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The ammonite and calpionellid stratigraphy of the Berriasian and lowermost Valanginian in the Pieniny Klippen Belt (Carpathians, Poland)

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ABSTRACT

The ammonite faunas of the Berriasian and lowermost Valanginian, generally poorly known in the western Carpathians, are described from the Czorsztyn succession in the Polish sector of the Pieniny Klippen Belt. The Rogoza Klippen at Rogoznik, and the Cisowa Klippe sections have yielded ammonites indicative of the Euxinus Zone (= Jacobi/Grandis Zone), whereas in the Sobotka klippe section at Czorsztyn ammonites of the Occitanica Zone, the Boissieri s.s. (= Rarefurcata) Zone, as well as of the earliest Valanginian (the Otopeta Zone or an early part of the Retrocostatum Zone sensu Hoedemaeker 1982) have been discovered. All these faunas are of the Mediterranean type being composed exclusively of Mediterranean-Caucasian species without any mixture of Boreal forms. The Sobotka Klippe section revealed also the presence of calpionellids enabling the differentiation of the Crassicollaria (= A) Zone, the Calpionella Zone (= Zones B + C), and the Calpionellopsis (= D) Zone. The common occurrence of ammonites and calpionellids in some parts of the section, i.e. in the middle part of the Occitanica Zone and of Zone C, as well as in the Otopeta Zone and Subzone D3, confirms the correlation of ammonite and calpionellid subdivisions, as established by Le Hégarat & Remane (1968).

ZUSAMMENFASSUNG

Die Ammonitenfaunen des Berriasien und untersten Valanginien der Westkarpaten sind bisher nur unvollständig bekannt. Hier werden Faunen aus der Schichtfolge von Czorsztyn im polnischen Teil der Pieninischen Klippen beschrieben.

Die Rogoza-Klippen bei Rogoznik und die Cisowa-Klippe lieferten Ammoniten, die die Euxinus-Zone (= Jacobi/Grandis-Zone) anzeigen, während in der Sobotka-Klippe bei Czorsztyn Ammoniten aus der Occitanica-Zone, der Boissieri-Zone s.str. (= Rarefurcata-Zone) und aus dem frühesten Valanginien (der Otopeta-Zone oder dem frühen Teil der Retrocostatum-Zone sensu Hoedemaeker 1982) gefunden werden. Alle Faunen sind typisch mediterran und bestehen ausschliesslich aus mediterran-kaukasischen Arten ohne jede Beimischung borealer Formen. In der Abfolge der Sobotka-Klippe fanden sich auch Calpionellen, sie erbrachten den Nachweis der Crassicollaria-Zone (= Zone A), der Calpionella-Zone (sowohl B als auch C) und der Calpionellopsis-Zone (= Zone D). Das gemeinsame Vorkommen von Calpionellen und Ammoniten in einem Teil der Abfolge, in der mittleren Occitanica-Zone und der Zone C, sowie der Otopeta-Zone und Subzone D3 bestätigt die Korrelation von Ammoniten- und Calpionellenzonen durch Le Hégarat & Remane (1968).

1. Introduction

Until recently the knowledge of the lowermost Cretaceous ammonite faunas of the Pieniny Klippen Belt in Poland has been extremely poor. The only older evidence was that of K. A. Zittel, M. Neumayr and V. Uhlig who reported, but without any descrip-

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tion or illustration, "*Hoplites/Perisphinctes* cf. *callisto*" (D'ORBIGNY) and "*Hoplites/Perisphinctes* cf. *occitanicus*" (PICTET) from the Maruszyna and Rogoznik area (cf. Birkenmajer 1963). This was newly supplemented by Dzik (1990, Pl. 3, Figs. 16–17) who illustrated two ammonites of the genus *Spiticeras* found in a loose block of the bright micritic limestone in the Rogoza Klippen at Rogoznik

The recently discovered ammonite faunas have been found in almost the whole sequence of the Lower Cretaceous in the Czorsztyn succession (cf. Birkenmajer 1977). Older faunas come from some micritic limestones of the Dursztyn Limestone Formation, from white and cream coloured micritic ammonite coquinas of the Rogoznik Coquina Member in the Rogoza Klippen at Rogoznik (Kutek & Wierzbowski 1986, Fig. 1, beds 7a–1), as well as from the pinkish to reddish micritic limestones, with a few intercalations rich in ammonites, belonging possibly to the Korowa Limestone Member, and occurring in the Cisowa Klippe at Nowa Biala (Fig. 1).

Somewhat younger faunas have been found in the white micritic limestones with intercalations of organodetrital limestones belonging to the Sobotka Limestone Member of the Dursztyn Limestone Formation and occurring in the Sobotka Klippe at Czorsztyn. Still younger ammonite faunas come from organogenic limestones consisting mainly of crinoid fragments with variable admixtures of brachiopod shells, aptychi, and less commonly other fossils, also cropping out in the Sobotka Klippe. These limestones belong to the Lysa Limestone Formation. The ammonites come from the lower part of the unit (Harbatowa Limestone Member), as well as from its upper part (Kosarzyska Limestone Member). So far, only the uppermost lower Cretaceous deposits the Czorsztyn succession, belonging to the Spisz Limestone Formation have not yielded identifiable ammonites.

Beside of its biogeographic value, the recently discovered ammonite faunas allow a more precise age assignment of the lower Cretaceous of the Czorsztyn succession. So far, the deposits have been attributed to the Berriasian, the Valanginian and the Hauterivian,

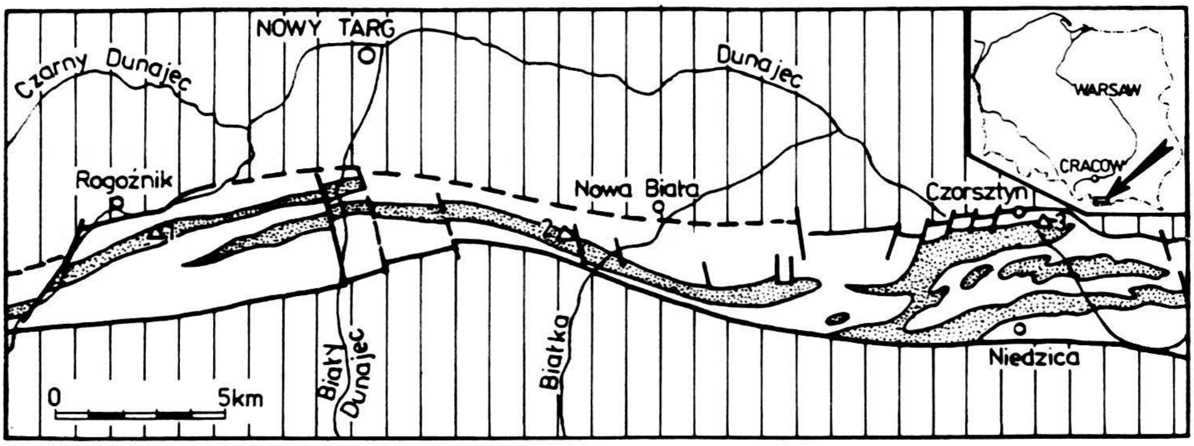

Fig. 1. Distribution of Jurassic and Cretaceous deposits of the Czorsztyn succession in the Pieniny Klippen Belt (after Birkenmajer 1977), Carpathians, Poland. The following patterns are used: stippled for Jurassic and Cretaceous of the Czorsztyn succession, white for Jurassic and Cretaceous of the remaining Klippen Belt succession, and of the Magura succession, hatched for Palaeogene of the Magura succession and of the Podhale succession (to the north and south of the Pieniny Klippen Belt, respectively). More important dislocations are indicated by solid lines. Triangles represent the studied localities (1 – Rogoza klippes, 2 – Cisowa klippe, 3 – Sobotka klippe).

based on aptychi, and to a lesser degree on calpionellids (Birkenmajer & Gasiorowski 1961; cf. also Birkenmajer 1977, and earlier papers cited therein). However, the biostratigraphy of the calpionellids, as presented in the papers in question, needs some corrections, due to the general progress in calpionellid zonation. A study of calpionellid faunas from the Sobotka Klippe section has revealed also some differences in the stratigraphic distribution of species when compared with an earlier study of the section by Nowak (1971). In the latter, the association of the calpionellid species reported from certain samples in the section is anomalous, which seems to result from imprecise identifications.

Ammonites are generally sufficiently well preserved to allow identification for biostratigraphic purposes, although the material is not sufficient for detailed paleontological studies. Ammonites are mostly represented by fragments of whorls; moreover, extracting of the specimens from the hard micritic limestones often results in their further fragmentation. Of the ammonites collected those coming from the Rogoza Klippen and Cisowa Klippe have been studied more thoroughly than those from the Sobotka Klippe where only a part of the material has been determined. The full study of the ammonites from the latter locality will be published later.

All the ammonites are registered in the Museum of the Geological Faculty of the Warsaw University collection number IGPUW/A 25/1–75. Thin sections are housed in the Institute of Geology of the Neuchâtel University.

2. Ammonite faunas and biostratigraphy (A.W.)

The ammonite subdivision of the Berriasian and the Lower Valanginian in the Mediterranean Province has been discussed more recently in several papers presenting the detailed ammonite successions in southern France and southern Spain (Le Hégarat 1971; Busnardo & Thieuloy 1979; Hoedemaeker 1982). The main problem is the position of stage boundaries, i.e. the Tithonian/Berriasian boundary, and the Berriasian/Valanginian boundary. The former is placed here according to the suggestion of Enay & Geyssant (1975), at the base of the Jacobi/Grandis Zone (= Euxinus Zone). The location of the latter is much more open to discussion, according to the interpretation of the ammonite fauna from the Callisto Subzone of Le Hégarat (1971). After Le Hégarat the fauna contains only Berriasian ammonites, and the Subzone should be placed in the latest part of the Boissieri Zone, i.e. still in the Berriasian. On the other hand, Hoedemaeker (1982) has described an ammonite fauna containing elements of both the Callisto Subzone as well as undoubted Valanginian forms. He distinguished this interval as the Alpillensis Subzone and considered it as earliest Valanginian. More recently, Hoedemaeker (1984) has correlated the Alpillensis Subzone with the greater later part of the Callisto Subzone. It should also be remembered that the Otopeta Zone as established by Busnardo & Thieuloy (1979) for the earliest Valanginian, contains in its lower part also some ammonites known from the Berriasian.

This part can generally be correlated with the basal part of the Pertransiens Subzone (Hoedemaeker 1982, 1984), i.e. with the earliest Valanginian of Le Hégarat (1971). The position of the Berriasian/Valanginian boundary differs thus, according to the preferred interpretation, by one ammonite subzone, and the problem still remains open to discussion. The discrepancies are, however, of minor importance for the stratigraphical interpretation of the sections in the Pieniny Klippen Belt, as the ammonite finds practically do not cover the critical interval. It is purely for descriptive purposes that we accept the Otopeta Zone as the earliest Zone of the Valanginian. This is in good agreement with the recommendation of the Subcommission on Cretaceous Stratigraphy in Copenhagen in 1983 (Birkelund et al. 1984).

In the Rogoza Klippen, beds 7a (below) and 6 (above) represent the oldest part of the section (Fig. 2); they did not yield stratigraphically important ammonites. The calpionellid faunas found in these beds belong to the earliest Berriasian and possibly latest Tithonian (Kutek & Wierzbowski 1986). Higher up, in bed 5, appears a rich assemblage of ammonites (Fig. 2; Pl. 1, Figs. 4, 6; Pl. 2, Fig. 5) including: *Berriasella (Berriasella) jacobi* MAZENOT, *B. (B.)* cf. *moreti* MAZENOT, *B. (Delphinella) subchaperi* (RETOWSKI), and *B.* (*D.*) cf. *delphinensis* (KILIAN). Some of these species continue upwards to bed 4, but there occur also (Pl. 1, Figs. 1–2, 5, 10, 11, Pl. 2, Figs. 2–4) *Himalayites cortazari* (KILIAN), *Berriasella (Berriasella) subcallisto* (TOUCAS), *B. (Delphinella)* cf. *obtusenodosa* (RETOWSKI), *B. (?Malbosiceras)* cf. *chaperi* (PICTET), and *Pseudosubplanites* cf. *lorioli* (ZITTEL).

This is the ammonite fauna of the Euxinus Zone, as established by Wiedmann [in: Allemann et al. 1975 and emended by Hoedemaeker 1982], corresponding to the Jacobi/Grandis Zone of Enay & Geyssant (1975). The sharp decline of *Berriasella (Delphinella)* at the top of bed 4 indicates moreover a transition from the Jacobi Subzone to the Grandis Subzone. It corresponds well to a marked increase in number of *Pseudosubplanites* observed in the still younger beds 3 and 2 which is indicative of the Grandis Subzone, i.e. of the younger part of the Euxinus Zone (Figs. 2–3; cf. also Le Hégarat 1971; Hoedemaeker 1982). It is also worth to note the occurrence of *Himalayites cortazari* (KILIAN) in bed 4 of this section, which extends the stratigraphical range of the species into the Jacobi Subzone as already suggested by Hoedemaeker (1982). The appearance of *Fauriella* spp. and the lack of *Pseudosubplanites* in bed 1 at the top indicate already the Occitanica Zone, with the boundary between the Euxinus Zone and the Occitanica Zone at the base of bed 1.

In the Cisowa Klippe section ammonites are not as common as in the Rogoza Klippen section, they are grouped in a few horizons (Fig. 4). The lowest horizon does not yield any diagnostic ammonites, but from the beginning of the second one – in the lower part of bed 3, there appear (Pl. 1, Fig. 7, Pl. 2, Fig. 1): *Berriasella (Berriasella) jacobi* MAZENOT, *B. (Delphinella) crimense* (BURCKHARDT) and *Pseudosubplanites* cf. *lorioli* (ZITTEL) indicative of the Euxinus Zone.

The boundary between the Jacobi Subzone and the Grandis Subzone is not so well marked as in the Rogoza Klippen; nevertheless some increase in number of *Pseudosubplanites* within the two highest ammonite horizons, in the upper part of the bed 3, suggests that the boundary runs somewhere in the middle of the bed. The occurrence in the uppermost ammonite horizon of *Berriasella (B.) jacobi* MAZENOT, *B. (Delphinella) crimense* (BURCKHARDT), *Pseudosubplanites* cf. *euxinus* (RETOWSKI), *Schaireria* sp., and *Cyrtosiceras macrotelum* (OPPEL) (Pl. 1, Figs. 3, 9; Pl. 2, Figs. 6–7) indicates the Euxinus Zone.

The oldest ammonite found in the Sobotka Klippe section (Fig. 5) comes from bed 3c. It is (Pl. 2, Fig. 8) *Fauriella incomposita* (RETOWSKI) very close to the type specimen of Retowski (1893, Pl. 4, Fig. 6). The stratigraphical range of the species is

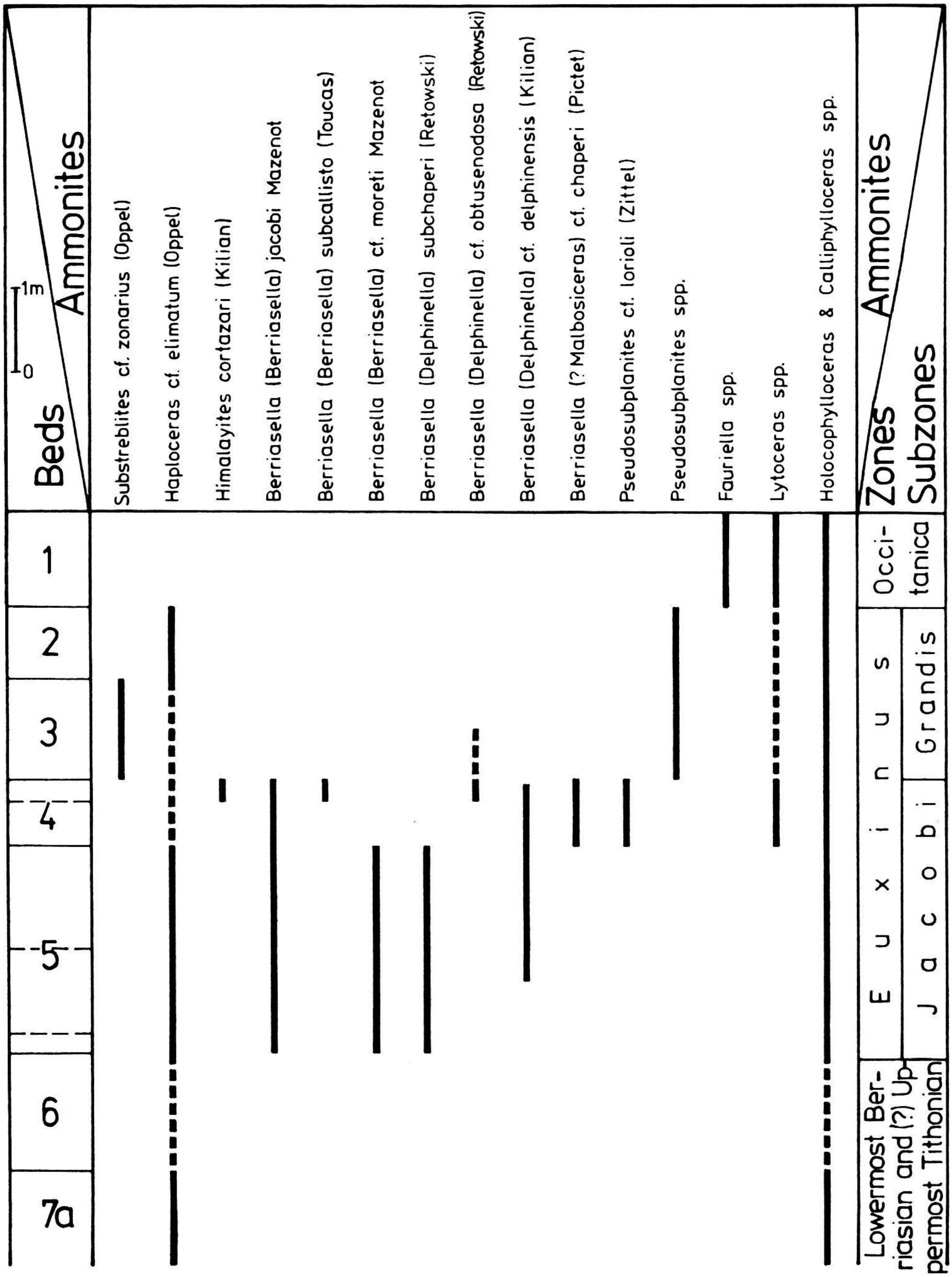

Fig. 2. Stratigraphic distribution of ammonites in the upper part of the Rogoza Klippen-section representing mostly the Lower Berriasian (cf. Kutek & Wierzbowski 1986, Fig. 1); beds 7a to 1 correspond to the micritic coquinas of the Rogoznik Coquina Member.

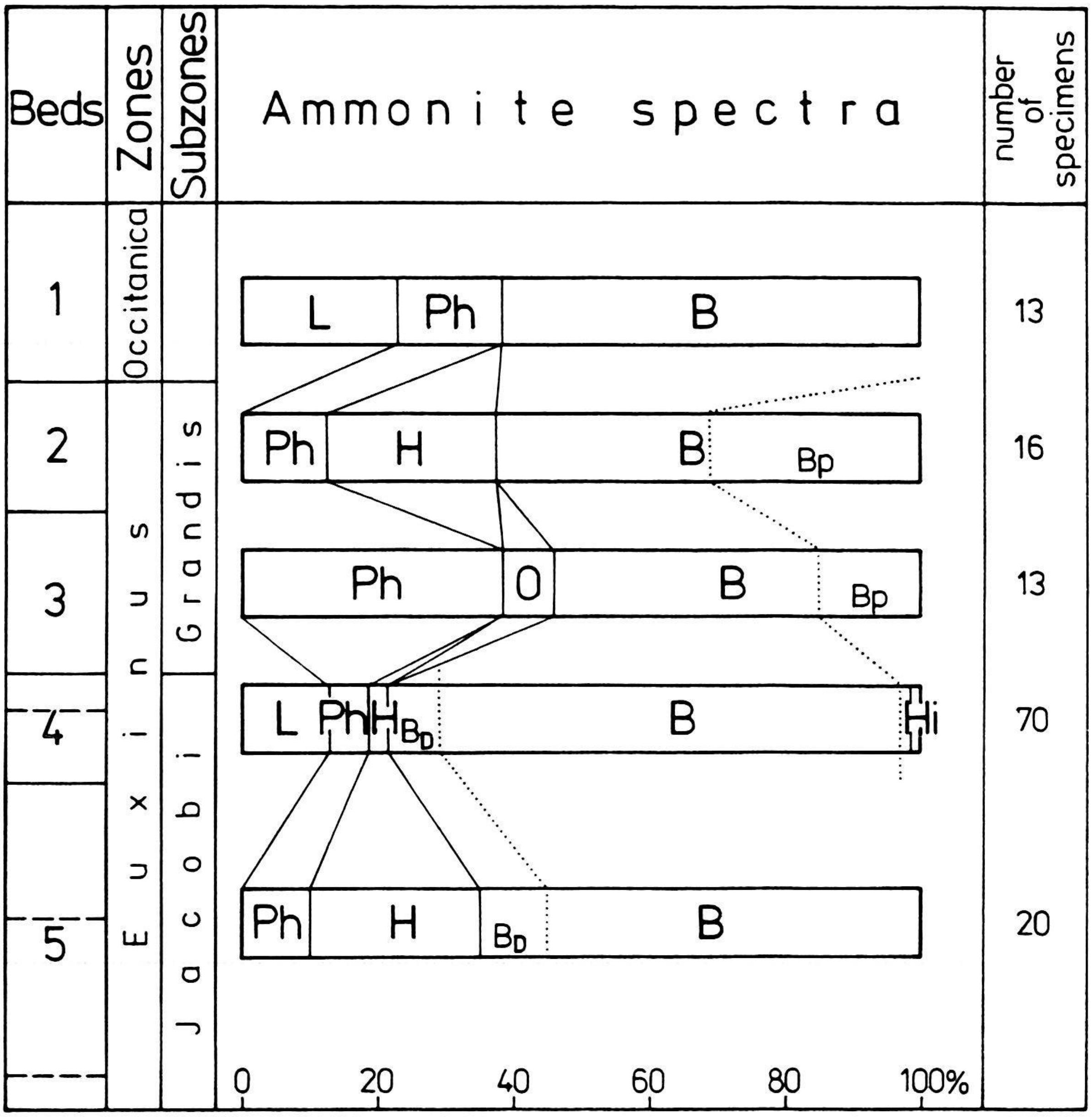

Fig. 3. Ammonite spectra for the beds 1–5 of the Rogoza klippes section (cf. Fig. 2): L-Lytocerataceae, Ph-Phyllocerataceae, H-Haploceratidae, O-Oppeliidae, B-Berriasellidae (B_D-*Delphinella*, B_P-*Pseudosubplanites*), Hi-Himalayitidae.

poorly known, but it seems to cover, at least partly, the Occitanica Zone (cf. Khimshiashvili 1989). This is in good agreement with the occurrence of a calpionellid fauna of Zone C in the same interval of the section (Figs. 5–6).

Higher in the section, in the uppermost part of bed 3e and in bed 3f, occur (Pl. 3, Fig. 11): *Berriasella (Berriasella)* cf. *privasensis* (Pictet), *Neocosmoceras* sp., *Spiticeras (Spiticeras)* aff. *groteanum* (Oppel) and *Neolissoceras grasianum* (d'Orbigny). The ammonites *B. (B.) privasensis* and *Neocosmoceras* indicate the Occitanica Zone, but rather excluding its upper part (i.e. the Dalmasi Subzone; cf. Le Hégarat 1971; Hoedemaeker 1982).

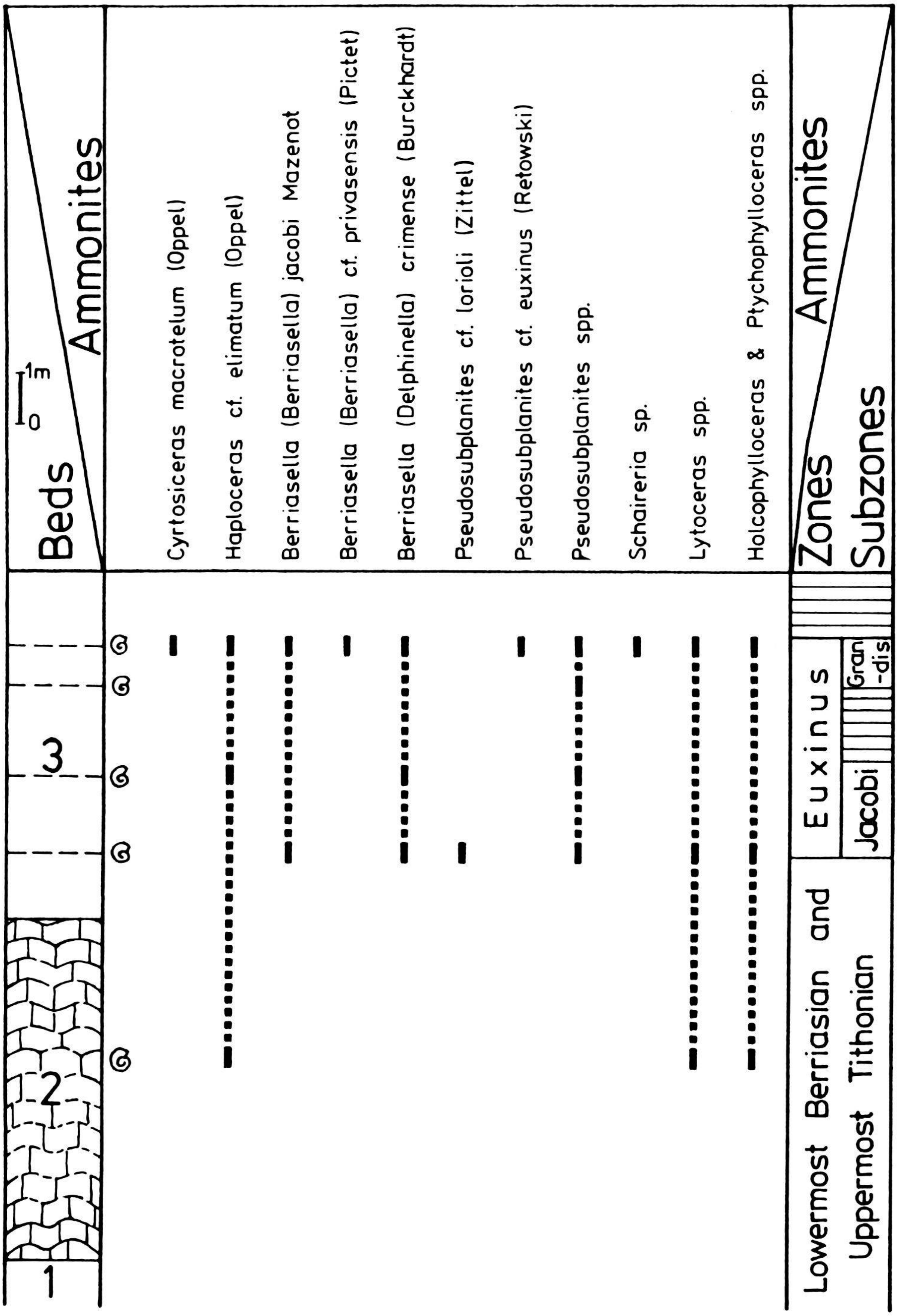

Fig. 4. Stratigraphic distribution of ammonites in the Cisowa klippe section: beds 1–2 represent the Crzorsztyn Limestone Formation, bed 3 possibly the Korowa Limestone Member of the Dursztyn Limestone Formation; the horizons rich in ammonites are indicated, for lithological symbols see Figure 5.

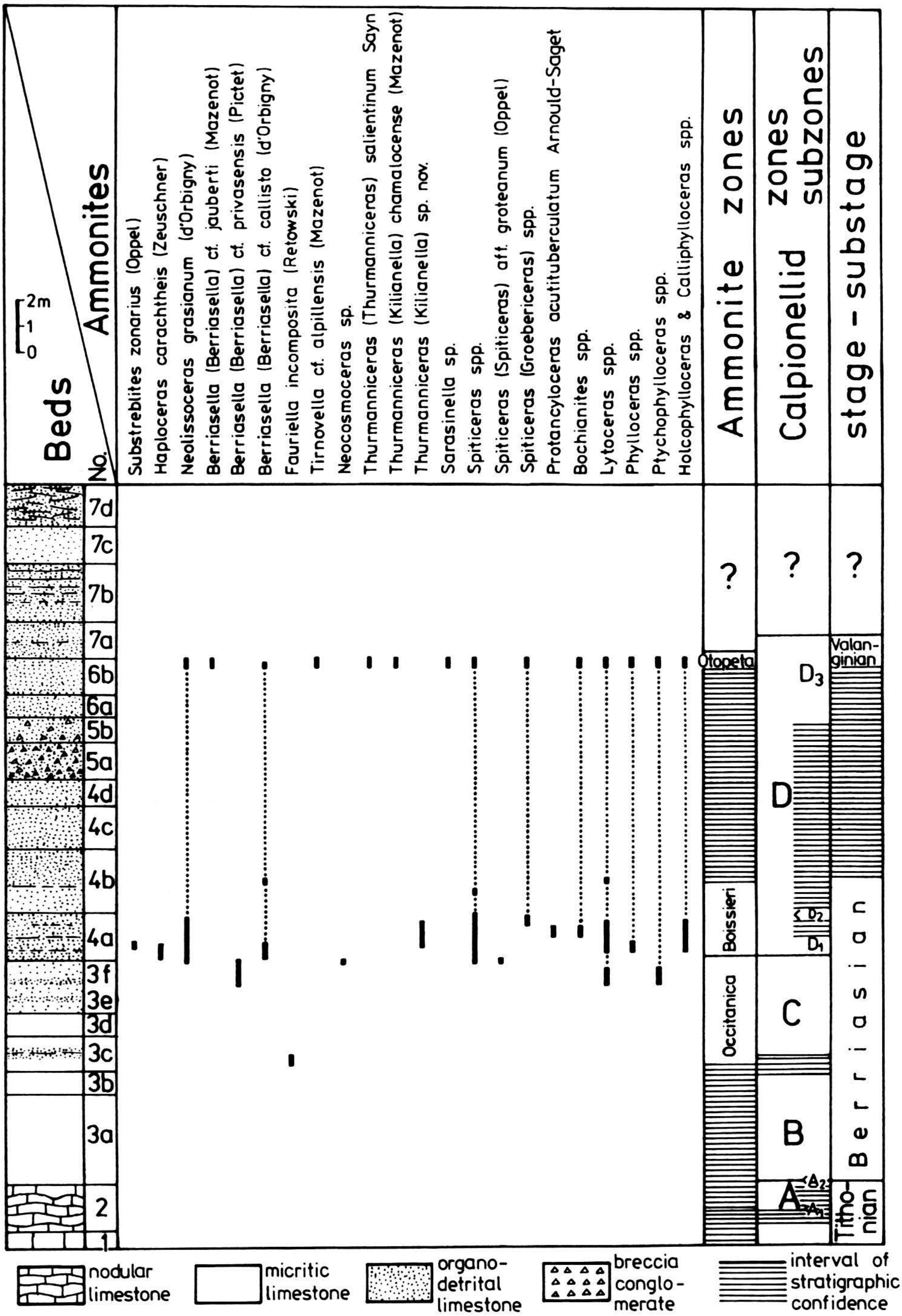

Fig. 5. Stratigraphic distribution of ammonites in the Sobotka klippe section: beds 1–2 represent the Czorsztyn Limestone Formation, beds 3a–3f the Sobotka Limestone Member of the Dursztyn Formation, beds 4–6 the Lysa Limestone Formation (4a–4d Harbatowa Limestone Member, 5a–5b Walentowa Breccia Member, 6a–6b Kosarzyska Limestone Member), beds 7a–7d Spisz Limestone Formation; 1 – nodular limestone, 2 – micritic limestone, 3 – organodetrital limestone, 4 – breccia/conglomerate, 5 – interval of stratigraphic confidence.

Immediately above, in bed 4a, beginning from its base, appear int. al. (Pl. 3, Figs. 1–3, 7–8): *Berriasella (Berriasella)* cf. *callisto* (D'ORBIGNY), *Spiticeras* spp. (including a representative of the subgenus *Groebericeras*), *Protancyloceras acutituberculatum* ARNOULD & SAGET, *Bochianites* sp., and *Thurmanniceras (Kilianella)* sp. nov. The last form is similar to *T. (K.) busnardoi* (PATRULIUS & AVRAM) differing mainly in its denser and weaker ribbing, as well as in the somewhat higher point of rib furcation (cf. Patrulius & Avram 1976, p. 183–184, Text-fig. 9, Pl. 8, Fig. 2; cf. also Hoedemaeker 1982). This ammonite fauna indicates the Boissieri Zone s.s. of Le Hégarat (1971) [= Rarefurcata Zone of Hoedemaeker 1982] as proved mainly by the occurrence of *B. (B.) callisto* and *Groebericeras*. The abrupt appearance of the fauna in question at the base of bed 4a, and directly above the fauna from beds 3e–3f, suggests a hiatus along which at least the upper part of the Occitanica Zone would be missing. This hiatus can be situated at the boundary between the micritic and organodetrital limestones corresponding to the boundary between the Sobotka Limestone Member of the Dursztyn Limestone Formation and the Harbatowa Limestone Member of the Lysa Limestone Formation (Fig. 5). It is worth to note that in some other sections of the Czorsztyn succession the lower boundary of the Lysa Limestone Formation is clearly erosional. Deposits of this formation may even occur in neptunian dykes, which indicate a marked stratigraphical non-sequence (Birkenmajer 1977; and earlier papers cited therein).

In bed 4b of the Sobotka klippe section only a few ammonites have been found. Stratigraphically most important is *Berriasella (Berriasella)* cf. *callisto* (D'ORBIGNY). Its occurrence and the lack of typical Valanginian genera suggests still the Boissieri Zone which is compatible with calpionellid datings (Figs. 5–6).

The youngest ammonite fauna comes from the upper part of bed 6b (Fig. 5). The ammonites are very common which suggests some condensation. Here occur (Pl. 3, Figs. 4–6, 10): *Berriasella (Berriasella)* cf. *jauberti* (MAZENOT), *B. (B.)* cf. *callisto* (D'ORBIGNY), *Tirnovella* cf. *alpillensis* (MAZENOT), *Thurmanniceras (Thurmanniceras) salientinum* SAYN, *T. (Kilianella) chamalocense* (MAZENOT), *Sarasinella* sp., *Spiticeras* spp., *Bochianites* sp., and others. The fauna is composed of characteristic "Berriasian" forms which are known to continue but into the lowermost Valanginian (*B. jauberti*, *B. callisto* and *T. alpillensis*) as well as of typical Valanginian ones (*Sarasinella*, *T. salientinum*). The recognized fauna thus corresponds well to the early part of the Otopeta Zone of Busnardo & Thieuloy (1979) or of the Retrocostatum Zone sensu Hoedemaeker (1982), namely to a part (?) of the Alpillensis Subzone, and a part of the Pertransiensis Subzone.

3. Calpionellid faunas from the Sobotka klippe section (J.R.)

3.1. Earlier observations from the Carpathians

Androusoff & Koutek (1927) were the first to observe calpionellids in the Carpathians, in Czechoslovakia. Since then, many authors have mentioned the presence of this group all over the Carpathians. The most important of these papers, dealing specifically with calpionellid stratigraphy, are the ones of Borza (1969), who developed a general microfacial zonal scheme for the W Carpathians, and of Dragastan, Mutiu &

Vinogradov (1973) for the E Carpathians. These authors showed, as did also Borza (1974, 1984) and Pop (1980) that the so-called Rome Standard Calpionellid Zones of Allemann et al. (1971) could be applied to the whole Carpathian arc. As to finer subdivisions, the one of Pop (1980) is interesting because he was able to distinguish also the S Mediterranean Calpionella elliptica Zone of Catalano & Liguori (1971). As will be shown, both this zone as well as the largely coeval Vocontian Zone C defined by Remane (1964) can be distinguished in the Lower Berriasian of the Sobotka Klippe.

Calpionellid Standard Zones and especially the more detailed Vocontoan zonation have been linked to ammonite zones at all levels and in several regions: in SE France for the Tithonian by Cecca & Santantonio (1986), for the Berriasian by Le Hégarat & Remane (1968), and for the Valanginian by Allemann & Remane (1979). These calibrations agree well with others from the Subbetic of S Spain by Enay & Geyssant (1975) for the Tithonian, and by Allemann, Grün & Wiedmann (1975) and Hoedemaeker (1982) for the Berriasian-Valanginian.

If there are any difficulties, these are due to the fact that ammonite specialists do not use the same zonal subdivision, not even for a limited domain as the W Mediterranean area.

So far, no detailed correlation between calpionellid and ammonite zones has been achieved in the Carpathians. Therefore, the Sobotka Klippe section at Czorsztyn is of special interest.

The zonal nomenclature used herein is mainly that of Remane (1964) and Le Hégarat & Remane (1968). A more general frame is given by the Rome Standard Zones (Allemann et al. 1971) and their further subdivision by Remane et al. (1986) through the Sümeg Standard Subzones. For a general overlook, see also Remane (1985).

There has been some confusion – also in my own publications (cf. Remane 1985 and Remane et al. 1986) – as to the position of the Tithonian Berriasian boundary. Classically placed in the middle of calpionellid Zone B, it should now be positioned at its base, according to a recommendation of the Colloque International sur la limite Jurassique/Crétacé Lyon-Neuchâtel 1973 (Proceedings, 1975, p. 385).

3.2. Own observations

Microfacies and the succession of sedimentary environments will not be dealt with in detail here. Only facts which are relevant for the reliability of calpionellid datations will be discussed.

The succession (Figs. 5–6) from bed 2 upwards to 3f reflects progressive condensation in a calm, pelagic environment. Especially in the lower part, we deal with mudstones or wackestones (sparse biomicrites) where planktic elements of one type or another (*Saccocoma,* radiolarians, calpionellids, *Globochaete alpina*, to a certain degree also protoglobigerinids) predominate clearly.

Necton is also present (ammonites resp. aptychi), whereas benthic forms are extremely rare. Condensation begins with the appearance of frequent crinoid remains in beds 3b–3c, and leads to ammonite packstones in the upper part of bed 3. Internal sediments show, however, that ammonite shells were not overturned.

Higher up, in bed 4, biogenes are often superficially impregnated with iron oxides and/or bored by microorganisms. Reworked elements of this kind, including rare micropebbles of micritic limestones, become more frequent in the upper part. At the same time high energy deposits such as biosparites appear. This development culminates with bed 5a, a microconglomerate with pebbles of typical calpionellid limestone – all from Zone B, which is considerably older than the substratum.

In the strata above this microconglomerate up into bed 7a, relatively calm conditions prevail again and calpionellids become frequent at certain levels. Bored biogenes impregnated by iron oxides are mostly present and, surprisingly, small pebbles of Zone B are dispersed in the biomicritic matrix. These pebbles, too, are often bored and superficially impregnated by iron oxides. Their constant presence over a thickness of 3,5 m above the microconglomerate of bed 5a is difficult to explain: microfacies indicate for the most a calm environment so that a transport by currents can be excluded. But a redistribution of pebbles by bioturbation over such a thickness seems also rather improbable.

From the upper part of bed 7a upwards microfacies are rather variable, some of them indicating agitated waters. There are no diagnostic calpionellids in these beds, only rare reworked *Calpionella alpina* from Zone B, dispersed in the matrix or included in small pebbles.

Under these conditions certain intervals cannot be dated by calpionellids, but this does not lead to major uncertainties concerning the sedimentary history in the section studied nor does it affect the correlation between ammonite and calpionellid zones.

The only problem with the lower part of the section more or less rich in calpionellids up to the top of bed 4a, is that no *Calpionellopsis* have been encountered in the middle of bed 4a (sample 8B), although the overlying and the underlying sample clearly belong to the Calpionellopsis Zone (= Zone D, see Fig. 6). The boundary between the Subzones D1 and D2 can therefore only be determined with a margin of uncertainty of about 1 meter.

In beds 4b to 4d calpionellids are too rare for a precise datation so that the boundary between the Subzone D2 and D3 cannot be positioned precisely within an interval of more than 7 m (between bed 4a and 5b). The Calpionellopsis Zone is, however documented there by rare occurrences of *Calpionellopsis simplex* or *Cs. oblonga.* In any case the Subzone D3 is clearly documented at several levels from the upper part of bed 5b up to the lower part of bed 7a.

Calpionellites darderi was not observed in the Sobotka klippe section so that there is no proof for the existence of the Calpionellites Zone (Zone E).

Above the conglomerate (bed 5a) there is also the problem of reworked material from Zone B, mostly pebbles, but in some cases also in the form of isolated specimens of the spherical variety of *C. alpina.* This does, however, not affect the reliability of calpionellid datations, as zonal and subzonal boundaries are defined by the first occurrence of characteristic forms.

To conclude with, we may say that calpionellid data, although imperfect at several levels, provide nevertheless interesting insights into the depositional history of the section (Fig. 6).

First of all, there are important gaps within the nodular limestones of bed 2. From sample 1 to sample 1/2 we pass directly from a typical *Saccocoma* microfacies to the lower part of the calpionellid Subzone A1 (= Remanei Subzone of the Sümeg standard, Remane et al. 1986). Hence, the Parachitinoidella malmica Zone, introduced by Borza

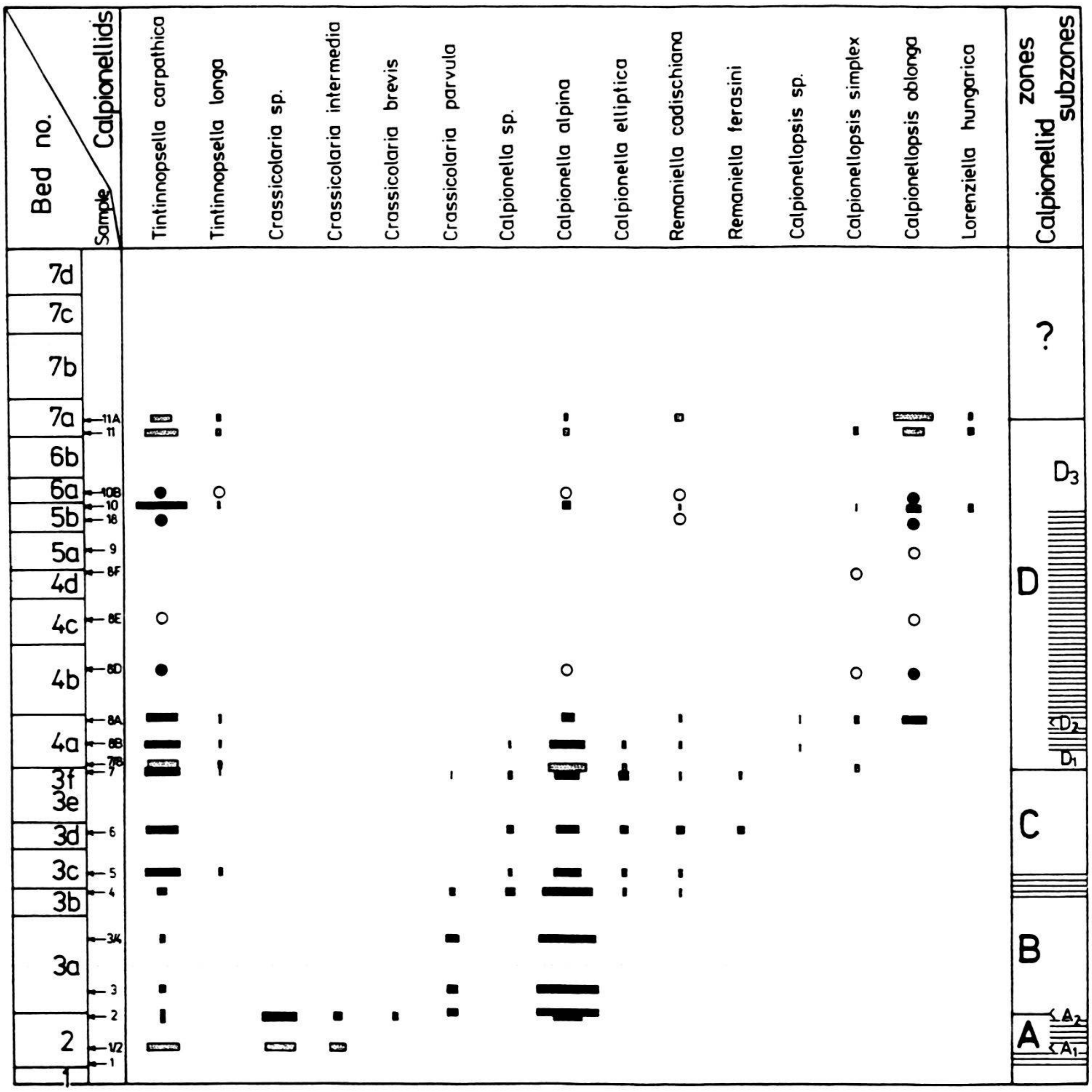

Fig. 6. Stratigraphic distribution of calpionellids in the Sobotka Klippe-section (cf. Fig. 5); frequencies of individual species in the samples are marked as follows: black bars – precise percentages for more than 50 determined specimens in the sample, dotted bars – approximate percentages for 25 to 50 determined specimens in the sample; for samples of less than 25 specimens the more frequent species are indicated with a black circle, and the rare species with an empty circle.

(1969) and also in the Polish Carpathians by Nowak (1976), as well as the Chitinoidella Zone, are absent or at least extremely reduced in this point. Nowak (1978) records, however, the Chitinoidella Zone and his Semichitinoidella-Praetintinnopsella Zone from the upper part of the Czorsztyn Limestone Formation in the Czorsztyn Castle (= Sobotka) klippe section. So local variations seem to be quite important, even if we take into account that Nowak's S-P Zone includes a part of Subzone A1.

In our profile there is another gap near the top of bed 2. In sample 2, Subzone A2 and Zone B coexist in one and the same thin section.

Sedimentation was more regular later, during the deposition of bed 3: Zone B is obviously complete, in bed 3b the uppermost B, corresponding to the lowermost Calpionella elliptica Zone, could be distinguished. Zone C is represented by beds 3c to 3f. Difficult to say whether it is complete or not, but in any case Subzone D1 is very thin, even for a section with a modest sedimentation rate like the Sobotka Klippe. So there may very well be another stratigraphic gap at the C-D transition (cf. also remarks on ammonite biostratigraphy in the present paper).

Higher up, the conglomerate bed 5a does not correspond to a measurable gap. Even though it lies in an interval where a precise datation is impossible, no term of the calpionellid zonation is missing there. Wherever the boundary D2/D3 may be situated with respect to the conglomerate, none of the two subzones would be much reduced in thickness.

Finally it should be mentioned that our observations do not agree with those of Nowak (1978; cf. also Nowak 1971 and remarks given in the introduction to the present paper) in some details concerning the lower part of the section studied. Only the basal part of calpionellid Zone B occurs in the Korowa Limestone Member or in the Czorsztyn Limestone Formation as treated in present paper (cf. Figs. 5–6), and most of this Zone corresponds indeed to the lower Sobotka Limestone Member. The upper Sobotka Member corresponds to Zone C, the top of which coincides with the top of the Sobotka Member. All of these boundaries are placed at a lower level in table 4 of Nowak (1978),with Zone B falling entirely in the nodular limestones and the Sobotka Member corresponding to Zone C and D.

Acknowledgements

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REFERENCES

ALLEMANN, F., CATALANO, R., FARES, F. & REMANE, J. 1971: Standard calpionellid zonation (Upper Tithonian-Valanginian) of the western Mediterranean Province – Proc. II Plankt. Conf. Roma 1970 (2), 1337–1340.

ALLEMANN, F., GRÜN, W. & WIEDMANN, J. 1975: The Berriasian of Caravaca (Prov. of Murcia) in the subbetic zone of Spain and its importance for defining this stage and the Jurassic-Cretaceous boundary. In: Colloque sur la limite Jurassique-Crétacé (Lyon, Neuchâtel – sept. 1973). Mém. Bur. rech. géol. min. 86, 14–22.

ALLEMANN, F. & REMANE, J. 1979: Les faunes de calpionelles du Berriasien supérieur/Valanginien. In: BUSNARDO, R., THIEULOY, J.-P., MOULLADE, M., Hypostratotype mésogéen de l'étage Valanginien. Les stratotypes français 6, 99–109.

ANDROUSSOFF, D. & KOUTEK, J. 1927: Contribution à la connaissance des calcaires à *Calpionella alpina* dans les Carpathes occidentales. Vestn. statn. geol. Ustavu Cesk. Repub. 3, 103–108.

BIRKELUND, T., HANCOCK, J. M., HART, M. B., RAWSON, P. F., REMANE, J., ROBASZYNSKI, F., SCHMID, F. & SURLYK, F. 1984: Cretaceous stage boundaries-proposals. Bull. geol. Soc. Denmark 33, 3–20.

BIRKENMAJER, K. 1963: Stratigraphy and paleogeography of the Czorsztyn series (Pieniny Klippen Belt, Carpathians in Poland): Studia Geol. Polonica 10, 1–380.

– 1977: Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland: Studia Geol. Polonica 45, 1–158.

BIRKENMAJER, K. & GASIOROWSKI, S. M. 1961: Stratigraphy of the Tithonian and Lower Neocomian of the Czorsztyn series (Pieniny Klippen Belt, Carpathians), based on aptychi. Bull. Acad. Pol. Sci., sér. géol. géogr. 9, 2, 121–128.

BORZA, K. 1969: Die Mikrofazies und Mikrofossilien des Oberjuras und der Unterkreide der Klippenzone der Westkarpaten. Vydav. Slov. Akad. Wiss., Bratislava, 301 pp.

– 1974: Die stratigraphische Verwendung von Calpionelliden in den Westkarpaten. Proc. X Congr. CBCA 1973, Sect. I, Stratigraphy and Paleontology, 31–34.

– 1984: The Upper Jurassic-Lower Cretaceous parabiostratigraphic scale on the basis of Tintinninae, Cadosinidae, Stomiosphaeridae, Calcisphaeridae and other microfossils from the West Carpathians. Geologica carpath. 35, 5, 539–550.

BUSNARDO, R. & THIEULOY, J.-P. 1979: Les zones d'ammonites du Valanginien. In: BUSNARDO, R., THIEULOY, J.-P. & MOULLADE, M. Hypostratotype mésogéen de l'étage Valanginien. Les statotypes français 6, 58–68.

CATALANO, R. & LIGUORI, V. 1971: Facies a calpionelle della Sicilia occidentale. Proc. II Plankt. Conf. Roma 1970, 1, 167–210.

CECCA, F. & SANTANTONIO, M. 1986: Le successioni del Giurassico superiore dell'Appennino umbre-marchigiano-sabino: osservazioni sulla geologia e sulla biostratigrafia. Atti I Conv. Fossili Evoluzione Ambiente, Pergola 1984, 111–118.

Colloque sur la limite Jurassique-Crétacé (Lyon, Neuchâtel – septembre 1973). Mém. Bur. rech. géol. min. 86, 1975.

DRAGASTAN, O., MUTIU, R. & VINOGRADOV, C. 1973: Zonele microfaciale si limita Jurasic-Cretacic in Carpatii orientali (Muntii Hagimas), si in Platforma Moesica. Stud. Cercet. Geol. Geofiz. Geogr. 18, 509–533.

DZIK, J. 1990: The concept of chronospecies in ammonites. Atti II Conv. Fossili Evoluzione Ambiente, Pergola 1987, 273–289.

ENAY, R. & GEYSSANT, J. 1975: Faunes d'ammonites du Tithonique des chaines bétiques d'Espagne méridionale. Mém. Bur. rech. géol. min. 86, 39–55.

HOEDEMAEKER, P. J. 1982: Ammonite biostratigraphy of the uppermost Tithonian, Berriasian and Lower Valanginian along the Rio Argos (Caravaca, SE Spain). Scripta geol. 65, 1–81.

– 1984: Proposals to the stratigraphic positions of the Berriasian-Valanginian and the Valanginian-Hauterivian boundaries. Bull. geol. Denmark 33, 139–146.

KHIMSHIASHVILI, N. G. 1989: Beriaselidi Kavkasa [in Russian]. 86 pp., 14 pls. Mestniereba, Tbilisi.

KUTEK, J. & WIERZBOWSKI, A. 1986: A new account on the Upper Jurassic stratigraphy and ammonites of the Czorsztyn succession, Pieniny Klippen Belt, Poland. Acta Geol. Polonica 36, 4, 291–316.

LE HÉGARAT, G. 1971: Le Berriasien du sud-est de la France. Doc. Lab. Géol. Fac. Sci. Lyon 43, 1, 1–308; 43, 2, 309–576.

LE HÉGARAT, G. & REMANE, J. 1968: Tithonique supérieur et Berriasien de la bordure cévenole. Corrélation des Ammonites et des Calpionelles. Géobios 1, 7–70.

NOWAK, W. 1971: Wyniki badan mikrofacjalnych profilu skalki zamku czorsztynskiego [in Polish]. In Przewodn. 43 Zjazdu Pol. Tow. Geol., Krakow 1971, 225–232.

– 1976: *Parastomiosphaera malmica* (BORZA) from the Polish Carpathians and their stratigraphical value for Lower Tithonian deposits. Rocz. Pol. Tow. Geol. 46, 80–134.

– 1978: *Semichitinoidella* n. gen. (Tintinnina) of the Upper Jurassic of the Czorsztyn succession, Pieniny Klippen Belt, Carpathians, Poland. Rocz. Pol. Tow. Geol. 48, 3–25.

PATRULIUS, D. & AVRAM, E. 1976: Les céphalopodes des couches de Carhaga (Tithonique supérieur-Barrémien inférieur). Mém. Inst. Géol. Géoph. 24, 153–194.

POP, G. 1980: Zones, sous-zones et ensembles caractéristiques de Calpionellidae tithonique-néocomiennes. Ann. Inst. Géol. Géophys. 56, 195–203.

REMANE, J. 1964: Untersuchungen zur Systematik und Stratigraphie der Calpionellen in den Jura-Kreide-Grenzschichten des Vocontischen Troges. Palaeontographica (A) 123, 1–57.

– 1985: Calpionellids. In: BOLLI, H. M., SAUNDERS, J. B. & PERCH-NIELSEN, K., Plankton stratigraphy. Cambridge Univ. Press, 555–572.

REMANE, J., BAKALOVA-IVANOVA, D., BORZA, K., KNAUER, J., NAGY, I., POP, G. & TARDI-FILACZ, E. 1986: Agreement on the subdivision of the Standard Calpionellid Zones defined at the II Planktonic Conference, Roma 1970. Acta geol. hung. 29, 5–14.

RETOWSKI, O. 1893: Die tithonischen Ablagerungen von Theodosia. Bull. Soc. Impér. Natur. Moscou 7, 2–3, 1–95.

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Plate 1

All figures natural size

Fig. 1–4. *Berriasella (Berriasella) jacobi* MAZENOT, Euxinus Zone.

Fig. 1–2. Rogoza klippes, bed 4 (cf. Fig. 2), IGPUW/A 25/2, and IGPUW/A 25/3.

Fig. 3. Cisowa klippe, bed 3, uppermost horizon with ammonites (cf. Fig. 4), IGPUW/A 25/31

Fig. 4. Rogoza klippes, bed 5, IGPUW/A 25/1.

Fig. 5. *Berriasella (Delphinella)* cf. *obtusenodosa* (RETOWSKI), body chamber, Euxinus Zone, Rogoza klippes, bed 4, IGPUW/A 25/7.

Fig. 6. *Berriasella (Berriasella)* cf. *moreti* MAZENOT, phragmocone, Euxinus Zone, Rogoza klippes, bed 5, IGPUW/A 25/4.

Fig. 7–9. *Berriasella (Delphinella) crimense* (BURCKHARDT), Euxinus Zone.

Fig. 7. Cisowa klippe, bed 3, lowermost horizon with ammonites, IGPUW/A 25/17.

Fig. 8a, b. Cisowa klippe, bed 3, second horizon with ammonites above the base, both sides of the specimen, IGPUW/A 25/18.

Fig. 8c. ditto, possibly inner whorls of the specimen presented in Figure 8a, b, IGPUW/A 25/19.

Fig. 9. Cisowa klippe, bed 3, uppermost horizon with ammonites, IGPUW/A 25/26.

Fig. 10a, b. *Berriasella* (?*Malbosiceras*) cf. *chaperi* (PICTET), lateral and ventral views, Euxinus Zone, Rogoza klippes, bed 4, IGPUW/A 25/5.

Fig. 11. *Himalayites cortazari* (KILIAN), body chamber, Euxinus Zone, Rogoza klippes, bed 4, IGPUW/A 25/9.

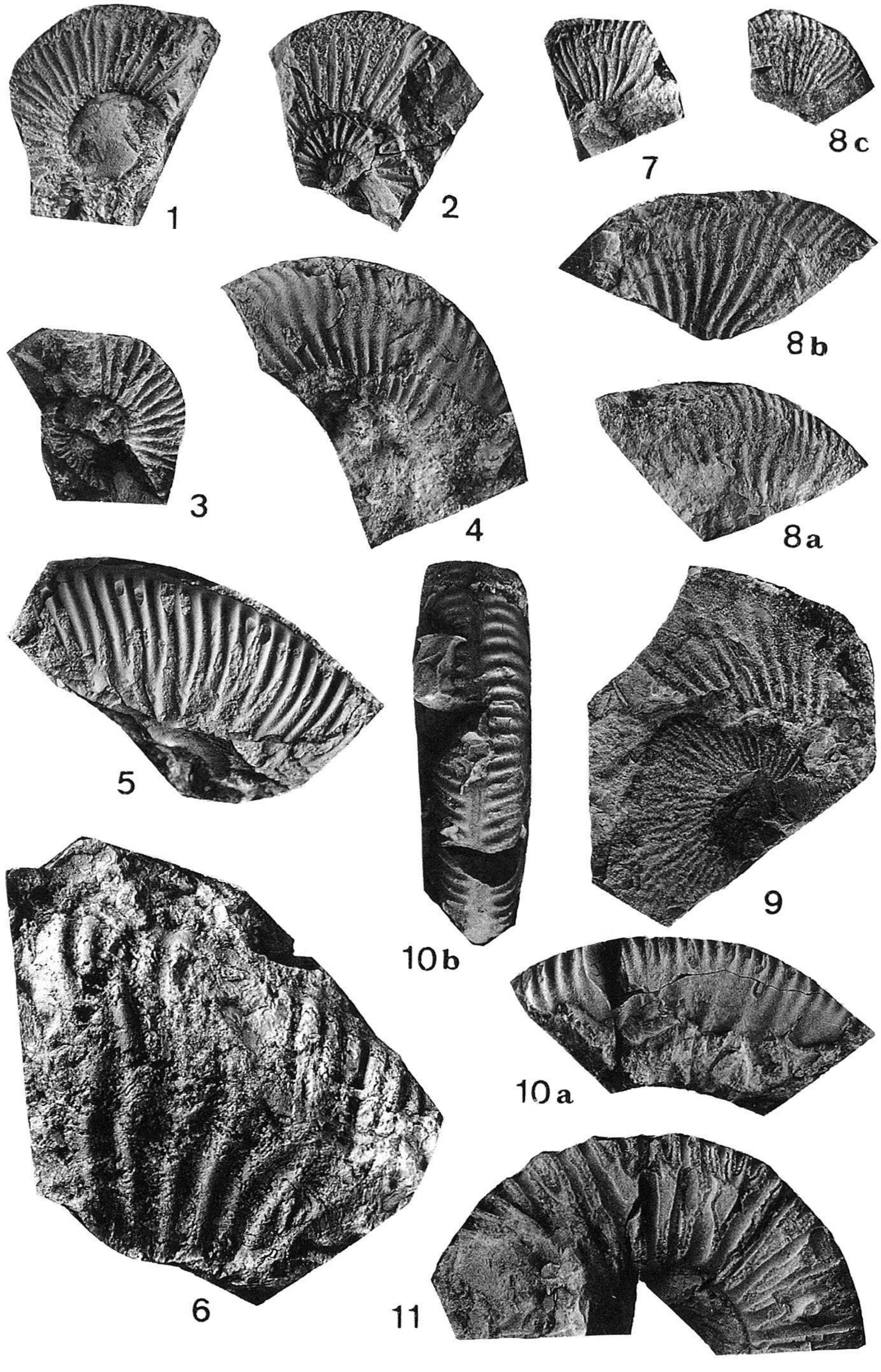
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Plate 2

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Fig. 1–2. *Pseudosubplanites* cf. *lorioli* (ZITTEL).

Fig. 1a, b. lateral and ventral views, Euxinus Zone, Cisowa klippe, bed 3, lowermost horizon with ammonites, IBPUW/A 25/28.

Fig. 2. body chamber, peristome with lappets, Euxinus Zone, Rogoza klippes, bed 4, IGPUW/A 25/6.

Fig. 3–4. *Berriasella (Delphinella)* cf. *delphinensis* (KILIAN), body chambers, Euxinus Zone, bed 4, IGPUW/A 25/14, and IGPUW/A 25/13.

Fig. 5. *Berriasella (Delphinella) subchaperi* (RETOWSKI), phragmocone, Euxinus Zone, Rogoza klippes, bed 5, IGPUW/A 25/10.

Fig. 6. *Pseudosubplanites* cf. *euxinus* (RETOWSKI), Euxinus Zone, Cisowa klippe, bed 3, uppermost horizon with ammonites, IGPUW/A 25/27.

Fig. 7a, b. *Schaireria* sp., anterior view, and lateral view of inner whorls, Euxinus Zone, Cisowa klippe, uppermost horizon with ammonites, IGPUW/A 25/20.

Fig. 8. *Fauriella incomposita* (RETOWSKI), Occitanica Zone, Sobotka klippe, bed 3c (cf. fig. 5), IGPUW/A 25/44.

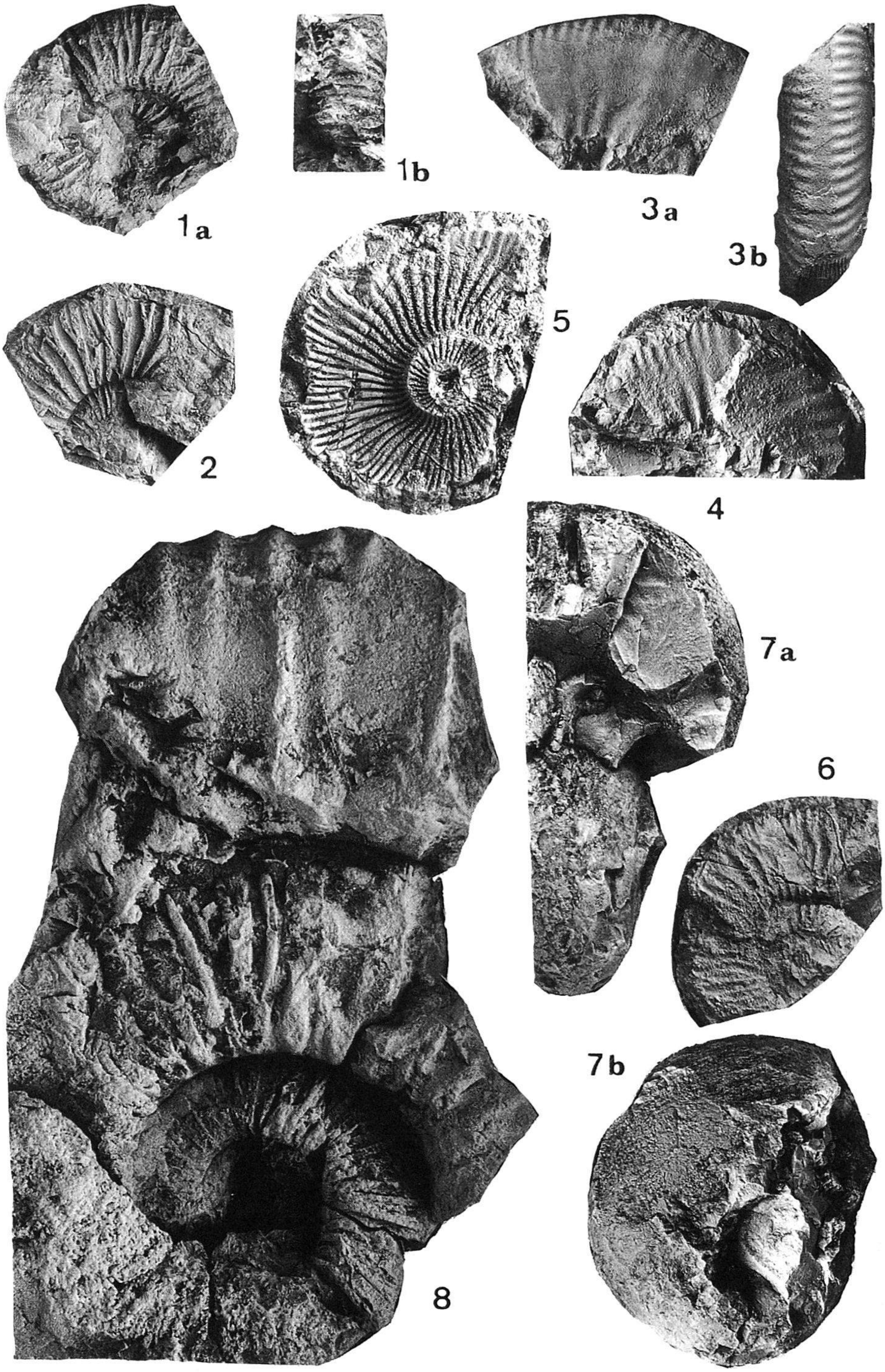
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Plate 3

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Fig. 1–3. *Thurmanniceras (Kilianella)* sp. nov., Boissieri Zone, Sobotka klippe, bed 4a, IGPUW/A 25/35, 36 und 37.

Fig. 4. *Thurmanniceras (Kilianella) chamalocense* (MAZENOT), Otopeta Zone, Sobotka klippe, bed 6b, IGPUW/A 25/41.

Fig. 5. *Thurmanniceras (Thurmanniceras) salientinum* SAYN, Otopeta Zone, Sobotka klippe, bed 6b, IGPUW/A 25/42.

Fig. 6a, b. *Sarasinella* sp., lateral and ventral views, Otopeta Zone, Sobotka klippe, bed 6b, IGPUW/A 25/43.

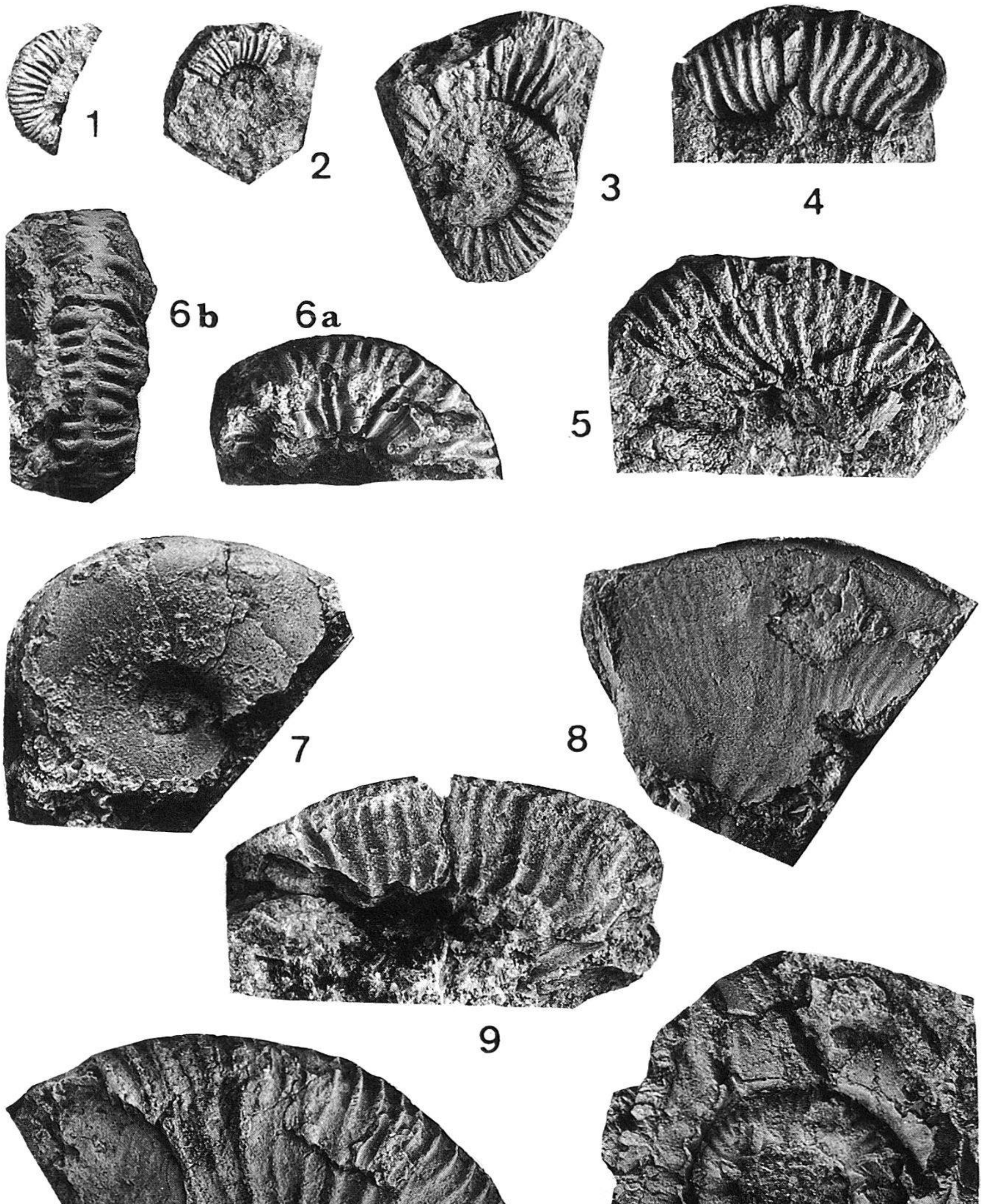
Fig. 7. *Neolissoceras grasianum* (D'ORBIGNY), Boissieri Zone, Sobotka klippe, bed 4a, IGPUW/A 25/55.

Fig. 8. *Substreblites zonarius* (OPPEL), Boissieri Zone, Sobotka klippe, bed 4a, IGPUW/A 25/68.

Fig. 9. *Berriasella (Berriasella)* cf. *callisto* (D'ORBIGNY), Boissieri Zone, Sobotka klippe, bed 4a, IGPUW/A 25/50.

Fig. 10. *Berriasella (Berriasella)* cf. *jauberti* (MAZENOT), Otopeta Zone, Sobotka klippe, bed 6b, IGPUW/A 25/45.

Fig. 11. *Spiticeras (Spiticeras)* aff. *groteanum* (OPPEL), Occitanica Zone, Sobotka klippe, bed 3f, IGPUW/A 25/51.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