Atti II Conv. Int. F.E.A. Pergola, 87	Pallini *et alii cur.*	pp. 383-387	Ammonite biogeography of Czorsztyn

Late Jurassic ammonite biogeography of the Czorsztyn Succession, Pieniny Klippen Belt, Carpathians

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RIASSUNTO

I sedimenti del Giurassico superiore della successione di Czorsztyn si accumulavano sulla ruga dei Czorsztyn, bordata a Sud e a Nord da bacini profondi. Le faune ad ammoniti del Calloviano, Oxfordiano e Kimmeridgiano somigliano molto a quelle del cratone europeo. Le faune titoniche della successione di Czosztyn sono puramente mediterranee. Questo può essere spiegato dallo sviluppo di diverse zone isopiche, favorevoli o sfavorevoli alle ammoniti, ai margini della Tetide carpatica all'inizio del Giurassico superiore e nel Titonico. Le migrazioni delle ammoniti attraverso i bacini profondi furono possibili ed anche influenzate da faglie trasformi che spezzavano la continuità delle distese di crosta oceanica e continentale e dei relativi bacini.

ABSTRACT

The Upper Jurassic sediments of the Czorsztyn Succession accumulated on the Czorsztyn Ridge which was bordered to the south and to the north by deep-water basins. The Callovian, Oxfordian and Kimmeridgian ammonite faunas bear a strong resemblance to faunas from cratonic Europe. In contrast, the Tithonian faunas from the Czorsztyn Succession are purely Mediterranean. This can be explained by the development of different facies belts, favorable or unfavorable for ammonites, at the margins of the Carpathian Tethys in the early Late Jurassic and in the Tithonian. Migrations of ammonites across deep-water basins were possible, and influenced by transform faults disrupting the continuity of stretches of oceanic and continental crust and of the superimposed basins.

KEY WORDS

Jurassic, Ammonites, Paleogeography, Biogeographym Capalhians.

INTRODUCTION

The Czorsztyn Succession, which is one of the sedimentary successions incorporated in the Pieniny Klippen Belt, provides in the Carpathians a possibility to study a stratigraphic succession of several Oxfordian, Kimmeridgian and Tithonian ammonite assemblages in one tectonic unit. These assemblages will be interpreted biogeographically, mainly from a paleogeographical and tectonic point of view.

THE CZORSZTYN RIDGE

The Jurassic sediments of the Czorsztyn Succession accumulated on the submerged Czorsztyn Ridge, a geanticlinal unit developed on continental crust (Birkenmajer, 1985, 1986). Middle Jurassic crinoid limestones, Callovian and Upper Jurassic nodular limestones (ammonitico rosso), and Tithonian to Berriasian ammonite coquinas belong to the characteristic lithofacies of the Czorsztyn Succession (Birkenmajer, 1963, 1977, 1986).

In Jurassic time, the Czorsztyn Ridge was bordered by two deep-water furrows, the Magura Trough to the north, and the Central Furrow (the depositional zone of the Pieniny and Branisko Successions of the Pieniny Klippen Belt) to the south. Middle Jurassic *Bositra* shales, upper Middle and lower Upper Jurassic radiolaria cherts, and biancone-type (cherty) limestones of Late Jurassic age accumulated in those furrows. The Aalenian black flysch in the Magura Succession is another characteristic sediment (Birkenmajer 1977, 1986). The furrows were underlain by attenuated continental, or oceanic, crust (Birkenmajer, 1985, 1986).

In the Czorsztyn Succession, rich ammonite faunas are provided by the Czorsztyn Limestone Formation and the Rogoza and Rogoznik Coquina Members (Birkenmajer, 1977). The bulk of the Czorsztyn Limestone (a nodular limestone of the ammonitico rosso type) corresponds to the Callovian, Oxfordian and Kimmeridgian, but in some sections the formation ranges up into the Lower and Middle Tithonian. Lists of ammonites reported from the Czorsztyn Limestone have been compiled by Birkenmajer (1963). The Rogoza and Rogoznik Coquinas (the red and white coquinas of earlier authors) are Tithonian and Berriasian in age (Kutek & Wierzbowski, 1986). Ammonites from these coquinas were monographed, together with Tithonian ammonites from the Central Apennines, by Zittel (1870) in his classical paper. Bed-by-bed collecting of ammonites in the lower, sparry coquinas of the Rogoźnik Member made it possible to recognize four successive Lower and Middle Tithonian zones: the *Hybonotum, Darwini, Semiforme* and *Fallauxi* Zones (Kutek & Wierzbowski, 1979, 1986).

The lower part of the Rogoźnik Member (the "Rogoźnik breccia" of earlier authors) has its lithologic counterpart in the French Alps, at Col du Lauzon, in an ammonite breccia, which stratigraphic range is restricted to the *Fallauxi* Zone (Enay *et al.*, 1979). The latter breccia occurs within the Briançonnais unit, which tectonic position between the South- and North Penninic (Piemonte and Valais) units is comparable to some extent with that of the geanticlinal Czorsztyn Ridge.

TECTONIC AND PALEOGEOGRAPHIC BACKGROUND

The depositional zone of the Pieniny Klippen Belt, together with some adjacent zones to the north and/or to the south, are commonly regarded as equivalent tectonically to the Penninic Zone of the Alps (Debelmas *et al.*, 1980; Mahel, 1982, 1983; Michalik & Kovac, 1982; Sandulescu, 1980, 1983, 1984, 1985; Birkenmajer, 1985, 1986). The interpretations differ in detail, depending on which zones are thought to have been underlain by oceanic crust. However, such a tectonic equivalence does not imply necessarily a strict tectonic "cylindrism". Drastic changes in tectonic development could have taken place at the junction of the Carpathian and Alpine depositional regions (Frisch, 1979), possibly resulting from the activity of a paleo-transform fault (Chorowicz & Geyssant, 1976; Birkenmajer, 1985). Such a fault could effectively separate stretches of oceanic crust of different age, and sedimentary basins superimposed on oceanic or attenuated continental crust (Birkenmajer, 1985). The position of the Carpathian tectonic units relative to that of the Alpine units may thus have been different at different times in the course of the Mesozoic.

The Czorsztyn Ridge, being bordered by deep-water troughs, was not a part of the northern Tethyan shelf in the Late Jurassic. In a broad paleogeographic sense, this submerged ridge can be regarded as a part of the northern Tethys. However, if some troughs north to the Czorsztyn Ridge were underlain by oceanic crust, as suggested by several authors, a Mid-Tethyan position should be ascribed to this ridge from a tectonic point of view.

In the Late Jurassic, the depositional region of the Outer (Flysch) Carpathians of Poland and Czechoslovakia was differenciated into several ridges and deeper-water basins (Książkiewicz, 1956; Misik, 1974; Ślaczka, 1976; Elias & Eliasova, 1984).

During the Mesozoic, most of cratonic Poland was included in the Central-European (North-West European) Basin, which was separated structurally, and at some times also paleogeographically, from the Carpathian basins by the Meta-Carpathian Arch (Kutek, 1980). However, in the Late Jurassic, this arch was strongly downwarped, and the cratonic area of Poland included in the northern shelf of the Tethys. As a consequence, the Late Jurassic ammonite faunas of cratonic Poland (Kutek *et al.*, 1984) are predominantly Submediterranean in type (in the Oxfordian and Kimmeridgian), or at least Tethyan-related (in the Volgian). On the other hand, as a result of the position of Poland south of the Baltic Shield, there was no direct marine connection between the Arctic Sea and Poland, so that Boreal ammonites are more poorly represented in cratonic Poland as, for instance, in England and on the Russian Platform.

The area of the Swabian and Franconian Alb in South Germany was also included in the northern Tethyan shelf in the Late Jurassic, with the result that the Oxfordian and Kimmeridgian ammonite faunas from South Germany and cratonic Poland are closely comparable (Kutek *et al.*, 1984). The faunal connections between those regions may have been established along the southern and east-southern shelves of the Bohemian Massif, and, as at least some parts of this massif were submerged during the Late Jurassic (Elias, 1981), possibly also across the Bohemian Massif.

MIDDLE OXFORDIAN AMMONITES

Phylloceratids and lytoceratids are common in the Callovian, Oxfordian, Kimmeridgian and Tithonian parts of the Czorsztyn Limestone. Within this formation, a stratigraphic gap can be recognized encompassing the latest Callovian and Lower Oxfordian (Kutek & Wierzbowski, 1986), so that the earliest Late Jurassic ammonites reported from the Czorsztyn Limestone are of Middle Oxfordian age.

In addition to phylloceratids and lytoceratids, the following Middle Oxfordian ammonites have been reported from the Czorsztyn Limestone: *Proscaphites anar* (Op.), *Cardioceras (Miticardioceras) tenuiserratum* (Op.), *C. (M.) crenocarinum* (Neum.), *Perisphinctes plicatilis* (Sow.), *P.* cf. *martelli* (Op.), *Gregoryceras neumayri* (Jeannet), *Euaspidoceras oegir* (Op.), and *Paraspidoceras simplex simplex* Zeiss. This list of ammonites comprises species that have been reported from many regions of cratonic Europe; some of them are known from England and the Russian Platform, and *C. tenuiserratum* is also known from Arctic regions. Thus the Middle Oxfordian ammonite assemblage from the Czorsztyn Limestone could be classified as Mediterranean only on the strength of the presence of phylloceratids and lytoceratids.

In this context Arkell's (1956) emphatic statement is worth remembering that the Early and Middle Oxfordian ammonites (cardioceratids, perisphinctids and aspidoceratids) from Cetechovice, a locality in the Outer Carpathians of Czechoslovakia, show closer affinity with England and North-West Germany, than with South Germany, and that only a crowd of phylloceratids brings the ammonite assemblages from Cetechovice within the Alpine-Mediterranean province.

The Czorsztyn unit is the southernmost tectonic unit of the Western Carpathians from which cardioceratids have been reported, but they are not rare in the Outer Carpathians. For instance, a rich fauna of Middle Oxfordian Cardioceratidae is provided by the locality of Kruhel Wielki near Przemyśl (Wójcik, 1914).

The northern connections of all these Carpathian faunas can be explained as follows. The submergence of large parts of Europe accounts for the relative uniformity of Middle Oxfordian ammonite faunas over much of cratonic Europe. Moreover, long stretches of the European shelf of the Tethys were occupied by the deep-neritic sponge facies, a facies highly favorable for ammonites. Furthermore, as indicated by Jurassic exotic blocks embodied in flysch sediments (Wójcik, 1914; Ksiazkiewicz, 1956; Burtan *et al.*, 1984), some of the ridges in the northern part of the depositional area of the Outer Carpathians was also occupied by the sponge facies. The exotic blocks from Bachowice (Ksiazkiewicz, 1956) supply evidence for a more pelagic area of deposition (a submerged plateau?), still favorable for ammonites. Such elevated areas within the Carpathian Tethys could serve as "stepping stones" facilitating ammonite migrations across deep-water basins.

LATE OXFORDIAN AND EARLY KIMMERIDGIAN AMMONITES

Except for the phylloceratids and lytoceratids, the Late Oxfordian and Early Kimmeridgian ammonite assemblages from the Czorsztyn Limestone bear a strong resemblance to the Submediterranean assemblages of cratonic Europe, especially to those of South Germany and Poland. The list of significant species from the Czorsztyn Limestone includes: *Orthosphinctes colubrinus* (Rein.), *Lithacosphinctes* cf. *achilles* (d'Orb.), *Ataxioceras polyplocum* (Rein.), *Ringsteadia vicaria* (Moesch.), *Rasenia (Involuticeras) involuta* (Qu.), *Rasenia (Prorasenia)* cf. *witteana* (Op.), *Crussoliceras* aff. *crussoliensis* (Font.), *Idoceras balderum* (Op.), *Epipeltoceras berrense* (Favre), *Euaspidoceras tietzei* (Op.), *E. eucyphum* (Op.), *Physodoceras altenense* (d'Orb.), *P. circumspinosum* (Qu.), *Aspidoceras binodum* (Op.), and *A. uhlandi* (Op.).

Curiously enough, the Czorsztyn Limestone is very poor in Haploceratacea of Late Oxfordian and Early Kimmeridgian age, the single good example being *Taramelliceras trachinotum* (Op.).

The genus *Nebrodites* seems to be rare in the Kimmeridgian part of the Czorsztyn Limestone; it is here represented by three species: *N. agrigentinus* (Gem.), N. *benianus* (Cat.), and N. *teres* (Neum). Ammonites have not been collected bed-by-bed from the Czorsztyn Limestone, but possibly the specimens have been found in parts of sections representing the Divisum Zone.

LAKE KIMMERIDGIAN AMMONITES

Taramelliceras pugile (Neum.), *T. compsum* (Op.), *T. holbeini* (Op.), *Aspidoceras acanthophalum* Zit. and *Hybonoticeras pressulum* (Neum.) are Upper Kimmeridgian fossils from the Czorsztyn Limestone, but other species, known to range down into the Lower Kimmeridgian, possibly were also found in the Upper Kimmeridgian part of that limestone, for instance: *Discosphinctoides roubyanus* (Font.), *Aspidoceras acanthicum* (Op.), *A. longispinum* (Sow.), and *A. microplum* (Opp.). Thus arises a picture of a fauna dominated by Taramelliceratinae and Aspidoceratidae, a feature which is also found in the *Beckeri* Zone of the Central Apennines (Cecca *et al.*, 1985).

The total absence of the genus *Aulacostephanus* in the Czorsztyn Limestone is a significant feature. In contrast, this genus is well represented in the lower parts of the Upper Kimmeridgian (the "Middle Kimmeridgian") of South Germany, and in the whole Upper Kimmeridgian of Central Poland, up to the *Autissiodorensis* Zone. As a consequence, the Submediterranean zonal subdivision of the Upper Kimmeridgian, and, *a fortiori*, the Subboreal one, could not be applied to the Czorsztyn Limestone.

Thus, in the Czorsztyn Succession, the Late Kimmeridgian ammonite fauna is an intermediate fauna between the Oxfordian and Early Kimmeridgian faunas, which display strong affinities with faunas from cratonic Europe, and the characteristically Mediterranean faunas of Tithonian age.

TITHONIAN AMMONITES

The ammonite fauna from the lower part of the Rogoźnik Coquina in the Czorsztyn Succession (Hybonotum, Darwini, Semiforme and Fallauxi Zones) is a typical Mediterranean fauna (Kutek & Wierzbowski, 1979, 1986). In addition to phylloceratids and lytoceratids, it comprises such characteristic forms (comp. Cariou *et al.*, 1985) as *Neochetoceras, Semiformiceras, Haploceras, Virgatosimoceras, Simoceras, Hybonoticeras, Aspidoceras, Richterella, Discosphinctoides geron* and *Subplanitoides contiguus*. The composition of the fauna is as follows: Phylloceratacea - 13%, Lytoceratacea - 7,3%, Protancyloceratinae - 1,2%, Haploceratacea - 61,5%, and Ataxioceratidae and Aspidoceratidae - 17% of the collected specimens (Kutek & Wierzbowski, 1979, 1986).

The Lower-Middle Tithonian ammonite assemblages from the Rogoźnik Coquina are comparable with those from the Subbetic Zone of Spain (Enay & Geyssant, 1975; Olóriz-Sáez, 1978) and from the Central Apennines (Cecca *et al.*, 1985). As a consequence, the same zonal scheme can be applied in all these regions. On the other hand, the fauna from the Rogoźnik Coquina markedly differs from the Tithonian or Volgian faunas occurring in South Germany (Zeiss, 1968; Barthel, 1975) and Central Poland (Kutek & Zeiss, 1974), where different zonal schemes are to be applied.

It is worth of note that the Tithonian ammonite successions display both in the Czorsztyn unit (Kutek & Wierzbowski, 1986) and in the Central Apennines (Cecca *et al.*, 1985) a feature which is not found in the Spanish sections (Enay & Geyssant, 1975; Olóriz-Sáez, 1978). Namely, in the former regions the Darwini-Albertinum Zone is followed by strata in which the genus *Semiformiceras* is only represented by the species *S. birkenmajeri*, a new species comprising the earlier of the forms previously ascribed to *S. gemmellaroi* (Kutek & Wierzbowski, 1986); the index species *S. semiforme* and *H. verruciferum* of the Semiforme-Verruciferum Zone appear in still higher strata. Semiformiceras birkenmajeri seems to be absent in Spain, where the index fossils of the Semiforme-Verruciferum Zone appear at its junction with the Darwini-Albertinum Zone.

Despite the fact that the depositional region of the Central Apennines was located south of the Penninic oceanic zones, the resemblance between the Tithonian faunas from Italy and the Czorsztyn ridge can be easily understood on the ground of the assumption that the Alpine ophiolithic zones did not extend directly eastwards beyound the junction of the Alpine and Carpathian regions (comp. e.g. Frisch, 1979, fig. 2).

An exemple of a Late Tithonian ammonite assemblage from the Czorsztyn succession is provided by the Kyjov section in Eastern Slovakia, from which, in addition to several phylloceratids and lytoceratids, *Haploceras elimatum* (Op.), *H. tithonium* (Op.), *Glochiceras carachtheis* (Zeuschn.), *Substreblites zonarius* (Op.), *Paraulacosphinctes transitorius* (Op.), *Micracanthoceras microcanthum* (Op.) and *Pseudovirgatites scruposus* (Op.) have been reported (Neumayr 1871; Birkenmajer, 1963).

It is of interest that the ammonites of the *Ilowaiskya - Pseudovirgatites - Zaraiskites* lineage (Kutek & Zeiss, 1974), which are known from the Carpatho-Balkan region, cratonic Poland and the Russian Platform, are virtually absent from regions west of Vienna (Kutek & Wierzbowski, 1986). A possible explanation may be sought in the uplift of, and development of shallow-water facies around of, the Bohemian Massif (Elias, 1981), possibly coupled with activity of a transform fault in the Vienna region, at the Carpatho-Alpine junction. In this context it is worth of note that the development of some equivalent Alpine and Carpathian tectonic zones began to differ in the Tithonian. In the depositional region of the Outer Western Carpathians, which northern part is equivalent to the Alpine Helvetic Zone, flysch sedimentation commenced in the Tithonian (Ślaczka, 1976), and persisted to the Tertiary. The Urgonian facies, a charac teristic facies of the Helvetic Zone, is not represented in the Outer Carpathians, and re-appears at the southern margin of the Pieniny Klippen Belt, in what might be called an Austro-Alpine position.

THE AMMONITES OF THE POLISH VOLGIAN

The Volgian ammonite faunas occurring in the epicratonic sediments of Central and Northern Poland are dominated by the ammonites of the *Subplanites - Ilowaiskya - Pseudovirgatites-* Zaraiskites lineage (Kutek & Zeiss, 1974). This lineage is rooted in the genus *Subplanites,* and thus of Tethyan origin. *Subplanites* is represented in the lower part of the Lower Volgian, *Ilowaiskya* and early representatives of the genus *Pseudovirgatites,* e.g. *P. puschi* (Kutek et Zeiss) in the upper Lower Volgian, and *Zaraiskites* in the Scythicus Zone, the lowest zone of the Middle Volgian. This zone, with two subzones, the lower Scythicus Subzone and the upper Zarajskensis Subzone, provides for the latest Jurassic ammonites hitherto found in cratonic Poland. As the Lower-Middle Volgian boundary is roughly equivalent to that of the Middle and Upper Tithonian (Kutek & Zeiss, 1974; Zeiss, 1977, 1983; Kutek & Wierzbowski, 1986), the Scythicus Zone corresponds to some lower part of the Upper Tithonian, and the Middle Tithonian to some upper part of the Lower Volgian.

The ammonite succession in the Polish Volgian is comparable with that in the Volgian of the Russian Platform where, however, the ammonites of the *Subplanites - Ilowaiskya - Pseudovirgatites - Zaraiskites* lineage are being replaced along a northward gradient by Boreal ammonites (Mesezhnikov, 1982). On the other hand, the Polish ammonite succession markedly differs from the Tithonian succession in South Germany, except for the lower part of the Polish Lowe Volgian, in which *Subplanites* and *Neochetoceras* are present. The differences between the Volgian ammonite faunas from Central Poland and the Tithonian faunas of the Czorsztyn Succession are still greater. An exemple of extreme faunal differentiation is given by the ammonite fauna of the Zarajskensis Subzone of Central Poland. This fauna, which in some layers is restricted to the ammonites of the group of *Zaraiskites zarajskensis* (Mich.), is roughly coeval with the Late Tithonian ammonites assemblage from the Kyjov section in Slovakia, mentioned above.

On the other hand, some faunal connections between Tethyan regions and Central Poland persisted to the *Scythicus* time. *Zaraiskites* has been found in the Outer Carpathians, and Zaraiskites and Ilowaiskya are known from the Klentnice Beds of Austria and Moravia (Ksiazkiewicz, 1974; Zeiss, 1977; Kutek & Wierzbowski, 1986). The late representatives of *Pseudovirgatites,* which are commonly found in the Carpatho-Balkan region (Zeiss, 1977), are also represented in the *Scythicus* Zone of Central Poland; the form, figured by Lewiński (1923, p. 11, fig. 3) as *Virgatites (Provirgatites?) bohdanowiczi,* can be reinterpreted as a form belonging to, or close to, *Pseudovirgatites scruposus* (Op.). The South German species *Isterites subpalmatus* (Schneid) and *I. spurius* (Schneid) also occur in the uppermost Lower Volgian of Poland (Kutek & Zeiss, 1974). Several ostracods, reported from the Klentnice Beds, have also been found in the Volgian of Central Poland (Kubiatowicz, 1983). More evidence for faunal connections could be presented.

A suitable biogeographic explanation can be sought in the development of Tithonian shallow-water carbonate platforms on the Tethyan shelves, developed on the Bohemian Massif and on the Polish and Ukrainian margins of the European continent, and also on the ridges located in the pericratonic parts of the depositional region of the Outer Carpathians (Ksiazkiewicz, 1956; Elias, 1981; Elias & Eliasova, 1984); reef complexes developed on some of these ridges (Elias & Eliasova, 1984). The lithologic varieties of these carbonate sediments are commonly referred to under the collective denomination of the Stramberk Limestone. The Stramberk Limestone corresponds to the Middle and Late Tithonian time span (Housa & Mencik, 1983), and thus to the late Early and early Middle Volgian, the period of the strong individualization of the ammonite faunas of cratonic Poland with respect to the Tethyan and South German ones.

Ammonites have been found in the Stramberk Limestone at several localities in the Carpathians, the type locality of Stramberk being the most important. However, even at such localities the ammonites are outnumbered by other groups of invertebrate fossils, e.g. brachiopods, bivalves, gastropods and corals (Blaschke, 1911; Wójcik, 1914; Morycowa 1964, 1974; Ksiazkiewicz 1956, 1974). In general, ammonites are "extremely rare" in the Stramberk limestones (Ksiazkiewicz, 1974).

Thus the belt of the Stramberk carbonates at the margins of the Carpathian Tethys, being still penetrable for some faunal migrations, could be an effective factor of differentiation of the Tithonian-Volgian ammonite faunas.

CONCLUSIONS

The biogeographic interpretations put forward in this paper can be regarded as an exemplification of the previous interpretations proposed for the whole Tethys (Cariou *et al.,* 1985). The distribution of ammonites within and around the Tethys was controlled by global tectonics but narrow deep-water basins were no obstacles to ammonite migrations, even if underlain by oceanic crust. Moreover, the migrations could be facilitated by transform faults disrupting the continuity of stretches of oceanic and attenuated continental crust, and of superimposed basins. On the other hand, the distribution of ammonites was also stronghly influenced by subsidence and uplifts at the margins of the European craton, and by the development of facies belts, favorable or unfavorable for ammonites.

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