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# Lower to Middle Tithonian ammonite succession at Rogoźnik in the Pieniny Klippen Belt

ABSTRACT: Bed-by-bed collected ammonites have permitted a recognition of the *hybonotum, darwini, semiforme,* and *fallauxi* Zones, Lower to Middle Tithonian, at the classic locality of Rogoźnik, in the Pieniny Klippen Belt of Poland, and a precise stratigraphic location of several ammonite species monographed by Zittel (1870).

## INTRODUCTION

The Rogoża klippes making part of the Pieniny Klippen Belt occur in the neighborhood of Rogoźnik village, some 7 km west of Nowy Targ (Text-figs 1—2). At these klippes there are exposed coquinas that have yielded lots of ammonites monographed by Zittel (1870) and widely discussed by subsequent authors (Neumayr 1871; Zaręczny 1876; Uhlig 1890; Arkell 1956; Birkenmajer 1962, 1963; Enay 1964; and others). Unfortunately, no ammonites derived from bed-by-bed collecting, while they were largely supplied by amateurs.

The coquinas of Rogoźnik are famous because of their rich Middle Tithonian ammonite asemblage and indeed the concept of the *semiforme* Zone was for long based upon this fauna. However, several ammonites suggestive of the Lower Tithonian and a few Berriasian ones were also reported from Rogoźnik, which made difficult a stratigraphic interpretation of the coquinas. The co-occurrence of ammonites of different geological age in a rather thin lithological set was sometimes regarded as an evidence for stratigraphic condensation. Furthermore, there are two distinct coquinas at the Rogoża klippes, namely the "White Rogoźnik Lumachelle" and "Red Rogoźnik Lumachelle" (Birkenmajer 1962, 1963).

The majority of the ammonites monographed by Zittel (1870) from the Rogoża klippes seem to have been collected from the White Lumachelle but some are representative of the Red Lumachelle (*see* discussion *in* Birkenmajer 1962, 1963).

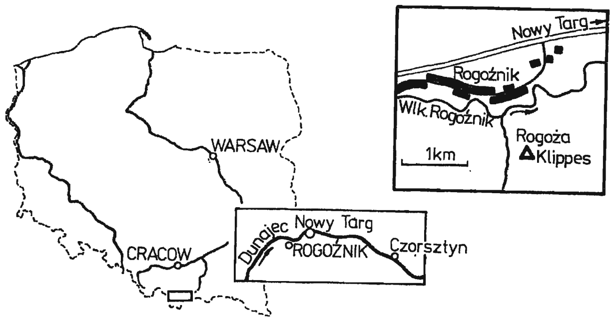


Fig. 1. Location map to show the investigated exposures at Rogoźnik in the Pieniny Klippen Belt

The two coquinas have been established by Birkenmajer (1977) as formal lithostratigraphic units, namely the White Rogoźnik Lumachelle as the *Rogoźnik Coquina Member*, and the Red Rogoźnik Lumachelle as the *Rogoża Coquina Member*, both of them making part of the Dursztyn Limestone Formation of the Czorsztyn succession of the Pieniny Klippen Belt. The Rogoża klippes are type locality for both the members. An early to Middle Tithonian age has been suggested by Birkenmajer (1977) for the Rogoża Coquina Member, and a Middle Tithonian to Berriasian age for the overlying Rogoźnik Coquina Member.

Exposures of the Rogoża and Rogoźnik Coquina Members occur in various parts of the Rogoża klippes. The best section of the Rogoźnik Coquina Member is in a small klippe above two abandoned quarries. Some 30 m thick coquinas are exposed in that klippe, with the stratigraphic section being but slightly disturbed by tectonic and pseudotectonic processes. Following a promotion by Professor K. Birkenmajer, the klippe is now protected as a monument of inanimate nature.

Ammonites were collected bed by bed by the present authors in the section of that klippe in 1976 to 1977. The Lower to Middle Tithonian ammonite succession is described in the present paper. The section extends however up into the Berriasian, and a larger publication will follow including descriptions and illustrations of the ammonites derived from the whole section, accompanied by a description of the calpionellid succession by Professor K. Birkenmajer.

*Acknowledgements.* Joint biostratigraphic research in the Rogoża klippes has been organized by Professor K. Birkenmajer, Institute of Geological Sciences, Polish Academy of Sciences, to whom the present authors are indebted for introduction into geology of the area. Thanks are also due to Docent J. Lefeld, the same Insti-

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## GEOLOGICAL SECTION

Location of the investigated klippe and its cross-sections are given by Birkenmajer (1962, Figs 1, 2, 5, and 10; 1963, Pls III—V and Figs 3, 5).

Twenty three beds numbered consecutively downwards have been recognized in the section for stratigraphic purposes (Text-fig. 3). They lie subvertically, with the youngest one (number *1*) at the northwestern side of the klippe. The sequence is disrupted by a 1—2 m wide gap covered with coquina rubble, and the klippe is divided into its northwestern (beds *1*—*7a*) and southeastern (beds *7b*—*23*) parts. There are also two minor gaps in the section (between the beds *20* and *21*, and *22* and *23*; Fig. 2).

The bulk of the section of the southeastern part of the klippe (beds *23*—*15* and *12*—*7b*, with a total thickness of some 20 m) consists of bedded, somewhat spotty, white or pinkish to red coquinas composed mostly of ammonite shells but enriched locally in crinoid fragments. Ammonite aptychi, brachiopods, and bivalves occur quite commonly, whereas other fossils (gastropods, echinoids, sponges, solitary corals, and fish teeth) are less frequent to rare. The coquinas comprise mostly densely packed debris and shell fragments but complete fossils do also occur, as *e.g.* brachiopods or ammonites preserved occasionally with an aperture. The ammonite shells are often size-sorted; one can here and there observe bands litterally crowded with shells of a single size-class. Sparry cement prevails in the coquinas, while sparse micritic matrix occurs only locally. The amomnite shells are empty or filled up with a sparry calcite and/or micritic matrix.

The beds *13* and *14* comprise micritic limestones with abundant calpionellids and scattered macrofossil debris, comparable to lithologies found in the northwestern part of the klippe. The two beds form jointly a stratiform body tending to wedge out, both its boundaries with the sparry coquinas being highly irregular but sharp and cutting across fossils (*e.g.* crinoid segments). These characteristics suggest that the beds represent an internal sediment, which is indeed confirmed by biostratigraphic data. The calpionellid assemblage of the bed *14* includes *Crassicolaria* and *Calpionella alpina* indicative of the Upper Tithonian *Crassicolaria* Zone (a still younger calpionellid assemblage has been recorded in the bed *13*), whereas the overlying and underlying coquinas (beds *12* and *15*) contain ammonites indicative of the Middle Tithonian *semiforme* Zone.

The lower part of the bed *7b* is a densely packed coquina with sparry cement and micritic matrix, while the upper part consists of a micritic limestone with scattered macrofossils and resembles closely in lithology the northwestern part of the klippe. No identifiable ammonites have been found in the latter part of the bed but a Late Tithonian age is suggested by the calpionellids. One may then suspect that this is also an internal sediment.

Poorly-bedded, whitish to creamy or pinkish coquinas approximating 9 m in thickness are exposed in the northwestern part of the klippe. Ammonite, crinoid,

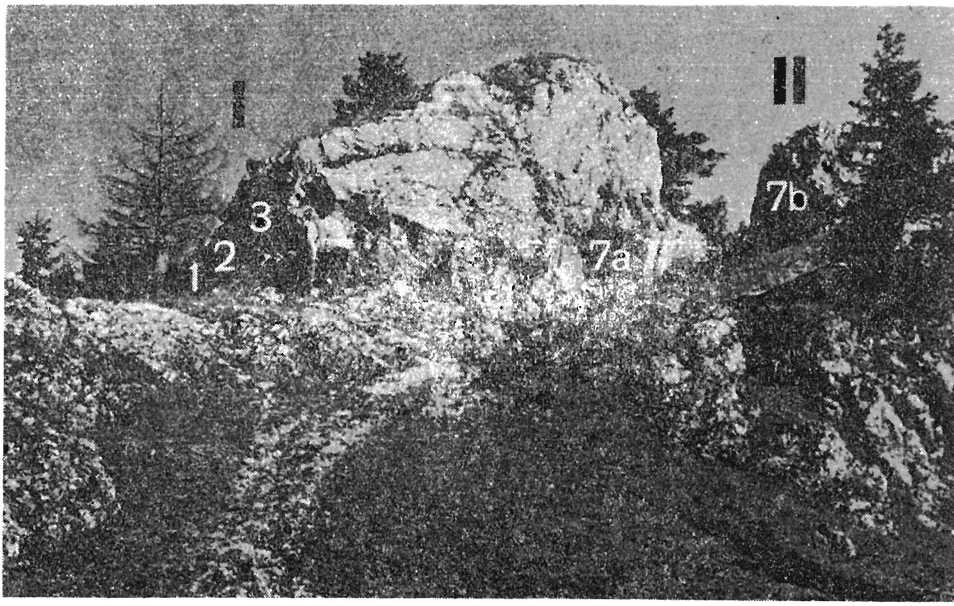



Fig. 2. General view of the investigated klippe at Rogoźnik, to show location of the sections (*I* and *II*) and some of the beds presented in Text-fig. 3

and brachiopod debris and fragments are scattered in a micritic matrix rich in calpionellids. Here and there, bands densely packed with fossils occur.

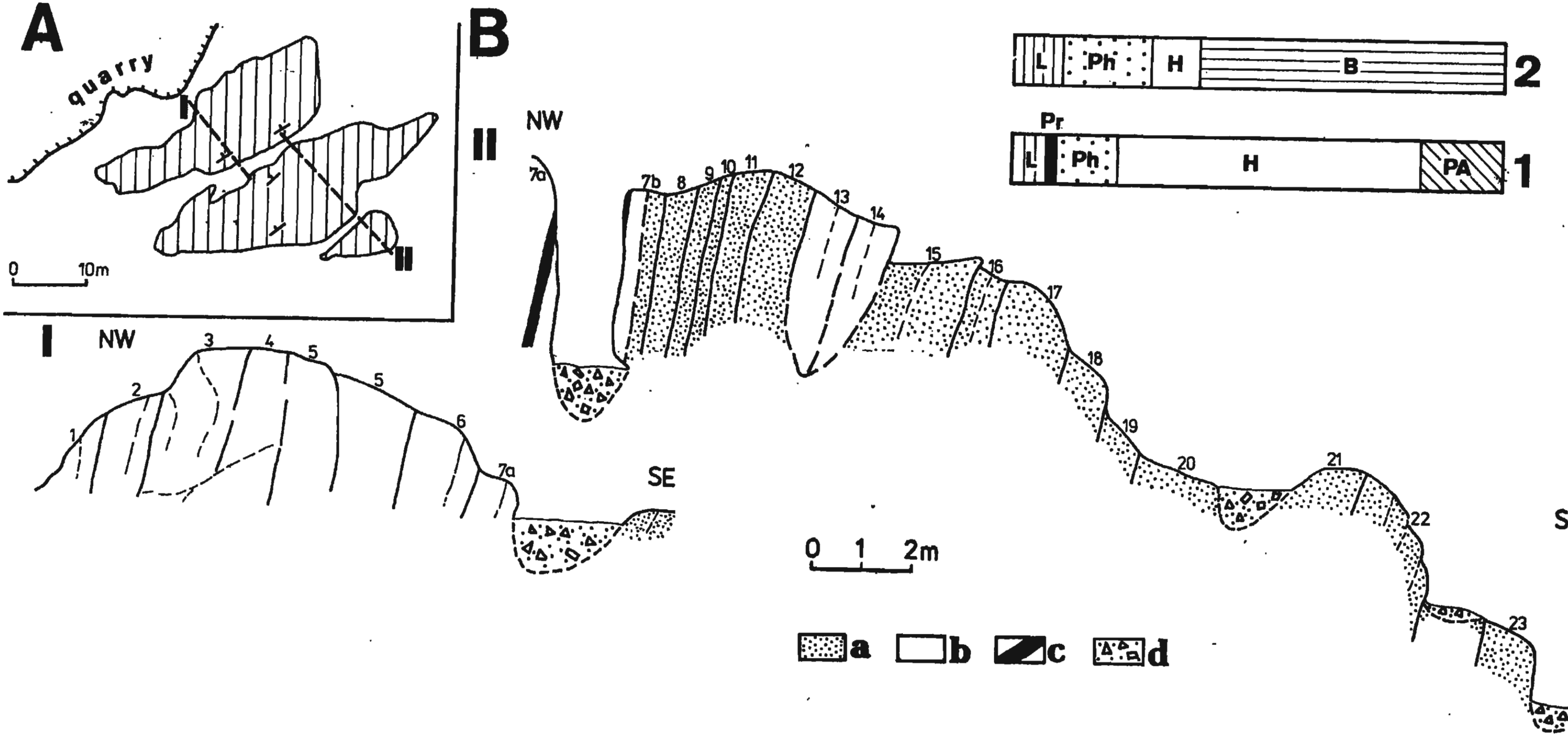
The investigated coquina beds are cut across by some veins of crinoidal-detrital limestone (Birkenmajer 1962, Figs 1, 5, 10; Birkenmajer 1963, Pls III, V and Figs 3, 5) interpreted as neptunian dykes of Valanginian (or Late Berriasian ?) age (Birkenmajer 1975, 1977).

## AMMONITES

The ammonite specimens collected from the Rogoźnik Coquina Member range usually in size from minute debris to some 3—4 cm. They are not flattened and hence, several small-sized ammonites (especially the haplocerataceans) can be identified to the specific level; the collection contains some specimens with an aperture preserved. In contrast, larger-sized ammonites (especially the perisphinctids and berriasellids) are represented merely by nuclei or whorl fragments, which precludes in most cases their identification even at the subgeneric or generic rank.

There is a sharp difference in relative proportions of particular ammonite groups between the collections taken from the upper and lower parts of the section (*cf.* 1 and 2 in Text-fig. 3). In the northwestern part of the klippe (beds *1*—*5*), the relative proportions are as

Profiles of the investigated klippe at Rogoźnik and ammonite spectra for the Lower-Middle Tithonian (*1*) and Berriasian strata (*2*)




**A** — Sketch map of the klippe (*after* Birkenmajer 1963) with lines of the profiles indicated (*I* and *II*)
**B** — Profiles: *a* sparry coquinas (Lower-Middle Tithonian), *b* — micritic coquinas (Upper Tithonian-Berriasian), *c* crinoidal-detrital limestones filling the neptunian dykes (? Late Berriasian-Valanginian), *d* rubble
**1** — Ammonite spectrum for the lower part of the section (beds *7b—12* and *15—23*, Lower — Middle Tithonian), **2**— Ammonite spectrum for the upper part of the section (beds *1—5*, Berriasian): **L** — Lytoceratacеae, **Pr** — Protancyloceratinae, **Ph** — Phylloceratacеae, **H** — Haploceratacеae, **B** — Berriasellidae, **PA** — Perisphinctidae and Aspidoceratidae

follows (sample size — 102): Phylloceratace — 18%, Lytoceratace — 10%, Haploceratace — 10%, and Berriasellidae — 62%. In the southeastern part of the klippe (beds *7b*—*12* and *15*—*23*), the relative proportions are as follows (sample size — 969): Phylloceratace — 13%, Lytoceratace — 7.3%, Protancyloceratinae — 1.2%, Haplocerataceae — 61.5%, Perisphinctidae and Aspidoceratidae — 17%.

For the moment, a reliable biostratigraphic interpretation can be proposed only for the lower part of the section (beds *7b*—*12* and *15*—*23*). The ammonite species described by Zittel (1870) occur actually in that part of the section. Further collecting is needed to recognize the ammonite succession in the upper part of the section. One may only note that the beriasellid fragments found in the northwestern part of the klippe suggest that the bulk of that sequence (beds *1*—*5*) is of Berriasian age, which is indeed consistent with the evidence from the calpionellids. These data show clearly that the Rogoźnik Coquina Member extends up into the Berriasian, as it was previously suggested by Birkenmajer (1977).

## ZONAL SCHEME

The Tithonian zonal scheme most adequate to the Rogoźnik section is that one proposed by Enay & Geyssant (1975) after the sequence of the Betic chains, Spain. It differs from the scheme established by Olóriz-Sáez (1978) in the same region mainly in that different index species have been chosen for some equivalent zones (Table 1). The former sche-

Table 1

Zonal scheme of the Tithonian stage

| Stages | Substages* | Zones | |
|---|---|---|---|
| | | Enay & Geyssant 1975 | Olóriz-Sáez 1978 |
| Berriasian | | jacobi | |
| Tithonian | Upper | Durangites | |
| | | microcanthum | |
| | Middle | ponti | Burckhardticeras |
| | | fallauxi | admirandum-biruncinatum |
| | | | richteri |
| | | semiforme | verruciferum |
| | Lower | darwini | albertinum |
| | | hybonotum | hybonotum |

*as defined in the present paper

me is adopted in the present paper because it allows to retain the *semiforme* Zone well-rooted in biostratigraphic tradition, and because *Semiformiceras fallauxi* (Opp.) has proven to be a good diagnostic fossil in the investigated section.

The *Berriasella jacobi* Zone is here considered to make up the lowest part of the Berriasian. For the sake of convenience only, the *Djurdjuriceras ponti, Semiformiceras fallauxi,* and *Semiformiceras semiforme* Zones are regarded as Middle Tithonian, which reduces the Lower Tithonian to the *Neochetoceras darwini* and *Hybonoticeras hybonotum* Zones. This is however not to imply any general suggestion as to a twofold *versus* threefold subdivision of the Tithonian.

The more detailed biostratigraphic pattern established by Zeiss (1968, 1975) in the Lower Tithonian of Franconia and based mostly upon successive perisphinctid assemblages appears thus far inapplicable to the investigated section.

## BIOSTRATIGRAPHIC INTERPRETATION

Actual stratigraphic ranges of the selected ammonites of the lower part of the Rogoźnik section (*cf.* Table 2) are given by Enay & Geyssant (1975) and Olóriz-Sáez (1978); some information comes also from other publications (*e.g.* Hölder & Ziegler 1959; Zeiss 1968, 1975; Barthel 1975; Sapunov 1977).

The bed *23* is tentatively ascribed to the *hybonotum* Zone, basing upon the occurrence of *Hybonoticeras mundulum* (Opp.) found commonly in the *hybonotum* Zone but reported also from the *Hybonoticeras beckeri* Zone, the uppermost zone of the Kimmeridgian. The bed may thus at least partly belong to the Kimmeridgian. The base of the Rogoźnik Coquina Member is not exposed in the investigated section and hence, the Member may well be expected to extend down into the uppermost Kimmeridgian.

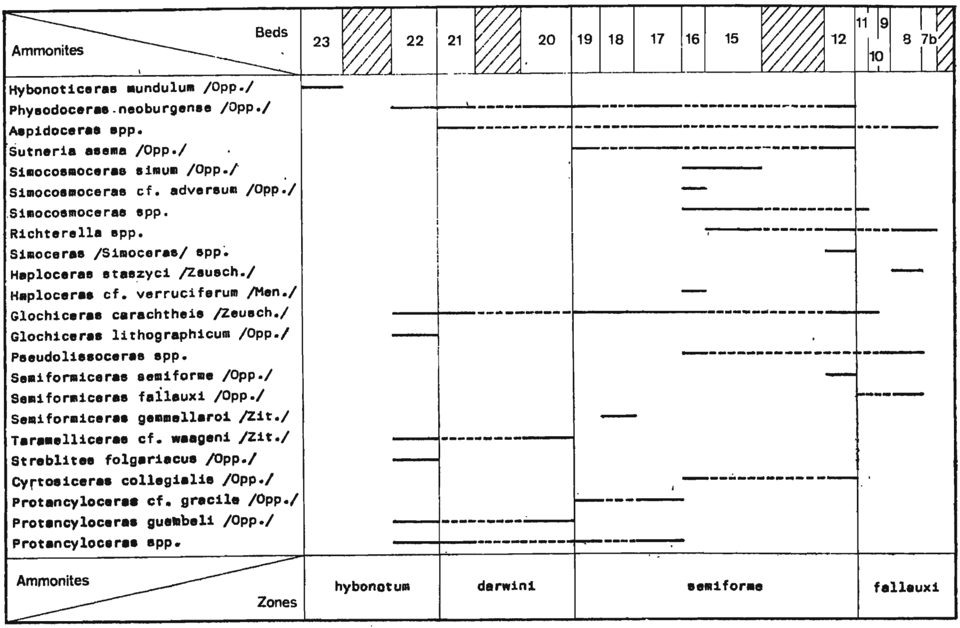
The species *Glochiceras lithographicum* (Opp.) recorded in the bed *22* is indicative of the *hybonotum* Zone. Its acme corresponds in Franconia to the upper part of that zone (Zeiss 1968).

The beds *21* and *20* are to be attributed to the *darwini* Zone because of the lack of any ammonites indicative of either the *hybonotum* or *semiforme* Zones, as well as because of the occurrence of *Taramelliceras (Parastreblites)* cf. *waageni* (Zitt.) in the bed *20*. In fact, the genus *Taramelliceras* does not extend up beyond the base of the *semiforme* Zone, while *T. waageni* (Zitt.) was indeed recorded in the *darwini* Zone in Spain (Enay & Geyssant 1975).

The beds *19—15* and *12* are ascribed to the *semiforme* Zone. The species *Sutneria asema* (Opp.) found in the bed *19* appears in Franconia

Table 2

Stratigraphic distribution of selected ammonites from the lower part of the section at Rogoźnik (numbers of beds the same as in Text-fig. 3; horizontal scale corresponds to the thickness of particular beds)




at the very base of the Middle Tithonian (Barthel 1975). The genus *Semiformiceras* appears for the first time in the investigated section in the bed *18*, represented by *S. gemmellaroi* (Zitt.); whereas the bed *12* yielded *S. semiforme* (Opp.) itself. The species *Haploceras verruciferum* (Men.) recorded in the bed *16* is also indicative of the *semiforme* Zone.

The beds *11—8* can be ascribed to the *fallauxi* Zone, basing upon the occurrence of *Semiformiceras fallauxi* (Opp.) in the beds *11* and *8*. The lower part of the bed *7b* is assigned to the *fallauxi* Zone because it yielded *Richterella*.

Perisphinctids showing a characteristic arching of ribs at the venter and hence, attributed to the genus *Richterella* were collected from the beds *15, 12,* and *8,* as well as from the lower part of the bed *7b*. There is little doubt that the species *R. richteri* (Opp.) reported already from Rogoźnik by Zittel (1870) does indeed occur in the bed *8*. Representatives of the genus *Richterella* make up a subordinate component of the perisphinctid assemblage of the beds *15* and *12*; in turn, they become dominant in the bed *8*. The genus occurs in both the *semiforme* and *fallauxi* Zones in Spain (Enay & Geyssant 1975) but its acme fall within the lower part of the *fallauxi* Zone equivalent to the *Richterella richteri* Zone of Olóriz-Sáez (1978; *cf.* Table 1). Sapunov (1977) reported *Richte-*

*rella* from the lower Middle Tithonian of Bulgaria and Rumania. The genus has insofar not been recorded above the *richteri* Zone (Olóriz--Sáez 1978). At Rogoźnik, it extends up to the lower part of the *bed 7b* which may indicate that that part of the Rogoźnik section represents but the lower part of the *fallauxi* Zone.

The occurrence of *Pseudolissoceras* in the Middle Tithonian in the investigated section is notable. The species *Glochiceras carachteis* (Zeuschn.) is by far the most abundant in that part of the section but it ranges actually down to the *hybonotum* Zone. It has insofar not been found below the *semiforme* Zone in Spain but it was reported from the Lower Tithonian of Franconia (Barthel 1975) and the *hybonotum* Zone of southern France (Hölder & Ziegler 1959) and Bulgaria (Sapunov 1977).

## FINAL REMARKS

The coquinas of Rogoźnik should not be regarded as a condensed sediment. They do not display any sedimentological features indicative of stratigraphic condensation (nodular limestones, phosphatic nodules, glauconite) and their ammonite succession representing four distinct Lower to Middle Tithonian biostratigraphic zones is entirely compatible with those reported from other European countries.

Several ammonite species monographed previously by Zittel (1870) are now located precisely in a detailed stratigraphic framework. Some taxa appear restricted to the Middle Tithonian (*e.g.* the genus *Semiformiceras* and the peculiar genus *Simocosmoceras*), while others occur exclusively in the Lower Tithonian (e.g. *Hybonoticeras, Taramelliceras*, and *Glochiceras lithographicum*). There are also some Middle Tithonian species extending down into the Lower Tithonian (*cf.* Table 2). Interestingly, the genus *Protancyloceras* occurs both in the Lower and Middle Tithonian.

The genus *Semiformiceras* appears at Rogoźnik first with *S. gemmellaroi* (Zitt.) represented in the present authors collection by 12 specimens derived from the bed *18* and entirely consistent with those illustrated by Zittel (1870, Pl. 4, Figs 10—11). All the investigated specimens from Rogoźnik are much more involute than those from the *admirandum-birucinatum* Zone of Spain referred by Olóriz-Sáez (1978) to as *S. gemmellaroi.* One may thus suppose that this species has insofar not been recorded anywhere outside Rogoźnik.

The above presented biostratigraphy of the Rogoźnik section may be subject to a reinterpretation in the future. This particularly concerns the base of the *semiforme* Zone taken actually at the base of the bed *18* on the assumption that *(i)* the species *Sutneria asema* (Opp.) does not range down into the Lower Tithonian, and *(ii)* the base of the Middle

Tithonian in Franconia (*i.e.* the base of the Neuburg Formation) is strictly equivalent to the base of the *semiforme* Zone. Either of these assumptions may not hold true. The problem is further obscured by the fact that the genus *Semiformiceras* does not appear first with *S. semiforme* (Opp.) at Rogoźnik.

More direct evidence is also desirable for the *darwini* Zone. Unfortunately, the scarcity of diagnostic fossils found in that part of the section is partly due to the poor preservation state of perisphinctids, insufficient usually to permit their precise identification.

The Lower to Middle Tithonian ammonite assemblages of the Rogoźnik Coquina Member are clearly of Mediterranean type. In fact, they resemble closely in composition the coeval assemblages from the Betic chains (*cf.* Enay & Geyssant 1975, Olóriz-Sáez 1978) while they differ from the Submediterranean ones dominated by the perisphinctids, as typified by the Franconian faunas (*cf.* Zeiss 1968, 1975; Barthel 1975).

The biostratigraphic interpretation of the Rogoźnik Coquina Member as ranging down to at least the lowermost Tithonian (Table 2) has also some bearing on the stratigraphy of the Czorsztyn succession of the Pieniny Klippen Belt. There is indeed some evidence for the Early to Middle Tithonian age of at least a part of the Rogoża Coquina Member (Birkenmajer 1962, 1963, 1977), which implies that the Rogoża and Rogoźnik Coquina Members are partly time equivalent to each other.

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## NASTĘPSTWO STRATYGRAFICZNE AMONITÓW DOLNEGO I ŚRODKOWEGO TYTONU W ROGOŹNIKU

(Streszczenie)

Muszlowce, występujące w obrębie pienińskiego pasa skałkowego w Rogoźniku (fig. 1—2), zawierają nadzwyczaj liczne amonity, które były przedmiotem klasycznej monografii K. A. Zittela (1870), a także rozważań stratygraficznych wielu innych autorów (np. Neumayr 1871; Zaręczny 1876; Uhlig 1890; Arkell 1956; Birkenmajer 1962, 1963; Enay 1964). Zespołowi środkowotytońskich amonitów z Rogoźnika przypadało doniosłe znaczenie w ogólnych rozważaniach dotyczących podziału piętra tytońskiego na podpiętra. Właściwa interpretacja stratygraficzna amonitów z muszlowców rogoźnickich utrudniona jednak była przez to, że ich następstwo nie zostało prześledzone w szczegółowych profilach stratygraficznych. Trudności interpretacyjne potęgowane były zarówno przez to, że w rozważanych muszlowcach znajdywane były również amonity wczesnotytońskie, jak i przez fakt, iż w skałkach Rogoźnika występują dwa różne muszlowce, „czerwone" i „białę" (Birkenmajer 1962, 1963).

W latach 1976—1977 autorzy zebrali amonity z kolejnych warstw odsłoniętych w skałce, stanowiącej obecnie rezerwat przyrody nieożywionej (Birkenmajer 1962); dostarcza ona najlepszego w obrębie skałek Rogoźnika profilu stratygraficznego ogniwa muszlowca z Rogoźnika. W północno-zachodniej części skałki (warstwy *1—7a;* patrz fig. 3) występują muszlowce mikrytowe. Zarówno niezbyt dobrze tu zachowane amonity (Beriasellidae), jak i kalpionelle dowodzą, że część tych muszlowców (warstwy *1—5)* należą już do beriasu. W południowo-wschodniej części skałki (warstwy *7b—12, 15—23*) występują sparytowe muszlowce dolnego i środkowego tytonu. Wyklinowujące się warstwy *13—14,* a prawdopodobnie i górna część warstwy *7b,* stanowią osad wewnętrzny, któremu na podstawie kalpionelli przypisać można późnotytoński, a częściowo i młodszy wiek.

Zasadniczym przedmiotem niniejszej publikacji są tylko amonity wczesno- i środkowotytońskiego wieku. Następstwo amonitów w tym profilu pozwala na wyróżnienie dolnotytońskich poziomów *Hybonoticeras hybonotum* i *Neochetoceras darwini,* a także środkowotytońskich poziomów *Semiformiceras semiforme* i *Semiformiceras fallauxi* (*patrz* tab. 1—2). Przeprowadzone badania pozwoliły także na zlokalizowanie w szczegółowym profilu stratygraficznym szeregu gatunków opisanych przez K. A. Zittela (1870).

Wczesno- i środkowotytońskie zespoły amonitowe muszlowców z Rogoźnika, charakteryzujące się licznym występowaniem przedstawicieli Phylloceratacеae, Lytoceratacеae i Haploceratacеae, są reprezentatywne dla prowincji medyterańskiej tytonu.