see e.g.* CARIOU & *al.* 1971). Higher up, *Taramelliceras* (*Taramelliceras*) *hauffianum* (OPPEL) marks the presence of the Hauffianum Subzone (CARIOU & *al.* 1971). The occurrence of *Taramelliceras* (*Taramelliceras*) *costatum* (QUENSTEDT) inbetween the two previously mentioned ammonite findings is indicative of the Bimammatum Subzone, and the lower part of the Hauffianum Subzone (*i.e.* the laufenensis horizon of SCHWEIGERT 1995a,b). This suggests that the boundary between the Bimammatum Subzone and the Hauffianum Subzone lies in the proximity of the latter finding in the sequence studied.

Still higher, in the sections at Raciszyn and Lisowice, the ammonite fauna of Submediterranean origin becomes monotonous being represented mostly by the two species of the Haplocerataceae: *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) and *Glochiceras* (*Coryceras*) *modestiforme* (OPPEL), that occur in profusion, and almost certainly represent the dimorphic pair. This part of the sequence is almost completely devoid of other Haplocerataceae (except single small specimens of *Ochetoceras* and *Trimarginites*), especially of such subgenera as *Taramelliceras* (*Taramelliceras*) and *Glochiceras* (*Lingulaticeras*). It is distinguished as the litocerum horizon (*see* Text-fig. 3). Within the litocerum horizon, the *Amoeboceras* Layer occurs, which is characterized by the common occurrence of ammonites of the genus *Amoeboceras*, as well as of some other genera of Boreal/Subboreal affinity thus reflecting a well marked invasion from the north. A similar fauna of the Boreal *Amoeboceras* is known from the bauhini horizon in the Swabian Alb; this horizon (SCHWEIGERT 1995a,b) also contains Submediterranean ammonites, such as *Taramelliceras* (*Taramelliceras*) *hauffianum* (OPPEL) indicative of the Hauffianum Subzone. It may thus be assumed that the litocerum horizon distinguished in the sequence studied also corresponds to the Hauffianum Subzone. Although the two species *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL) and *Glochiceras* (*Coryceras*) *modestiforme* (OPPEL) show a wide stratigraphic range (ZIEGLER 1958, SCHAIRER 1983), their profuse occurrence in the stratigraphically narrow interval of the litocerum horizon is an ecological phenomenon which may be useful in local correlations.

The youngest part of the sequence studied, still attributed to the Hauffianum Subzone, is marked by the reappearance of the subgenus *Taramelliceras*, represented here by *Taramelliceras* (*T.*) *broilii* (WEGELE), but without *T.* (*T.*) *hauffianum* (OPPEL). The species *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT) and *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT) also appear at this level. The discussed part of the sequence, representing the uppermost part of the Bimammatum Zone, is distinguished herein as the broilii horizon.

The boundary between the Bimammatum and Planula Zones is placed at the level at which *Idoceras* (*Subnebrodites*) appears. Three horizons are recognized in the studied parts of the sequence corresponding to the Planula Subzone of the Planula Zone (*see* ATROPS 1982). The lowest is the minutum horizon characterized by the occurrence of *Idoceras* (*Subnebrodites*) *minutum* DIETERICH and the virtual absence of other species of this subgenus. The species *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE) ranges up into the lower part of the minutum horizon.

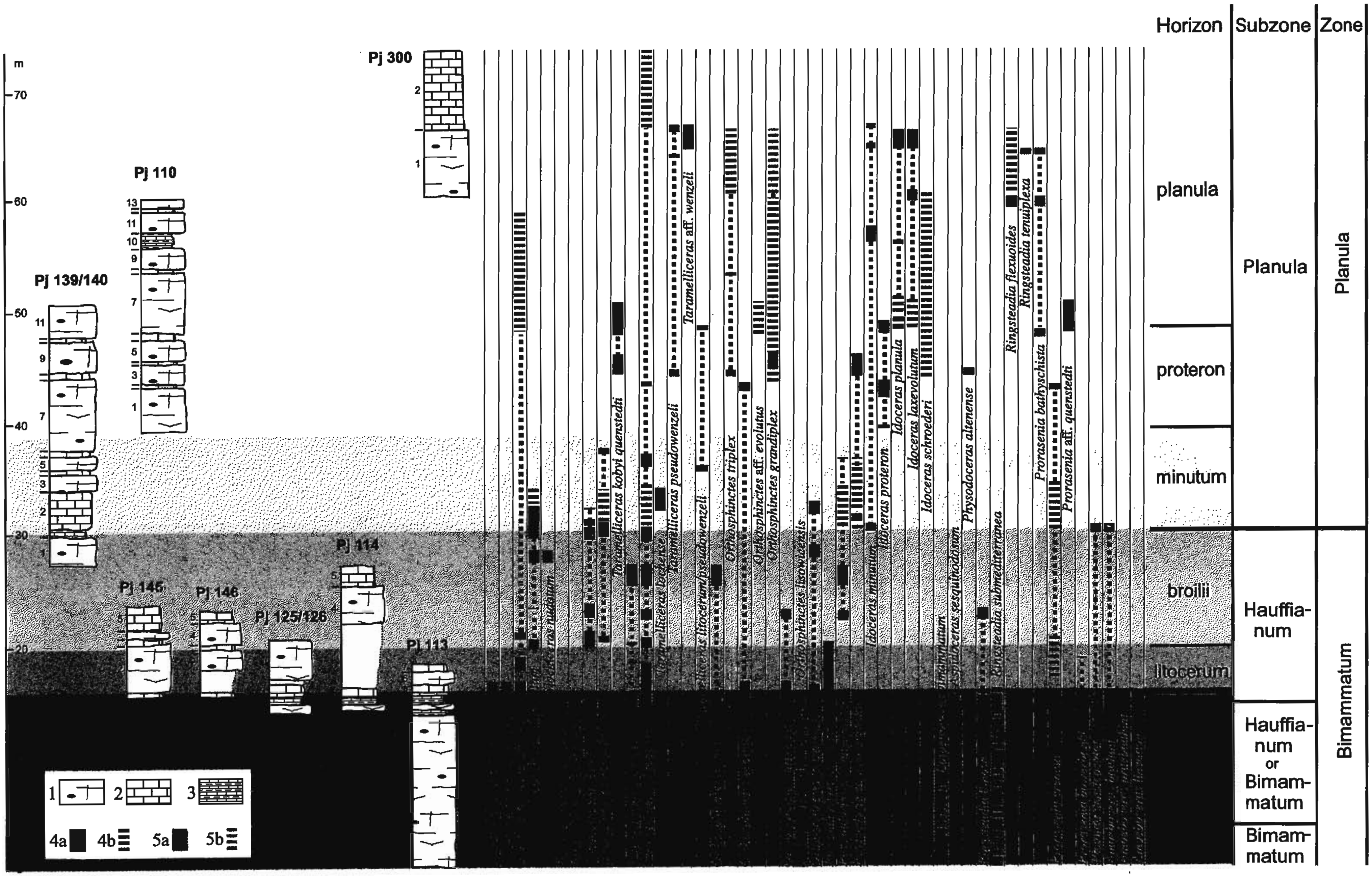
Still higher in the sequence is the proteron horizon, characterized by the occurrence of *Idoceras* (*Subnebrodites*) *proteron* NITZOPOULOS. This species occurs together with *I.* (*S.*) *minutum* which ranges up from below and is also known from still younger levels. Other species include *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT), *Prorasenia crenata* (QUENSTEDT) and *Passendorferia* (*Enayites*) *wierzbowskii* MELENDEZ ranging up from below, which however, do not cross the upper boundary of the proteron horizon.

The highest is the planula horizon, the base of which is marked by the appearance of *Idoceras (Subnebrodites) planula* (HEHL) and *Idoceras (Subnebrodites) laxevolutum* (FONTANNES). The species *I. (S.) minutum* is still present, but *I. (S.) proteron* disappears at the lower boundary of the planula horizon. Characteristic elements which appear in this horizon include *Prorasenia bathyschista* (KOERNER), *Ringsteadia flexuoides* (QUENSTEDT), and *Ringsteadia* cf. *tenuiplexa* (QUENSTEDT).

Correlation of the discussed horizons of the lower parts of the Planula Zone in the Wieluń Upland, with those recognized in other Submediterranean/Mediterranean areas involves some detailed stratigraphic problems. In the Iberian Chain and SE France, the three successive horizons, *i.e.*, the minutum horizon, the proteron horizon, and the planula horizon, have been distinguished recently in the Planula Subzone (*see* ATROPS & MELENDEZ 1994a,b). The minutum horizon has, however, never been precisely defined in the succession. In the Moscardon section (Teruel province, Central Iberian Chain) it corresponds to the "niveles con *Idoceras minutum* DIETERICH" of MELENDEZ & *al.* (1983; *see also* MELENDEZ 1989) which, in addition to the index species, yield such species as *Idoceras* ex gr. *planula* (HEHL) and *Sutneria praecursor* DIETERICH. The Minutum Subzone distinguished in the Tiaret section in the Tellian area (Algeria) also corresponds to the minutum horizon of ATROPS & MELENDEZ (1994a,b; *see also* ATROPS & *al.* 1990), characterized (ATROPS & BENEST 1984, 1994) by the occurrence of *Idoceras (Subnebrodites) minutum* DIETERICH, *Sutneria praecursor* DIETERICH, *Physodoceras circumspinosum* (QUENSTEDT), *Passendorferia (Enayites)* sp., and *Orthosphinctes* spp. The fauna from the minutum horizon *sensu* ATROPS & MELENDEZ seems to be very close to that coming from the higher parts of the Planula Subzone, directly below the Galar Subzone, in southern Germany (*see e.g.* NITZOPOULOS 1974), as well as in SE France, where the interval in question showing a similar fauna has been distinguished by ATROPS (1982) as the praecursor horizon. It seems highly probable, therefore, that the minutum horizon as distinguished by ATROPS & MELENDEZ (1994a,b) does not correspond to the minutum horizon as understood in the present paper, but is markedly younger being at least partly equivalent to the planula horizon.

The proteron horizon (*see* Text-fig. 3) possibly corresponds to the tonnerense horizon distinguished directly below the praecursor horizon in the upper part of the Planula Subzone in SE France (ATROPS 1982). The proteron horizon may also be recognized in the Franconian Alb (*see* NITZOPOULOS 1974) where it is defined by the occurrence of the index species well below the appearance of *I. (S.) planula* and *I. (S.) laxevolutum*. Recently, the proteron = tonnerensis horizon has been established in the

## Ammonite succession and biostratigraphic interpretation of studied sections in the Wieluń Upland




1 - Chalky limestones, 2 - micritic limestones, 3 - marly limestones and marls, 4 - precise (**4a**) and approximate (**4b**) range of the species; 5 - precise (**5a**) and approximate (**5b**) range referred to as of *cf. species*; red line indicates the *Amoeboceras* Layer

Swabian Alb (SCHWEIGERT 1995a,b), in the lowermost part of the Planula Zone, directly above the bauhini horizon.

When compared with the ammonite succession at the boundary of the Bimammatum and Planula Zones in the Wieluń Upland, that recognized in the Swabian Alb seems less complete. The bauhini horizon distinguished in the uppermost part of the Hauffianum Subzone in the Swabian Alb (SCHWEIGERT 1995a,b) corresponds, partly at least, to the litocerum horizon (and undoubtedly to the *Amoeboceras* Layer) in the Wieluń Upland. On the other hand, the proteron horizon recognized in the Swabian Alb (SCHWEIGERT 1995a,b) can easily be correlated with the proteron horizon distinguished in the Wieluń Upland. Such a correlation suggests that the two horizons recognized in the Wieluń Upland at the boundary of the Bimammatum and Planula Zones, *viz*. the broilii horizon at the top of the Hauffianum Subzone, and the minutum horizon at the base of the Planula Subzone, have no counterparts in the sections of the Swabian Alb. In order to interpret this phenomenon, a comment is needed on the character of sediments in the Swabian Alb, in the discussed stratigraphic interval. The stratigraphic interval from the uppermost part of the Bimammatum Zone to the lowermost part of the Planula Zone corresponds to that part of the lithostratigraphic sequence of the Swabian Alb represented by marls and limestones of the *Impressamergel* Formation, and the well-bedded limestones of the *Wohlgeschichteten Kalke* Formation. The boundary of the two lithostratigraphic units corresponds to the boundary of the QUENSTEDT's Malm alpha and Malm beta (*see e.g.* ZIEGLER 1977). In the section of the Hundsrücken area, which may be treated as the type section for the boundary of the Malm alpha and Malm beta, the bed with *Chondrites* (= *"Fukoidenbank"*) occurs at this very level. This bed lies at the base of the bauhini horizon (SCHWEIGERT 1995a,b). The position of the Malm alpha and Malm beta boundary has been placed, however, at different levels due to repeated occurrences of beds rich in *Chondrites* burrows within this stratigraphic interval in the Swabian Alb. The boundary between the Malm alpha and Malm beta was often recognized as the equivalent of the boundary between the Bimammatum Zone and the Planula Zone (*see e.g.* KOERNER 1963).

The data given suggest that the absence of the two indicated biostratigraphic horizons from the Wieluń Upland (*see* Text-fig. 3), in the sections of Swabian Alb may result from stratigraphic gaps at the boundary of the Bimammatum and Planula Zones. The lithological evidence of these gaps could be the abrupt change in facies from marly deposits of Malm alpha to well-bedded limestones of Malm beta, as well as the occurrence at this boundary of highly bioturbated levels with *Chondrites* which may reflect reduced rates of deposition.

The ammonite succession at the boundary of the Bimammatum Zone and the Planula Zone in the Wieluń Upland was studied by WIERZBOWSKI (1970, 1978) who distinguished the planula-costatum horizon characterized by the occurrence of the subgenus *Idoceras* (*Subnebrodites*) and the group of *Taramelliceras* (*Taramelliceras*) *costatum* – mostly such species as *T. costatum*, *T. broilii*, and *T. hauffianum*; this horizon was placed in the lowermost part of the Planula Zone. The stratigraphic position of this horizon, however, was in part based on a miscorrelation which resulted from the erroneous location of ammonites found in the rubble (*see* description of Pj 113 quarry at Raciszyn). The new data have shown that the planula-costatum horizon represents a much wider stratigraphic interval from the uppermost Bimammatum Subzone, through the Hauffianum Subzone to the lowermost part of the Planula Subzone. The horizon is thus unsuitable for stratigraphic correlation and has to be abandoned. It should be remembered, that the *Amoeboceras* Layer, due to its occurrence within the planula-costatum horizon, was originally assigned to the lowermost part of the Planula Zone, instead of the Hauffianum Subzone as documented subsequently (*see* MATYJA & WIERZBOWSKI 1988, 1994; WIERZBOWSKI 1991, 1992; ATROPS & *al.* 1993; *and* Text-fig. 3 in the present paper, *cf. also* SCHWEIGERT 1995a,b).

## CORRELATION BETWEEN BOREAL/SUBBOREAL AND SUBMEDITERRANEAN AMMONITE SUCCESSIONS

Due to strong ammonite differentiation since the early Middle Oxfordian in relation to the "Oxfordian Tilt Event" (CALLOMON 1964), the three bioprovinces could be distinguished in the territory of Europe, and the neighboring areas, north of the Tethys during Oxfordian times (CARIOU 1973; SYKES & CALLOMON 1979, pp. 839-840):

(1) The **Submediterranean Province** including the territory of Portugal, Spain, most of France, Switzerland, southern Germany, and most of Poland, the peri-Tethyan Balkans, Crimea, and Caucasus;

(2) The **Subboreal Province** embracing areas occupied by the carbonate platform: Normandy, the Boulonnais, southern England, northern Germany, and the shallow siliciclastic shelf of northwestern Poland;

(3) The **Boreal Province** including Scotland, Greenland, Spitsbergen, the Barents Shelf, and the Russian Platform.

With the beginning of the Kimmeridgian, the Subboreal Province shifted to the North embracing Scotland, East Greenland, subpolar Ural, and a large part of northern Siberia; during the Late Kimmeridgian, in the Eudoxus Chron, it also shifted to the south occupying Central Poland, and southern Germany.

The separate zonal schemes consisting of standard ammonite zones have been worked out for each province. The schemes are often refined and modified when the ammonite successions become better known, but their detailed correlation remains the main problem.

## BOREAL AND SUBBOREAL AMMONITES IN THE SUBMEDITERRANEAN SUCCESSION

The ammonites of Boreal and Subboreal affinity occur in the Submediterranean Succession in the Bimammatum and Planula Zones in Central Polish Uplands, including the Wieluń Upland. These ammonites are the Cardioceratidae represented by the genus *Amoeboceras*, and the Aulacostephanidae with the genera *Microbiplices*, *Prorasenia*, *Ringsteadia*, and *Pictonia*. The two divergent lineages within the Aulacostephanidae may be recognized in the indicated stratigraphic interval (WIERZBOWSKI 1970, 1978). One of them has been developed mostly in the Subboreal Province in the Pseudocordata and Baylei Zones and it is represented by the Subboreal species of *Ringsteadia*, such as *R. caledonica* SYKES & CALLOMON, *R. pseudoyo* SALFELD, *R. pseudocordata* (BLAKE & HUDLESTON), and *R. evoluta* SALFELD, the Subboreal *Microbiplices*, and *Prorasenia* (as *P. bowerbanki* SPATH and *P. hardyi* SPATH), and the Subboreal species of *Pictonia* (as *P. densicostata* BUCKMAN and *P. normandiana* TORNQUIST). The representatives of Cardioceratidae and of the Subboreal lineage of Aulacostephanidae are of great value for correlation, being known from some levels in the Submediterranean Succession.

The second lineage of the Aulacostephanidae includes species known from the Submediterranean Province. Here belong the more involute species of the genus *Ringsteadia*, such as *R. submediterranea* WIERZBOWSKI, *R. limosa* (QUENSTEDT), *R. flexuoides* (QUENSTEDT), and *R. tenuiplexa* (QUENSTEDT), occurring in the upper Bimammatum Zone, and in the Planula Zone, and smoothly evolving into the first representatives of *Eurasenia* at the turn of the Planula and Platynota Zones. Beginning from the Bimammatum Subzone there appears also the Submediterranean representatives of *Prorasenia*, such as *P. crenata* (QUENSTEDT), replaced later by *P. bathyschista* (KORNER), and *P. quenstedti* SCHINDEWOLF. These ammonites have low value for correlation as they are unknown outside of the Submediterranean Province. The treatment in common of the ammonites of the genus *Ringsteadia* from the Submediterranean Province as well as those from the Subboreal Province has resulted in the past in some misinterpretations. An example is the suggestion of a presumed stratigraphic gap at the top of the Pseudocordata Zone in England (ARKELL 1956, pp. 115-116,

Table 10) to explain the absence there of the Submediterranean *Ringsteadia* species from the early Planula Zone of the Swabian and Franconian Alb.

The Boreal and Subboreal ammonites occurring in the Submediterranean Succession of the Central Polish Uplands are known from deposits belonging to the sponge megafacies. They occur mostly as rarities, but in a few cases they are encountered in larger numbers in thin layers of wide lateral extent (*Amoeboceras* layers – *see* ZNOSKO 1953, RÓŻAK & BROCHWICZ-LEWIŃSKI 1978, MATYJA & WIERZBOWSKI 1988). Such layers have been also recognized outside of Poland, in France, Switzerland, and Germany (ATROPS 1982, ATROPS & *al.* 1993, SCHWEIGERT 1995a,b). The origin of these *Amoeboceras* layers is possibly related to transgressive pulses (MATYJA & WIERZBOWSKI 1995).

In the Wieluń Upland, Boreal and Subboreal ammonites occur mostly in the *Amoeboceras* Layer (indicated in red *in* Text-fig. 3), in the litocerum horizon of the Hauffianum Subzone of the Bimammatum Zone. The following ammonites of Boreal/Subboreal origin have been recognized in that Layer: *Amoeboceras bauhini* (OPPEL), *A. praebauhini* SALFELD, *A. lineatum* (QUENSTEDT), *Pictonia densicostata* BUCKMAN, and *Prorasenia bowerbanki* SPATH. The latter species have also been found somewhat above the *Amoeboceras* Layer, but still in the litocerum horizon. Only a single specimen of *Pictonia densicostata* BUCKMAN has been found in the minutum horizon of the lowermost Planula Zone. All these ammonites are of great importance for correlation and are discussed below.

## OXFORDIAN/KIMMERIDGIAN BOUNDARY IN THE VARIOUS ZONAL SCHEMES – HISTORICAL REVIEW AND CURRENT STATE OF STUDIES

The term "l'étage kimméridgien" was introduced by D'ORBIGNY in 1850 (D'ORBIGNY 1842-1851) and refined by SALFELD (1913) as a succession of ammonite zones recognized in England and northern France. Later, ARKELL (1947) chose his bed *26* (*Rhactorhynchia inconstans* Bed) at Ringstead, Dorset, as the basal bed of the Baylei Zone, the lowermost ammonite zone of the Kimmeridgian in the Subboreal Succession. More recently, SYKES & CALLOMON (1979) stated that the common form of *Pictonia* found in the *Rhactorhynchia* (or *Torquirhynchia*) *inconstans* Bed in Dorset is *Pictonia densicostata* BUCKMAN, and that the index form of the Baylei Zone, *P. baylei* TORNQUIST, occurs in the next, younger faunal assemblage.

Until the late sixties and early seventies, it was widely assumed (GEYER 1961; ZIEGLER 1964, 1977; ZEISS 1966; ENAY & *al.* 1971) that the

Subboreal Baylei Zone corresponded to the Platynota Zone of the Submediterranean Succession. Thus, the boundary of the Planula Zone and the Platynota Zone has been treated in the Submediterranean Succession as the boundary of the Oxfordian and Kimmeridgian, corresponding to the boundary of the Pseudocordata Zone and the Baylei Zone of the Subboreal Succession. The Galar Subzone, which was originally attributed to the Platynota Zone (*see e.g.* ARKELL 1956), was transferred by GEYER (1961) to the Planula Zone, and treated as the youngest biostratigraphic unit of the Submediterranean Oxfordian.

As suggested by SYKES & CALLOMON (1979, pp. 894), but without detailed argumentation, the Planula Zone of the Submediterranean Succession has been interpreted as possibly not corresponding to the uppermost Subboreal Oxfordian, but being rather of earliest Kimmeridgian age. This opinion was, however, soon neglected, as among the ideas expressed during the Jurassic Symposium in Erlangen in 1984, either the former correlation was supported (*see* ZEISS, Table 6 *in*: ENAY & MELENDEZ 1984), or only some minor modification of it was proposed according to which the base of the Subboreal Baylei Zone should be correlated with the base of the Galar Subzone in the Submediterranean Succession (ENAY & MELENDEZ 1984). This latter opinion was based partly on new interpretation of the stratigraphic position of *Amoeboceras bauhini* published somewhat later (BIRKELUND & CALLOMON 1985).

SYKES & CALLOMON (1979) proposed, for the Oxfordian of the Boreal Succession, the new zonal scheme based wholly on the ammonites of the family Cardioceratidae: the Rosenkrantzi Zone distinguished there as the uppermost zone of the Oxfordian was subdivided into two subzones - the Marstonense Subzone (lower) and the Bauhini Subzone (upper). The latter has been "characterised by the incoming of diminutive species of the group of *Amoeboceras bauhini*, including *A. praebauhini* SALFELD, and *A. tuberculatoalternans* (NIKITIN). ... *A. rosenkrantzi* persists, as does *Ringsteadia* cf. *pseudocordata*. Type locality Staffin, beds 36-37" (SYKES & CALLOMON 1979, p. 856).

It should be noted that, of the *Amoeboceras* species, the role of the *Amoeboceras bauhini* (OPPEL) is unquestionably peculiar. This species is known to occur in the Submediterranean Succession as well as in the Boreal/Subboreal Successions, marking a level where the "*Amoeboceras* of the Franco-German affinities" appear in Britain and Greenland (SYKES & CALLOMON 1979, p. 889).

Based on new stratigraphic information, the abundant specimens of *Pictonia densicostata* have been successively stated to occur in the lowest 1-1.5m of bed *37* at Staffin, the type locality of the Bauhini Subzone, whereas the occurrence of *Amoeboceras bauhini* was limited therein to the interval from 2 to 4-5 meters above the base of bed *37*. Hence, the Bauhini Subzone has appeared "largely, if not exactly equivalent to the Baylei Zone... and is entirely Kimmeridgian in age" (BIRKELUND & CALLOMON 1985, p. 17). The same opinion on the relation between the Baylei Zone and the Bauhini Subzone has resulted from new studies of the section at South Ferriby in eastern England (BIRKELUND & CALLOMON 1985, p. 17).

On the other hand, other sections are known in the Subboreal and Boreal Provinces showing the presence of *Amoeboceras bauhini*, clearly below the Baylei Zone. These are as follows:

— in Yorkshire, England, where *A. bauhini* occurs (*see* COX & RICHARDSON 1982, p. 56, and Fig. 2) in the Harome Borehole in the uppermost part of the Rosenkrantzi Zone, below the appearance of *Pictonia*;

— in southern England, where *A.* cf. *bauhini* associated with *Ringsteadia evoluta* is known from the Ringstead Coral Bed (SYKES & CALLOMON 1979, p. 857);

— in southwestern Barents Sea, where in borehole 7230/05-U-02 *A.* cf. *praebauhini* and "variants similar to *A. bauhini*" co-occur with *Amoeboceras rosenkrantzi* (see WIERZBOWSKI & SMELROR 1993, p. 233, Pl. 1).

From the aforegoing, it becomes evident that the species *Amoeboceras bauhini* in the Boreal/Subboreal Successions occurs at the turn of the Oxfordian and Kimmeridgian (PAGE & COX 1995): in the lower part of its stratigraphic range, it is associated with ammonites of the genus *Ringsteadia* and *Amoeboceras rosenkrantzi*, indicating the Pseudocordata Zone or the Rosenkrantzi Zone (*i.e.*, the uppermost Oxfordian in the Boreal/Subboreal subdivisions), whereas only in the upper part of its stratigraphic range does this species co-occur with *Pictonia densicostata*, indicating already the lower part of the Baylei Zone (*i.e.*, the lowermost Kimmeridgian in the Subboreal subdivision).

In the *Amoeboceras* zonation recently proposed for the Kimmeridgian of the western part of the Boreal Province (WIERZBOWSKI & SMELROR 1993), the lowermost distinguished zone is the Bauhini Zone. It is characterized "by the incoming of... *Amoeboceras bauhini*... and *Amoeboceras schulginae* MESEZHNIKOV". This Bauhini Zone covers the upper part of the stated range of *A. bauhini*, well above the occurrence of *A. rosenkrantzi* and has been theoretically compared with the stratigraphic interval of co-occurrence of *A. bauhini* and *Pictonia densicostata* (*i.e.* with lower part of the Baylei Zone); the type section of this newly erected zone has been proposed at Staffin, beds 37-38 (WIERZBOWSKI & SMELROR 1993, p. 242). However, until the detailed stratigraphic ranges of *A. bauhini* and *Pictonia densicostata* are compared, it cannot be unequivocally proven if the lower boundary of the Bauhini Zone as established by WIERZBOWSKI & SMELROR (1993) corresponds exactly to the base of the Baylei Zone, *i.e.* the base of the Kimmeridgian in the Subboreal zonal scheme.

The stratigraphic position of *Amoeboceras bauhini* in the Submediterranean Succession was unclear for some years. SYKES & CALLOMON (1979, pp. 893-894) followed WEGELE (1929) who indicated the stratigraphic range of this species from the upper Hypselum Subzone to the Hauffianum Subzone of the Bimammatum Zone, but later, BIRKELUND & CALLOMON (1985, p. 18) favored the Galar Subzone of the uppermost Planula Zone, just below the Malm beta/Malm gamma boundary, as the main level of its occurrence. On the other hand, the presence of this very species in the Planula Zone was indicated by MATYJA & WIERZBOWSKI (1988, 1994), and ATROPS & *al.* (1993). Recently, however, SCHWEIGERT (1995a,b) distinguished the bauhini horizon in the Hauffianum Subzone, just below the base of the Planula Zone.

The new data gathered during revision of the ammonite fauna from the extremely fossiliferous cores of the Kcynia *IG-IV* Borehole in northern Poland (MATYJA & WIERZBOWSKI 1998), have shown that the ammonite group consisting of *Amoeboceras bauhini* (OPPEL), *A. praebauhini* (SALFELD), and *A. lineatum* (QUENSTEDT), and representing the subgenus *Plasmatites*, reveals a wide stratigraphic range, from directly above the Hypselum Subzone till the upper boundary of the Planula Zone. Such a stratigraphic position of *A. bauhini* is consistent with the older information (*see* WEGELE 1929) being of great importance for the correlation between the Submediterranean and Boreal/Subboreal Successions.

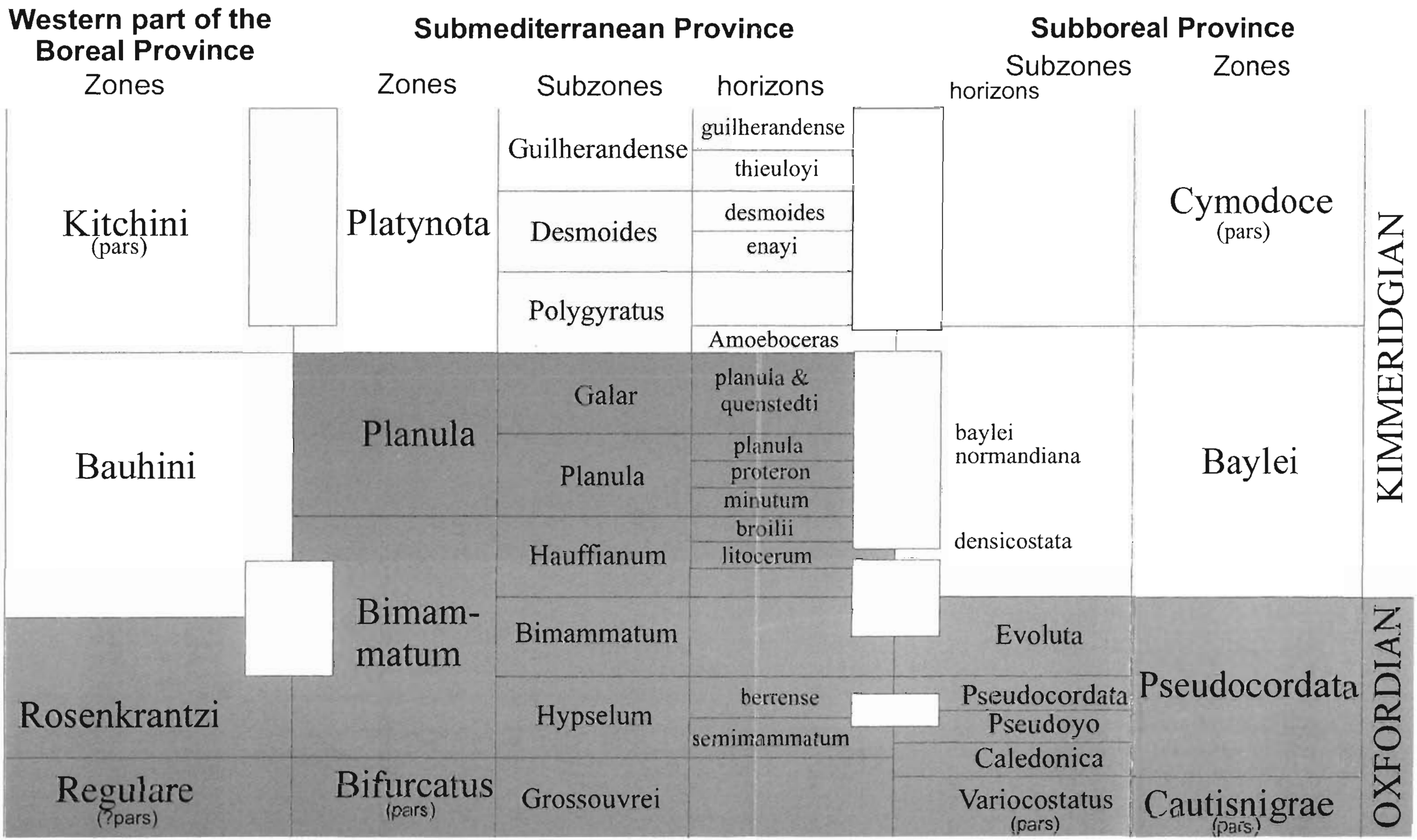
The *Amoeboceras* Layer from the Wieluń Upland which yielded the *A. praebauhini* – *A. bauhini* – *A. lineatum* assemblage was originally attributed to the lowermost Planula Zone (*i.e.* the Planula & Costatum horizon, *see* WIERZBOWSKI 1978). The assemblage is biologically obviously monospecific (MATYJA & WIERZBOWSKI 1988) and has been named *A. praebauhini* (SALFELD) after the type dominant in the collection. Although the name *A. praebauhini* better characterizes the morphology of this assemblage, other workers may prefer to distinguish this assemblage under the name of *A. bauhini* which is the oldest name of the forms occurring in the discussed layer.

The *Amoeboceras* Layer from the Wieluń Upland as revised in the present paper corresponds to the bauhini horizon of SCHWEIGERT (1995a,b) from southern Germany. The bauhini horizon represents the upper part of the Hauffianum Subzone, and it is possibly the type horizon of the species *Amoeboceras bauhini* (OPPEL). The occurrence of *A. bauhini* in the discussed stratigraphic level of Central Poland and southern Germany was treated as an argument for the correlation of the Planula Zone (or at least a large part of it) of the Submediterranean Succession with the lowermost Boreal/Subboreal Kimmeridgian (MATYJA & WIERZBOWSKI 1988, 1994;

WIERZBOWSKI 1991; ATROPS & *al.* 1993; SCHWEIGERT 1995a,b). This correlation was not accepted, even rather recently, by some authors who still compared the Planula Zone either with Pseudocordata Zone, *i.e.* with Subboreal uppermost Oxfordian (CARIOU & *al.* 1991, HANTZPERGUE & *al.* 1991), or correlated only the Galar Subzone of the uppermost Planula Zone with the lower part of the Baylei Subzone, *i.e.* with the Subboreal lowermost Kimmeridgian (ATROPS, ENAY & MELENDEZ 1993, ATROPS & MELENDEZ 1994b).

The appearance of *Amoeboceras bauhini* in the succession cannot be treated, however, as indicating precisely the base of the Baylei Zone, *i.e.* the base of the Kimmeridgian in the Subboreal zonal scheme. This species appears close to the upper boundary of the Hypselum Subzone, and ranges up to the end of the Planula Zone, in the Submediterranean Succession, what makes it possible to correlate the indicated stratigraphic interval with the upper part of the Pseudocordata Zone (mostly with the Evoluta Subzone), and with the bulk of the Baylei Zone of the Subboreal Succession. As the occurrence of *A. bauhini* alone cannot be used for delimitation of the base of the Subboreal/Boreal Kimmeridgian, the previous opinions on the position of this boundary based on this criterion should be now partly modified (*cf. e.g.* MATYJA & WIERZBOWSKI 1988, 1994; WIERZBOWSKI 1991; SCHWEIGERT 1995a,b; ATROPS 1997). It is the presence of *Pictonia densicostata* in the *Amoeboceras* Layer in the litocerum horizon of the Hauffianum Subzone discovered recently in the Wieluń Upland (*see* Text-fig. 3) which indicates firmly the Baylei Zone age. To date, this is the lowest occurrence of *Pictonia*, represented moreover by the earliest member of this genus, discovered in the Submediterranean Succession. This record shows that the lower boundary of the Subboreal Kimmeridgian lies not higher than the litocerum horizon of the Hauffianum Subzone of the Bimammatum Zone in the Submediterranean Succession. This boundary may lie, however, somewhat lower, in the Hauffianum Subzone, or even in the upper part of the Bimammatum Subzone (*see* Text-fig. 4). It should be remembered, that at least a part of the Bimammatum Subzone, due to the occurrence of representatives of *Ringsteadia*, directly evolving from the *R. pseudoyo* – *R. pseudocordata* group, can be correlated with the uppermost part of the Pseudocordata Zone corresponding mostly to the Evoluta Subzone of the uppermost Subboreal Oxfordian. Such a correlation is consistent with the appearance of the genus *Prorasenia* at the base of the Bimammatum Subzone in the Submediterranean Succession, and in the upper part of the Pseudocordata Zone in the Subboreal Succession (BIRKELUND & CALLOMON 1985, WIERZBOWSKI 1991).

**Correlation of the Submediterranean zonal scheme with the Boreal and Subboreal ones**




Gray blocks indicate the interval of uncertain correlation

## CONCLUSIONS

For the first time, the occurrence of *Pictonia densicostata* BUCKMAN is documented in the Submediterranean Succession. It shows that the base of the Baylei Zone corresponding to the base of the Kimmeridgian in the Subboreal zonal scheme lies not higher than the litocerum horizon of the Hauffianum Subzone of the Bimammatum Zone in the Submediterranean Succession.

The precise position of the lower boundary of the Subboreal Kimmeridgian in the Submediterranean Succession remains so far unknown: it lies below the broilii horizon of the Hauffianum Subzone of the Bimammatum Zone, *i.e.* either in the mid-lower parts of the Hauffianum Subzone, or in the upper part of the Bimammatum Subzone.

The base of the Kimmeridgian in the Submediterranean Succession corresponding to the boundary of the Planula and Platynota Zones, can be precisely correlated with the base of the Kitchini Zone of the Boreal Succession: the lower boundary of the Kitchini Zone is marked (*see* MESEZHNIKOV 1982, MESEZHNIKOV & *al.* 1989, WIERZBOWSKI & SMELROR 1993) by the substitution of the ammonites of the subgenera *Amoeboceras* and *Plasmatites* by those of the subgenus *Amoebites*.

It is much easier and more simple to recognize at this moment the boundary between the Planula and Platynota Zones in the Submediterranean Succession as the uniform boundary of the Oxfordian and Kimmeridgian, as it corresponds to the base of the Kitchini Zone (= boundary of the Ravni and Kitchini Zones in Russian zonal scheme, and the boundary of the Bauhini and Kitchini Zones) in the Boreal Succession, than to approximate the time-counterpart of the base of the Subboreal Kimmeridgian (*i.e.*, the base of the Baylei Zone) which seems also to show less correlation potential.

It is premature at this moment to indicate the candidates for the "Global Sections and Points" (GSSPS) of the International Commission on Stratigraphy (ICS) for the base of the Kimmeridgian. The Subboreal sections mentioned as candidates (PAGE 1994): South Ferriby (Lincolnshire, England), Staffin Bay (Skye, Scotland), Osmington Mills and Ringstead at Dorset, Westbury (Wiltshire, England) need detailed studies to resolve the relationships between the ranges of different species of *Ringsteadia* and *Pictonia* from one side, and those of the genus *Amoeboceras* from the other.

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# PLATES 4 – 10

# PLATE 4

**1** — *Glochiceras* (*Lingulaticeras*) *lingulatum* (QUENSTEDT); Specimen No. IGPUW/A/33/1; Quarry Pj 140, unit *1* or *2*

**2** — *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL)/*pseudowenzeli* (WEGELE); Specimen No. IGPUW/A/33/2; Quarry Pj 140, unit *4*

**3** — *Taramelliceras* (*Metahaploceras*) aff. *wenzeli* (OPPEL); Specimen No. IGPUW/A/33/3; Quarry Pj 300, unit *1d*

**4** — *Taramelliceras* (*Metahaploceras*) *kobyi kobyi* (CHOFFAT); Specimen No. IGPUW/A/33/4; Quarry Pj 140, unit *2*

**5** — *Taramelliceras* (*Metahaploceras*) *litocerum* (OPPEL); Specimen No. IGPUW/A/33/5; Quarry Pj 145, unit *1*

**6** — *Taramelliceras* (*Metahaploceras*) *lochense* (OPPEL); Specimen No. IGPUW/A/33/6; Quarry Pj 140, unit *2*

**7** — *Taramelliceras* (*Metahaploceras*) *wenzeli* (OPPEL); Specimen No. IGPUW/A/33/7; Quarry Pj 114, unit *5*

**8** — *Taramelliceras* (*Metahaploceras*) *pseudowenzeli* (WEGELE); Specimen No. IGPUW/A/33/8; Quarry Pj 300, uppermost part of bed *1d*

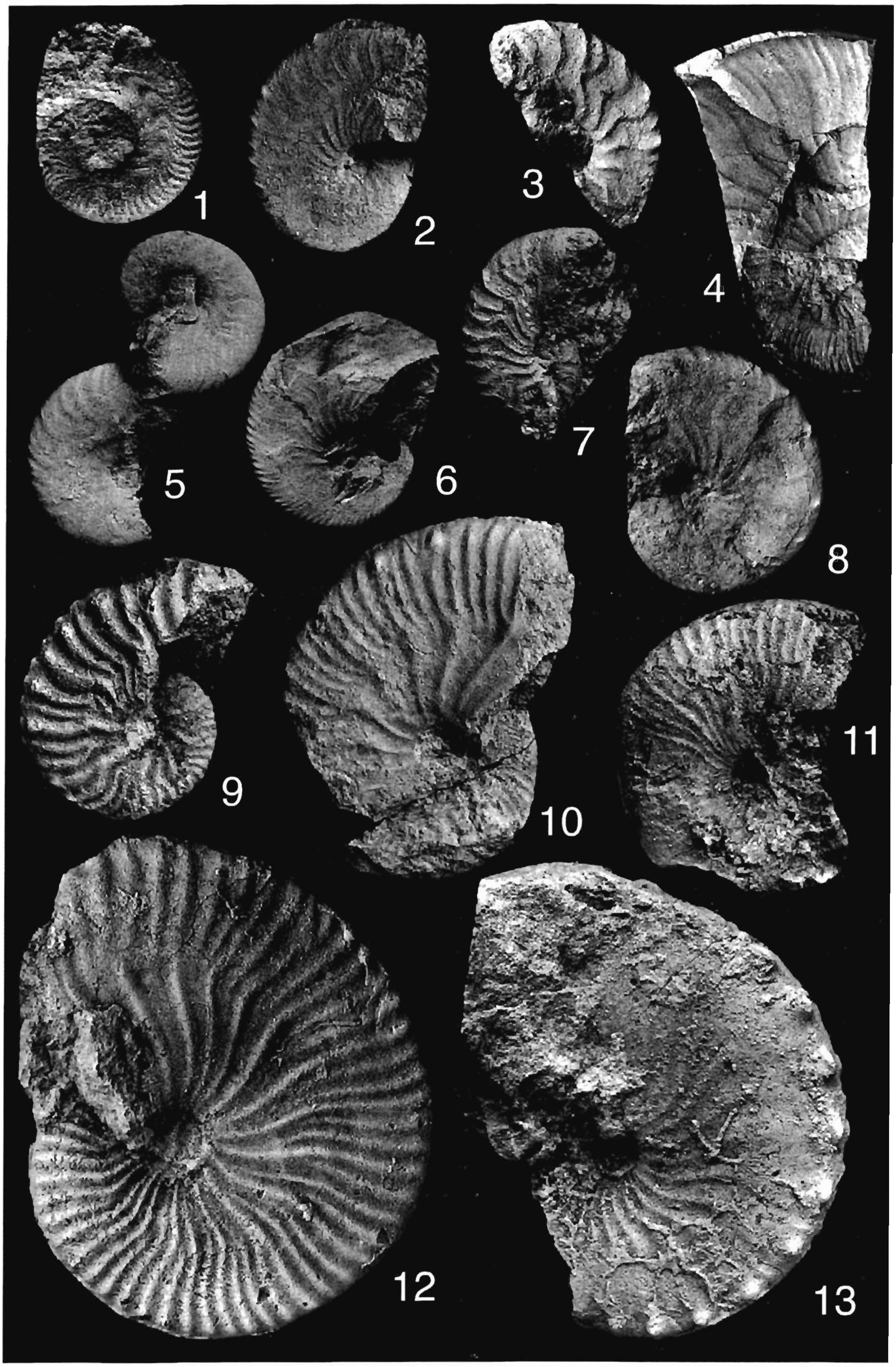
**9** and **12** — *Taramelliceras* (*Taramelliceras*) *broilii* (WEGELE); 9 – Specimen No. IGPUW/A/33/9; Quarry Pj 140, units *2-5*; 12 – Specimen No. IGPUW/A/33/12; Quarry Pj 145, bed *4b*

**10** — *Taramelliceras* (*Metahaploceras*) *kobyi quenstedti* HÖLDER; Specimen No. IGPUW/A/33/10; Quarry Pj 140, unit *8*

**11** — *Taramelliceras* (*Taramelliceras*) *hauffianum* (OPPEL); Specimen No. IGPUW/A/33/11; Quarry Pj 113, unit *4*

**13** — *Taramelliceras* (*Taramelliceras*) *costatum* (QUENSTEDT); Specimen No. IGPUW/A/10/9; Quarry Pj 113, unit *2*

All specimens in natural size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# PLATE 5

1 — *Amoeboceras* (*Plasmatites*) *lineatum* (QUENSTEDT); Specimen No. IGPUW/A/33/134; Quarry Pj 145, bed *1a*

2 — *Amoeboceras* (*Plasmatites*) *praebauhini* (SALFELD); Specimen No. IGPUW/A/33/132; Quarry Pj 114, unit *3*

3-4 — *Amoeboceras* (*Plasmatites*) *bauhini* (OPPEL); 3 – Specimen No. IGPUW/A/33/131; Quarry Pj 113, bed *5b*; 4 – Specimen No. IGPUW/A/33/133; Quarry Pj 145, bed *1a*

5-11 — *Pictonia densicostata* BUCKMAN; 5 – Specimen No. IGPUW/A/33/105; Quarry Pj 140, bed *2a*; 6 – Specimen No. IGPUW/A/33/101; Quarry Pj 114, unit *3*; 7 – Specimen No. IGPUW/A/33/100; Quarry Pj 113, bed *5b*; 8 – Specimen No. IGPUW/A/33/99 together with *Amoeboceras* (*Plasmatites*) sp.; Quarry Pj 113, bed *5b*; 9 – Specimen No. IGPUW/A/33/102; Quarry Pj 114, unit *3*; 10 – Specimen No. IGPUW/A/33/103; Quarry Pj 145, bed *1a*; 11 – Specimen No. IGPUW/A/33/104; Quarry Pj 145, bed *1a*

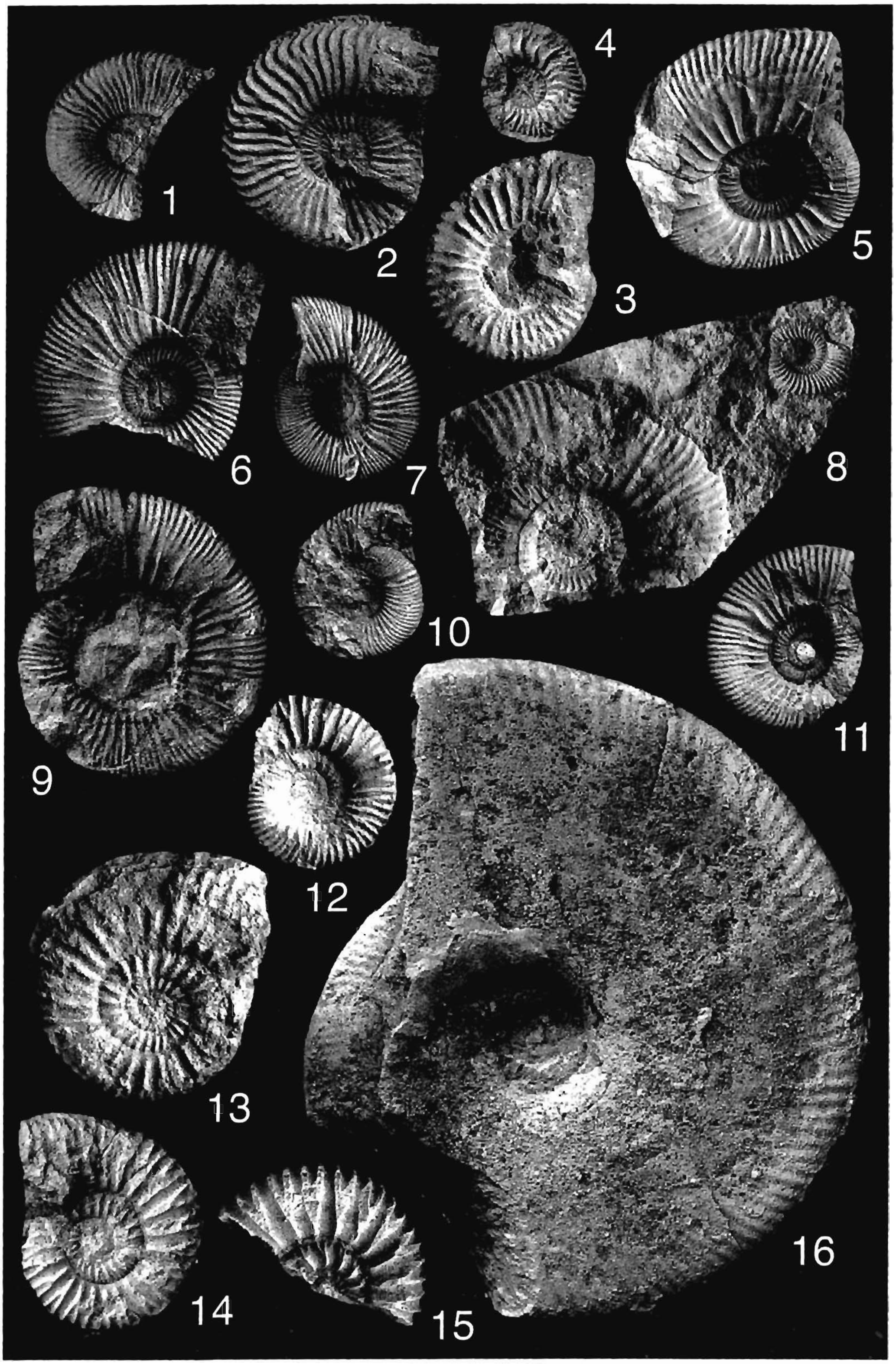
12-13 — *Prorasenia bowerbanki* SPATH; 12 – Specimen No. IGPUW/A/33/107; Quarry Pj 145, just above the *Amoeboceras* Layer; 13 – Specimen No. IGPUW/A/33/106; Quarry Pj 125, unit *4* (2m above the *Amoeboceras* Layer)

14 — *Prorasenia bathyschista* (KOERNER); Specimen No. IGPUW/A/33/108; Quarry Pj 300, bed *1c*

15 — *Prorasenia crenata* (QUENSTEDT); Specimen No. IGPUW/A/33/109; Quarry Pj 140, rubble of units *1-5*

16 — *Ringsteadia submediterranea* WIERZBOWSKI; Specimen No. IGPUW/A/10/334; Quarry Pj 113, unit *1*

All specimens in natural size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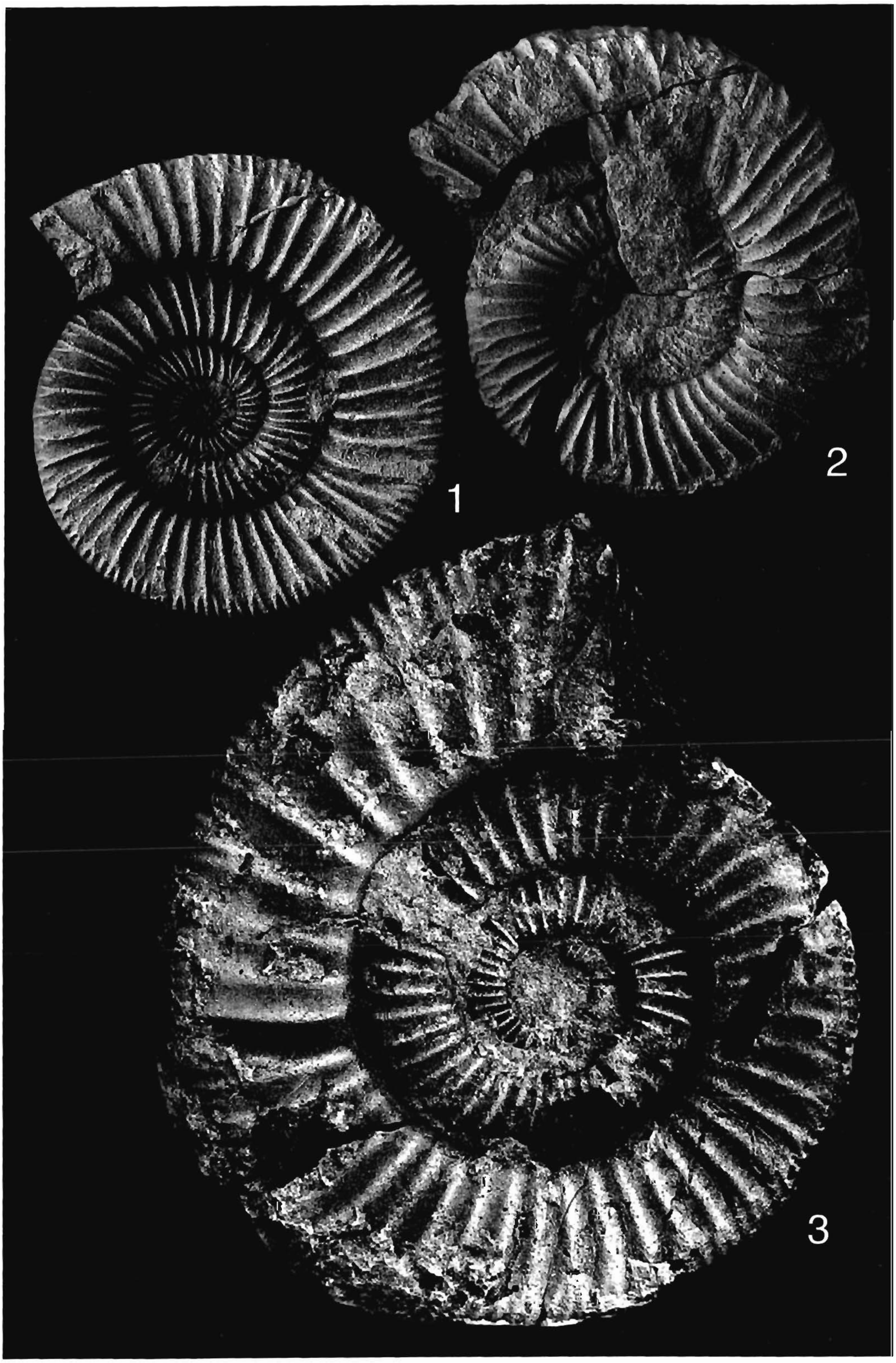
# PLATE 6

1 — *Orthosphinctes* (*Orthosphinctes*) *tiziani* (OPPEL); Specimen No. IGPUW/A/33/219; Quarry Pj 113, unit *4*

2 — *Orthosphinctes* (*Orthosphinctes*) *triplex* (QUENSTEDT); Specimen No. IGPUW/A/33/239; Quarry Pj 300, bed *1b*

3 — *Orthosphinctes* (*Pseudorthosphinctes*) *lisowicensis* WIERZBOWSKI; Specimen No. IGPUW/A/33/220; Quarry Pj 114, unit *2*

All specimens in natural size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# PLATE 7

*Orthosphinctes* (*Pseudorthosphinctes*) *alternans* ENAY; Specimei No. IGPUW/A/33/242; Quarry Pj 125, unit *3*

Specimen taken × 0.7 of natural size

# PLATE 8

**1** — *Orthosphinctes grandiplex* (QUENSTEDT); Specimen No. IGPUW/A/33/231; Quarry Pj 110, rubble of units *3-13*

**2** — *Orthosphinctes laufenensis* M (SIEMIRADZKI); Specimen No. IGPUW/A/33/232; Quarry Pj 140, bed *2b*

All specimens in natural size


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# PLATE 9

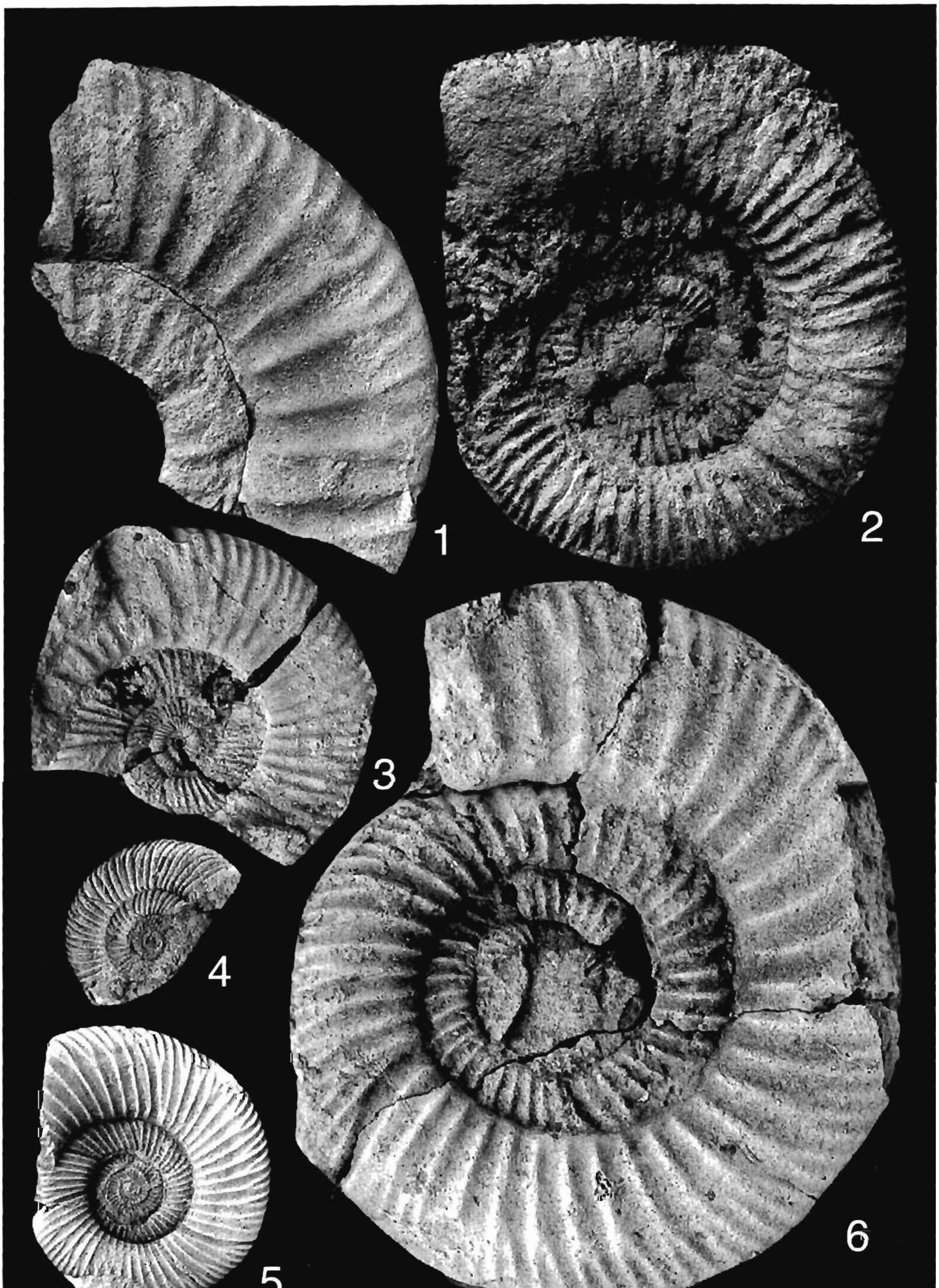
**1** and **6** — *Idoceras* (*Subnebrodites*) *planula* (HEHL); 1 – Specimen No. IGPUW/A/33/181; Quarry Pj 110, bed *7d*; 6 – Specimen No. IGPUW/A/10/330; Quarry Pj 139, unit *11*

**2** — *Passendorferia* (*Enayites*) *wierzbowskii* MELENDEZ; Specimen No. IGPUW/A/33/204; Quarry Pj 140, unit *9*

**3** — *Idoceras* (*Subnebrodites*) *schroederi* (WEGELE); Specimen No. IGPUW/A/33/182; Quarry Pj 110, rubble of units *3-13*

**4-5** — *Idoceras* (*Subnebrodites*) *minutum* DIETERICH; 4 – Specimen No. IGPUW/A/33/183; Quarry Pj 140, uppermost part of unit *1*, or unit 2; 5 – Specimen No. IGPUW/A/33/184; Quarry Pj 300, unit *2*

All specimens in natural size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# PLATE 10

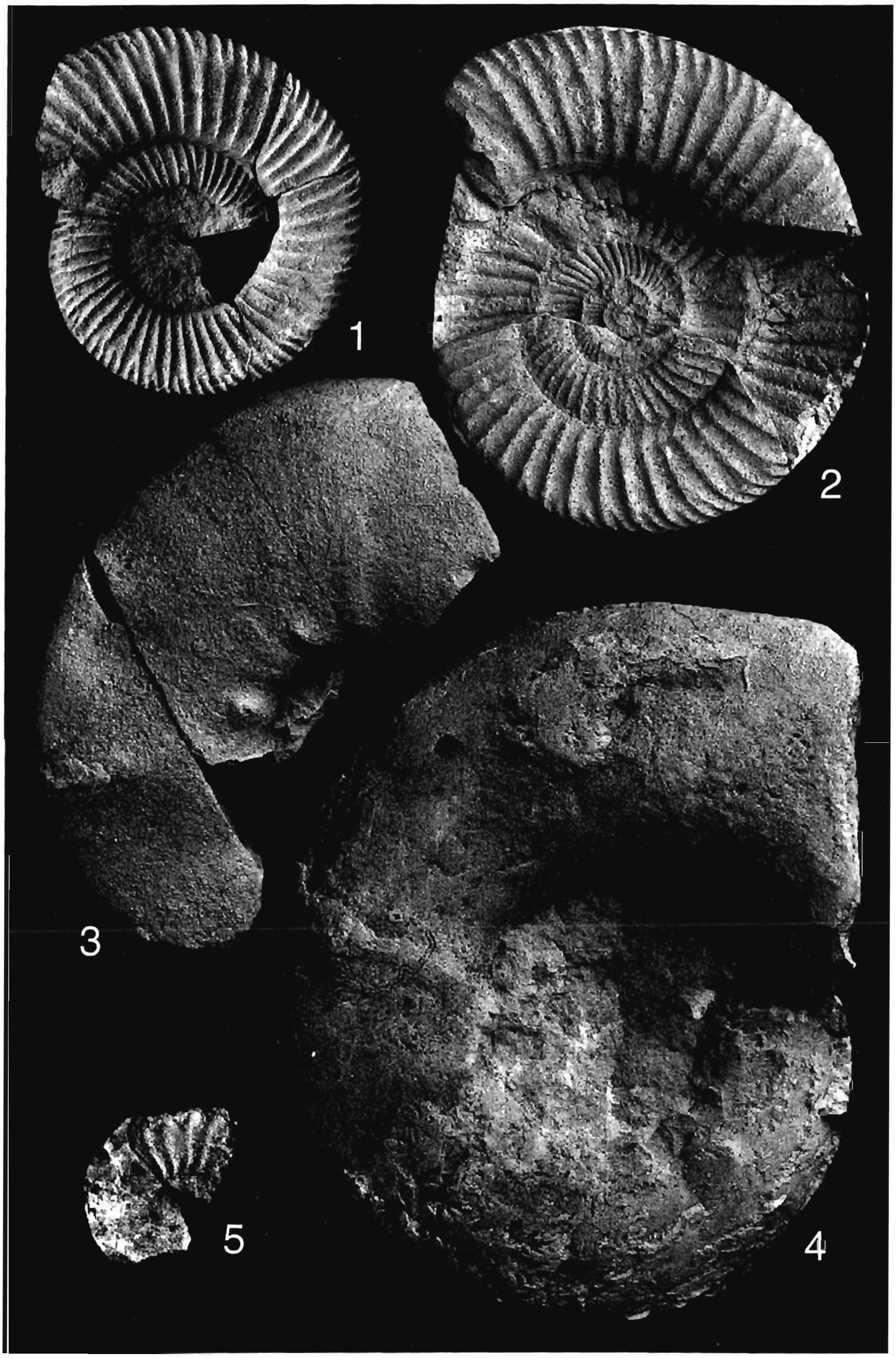
**1-2** — *Idoceras* (*Subnebrodites*) *proteron* NITZOPOULOS; 1 – Specimen No. IGPUW/A/33/179; Quarry Pj 140, unit *7* (about 1.5m above the base); 2 – Specimen No. IGPUW/A/33/180; Quarry Pj 110, bed *1d* (the uppermost part)

**3** — *Physodoceras altenense* (D'ORBIGNY); Specimen No. IGPUW/A/33/97; Quarry Pj 140, unit *8*

**4** — *Aspidoceras sesquinodosum* FONTANNES; Specimen No. IGPUW/A/33/98; Quarry Pj 114, unit *2*

**5** — *Epipeltoceras bimammatum* (QUENSTEDT); Specimen No. IGPUW/A/33/96; Quarry Pj 113, unit *1*

All specimens in natural size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