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A new account on the Upper Jurassic stratigraphy and ammonites of the Czorsztyn succession, Pieniny Klippen Belt, Poland

ABSTRACT: The Czorsztyn succession in the Pieniny Klippen Belt of Poland comprises, at the Rogoża klippes near Rogoźnik, the Rogoźnik Coquina Member (Lower Tithonian — Berriasian) and the Rogoża Coquina Member (Lower and Middle Tithonian) overlain by white micritic coquinas (? Upper Tithonian — Berriasian); and, at the Stankowa-Skała klippe, the Czorsztyn Limestone Formation (Oxfordian — Kimmeridgian) and the Rogoźnik Member (Tithonian — Berriasian). It is suggested that the Rogoża Coquina ranges down to the Kimmeridgian (and Oxfordian ?), its lower part thus being coeval with the Czorsztyn Limestone of other sections. A new formal lithostratigraphic unit is suggested which should comprise the white micritic coquinas that form the upper part of the present Rogoźnik Member and overlie the Rogoża Member. The succession of Early and Middle Tithonian ammonites in both localities comprises i. a. the genera *Semiformiceras, Taramelliceras, Sutneria* and *Simocosmoceras*, the representatives of which are described and illustrated, and a new species, *Semiformiceras birkenmajeri* sp. n., is established. An analysis of the ammonite faunas of the classical section at Stankowa Skała allows to conclude that in the Czorsztyn Limestone there appears a stratigraphic gap which corresponds to the uppermost Callovian and Lower Oxfordian. The Mediterranean ammonite assemblages of the Late Jurassic Czorsztyn ridge show affinities with assemblages from platformic Europe and several units of the Alpine and Carpatho-Balcanic regions; this indicates migration of ammonites across bathyal basins. A special attention is paid to stratigraphic and biogeographic aspects of the genus *Pseudovirgatites*, and arguments are put forward in favour of approximate stratigraphic equivalence of the Middle/Upper Tithonian and Lower/Middle Volgian boundaries.

INTRODUCTION

In an earlier paper, the authors (KUTEK & WIERZBOWSKI 1979) described a succession of Early to Middle Tithonian ammonites in a section of the Rogoźnik Coquina Member exposed at the Rogoża klippes, near Rogoźnik. In the present paper, this section is discussed once more, taking into account new discoveries of ammonites. This paper deals also with a section of the Rogoża Coquina Member at the Rogoża klippe and a section of Upper Jurassic and Berriasian strata at the Stankowa-Skała klippe. Stratigraphy based on ammonites will be the main topic of the paper; information on occurrences of calpionellids is only given in some instances to substantiate some stratigraphic conclusions.

SUBDIVISION OF THE TITHONIAN STAGE

As shown in an earlier paper (KUTEK & WIERZBOWSKI 1979), the Tithonian zonal scheme established by ENAY & GEYSSANT (1975) as well as the largely equivalent scheme established by OLORIZ-SAEZ (1978) in southern Spain, can easily be applied to the Tithonian sections of the Czorsztyn succession in the Pieniny Klippen Belt (*see* Table 1). As a tripartite subdivision of the Tithonian into substages has been used for a long time in the Pieniny Klippen Belt, it is retained in this paper for the sake of convenience.

Table 1

Zonal schemes of the Tithonian stage

Stages	Substages	Ammonite Zones		Callpionellid Zones
		Enay & Geyssant 1975	Olóriz-Sáez 1978	
Berriasian		jacobi		Zone B Calpionella
Tithonian	Upper	Durangites		Zone A Crassicollaria
		microcanthum		
	Middle	ponti	Burckhardticeras	Chitinoidella
		fallauxi	admirandum-biruncinatum	
			richteri	
		semiforme	verruciferum	
	Lower	darwini	albertinum	
		hybonotum	hybonotum	

The zonal scheme of ENAY & GEYSSANT (1975) will be used also in this paper, primarily because there is no reason to replace the *semiforme* Zone, well rooted in biostratigraphic tradition, by an equivalent *verruciferum* Zone, especially since the index form, *Haploceras verruciferum* (MEN.), has been reported in some Italian and Hungarian sections as early as in the *hybonotum* Zone (SARTI 1984, VIGH 1984).

THE ROGOŹNIK COQUINA MEMBER IN THE ROGOŻA KLIPPES

The Rogoża klippes near Rogoźnik, which are well known owing to the wealth of ammonites contained in Tithonian coquinas, provide the type locality for two formal lithostratigraphic units, the Rogoźnik Coquina Member, and the Rogoża Coquina Member (BIRKENMAJER 1977). The klippes were described in detail by BIRKENMAJER (1962, 1963); however, subsequent quarrying in the klippes provided a new exposure of the Rogoża coquinas.

A good section of the Rogoźnik Coquina Member can be studied in a small klippe protected as a monument of nature. The description of this section, given by the authors earlier (KUTEK & WIERZBOWSKI 1979) is briefly repeated below.

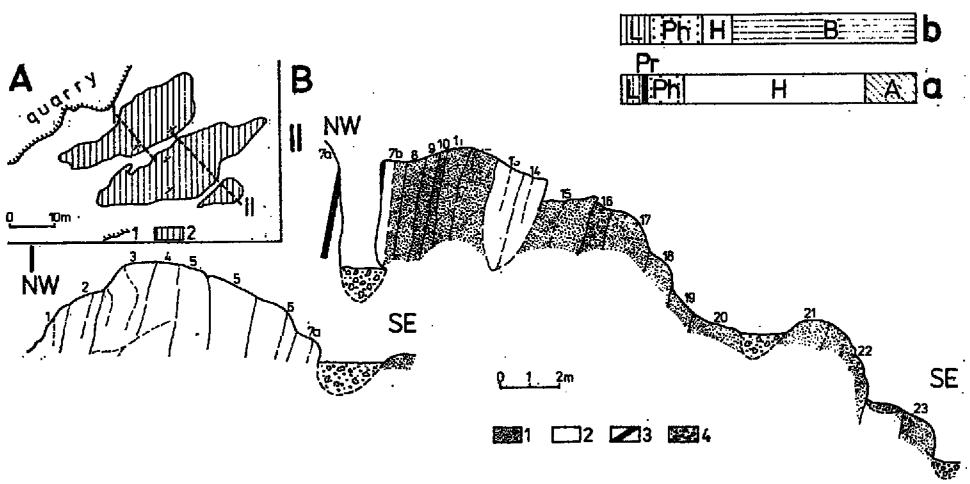


Fig. 1. Rogoża klippes: cross-section of the protected klippe

A — Sketch map of the klippe with lines of sections indicated: *1* quarry, *2* outcrops of the Rogoźnik Coquina Member
B — Cross-sections of the klippe: *1* sparry coquinas (Lower-Middle Tithonian), *2* micritic coquinas, also in neptunian dykes (Upper Tithonian — Berriasian), *3* crinoid-detrital limestones in neptunian dykes (? Uppermost Berriasian — Valanginian), *4* rubble
a — ammonite spectrum for the lower part of the sequence, beds *7b* (lower part) through *12* and *15-23*; **b** — ammonite spectrum for the upper part of the sequence, beds *1-5*: **L** — Lytocerataceae, **Pr** — Protancyloceratinae, **Ph** — Phylloceratacea, **H** — Haplocerataceae, **B** — Berriasellidae, **A** — Ataxioceratidae and Aspidoceratidae

The strata in the klippe (beds *1-23*) are numbered from top downwards (*see* Text-fig. 1). The sequence is disrupted by a gap where the strata are obscured by debris, and the klippe is thus divided into the northwestern (smaller) and the south-western (larger) part. The sequence of strata exposed in the klippe is *ca.* 30 m thick.

The higher strata in the north-western part of the klippe (beds *1-7a*) are developed as white, also creamy or pinkish micritic coquinas approximating 9 m in thickness. Ammonite, crinoid and brachiopod detritus and fragments are scattered in micritic matrix. Here and there, bands with densely packed skeletal material occur.

The ammonites, mostly preserved as fragments, do not allow identification with desired accuracy; in the beds *1-5* most of them belong to the Berriasellidae.

The calpionellids found in the beds *4-6* are indicative of the Berriasian *Calpionella* Zone. In the topmost part of the bed *7a* there occur abundantly *Calpionella alpina* LOR., and somewhat less commonly *Crassicolaria* sp. (? *parvula* REM.) which indicate (*cf.* REMANE 1984) either the uppermost part of the Upper Tithonian *Crassicolaria* Zone (Zone *A*) or the lowermost part of the Berriasian *Calpionella* Zone (Zone *B*).

The bulk of the section in the south-eastern part of the klippe (beds *7b* — lower part, *8-12*, and *15-23*) consists of densely-packed sparry coquinas, composed mostly of ammonite shells but enriched at some levels in crinoid material; this is the typical "ammonite-breccia" of early writers. Aptychi, brachiopods and bivalves are quite common, whereas other fossils (gastropods, echinoids, sponges, solitary corals, fish teeth) are less frequent to rare. The coquinas mostly comprise densely packed debris and shell fragments, but complete fossils also occur. Sparry cement prevails, sparse micrite matrix occurring occasionally. The coquinas are spotty, white and pinkish, and red, the white color being due to sparry calcite forming the cement or infilling ammonite shells, whereas the micritic constituents of the rock (*e. g.* ammonite steinkerns) are usually red or pink.

The beds *13* and *14* form jointly a stratiform neptunian dyke containing calpionellids of the *Crassicolaria* Zone and the *Calpionella* Zone. They consist of micritic limestones with scattered macrofossils, their lithology being comparable with that of the strata exposed in the northwestern part of the klippe.

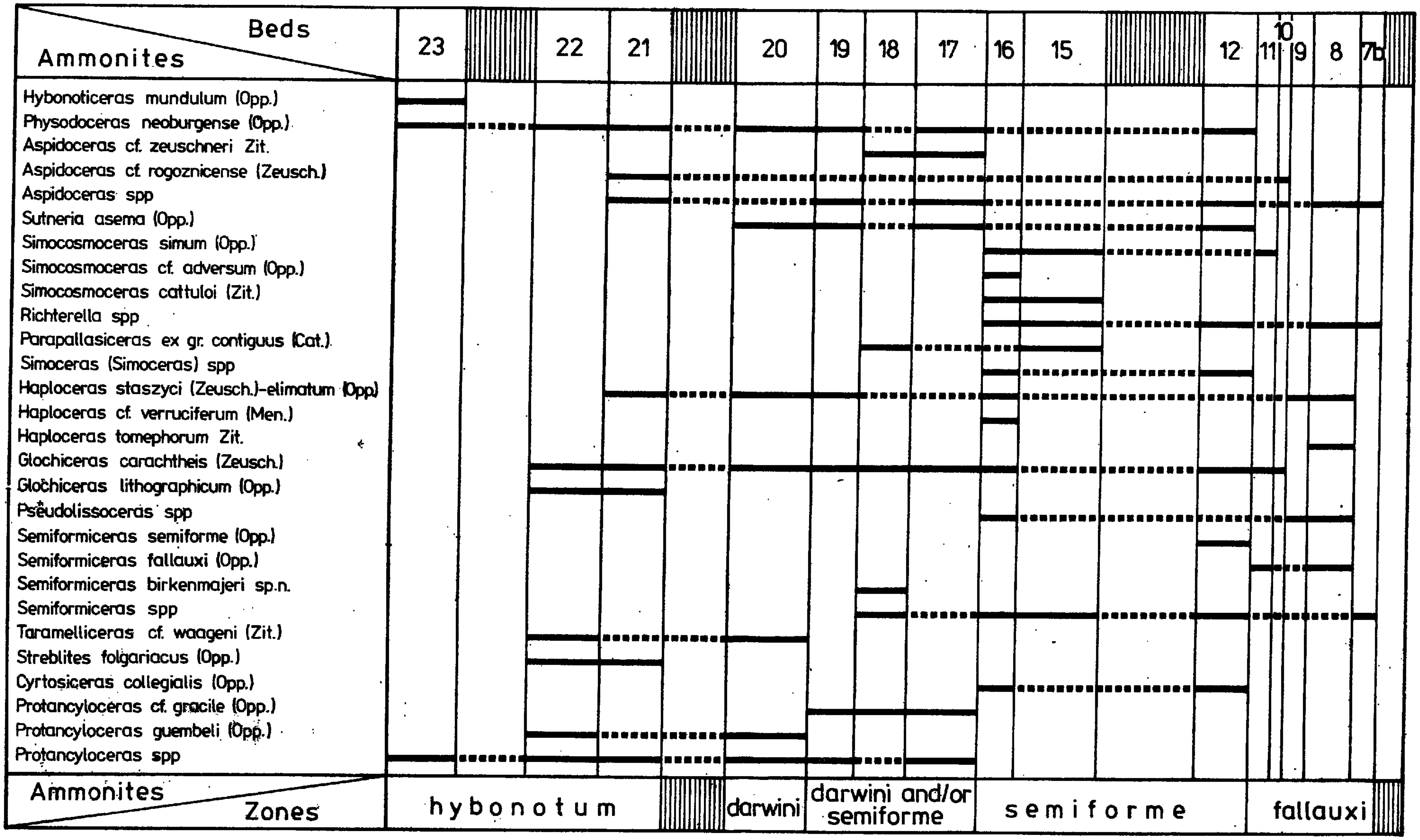
Similar micritic limestones containing Late Tithonian calpionellides appear also in the upper part of the bed *7b*. Below, there is a sharp change to sparry coquinas forming the lower part of the bed *7b* which have yielded ammonites of the *fallauxi* Zone (*see* Table 2). It is difficult to say whether the micritic limestone of the upper part of the bed *7b* is an internal sediment of a neptunian dyke, or a normal sediment overlying a non-sequentional junction with the Middle Tithonian sparry coquinas.

The micritic strata (*see* Text-fig. 1) are also cut by some neptunian dykes formed by a crinoidal limestone of Valanginian (or Late Berriasian ?) age (BIRKENMAJER 1962, 1963, 1975, 1977).

The identifiable ammonites from the Lower to Middle Tithonian part of the section are listed in Table 2. This table is slightly enlarged and modified with repect to that enclosed in an earlier paper (KUTEK & WIERZBOWSKI 1979, Table 2), partly as a result of new findings of ammonites in recent years. Ammonites formerly quoted from here as *Semiformicers gemmellaroi* (ZIT.) are now referred to *Semiformiceras birkenmajeri* sp. n., a new species established in the paleontological section of this paper.

It should be remembered that the ammonites usually found in the Rogoźnik coquinas range in size from minute debris to some 3—4 cm in diameter, slightly larger specimens being only found as rarities. As

Stratigraphic distribution of ammonites in the lower part of the Rogoźnik Coquina Member (for section shown in Text-fig. 1)



a consequence, numerous specimens of the small-sized Haploceratаceae can easily be identified. On the other hand, the ammonites belonging to the Phylloceratаceae, Lytoceratаceae, Aspidoceratidae and Ataxiaceratidae (as classified by CALLOMON *in:* DONOVAN & CALLOMON 1981), which form significant parts of the ammonites assemblages (*see* Text-fig. 1a-1b), are preserved as nuclei or fragments of whorls, this usually precluding their identification with desired accuracy.

It is worth of note that the Ataxioceratidae collected from the Rogoźnik coquinas are highly diversified, comprising specimens showing strong variability in shape of whorl section and type of ribbing. To some extent at least, the succession of Ataxioceratidae seems to compare with that in the Spanish sections (ENAY & GEYSSANT 1975, OLORIZ-SAEZ 1978). For instance, some of the specimens from the *hybonotum* Zone of the Rogoża klippes could easily be accommodated in *Subplanites* or *Lithacoceras*, whereas some fragments of ammonites from the *semiforme* Zone match the "*contiguus*" group.

The sparry coquinas of the Rogoźnik Member can be assigned to the *hybonotum*, *darwini*, *semiforme* and *fallauxi* Zones (*see* Table 2), this biostratigraphic interpretation being largely based on comparisons with the Spanish sections described by ENAY & GEYSSANT (1975) and by OLORIZ-SAEZ (1978). This interpretation, discussed in an earlier paper (KUTEK & WIERZBOWSKI 1979), needs no comment here, except for the problems discussed below.

The bed *21*, previously assigned to the *darwini* Zone, is now transferred (*see* Table 2) to the *hybonotum* Zone because it has yielded specimens of the species *Glochiceras lithographicum* (OPP.).

The lower boundary of the *semiforme* Zone was previously taken tentatively at the base of bed *19* (KUTEK & WIERZBOWSKI 1979, Table 2) because of the first appearance of *Sutneria asema* (OPP.), a species hitherto known only from the Rogoża klippes and Franconia. In the latter region the first appearance of this species is noted in the lower part of the Neuburg Formation of Middle Tithonian age. However, *Sutneria asema* makes part of an Tethyan ammonite assemblage which appears in the lower part of the Neuburg Formation (BARTHEL & GEYSSANT 1973) and is not represented in the underlying strata, so it does not seem possible to define the total stratigraphic range of *S. asema* in Franconia. A recent discovery of *Sutneria asema* in the bed *20* of the Rogoża section, together with representatives of the genus *Taramelliceras*, now indicates that this species cannot be regarded as a diagnostic fossil of the Middle Tithonian.

The bed *20* is assigned to the *darwini* Zone mainly because of the presence of *Taramelliceras*, as in the Spanish sections (ENAY & GEYSSANT 1975, OLORIZ-SAEZ 1978) the subfamily Taramelliceratinae does not range up into the *semiforme* Zone. This interpretation seems to be still valid in spite of the fact that *Taramelliceras waageni* (ZIT.) has been reported from the Middle Tithonian of Hungary (VIGH 1984).

The new species *Semiformiceras birkenmajeri* sp. n., which occurs in the bed *18* of the Rogoża section, has been reported (as *Semiformiceras* *gemmellaroi* — see paleontological part of the paper) from Italy (CECCA & *al.* 1985) just above the *darwini* Zone, with its occurrence being restricted to the lowest part of the *semiforme* Zone. Thus, *S. birkenmajeri* sp. n. seems to appear at exactly the same stratigraphical level both in Italy and in the Pieniny Klippen Belt. However, *S. birkenmajeri* sp. n. is not known from Spain, and some doubt is left whether the first appearance of this species is indicative of the base of the *semiforme* Zone as defined in the Spanish sections. Hence, the biostratigraphic status of the beds *17-19* of the Rogoża section is left unsettled.

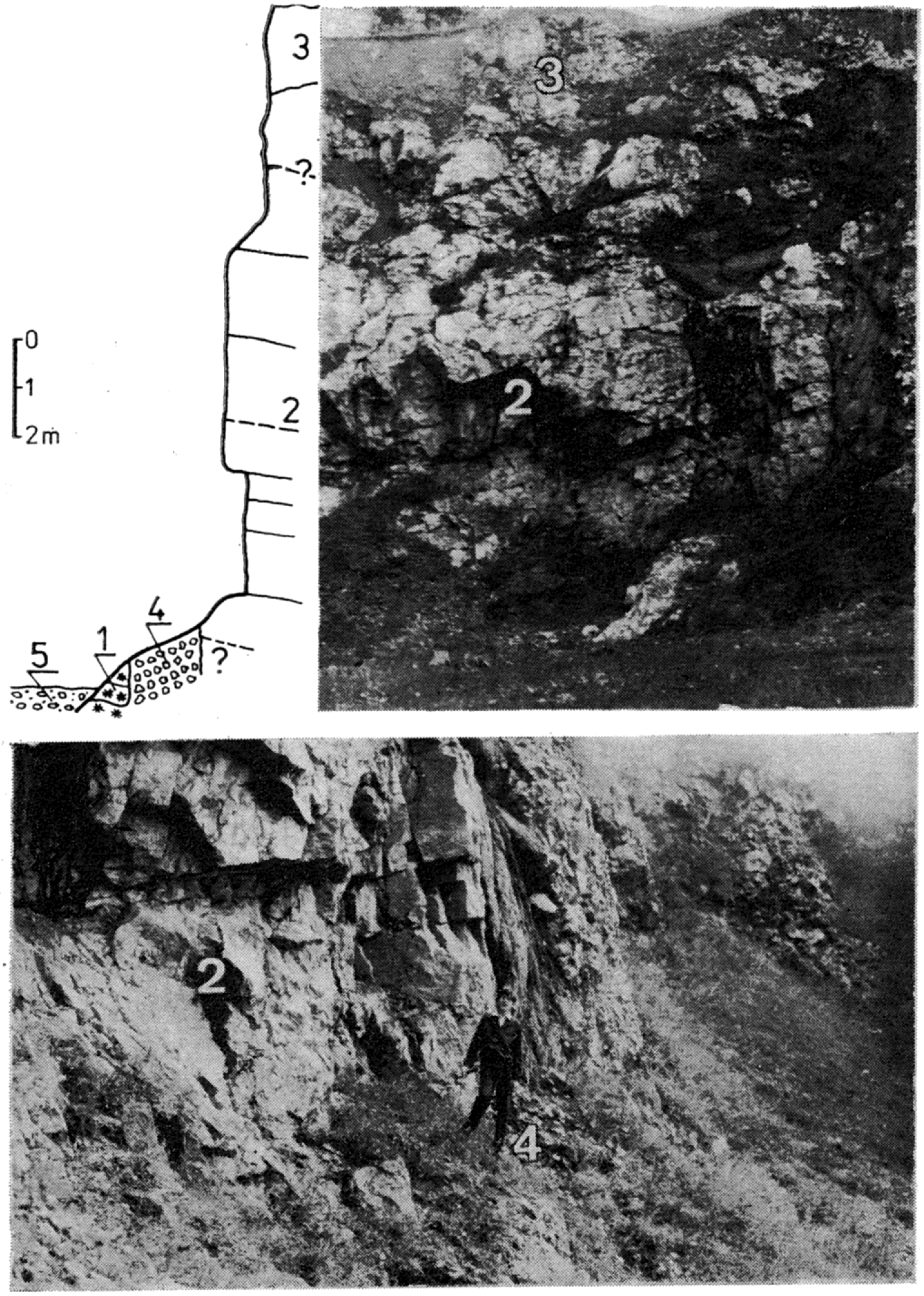
THE ROGOŻA COQUINA MEMBER AT THE ROGOŻA KLIPPES

Red micritic limestones, *ca.* 10 m thick, belonging to the Rogoża Coquina Member, are seen in the disused quarry at the Rogoża klippes; their base is not exposed (*see* Text-fig. 2). There is much skeletal material in the rock, with a marked predominance of ammonites, brachiopods and crinoids. The ammonites are mostly preserved as debris, which in some levels is concentrated into thin bands. There cccur some ferromanganese nodules, up to 4 cm in size (ZYDOROWICZ & WIERZBOWSKI 1986). No calpionellids have been found in the red coquinas.

These strata are overlain stratigraphically by a few metres of white micritic coquinas, which do not differ in lithology from the white micritic coquinas forming the upper part of the Rogoźnik Coquina Member in the section described above (*see* Text-fig. 1). In the uppermost white coquinas exposed in the quarry, calpionellids indicative of Berriasian age have been found. The junction of the red and white coquinas is visible in a vertical wall of the quarry, hard of access; it seems to be a gradational sedimentary contact.

Poorly preserved ammonites, collected by the authors from the red coquinas of the Rogoża Member, and identified as *Physodoceras neoburgense* (OPP.) and *Glochiceras carachtheis* (ZEUSCHN.), suggest an Early to Middle Tithonian age of the red coquinas. This is in accordance with the occurrence of *Glochiceras lithographicum* (OPP.) and *Semiformiceras semiforme* (OPP.) in these coquinas as reported by earlier writers (*cf.* BIRKENMAJER 1963, p. 298). From this it follows that a part, at least, of the Rogoża Coquina Member is coeval with the sparry coquinas of the Rogoźnik Coquina Member. The white micritic coquinas overlying the Rogoża Coquina Member in the quarry are an age-correlative of a part of the white micritic coquinas included in the Rogoźnik Coquina Member (*see* Text-figs 1—2 and 4).

Crinoid limestones of the Smolegowa Limestone Formation (Bajocian; *see* BIRKENMAJER 1963, 1977) are also exposed in the quarry. They are separated from the red coquinas of the Rogoża Member by a subvertical tectonic breccia,



Rogoża klippes: Jurassic strata in the quarry

1 — crinoid limestones, Smolegowa Limestone Formation; 2 — red micritic coquinas, Rogoża Coquina Member; 3 — white micritic coquinas; 4 — tectonic breccia; 5 — rubble

1-2 m thick (*see* Text-fig. 2). The breccia contains fragments of crinoid limestones as well as fragments of red and white micritic coquinas; there are no fragments of sparry coquinas of the Rogoźnik Member type. There also has been found a clast presenting a contact of the crinoid limestone with red limestone of the Rogoża Coquina type. Thus, the conclusion appears that at the Rogoża klippes the Rogoża Coquina Member rests directly on the Smolegowa Limestone Formation, an interpretation advanced already by BIRKENMAJER (1963, 1977) on similar evidences.

As the lowest part of the Rogoża Member is not exposed in the quarry, there are no direct indications of its age. However, it appears likely that this member ranges down into the Kimmeridgian (and Oxfordian ?). Such a suggestion finds support in the list (compiled by BIRKENMAJER 1963, p. 288) of ammonites reported by earlier writers (ZITTEL 1870; NEUMAYR 1871a, b; *see also* UHLIG 1890) from the red coquinas of the Rogoża klippes. It includes such Kimmeridgian species as *Taramelliceras compsum* (OPP.), *Streblites tenuilobatus* (OPP.), and *Aspidoceras iphicerum* (OPP.).

THE JURASSIC IN STANKOWA SKAŁA

The Stankowa-Skała klippe belongs to a sector of the Czorsztyn unit from which rich ammonite faunas of Callovian, Oxfordian, Kimmeridgian and Tithonian age have been reported by NEUMAYR (1871a, b), ZARĘCZNY (1876), UHLIG (1890), and others (*see* lists compiled by BIRKENMAJER 1963). As usually in the Pieniny Klippen Belt, there is much tectonic complexity in the Stankowa-Skała klippe. The original sequence of Jurassic rocks can be most conveniently studied in a section across the middle part of the klippe (Text-fig. 3).

The oldest Jurassic rocks visible in this section are the white crinoid limestones of the Bajocian Smolegowa Limestone Formation. The irregular top-surface of this formation is coated over with ferromanganese material.

The Smolegowa Formation is overlain by 3-4 metres of red and red-brownish limestones, the micritic matrix of which is partly recrystallized. Abundant bioclastic, predominantly crinoid material occurs at some levels. Non-fragmented fossils (ammonites, belemnites, bivalves, brachiopods, echinoids, calices of crinoids) are found in some parts of the section; some of these fossils are corroded and coated with ferruginous material. There also occur some ferromanganese nodules, up to a few centimetres in size (ZYDOROWICZ & WIERZBOWSKI 1986).

The red limestones described above are ascribed to the Czorsztyn Limestone Formation (BIRKENMAJER 1963, 1977), but they differ from typical representatives of this formation in not being nodular, and in containing ferromanganese nodules; the mode of preservation of fossils is also different. The peculiar lithological development of the Czorsztyn Limestone at Stankowa Skała and in some adjacent klippes was already pointed out by NEUMAYR (1871b) and UHLIG (1890). On the other hand, the red limestones from Stankowa Skała display some similarity in lithology with the red Rogoża coquinas.

At Stankowa Skała, identifiable ammonites have been found by the present authors *ca.* 2.4 m above the base of red limestones of the Czorsztyn Formation (assemblage *1* in Text-fig. 3); besides the phylloceratids and lytoceratids, they include forms of the genera *Taramelliceras, Euaspidoceras, Neaspidoceras,* and *Perisphinctes,* suggestive of Middle and or Late Oxfordian age. The list (BIRKENMAJER 1963, pp. 272—273) of ammonites reported by NEUMAYR (1871a) and UHLIG (1890) from the Czorsztyn Limestone of Stankowa Skała, includes Middle and Late Oxfordian as well as Kimmeridgian species, e.g.: *Cardioceras (Miticardio-*

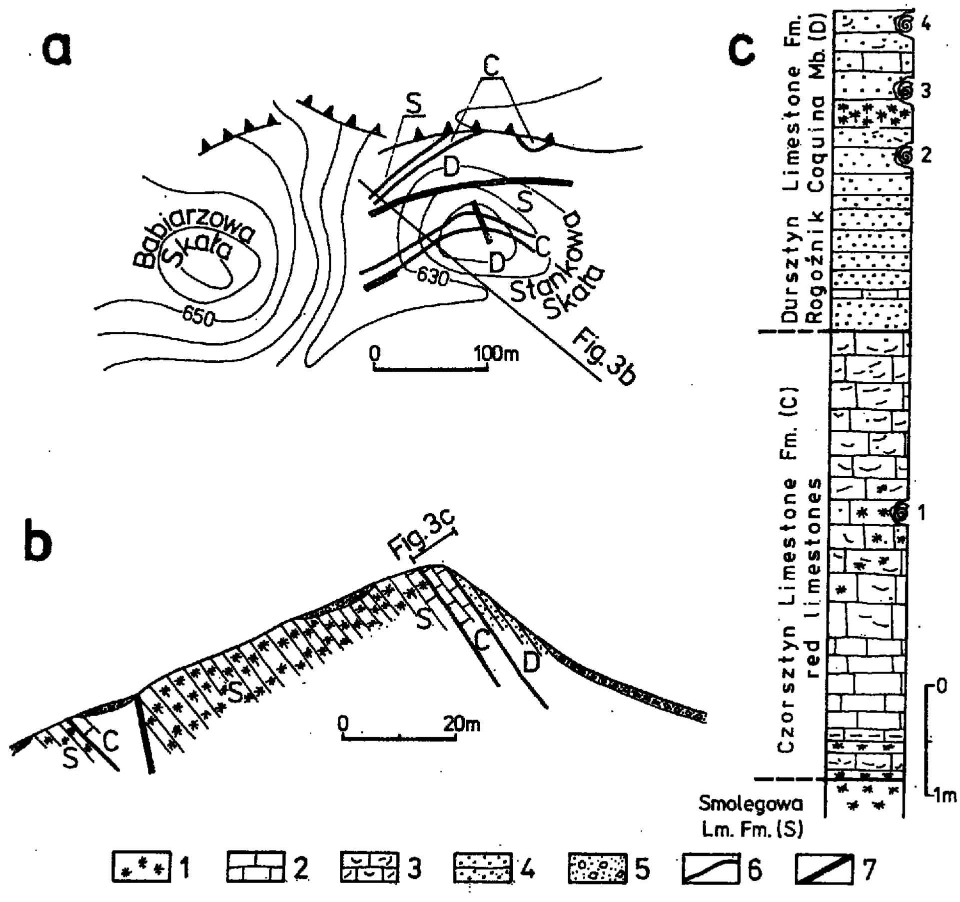


Fig. 3. Succession of Jurassic strata in Stankowa Skała

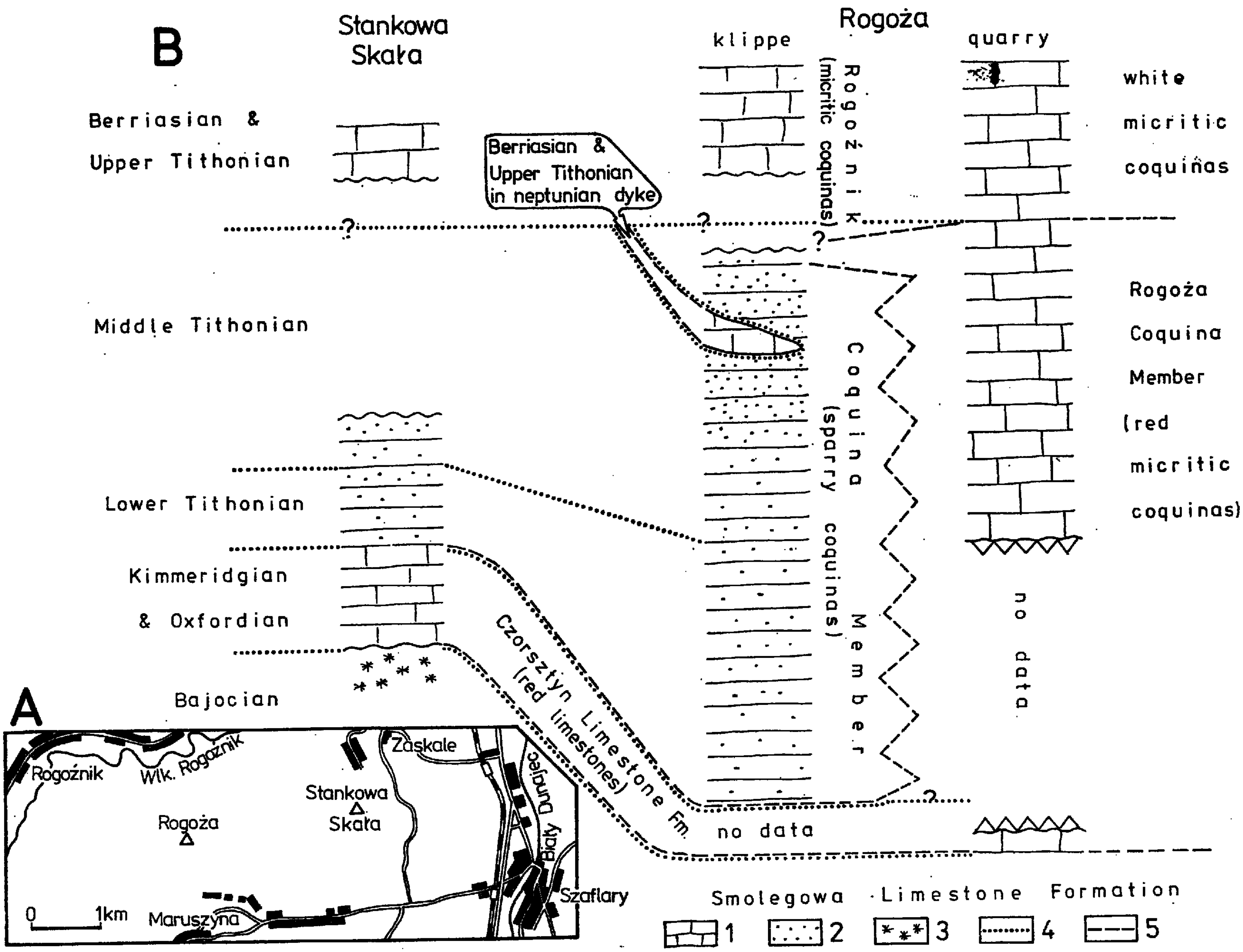
a — geological sketch map, b — geological cross-section of the middle part of the klippe, c — stratigraphic column corresponding to a part of the section; the successive ammonite assemblages *1-4* are indicated

S — Smolegowa Limestone Formation, C — Czorsztyn Limestone Formation (red limestones), D — Rogoźnik Coquina Member (sparry and micritic coquinas) of the Dursztyn Limestone Formation

1 crinoid limestones, *2* micritic limestones, *3* micritic limestones with bioclasts, *4* sparry coquinas, *5* rubble, *6* lithostratigraphic boundaries, *7* faults

Stratigraphic correlation (thicknesses of beds approximated) of the investigated sections

A — Location map; B — Stratigraphic columns: *1* micritic limestones and coquinas, *2* sparry coquinas, *3* crinoid limestones (in large rock units), *4* chronostratigraphic boundaries, *5* lithostratigraphic boundaries



ceras) tenuiserratum (OPP.), *Cardioceras (Miticardioceras) crenocarinum* (NEUMAYR), *Taramelliceras anar* (OPP.), *Perisphinctes plicatilis* (SOW.), *Euaspidoceras oegir* (OPP.), *Neaspidoceras tietzei* (NEUMAYR), *Ringsteadia vicaria* (MOESCH), *Taramelliceras compsum* (OPP.), *Taramelliceras trachinotum* (OPP.), *Aspidoceras acanthicum* (OPP.), *A. longispinum* (SOW.), and *Hybonoticeras* cf. *pressulum* (NEUM.). On the other hand, no diagnostic Callovian and Early Oxfordian ammonites have been recorded from Stankowa Skała. This suggests a stratigraphic gap between the Smolegowa Formation and the Czorsztyn Formation, encompassing the Bathonian, Callovian and Lower Oxfordian. It is worth of note that some neighboring klippes supplied good sedimentological and structural evidence for a significant gap between the Smolegowa and the Czorsztyn formations (BIRKENMAJER 1963). The occurrence of *Hybonoticeras* in the limestones of the latter formation at Stankowa Skała indicates that these limestones range up into the topmost Kimmeridgian (*beckeri* Zone). It should be born in mind, however, that the ammonites reported by NEUMAYR and UHLIG from Stankowa Skała were most probably collected not from the section studied by the present authors.

The red limestones of the Czorsztyn Formation are followed in the section at Stankowa Skała by sparry coquinas of the Rogoźnik Coquina Member. They differ from the sparry Rogoźnik coquinas of the Rogoża klippes only in having a few intercalations of micritic limestones, up to 15 cm thick. Identifiable ammonites have been found by the present authors only at some levels in the sparry coquinas at Stankowa Skała; some of the ammonites have been collected from trenches.

In the south-eastern part of the klippe, beyond the main section, a small ammonite assemblage indicative of the *hybonotum* Zone has been found *ca.* 1.5 m above the base of the coquinas. It includes *Hybonoticeras* sp. and *Glochiceras lithographicum* (OPP.). This fact together with the presence of *Hybonoticeras* in the underlying Czorsztyn Formation, suggest that the base of the Rogoźnik Member at Stankowa Skała corresponds approximatively to the boundary between the Kimmeridgian and Tithonian.

Ammonites of an younger assemblage (assemblage *2* in Text-fig. 3) have been found in the main section, 1.4 — 1.8 m from the base of the coquinas. It is an assemblage of the *darwini* Zone, including *Glochiceras carachtheis* (ZEUSCHN.), *Haploceras elimatum* (OPP.), *Streblites folgariacus* (OPP.), *Physodoceras neoburgense* (OPP.), *Virgatosimoceras albertinum* (CAT.), and *Protancyloceras* sp.

The next assemblage from a level *ca.* 2 m above the base of the Rogoźnik Member (assemblage *3* in Text-fig. 3) includes *Glochiceras carachtheis* (ZEUSCHN.), *Haploceras elimatum* (OPP.), *Semiformiceras* cf.

darwini (NEUM.), and *Protancyloceras* sp. This is also an assemblage indicative of the *darwini* Zone.

Worth of note is the occurrence of *Semiformiceras darwini* (NEUM.) and *Virgatosimoceras albertinum* (CAT.) at Stankowa Skała. These zonal indices of the *darwini* Zone and the equivalent *albertinum* Zone have not been recorded from the Rogoźnik Coquina Member at its type locality in the Rogoża klippes.

A still younger assemblage comes from a level ca. 3 m above the base of the coquinas (assemblage *4* in Text-fig. 3). There have been found: *Glochiceras carachtheis* (ZEUSCHN.), *Haploceras elimatum* (OPP.), *Taramelliceras (Parastreblites)* cf. *waageni* (ZIT.), *Physodoceras neoburgense* (OPP.), and *Sutneria asema* (OPP.). In general aspect, this assemblage compares with that occurring in the Rogoża klippes in strata transitional from the *darwini* to the *semiforme* Zone (*see* Text-fig. 1 and Table 2). The presence of *Taramelliceras (Parastreblites)* allows to place the assemblage *4* from Stankowa Skała still in the *darwini* Zone.

Still younger ammonites, indicative of the *semiforme* Zone, have been found at Stankowa Skała in debris littering the hill near the limit of the outcrop of sparry coquinas. They are identified as *Cyrtosiceras collegialis* (OPP.), *Semiformiceras* sp., *Richterella* sp., *Discosphinctoides geron* (ZIT.), and *Protancyloceras* sp.

In the section here discussed, the sparry Rogoźnik coquinas are limited from above by a tectonic contact with white micritic coquinas, so it may be concluded that some upper part of the sparry coquinas is not preserved.

The white micritic coquinas overlying tectonically the sparry ones represent the upper micritic part of the Rogoźnik Coquina Member, and they contain calpionellids of Berriasian age.

LITHOSTRATIGRAPHIC REMARKS

The relationships between the lithostratigraphic units discussed above can be summarized as follows (*see* Text-fig. 4).

In both the section at the Rogoża klippes and at Stankowa Skała, the Rogoźnik Coquina Member can be divided into two parts with different lithology: the spotty sparry coquinas of Early to Middle Tithonian age, and the overlying white micritic coquinas, Late Tithonian and Berriasian in age. The latter coquinas have their coeval lithological correlative in the white micritic coquinas that overlay red coquinas of the Rogoża Coquina Member at the Rogoża klippes. Therefore, the following modification of the present lithostratigraphic classification (BIRKENMAJER 1977) may be suggested. Namely, the white micritic coquinas hitherto included in the Rogoźnik Coquina Member could be separated from the underlying sparry coquinas of this member, to form a new, separate formal lithostratigraphic unit together with the white micritic coquinas that overlie the red coquinas of the Rogoża Member.

The sections in the Rogoża klippes and at Stankowa Skała, do not allow to examine the primary junction between the sparry and the micritic coquinas of the Rogoźnik Member. Nevertheless, it may be suggested that this is a non-sequentional junction, at least in some sections. Such a conclusion can be drawn from the occurrence of neptunian dykes consisting of an internal sediment of Late Tithonian and Early Berriasian age as seen in the Rogoża klippes (Text-figs 1 and 4). Neptunian dykes filled with sediments of the Upper Tithonian *Crassicolaria* Zone have also been reported from the Czorsztyn succession of Slovakia (MIŠIK 1979). Hence the origin of the Tithonian neptunic dykes can be linked with a Late Tithonian tectonic event of regional significance.

As the micritic constituents of the sparry coquinas of the Rogoźnik Member are red or pink, these coquinas may be regarded as belonging to the family of "red" lithostratigraphic units of Tithonian (mainly Early and Middle Tithonian) age, comprising mainly the red coquinas of the Rogoża Member as well as the "red *Calpionella* limestones" and the "pink *Globochaete* limestones" (now included in the Korowa Limestone Member, *see* BIRKENMAJER 1977; *cf. also* BIRKENMAJER & GĄSIOROWSKI 1961) of the Czorsztyn succession. The younger white micritic coquinas of the Rogoźnik Member show, in turn, affinity to the "white *Calpionella* limestone" and the "white *Globochaete* limestone" (now ascribed to the Sobótka Limestone Member, BIRKENMAJER 1977), of Late Tithonian to Berriasian age. Such a sequence of lithostratigraphic units reflects a change in deposition from red to white sediments, that took place towards the end of the Jurassic within the Czorsztyn unit, similarly as in many other parts of the Tethyan Realm. On this background, the division of the present Rogoźnik Coquina Member into two independent lithostratigraphic units, as suggested above, would be consistent with the general lithostratigraphical scheme applied in the Czorsztyn succession.

As remarked above, the Rogoża coquinas, which at the Rogoża klippes rest non-sequentialy on the Bajocian Smolegowa Formation, range most probably down into the Kimmeridgian (and possibly also into the Oxfordian). Hence, it is probable that some lower parts of the Rogoża Coquina Member have their time-correlative in the Czorsztyn Limestone of Stankowa Skała, which ranges up from the Middle Oxfordian into the Upper Kimmeridgian, overlying non-sequentialy the Smolegowa Formation (Text-fig. 3). The lithological affinity between the non-typical representatives of the Czorsztyn Formation of Stankowa Skała and the red coquinas of the Rogoża Member are consistent with such an interpretation.

The absence of Callovian and Lower Oxfordian deposits in the section of Stankowa Skała (Text-figs 3 — 4) requires some comment. In several sections of the Czorsztyn succession, some lower parts of the Czorsztyn Limestone Formation are known to be of Callovian age (BIRKENMAJER 1963, 1977), and the richest Callovian fauna so far reported from the Czorsztyn succession (comprising Late, but not latest Callovian forms) was found in the Babiarzowa-Skała klippe, near Stankowa Skała (UHLIG 1890, BIRKENMAJER 1963). On the other hand, it is of interest that the lists compiled by BIRKENMAJER (1963) of Callovian and Oxfordian ammonites reported from the Czorsztyn succession do not comprise any diagnostic ammonites indicative of latest Callovian *(lamberti)* and of Early Oxfordian *(mariae* and *cordatum)* age. This cannot be explained by biogeographical factors, as there is a significant absence of both Boreal genera (*Quenstedtoceras* and early representatives of *Cardioceras* which genus, on the other hand, is represented in the Czorsztyn Formation by Middle Oxfordian forms), and Tethyan genera or subgenera, such as *Parawedekindia, Peltomorphites,* and *Prososphinctes.* This, for instance, is in marked contrast with the well-known ammonite assemblage from Cetechovice in Czechoslovakia, a locality in the Outer Carpathians displaying a Jurassic section of the Magura succession (the succession next to the north with respect to the Czorsztyn succession). Several Early Oxfordian peltoceratids are known from Cetechovice; ARKELL (1956, pp. 168—169) remarked on the Middle Oxfordian age of the cardioceratids reported from Cetechovice, but according to Dr. B. A. MATYJA *(personal information)* a collection of ammonites from Cetechovice, housed at the University of Vienna, contains also specimens of undoubtedly Early Oxfordian cardioceratids.

It should be remarked that the ammonite reported by BIRKENMAJER & MYCZYŃSKI (1984) from the Czorsztyn Formation of the Czorsztyn succession as an Early Oxfordian *Peltomorphites* is a Middle Oxfordian *Gregoryceras* (according to Dr. B. A. MATYJA who examined the specimen kindly supplied by Dr. R. MYCZYŃSKI).

The data presented allow to conclude that in the Czorsztyn succession, at least in some sections, there is a stratigraphic gap encompassing the latest Callovian and Lower Oxfordian. This gap, as well as other gaps within the Czorsztyn succession (between Callovian and Bathonian or Bajocian deposits; *see* BIRKENMAJER 1963), together with several features of stratigraphic condensation and hiatuses, can be explained as a result of "Meso-Cimmerian" extentional tectonics (*cf.* BIRKENMAJER 1986).

DESCRIPTION OF TITHONIAN AMMONITES

The ammonites described hereafter were collected in the Rogoża klippes and the Stankowa Skała klippe from the sparry coquinas of the Rogoźnik Coquina Member ("Rogoźniker Breccia" or "Cephalopodenbreccie" of older authors). The description pertains only to some more important taxa having their type locality in the studied area, such as *Simocosmoceras*, *Sutneria asema* (OPP.) and a new species *Semiformiceras birkenmajeri*, as well as to some forms hitherto poorly known from this area *(Taramelliceras)*.

This collection consisting of 36 specimens is kept in the Institute of Geology, University of Warsaw, and abbreviated as *IGPUW;* collection numbers are *A19/1* through *A19/36*.

The following abbreviations are used in paleontological descriptions: D — diameter (*in* mm), Ud — umbilicus diameter (*in* mm or *in* D%, as indicated), Wh — whorl height (*in* mm or *in* D%), Wt — whorl thickness (*in* mm or *in* D%).

Semiformiceras

The present material includes several specimens of the species *Semiformiceras semiforme* (OPP.) and *S. fallauxi* (OPP.), two specimens tentatively referred to the species *Semiformiceras darwini* (NEUM.) and, finally, several specimens previously referred (KUTEK & WIERZBOWSKI 1979, 1986) to *Semiformiceras gemmellaroi* (ZIT.) which are transferred here to a new species, *Semiformiceras birkenmajeri* sp. n.

The following discussion is restricted to the forms originally attributed to the *Semiformiceras gemmellaroi* (ZIT.).

The species *Semiformiceras gemmellaroi* (ZIT.) as established by ZITTEL (1870, p. 62, Pl. 4, Figs 10-11) needs a revision as it includes forms differing in stratigraphical occurrence and morphological development.

According to ENAY (1983), *Semiformiceras gemmellaroi* (ZIT.) marks the end part of the *Semiformiceras* lineage. This opinion is based on the findings of that species in the *fallauxi* Zone in Spain (OLORIZ-SAEZ 1978, ENAY 1983) and France (ENAY & *al.* 1979) as well as the occurrence of some forms transitional between *S. gemmellaroi* (ZIT.) and *S. fallauxi* (OPP.), as already stressed by BLANCHET (1927). All these specimens, which come from the *fallauxi* Zone, are evolute with umbilical width bigger than the whorl height, and generally they bear up to six ribs with nodes at the venter on the body chamber; these specimens are very close to the first syntype of *Semiformiceras gemmellaroi* illustrated by ZITTEL (1890, Pl. 4, Fig. 10). This syntype, which is deposited in the *Bayerische Staatssammlung für Paläontologie und historische Geologie* in Munich, is designated here as the lectotype of the species *Semiformiceras gemmellaroi* (ZIT.).

On the other side, there are known specimens closely comparable to the second syntype of *Semiformiceras gemmellaroi* illustrated by ZITTEL (1890, Pl. 4, Fig. 11), which occur in clearly older deposits than the specimens discussed above. These are the specimens from the bed *18* of the Rogoża klippes section (Text-fig. 1, Table 2; *see also* KUTEK & WIERZBOWSKI 1979, 1986), this bed occurring near the boundary between *darwini* and *semiforme* Zones and most possibly representing the lowest part of the *semiforme* Zone. Also CECCA & *al.* (1985) have remarked on the occurrence of a specimen close to the second ZITTEL's syntype of *Semiformiceras gemmellaroi* in the lowest part of the *semiforme* Zone of the Central Apennines. When comparing the specimens from the *semiforme* Zone (and corresponding ZITTEL's second syntype) with those discussed before from the *fallauxi* Zone, it may be easily stated that the former are generally more involute, with umbilical width smaller than the whorl height, and they bear smaller number of ribs with clavi on the body chamber.

The differences between the two groups of specimens allow the differentiation of two distinct species, as already suggested by CECCA & *al.* (1985). Consequently, only the specimens coming from the *fallauxi* Zone, and being close to the lectotype here designated (ZITTEL 1870, Pl. 4, Fig. 10), are left in the species *Semiformiceras gemmellaroi* (ZIT.), whereas the specimens from the *semiforme* Zone are here attributed to the new species *Semiformiceras birkenmajeri* sp. n. It may be added that the presence of the species *Semiformiceras birkenmajeri* sp. n. in the lower part of the *semiforme* Zone is of phylogenetic significance as it introduces some complications into the phyletic pattern of the genus *Semiformiceras* interpreted by ENAY (1983).

Semiformiceras birkenmajeri sp. n.
(Pl. 1, Figs 1—5)

Partim 1870. *Oppelia gemmellaroi* ZITTEL; ZITTEL, pp. 62—63, Pl. 4 (28), Fig. 11ab.

HOLOTYPE: Specimen No. IGPUW/A19/1, figured in Pl. 1, Fig. 1a-b, deposited in the Institute of Geology, University of Warsaw.
PARATYPES: Specimens No. IGPUW/A19/2,3 figured in Pl. 1, Figs. 2-3.
TYPE HORIZON: Rogoźnik Coquina Member, Rogoża klippes, bed *18* of the section (Text-fig. 1 and Table 2), most probably the lower part of the *semiforme* Zone.
TYPE LOCALITY: Rogoża klippes near Rogoźnik (Text-fig. 1).
DERIVATION OF THE NAME: In honour of Professor Krzysztof BIRKENMAJER, an outstanding student of the Pieniny Klippen Belt.
MATERIAL: 3 nearly complete specimens and 13 fragments representing mostly parts of body chamber.
DIMENSIONS:

Table 3

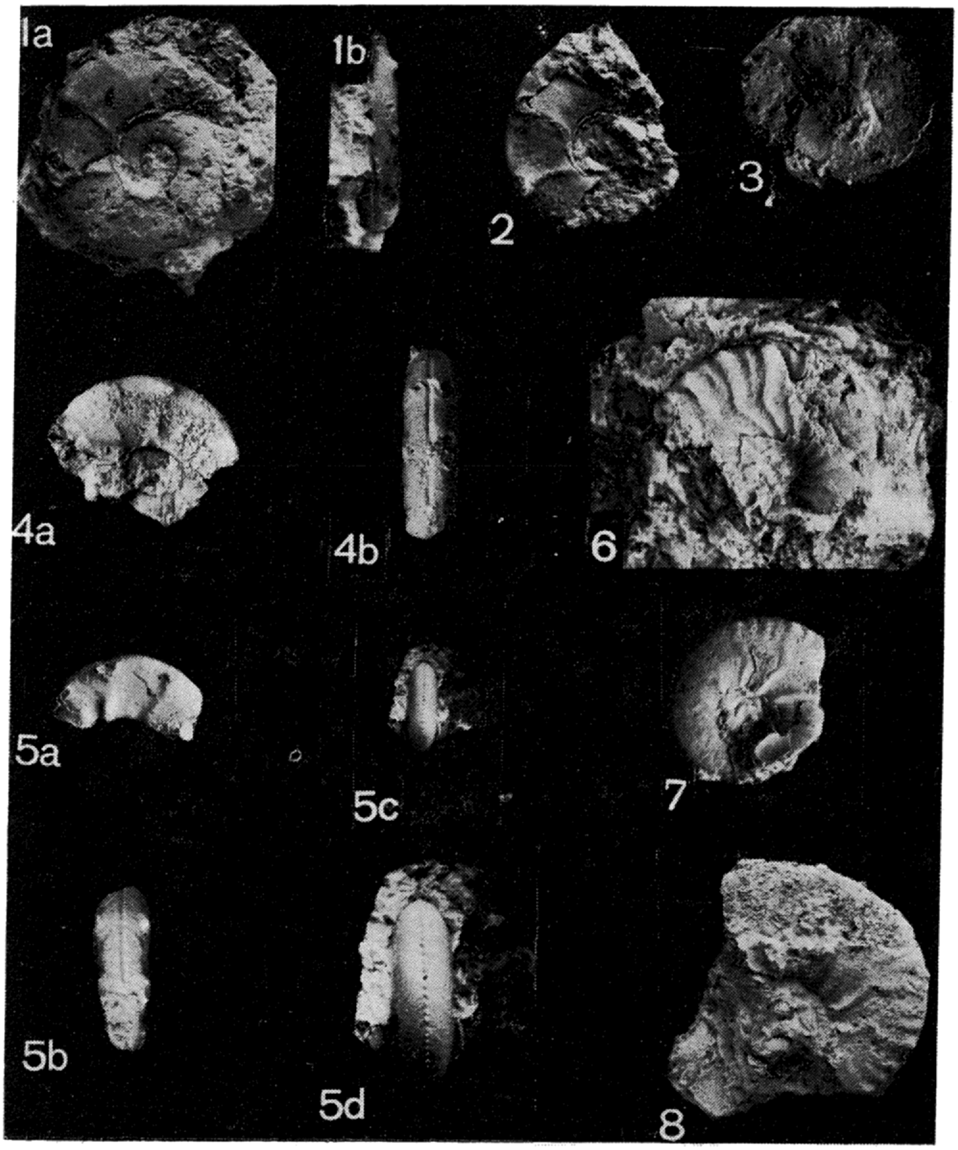
Specimen No.	D (mm)	Ud (mm)	Ud (%)	Wh (mm)	Wh (%)
holotype JGPUW/A19/1	27 23	9 7.5	33 32.5	9.5 9	35 39
paratype JGPUW/A19/2	25 20	8 5	31.5 25	10 9	40 44.5
paratype JGPUW/A19/3	25	7	28	10	40

DESCRIPTION: The more complete specimens attain about 25—27 mm in diameter, but the maximum diameter is slightly bigger as the peristome is broken off; the flexuous end-peristome is preserved only in some fragmentary specimens. The species is rather weakly involute at the end of the last whorl, and moderately involute in the more inner part of the whorl (Table 3). A few ribs (about 3) bearing strong marginal clavi appear on the body chamber, whereas on the inner as well as on the outer whorls fine striae are well visible when the shell is preserved. The ventral side of the last whorl bears a distinct groove which shallows but slightly at the end part of the whorl. On the inner whorls the venter is minutely serrated (Pl. 1, Figs 5c-5d).

REMARKS: The differences between the new species and *Semiformiceras gemmellaroi* (ZIT.) emended here have been discussed above. The species *S. birkenmajeri* sp. n. differs from "*Oppelia*" *domoplicata* ZITTEL, 1870, mostly by its bigger size and the presence of a groove on the ventral side.

Taramelliceras

The ammonites of this genus are rather rare in the deposits studied: four specimens have been collected in the beds *20* and *22* of the Rogoża klippes (*cf.* Table 2) and two others in the Stankowa-Skała klippe. All the specimens belong to the subgenus *Parastreblites* of DONZE & ENAY (1961) as indicated by the presence of smooth, flattened ventral side of

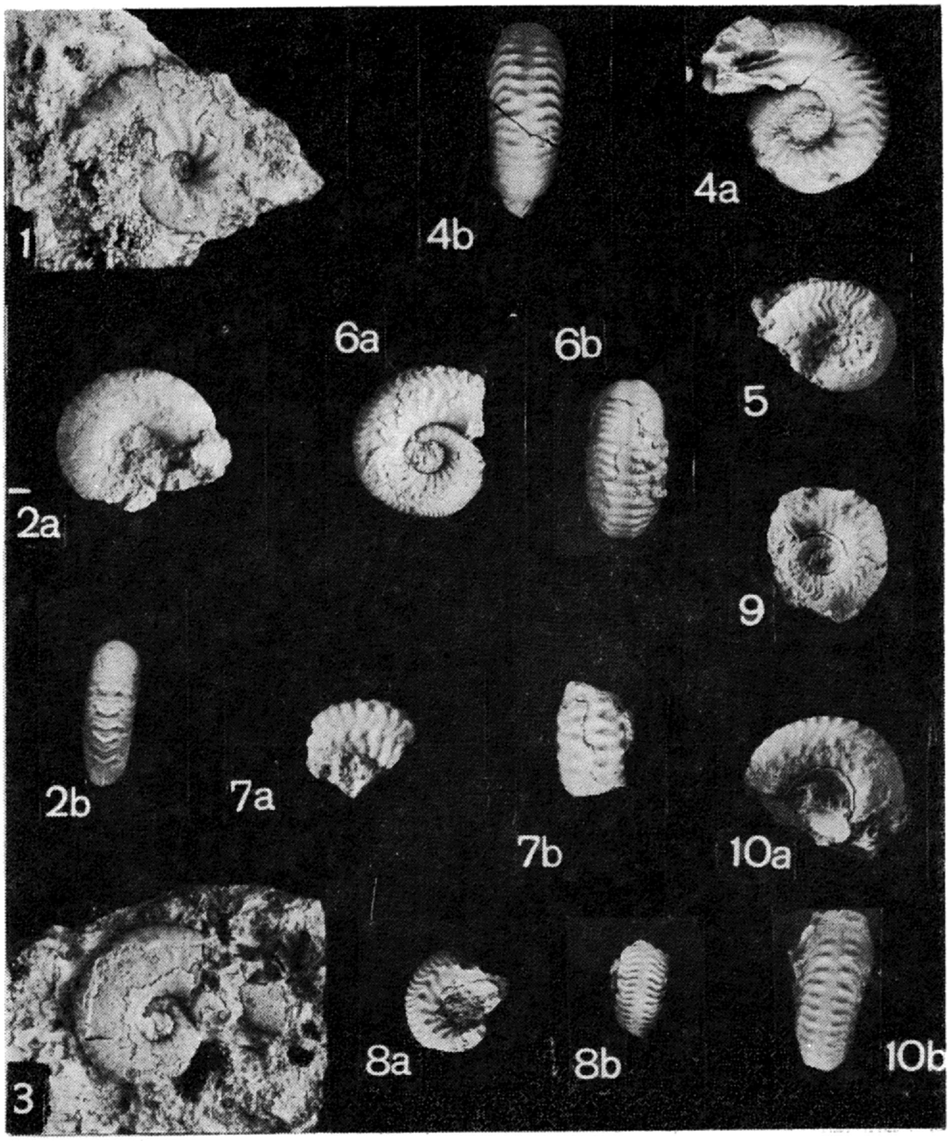


Ammonites from the Rogoźnik Coquina Member

1-5 — *Semiformiceras birkenmajeri* sp. n.; 1a-1b specimen No. IGPUW/A19/1, holotype; 2 (IGPUW/A19/3), paratype; 3 (IGPUW/A19/2), paratype; 4a-4b (IGPUW/A19/4); 5a-5d (IGPUW/A19/5), *5a-5b* fragment of outer whorl, *5c* ventral side of inner whorl, *5d* ditto × 2; all specimens from the Rogoża klippes, section (cf. Table 2), bed 18;

6-8 — *Taramelliceras (Parastreblites)* cf. *waageni* (ZITTEL); 6 (IGPUW/A19/15), Stankowa-Skała klippe, section (cf. Text-fig. 3); 7 (IGPUW/A19/13) and 8 (IGPUW/A19/12), Rogoża klippes, section (cf. Table 2), bed 22

All photos (except of 5d) of natural size; taken by S. KOLANOWSKI



Ammonites from the Rogoźnik Coquina Member

1 — *Taramelliceras (Parastreblites)* cf. *waageni* (ZITTEL); specimen No. IGPUW/ /A19/14, Stankowa-Skała klippe, section (cf. Text-fig. 3);

2-3 — *Sutneria asema* (OPPEL); 2a-2b (IGPUW/A19/31), Rogoża klippes, section (cf. Table 2), bed 17; 3 (IGPUW/A19/33), Stankowa-Skała klippe, section (cf. Text-fig. 3)

4-6 — *Simocosmoceras simum* (OPPEL); 4a-4b (IGPUW/A19/27), Rogoża klippes, section (cf. Table 2), bed 11; 5 (IGPUW/A19/23) and 6a-6b (IGPUW/A19/24); Rogoża klippes, section (cf. Table 2), bed 16

7 — *Simocosmoceras* cf. *adversum (OPPEL)*; specimen No. IGPUW/A19/34, Rogoża klippes, section (cf. Table 2), bed 16

8-10 — *Simocosmoceras catulloi* (ZITTEL); 8a-8b (IGPUW/A19/29), Rogoża klippes, section (cf. Table 2), bed 15; 9 (IGPUW/A19/25) and 10a-10b (IGPUW/A19/26), Rogoża klippes, section (cf. Table 2), bed 16

All photos of natural size; taken by S. KOLANOWSKI

the whorl, the falcoid ribbing and the ventrolateral tubercles (Pl. 1, Figs 6-8; Pl. 2, Fig. 1). The specimens are small, fragmentary, and hence they may be referred but with reservation to the species *Taramelliceras (Parastreblites) waageni* (ZIT.) reported previously, but not illustrated from Rogoźnik (ZITTEL 1870, p. 24).

Sutneria

The representatives of the species *Sutneria asema* (OPPEL) have been found in the beds *12, 17, 19* and *20* in the Rogoża klippes (*cf.* Table 2) as well as in the Stankowa-Skała klippe section (Text-fig. 3). The specimens are involute (close to the peristome, at D 21 — 24 mm: Wh = = 39.5—40.5%, Ud = 27—33%; in the more inner part of the body-chamber, at D 16 — 18 mm: Wh = 45—50%, Ud = 26—28%), show an oval whorl-section with somewhat flattened sides, and falcate ribbing (Pl. 2, Figs 2-3). The ribbing is generally fine except for the periumbilical part of the whorl where small umbilical folds can be observed, and for the venter. On the phragmocone and the initial to the middle part of the body chamber some ribs become more swollen at the ventral side of whorl and form backward knee bends truncating normal fine ribs which seem to indicate that they are of parabolic type (Pl. 2, Fig. 2b). The end part of the body chamber is very weakly ribbed, but with markedly developed peristomal constriction. The lappets are not preserved in any specimens.

The relation of the discussed species to the other species of the genus is not clear. After GEYER (1969, Text-fig. 1) the species is closely related to *Sutneria eugyra* BARTHEL, but the whorl section, including the relation of whorl height to whorl thickness, and the characters of ribbing at umbilicus and at the ventral side of the two forms are different (*see* BARTHEL 1959). On the other side, the species *Sutneria asema* and *Sutneria bracheri* BERCKHEMER show similar end-size, flattened whorl-sides and a comparable character of ribbing, *e.g.* the presence of the umbilical folds visible even in specimens devoid of the shell (*see* BARTHEL 1959, 1962). In any case the species *Sutneria asema* (OPPEL) ought to be placed within the group of finely ribbed species distinguished as the *Sutneria rebholzi* group by GEYER (1969).

Simocosmoceras

The genus distinguished by SPATH in 1925 is based mostly on the material from Rogoźnik, and it includes three species (of four placed actually in the genus) established here by OPPEL & ZITTEL (*see* ZIT-

TEL 1870). Of these, *Simocosmoceras* [= "*Cosmoceras*"] *adversum* (OPP.) is the type species of the genus, whereas two others, *Simocosmoceras simum* (OPP.) and *Simocosmoceras catulloi* (ZIT.), have been placed by SPATH (1925) "provisionally" in the genus. The fourth species, *Simocosmoceras pampalonii* C. & PALL., has recently been established by CRESTA & PALLINI (1985) on the base of a single specimen from Italy.

The genus is poorly represented in the collections described until recently: generally there are known about 15 specimens (*see* CRESTA & & PALLINI 1985) found in a few places in Spain, France, Italy, Poland, and Romania, within the Middle Tithonian strata of the Mediterranean province. The new material recently collected in Rogoźnik comprises 10 specimens, of which four well preserved belong to the species *Simocosmoceras simum* (OPP.), three to *S. catulloi* (ZIT.), one fragmentary specimen — most possibly to *S. adversum* (OPP.), and two small and fragmentary specimens cannot be unequivocally assigned to any of these species — but they seem to be closest to *S. catulloi* (ZIT.). Hence, the material studied is relatively abundant (*see* Pl. 2, Figs 4-6 and 8-10; Table 4) and it makes possible some new observations mostly on the species *Simocosmoceras simum* (OPP.) and *S. catulloi* (ZIT.).

The specimens of *Simocosmoceras simum* (OPP.), as stated in the material studied, attain 23 mm in diameter; the aperture exhibits the elongate lappets (Pl. 2, Fig. 4a). The body chamber is about half a whorl long. The coiling is involute; whorl section depressed, pentago-

Table 4

Specimen No.	D(mm)	Ud(mm)	Ud(%)	Wh(mm)	Wh(%)	Wt(mm)	Wt(%)
Simocosmoceras simum (Opp.)							
JGPUW/A19/27	22.5 16	7.75 5	34.5 31	8.5 7	37.5 43.5	9 9	40 56
JGPUW/A19/23	20.5 18.5	7 5.5	34 30	8 8	39 43.5	8.5 8.5	41.5 48.5
JGPUW/A19/24	17.5	5	28.5	8	45.5	9.5	54
JGPUW/A19/28	15	5	33	6.5	43	7.5	50
Simocosmoceras catulloi (Zittel)							
JGPUW/A19/26	21.5	7.5	34.5	8	37	8.5	39.5
JGPUW/A19/25	17.5	5.75	32.5	6.75	38.5	8	46
JGPUW/A19/29	15	4.5	30	5.5	37	6.5	43

nal in cross section on the last whorl. The inner whorls are ornamented with short primary ribs only in the periumbilical part. At a diameter of about 10 mm, which corresponds to the beginning of the last whorl, there appear secondary ribs at the ventral side. The primaries are almost rectiradiate at the umbilicus, and distinctly prorsiradiate on the whorl side; the branching of primaries and/or intercalated ribs may appear somewhat above the umbilical wall. At the mid-height of the last whorl the primaries become swollen and they show a distinct knee-bent, splitting afterwards into 2 — 4 secondaries in the older part of the whorl, and up to 2 secondaries closer to the aperture. The secondary ribs are rursiradiate, concave, thinner than primaries in the inner part of the last whorl and uniformly developed in the outermost part of the whorl. The ventral side of the inner whorls is rounded; on the last whorl it becomes flattened and somewhat grooved closer to the aperture. The ribbing in the middle of the venter fades more or less, sometimes even completely when the ventral groove is deeper incised. At the borders of the median ventral band of weakening of ribbing, the secondary ribs become slightly swollen, and occasionally when the ribs are looped, weak tubercles may also appear (Pl. 2, Figs 4b, 6b).

The species *Simocosmoceras catulloi* (ZIT.) shows close affinity to *S. simum* (OPP.), as indicated already by ZITTEL (1870) who separated *S. catulloi* from *S. simum* due to such features as the development of lateral tubercles, smaller thickness of whorl, the presence of the smooth spiral band on the ventral side of whorl, and a different rib division. However, ZITTEL (1870) also pointed out that there is a transition between the two species when taking into account the degree of development of the lateral tubercles.

The new material of *Simocosmoceras catulloi* (ZIT.) from the Rogoża klippes section (Pl. 2, Figs 8-10) provides additional evidence for the affinity between the two discussed species. The most important observations are:

(i) The presence of a smooth spiral band on the venter is a common feature of the studied specimens of *S. catulloi* but, as shown before, it is stated also in some specimens of *S. simum;*
(ii) The looped secondary ribs occur rather frequently at the venter in the studied specimens of *S. catulloi,* and are also found occasionally in *S. simum.*

Morphologically, *Simocosmoceras catulloi* (ZIT.) occupies a position very close to *S. simum* (OPP.) sharing with the latter many of its features (*see also* CRESTA & PALLINI 1985, Tab. 1). Because of the scarcity of the material available, and until new material is collected, it is difficult to state whether they represent two closely related species, as treated actually, or but variants of a single highly variable species.

The new material of *Simocosmoceras adversum* (OPP.) from the Rogoża klippes is too scanty to contribute much that is new, and to characterize the species more closely (Pl. 2, Fig. 7). The specimen is characterized by the presence of strong lateral and ventral tubercles, the latter alternating on the venter, and the common occurrence of looped secondary ribs (*see* ZITTEL 1870, OLORIZ-SAEZ 1978, CRE-

STA & PALLINI 1985). The species *Simocosmoceras pampalonii* CRESTA & PALLINI, not stated in the material studied, seems to be very close to if not conspecific with *S. adversum*.

The stratigraphical ranges of the discussed species of *Simocosmoceras* in the section of the Rogoża klippes are very similar: the specimens of *Simocosmoceras simum* (OPP.) are known from the beds *16*, *15* and *11*, those of *S. catulloi* (ZIT.) from the beds *16* and *15* (but note also the presence of poorly preserved specimens possibly belonging to this species in the beds *11* and *9*), the species *S. adversum* (OPP.) from the bed 16. All these species are closely related, and it is quite possible that they represent in fact but variants of one biospecies.

There exists an almost overall agreement that *Simocosmoceras* is most possibly related to *Sutneria* (see OLORIZ-SAEZ 1978, CRESTA & & PALLINI 1985, and earlier papers cited therein). Of the possible forerunners of the *Simocosmoceras* group the two species could be indicated especially: *(i)* the poorly known *"Cosmoceras" nitidulum* NEUMAYR (belonging possibly to the genus *Sutneria;* see CRESTA & & PALLINI 1985) which relation to *S. catulloi* (ZIT.) was already indicated by NEUMAYR (1873); *(ii) Sutneria subeumela* SCHNEID which presents some similarities mostly in the character of the ventral side and in the whorl-section.

PALEOTECTONIC POSITION OF THE CZORSZTYN SUCCESSION

The Upper Jurassic sediments of the Czorsztyn succession accumulated on the Czorsztyn ridge, a "geanticlinal" unit developed on continental crust (BIRKENMAJER 1986). This ridge was bordered by two radiolarite-bearing basins, the Magura basin to the north and the Pieniny basin to the south; these basins had a basement built up of oceanic, or at least attenuated continental crust.

In the Late Jurassic, the depositional area of the Outer Carpathians was also differentiated into deeper basins in which pelagic sedimentation prevailed, and elevated areas from which various shallow-marine sediments (*e.g.* the Stramberk Limestone) are known (MIŠIK 1974).

The Czorsztyn ridge can be interpreted as a splinter of continental crust separated during Jurassic time from the European continent by rifting and transformation of rifts into bathyal basins (BIRKENMAJER 1986). In the Late Jurassic, however, the Czorsztyn ridge, being already separated from the European continent by bathyal zones, was no more part of the northern shelf of the Tethys (in which shelf, in turn, large parts of the cratonic area of Poland were included during most of Late

Jurassic time). In a very broad sense, the Czorsztyn ridge can be regarded as part of the northern margin of the Tethys.

The Pieniny Klippen Belt, and/or some adjacent zones, are generally regarded as a suture zone linking the ophiolitic units of the Penninic Zone of the Alps with the ophiolite-bearing units of Romania. The interpretations differ in detail, an oceanic basement being attributed to the Magura basin, the Pieniny Basin and/or to some zones still further south (comp. *e.g.* DEBELMAS & *al.* 1980, MAHEL 1982; MICHALIK & KOVAC 1982; SANDULESCU 1983, 1986; BIRKENMAJER 1986). In any case, however, it is admitted that the Upper Jurassic sediments of the Austroalpine units as well as those of the Hungarian Transdanubian Mid-mountains accumulated, within the Tethys, south of a zone (or zones) underlain by oceanic crust, whereas those of the Czorsztyn ridge were laid down to the north of this zone, or between such zones.

TITHONIAN BIOGEOGRAPHY

The Early and Middle Tithonian ammonite faunas of the Czorsztyn succession are typical of the Mediterranean province, as indicated by the occurrence of numerous lytoceratids and phylloceratids together with such characteristic forms as, for instance, *Haploceras, Semiformiceras, Cyrtosiceras, Simoceras, Virgatosimoceras, Simocosmoceras, Richterella,* the "*contiguus* group" and *Discosphinctoides geron* (comp. ZEISS 1968; ENAY 1972, 1973; CARIOU & *al.* 1985). Such forms are commonly found along the European border of the Tethys, as well as in Tethyan regions farther south, a marked biogeographical contrast between the northern and the southern margin of the Tethys having existed in Tithonian time only east of the Apulian block (CARIOU & *al.* 1985). The presence of *Buchia* (reported as *Aucella*) as a Boreal faunistic element in the Czorsztyn succession of the Pieniny Klippen Belt (ZITTEL 1870), as well as in the Outer Carpathians of Austria (VETTERS 1905), seems to be of some biogeographic significance.

Several genera and species found in the Czorsztyn succession, for instance *Protancyloceras, Glochiceras lithographicum* (OPP.), *G. carachtheis* (OPP.), *Sutneria asema* (OPP.), *Virgatosimoceras albertinum* (CAT.) and *Semiformiceras fallauxi* (OPP.) are also known from platformic areas of Europe such as southern Germany and southern France (comp. *e.g.* HÖLDER & ZIEGLER 1959, ZEISS 1968, BARTHEL & GEYSSANT 1973, ENAY 1983). It is also highly probable that the Tithonian Ataxioceratidae from the Czorsztyn succession, which cannot be identified at generic or specific level, comprise several genera and species known from platformic areas of Europe. On the other hand, many Early and Middle Tithonian genera and species known from the

Czorsztyn succession have been reported by VIGH (1984) from sections in the Hungarian Transdanubian Mid-mountains, a region situated south of the Alpine-Carpathian Penninic-Pieninic suture zone. The Mediterranean ammonite assemblages of Hungary, in turn, comprise *i.a.* many genera and species of the Ataxioceratidae, established in Franconia.

THE GENUS *PSEUDOVIRGATITES*: STRATIGRAPHIC AND BIOGEOGRAPHIC ASPECTS

The genus *Pseudovirgatites*, as interpreted by KUTEK & ZEISS (1974) and ZEISS (1977) evolved from *Ilowaiskya* and gave rise to the genus *Zaraiskites*. In Central Poland the boundary between the Lower Volgian (*pseudoscythica* or *puschi* Zone) and the Middle Volgian (*scythicus Zone*) substages (KUTEK & ZEISS 1974) is marked by the evolution of *Zaraiskites* from *Pseudovirgatites*. This, together with the known occurrence of *Pseudovirgatites* with Late Tithonian ammonites in the outer West Carpathians, made it possible to suggest that the base of the Middle Volgian is equivalent to the base of the Upper Tithonian (ZEISS 1977, 1983), or corresponds to a level slightly above the lower boundary of the Upper Tithonian Substage (KUTEK & ZEISS 1974). It should be born in mind, however, that no detailed sequence of ammonites could be established in the Outer Carpathians at the localities at which *Pseudovirgatites* had been reported to occur within the Klentnice Beds or the Stramberk Limestone. Different correlations have been proposed recently by MESEZHNIKOV (1982) and JELETZKY (1984), in which a pre-Late Tithonian age is suggested for large parts or the total of the Middle Volgian Substage.

The genus *Pseudovirgatites* has not been found in the Czorsztyn succession in Poland, but it was reported by NEUMAYR (1871b, pp. 479—480) to occur in this succession at Kyjov (Kiow) in eastern Slovakia; a description of the same section was given by BIRKENMAJER (1963, pp. 296—297). At Kyjov, strata displaying lithologies commonly found in Lower to Middle Tithonian sections of the Czorsztyn succession and containing unidentifiable ammonites, are overlain by white massive coquinas *ca.* 10 m thick. The list of ammonites found by NEUMAYR in these coquinas includes, in addition to several lytoceratids and phylloceratids, *Haploceras elimatum* (OPP.), *H. tithonium* (OPP.), *Glochiceras carachtheis* (ZEUSCHN.), *Substreblites zonarius* (OPP.), *Paraulacosphinctes transitorius* (OPP.), *Microcanthoceras microcanthum* (OPP.), *Pseudovirgatites scruposus* (OPP.), and a from referred to as *Perisphinctes* cf. *occitanicus* PICTET. Except for the last form, this is a clearly Late Tithonian assemblage, and it was already recognized as such by NEUMAYR (1871b). This assemblage comprises several significant Late Tithonian but no diagnostic Middle Tithonian forms, thus providing evidence for an Late Tithonian age of *Pseudovirgatites*.

Several important ammonite successions from sections of the Hungarian Transdanubian Mid-mountains have recently been described by VIGH (1984). Here again the occurrence of *Pseudovirgatites* is restricted to the Upper Tithonian Substage. Most specimens of this genus, referred to as *Pseudovirgatites* cf. *seorsus* (OPP.), *Pseudovirgatites* sp. ex gr. *seorsus* (OPP.) and *Pseudovirgatites* sp., have been found in the *microcanthum* Zone. The presence of forms referred to as ?*Pseudovirgatites* aff. *scruposus* (OPP.) above the *microcanthum* Zone may suggest that some representatives of *Pseudovirgatites* range up into higher horizons of the Upper Tithonian.

Another line of stratigraphic evidence is provided by the finding of a specimen of *Zaraiskites* by NOWAK (1971, Pl. 1) in the Stara Planina in Bulgaria, in a rock containing calpionellids indicative of the Upper Tithonian *Crassicollaria* Zone; it was suggested by SAPUNOV (1977, 1979) that the strata that yielded this specimen belong to the *microcanthum* Zone. The specimen itself displays the type of ribbing peculiar to the late zaraiskitids occurring in cratonic areas of Poland and Russia in the *zaraiskensis* Subzone, which is the upper subzone of the *scythicus* Zone of Poland and also of the equivalent *panderi* Zone of the Russian platform. The Bulgarian data thus indicate un Upper Tithonian age of the upper part of the Middle Volgian *scythicus* Zone at least.

In the Tethyan Realm, true *Pseudovirgatites* has been reported from Upper Tithonian strata only, and this genus is known to be the ancestor of the genus *Zaraiskites*. In Volgian sections the occurrences of *Zaraiskites* are restricted to the *scythicus* Zone (or the *panderi* Zone, the stratigraphic range of these two zones being the same). From this the conclusion may be drawn that the *scythicus* Zone corresponds to some part of the Upper Tithonian; and, as the *scythicus* Zone (or the equivalent *panderi* Zone) is by definition the basal zone of the Middle Volgian, this also implies a post-Middle Tithonian age for the total of this substage. More sophistication, however, must be introduced into this line of reasoning as in Central Poland, where the evolution of *Zaraiskites* from *Pseudovirgatites* can be demonstrated, the latter genus is only represented by the species *P. passendorferi* (KUTEK & ZEISS) and *P. puschi* (KUTEK & ZEISS), whereas other species are known (KUTEK & ZEISS 1974, ZEISS 1977, VIGH 1984) from the Tethyan sections of the Carpatho-Balcanic region: *Pseudovirgatites scruposus* (OPP.), *P. seorsus* (OPP.) and P. *sorgenfrei* (ZEISS). Thus a lineage of *Pseudovirgatites* may have still evolved in some Tethyan areas after the Polish representatives of this genus had been replaced by *Zaraiskites*. Such an interpretation has been advanced by ZEISS (1977, 1983), and it seems to find support in VIGH's (1984) data suggesting the presence of *Pseudo-*

virgatites at rather high levels of the Upper Tithonian. On the other hand, the Bulgarian data discussed above indicate independently a Late Tithonian age of at least the upper part of the *scythicus* Zone. Therefore, at the present state of knowledge, an approximate stratigraphic equivalence of the Lower/Middle Volgian and Middle/Upper Tithonian boundaries, as advocated by ZEISS (1977, 1983; ZEISS *in* JELETZKY 1984), may be considered to be a reasonable solution of the problem here discussed.

The genus *Pseudovirgatites* is known to occur in the Hungarian Transdanubian Mid-mountains, in the Czorsztyn succession of the Pieniny Klippen Belt, in the outer West Carpathians in Austria, Czechoslovakia and Poland, and in the cratonic area of Central Poland (for earlier biostratigraphic data not discussed above *see* KUTEK & ZEISS 1974, 1975; ZEISS 1977). Some specimens from the highest Lower Volgian of the Russian platform, described by MIKHAILOV (1964) as *Wheatleyites*, seem also to belong to *Pseudovirgatites*.

The genus *Ilowaiskya*, common in the Lower Volgian deposits of Poland and the Russian platform, is also represented by a few specimens found in Franconia and the outer Carpathians of Czechoslovakia (ZEISS 1968, 1977). A questionable specimen of *Ilowaiskya* has been reported by VIGH (1984) as? *Ilowaiskya* sp. (ex gr. *klimovi* IL. & Flor.) from the *hybonotum* Zone of the Transdanubian Mid-mountains.

The genus *Zaraiskites*, which occurs in profusion in cratonic areas of Poland and in the Russian platform, especially in its southern parts (MESEZHNIKOV 1982), has also been found in the outer West Carpathians of Austria and Poland (KSIĄŻKIEWICZ 1974, ZEISS 1977). The specimens from Franconia reported in earlier papers as *Zaraiskites* do not belong to this species (*cf.* KUTEK & ZEISS 1975, p. 127). NOWAK's specimen of *Zaraiskites* was found in a region of Bulgaria which formed part of the Eurasian plate during Jurassic time (*cf.* SANDULESCU 1980).

Thus, with the notable exception of the Transdanubian region of Hungaria, the occurrences of the evolutionary lineage *Ilowaiskya* → *Pseudovirgatites* → *Zaraiskites* seem to have been restricted to what may be called the eastern part of the European margin and shelf of the Tethys, the epicratonic Tethyan-connected sea of the Russian platform included.

OXFORDIAN AND KIMMERIDGIAN BIOGEOGRAPHY

Lists of Oxfordian and Kimmeridgian ammonites reported from the Czorsztyn succession by earlier authors (*e.g.* NEUMAYR 1871a, b, 1873; UHLIG 1890) have been compiled by BIRKENMAJER (1963). The lists, which comprise over seventy species, reveal the Mediterranean characters of the Oxfordian and Kimmeridgian assemblages, including numerous species of Lytoceratidae and Phylloceratidae. Other families are mainly represented by genera and subgenera known both from the

Mediterranean province of the European Tethys and from the Submediterranean province of cratonic Europe, such as *Taramelliceras*, *Proscaphites*, *Gregoryceras*, *Epipeltoceras*, *Paraspidoceras*, *Euaspidoceras*, *Aspidoceras*, *Hybonoticeras*, *Perisphinctes* s.s., *Arisphinctes*, *Orthosphinctes*, *Larcheria*, *Idoceras*, *Ataxioceras*; the presence of *Ringsteadia*, *Involuticeras* and *Prorasenia* is also worth of note. With the exception of the lytoceratids and phylloceratids, the bulk of the Middle and Late Oxfordian and Kimmeridgian ammonite faunas of the Czorsztyn succession is composed of species which also occur in Europe beyond the Alpine chains, *a.o.* in the Polish foreland of the Carpathians. This fact was already pointed out by NEUMAYR (1871a, b, 1873). It is also worth of note that several taxa known from the Czorsztyn succession have also been reported from the Eastern Alps (see *e.g.* TOLLMANN 1976).

The presence of the genus *Cardioceras*, represented by the species *Cardioceras (Miticardioceras) tenuiserratum* (OPP.) and *C. (M.) crenocarinum* (NEUM.), in the Middle Oxfordian deposits of the Czorsztyn succession (NEUMAYR 1871a, p. 366, Pl. 18, Figs 6-7), is of special interest. In the Carpatho-Balkan region, the southern limit of occurrence of *Cardioceras* falls within the Pieniny Klippen Belt, but this genus is fairly well represented in different structural units of the Outer Carpathians of Czechoslovakia and Poland, having been reported from the localities of Cetechovice (ARKELL 1956), Bachowice (KSIĄŻKIEWICZ 1956) and Kruhel (WÓJCIK 1914).

The occurrence, in the Czorsztyn succession, of many Oxfordian and Kimmeridgian ammonites known from cratonic Europe, and especially the presence of *Cardioceras*, is consistent with the location of the Czorsztyn ridge in Late Jurassic time within the northern margin of the Tethys.

CONCLUSIONS

The area of deposition of the Czorsztyn succession belonged to the Late Jurassic Mediterranean province. The Oxfordian, Kimmeridgian and Tithonian faunas of the Czorsztyn succession are typical of the northern margin of the European Tethys, and some taxa, *e.g.* Cardioceratidae and *Buchia*, have their southern limit of occurrence in the Pieniny Klippen Belt. On the other hand, many ammonites forming part of the assemblages of the Czorsztyn succession are also known from cratonic areas of Europe, and/or the Eastern Alps and the Transdanubian Mid-mountains, the latter regions located south of the Penninic-Pieninic suture zone; even *Pseudovirgatites*, which could have been regarded as characteristic of the northern margin of the Tethys, has been reported from the Transdanubian region. Thus, taking into account the fact that the Late Jurassic Czorsztyn ridge was bordered by bathyal zones, the conclusion can be drawn that bathyal basins, even those underlain by oceanic crust, were no obstacles to the migration of many ammonites. This is consistent with the narrowness of the bathyal zones of the Alpine and Carpathian regions, an explanation already suggested by CARIOU & *al.* (1985).

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NOWE DANE O STRATYGRAFII I AMONITACH SUKCESJI CZORSZTYŃSKIEJ PIENIŃSKIEGO PASA SKAŁKOWEGO POLSKI

(Streszczenie)

Pierwsza część publikacji poświęcona jest muszlowcom ogniwa z Rogoźnika i ogniwa z Rogoży, występujących w ich miejscowości typowej — skałkach Rogoża (*por.* BIRKENMAJER 1977). Górna część muszlowców z Rogoźnika, głównie beriaskiego wieku, wykształcona jest w postaci białych muszlowców mikrytowych, natomiast ich dolna część w postaci czerwonawych muszlowców sparytowych (fig. 1). W muszlowcach sparytowych autorzy prześledzili już dawniej następstwo amonitów (KUTEK & WIERZBOWSKI 1979), co pozwoliło (tab. 1) na wydzielenie dolnotytońskich poziomów *hybonotum* i *darwini* oraz środkowotytońskich poziomów *semiforme* i *fallauxi*. Nowe znaleziska amonitów pozwoliły na wzbogacenie listy amonitów zlokalizowanych w profilu (tab. 2), doprowadzając zarazem do pewnej modyfikacji uprzednich interpretacji stratygraficznych. Rozważane skałki dostarczają także profilu (fig. 2), w którym ponad czerwonymi mikrytowymi muszlowcami ogniwa muszlowca z Rogoży, reprezentującymi dolny i środkowy tyton, leżą białe muszlowce mikrytowe beriaskiego (i późnotytońskiego ?) wieku. Z pośrednich danych wynika, że ogniwo z Rogoży spoczywa na doggerskiej formacji wapienia ze Smolegowej, i że dolne partie ogniwa z Rogoży reprezentują kimeryd i być może także oksford.

Kolejna część publikacji poświęcona jest profilowi utworów górnojurajskich ze Stankowej Skały, która wraz z sąsiednią Babiarzową Skałą dostarczała w przeszłości licznych amonitów oksfordu, kimerydu i tytonu (NEUMAYR 1871a, b, UHLIG 1890, BIRKENMAJER 1968). Na Stankowej Skale ponad formacją ze Smolegowej występują, oddzielone luką stratygraficzną, czerwone wapienie (fig. 3) zaliczane do formacji wapienia czorsztyńskiego i reprezentujące środkowy i górny oksford oraz kimeryd. Wyżej pojawiają się sparytowe muszlowce ogniwa z Rogoźnika, w obrębie których znaleziono w kilku horyzontach, zespoły amonitowe reprezentujące poziomy *hybonotum*, *darwini* i *semiforme*. Na uwagę zasługuje występowanie tu nie stwierdzonych w skałkach Rogoży taksonów indeksowych (por. tab. 1): *Semiformiceras darwini* (NEUM.) i *Virgatosimoceras albertinum* (CAT.). Ze wspomnianymi muszlowcami wzdłuż kontaktu tektonicznego stykają się zawierające beriaskie kalpionelle białe muszlowce mikrytowe, reprezentujące wyższą część ogniwa z Rogoźnika.

Górna część ogniwa muszlowców z Rogoży jest odpowiednikiem wiekowym dolnej części ogniwa muszlowca z Rogoźnika, wykształconej w postaci muszlowców sparytowych (fig. 4).

Dolna część ogniwa z Rogoży znajduje swój odpowiednik wiekowy w formacji wapienia czorsztyńskiego. Z kolei odpowiednikiem zarówno wiekowym, jak i litologicznym, białych muszlowców mikrytowych późnotytońskiego i beriaskiego wieku, stanowiących górną część obecnego ogniwa z Rogoźnika, są białe muszlowce mikrytowe, występujące ponad ogniwem muszlowca z Rogoży. Wyrażono sugestię, że owe białe muszlowce mikrytowe, w tym i muszlowce obecnie włączane do ogniwa muszlowca z Rogoźnika, zasługują na wyodrębnienie w postaci osobnej jednostki litostratygraficznej.

Paleontologiczna część publikacji zawiera opisy i ilustracje wybranych amonitów (*patrz* tab. 3—4 oraz pl. 1—2), reprezentującyh rodzaje *Semiformiceras, Taramelliceras, Sutneria* i *Simocosmoceras*. Część amonitów, zaliczanych dotychczas do gatunku *Semiformiceras gemmellaroi* (ZIT.), włączona została do gatunku nowego, *Semiformiceras birkenmajeri* sp. n.

Końcowa część publikacji obejmuje rozważania biogeograficzne, przy czym szczególną uwagę poświęcono stratygraficznej i biogeograficznej problematyce rodzaju *Pseudovirgatites*. Dodatkowe dane dotyczące występowania tego rodzaju, a także rodzaju *Zaraiskites* w górnotytońskich utworach Słowacji, Węgier i Bułgarii wzmacniają argumentację na rzecz wcześniejszych korelacji stratygraficznych (KUTEK & ZEISS 1974, 1975; ZEISS 1977, 1983), wedle których środkowy wołg znajduje swój odpowiednik wiekowy w górnym, a nie w środkowym tytonie. Późnojurajskie zespoły faunistyczne sukcesji czorsztyńskiej reprezentują medyterańską prowincję biogeograficzną, wykazując zarazem cechy zespołów charakteryzujących w późnej jurze północne obrzeże europejskiej Tetydy; z sukcesją tą związana jest m.in. południowa granica występowania Cardioceratidae i rodzaju *Buchia*. Z drugiej jednak strony wiele oksfordzkich, kimerydzkich i tytońskich amonitów, stwierdzonych w sukcesji czorsztyńskiej, występuje także na kratonicznych obszarach Europy, a ponadto np. we Wschodnich Alpach i w Średniogórzu Zadunajskim, czyli w regionach położonych na południe od penińsko-pienińskiej strefy suturalnej. Zważywszy ponadto, iż późnojurajski grzbiet czorsztyński był obrzeżony basenami batialnymi, można wysnuć wniosek, że baseny takie, w tym również baseny podesłane skorupą oceaniczną, nie stanowiły przeszkody dla migracji wielu amonitów. Fakt ten, zgodnie ze wcześniejszymi sugestiami (CARIOU & *al.* 1985) może znaleźć wytłumaczenie w ograniczonej szerokości tego typu basenów, wykształconych w późnej jurze w regionie karpacko-alpejskim.