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The Lower Kimmeridgian of the Wieluń Upland and adjoining regions in central Poland: lithostratigraphy, ammonite stratigraphy (upper Planula/Platynota to Divisum zones), palaeogeography and climate-controlled cycles

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Key words: ammonites, biostratigraphy, facies, Lower Kimmeridgian, central Poland, Wieluń Upland, synsedimentary tectonics, palaeogeography, primary sedimentary cyclicity.

Abstract. The Early Kimmeridgian of the Wieluń Upland and adjoining regions, after the decline of sedimentation of the deep-neritic sponge megafacies (Częstochowa Sponge Limestone Fm.) and associated limestones and marls with poor benthic fauna (Pilica Fm.) during the Planula Chron, showed the subsequent development of moderately shallow-water biostromal chalky limestones with siliceous sponges and corals, replaced laterally by micritic limestones and marls (Prusicko Fm.) during the Platynota Chron and the earliest Hypselocyclum Chron. Towards the north and south shallow-marine carbonate platforms occurred (represented by deposits of the "oolitic" fm.), whereas towards the north-west and west deeper marine facies, represented initially by limestones with siliceous sponges (Częstochowa Sponge Limestone Fm.), and later during the Hypselocyclum Chron by bedded limestones and marls with ammonites (Burzenin Fm.) were deposited. This palaeogeographic pattern was controlled by the synsedimentary tectonics. The detailed biostratigraphical classification of the deposits studied from the Platynota to the Divisum zones, and their lithological character, enable the recognition of the primary sedimentary cyclicity by comparison with the well dated short eccentricity cycles in the coeval succession of south-eastern France. The two appendixes enclosed give the characteristics of: (1) the characteristics of the ammonite faunas especially of the families Ataxioceratidae and Aulacostephanidae (where two new species are established – *Balticeras samsonowiczi* sp. nov., and *Rasenioides glazeki* sp. nov.); (2) the newly established lithostratigraphical units: the Prusicko Fm., and the Burzenin Fm., and the smaller rank units (members, beds) recognized therein.

INTRODUCTION

The Wieluń Upland is the northernmost morphological unit of the region occupied by the Upper Jurassic limestones of the sponge megafacies in central Poland. This region, the so-called Polish Jura, manifesting itself in the development of a rocky hill landscape, extends between Cracow in the south and Wieluń in the north. The Wieluń Upland is bordered by the Warta river valley separating it from the Częstochowa Upland in the south, and delimited by a morphological escarpment related to existence of the Wieluń – Siemkowice tectonic zone in the north (Kondracki, 1994). The limestones cropping out in the Wieluń Upland are the bedded and the massive biohermal deposits of the Często-

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chowa Sponge Limestone Formation of Oxfordian and Early Kimmeridgian age, in their upper part in lateral contact with bedded micritic limestones, marly limestones and marls with a poor benthic fauna of the Pilica Formation. All these deposits represent the stratigraphical interval from the Lower and Middle Oxfordian, up to the Bifurcatus and Hypselum ammonite zones, and the following Bimammatum and Planula ammonite zones, above. The lithological development and ammonite stratigraphy of the upper part of the succession have been presented in several papers (Wierzbowski, 1965, 1966, 1978; Wiśniewska-Żelichowska, 1971; Wierzbowski *et al*., 1983, 2010; Matyja, Wierzbowski, 1997; Wierzbowski, Matyja, 2014). It should be remembered that all the ammonite zones in question in previous Submediterranean subdivisions have been treated as belonging to the Upper Oxfordian, but a new interpretation shows that only the Bifurcatus and Hypselum zones should be correlated with Upper Oxfordian (as defined on the basis of the Subboreal and Boreal subdivisions – see Wierzbowski *et al*., 2016), whereas the Bimammatum and Planula zones should be correlated already with the lowermost Kimmeridgian. In the present study the uppermost part of these deposits, corresponding to the upper part of the Planula Zone only is considered.

The younger Kimmeridgian deposits from the Platynota Zone up to the Hypselocyclum Zone (and locally also the Divisum Zone) are known from the regions extending east and north of the Wieluń Upland. They are represented there by well-bedded organogenic and micritic limestones and marls attributed to the Prusicko Formation (Matyja, Wierzbowski, 2004) which are in part laterally replaced and overlain by oolite and oncolite limestones, and other deposits of shallow-water origin belonging to the "oolitic " formation in the north, as well as by the micritic limestones and marls with ammonites of the Burzenin Formation in the north and north-west. Their present distribution results from the successive stages of post-Jurassic, mostly pre-Albian, Laramian and pre-Miocene erosion and tectonics. These deposits, showing a small regional tectonic dip of about 1–2° towards north-east (but heavily disturbed tectonically at the northern border of the Wieluń Upland), together with older deposits of the Częstochowa Sponge Limestone Formation and those of the Pilica Formation, represent a part of the Silesian-Cracow Monocline which is the western limb of the Laramide Miechów Synclinorium in the south and the Łódź Synclinorium in the north. They are covered with a small angular unconformity by Albian-Cenomanian siltstones and sandstones.

The following areas at the borders of the Wieluń Upland, differing in geological structure and development of their Lower Kimmeridgian deposits, are recognized herein: (1) the areas at the eastern border which is the type area of the Prusicko Fm., which extends from Kuchary village near Mstów in the Warta river valley in the south, north-westwards towards Prusicko village in the Warta river valley in the north, and then north and north-westwards through Brzeźnica and Pajęczno towns where locally there are preserved younger deposits of the "oolitic" fm., and the Burzenin Fm (areas 1a, 1b and 1c in Fig.1); (2) the areas at the northern border, showing the upper part of the Prusicko Fm., and the "oolitic" fm. overlain by the Burzenin Fm., extending from the brown-coal fields of Szczerców and Bełchatów, and adjoining area of Kiełczygłów town to the west (areas 2a and 2b in Fig. 1); (3) the areas containing localities situated northward from the Wieluń Upland, which are typical of the Burzenin Fm., at Burzenin town in the middle course of the Warta river valley, and east to Sarnów village at the Widawka river; additionally some comments are given on similar deposits in the environs of Kalisz town on the Prosna river to the north-west (areas 3a, 3b and 3c in Fig. 1); all these deposits of the Burzenin Fm. are underlain by the Częstochowa Sponge Limestone Fm., and the Pilica Fm., which range stratigraphically much higher here than in other discussed areas.

The aim of the current study is the recognition of the detailed lithological succession, stratigraphy and facies of the Early Kimmeridgian deposits dating from the decline of the dominance of the sponge megafacies responsible for the original development of the sponge-cyanobacteria bioherm – to basin facies pattern up to the younger deposits of the Prusicko Fm., and the Burzenin Fm., representing already more uniform facies development, as well as the locally developed "oolitic" fm., representing their lateral equivalent. These Early Kimmeridgian deposits, being the youngest preserved Jurassic deposits of the area of study, were exposed in the past in numerous exposures and penetrated by shallow boreholes, but they are generally poorly accessible nowadays. Although general descriptions of some of these deposits have already been published (Premik, 1926, 1931; Czermiński, 1953; Kowalski, 1958; Wierzbowski, 1964, 1966, 1978; Wierzbowski *et al*., 1983, and older references given therein), the partly revised and supplemented description of the whole succession given herein is based both on reinterpretation of the older data and ammonites collected previously, as well as stratigraphical and taxonomical interpretation of the newly collected material. Helpful in this study also were descriptions of the cores from the Szczerców-Bełchatów brown-coal fields area by Szewczyk *et al*. (1975–2015), and the ammonites coming from these cores which were determined by the present author. The succession recognized is the basis for a wider stratigraphical and palaeogeographical correlation. This results in the recognition of the presence of synsedimentary tectonics affecting the depositional environments as well as the palaeogeography of the Early Kimmeridgian in the Wieluń Upland and the adjoining regions. On the other hand, because the detailed ammonite dating offers the possibility of discussion

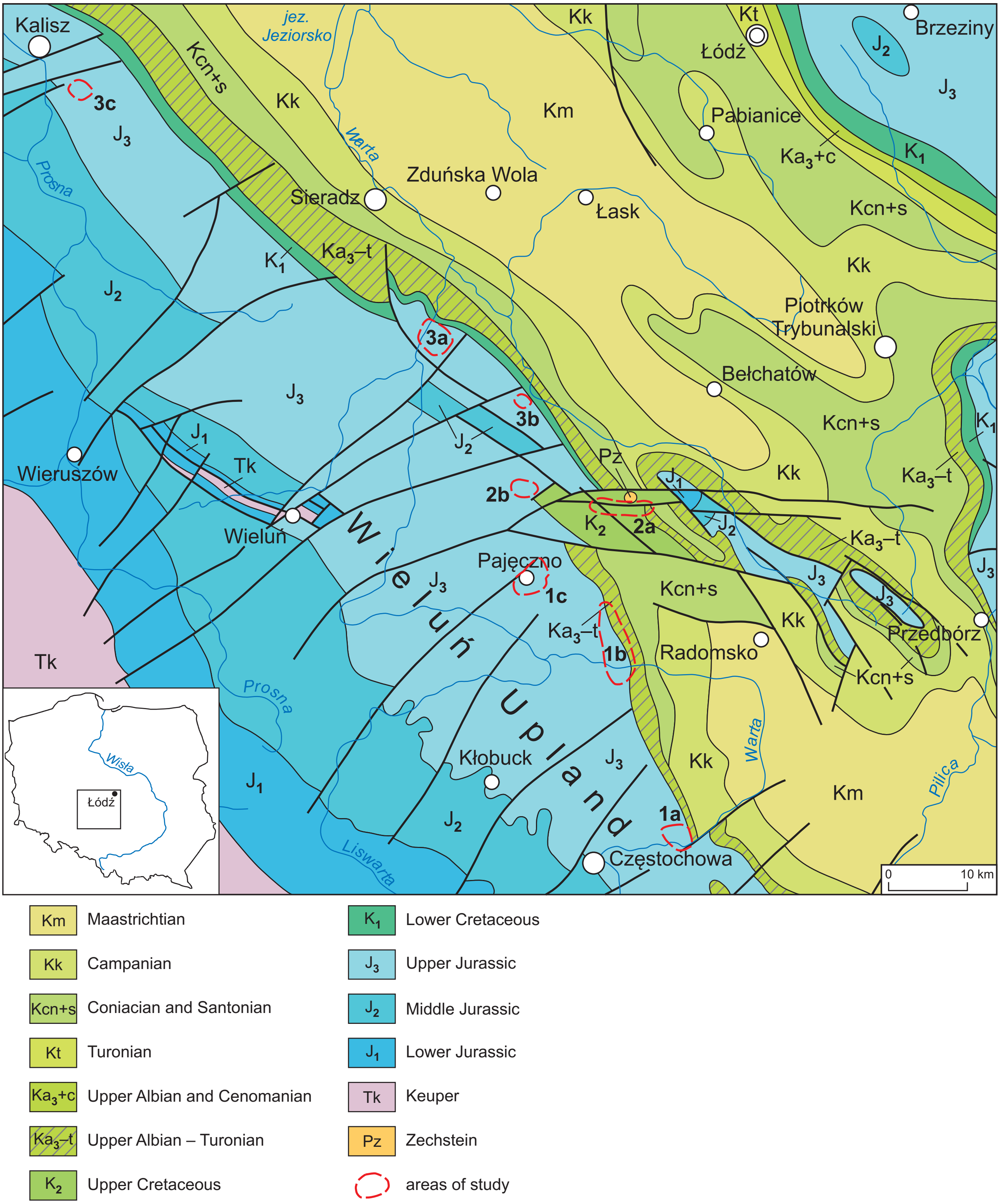


Fig. 1. Geological map of the Wieluń Upland and adjoining regions (after Dadlez *et al.*, 2000) with location of the areas of study

1 – eastern border (1a – vicinity of Mstów and Kuchary; 1b – vicinity of Prusicko, Brzeźnica and Dubidze; 1c – vicinity of Pajęczno); 2 – northern border (2a – brown-coal fields of Bełchatów and Szczerców; 2b – Kiełczygłów area); 3 – areas north of the Wieluń Upland (3a – Burzenin area; 3b – Sarnów area; 3c – Kalisz area)

of wider stratigraphical ideas, the succession studied is compared with the well dated coeval succession in SE France to recognize climate controlled cycles.

The preliminary results of the study were presented by the author during the international conference "Jurassica XIII" at Zakopane, Poland (Wierzbowski, 2017a). The detailed discussion on the taxonomical interpretation of the most important ammonite findings is given in Appendix I. The description of the newly recognized formal lithostratigraphic units is given in Appendix II.

STRATIGRAPHY AND FACIES

THE SPONGE MEGAFACIES DEPOSITS OF THE WIELUŃ UPLAND (CZĘSTOCHOWA SPONGE LIMESTONE FM. – UPPER PART) AND MICRITIC LIMESTONES AND MARLS (PILICA FM.)

These deposits are represented by massive and bedded limestones of the cyanobacteria-sponge biohermal complexes of the Częstochowa Sponge Limestone Fm. which contact laterally with well-bedded, poorly fossiliferous micritic limestones with marly intercalations of the Wolbrom Limestone Member of the Pilica Formation of the interbiohermal basins (Fig. 2). The bioherm to basinal relief of the sea bottom was originally quite large attaining about 200 meters between the top of the bioherms and the base of the neighbouring basins (Matyja, Wierzbowski, 1996). The contact between biohermal and basinal deposits runs commonly along the markedly inclined slopes, often at about 30^0 or steeper, of the massive biohermal limestones. The basinal micritic limestone and marly beds of the Wolbrom Limestone Member overlap the biohermal slope, and often thin towards the bioherms. Mass-gravity transport off the bioherms resulted locally in the accumulation of breccias which occur at some levels within the micritic limestones. The composition of the breccias ranges from a boulder mass (with big fragments of the massive limestones) closer to the bioherms, to finer-grained deposits in more distal areas (Matyja, Wierzbowski, 2006). These deposits formed as debris-flows, but some finer-grained deposits showing graded bedding are of allodapic character (Marcinowski, 1970). Still younger deposits are the marls with intercalated marly limestones of the Latosówka Marl Member of the Pilica Formation. Both the deposits of the Wolbrom Limestone Member and the Latosówka Marl Member (originally described as the "lower platy limestones" and the "lower marly unit", respectively; see Wierzbowski, 1966, 1978; Kutek *et al*., 1977), show marked differences in their thickness – even disappearing, or showing very small thicknesses near the bioherm complexes, but attaining quite large thicknesses at a some distance from them – in the interbiohermal basins (up to about 150 m, and about 100 m, respectively, for these two units; *cf.* Matyja, Wierzbowski, 2016).

The southern and northern parts of the Wieluń Upland are distinctive in morphology due to the occurrence of the massive sponge-cyanobacteria biohermal complexes. The biohermal complexes crop out along the southern and northern segments of the Warta river valley (see Matyja, Wierzbowski, 1996, 2004). The southern complexes of the biohermal deposits of the Częstochowa Sponge Limestone Formation include the Rudniki Biohermal Complex and a northern part of the Mstów Biohermal Complex of Matyja and Wierzbowski (2004, see also Matyja, Wierzbowski, 2006, fig. B2.35); the bedded limestones and marls of the Pilica Formation occur in the area of the Rędziny Interbiohermal Basin and the Wąsosz Interbiohermal Basin – which is the largest basin of the whole area and stretches up to the Działoszyn Biohermal Complex in the north. In addition, fragmentary outcrops of the two interbiohermal basins are known in the northernmost part of the Wieluń Upland: the Szczyty Interbiohermal Basin, and the newly recognized Pajęczno Intebiohermal Basin, which are subdivided by the Trębaczew Biohermal Complex (Fig. 3).

The deposits discussed show generally two partly overlapping phases in their development. The massive biohermal limestones in the quarries such as the Latosówka Cement Work quarry in the south, and the Warta Cement Work quarry in the north, corresponding to the uppermost part of the Częstochowa Limestone Formation, represent the last phase of growth of the biohermal complexes. The well-bedded micritic limestones and marls of the Pilica Formation with mass-movement deposits represent the phase of gradual smoothing of the original sea-bottom topography between the biohermal complexes and the interbiohermal basins. The youngest deposits of the Pilica Formation (mostly Latosówka Marl Member) are sometimes missing at the top of the biohermal complexes but attain very large thickness in the basins, indicating the general decline of the bioherm development. The sedimentation rate had to be rapid as shown by the large thickness of carbonate-marly deposits which infilled the deep interbiohermal basins. These unusual conditions resulted also in the special character of the faunal assemblage encountered in the deposits of the Pilica Fm., generally composed of small-sized bivalves (mostly *Astarte*), isolated small-sized plates of crinoids – *Pentacrinus* – possibly of a pseudoplanktonic mode of life, and numerous benthic holothurian sclerites as well as foraminifers, with marked abundance of agglutinated forms (Wierzbowski, 1966; Garbowska, Wierzbowski, 1967; Garbowska, 1970).

The deposits of the Częstochowa Sponge Limestone Formation composed both of massive limestones and associated bedded chalky limestones with cherts, rich in benthic

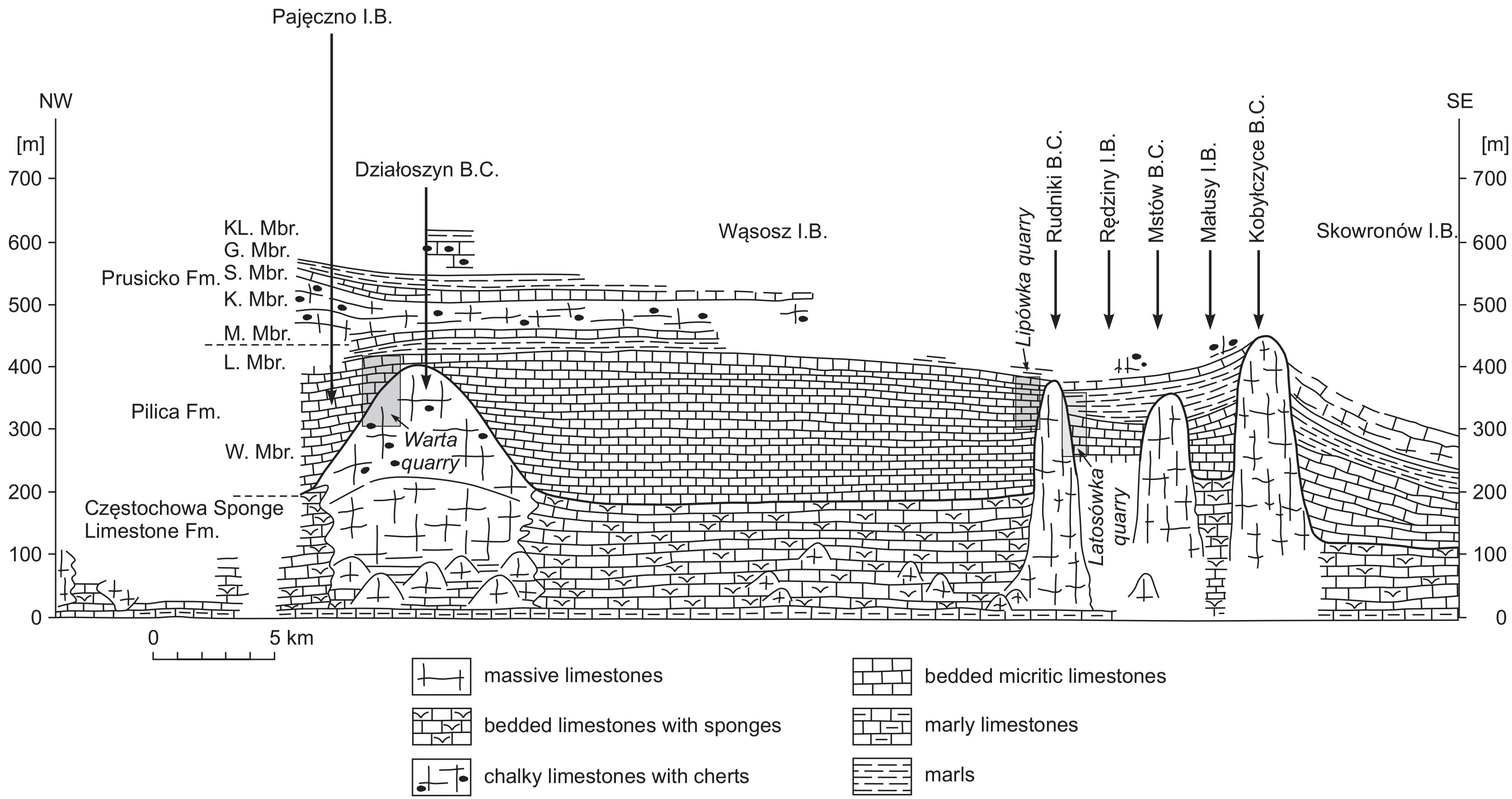


Fig. 2. Spatial relationships between the biohermal complexes (B.C.) and the interbiohermal basins (I.B.) of the Częstochowa Sponge Limestone Formation and the Pilica Formation, and the overlying Prusicko Fm., along the eastern border of the Wieluń Upland and adjoining part of the Częstochowa Upland (after Matyja, Wierzbowski, 2016); the relative position of the rock units in the succession is given from the base of the Upper Jurassic.

Lithostratigraphy: Pilica Formation: W.Mbr. – Wolbrom Limestone Member, L.Mbr. – Latosówka Marl Member; Prusicko Formation: M.Mbr. – Mstów Limestone Member, K.Mbr. – Kuchary Chalky Limestone Member, S.Mbr. – Skowronów Limestone Member, G.Mbr. – Góry Marl Member, Kl. Mbr. – Kule Chalky Limestone Member.

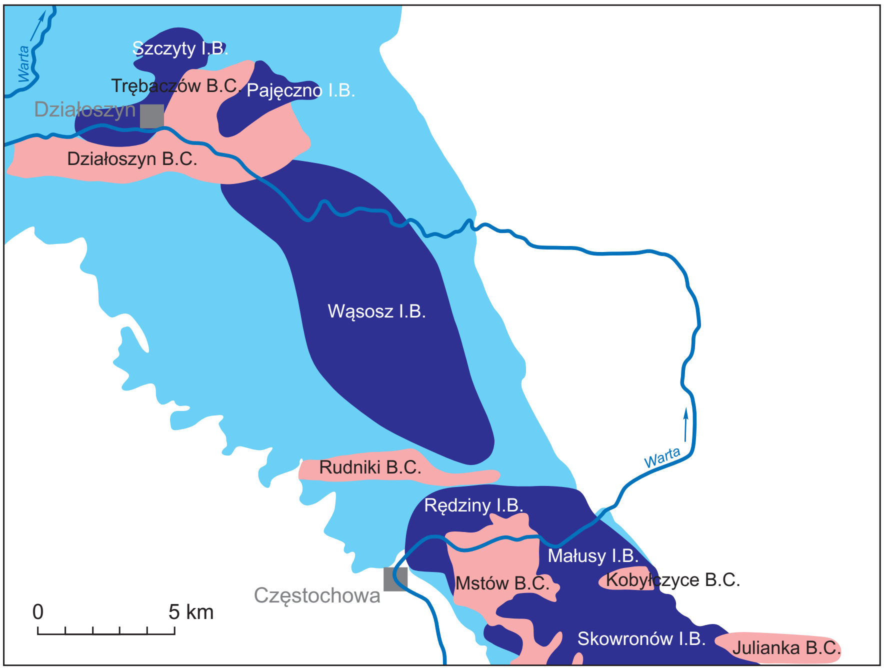


Fig. 3. Distribution of the biohermal complexes of the Częstochowa Sponge Limestone Fm. (B.C., pink coloured), and the interbiohermal basins of the younger deposits of the Częstochowa Sponge Limestone Fm., and the Pilica Fm. (I.B., dark blue coloured) in the northern part of the Częstochowa Upland and in the Wieluń Upland; light blue – older bedded limestones with small bioherms of the Częstochowa Sponge Limestone Fm. – to the west, and the deposits of the Prusicko Fm. – to the east (after Matyja, Wierzbowski, 1996, 2004, somewhat modified)

fossils (mostly siliceous sponges and microbial structures, brachiopods, bryozoans, serpulids) crop out in the quarries at Rudniki (the abandoned Lipówka quarry of the Cemex Enterprise which includes jointly the old Kanigowskie Sister and the Wapnorud quarries – see Wiśniewska-Żelichowska, 1971) and the Latosówka Cement Works quarry of Cemex between Rudniki and Mstów in the southern segment of the eastern border of the Wieluń Upland. Similar deposits were encountered between Prusicko and the vicinity of Pajęczno in the north. These crop out in the Warta Cement Works quarry near Pajęczno and have been recognized in numerous boreholes studied by the author (see Fig 2; see also Wierzbowski *et al*., 1983, fig. 3; see also Wierzbowski *et al.*, 1981). The most representative from the stratigraphical point of view is the section at Niwiska Dolne on the southern slope of the Działoszyn Biohermal Complex (Matyja, Wierzbowski, 1997, p. 86), which shows the bedded limestones with cherts of the Częstochowa Sponge Limestone Formation and the overlying thin-bedded micritic limestones with marly intercalations of the Wolbrom Limestone Member of the Pilica Formation. The bedded limestones of the Wolbrom Limestone Member and overlying marls of the Latosówka Marl Member cropped out also in numerous small quarries, now mostly abandoned, near the Warta river valley, between Gajęcice Stare and Wólka Prusicka (see Wierzbowski, 1966, 1978; see also Kutek *et al*., 1977). The presence of such a strongly diversified facies pattern greatly complicates the recognition of the stratigraphy.

The ammonite faunas coming from the topmost part of the Częstochowa Sponge Limestone Formation, and the upper, more marly part of the Wolbrom Limestone Member, about 30 m in thickness, have been described previously by Wierzbowski (1965, 1966, 1970, 1978), by Wiśniewska-Żelichowska (1971) and by Matyja and Wierzbowski (1997). The revision of some older identifications, and the description of some new specimens are given in the palaeontological part of this study (see Appendix I).

In the massive and bedded limestones of the Częstochowa Sponge Limestone Formation several ammonites have been recognized. Those of the southern part of the Wieluń Upland include specimens found in: (1) Lipówka quarry at Rudniki – *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke) (Pl. 1: 3), *O.* (*O.*) *freybergi* , *O.* (*Lithacosphinctes*) *evolutus* (Quenstedt), *Subnebrodites planula* (Hehl) (Pl. 2: 2), *Pictonia* (*Pictonites*) cf. *perisphinctoides* (Wegele) (Pl. 9: 3), *Vineta* cf. *striatula* (Schneid) (Pl. 10: 7), *Vielunia* cf. *flexuoides* (Quenstedt), *Prorasenia* sp.; and (2) Latosówka quarry – *Subnebrodites minutum* (Dieterich), "*Taramelliceras* (*Metahaploceras*) *ausfeldi* (Würtemberger) sensu Wegele (1929)". The specimens from the northern part of the Wieluń Upland found in a similar stratigraphical position (especially the Niwiska Dolne section) include *int. al*.: *Subnebrodites planula* (Hehl), *S. minutum* (Dieterich), *Vielunia flexuoides* (Quenstedt), *V.* cf. *limosa* (Quenstedt) (Pl. 9: 5), *V.* cf. *tenuiplexa* (Quenstedt), *Pictonia* (*Pictonites*) cf. *perisphinctoides* (Wegele), *Prorasenia bathyschista* (Koerner), *Orthosphinctes* spp., and rare *Taramelliceras* (*Metahaploceras*). All these deposits belong to the Planula Zone, and range no higher than the *minutum* = *schroederi* horizon as shown by *S. minutum* which occurs at the top of the Planula Zone [or Subzone, directly below the Galar Subzone as indicated by Schweigert and Callomon (1997), and discussed by Wierzbowski *et al*. (2010)]. It should be also remembered that the youngest deposits of the Częstochowa Sponge Limestone Formation in some of the sections (as *e.g*., in the Lipówka section), which did not yield *S. minutum*, may be somewhat older and belong to the *planula* horizon only (see *e.g*., Wierzbowski, Matyja, 2014). On the other hand, no indications have ever been found here for the occurrence of the ammonite fauna of the Galar Subzone in the Częstochowa Sponge Limestone Formation. Thus, the youngest deposits of the Częstochowa Sponge Limestone Formation in the studied area do not range higher than the *minutum* horizon of the uppermost Planula Zone. It should be noted that the *minutum* horizon as interpreted herein, according to its original definition, occurs at the top of the Planula Zone (Subzone), directly below the Galar Subzone, and it does not correspond to the so-called "*minutum*" horizon recognized at the base of the Planula Zone (*e.g*., Cariou *et al*., 1997; Matyja, Wierzbowski, 1997, and earlier papers cited therein); the latter shows the presence of somewhat differently ornamented small-sized representatives of *Subnebrodites* called *S. matyjai* Wierzbowski et Głowniak, and it is distinguished as the *matyjai* horizon (Wierzbowski *et al.*, 2010).

The ammonite fauna from the Wolbrom Limestone Member of the Pilica Fm. includes also some ammonites, partly described before (see Wierzbowski, 1965, 1966, 1970, 1978; Matyja, Wierzbowski, 1997), and partly new, discussed in the palaeontological part of the study. The ammonites found in the southern part of the Wieluń Upland include: (1) in Lipówka quarry at Rudniki – *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel), *Subnebrodites minutum* (Dieterich) (Pl. 2: 3), *Prorasenia* sp., *Vineta* sp. (m) (Pl. 10: 8); (2) in Latosówka quarry – *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel), "*Taramelliceras* (*Metahaploceras*) aff. *tenuinodosum* (Wegele) sensu Wierzbowski (1978)", *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke), *O.* (*O.*) *freybergi* (Geyer) (Pl. 1: 5), *O.* (*Lithacosphinctes*) cf. *gidoni* Atrops, *Vielunia flexuoides* (Quenstedt). The specimens from the northern part of the Wieluń Upland include: (1) at Niwiska Dolne – *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel) and other closely related forms as well as *Subnebrodites minutum* (Dieterich); (2) in the area between Wólka Prusicka and Gajęcice Stare – *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel), *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke) and *Vielunia flexuoides* (Quenstedt). These ammonites indicate that the upper part of the Wolbrom Limestone Member belongs to the Planula Zone, and represents the *minutum* horizon, being thus of similar age to the uppermost part of the Częstochowa Sponge Limestone Formation discussed above.

The still younger deposits of the Latosówka Marl Member of the Pilica Formation have yielded but a few ammonites. Important stratigraphically is *Subnebrodites* sp. (Pl. 5: 1) found in the rubble from some upper parts of the Latosówka Marl Member cropping out on the slopes of the hill directly south of Mstów. This find suggests that at least a large part of the Latosówka Marl Member still corresponds to the *minutum* horizon of the uppermost part of the Planula Zone. Other ammonites from the same member are not numerous and include: *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel) in the top of the member in the core near Mstów, as well as *Pictonia* (*Pictonites*) sp. (Pl. 9: 2) found in the upper part of the member, in core 2B at Ważne Młyny in the northern part of the Wieluń Upland (Fig. 4; see locality 54 in Wierzbowski, 1966). The stratigraphically most important occurrence is, however, that of the ammonite *Subnebrodites schroederi* Wegele found in the micritic limestones at the base of the Prusicko Fm. in the quarry at Mstów [described originally as "*Ataxioceras* (*Parataxioceras*) cf. *desmoides* Wegele" by Malinowska (1964, fig. on p. 426)], indicating still the presence of the *minutum* horizon. This specimen was found along with a poorly preserved ammonite belonging to the Aspidoceratinae in the quarry (Malinowska, 1964), which together with the reported occurrence of ammonites (mostly of the genus *Orthosphinctes*) in a similar stratigraphical position in the cores in this area suggest a stratigraphical condensation at the boundary between the Częstochowa Sponge Limestone Fm. / Pilica Fm. and the Prusicko Fm.

These stratigraphical interpretations indicate that the uppermost part of the massive limestones and associated bedded limestones of the Częstochowa Sponge Limestone Formation, and the micritic limestones and marls of the Pilica Formation in the Wieluń Upland are generally of similar age and correspond in general to the uppermost part of the Planula Zone. The deposits of the Częstochowa Limestone Formation at the top of the biohermal complexes were possibly the lateral time-equivalent of some micritic limestones of the Wolbrom Limestone Member of the Pilica Fm. Partly coeval deposits of the Częstochowa Sponge Limestone Formation and the Wolbrom Limestone Member show marked differences in the composition of the ammonite assemblages as based on about 30 ammonite specimens coming from each of these units. The obtained data indicate a marked dominance of Ataxioceratidae (65.4%), a smaller number of Aulacostephanidae (30.8%), and rare Oppeliidae (3.8%) in the topmost part of the Częstochowa Sponge Limestone Formation, as compared with the common occurrence of Oppeliidae (mostly small *Metahaploceras*) (45.8%), less common Aulacostephanidae (29.2%), and Ataxioceratidae (25.0%) in the upper, marly part of the Wolbrom Limestone Member. These differences in ammonite faunas were strictly related to the differing environmental conditions between the biohermal and basinal areas – with the dominance of ammonites confined mostly to the benthic environment in the former, and the nektonic or necto-pelagic environment in the latter.

A different situation occurs only in the north-western part of the Wieluń Upland in the Szczyty Interbiohermal Basin (see Fig. 3) where the deposits of the basin are developed as bedded limestones with siliceous sponges and yielded the ammonites *Subnebrodites minutum* and *S. schroederi* indicative of the *minutum* horizon of the uppermost part of the Planula Zone (see Matyja, Wierzbowski, 1997, locality Pj 110, p. 85–86, pl. 9: 3). The result of the aforegoing is that the bedded limestones of the Częstochowa Sponge Limestone Fm. range stratigraphically higher in the Szczyty Interbiohermal Basin in north-west, than in any other area of the Wieluń Upland, replacing here laterally the micritic limestones of the Pilica Formation.

THE EASTERN BORDER OF THE WIELUŃ UPLAND (PRUSICKO FM., AND LOCALLY "OOLITIC" FM. AND BURZENIN FM.)

The deposits of the Prusicko Formation occur from the vicinity of Mstów in the south up to the environs of Pajeczno to the north, showing a uniform facies pattern over the whole area of study, overlying those of the sponge megafacies (Częstochowa Sponge Limestone Fm.) and the related deposits of the Pilica Fm. The newly distinguished formation – the Prusicko Fm., includes several smaller rank units (members, beds) formally recognized herein (see Apendix II – where the formal definitions of the newly established lithostratigraphical units are given).

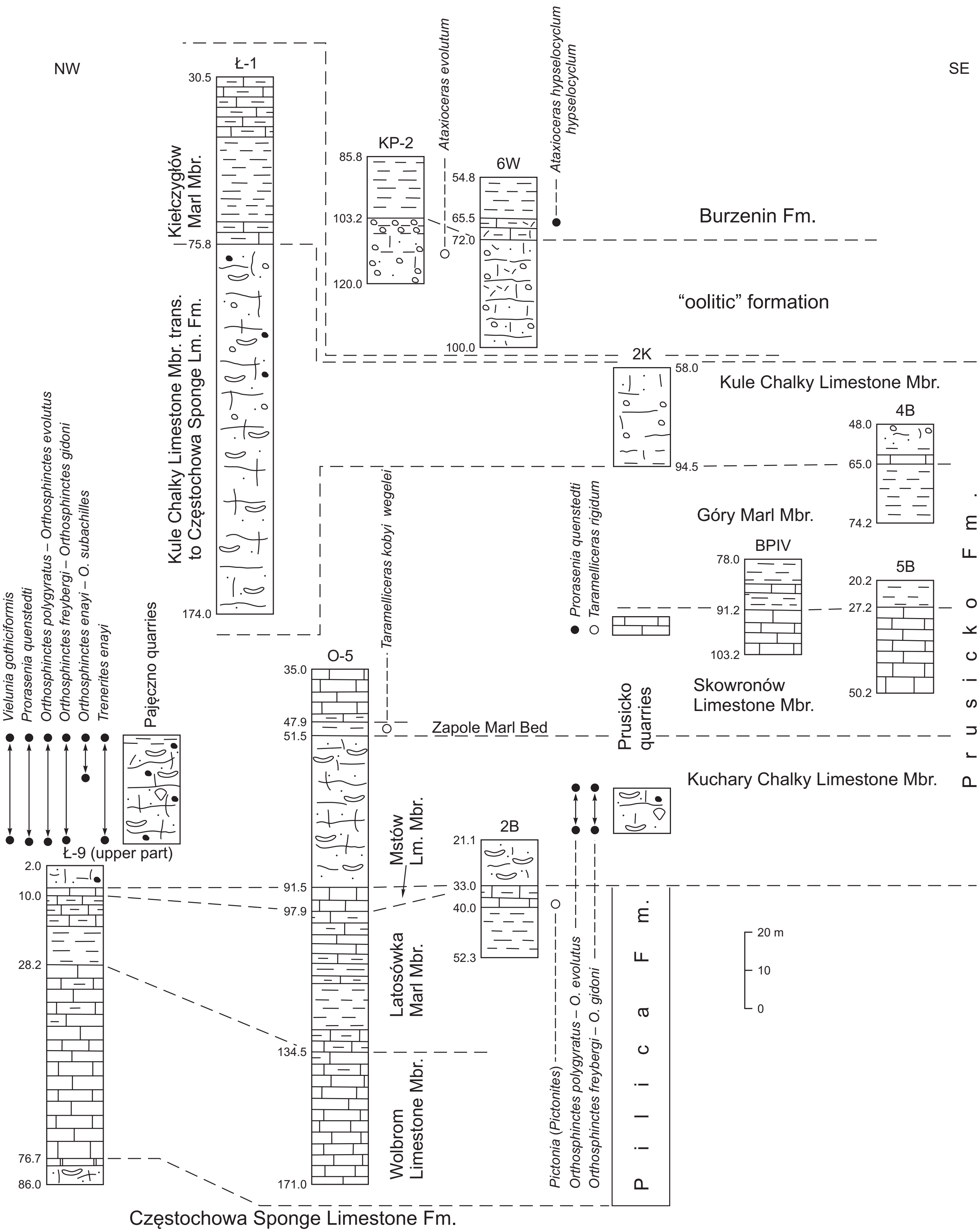
The Prusicko Formation (Fig. 4) is represented commonly in its lower part by soft, friable, well-bedded chalky limestones, generally rich in fossils (siliceous and calcareous sponges, brachiopods, serpulids, and less common hermatypic corals – mostly of the genus *Microsolena*). These deposits attaining about 30–40 meters in thickness in the area of study are distinguished as the Kuchary Chalky Limestone Member (*e.g.*, Kutek *et al.*, 1977; Wierzbowski, 1978).

The limestones of the Kuchary Chalky Limestone Member are often underlain by well-bedded micritic limestones with a poor benthic fauna, with marly intercalations, usually a few meters thick; rarely, and in some sections only, these deposits attain a larger thickness (20–30 m), and replace the whole Kuchary Chalky Limestone Member. These micritic limestones are distinguished herein as the Mstów Limestone Member. Overlying the Kuchary Chalky Limestone Member is the Skowronów Limestone Member, which is represented mostly by thin-bedded micritic limestones with marly intercalations and a poor benthic fauna, attaining about 25–30 meters in thickness. These limestones are underlain by marls up to about 5 meters thick, recognized as the Zapole Marl Bed (Fig. 4). The higher parts of the Prusicko Formation are represented by a thick, up to 30 meters in thickness, marly unit composed of marls and marly limestones with poor benthic fauna. These deposits, cropping out at Prusicko and encountered in boreholes BPIV, 4B, 5B and others, at Prusicko, Brzeźnica Stara and Zakrzówek Szlachecki (Figs 4, 8A; see also Wierzbowski, 1966, fig. 5), are recognized herein as the Góry Marl Member. Although the micritic limestone and marly members of the Prusicko Fm. are generally poorly fossiliferous, the fairly diversified infaunal-semiinfaunal bivalve assemblages, more rich than those of the underlying Pilica Fm., occur at some levels (see Wierzbowski, 1966). Also the assemblage of foraminifers is generally diversified, being composed mostly of the benthic calcareous forms as recognized in the marly units (Garbowska, 1970), associated with commonly occurring holothurian sclerites (Garbowska, Wierzbowski, 1967).

The highest deposits of the Prusicko Formation are also represented by well-bedded chalky limestones with cherts, rich in benthic fauna (siliceous and calcareous sponges, hermatypic corals – mostly of the genus *Microsolena*, brachiopods, serpulids, bivalves). Such deposits were encountered in boreholes 4B, 2K and others, at Zakrzówek Szlachecki near Prusicko and at Brzeźnica Nowa, as well as in the outcrops in the northern border of the Wieluń Upland, near Kule at Kiełczygłów (Wierzbowski, 1966). They have been

→

Fig. 4. Succession of the Kimmeridgian deposits and their lithostratigraphical interpretation in selected sections in the eastern border of the Wieluń Upland between Prusicko and Pajęczno (mostly after Wierzbowski, 1966 and Wierzbowski *et al.*, 1981); the most important ammonite finds are indicated (for explanations and location of the sections see Figs 6, 8A). The succession shows the transition from deep-neritic deposits (Częstochowa Sponge Limestone Fm. and Pilica Fm.) through moderately-shallow water deposits (Prusicko Fm.), which are laterally replaced by deeper-marine deposits transitional to the Częstochowa Sponge Limestone Fm., to shallow-water carbonate platform deposits ("oolitic" fm.) and finally to open-marine basinal deposits (Burzenin Fm.) (see text)


NW
SE
Ł-1
30.5
75.8
174.0
Kiełczygłów Marl Mbr.
Kule Chalky Limestone Mbr. trans. to Częstochowa Sponge Lm. Fm.
KP-2
85.8
103.2
120.0
Ataxioceras evolutum
6W
54.8
65.5
72.0
100.0
Ataxioceras hypselocyclum hypselocyclum
Burzenin Fm.
"oolitic" formation
2K
58.0
94.5
Kule Chalky Limestone Mbr.
4B
48.0
65.0
74.2
Góry Marl Mbr.
BPIV
78.0
91.2
103.2
5B
20.2
27.2
50.2
Skowronów Limestone Mbr.
Prusicko Fm.
Taramelliceras kobyi wegelei
Prorasenia quenstedti
Taramelliceras rigidum
Prusicko quarries
O-5
35.0
47.9
51.5
91.5
97.9
134.5
171.0
Zapole Marl Bed
Kuchary Chalky Limestone Mbr.
Vielunia gothiciformis
Prorasenia quenstedti
Orthosphinctes polygyratus – Orthosphinctes evolutus
Orthosphinctes freybergi – Orthosphinctes gidoni
Orthosphinctes enayi – O. subachilles
Trenerites enayi
Pajęczno quarries
Ł-9 (upper part)
2.0
10.0
28.2
76.7
86.0
Mstów Lm. Mbr.
Latosówka Marl Mbr.
Wolbrom Limestone Mbr.
2B
21.1
33.0
40.0
52.3
Pictonia (Pictonites)
Orthosphinctes polygyratus – O. evolutus
Orthosphinctes freybergi – O. gidoni
Pilica Fm.
20 m
10
0
Częstochowa Sponge Limestone Fm.

distinguished originally as the Kule Chalky Limestone Member (Figs 4, 8A, C; see also Kutek *et al.*, 1977; Wierzbowski, 1978). Similar deposits represented by bedded limestones with cherts, and with commonly occurring siliceous sponges and *Tubiphytes*, but without corals, were encountered in borehole Ł-1, north-west of Pajęczno (Figs 4, 8A). They represent the lateral transition from the uppermost part of the Prusicko Fm. (Kule Chalky Limestone Mbr.) to the Częstochowa Sponge Limestone Formation.

The total thickness of the Kule Chalky Limestone Member is difficult to estimate precisely, but it reaches at least some tens of meters at Zakrzówek, and more than 100 meters near Kule. The top of the member marks the top of the Prusicko Formation.

The oldest ammonite fauna of the Prusicko Formation coming from the lower part of the Kuchary Chalky Limestone Member, and underlying deposits of the Mstów Limestone Member is generally poorly known in the area of study. Rare ammonites were reported from this stratigraphical interval in the southern area of study, in the Kuchary section by Wierzbowski (1964, 1970). These include especially some specimens of Aulacostephanidae, such as *Vielunia tenuiplexa* (Quenstedt), *Prorasenia* cf. *hardyi* Spath (Pl. 9: 4) and *Prorasenia* sp., and less common Ataxioceratidae (*Orthosphinctes*). Possibly coeval are ammonites coming from poorly exposed micritic limestones and the bedded limestones at Gawłów near Pajęczno (Wierzbowski, 1966): *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke) and *Vielunia tenuiplexa* (Quenstedt). These poor assemblages of ammonites makes closer stratigraphical interpretation of the deposits difficult. More useful for stratigraphy appear, however, ammonites coming from the deposits corresponding to a lower part of the Kuchary Chalky Limestone Member, at Julianka quarry, placed about 25 kilometers south-east of the area of study. These deposits (Matyja, Wierzbowski, 2006) yielded rich assemblage of aulacostephanids composed of *Prorasenia quenstedti* (Schindewolf), *Pictonia* (*Pictonites*) *kuyaviensis* Matyja et Wierzbowski, *Prorasenia* cf. *hardyi* Spath, and additionally a few *Orthosphinctes* (*Orthosphinctes*) sp., and even a single small specimen of *Subnebrodites* sp. The assemblage although not described so far in detail undoubtedly indicates the lower part of the Galar Subzone (*e.g.*, Matyja, Wierzbowski, 2002 – where the occurrence of *P. kuyaviensis* is well documented). The general similarity of the assemblage in question to that from the lower part of the Kuchary Chalky Limestone Member at Kuchary may suggest their similar stratigraphical position.

The Galar Subzone as named by Dieterich (1940) was treated originally as a lower part of the Platynota Zone (or Subzone) – *e.g.*, Arkell (1956, p. 115). The interpretation of the boundary between the Galar Subzone and the Platynota Subzone as corresponding to the boundary between the South Germany *Weissjura β* and *γ*, and independently the *Idoceras- Schichten* and the *Ataxioceras-Schichten*, resulted in the transformation of the Galar Subzone into the Planula Zone, and the restriction of the Platynota Zone to the original range of the Platynota Subzone (see Geyer, 1961, pp. 141–143). The placing of the Galar Subzone in the upper part of the Planula Zone has been generally accepted in the Submediterranean zonal scheme, although some authors have indicated marked inconveniences relating to such a stratigraphical interpretation, and some of them treated the Galar Subzone as the lowermost part of the Platynota Zone (Atrops, 1982, p. 322–323; Meléndez *et al.*, 2006). Similar classification of the Galar Subzone as the lowermost subzone of the Platynota Zone is also accepted herein. There are some general reasons for such an interpretation – not only historical but also practical ones: (1) the ammonites of the genus *Subnebrodites* are really very uncommon in the Galar Subzone and not important for stratigraphy (*e.g.*, Atrops, Meléndez, 1994); (2) the overall character of the ammonite fauna of the Galar Subzone is close to that of the Platynota Subzone (*e.g.*, Atrops, Ferry, 1989), and (3) the correlation between the Submediterranean zonal scheme, and the Boreal scheme is easier when the Galar Subzone is placed within the Platynota Zone, because the base of this zone corresponds to the base of the Boreal Kitchini Zone (*e.g.*, Matyja, Wierzbowski, 2002).

The ammonite fauna coming from the upper part of the Kuchary Chalky Limestone Member is dominated by ammonites of the family Ataxioceratidae – of the genus *Orthosphinctes* (over 83% of the whole number of specimens, with some admixture of Aulacostephanidae – about 14%, and very rare representatives of other ammonite groups). The following dimorphic species pairs have been recognized: *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke) (m) – *O.* (*Lithacosphinctes*) *evolutus* (Quenstedt) (M) (Pl. 1: 4), and *O.* (*O.*) *freybergi* (Geyer) (m) – *O.* (*L.*) *gidoni* Atrops (M) (Pl. 2: 1; Pl. 3). These ammonites have been found in several quarries which no longer exist, both in the southern part of the eastern margin of the Wieluń Upland at Kuchary (see Wierzbowski, 1964, figs 1–2, locality K-1; Atrops, Wierzbowski, 1994), as well as its northern part at Prusicko (Wierzbowski, 1966, locality no. 36; Wierzbowski, 1978, fig. 1) and Pajęczno (Wierzbowski, 1966, locality no. 47 – "New Urban" quarry, figs 1, 2; and locality no. 59 – "Na Targowicy" quarry, fig. 3, pl. 2: 1, 2; see also Figs 4, 8A, and comments on ammonites in the palaeontological part of the study – see Appendix I). These ammonites generally are indicative of the lower part of the Platynota Zone (as interpreted) herein) – *i.e.* the Galar Subzone, as well as the Polygyratus (= Orthosphinctes) Subzone (Atrops, Wierzbowski, 1994; see also Fig. 13), and do not range into higher parts of the Zone. Additionally, in some sections (Kuchary, locality K-1, and Pajęczno – "New Urban" quarry) have been found ammonites of the dimorphic pair *Orthosphinctes* (*Ardescia*) *enayi* Atrops (m) (Pl. 4: 1) and *O.* (*Lithacosphinctes*) *pseudoachilles* (Wegele) (M) (Pl. 4: 2) which are indicative of the *enay* horizon of the lowermost part of the Desmoides Subzone of the middle part of the Platynota Zone (Atrops, Wierzbowski, 1994). These come from the highest deposits of the Kuchary Chalky Limestone Member characterized by abundantly occurring ammonites in a fairly narrow stratigraphical interval which indicates stratigraphical condensation. This condensation includes some upper parts of the Polygyratus Subzone, and the lowermost part of the Desmoides Subzone. In the same stratigraphical interval were also found Subboreal aulacostephanid ammonites including late representatives of the genus *Vielunia*, and interpreted herein as *Vielunia gothiciformis* (Schneid) (Pl. 10: 1, 2), and *Prorasenia* including *Prorasenia quenstedti* Schindewolf (see discussion in the palaeontological part of the study). It should be remembered that the genus *Vielunia* is recognized as closely related to the Subboreal genus *Pictonia* (see Wierzbowski *et al*., 2010), and thus the occurrence of these ammonites at the boundary between the Polygyratus and the Desmoides subzones of the Platynota Zone of the Submediterranean zonal scheme suggests the correlation of this stratigraphical interval with some upper parts of the Baylei Zone of the Subboreal zonal scheme.

Some comments may be also given on ammonites originally attributed to the genus *Subnebrodites* and coming from the Kuchary Chalky Limestone Member at Pajęczno ("New Urban" quarry in Wierzbowski, 1966). One of these ammonites (Wierzbowski, 1966, pl. 8: 1) originally referred to as "*Subnebrodites planula* (Hehl)" is in fact *Trenerites enayi* Sarti – the Mediterranean species indicative of the Silenum Zone, corresponding to the Submediterraenan Platynota Zone (Sarti, 1993). The second ammonite referred to as "*Subnebrodites laxevolutum* (Fontannes)" (Wierzbowski, 1966, pl. 6: 2) undoubtedly belongs to this species – and may represent a very late representative of the genus which ranges sporadically up into the lower part of the Platynota Zone as reported by Schairer (1995). Another solution may however be considered, according to which the specimen did not come from this location, but had been transported from other place, maybe with limestones used for lime-burning. The stratigraphical proposal given in the past by the author (Wierzbowski, 1978) to distinguish the horizon "*Idoceras planula-Prorasenia quenstedti*" as covering the deposits of the uppermost part of the Planula Zone (including the Galar Subzone) in the area of study thus appeared erroneous.

Younger deposits of the Prusicko Formation were described mostly in the northern part of the eastern border of the Wieluń Upland, especially close to Prusicko village, where they had been accessible in the past in small quarries, and clay pits (Figs 4, 8A). A few ammonites coming from the upper part of the micritic limestones of the Skowronów Limestone Member together with rich bivalve assemblage (locality no. 62 in Wierzbowski, 1966; see also comments in the palaeontological part of the study) include: *Taramelliceras* cf. *rigidum* (Wegele) (Pl. 1: 1), *Orthosphinctes* (? *Ardescia*) sp., and *Prorasenia quenstedti* Schindewolf. Another ammonite referred to as *Taramelliceras* cf. *kobyi wegelei* Schairer (Pl. 1: 2) was found a few kilometers east of Pajęczno, in core O-5 at depth 47.3 m, in the lower part of the Skowronów Limestone Member, directly above the marls of the Zapole Marl Bed (Fig. 4). The occurrence of the two representatives of the genus *Taramelliceras* listed above indicates the presence of the Platynota Zone (*e.g*., Schairer, 1972, 1983).

No ammonites were found in the upper part of the Prusicko Formation in the eastern border of the Wieluń Upland. Ammonite dating from the northern border of the Wieluń Upland suggests that these deposits correspond to the Platynota Zone, and the lowermost part of the Hypselocyclum Zone (see below).

Younger deposits representing the topmost part of the Jurassic succession were penetrated in the boreholes in the north-eastern border of the Wieluń Upland, directly below the Albian-Cenomanian sandstones and siltstones. They are developed as limestones and marly limestones with common oncolites and bioclasts, and a rich benthic fauna represented mostly by different infaunal and semiinfaunal bivalves (*Astarte*, *Cucullaea*, *Isoarca*, *Mytilus*, *Gervillia*, *Pleuromya*), with rare oysters (*Nanogyra*), brachiopods, crinoids, and ammonites (*Prorasenia* sp.); these limestones attain here at least 35 meters in thickness (but their base was not encountered in the boreholes). The ammonites occur commonly in the upper marly part of the limestone unit, in an interval a few meters thick. Overlying deposits are blue grey and yellowish marls with a poor benthic fauna, about 10–18 meters thick (Figs 4, 8A). All these deposits were described in localities 78 (borehole 6W at Dubidze, at depth 54.8–100.0 m), and 80 (borehole KP-2 at Błota Kruplińskie, depth 85.8–120.0 m) (Wierzbowski, 1966). The deposits may be correlated with upper unit of the "oolitic" fm., and the overlying part of the Burzenin Formation from the succession at the northern border of the Wieluń Upland. They have yielded some ammonites. These were found in the boreholes, in a narrow stratigraphical interval at the top of the limestones with oncolites of the "oolitic" fm.: *Ataxioceras* (*Parataxioceras*) cf. *evolutum* Atrops found at 113.7–115.0 in borehole KP-2; and at the base of the overlying marls and marly limestones (Burzenin Fm.): *Ataxioceras* (*Ataxioceras*) *hypselocyclum hypselocyclum* (Fontannes) (Pl. 6: 3) and *A.* (*A.*) cf. *hypselocyclum* (Fontannes) at 66.8–68.1 m in borehole 6W. The former is known in the Hippolytense Subzone of the Hypselocyclum Zone, but is especially common in the *discoidale* horizon of the lowermost Lothari Subzone of the Hypselocyclum Zone, the latter occurs in the directly younger *hypselocyclum* horizon of the lower part of the Lothari Subzone of the Hypselocyclum Zone (Atrops, 1982; see also Fig. 13). The occurrence of numerous ammonites, representing different stratigraphical levels in a fairly narrow part of the succession, indicates a slow sedimentation rate, and stratigraphical condensation. This occurs here in the stratigraphical interval from the top of the Hippolytense Subzone (?) up to the lower part of the Lothari Subzone of the Hypselocyclum Zone.

NORTHERN BORDER OF THE WIELUŃ UPLAND (PILICA FM., PRUSICKO FM., "OOLITIC" FM., AND THE BURZENIN FM.)

The most completely recognized succession of the deposits representative of the northern border of the Wieluń Upland, is known from its eastern part, along the brown-coal fields of the Bełchatów and Szczerców at Kleszczów, Dębina and Stróża, where it has been studied mainly in boreholes.

A very complete succession of the deposits (Figs 5, 8B; after Szewczyk *et al.*, 1975–2015, modified), attaining about 280 m in thickness, is based on the sections of boreholes drilled at the brown-coal field at Szczerców (especially core 37/13.5, and additionally the section in the southern part of the outcrop studied by the author of the study), the core sections at Dębina south of the outcrop (PD20B, PW408, 130SP, and 120G-1P and PW393), and the core section from the Bełchatów outcrop (KT109).

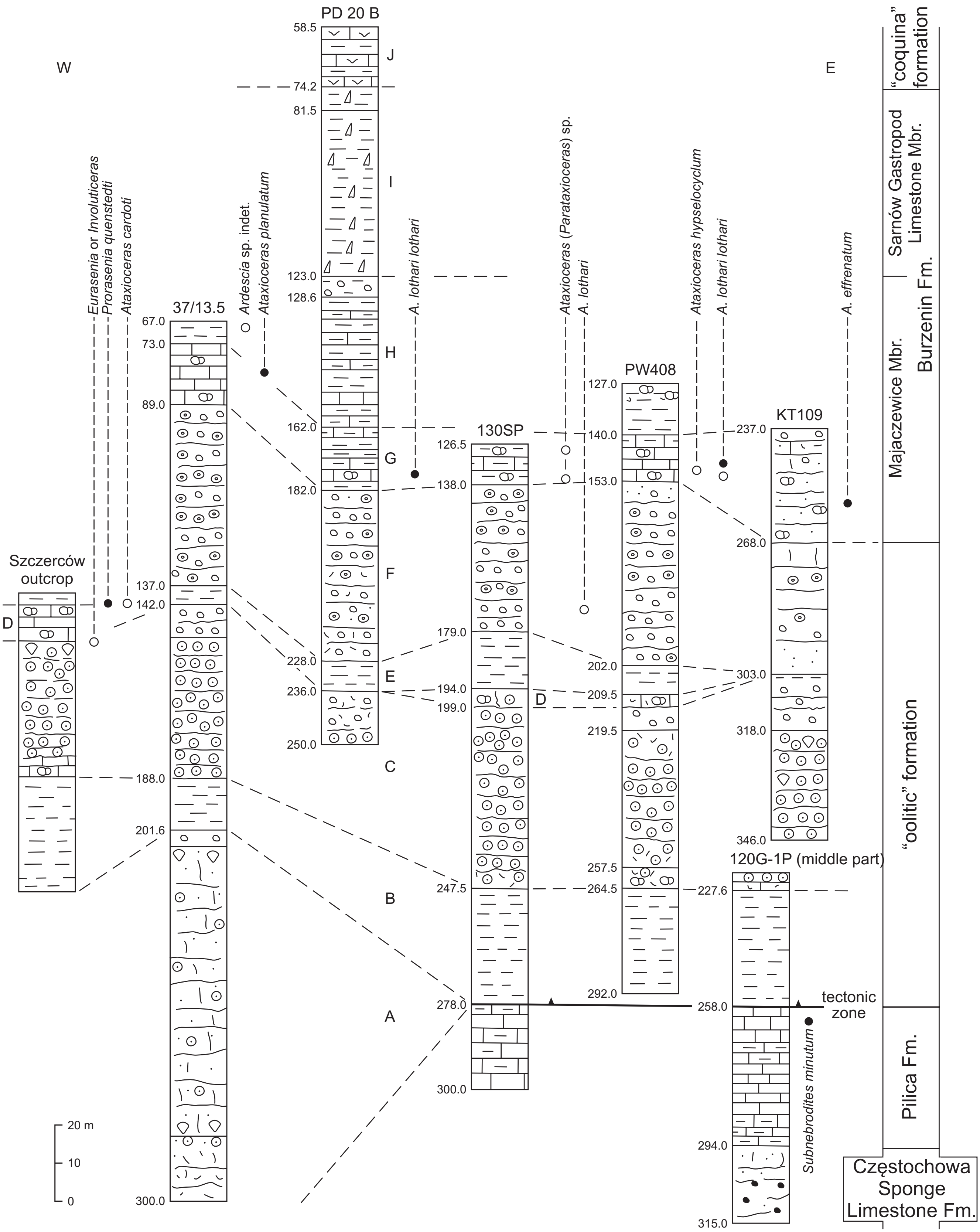
The oldest deposits are recognized in cores 130SP, 120G-1P and PW393. These are the micritic limestones with intercalations of marly limestones with a poor benthic fauna (small bivalves *Astarte* sp.). These deposits attain about 75 m in core PW393 and 36 m in core 120GP-1P (and at least 22 m in thickness in core 130SP where the base of these deposits was not encountered), and they rest in both cores on thick-bedded limestones with cherts. The micritic limestones have yielded some ammonites (Fig. 5): *Subnebrodites minutum* (Dieterich) (Pl. 2: 4) at 266.5 m depth in core 120GP-1, and *Orthosphinctes* (*Orthosphinctes* or *Lithacosphinctes*) at 240 m depth in core PW 393. The former found in the upper part of the unit indicates the presence of the *minutum* horizon of the uppermost part of the Planula Zone, the latter suggests the Planula Zone. The micritic limestones correspond to the Wolbrom Limestone Member of the Pilica Fm., the underlying thick-bedded limestones with cherts represent possibly the bedded limestones of the Częstochowa Sponge Limestone Fm. The cores which yielded the deposits discussed are located along a straight line parallel to the tectonic border of the Kleszczów Graben, and the deposits are almost surely in tectonic contact with the overlying deposits, described below.

The overlying deposits represent the complete succession (Figs 5, 8B and 9) which is composed of the following lithostratigraphical units (from the base):

A. biodetrital chalky limestones with an abundant fauna (hermatypic corals, brachiopods, bivalves – including *Trichites*, echinoderms – in the lowermost part ooids are common – thickness is at least 98.4 m – base not exposed (core 37/13.5), at the topmost part (about 5 m thick) oncolites are common;
B. blue grey marls attaining at least (base not exposed) 27.5 m (core PW408), and about 30 m (brown-coal outcrop) in thickness, or marly micritic limestones with poor benthic fauna (22 m in thickness, base not exposed) overlain by marls (30.5 m thick) (core 130SP), but locally of reduced thickness (13.6 m; core 37/13.5) – a tectonic reduction may be taken into account;
C. micritic limestones with marly intercalations locally with common infaunal and semiinfaunal bivalve fauna (*Pholadomya*, *Goniomya*, *Inoperna*) – the deposits may contain locally ooids in their upper part – total thickness of deposits is about 7 m (boreholes PW408 and 130SP, and brown-coal outcrop), but locally they are missing (borehole 37/13.5); these deposits are overlain by oolitic limestones attaining from 37–38 m (cores 37/13.5, and PW 408) – in the latter a marked admixture of bioclasts in the uppermost and lowermost parts of the unit is seen, and up to 42 m in thickness (core 130SP); such deposits were recognized also in the basal part of core PD20B (at least 14 m), and in core KT109 (at least 28 m in thickness); the oolites are seen also in the brown-coal mine of the Szczerców outcrop where they attain about 30 meters in thickness, at the top of the unit commonly occur here large colonies of the hermatypic corals, and thick-shell bivalves *Trichites* bored by lithophags; the oncolitic limestones are locally recognized at the top of C unit (9 m in core 37/13.5; 11 m in core PD 20B, and 15 m in core KT109);
D. micritic limestones with common infaunal and semiinfaunal bivalves often in growth positions (*Pleuromya*,

→

Fig. 5. Succession of the Kimmeridgian deposits and their lithostratigraphical interpretation in selected sections in the Szczerców and Bełchatów brown-coal fields in the northern border of the Wieluń Upland (based on lithological succession after Szewczyk *et al.*, 1975-2015, modified); the most important ammonite finds are indicated (for explanations and location of the sections see Figs 6 and 8B). The oldest deposits of the succession represent the deep-neritic environment (Częstochowa Sponge Limestone Fm. and Pilica Fm.), whereas the younger ones (in tectonic contact) show the transition from shallow-water carbonate platform deposits ("oolitic" fm.) to open marine basinal deposits (Burzenin Fm.) (see text)


W
E
PD 20 B
37/13.5
Szczerców outcrop
130SP
PW408
KT109
120G-1P (middle part)
J
I
H
G
F
E
D
C
B
A
Eurasenia or Involuticeras
Prorasenia quenstedti
Ataxioceras cardoti
Ardescia sp. indet.
Ataxioceras planulatum
A. lothari lothari
Ataxioceras (Parataxioceras) sp.
A. lothari
Ataxioceras hypselocyclum
A. lothari lothari
A. effrenatum
Subnebrodites minutum
tectonic zone
“coquina” formation
Sarnów Gastropod Limestone Mbr.
Majaczewice Mbr.
Burzenin Fm.
“oolitic” formation
Pilica Fm.
Częstochowa Sponge Limestone Fm.
20 m
10
0

Pholadomya, *Inoperna*), brachiopods, gastropods (thickness: 2.5 m in core PW408; 5 m in core 130SP; about 10 m in the section at the brown-coal outcrop);

E. marls (thickness: 7.5 m in core PW408; 15 m in core 130SP; 5 m in core 37/13.5; 8 m in core PD20B, a few meters in the brown-coal outcrop); the contact between limestones of unit D and marls of unit E as seen in the outcrop section is marked by the prominent omission surfaces on the two topmost limestone beds – the lower surface is marked by a lag of inner moulds of infaunal bivalves, the upper – shows common borings of lithophags; in some sections this unit is missing (? tectonic contact);

F. oncolitic limestones (thickness: 49 m in core PW408; 41 m in core 130SP; 48.2 m in core 37/13.5; 46.3 m in core PD20B); in core KT109 this unit is represented by chalky limestones with intercalations of oncolites (35 m thick);

G. micritic limestones with bioclasts and oncoids overlain by marls and marly limestones heavily penetrated by burrows (*Chondrites*, *Planolites*); infaunal bivalves (*Astarte*), brachiopods, serpulids, crinoids and ammonites are commonly encountered (thickness: 13 m in core PW408; 16 m in core 37/13.5; 20 m in core PD20B; at least 11.5 m seen in core 130SP, and at least 31 m in core KT109);

H. marls with intercalations of limestones with a poor fauna (39 m in PD20B where an oncolitic subunit about 5 m in thickness is recognized at the top; at least 13.5 m in core PW 408, and 6 m seen in core 37/13.5);

I. marls and marly limestones with bivalves, and commonly occurring concentrations of tiny gastropods (*Cerithium* and others) at some levels; these deposits encountered in core PD 20B b) attain about 50 m in thickness;

J. marls and marly limestones with commonly occurring intercalations of coquina composed of fragments of *Nanogyra* shells; the unit attains at least about 16 m in core PD 20B.

The lithostratigraphical interpretation of these deposits is given as follows (Fig. 5). Units A to F are dominated by shallow-water origin deposits and their correlation with the informally distinguished "oolitic" formation of Dembowska (1979) is for the time-being accepted. The marls of the Kiełczygłów Member, treated herein as the lowest member of the newly distinguished Burzenin Formation (see description in appendix II), are also distinguished in the "oolitic" fm. (unit B as described above), and treated as a member in common to the two formations discussed. A marked change in the character of the deposits is observed at the base of unit G represented in the area of study by micritic limestones with common infaunal bivalves and ammonites. These deposits together with the overlying marls of unit H belong already to the Majaczewice Member of the Burzenin Formation. The younger unit I represented by marls with tiny gastropod accumulations should also be included into the Burzenin Formation, and it is treated as a new member – the Sarnów Gastropod Limestone Member (see description of the succession at Burzenin). The youngest deposits in the succession studied (unit J) characterized by accumulations of *Nanogyra* hash represent already the "coquina" formation.

Ammonites have been encountered in several stratigraphical intervals of the succession recognized in the boreholes and the outcrop within the brown-coal field at Szczerców (Fig. 5). The oldest fauna comes from micritic limestones (unit D), directly above the oolites of unit C at the southern border of the brown-coal outcrop. Ammonites have been found in the lowermost part of unit D (*Eurasenia* or *Involuticeras*), as well as its uppermost part, close to the omission surfaces [*Ataxioceras* (*Ataxioceras*) sp. – early form; *Prorasenia* cf. *quenstedti* (Schindewolf) (Pl. 10: 4), *Prorasenia* sp]; further specimens have been found loose in the rubble (Aulacostephanidae indet., "*Orthosphinctes* sp." similar to *Orthosphinctes* sp. indet. of Sarti (1993, p. 75, pl. 2: 2). The most important stratigraphically is *Ataxioceras* (*Ataxioceras*) sp. – early form, which is similar to *A.* (*A.*) *cardoti* Atrops and the allied species (*cf.* Atrops, 1982). It indicates the Hypselocyclum Zone close to the boundary between the Hippolytense Subzone and the Lothari Subzone. Worth noting is the occurrence of the Tethyan form (although poorly preserved) "*Orthosphinctes* sp." which is similar to *Orthosphinctes* sp. indet of the Mediterranean Strombecki Zone as reported by Sarti (1993). The composition of the discussed ammonite fauna is remarkable, being represented mostly by Aulacostephanidae with a lesser number of Ataxioceratidae.

A younger ammonite is *A.* (*P.*) cf. *lothari* (Oppel) found in the middle part of the oncolitic limestones (unit F) representing the top of the "oolitic" formation (core 130SP, depth 173 m). It suggests the lowermost part of the Lothari Subzone of the Hypselocyclum Zone (Fig. 9; *cf.* Atrops, 1982).

Very abundant ammonites of the genus *Ataxioceras* have been found in the lower part of the micritic limestones with bioclasts overlain by marls and marly limestones (unit G) referred already to the Burzenin Fm. The ammonite fauna includes: *Ataxioceras* (*Parataxioceras*) *effrenatum* (Fontannes) (Pl. 7: 1) (core KT109, depth 256.5 m); *Ataxioceras* (*Parataxioceras*) cf. *lothari* (Oppel) (core PW408 depth 152.6 m, and 149 m); *A.* (*P.*) *lothari lothari* (Oppel) (Pl. 6: 4) – a very heavily ribbed form similar to variety "*A. nudocrassatum* Geyer" (core KT109, depth 149.5 m); *A.* (*Ataxioceras*) ex gr. *hypselocyclum* (Fontannes) (core KT109, depth 150 m); *Ataxioceras* (*Parataxioceras*) spp (core 130SP, depth 127 m); *Ataxioceras* (*Parataxioceras*) sp. (core 37/13.5, depth 83 m); *A.* (*P.*) *planulatum* (Quenstedt) (Pl. 8: 2) (core 37/13.5, depth 81 m); *Ataxioceras* (*Parataxioceras*) *lothari lothari* (Oppel) (core PD20B, depth 175–

176 m). The occurrence of these ammonites is indicative of the lower part of the Lothari Subzone of the Hypselocyclum Zone (Fig. 13), especially the *hypselocyclum* horizon as shown by occurrence of *A.* (*P.*) *planulatum*, *A.* (*A.*) *hypselocyclum* and the common occurrence of *A.* (*P.*) *lothari lothari* (*cf.* Atrops, 1982, p. 329). Here also, the mass occurrence of ammonites in the narrow interval in the cores studied indicates stratigraphical condensation.

Somewhat stratigraphically isolated is the youngest specimen in the succession, a very interesting but poorly preserved form referred to as *Orthosphinctes* (*Ardescia*) sp. indet. It derives from a lowermost part of the marly unit (unit H; core 37/13.5 at 69 m; see Fig. 5) belonging still to the Burzenin Fm. – the Majaczewice Member. The ammonite shows some similarity with *O.* (*A.*) *schaireri* Atrops and especially with the closely related form *O.* (*A.*) *retrofurcatus* (Fontannes), but it is smaller, somewhat similar in size to *O.* (*A.*) *perayensis* Atrops – from which it differs in its more regular ornamentation, except on the final part of the shell. This specimen may represent a transitional form between the older ammonites of the subgenus *Ardescia* and the final species of the *Ardescia* lineage – *A. perayensis* (*cf.* Atrops, 1982). This, together with the stratigraphical position in the succession, suggests some upper parts of the Hypselocyclum Zone.

The youngest deposits in the succession studied did not yield any ammonites, and hence their stratigraphical interpretation is unclear.

The succession of deposits in the western part of the northern border of the Wieluń Upland is known at Kiełczygłów (Figs 6, 8C). The deposits outcropped in the past in small quarries (Wierzbowski, 1966, localities 83-88), and have been penetrated by shallow boreholes (Wierzbowski *et al*., 1981, 1983). This area shows marked lateral facies changes. North-east of Kiełczygłów, the succession recognized in cores J-1, J-4 and J-10 indicates similarity to that described from the brown-coal fields of Bełchatów and Szczerców (see Figs 5 and 6). All the lithostratigraphic units of the the "oolitic" formation (A to F) may be distinguished here as well, although the deposits differ in the smaller size of the oolite and oncolite grains, and in the larger amount of fine-grained bioclastic limestones and marls in the succession. These deposits are overlain by micritic limestones with common infaunal bivalves and locally occurring ammonites – which may be correlated with unit G and correspond already to the Majaczewice Member of the Burzenin Formation. The deposits of unit G, above the limestones with common oncolites and bioclasts (unit F – "oolitic" fm.), and directly below the overlying marls (unit H), yielded numerous ammonites in core J-10 (Fig. 6; see also Wierzbowski *et al*., 1983, fig. 2). These ammonites were found at depth 22.7–37.5 m in the marly limestones, with the most numerous specimens coming from the lower part of this interval – especially between 30.6-32 m. Here were recognized: *Ataxioceras* (*Parataxioceras*) *lothari lothari* (Oppel) (Pl. 7: 3) and *A.* (*P.*) cf. *lothari* (Oppel) (Pl. 7: 2) at 30.6 m, and *Ataxioceras* (*Ataxioceras*) cf. *hypselocyclum* (Fontannes) (Pl. 7: 5) together with *Involuticeras* sp. ex gr. *I. involutum* (Quenstedt) or *I. limbatum* (Schneid) (Pl. 8: 5) at 32 m. The interval with ammonites studied may be correlated with the lower part of the Lothari Subzone of the Hypselocyclum Zone (Fig. 9; *cf.* Atrops, 1982). It may be correlated with deposits containing a similar ammonite fauna described above from the upper part of the limestone interval (unit G) in the north-eastern border of the Wieluń Upland.

The succession changes laterally markedly in its character in the area north of Kiełczygłów (Figs 6, 8C). It was studied in the outcrops at Kule (Wierzbowski, 1966, localities 83–84), and in cores A-4 and A-10 (Fig. 5; see also Wierzbowski *et al*., 1981, 1983). The outcrops at Kule showed the presence of the bedded chalky limestones with abundant benthic fauna and cherts. The fauna usually is represented by siliceous and calcareous sponges, serpulids, brachiopods, bryozoans and bivalves; less commonly by gastropods, crinoids, and hermatypic corals (mostly *Microsolena*). Similar deposits attain at least about 90 meters in thickness in core A-4. They are recognized as the Kule Chalky Limestone Member of the uppermost part of the Prusicko Formation. They represent the lateral equivalent of the unit A (chalky limestones with corals) of the "oolitic" formation from the Bełchatów–Szczerców brown-coal field area, but they differ in the more common occurrence of siliceous sponges, the presence of cherts, a poorer coral assemblage, and the complete lack of oolite intercalations. More towards the north, in core A-10, the corresponding deposits are represented by bedded limestones with cherts and commonly occurring siliceous sponges, and *Tubiphytes*, but without corals. They represent thus the lateral transition from the uppermost part of the Prusicko Fm. (Kule Chalky Limestone Mbr.) to the Częstochowa Sponge Limestone Formation.

The deposits of the Kule Chalky Limestone Member and directly overlying deposits outcropping at Kule village have yielded in their upper parts several ammonites. These were partly described before (Wierzbowski, 1966, localities 83 and 84), but the determinations are revised herein (see palaeontological part of the study). The ammonite fauna from the Kule Chalky Limestone Member includes: *Ataxioceras* (*Parataxioceras*) *homalinum* Schneid (Pl. 5: 2, 3), *Ataxioceras* (*P.*) *lautum* Schneid (Pl. 5: 4), *Ataxioceras* (*Ataxioceras*) *eudiscinum* Schneid (Pl. 2: 5; Pl. 5: 7), and several fragments of *Ataxioceras* difficult for closer determination, along with a single aulacostephanoid – *Pictonia* (*Pictonites*) *constricta* Schneid (Pl. 9: 1a, b). The ammonites are gener-

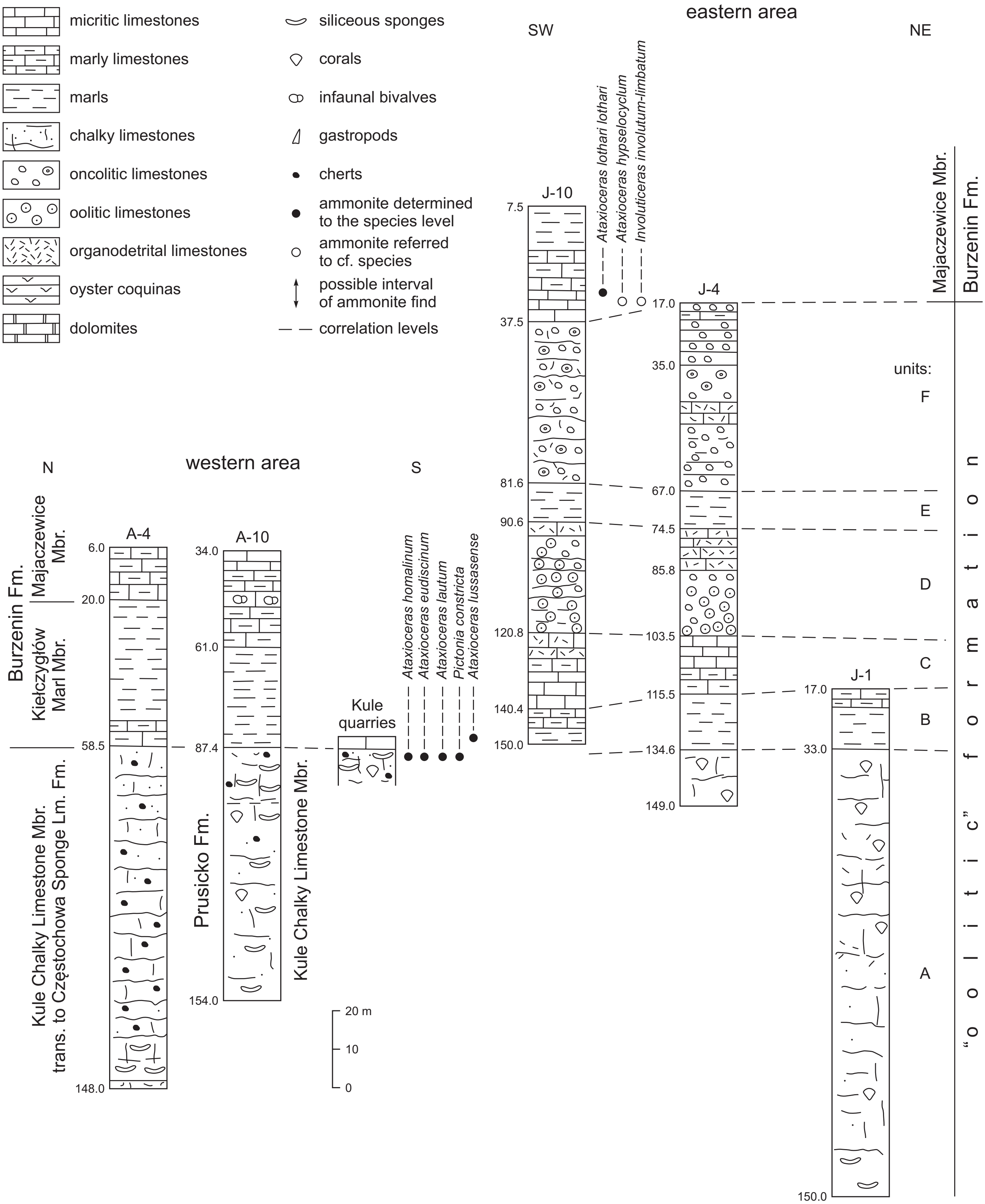

micritic limestones
marly limestones
marls
chalky limestones
oncolitic limestones
oolitic limestones
organodetrital limestones
oyster coquinas
dolomites
siliceous sponges
corals
infaunal bivalves
gastropods
cherts
ammonite determined to the species level
ammonite referred to cf. species
possible interval of ammonite find
correlation levels
eastern area
SW
NE
western area
N
S
J-10
J-4
J-1
A-4
A-10
Kule quarries
Ataxioceras lothari lothari
Ataxioceras hypselocyclum
Involuticeras involutum-limbatum
Ataxioceras homalinum
Ataxioceras eudiscinum
Ataxioceras lautum
Pictonia constricta
Ataxioceras lussasense
Majaczewice Mbr.
Burzenin Fm.
Kiełczygłów Marl Mbr.
Kule Chalky Limestone Mbr. trans. to Częstochowa Sponge Lm. Fm.
Prusicko Fm.
Kule Chalky Limestone Mbr.
“oolitic” formation
units:
F
E
D
C
B
A
7.5
37.5
81.6
90.6
120.8
140.4
150.0
17.0
35.0
67.0
74.5
85.8
103.5
115.5
134.6
149.0
33.0
6.0
20.0
58.5
148.0
34.0
61.0
87.4
154.0
20 m
10
0

Fig. 6. Succession of the Kimmeridgian deposits and their lithostratigraphical interpretation in selected sections at Kiełczygłów in the northern border of the Wieluń Upland (mostly after Wierzbowski *et al.*, 1981, 1983; the most important ammonite finds are indicated (for location of the sections studied see Fig. 8C). The succession shows the transition from moderately-shallow water deposits (Prusicko Fm.) replaced laterally by deeper-water deposits transitional to the Częstochowa Sponge Limestone Fm., both followed by open-marine basinal deposits (Burzenin Fm.) (see text)

ally indicative of the basal part of the Hypselocyclum Zone – and most possibly correspond to the *lussasense* horizon of the lowermost part of the Hippolytense Subzone (Fig. 13; see Atrops, 1982), and, because of the fairly large number of specimens found in a narrow stratigraphical interval, suggest a condensation. The directly overlying marly limestones of the basal part of the Kiełczygłów Marl Member of the Burzenin Formation at Kule yielded some specimens of *Ataxioceras* (*Schneidia*) *lussasense* Atrops (Pl. 5: 5) – *A.* (*Sch.*) cf. *lussasense* Atrops which confirm such a stratigraphical interpretation of these deposits. The general composition of the ammonite assemblage bears a close similarity to that of the older Kuchary Chalky Limestone Member of the Prusicko Formation, being composed mostly of Ataxioceratidae with a markedly smaller number of Aulacostephanidae.

Younger deposits recognized in cores A-4 and A-10 north of Kiełczygłów are represented by marls and micritic limestones, sometimes with infaunal bivalves (Fig. 6). They correspond already to the Burzenin Formation including both the Kiełczygłów Marl Member, and the Majaczewice Member. These deposits are the lateral facies equivalent of a large part of the "oolitic" formation from the western part of the northern border of the Wieluń Upland.

AREAS AT BURZENIN AND KALISZ (CZĘSTOCHOWA SPONGE LIMESTONE FM. – UPPERMOST PART, PILICA FM., BURZENIN FM.)

In the area of Burzenin the deposits have been studied in the past in outcrops (Kowalski, 1958), as well as more recently in boreholes A-6, G-3 and G-6 drilled near Wielka Wieś and Brzyków (Figs 7, 8D; see also Wierzbowski *et al.*, 1981, 1983), and in the field by the present author. The oldest deposits recognized in the boreholes are represented by the chalky limestones (at least about 60 m in thickness, base not recognized) with common siliceous sponges, cyanobacteria structures (including *Tubiphytes*), serpulids and bryozoans, as well as by the directly overlying micritic limestones and marly limestones with a poor benthic fauna, about 42 to 54 m in thickness. The former correspond to the Częstochowa Sponge Limestone Formation, the latter – to the Pilica Formation. These deposits did not yield any ammonites but their stratigraphical position must be higher than in the Wieluń Upland, and corresponds mostly to the Platynota Zone.

Similar deposits at Kalisz outcropped in the past at Szałe village, about 8 km south-east of the town. They were studied by Premik (1926), and Czermiński (1953) who collected a number of fossils (mostly ammonites and bivalves). These deposits are represented by well-bedded limestones splitting into thin flags, and marls, with a rather poor assemblage of bivalves, and rather infrequent ammonites; grey cherts were commonly encountered in the rubble of the old quarries (Czermiński, 1953). The ammonite fauna consists of Ataxioceratidae (25 specimens), including some specimens of *Ataxioceras* (*Schneidia*) *lussasense* Atrops (Pl. 6: 5), and a single *Orthosphinctes* (*Ardescia*) cf. *schaireri* Atrops, and very rare Oppeliidae ("*Glochiceras*" sp.). These deposits possibly represent the Pilica Fm., and may be transitional to the Częstochowa Sponge Limestone Fm.; they can be attributed to the uppermost part of the Platynota Zone (the Guilherandense Subzone) and the lowermost part of the Hypselocyclum Zone (the *lussasense* horizon of the lowermost part of the Hippolytense Subzone) (*cf.* Atrops, 1982).

The youngest Kimmeridgian deposits at Kalisz, about 8 km south-east of the town, outcropped in the past at Trojanów village. The deposits were well-bedded limestones and marls with rich faunas of bivalves and ammonites which have been studied by Premik (1926), and Czermiński (1953) who collected here a large number of fossils. The assemblage of ammonites collected by Premik (1926) consists of about 60 specimens with the dominant Ataxioceratidae (75%), less common Aspidoceratidae – of the genus *Aspidoceras* (21.5%), and rare Aulacostephanidae – of the genus *Prorasenia* (3.5%). The Ataxioceratidae are represented by the genus *Ataxioceras* – mostly numerous *Ataxioceras* (*Schneidia*) aff. *lussasense* Atrops (Pl. 7: 4) – possibly a new species, representing a late representative of the subgenus, and *Ataxioceras* (*Ataxioceras*) *suberinum* (von Ammon) (Pl. 8: 1). These ammonites are generally indicative of the Hypselocyclum Zone, but their detailed stratigraphical position is somewhat disputable: they are not older than the lower part of the Hippolytenese Subzone, but may be somewhat younger – possibly even corresponding to some higher parts of this subzone. The deposits should be correlated with the Majaczewice Member of the Burzenin Formation as interpreted herein.

The deposits of the Burzenin Formation at Burzenin (Fig. 7) can be subdivided into two members (from the base): (1) marls and marly limestones of the Kiełczygłów Marl Member (about 25 to 34 m in thickness); (2) micritic limestones, marly limestones with common infaunal and semiinfaunal bivalves, and intercalations of organodetrital limestones, and marls with ammonites occurring at some levels, comprising the Majaczewice Member (about 25 m in thickness). The marly deposits of the Kiełczygłów Marl Member of the Burzenin Formation did not yield here any ammonites, but their stratigraphical position, as in the Kiełczygłów area, should correspond to the lower part of the Hypselocyclum Zone.

Some of the deposits of the Majaczewice Member have been accessible in the past (and some are seen nowadays) in the local quarries between Burzenin, Majaczewice and Brzyków (Fig. 7; see Kowalski, 1958, localities 47, 48, 49, 50, 51, 52; and observations of the present author). These deposits represent mostly the limestone intervals of the succession, whereas the marly intervals usually do not crop out. The oldest limestone unit is represented by alternation of limestones and marly limestones with very common oncolites (up to about 2 cm diametres) and containing oysters *Nanogyra*. These deposits, about 2.2–3.6 m in thickness, are distinguished herein as the Brzyków Oncolite Bed (they were described originally as the "conglomeratic bed" by Premik, 1931; Kowalski, 1958, localities 49, 52).

The Brzyków Oncolite Bed from the lowermost part of the Majaczewice Member yielded numerous ammonites collected in the old quarry at Brzyków (locality 52 of Kowalski, 1958) and these ammonites are revised herein. The assemblage of ammonites found mostly in the upper part of the Bed consists of: *Streblites tenuilobatus* (Oppel), *Ataxioceras* (*Parataxioceras*) *evolutum* Atrops (Pl. 5: 6), *A.* (*P.*) *hippolytense* Atrops (Pl. 6: 1), *Orthosphinctes* (*Ardescia*) cf. *inconditus* (Fontannes), *Eurasenia vernacula* (Schneid) (Pl. 9: 6), *E. trimera* (Oppel) (Pl. 10: 3), *Involuticeras limbatum* (Schneid) (Pl. 10: 5), *I.* cf. *involutum* (Quenstedt), *I.* cf. *crassicostatum* (Geyer), *Rasenioides paralepidulus* (Schneid) (Pl. 10: 10), *Balticeras samsonowiczi* sp. nov. (Pl. 10: 9; Pl. 11: 1a–c), and *Aspidoceras binodum* (Oppel). Remarkable is the marked share of the aulacostephanids (over 50%) when compared with other groups of ammonites. The stratigraphical position of this fairly thin rock unit, a few meters in thickness, must correspond to the Hippolytense Subzone as proved by occurrence of *A. hippolytense*, and to the upper part of the Hippolytense Subzone – the lowermost part of the Lothari Subzone of the Hypselocyclum Zone as proved by occurrence of *A. evolutum* and *O. inconditus* (Fig. 13; see Atrops, 1982). However, because the directly younger limestone interval in the succession yielded ammonites indicative of the boundary beds between the two subzones, the Brzyków Oncolite Bed should be correlated with the upper part of the Hippolytense Subzone only. This dating is important for the stratigraphical interpretation of the position of the older deposits in the succession, but also for the dating of the rare and new ammonite species found in this unit.

The younger limestone interval occurs above the underlying marls. These deposits crop out actually at Majaczewice-M (Fig. 7): they are developed as well-bedded limestones, marly limestones and marls at least about 2.5 m in thickness (in beds from 10–15 cm up to 40 cm thick) with a common bivalve fauna (mostly of infaunal and semiinfaunal character – *Pholadomya*, *Pleuromya*, *Anisocardia*, *Inoperna* and others, but some oysters are known as well), some brachiopods, and echinoids. The organodetrital limestone bed (composed mostly of oyster detritus and common tiny gastropods and containing washed out the inner moulds of the deep-burrowing bivalve *Pholadomya*), about 20 cm in thickness, and marked at its base by a well developed omission surface (Fig. 10), has yielded also the ammonites collected by the present author, and discussed in the palaeontological part of the study. The ammonites found here are as follows: *Ataxioceras* (*Ataxioceras*) *cardoti* Atrops (Pl. 6: 2), *Involuticeras* cf. *crassicostatum* (Geyer) (Pl. 6: 10), *Rasenioides glazeki* sp. nov. (Pl. 12). As indicated by occurrence of *A. cardoti*, the bed in question may be correlated with a narrow stratigraphical interval at the boundary of the Hippolytense Subzone and the Lothari Subzone of the Hypselocyclum Zone (Fig. 13; Atrops, 1982). The fairly common occurrence of ammonites directly above the omission surface suggests stratigraphical condensation.

Still younger deposits of the Majaczewice Member, showing usually from about 2 m to about 4–5 meters in thickness in particular sections, were seen in the local quarries between Burzenin and Majaczewice, at Winna Góra and at Brzyków (Fig. 7; see Kowalski, 1958, localities 48, 50 and 51). These are limestones with marly intercalations yielding a bivalve fauna similar to that given above, and in some intervals also ammonites. The correlation of these sections is difficult because of the monotonous character of the deposits but it may be suggested that the lower parts of the sections seen at localities 48 and 51 correspond to each other, as shown by the similar character of the ammonite faunas occurring in the two limestone beds, and the occurrence in common of overlying hard limestone beds with abundant small gastropods corresponding possibly already to the lowermost part of the Sarnów Gastropod Limestone Member (see discussion below). On the other hand, the deposits of quarry 50 may be older as shown by their somewhat different lithology and their fairly low morphological position at the slope of the Warta river valley. This suggests that the whole stratigraphical interval discussed corresponding to some parts of the Majaczewice Member is represented by a marly- limestone interval at least about 9 m in thickness.

The deposits from locality 50 have yielded only a whorl fragment of *Ataxioceras* (*Ataxioceras*) cf. *hypselocyclum* (Fontannes), and because they are directly older than those described above – possibly correspond to some lower part of the Lothari Subzone of the Hypselocyclum Zone.

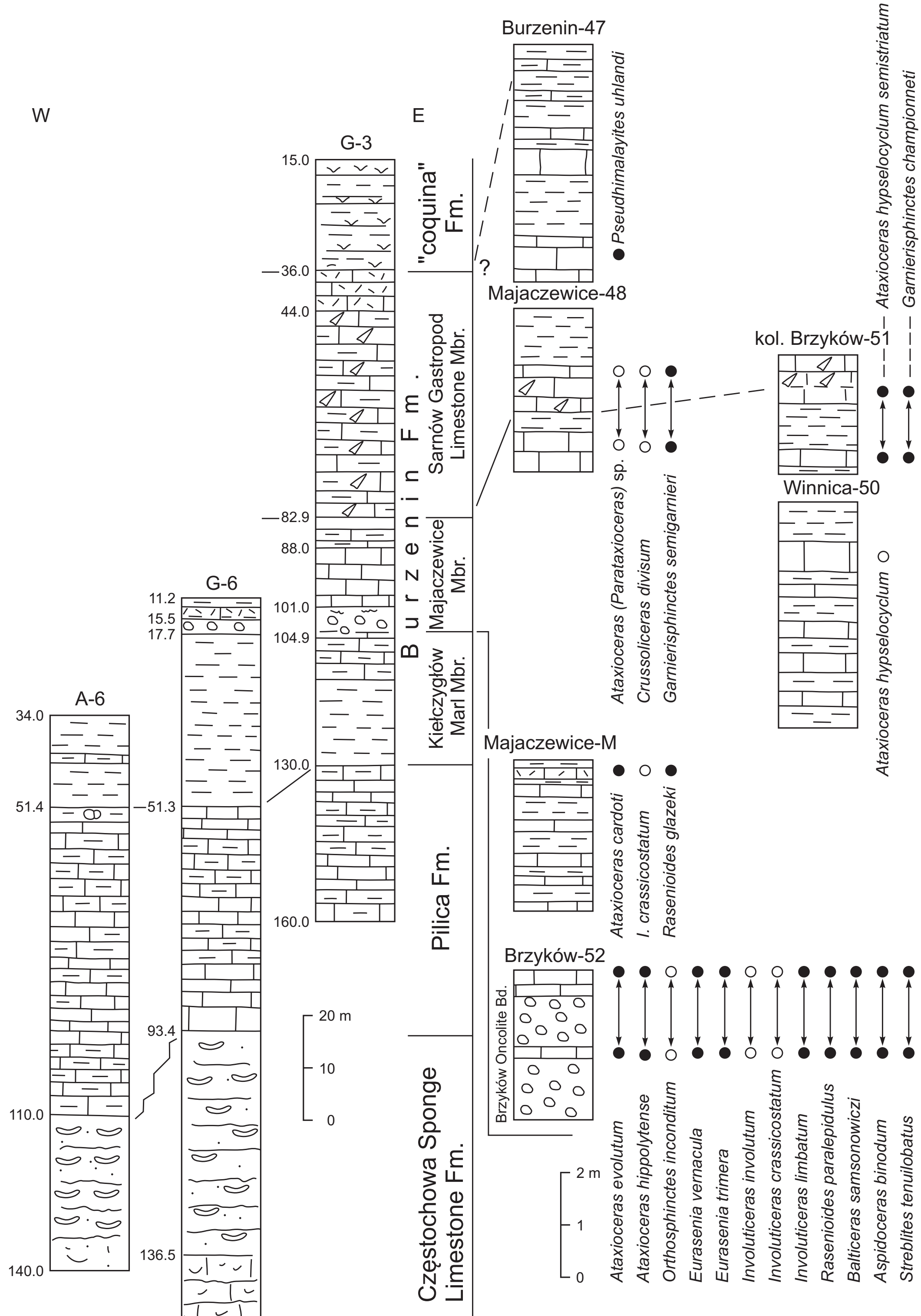


Fig. 7. Succession of the Kimmeridgian deposits and their lithostratigraphical interpretation in selected core-sections in the Burzenin area (after Wierzbowski *et al.*, 1981, 1983), and detailed sections of quarries (mostly after Kowalski, 1958); the most important ammonite finds are indicated (for explanations and location of the sections see Figs 6 and 8D). The succession shows the transition from deep-neritic deposits (Częstochowa Sponge Limestone Fm., and the Pilica Fm.) to open-marine basinal deposits (Burzenin Fm.) (see text)

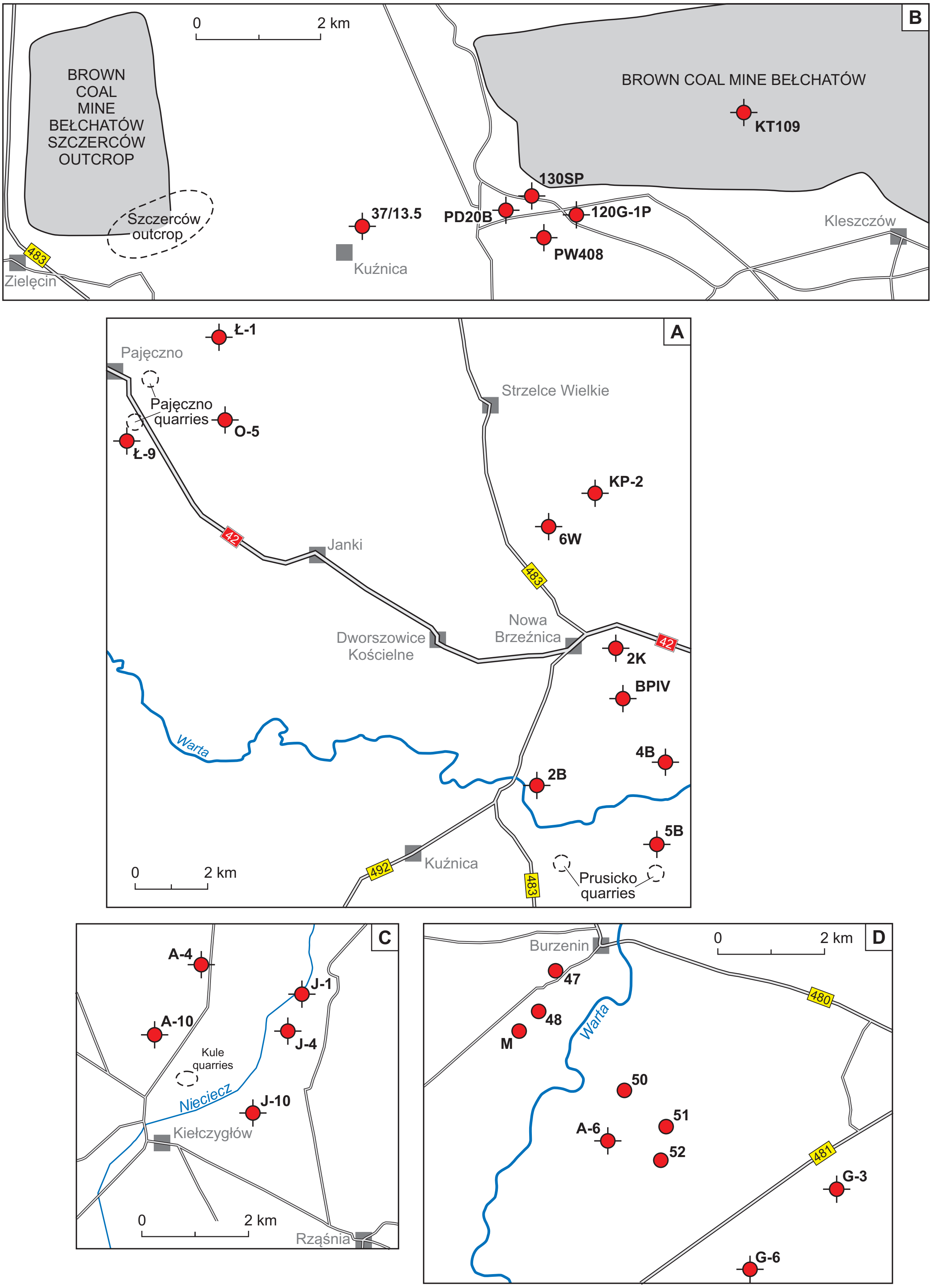

B
0
2 km
BROWN
COAL
MINE
BEŁCHATÓW
SZCZERCÓW
OUTCROP
Szczerców
outcrop
BROWN COAL MINE BEŁCHATÓW
KT109
130SP
PD20B
120G-1P
PW408
37/13.5
Kuźnica
Kleszczów
Zielęcin
483
A
Ł-1
Pajęczno
Pajęczno
quarries
O-5
Ł-9
Strzelce Wielkie
KP-2
6W
Janki
42
483
Nowa
Brzeźnica
Dworszowice
Kościelne
2K
BPIV
Warta
4B
2B
5B
Prusicko
quarries
Kuźnica
492
483
0
2 km
C
A-4
J-1
A-10
J-4
Kule
quarries
Nieciecz
J-10
Kiełczygłów
0
2 km
Rząśnia
D
Burzenin
0
2 km
47
480
48
M
Warta
50
51
A-6
52
481
G-3
G-6

Fig. 8. Location maps of the sections studied (cores and quarries; see Figs 4–7):

A – eastern border of the Wieluń Upland (areas between Prusicko and Pajęczno), B – Bełchatów and Szczerców brown-coal fields, C – Kiełczygłów area, D – Burzenin area

The ammonites found in the discussed limestone beds from localities 48 and 51 include: (1) *Crussoliceras* cf. *divisum* (Quenstedt) (Pl. 7: 7), *Garnierisphinctes* cf. *semigarnieri* (Geyer) (Pl. 8: 4), as well as *Ataxioceras* (*Parataxioceras*) sp. of the *A. oppeli* group of Atrops (1982) in locality 48, and (2) *Ataxioceras* (*Ataxioceras*) *hypselocyclum semistriatum* Schneid (Pl. 7: 6) and *Garnierisphinctes championneti* (Fontannes) (Pl. 8: 3) in locality 51. Moreover, Kowalski (1958, p. 42) reported from locality 48: "*Ataxioceras* cf. *lothari* (Oppel)", "*Ataxioceras permutabile* Wegele" and some aulacostephanids (*Involuticeras* and "*Rasenia*"); as well as "*Ataxioceras* cf. *barbatum* Schneid" from locality 51 – but they are not represented in the collection studied. Additionally, possibly from either of these two localities comes a single specimen of *Orthosphinctes* (*Ardescia*) *perayensis* Atrops (Pl. 7: 7) recognized in Kowalski's collection, without unequivocal indication of its position in the succession studied. The whole assemblage of these ammonites points to the upper part of the Lothari Subzone of the Hypselocyclum Zone (the *semistriatum* horizon of Atrops, 1982), as well as the boundary beds between the Hypselocyclum Zone (the *perayensis* horizon of Atrops, 1982) and the Divisum Zone (lowermost part of the the Divisum Subzone, see Geyer, 1961; Sarti, 1993; see Fig. 13). Although the detailed distribution of these ammonites in the sections was not given by Kowalski (1958), the two discussed ammonite

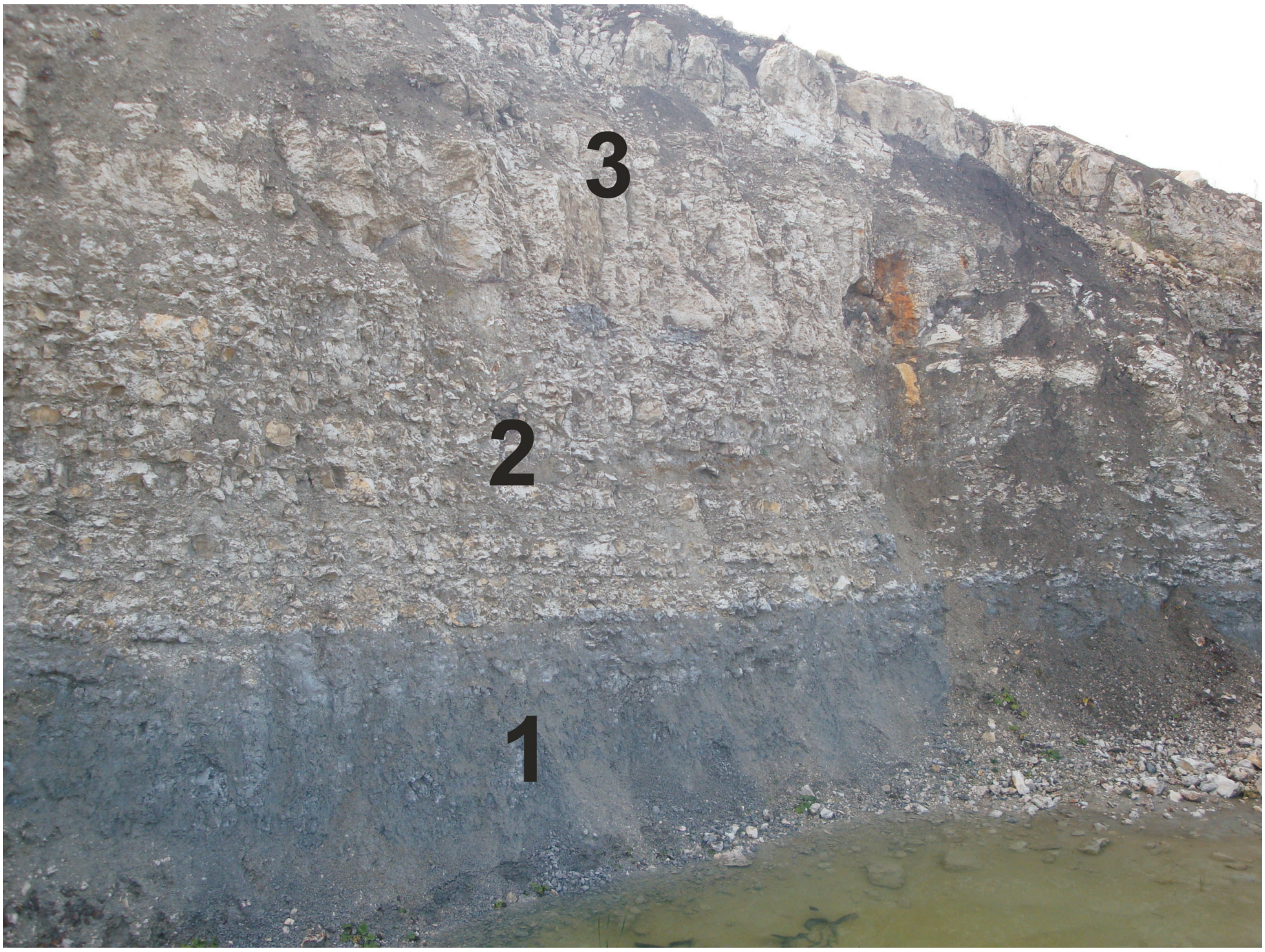


Fig. 9. Szczerców brown-coal mine outcrop

1 – marls (unit B corresponding to the Kiełczygłów Marl Mbr.); 2 – bedded micritic limestones with marly intercalations overlain by 3 – fine-grained oolitic limestones (unit C of the "oolitic" fm.)

Fig. 10. Majaczewice quarry near Burzenin: well bedded micritic limestones and marls with infaunal bivalve fauna overlain by an organodetrital limestone bed (arrowed) with oyster detritus, small gastropods, and inner moulds of deep-burrowing bivalve *Pholadomya* ; the bed indicates level no. 9 at the top of the corresponding cyclostratigraphic cycle, Majaczewice Mbr. of the Burzenin Fm.

assemblages may be possibly ascribed to the two discussed limestone beds from localities 48 and 51. Each of the assemblages marks possibly a single episode of stratigraphical condensation. It may be added that two similar ammonite assemblages, an older one corresponding to the *semistriatum* horizon, and a younger one placed at the boundary of the Hypselocyclum and Divisum zones (including the *preayensis* horizon), are widely recognized in the borehole sections in northern Poland (Matyja, Wierzbowski, 2000).

The younger deposits of the Burzenin Formation in the discussed localities 48 and 51 of Kowalski (1958) show the presence of a few limestone beds with a rich fauna of small gastropods. Similar deposits represented by marly limestones and marls with small gastropods were recognized in core G-3 west of Brzyków where they attain about 50 meters in thickness (Fig. 7). Deposits of such thickness were not known to Kowalski (1958), and thus not distinguished as a separate lithostratigraphic unit in his stratigraphic study of the Burzenin area, possibly because of their poor tendency to form natural outcrops, and/or of their tectonic reduction. On the other hand, deposits of similar character and thickness, attaining about 50 m were placed in unit I (Fig. 5) directly above the deposits of units G-H in the northern border of the Wieluń Upland along the brown-coal fields of Bełchatów and Szczerców. These limestones with abundant small gastropods were moreover reported by Michalski (1885) and Premik (1931) at Sarnów and Korablew on the Widawka river, east from the Burzenin area. The occurrence of these deposits in the old, mostly overgrown quarry at Sarnów was confirmed recently by the present author. The deposits are formally distinguished herein as the Sarnów Gastropod Limestone Member in the uppermost part of the

Burzenin Formation (see Appendix 2). Their occurrence in the Burzenin succession, most probably below the ammonite fauna with *Pseudhimalayites uhlandi* (Oppel) from locality 47 of Kowalski (1958), indicates a lower part of the Divisum Zone (see below). Additionally the occurrence of the ammonite "*Olcostephanus trimera* (Oppel)", as cited by Michalski (1885) from the deposits in question, which is possibly a heavily ribbed representative of the genus *Eurasenia*, confirms such a stratigraphical interpretation.

The youngest deposits of the Burzenin Formation which have yielded a rich ammonite fauna cropped out in the small quarry south of Burzenin (Fig. 7; see locality 47 of Kowalski, 1958) where the marly-limestone succession with two thicker limestone intervals with ammonites was recognized: these occurring at the base and in the middle of the 4.5 m thick succession. The lower of them yielded a very rich ammonite fauna – including stratigraphically important specimens of *Pseudhimalayites uhlandi* (Oppel) (Pl. 11: 2a-b), and perisphinctids. Its stratigraphical position corresponds strictly to the upper part of the Divisum Zone – the Uhlandi Zone (as indicated by presence of *P. uhlandi*) – (Fig. 13; see Olóriz, 1978; Sarti, 1993). The other ammonites recorded as coming both from the limestone bed at the base of the succession as well as that in its middle part cannot be studied, however, because they are not preserved in the collection studied. They were only referred by Kowalski (1958, p. 47) to as: " *Ataxioceras inconditum* (Fontannes)", *"Pseudosimoceras acer* (Fontannes)", "*Katroliceras crussoliensis* (Fontannes)", *"Subdichotomoceras lamplughi* Spath" and several others referred with the reservation cf. They may represent different ataxioceratid genera of the upper part of the Divisum Zone, but also may possibly be younger – and may even come from the Acanthicum Zone. These deposits the most possibly occur at the top of the Sarnów Gastropod Limestone Member, and directly below the "coquina" formation.

The youngest Upper Jurassic deposits of the area were seen in the past in the escarpment of the Warta river valley and in a shaft dug at Burzenin. These were well-bedded limestones and marls with common accummulations of *Nanogyra* shells having the character of an oyster coquina. The lower part of these deposits attained about 14 meters in thickness (after Kowalski, 1958, localities 45 and 46), and it corresponds already to the "coquina" formation. These youngest Jurassic deposits at Burzenin yielded very few ammonites found mostly in the rubble. One of them, present in Kowalski's collection, and preserved in a limestone matrix with *Nanogyra*, is a form very close to "*Orthosphinctes*" *praenuntians* (Fontannes) (see Geyer, 1961; Bantz, 1970), possibly representing the genus *Discosphinctoides* Olóriz (see Olóriz, 1978), known already from the Acanthicum Zone.

DISCUSSION

PALAEOGEOGRAPHY AND SYNSEDIMENTARY TECTONICS

The development of the deep-neritic cyanobacteria-sponge biohermal complexes in the southernmost and northernmost parts of the Wieluń Upland during the earliest Kimmeridgian (Bimammatum and Planula chrons) was strictly controlled by syn-sedimentary tectonic activity (Matyja, Wierzbowski, 2004).

The southernmost biohermal complexes (the Rudniki Biohermal Complex and a part of the Mstów Biohermal Complex, see Matyja, Wierzbowski, 2004, 2006), at the boundary between the Częstochowa Upland and the Wieluń Upland, stretched mainly in a latitudinal direction along the zone of the synsedimentary active fault, or of a set of faults, which caused marked facies changes through relative vertical movements. This tectonic activity influenced initially the growth of the biohermal complexes of the Częstochowa Sponge Limestone Formation, and later during the late Planula Chron resulted in the appearance of the bedded limestones of the Wolbrom Limestone Member of the Pilica Formation which strongly contrast in thickness north and south of this tectonic zone (Fig. 2; see Matyja, Wierzbowski, 2016), and additionally revealed the presence of redeposited material from neighbouring bioherms (Marcinowski, 1970; Matyja, Wierzbowski, 2006). The time of this tectonic activity as corresponding to the Planula Chron of the Early Kimmeridgian has been well proved palaeontologically by ammonites as well as by analysis of the assemblage of dinocysts recognized in the infillings of neptunian dykes related to the faults in question (Barski, 2012). The area placed south of the active fault zone, corresponding to the adjoining parts of the Częstochowa Upland, was also additionally uplifted during the Early Kimmeridgian. This is demonstrated by the appearance of coral buildups on the tops of the cyanobacteria-sponge complexes, such as the Julianka Biohermal Complex (Fig. 3; see also Matyja, Wierzbowski, 2006)), and the occurrence of other shallow-water deposits fragmentarily preserved in the Częstochowa Upland, detailed study of which will be given elsewhere.

Similar tectonic activity took place also during development of the northern cyanobacteria-sponge biohermal complex (the Działoszyn Biohermal Complex, after Matyja, Wierzbowski, 2002, 2004; see Figs 2 and 3) in the northernmost part of the Wieluń Upland. The occurrence of this biohermal complex was possibly related with to the elevation of the horst type in its basement. The elevation took place at an early stage during the Palatinian movements as evidenced by marked differences in thickness of the surrounding deposits of Early Triassic age, and the distribution of the underlying deposits of Early Carboniferous and Permian age (Deczkowski, 1977, p. 28–30, figs 9, 10, 17). The reflection of this tectonic structure during the Late Oxfordian and earliest Kimmeridgian was the development of the cyanobacteria-sponge complex strictly superimposed on it (Wierzbowski *et al.*, 1983, fig. 2). Tectonic activity during the Late Oxfordian and the earliest Kimmeridgian related to one of the bordering faults has been recognized also by Barski (2012) by analysis of the assemblage of dinocysts in a neptunian dyke. During the late Planula Chron the biohermal structure here became buried under the deposits of the Pilica Fm. (see Wierzbowski *et al*., 1983).

After the development of the Częstochowa Sponge Limestone Formation and the Pilica Formation, nearly the whole area of the Wieluń Upland, from the Rudniki Biohermal Complex in the southern margin of the Wąsosz Interbiohermal Basins up to the Działoszyn Biohermal Complex in the northern part of the Basin, and partly even further northwards, was covered by deposits of the Prusicko Formation. This took place during the Platynota Chron of the Early Kimmeridgian, and the older biohermal complexes did not manifest their presence during that time. This resulted in the development of a fairly uniform facies pattern over wide areas (Wierzbowski *et al.*, 1983; Matyja, Wierzbowski, 2016). The deposits of the Prusicko Fm., preserved actually along the eastern border of the Wieluń Upland, are developed as very flat biostromal limestones showing the presence of siliceous and calcareous sponges, brachiopods, serpulids, bryozoans, bivalves, and the pioneer assemblage of *Microsolena* corals, laterally and vertically replaced by micritic limestones and marls (Fig. 4). The character of these deposits and their fauna, including the occurrence of special coral assemblage of Microsolenidae with their presumed adaptations to a filtering mode of nutrition (Roniewicz, 2004) indicate a moderately shallow, and rather calm water environment, below fair-weather wave base, and a poorly diversified bottom relief.

Another tectonic zone has been located further northward along the present northern border of the Wieluń Upland. This zone of highly complicated tectonic structure extended generally in a WNW–ESE direction. It was responsible for the formation of several young tectonic units such as the Kleszczów Graben filled with Neogene brown-coal deposits, as well as the Widoradz-Wieluń Horst structure. The main system of faults originated after the formation of the Laramian structure, especially during the Oligocene and Miocene. Additional tectonic complications appeared at that time due to the strong halokinetic processes of the Permian salts, responsible *e.g*., for the formation of the Dębina salt dome separating the Bełachatów sector of the Kleszczów Graben in the east from the Szczerców one in the west. All these phenomena resulted from the activity of the deep tectonic zone joining the Holy Cross lineament with dislocations of the Fore Sudetic Monocline (*e.g.*, Głazek, 1999; Głazek *et al*., 2015, and the references given therein; see also Fig. 1 herein). Although the Oligocene-Miocene activity of the tectonic zone in question is well documented, its activity during the sedimentation of the Mesozoic deposits has been also indicated. Deczkowski and Gajewska (1980, 1983) pointed out that the major structure of the dislocation system of the Fore Sudetic Monocline formed during the latest Cretaceous – Early Paleogene, and that these movements rejuvenated an older Rheatian-Early Jurassic fault system. According to Matyja and Wierzbowski (2014, fig. 4) the progradation of the Kimmeridgian shallow-water carbonate platform towards the west onto the area of the northern border of the Wieluń Upland was controlled already during the earliest Kimmeridgian by the activity of the tectonic zone being the prolongation of the Holy Cross lineament. This assumption is strongly supported by the occurrence of shallow-water deposits in the Early Kimmeridgian in the area of study close to the Szczerców brown-coal field, at the present northern border of the Wieluń Upland (Figs 5, 6). This area represents thus the western promontory of the shallow-water carbonate platform ranging here from the north-western areas of the Holy Cross Mts through the area of the anticlines of Chełmo and Smotryszów (see Kutek, 1968), and the neighbouring Bełchatów area (see Mrozek, 1975) of the Łódź Synclinorium. It corresponds possibly also to the "Bełchatów High" of Krajewski *et al.* (2016, fig. 9).

Although the detailed succession of the stratigraphically well-dated deposits of the sponge megafacies during the Late Oxfordian and the earliest Kimmeridgian is not fully recognized in the Szczerców area, the occurrence of the sponge-cyanobacteria massive limestones forming the hypothetical Szczerców Biohermal Complex in the substrate of the shallow-water carbonate platform is highly probable here (see Fig. 11). Such a biohermal complex was recognized recently west of the area of study, in the Złoczew Graben filled also with Neogene brown-coal deposits. The development of this young graben structure was strictly related with the distribution of the particular facies type in its Upper Jurassic substrate – from the microbial-sponge reef facies (*i.e*. the biohermal complex as understood herein) on the flank to the bedded facies in the central part of the graben (Krajewski *et al*., 2016). Unfortunatelly, poor biostratigraphical dating of the Upper Jurassic deposits makes difficult the precise reconstruction of the time relations between the particular facies types and correlation with the deposits from other areas described herein. The final development of the microbial-sponge reef succession in the Złoczew Graben may really be marked by the appearance of gravity flow deposits and fine-grained detrital limestones (facies FT5 and FT6) as recognized by Krajewski *et al.* (2016), being the

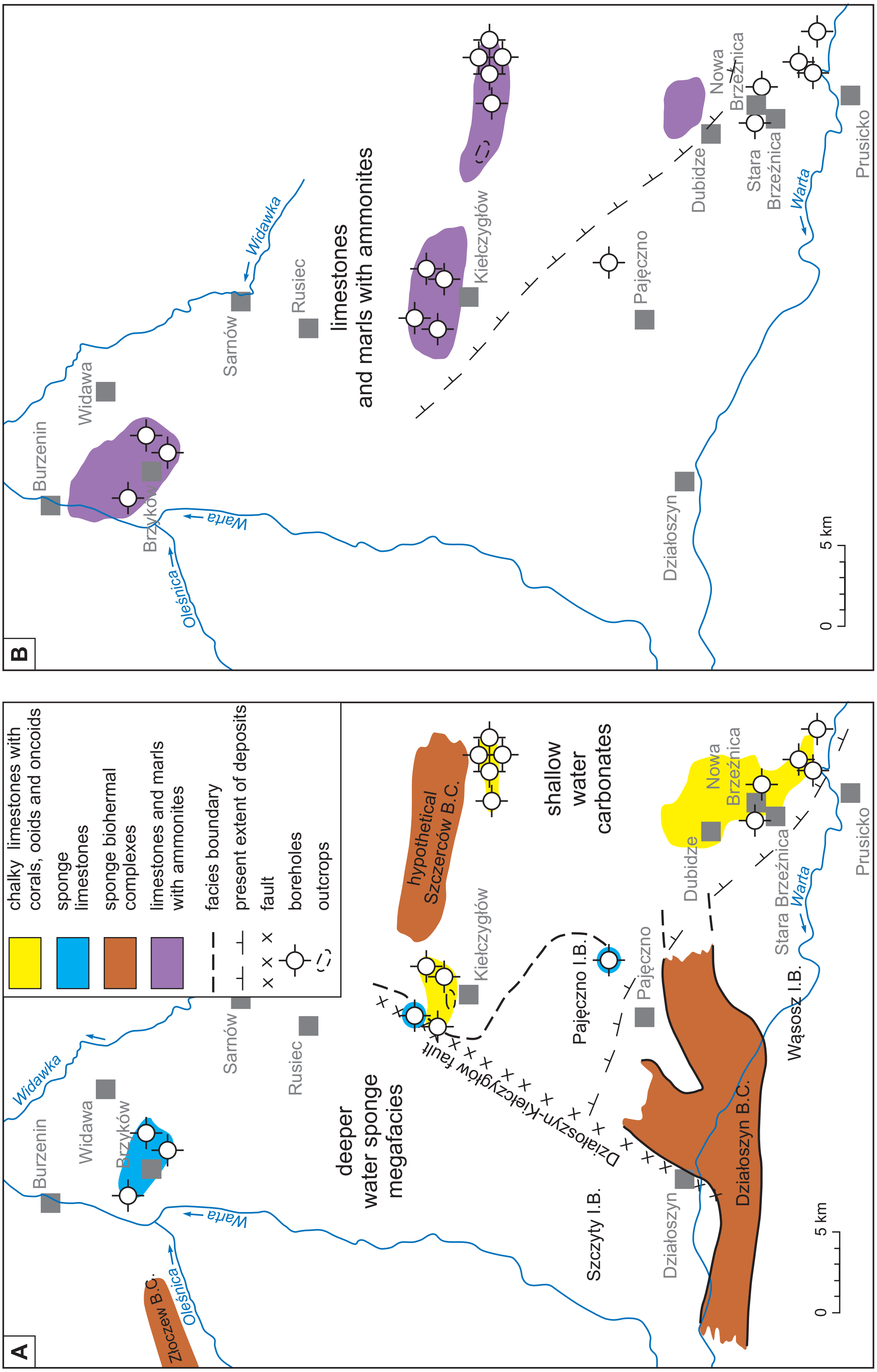


Fig. 11. Palaeogeographic maps for the late Platynota Chron (A) and the late Hypselocyclum Chron (B) of the northern part of the Wieluń Upland and adjoining areas; location of the older biohermal complexes is shown in Fig. 11A

consequence of the synsedimentary tectonic activity, but this did not occur necessary at the Planula/Platynota chron transition. There are no arguments, moreover, for the treatment of the facies FT6 (marly limestone and marl) as the lateral – age counterpart of the FT5 and FT6 facies as has been interpreted by Krajewski *et al*. (2016). The FT6 facies is locally developed as oncolitic-bivalve wackstone-floatstone with particular oncoids ranging in size up to 3 cm diameter, and it yields locally "abundant fragments of ammonites" (Krajewski *et al*., 2016, p. 13) – unfortunately not used by these authors for stratigraphical correlation, and it may be stratigraphically younger. Similar deposits are known in the Hypselocyclum Zone in the succession of the northern border of the Wieluń Upland as shown herein.

The deposits of the "oolitic" fm. of the upper Platynota Zone and the lowest Hypselocyclum Zone of the shallow-water carbonate platform of the Szczerców area as described herein reveal marked similarity to the youngest deposits of the Prusicko Fm. near Kiełczygłów (Kule Chalky Limestone Mbr.), but the former are much thicker and show the presence of an abundant shallow-marine fauna. The area of Kiełczygłów in the northern border of the Wieluń Upland is of special importance for recognition of the palaeogeographic position and interrelation of the two formation types. The typical chalky limestones with corals and oolites occurring to the east in the Szczerców brown-coal field (unit A of the "oolitic" fm., see Fig. 5), are replaced at Kiełczygłów by the chalky limestones with siliceous sponges and *Microsolena* corals belonging to the Kule Chalky Limestone Mbr. of the Prusicko Fm. The area shows also another facies transition between the Kule Chalky Limestone Mbr. and bedded limestones with siliceous sponges, similar to the Częstochowa Sponge Limestone Formation (Figs 6, 8C). The same situation applies in borehole Ł-1, north-east of Pajęczno, in the northernmost part of the eastern border of the Wieluń Upland, where deposits transitional between the Kule Chalky Limestone Mbr. of the Prusicko Fm. (known in its typical development more towards the south-east at Brzeźnica and Zakrzówek), and the Częstochowa Sponge Limestone Formation, have been recognized (Figs 4, 8A). These observations indicate that the youngest deposits of the Prusicko Formation developed as chalky limestones with *Microsolena* corals are laterally replaced towards the west and north-west by deposits with common siliceous sponges belonging already to the Częstochowa Sponge Limestone Formation, and representing markedly deeper marine deposits.

Such a facies interpretation of the deposits studied suggests that generally towards the west and north-west from the area of the occurrence of the shallow-water carbonates of the "oolitic" fm., and the adjoining youngest deposits of the Prusicko Fm. of moderately-shallow water origin, deeper marine areas have existed, where the sponge megafacies deposits were still accumulating during the Platynota Chron (Fig. 11). This is in good accordance with occurrence of the bedded limestones with siliceous sponges of the Częstochowa Sponge Limestone Formation in the Szczyty Interbiohermal Basin in the north-western part of the Wieluń Upland (Fig. 3), ranging here stratigraphically much higher (*i.e*. at least up to the uppermost Planula Zone) than in any other of the interbiohermal basins of the Wieluń Upland, where the coeval deposits are developed as the micritic limestones of the Wolbrom Limestone Mbr. of the Pilica Fm. Such a palaeogeographical interpretation corresponds also well with the occurrence of the deep neritic deposits of the Częstochowa Sponge Limestone Formation, and the Pilica Formation, north and north-west of the area of study, in the Burzenin area (Figs 1, 7, 8D), and possibly in the Kalisz area. These deposits range here up to the end of the Platynota Zone, and may also belong to the lowermost Hypselocyclum Zone.

The distribution of the main facies types during the late Platynota Chron (Fig. 11A) suggests activity of the synsedimentary fault, called here the Działoszyn-Kiełczygłów Fault, running generally in a NNE–SSW direction, and lowering the western block of the Wieluń Upland, and adjoining areas. The fault was possibly active during the Late Jurassic, but especially at the end of the Platynota-early Hypselocyclum chrons. Its activity resulted in the distribution of the deposits and the formation of the related palaeogeographic pattern discussed, but it possibly controlled earlier the development of the Działoszyn Biohermal Complex, which furcated along the fault in a northern direction into another complex, the poorly recognized Trębaczew Biohermal Complex. The fault later affected moreover the course of the main WNW–ESE dislocation in the northern border of the Wieluń Upland, and the development of younger strictly related forms such as the Kleszczów Graben.

The younger deposits of the Hypselocyclum Zone are well recognized mainly in the northern border of the Wieluń Upland. The preserved deposits include the locally cross-bedded oolites (unit C of the "oolitic" fm.) of the Szczerców brown-coal field area representing the marginal sediments of the shallow-water carbonate platform formed during the early Hypselocyclum Chron. The oolite unit becomes markedly thinner towards the west in the environs of Kiełczygłów, where it is composed of finer oolite grains (and oncolites), representing thus the fore-slope of the platform. It consequently disappears north of Kiełczygłów (Figs 5, 6, 8B–C, 9), near the line of the Kiełczygłów-Działoszyn Fault, as discussed above. The oncolitic limestones and marls, occurring at the top of the oolitic limestones in the northern border of the Wieluń Upland (unit F of the "oolitic" fm. see Figs 5, 6), possibly developed in the lower-energy outer platform setting, and represent the final stage of development of the shallow-water carbonate platform (*cf*. Gutowski, 2006) in this area. The same deposits originally occurred more towards the south, but have been preserved only in the eastern border of the Wieluń Upland (down to the Dubidze area in the most north-eastern border – see Fig. 4), being mostly removed from more southern areas due to pre-Albian erosion.

The time of the late Platynota Chron and the early Hypselocyclum Chron was characterized thus by marked facies changes, generally related to tectonic activity. The contrasting facies pattern was represented by the development of the carbonate platform in the northern border of the Wieluń Upland, and by the continuous sedimentation of the sponge megafacies and related deposits on its western border, and in the areas of Burzenin and Kalisz in the western limb of the Laramian Łódź Synclinorium, north and northwest of the Wieluń Upland. The development of some deposits of the Burzenin Formation such as the Brzyków Oncolite Bed (see Fig. 7) in the Burzenin area during the early Hypselocyclum Chron, may be treated as a distant signal of development of the shallow-water carbonate platform. On the other hand, the thick marly unit (Kiełczygłów Marl Member), shows a wide palaeogeographical distribution and it is known both in the areas of marly-limestone sedimentation of the Burzenin Formation, as well as in the areas of occurrence of the "oolitic" fm. (Figs 5–7, 9, 13). The occurrence of the coeval marly deposits even more towards the north, in the Kcynia IG IV borehole, in the area of Kujawy, within the typical succession of the Late Jurassic Polish Basin (Matyja, Wierzbowski, 1998), indicates the marked input of fine siliciclastic material during the early Hypselocyclum Chron which may be tectonically and/or climatically induced.

The younger deposits of the Majaczewice Member of the Burzenin Fm. (distinguished also as units G-H in the northern border of the Wieluń Upland) are the bedded limestones and marls with ammonites (Figs 4–7) of the late Hypselocyclum Chron (late Hippolytense Subchron, but mostly the Lothari Subchron) and the earliest Divisum Chron which represent the typical open-marine facies of the basin of Central Poland (*e.g*., Matyja, Wierzbowski, 1998). They show fairly uniform development over wide areas of study from Kalisz and Burzenin in the north down to the northern border of the Wieluń Upland, and even to the area at Dubidze on the north-eastern border of the Wieluń Upland, where some erosional remnants of these deposits are still preserved (Figs 4, 5, 11B). This phenomen resulted from the uniform subsidence of a wider area – including at least a bulk of the Wieluń Upland and its borders, but even possibly wider areas, between the SW margin of the Holy Cross Mts and the Częstochowa Upland in the south and the southern Łódź Synclinorium in the north, during the late Hypselocyclum Chron, being thus a forunner of younger tectonic activity, and changing the older subsidence pattern (see also Kutek, 1994).

The youngest deposits of the Burzenin Formation in the northern border of the Wieluń Upland and in the Burzenin area belong to the Sarnów Gastropod Limestone Member (Figs 5, 7). The unit is composed of intercalations of limestones rich in small-sized gastropods, pure micritic limestones and marls. The deposits are, however, poorly exposed and their environmental interpretation is difficult. Possibly the mass-occurrence of tiny herbivorous gastropods was related with blooms of floating algae meadows, and this might suggest a high fertility of the sea water. The deposits of the Sarnów Gastropod Limestone Mbr. correspond to some parts of the Divisum Zone (the Crussoliensis Subzone), directly below the Uhlandi Subzone, and can be correlated stratigraphically with the lowermost part of the transgressive deposits of the "coquina" fm. from the SW margin of the Holy Cross Mts. (Kutek, 1994; see also Kutek, 1968). In the Burzenin area, the *Nanogyra* coquinas appear at the boundary of the Divisum and Acanthicum zones.

CLIMATE-CONTROLLED CYCLES

The reported lithological framework of the area of study as described above has been affected to a large degree by climate changes as shown by the fairly regular alternation of more carbonate rich and marly intervals in the succession. The detailed ammonite stratigraphy enables precise datings of the changes in lithology, which gives the basis for wider stratigraphical correlations. The comparison of the succession studied with well dated orbitally controlled sedimentary cylicity of coeval deposits from similar domains is thus of special importance for the recognition of high-resolution correlations. This can be done by correlation of the succession studied with the sedimentary sequences in southeastern France where primary sedimentary cyclicity is well recognized – mostly in terms of short eccentricity cycles (Boulila *et al*., 2008, 2010), attributed to precise biostratigraphical classification in the Platynota to Divisum zones interval, mostly on the basis of the Ataxioceratidae ammonites (Atrops, 1982).

The problem of the tectonic movements during the late Planula Chron in a large part of the area of study was discussed above. It should be remembered that possible tectonic activity close to the boundary between the Planula Chron and the Galar Subchron has been evidenced from several Submediterranean areas in Europe. The marked input of detrital material during the late Planula Chron (just before the Galar Subchron) has been interpreted as the proof of a tectonic event in the carbonate platform area of north-eastern Spain (Colombié *et al*., 2014). In south-eastern France the base of the Galar Subzone shows the end of the Oxfordian carbonate reef sequence, and it is marked by a transgression surface (*e.g.*, Atrops, Ferry, 1989). The Galar Subchron was also the time of a strong turnover in the development of the ammonite faunas, and of related migrations into Submediterranean areas – such as the abrupt invasion of the Boreal ammonites of the genus *Amoeboceras* – late *Plasmatites* and early *Amoebites* (Schweigert, 2000; Matyja, Wierzbowski, 2002), possibly due to the opening of new sea-ways. In the area of study the beginning of the Galar Subzone is also related to the appearance of the Subboreal Aulacostephanidae, possibly corresponding to the development of the shallow-water carbonate platforms. All these observations suggest the strong interrelations between the tectonic and climatic events during the late Planula Chron and the Galar Subchron and make difficult the recognition of the cyclostratigraphic correlation. In the area of study additionally the deposits of these stratigraphical intervals are generally poorly exposed, and of a rather small thickness. Thus, this part of the succession representing the basal beds of the Prusicko Formation cannot be interpreted in terms of sedimentary cycles.

The younger deposits in the succession studied generally show closely interrelated changes in lithology and in faunal content which may be useful in the interpretation of the palaeoclimatic cycles. The most characteristic are: strongly marked lithological variations (indicated by the occurrence of well-developed carbonate and marly units), and evidence of a slow sedimentation rate of the carbonates marked by well-developed levels of stratigraphical condensation – each of them well dated by ammonite faunas (represented mostly by different groups of Ataxioceratidae), and usually recognized at the top of thicker carbonate units. The attempt is given here to interpret such marly-carbonate units in terms of sequence stratigraphy – through the recognition of the condensation levels as corresponding to “maximal flooding surfaces” – and consequently to compare such cycles with those recognized by Boulila *et al.* (2008, 2010) in south-eastern France (sections Châteauneuf – d’Oze and La Méouge) where 15 short eccentrity cycles were recognized in the stratigraphical interval from the base of the Galar Subzone, up to the top of the Divisum Zone of the Lower Kimmeridgian.

A well developed condensed stratigraphical level is recognized at the top of the Kuchary Chalky Limestone Member of the Prusicko Fm. in the north-eastern border of the Wieluń Upland. The ammonites occurring here indicate the top of the Polygyratus Subzone, and the base the Desmoides Subzone (*i.e.* the *enay* horizon, after Atrops, 1982) of the Platynota Zone. Immediately above, the marly deposits of the Zapole Marl Bed occur, representing the basal part of the Skowronów Limestone Member of the Prusicko Fm. The topmost part of the Kuchary Chalky Limestone Mbr. may be thus correlated with the top of eccentrity cycle no. 4 at the top of the Polygyratus Subzone after Boulila *et al* (2008, fig. 2; see also Fig. 12 herein). A younger level of condensation occurs at the topmost part of the Skowronów Limestone Member near Prusicko directly below the Góry Marl Member of the Prusicko Fm. where an abundant assemblage of ammonites and bivalves appears in the highest beds of micritic limestones otherwise poor in fossils. The ammonites are generally indicative of the Platynota Zone, and the level in question may be possibly correlated with the top of cycle 5 in upper part of the Desmoides Subzone of the Platynota Zone.

A younger condensed stratigraphical level was found at the top of the Kule Chalky Limestone Member of the Prusicko Fm., directly below the marly deposits of the Kiełczygłów Marl Mbr. (Burzenin Fm.) in the northern border of the Wieluń Upland. These deposits which crop out in the small quarries at Kule village yielded an assemblage of ammonites indicative of the basal part of the Hypselocyclum Zone, the *lussasense* horizon of the lowermost part of the Hippolytense Subzone. This indicates that the level in question may be correlated with the top of cycle no. 6 of Boulila *et al.* (2008).

When comparing the calculated rate of sedimentation as based on correlation with the duration of the eccentrity cycles recognized – it appears that during sedimentation of the older deposits of the Prusicko Formation (from the Mstów Limestone Mbr. / Kuchary Chalky Limestone Mbr. up to the Góry Marl Member) in the north-eastern border of the Wieluń Upland the rate of sedimentation was rather low (about 0.15–0.25 cm/1000 years). The rate of sedimentation at the topmost part of the Prusicko Fm. (Kule Chalky Limestone Mbr.) in the northern border of the Wieluń Upland, on the northern shallow-water carbonate platform was extremely high and it reached over 1 m/1000 years.

The stratigraphical interval corresponding to the upper Platynota Zone and the large part of the Hippolytense Subzone of the Hypselocyclum Zone is another interval characterized by marked facies changes (Fig. 11A), resulting from strong tectonic activity. Additionally, the marked input of detrital material in the thick Kiełczygłów Marl Member may suggest strong interrelations between tectonic and climatic events during the early Hypselocyclum Chron. Poor accessibility of this marly unit, and its uncertain relation to the overlying deposits (? possible stratigraphical gap) yield no indications for recognition of the cyclostratigraphic correlation. Thus, this part of the succession representing the marly deposits of the basal parts of the “oolitic” fm, and the corresponding basal parts of the Burzenin Fm., cannot be inter-

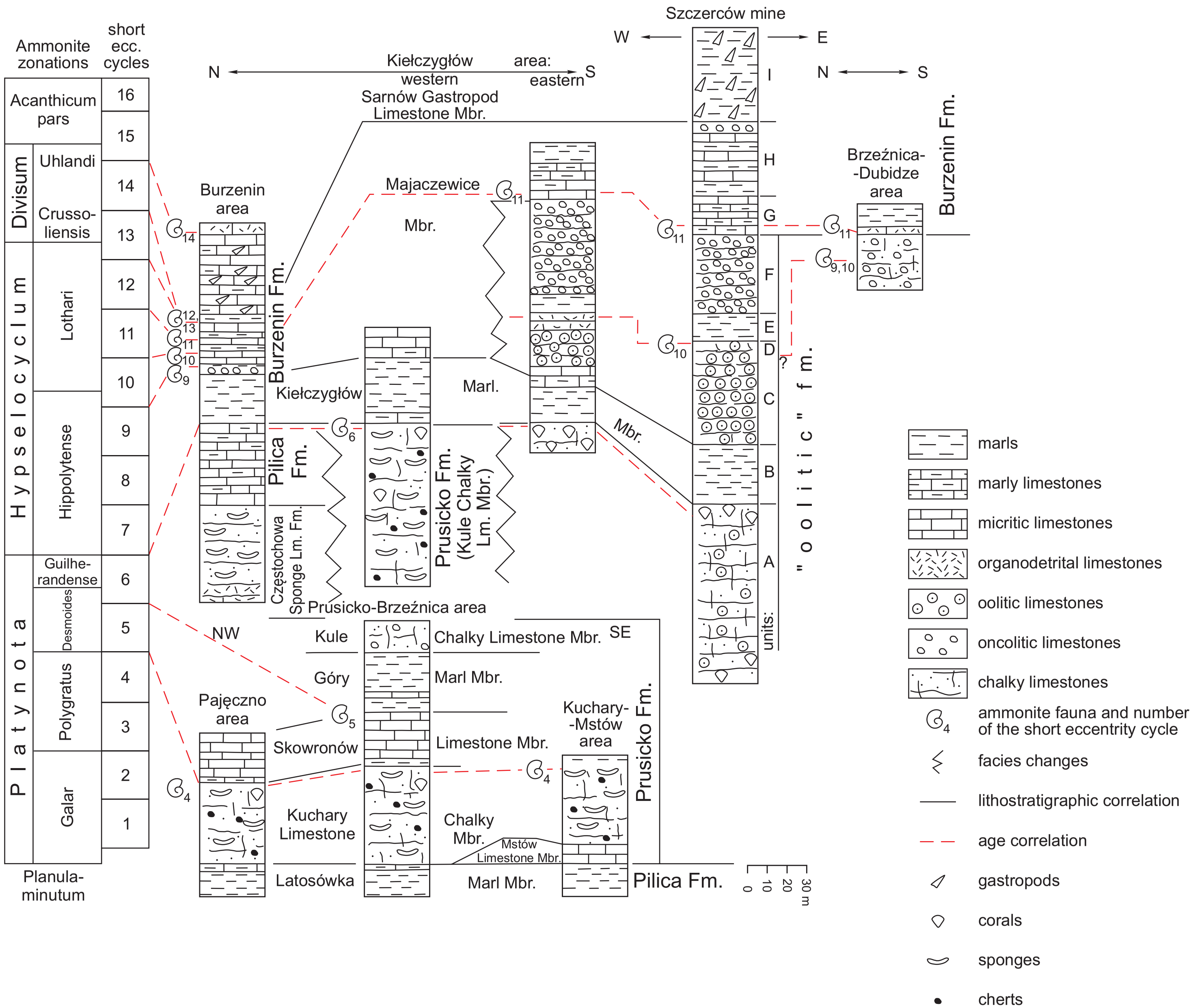


Fig. 12. Chronostratigraphical correlations between the successions studied in the regions adjoining to the Wieluń Upland; the proposed primary sedimentary cyclicity is indicated – the following numbers of the short eccentrity cycles correspond to those distinguished in south-eastern France by Boulila *et al.* (2008, 2010). Note that the Galar Subchron is included in the Platynota Chron (see text)

preted in term of sedimentary cyclicity. It should be remembered that the Châteauneuf – d'Oze section of south-eastern France shows also stratigraphical disturbance of the succession of the Hippolytense Subzone related to synsedimentary slumping of the marly deposits which makes it impossible to recognize sedimentary cyclicity in that interval (Boulila *et al.*, 2008; see also Atrops, 1982). The upper Platynota – lower Hypselocyclum Zone interval corresponds in the Submediterranean areas to the development of a new ammonite fauna (especially of Ataxioceratidae) – which represents the next main faunal turnover, resulting from changes of environment (Atrops, Ferry, 1989). This faunal turnover is seen mostly in the acceleration (in term of heterochrony) in the morphological development of the ataxioceratids which show the appearance of polyplocoidal ornamentation at smaller diameters when compared with their forunners (see Atrops, 1982). This is also the second interval of marked occurrence of Aulacostephanidae which has been related to the development of the shallow-water carbonate platforms in the area of study. The difference in the distribution of the ammonite fauna between Ataxioceratidae and Aulacostephanidae in Poland – the former generally confined to a more open marine environment, the latter to a shallow-water carbonate environment was indicated already by Kutek (1962).

Levels rich in ammonites which could be interpreted as condensed stratigraphical horizons are recognized in the younger deposits of the Burzenin Fm. of the Burzenin area, and in the corresponding deposits of the "oolitic" fm. in northern and some parts of the north-eastern borders of the Wieluń Upland. The oldest of them (Fig. 12) is recognized at the top of the Brzyków Oncolite Bed, at the base of the Majaczewice Mbr., where the ammonites indicate its correlation with the upper part of the Hippolytense Subzone of the Hypselocyclum Zone. This level may be correlated with the top of cycle 9 of Boulila *et al.* (2008). Possibly the same level may be represented by a poorly recognized horizon with ammonites occurring directly above oolite unit C, at its contact with the overlaying micritic limestones of unit D in the Szczerców brown-coal outcrop.

The younger condensed horizons yielded ammonites indicative of the Lothari Subzone of the Hypselocyclum Zone. A directly younger level with ammonites is reported both from the Majaczewice section close to the well developed omission surface, as well as in the section of the Szczerców brown-coal outcrop, with ammonites at the top of unit "D" markedly above the oolite unit C, close to the omission surface. The level may be possibly correlated with the top of cycle no. 10 of Boulila *et al*. (2008) and identified as representing the lowermost part of the Lothari Subzone. This level as well as immediately older level described above show the fairly common occurrence of Subboreal Aulacostephanidae, possibly related to the appearance of the less stable environmental conditions of the carbonate platform which generally favoured this ammonite group.

A directly younger horizon (Fig. 12) is recognized from the south-eastern border of the Wieluń Upland (borehole near Dubidze), through its northern border (boreholes near Kiełczygłów, and in the Szczerców coal field) up to the Burzenin area in the north-west. It has yielded abundant ammonites indicative of the *discoidale – hypselocyclum* horizons in the lower part of the Lothari Subzone (Atrops, 1982). This horizon can be correlated with the top of cycle 11 of Boulila *et al.* (2008).

The succession of condensed horizon in the Burzenin area may be reconstructed only on the basis of ammonites collected by Kowalski (1958), and his relevant descriptions of the sections. Two limestone beds in localities 48 and 51 yielded ammonites indicative of the upper part of the Lothari Subzone – of the *semistriatum* horizon, and the *perayensis* horizon (see Atrops, 1982) and the lowermost part of the the Divisum Zone. Because the detailed distribution of the ammonites in the sections is unknown, the discussed horizons may be treated jointly as corresponding to the top of cycles 12 and 13 of Boulila *et al.* (2008). The youngest recognized condensed level in the Burzenin area in locality 47 of Kowalski (1958) yielded ammonites indicative of the upper part of the Divisum Zone – the Uhlandi Subzone, and may be correlated with the top of the cycle 14 of Boulila *et al.* (2008).

The rate of sedimentation calculated on the correlation given for the well-dated stratigraphical interval which corresponds to the lower part of the Lothari Subzone of the Hypselocyclum Zone, equals about 35 cm/1000 years in the northern border of the Wieluń Upland (Kiełczygłów, and the brown-coal field of Szczerców). The stratigraphical interval from the topmost part of the Hippolytense Subzone, and the whole Lothari Subzone in the Burzenin area shows much lower sedimentation rates (about 11 cm/1000 years).

CONCLUSIONS

Three facies assemblages (megafacies) may be distinguished in the successions studied (Fig. 13): (1) the sponge megafacies represented by bedded and massive limestones rich in siliceous sponges, with the related micritic limestones and marls with a poor benthic fauna which appeared at the decline of the sponge deposit sedimentation and filled the depressions between the sponge bioherm complexes, (2) the chalky limestones with corals replaced laterally by micritic limestones and marls, and with the overlying oolitic and oncolitic limestones, (3) micritic limestones and marls with ammonite and bivalve, and upwards also gastropod faunas.

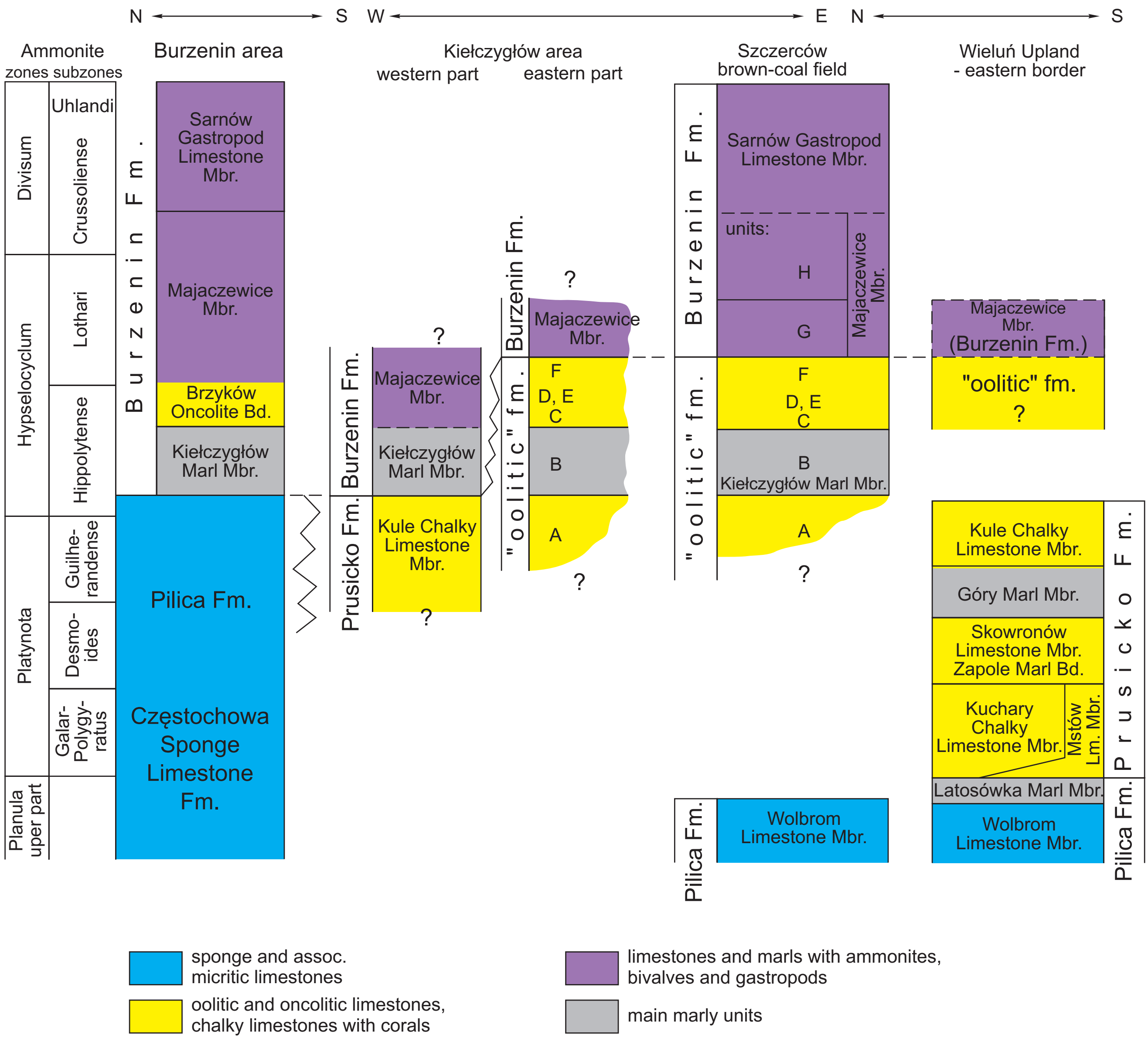


Fig. 13. The distinguished lithostratigraphical units in the regions adjoining to the Wieluń Upland along with the main facies assemblages (shown in colour) and their chronostratigraphical correlation

The facies assemblage 1 appeared in central and southern Poland at the Callovian/Oxfordian boundary and continued its existence up to the earliest Kimmeridgian in the area of study. The occurrence of these deposits was related to the marked deepening of the basin. This facies assemblage may be treated as indicative of the deep-neritic environment along the North Tethyan shelf as a consequence of tectonic extension in the adjoining oceanic basins (Matyja, Wierzbowski, 1996; Matyja, 2009, 2015). The decline of the facies assemblage began already in central Poland during the Late Oxfordian (Bifurcatus Chron), when locally the deposits of facies assemblage 2 occurred. A wider development of the deposits of facies 2, corresponding to the development of the shallow-water carbonate platform or ramp areas, appeared at the end of the Oxfordian – beginning of the Kimmeridgian (Bimammatum Chron), and continued during the Early Kimmeridgian (from the Planula Chron to the Hypselocyclum Chron). The appearance of these shallow water deposits was strictly related to the activity (or rejuvenation) of older tectonic zones, and was not strictly isochronous.

The succession of the facies assemblage 2 deposits in the Wieluń Upland and its borders begins with moderately shallow-water chalky limestones with siliceous sponges and *Microsolena* corals (lower part of the Prusicko Fm.), representing the moderately shallow environment of the outer part of the carbonate ramp; these are succeded by biogenic chalky limestones with fairly common corals, and with oncolites (upper part of the Prusicko Fm.; unit A of the "oolitic" fm.), and then, appearing stratigraphically higher, the oolitic and oncolitic limestones of the slope of the carbonate platform (unit C of the "oolitic" fm.). The succession is closed by oncolitic limestones (unit F of the "oolitic" fm.), indicating the deepening of the environment, and showing the general decline of the shallow-water carbonate platform (*cf.* Gutowski, 2006, fig. B2.2).

Such shallow-water deposits whose occurrence was controlled tectonically appeared both in northern Poland (within a quite different facies pattern, near the Baltic Shield – see Wierzbowski *et al*., 2015), as well as in the area of study which represents the continuation of the carbonate platform development of south-eastern Poland (see also Matyja, Wierzbowski, 2014). Thus, the occurrence of shallow-water carbonates took place in wide areas of northern and central-southern Poland, north and south of the so-called Polish Basin (*i.e*. the eastern continuation of the Central European Basin). Locally, these shallow-water deposits were laterally replaced by the youngest sponge-megafacies deposits (like in western area of the Wieluń Upland), but mostly by the well-bedded limestones and marls of assemblage 3, representing the deeper marine environment of the Polish Basin. It is interesting to note that the maximal development of the shallow-water carbonates corresponds to the Hypselocyclum Zone, and finds its equivalents in the character of the deposits of the deeper-water assemblage 3 in the Polish Basin. In the Kcynia IG-IV borehole in northern Poland (Kujawy area) the carbonate deposits (marls and limestones) of the Burzenin Formation appear near the boundary of the Platynota and Hypselocyclum zones, directly above the siltstones and silty limestones of the Łyna Formation (Matyja, Wierzbowski, 1998). This suggests also climatic control on the formation of these deposits. This discussed facies pattern existed in southern areas only on the elevated part of the Northern Tethyan shelf – the so-called "Meta-Carpathian Arch" sensu Kutek (1994), because further towards the south (south of the Zawiercie-Busko line) below the Carpathian Fordeep – the deep-neritic sponge megafacies existed up to the Early Tithonian (Matyja, 2009, 2015).

The succession of deposits of facies assemblages 1 and 2 in the south-eastern and central regions of epicratonic Poland corresponds generally to the so-called COK sequence of Kutek (1994). This sequence has been treated by Kutek (1994) as a "transgressive-regressive unit" but without any relation to its eustatic origin, having in fact the character of a "tectono-stratigraphic unit". The overlying deposits of the LUK sequence according to Kutek (1994) were developed mostly as oyster coquinas, having a transgressive character, and marking the decline of the shallow-water carbonate platform in the areas studied by him at the SW margin of the Holy Cross Mts. The base of the LUK sequence although placed near the boundary of the Hypselocyclum and Divisum zones, has not been treated as everywhere strictly isochronous, because it "would still display some diachronism" even at the SW margin of the Holy Cross Mts (Kutek, 1994). This feature is more pronounced when one compares the time of appearance of the deposits of the LUK sequence in the discussed area of the Holy Cross Mts, and the borders of the Wieluń Upland studied herein. The appearance of the transgressive deposits with ammonites of the Burzenin Fm. over the shallow-water deposits of the "oolitic" fm., marking the beginning of the LUK sequence in the area of study, took place during the Lothari Subchron, well below the boundary of the Hypselocyclum and Divisum chrons, and thus before the appearance of the transgressive deposits in the SW margin of the Holy Cross Mts (see Kutek, 1968; Matyja *et al*., 2006). This indicates that the COK and LUK sequences have really a tectono-stratigraphic character, and that their boundary is not strictly isochronous over larger areas.

In this aspect some comments may be also given on the relation between the marked tectonic unconformities recognized in the succession studied, and the occurrence of thick marly units often associated with such boundaries. In the area of study these are: the Latosówka Marl Mbr., and the Kiełczygłów Marl Mbr. (as well as to a lesser degree – the Góry Marl Mbr. which occurs in between); these units were distinguished originally as the lower, the middle and the upper marl members by Wierzbowski (1966) and treated as marking the beginning of successive sedimentary complexes. It seems highly probable that their appearance was controlled by tectonic events, but possibly superimposed on the climatic cycles. These marly units border the deposits in the successions from the SW margin of the Holy Cross Mts up to those from the Wieluń Upland margins which have been formed in different environmental conditions, and additionally show a different subsidence pattern (Kutek, 1994).

The continuous tectonic subsiding of the elevated Meta-Carpathian Arch resulted in the wide openinig of the connection of the Polish Basin with the Tethys Ocean, and the subsequent appearance of new Tethyan ammonites at the end of the Early Kimmeridgian (Divisum Chron), and the beginning of the Late Kimmeridgian (Acanthicum Chron) (*cf.* Kutek, 1968, 1994). The ammonite faunas appearing at the boundary of the Hypselocyclum and Divisum zones indicate a marked "brutal crisis mainly marked by extinctions, not a real turnover" (Atrops, Ferry, 1989). This extinction eliminated, however, the older Ataxioceratidae only, whereas the appearance of new representatives of the group, such as *Crussoliceras* and *Garnierisphinctes*, have had the character of a new ammonite invasion from the Tethyan Province (Pavia *et al*., 1987; see also Enay *et al*., 2014). The marked ammonite migrations not only from southern but also from northern areas at the transition between the Hypselocyclum and Divisum chrons are well documented: the latter include migrations from the Subboreal (genus *Rasenoides*) and Boreal (genus *Amoeboceras*) provinces (see *e.g*., Matyja, Wierzbowski, 2000, and the earlier papers cited therein). All these changes in ammonite faunas resulted possibly from tectonic events and the related phases of subsidence in the area of central Poland, but also in other areas of Europe along the northern Tethyan shelf (*e.g.*, Rogov *et al.*, 2017).

Attention should be payed also to the occurrence of climatically controlled changes in the environment. These climate-controlled cycles are demonstrated by changes in the character of the deposits studied and in the distribution of the ammonite faunas as interpreted herein (Fig. 12), representing not only changes of the environment, but measuring also their time-duration. Such an interpretation has been, however, impossible without the detailed biostratigraphy which is the main correlation method used in these marine sedimentary successions.

Appendix I

SYSTEMATIC PALAEONTOLOGY

The following abbreviation are used in the description of the ammonites: D – diameter of specimen in mm; Wh – whorl height as a percentage of D; Ud – umbilical diameter as a percentage of D; PR – number of primary ribs per whorl (or PR/2 – per half of whorl); SR/PR – secondary/primary ribs ratio counted on 5 primary ribs at given diameter.

Generic and specific names are used in the sense of "morphospecies" having vertical ranges as opposed to isochronous "horizontal biospecies". Such an approach includes also the acceptance of the taxonomy of the dimorphic forms (macro- and microconchs), which show marked differences in shell morphology, as being represented by separate generic and species level names. The taxonomical interpretation given, although morphotaxonomical in its character, is controlled by the general changes in shell morphology shown in particular ammonite lineages, which have phylogenetic significance and enable the recognition of successive stages of ammonite evolution. This is possible, however, in Ataxioceratidae and Aulacostephanidae only, which are the commonly encountered ammonites in the succession studied. Other ammonite groups (Oppeliidae, Perisphinctidae and Aspidoceratidae) occur only sporadically, and are briefly commented on.

The review of ammonite finds given below concentrates also on the description of forms unknown so far or poorly known from the territory of Poland, as well as on the reinterpretation of specimens described in older papers.

The bulk of the specimens studied is housed in the Museum of the Faculty of Geology, University of Warsaw [new collection number MWG UW ZI/84/001-130; older collections of the author: collections IGPUW/A/6, 7 and 10 including ammonites described by Wierzbowski (1964, 1966, 1978); the collection of Kowalski (1958: collection numbers MWG UW ZI/83/01-23) which is not complete; some ammonites originally recorded by Kowalski are evidently missing, they were already missing in the late 60s when the collection was reviewed by J. Kutek, who wrote a short hand-written comment on its content, now in the Museum]: some of the ammonites studied by Kowalski are housed also in Museum of the Polish Geological Institute – National Research Institute in Warszawa (MUZ PIG 1817.II.1-7) where are housed also the collection of Premik (1926) – MUZ PIG 239.II, and a single specimen from collection of Malinowska (1964) – specimen 1078.II.1].

Family Oppeliidae Bonarelli, 1894

Genus ***Taramelliceras*** **Del Campana, 1905** (subgenus ***Metahaploceras*** **Spath, 1925**). The bulk of the specimens are typical representatives of *Taramelliceras* (*Metahaploceras*) *litocerum* (Oppel) and they come mostly from the micritic limestones of the Wolbrom Limestone Member (Pilica Fm.) in the Rudniki (Lipówka) section, the Latosówka section, as well as the Niwiska Dolne and other sections between Prusicko and Pajęczno [*e.g.*, *T.* (*M.*) *litocerum* (Oppel) in Wierzbowski (1966, p. 190, pl. 10: 3)]. A few specimens coming from the Latosówka section differ somewhat from typical representatives of the species. These include a form having small ventrolateral nodes on the body-chamber and recognized as "*Taramelliceras* (*Metahaploceras*) *ausfeldi* (Würtemberger) sensu Wegele (1929)" and the other one showing the presence of minute tubercles or swellings of the ribs on the ventral side of the final part of the phragmocone and on the body-chamber and recognized as "*Taramelliceras* (*Metahaploceras*) aff. *tenuinodosum* (Wegele) sensu Wierzbowski (1978)". These forms may be treated as variants of *T. litocerum* or closely related subspecies (cf. *e.g.*, Schairer, 1983).

A single small specimen (Pl. 1: 1) coming from younger micritic limestones of the Skowronów Limestone Member of the Prusicko Formation in the Prusicko-Miroszowy section (*Taramelliceras* sp. in locality 62 of Wierzbowski, 1966), although fragmentarily preserved, shows the presence of fairly strong falcate ribs with marked swellings at the mid-height of the whorl. It may be referred to as *Taramelliceras* cf. *rigidum* (Wegele) (see description of the species *e.g.*, in Schairer, 1972, p. 48–51, fig. 10, with synonymy given). Another small specimen (Pl. 1: 2) found in a similar stratigraphical position in core O-5 near Pajęczno at 47.3 m (Wierzbowski *et al.*, 1981, unpubl. report) shows a fairly wide umbilicus (at D = 19 mm, Wh = 42.1, Ud = 23.6) and falcate ribbing consisting of short, distant umbilical ribs splitting at the mid-height of the whorl into three secondary ribs – which continue into very thin ribblets at the ventral side. The specimen is very similar to "*Taramelliceras* (*Metahaploceras*) *kobyi wegelei*" of Schairer (1972, p. 46–48, fig. 8, with given synonymy), but because of its small-size it is referred to that species with reservation.

Family Ataxioceratidae Buckman, 1921

The classification of ammonites of the subfamily Ataxioceratinae (genera *Orthosphinctes* and *Ataxioceras*) in the area of study is given herein according to that of Atrops (1982) in south-eastern France because of the similarity of the ammonite faunas between the two regions. It differs from that elaborated recently by Molinar (2009) for south-eastern Spain because of the dissimilarity in composition of the ammonite assemblages, and the stratigraphical distribution of particular taxa (*e.g.*, the occurrence of the subgenus *Schneidia* in the Platynota Zone only in Spain as opposed to its continued occurrence in the Hypselocyclum Zone in southern France and central Poland).

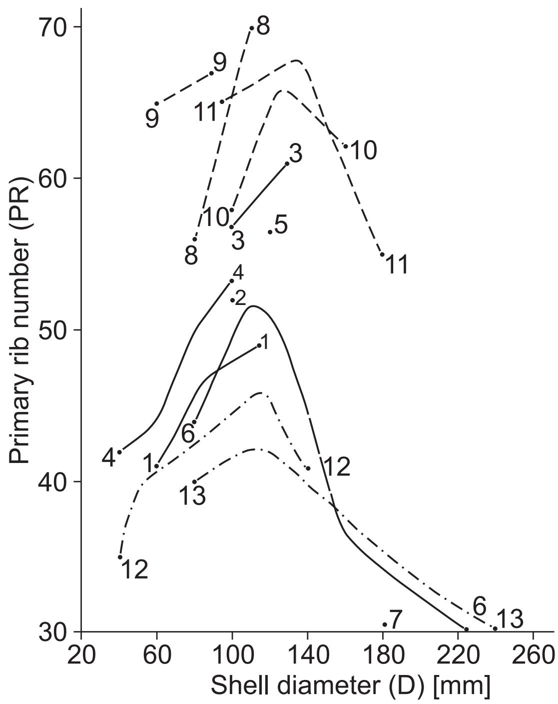


Fig. 14. Number of primary ribs (PR) against shell diameter (D) for dimorphic pairs of the genus *Orthosphinctes*

Orthosphinctes (*Orthosphinctes*) *polygyratus* (Reinecke) (m): 1 – IGPUW/A/6/2, Kuchary (= *O. tiziani* in: Wierzbowski, 1965), 2 – IGPUW/A/6/1, Kuchary (= *O. tiziani* in: Wierzbowski, 1965, pl. 1: 1); 3 – MWG UW ZI/84/025, Kuchary; 4 – MWG UW ZI/84/028, Kuchary; 5 – MWG UW ZI/84/053, Rudniki (Pl. 1: 3); *O.* (*Lithacosphinctes*) *evolutus* (Quenstedt) (M): 6 – MWG UW ZI/84/050, Prusicko; 7 – IGPUW/A/6/4, Kuchary (= *Lithacoceras pseudolictor* in: Wierzbowski, 1965, pl. 2: 2);

Orthosphinctes (*Orthosphinctes*) *freybergi* (Geyer) (m): 8 – MWG UW ZI/84/052, Latosówka (Pl. 1: 5); 9 – MWG UW ZI/84/046, Pajęczno; *O.* (*Lithacosphinctes*) *gidoni* Atrops (M): 10 – MWG UW ZI/84/030, Kuchary (Pl.2: 1); 11 – MWG UW ZI/84/018, Kuchary;

Orthosphinctes (*Ardescia*) *enayi* Atrops (m): 12 – MWG UW ZI/84/016, Kuchary (Pl. 4: 1); *O.* (*Lithacosphinctes*) *pseudoachilles* (Wegele) (M): 13 – IGPUW/A/6/3, Kuchary (= *Lithacoceras subachilles*, pl. 2: 1)

Genus ***Orthosphinctes*** **Schindewolf, 1925**. The genus is interpreted according to Atrops (1982), who distinguished in the studied stratigraphical interval two groups of microconchs attributed to the subgenera ***Orthosphinctes*** **Schindewolf, 1925** and ***Ardescia*** **Atrops, 1982**, and one group of macroconchs attributed to the subgenus ***Lithacosphinctes*** **Oloriz, 1978**.

The ammonites of the subgenus *Orthosphinctes* are represented by the species *O.* (*O.*) *polygyratus* (Reinecke) (Pl. 1: 3) and *O.* (*O.*) *freybergi* (Geyer) (Pl. 1: 5) which differ markedly in the density of ribbing and the type of coiling – generally the latter being more densely ribbed and showing the more involute coiling (see Fig. 14). Some reinterpretation of the specimens illustrated in older papers may be given (see also Atrops, Wierzbowski, 1994): the specimens referred to as "*Perisphinctes* (*Orthosphinctes*) *tiziani* (Oppel)" in: Wierzbowski (1964, p. 161, pl. 1: 1) and "*P.* (*O.*) *colubrinus* (Reinecke)" in: Wierzbowski (1966, pl. 3: 1) belong to *O.* (*O.*) *polygyratus* (Reinecke), as does the specimen ascribed to *O. polygyratus* by Wierzbowski (1966, pl. 4: 1). These specimens come from the Kuchary Chalky Limestone Member (Prusicko Formation) of the Kuchary section as well as of the Pajęczno and Gawłów sections. Such a systematic reinterpretation may be given also to specimens described as "*Perisphinctes* (*Orthosphinctes*) *colubrinus* (Reinecke)" by Wiśniewska-Żelichowska (1971, p. 35, pl. 19: 1–3) from the massive limestones of the Częstochowa Sponge Limestone Formation in the Rudniki (Lipówka) section. The corresponding macroconchs (see Atrops, 1982) are *Orthosphinctes* (*Lithacosphinctes*) *evolutus* (Quenstedt) (Pl. 1: 4) for *O. polygyratus*, and *O.* (*L.*) *gidoni* Atrops (Pl. 2: 1; Pl. 3) for *O. freybergi*, differing also in their density of ribbing and the type of coiling (Fig. 14). The species discussed are represented by several specimens from the Częstochowa Sponge Limestone Fm. (Rudniki: Lipówka section), and the Wolbrom Limestone Member of the Pilica Fm. (Latosówka section), but mostly from the Kuchary Chalky Limestone Member (Prusicko Fm.) of the Kuchary section, the Prusicko section and the Pajęczno sections. Of the specimens wrongly attributed in the past to other species can be also mentioned: " *Lithacoceras* (*Lithacoceras*) *pseudolictor* (Choffat)" in Wierzbowski (1964, p. 162, pl. 2: 2) which is *O.* (*L.*) *evolutus*, and "*Progeronia subachilles* (Wegele)" in Wierzbowski (1978, p. 324–325, pl. 7: 1) which is *O.* (*L.*) *gidoni* (see also Atrops, Wierzbowski, 1994).

The ammonites of the subgenus *Ardescia* include two very complete and adult specimens of *Orthosphinctes* (*Ardescia*) *enay* Atrops (Pl. 4: 1) found in the Chalky Limestone Member of the Kuchary section. The specimens are 125–155 mm in diameter, one of them showing a nearly complete final aperture but without the lappet preserved; the body chamber is about 4/5 of whorl length; PR equals about 35 and 40, at D = 40 mm and 50 mm, respectively, and then PR increases up to 46 at D = 70–125 mm (Fig. 14), to decrease finally to PR = 41 at D = 140 mm. The ribs are biplicate to triplicate often with polygyrate subdivision, and commonly occurring intercalatory ribs (SR/PR ratio oscillates between 2.6 at D = 100 mm to 3.4–4.0 at D = 125 mm). The specimens are very close to less densely ribbed representatives of the type series of *O.* (*A.*) *enayi* (*cf.* Atrops, 1982, pp. 65–71, p. 17: 2, 3; pl. 18: 1, 4). Two other less complete specimens come from the same deposits in the Pajęczno section: these are about 70–80 mm in diameter, and show a fairly high SR/PR ratio attaining about 2.6 to 3.0. The corresponding macroconch of *O.* (*A.*) *enay* is *Orthosphinctes* (*Lithacosphinctes*) *pseudoachilles* (Wegele) (see Atrops, 1982) represented by two fairly complete specimens from the Kuchary section (including that referred in the past as "*Lithacoceras* (*Lithacoceras*) *subachilles* (Wegele)" in Wierzbowski (1964, p. 161, pl. 2: 1), and two fragmentary preserved specimens from the Pajęczno section (Pl. 4: 2). The largest specimens attain about 250 mm in diameter, but the remaining ones are smaller (140–170 mm), with high SR/PR ratio attaining 6.4–7.5 at D = 150–175 mm; the ribbing disappears on the outer part of whorl at about 180 mm diameter.

Genus ***Subnebrodites*** **Spath, 1925**. *Subnebrodites laxevolutum* (Fontannes) sensu Ziegler, 1959 and *Subnebrodites planula* (Hehl), the corresponding micro- and macroconchiate forms, are commonly encountered in the massive limestones of the Częstochowa Sponge Limestone Fm. at Rudniki in the Lipówka section (Pl. 2: 2; see also Wiśniewska-Żelichowska, 1971, p. 37, pl. 22: 1a–c) and in the Niwiska Dolne section near Pajęczno (Matyja, Wierzbowski, 1997). These ammonites were originally referred to the genus *Idoceras* of the subfamily Idoceratinae (and of the family Perisphinctidae), but their phylogenetic relation with the genus *Praeataxioceras* of the family Ataxioceratidae seems more likely (*e.g.*, Schweigert, Callomon, 1997; see also Wierzbowski, Matyja, 2014, p. 74; Schweigert, Kuschel, 2017), and they are placed in the genus *Subnebrodites*. Special attention should be paid to the occurrence of another species of *Subnebrodites* – *Subnebrodites minutum* (Dieterich) (Pl. 2: 3, 4). It is characterized by a fairly small size (31–35 mm in diameter), and generally involute coiling with Wh ranging between 37 to 44, and Ud between 31–35 (although rare evolute forms with Wh = 29, and Ud = 54.8 representing possibly end-members of the whole assemblage are known as well), and the common occurrence of single ribs (*cf.* also variability of the species as shown by Schairer, 1989, pl. 8: 1–14). These ammonites were found mostly in the topmost part of the massive limestones of the Częstochowa Sponge Limestone Fm. (Latosówka section), and in the micritic bedded limestones (Wolbrom Limestone Member) of the Pilica Fm. (Latosówka section, Rudniki: Lipówka section; see also the specimen from the Niwiska Dolne section at Pajęczno illustrated in pl. 9: 5 by Matyja and Wierzbowski, 1997). Another specimen of this species was found in core 120G-1P at depth 266.5 m in the deposits of the Wolbrom Limestone Mbr., in the Szczerców browncoal field at the northern border of the Wieluń Upland: it is about 40 mm in diameter, shows evolute coiling, dense ribbing (about 50 PR per whorl) with the common occurrence of single ribs. The specimen referred to as *Subnebrodites* sp. (Pl. 5: 1) from the Latosówka Marl Member of the Pilica Fm. exposed at Mstów seems similar to *S. minutum* but it is too fragmentarily preserved for unequivocal determination to the species level. It is about 30 mm in diameter, shows involute coiling and the common occurrence of single ribs.

The specimen coming from the micritic limestones at the base of the Prusicko Fm. near Mstów, originally referred to as "*Ataxioceras* (*Parataxioceras*) cf. *desmoides* Wegele" by Malinowska (1964, fig. on p. 426; collection MUZ PIG 1078/II/1) is *Subnebrodites schroederi* Wegele. It consists of the body-chamber with the peristomal part preserved of a specimen about 100 mm in diameter, and it shows the characteristic biplicate and single ribs with marked forward spread of the secondaries, and a ventral smooth band; the numerous constrictions and common secondary ribs appear on the final part of the whorl as in other fully grown specimens of that species (*e.g.*, Schairer, 1989, pl. 7: 4)

Genus ***Ataxioceras*** **Fontannes, 1879**. This is interpreted according to Atrops (1982), who distinguished two microconch subgenera: ***Parataxioceras*** **Schindewolf, 1925** and ***Schneidia*** **Atrops, 1982** and the nominative subgenus ***Ataxioceras***, corresponding to the macroconchs.

The oldest ammonites of this genus come from the upper part of the Kule Chalky Limestone Member at Kule in the northern border of the Wieluń Upland. Some of these were described by Wierzbowski (1966, locality 84), some are new.

The fairly large specimens from about 80 mm to 120 mm in diameter are characterized by moderately dense and prorsiradiate primary ribs (PR = 29–30 at D = 50 mm; PR = 26–28 at D = 70–120 mm) with numerous secondaries (SR/PR = 4.0–5.0 on the outer whorl) and polyplocoidal rib division on the body-chamber. The coiling is moderately evolute on the last whorl, a large part of which is occupied the body-chamber (at D = 73 mm, Wh = 36.3, Ud = 41; at D = 122 mm, Wh = 32, Ud = 42.6), but it is markedly less evolute or even weakly involute in the inner whorls. The wide constrictions observed on the last part of the body-chamber indicate that the specimens are fully grown, and are microconchs. These specimens (Fig. 15; Pl. 5: 2, 3) may be compared with *Ataxioceras* (*Parataxioceras*) *homalinum* Schneid – a rather poorly known species (see Atrops, 1982, p. 189), whose synonymy includes several previously illus-

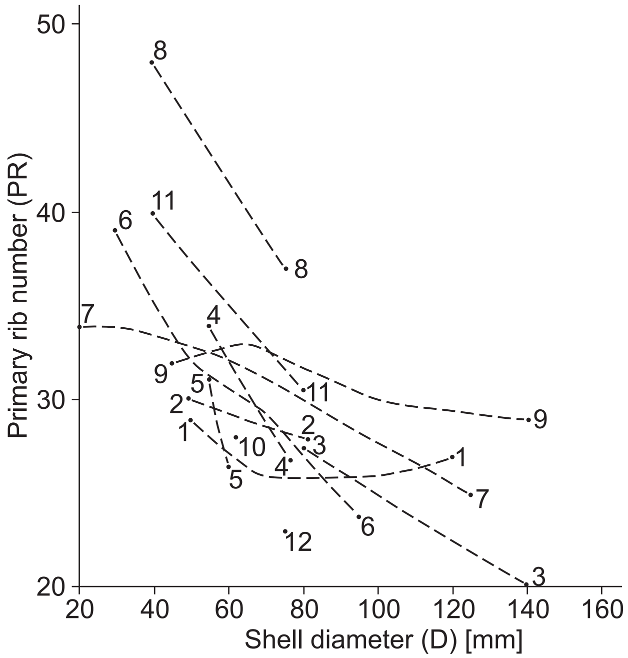


Fig. 15. Number of primary ribs (PR) against shell diameter (D) for selected ammonites of the genus *Ataxioceras*

1 – *Ataxioceras* (*Parataxioceras*) *homalinum-connatum* Schneid – MWG UW ZI/84/096, Kule (Pl. 5: 2); 2 – *A.* (*P.*) *homalinum* – IGPUW/A/7/7, Kule (= *A. hoelderi* in: Wierzbowski, 1966, pl. 5: 2; see also Pl. 5: 3, herein); 3 – *A.* (*P.*) aff. *homalinum*, close to *A. connatum* Schneid, MWG UW ZI/84/097, Kule; 4 – *A.* (*P.*) *lautum* Schneid, IGPUW/A/7/6, Kule (= *A. effrenatum* in: Wierzbowski, 1966, pl. 5: 1; see also Pl. 5: 4, herein); 5 – *A.* (*Schneidia*) *lussasense* Atrops, MWG UW ZI/84/101, Kule (Pl. 5: 5); 6 – *A.* (*Ataxioceras*) *eudiscinum* Schneid, MWG UW ZI/84/098, Kule (Pl. 2: 5); 7 – *A.* (*A.*) *eudiscinum* Schneid, MWG UW ZI/84/098, Kule (Pl. 5: 7); 8 – *A.* (*P.*) *effrenatum* (Fontannes), MWG UW ZI/84/113, Bełchatów brown-coal field, core KT 109, depth 256.5 m (Pl. 7: 1); 9 – *A.* (*A.*) *cardoti* Atrops, MWG UW ZI/84/001, Majaczewice (Pl. 6: 2); 10 – *A.* (*P.*) *lothari lothari* (Oppel), MWG UW ZI/84/108, Kiełczygłów, core J-10, depth 30.6 m (Pl. 7: 3); 11 – *A.* (*P.*) *lothari lothari* (Oppel), MWG UW ZI/84/119, Szczerców brown-coal field, core PD 20B, depth 175 m; 12 – *A.* (*P.*) *planulatum* (Quenstedt), MWG UW ZI/84/121, Szczerców brown-coal field, core 37/13.5, depth 81 m (Pl. 8: 2)

trated specimens: *A. homalinum* of Schneid (1944, p. 13, pl. 5: 1–2), *A.* (*P.*) *effrenatum* of Geyer (1961, pl. 15: 1) and *A. homalinum* Schneid in: Geyer (1961, p. 66, pl. 14: 3), as well as *A.* (*P.*) *homalinum* Schneid in: Gygi (2003, p. 103–104, fig. 120). Here belongs also: *A.* (*P.*) *hoelderi* Geyer in: Wierzbowski (1966, p. 185, pl. 5: 2), and possibly the larger, not previously illustrated specimen of those referred to *A.* (*P.*) *effrenatum* (Fontannes) in: Wierzbowski (1966, p. 184). The latter (Pl. 5: 2) shows weakening of the ribbing in the middle part of the last whorl at larger diameter which resembles *Ataxioceras connatum* Schneid (see Schneid, 1944, p. 17, pl. 5: 8), a form very close to *A. homalinum*, showing several features in common such as a similar size, a fairly thick whorl section, and a poorly individualized polyplocoidal rib division, but differing in somewhat more involute coiling of the outer whorl.

Another specimen from the Kule Chalky Limestone Member referred previously to as "*Ataxioceras* (*Parataxioceras*) *effrenatum* (Fontannes)" by Wierzbowski (1966, p. 184–185, pl. 5: 1) differs from those attributed herein to *A.* (*P.*) *homalinum* in its more contrasted primary rib number between the inner and outer whorls (at D = 55 mm, PR = 34; at D = 80 mm, PR = 27; see Fig. 15), and its very flat whorl sides; the ornamentation is sharp with common polyplocoidal rib division, and deep constrictions on the body-chamber. This specimen (Pl. 5: 4) possibly belongs to another poorly known species – *Ataxioceras* (*Parataxioceras*) *lautum* Schneid (see Schneid, 1944, p. 27, pl. 8: 5; see also Geyer, 1961, p. 66). The full range of variability of the species cannot be recognized because of the small number of described specimens. This was possibly the reason that a single specimen, differing from *A.* (*P.*) *lautum* in its weaker development of the polyplocoidal subdivision of ribs and smaller number of secondary ribs, was described by Atrops (1982, p. 190–192, pl. 39: 3) as *Ataxioceras* (*Parataxioceras*) nov. sp. aff. *lautum* Schneid.

Three larger specimens from the Kule Chalky Limestone Member are represented by phragmocones occasionally with a part of the body-chamber preserved. They attain about 105–130 mm in their diameters, and show involute coiling (at D = 93–118 mm, Wh = 37–41, Ud = 32–37), the whorl section is high, tapering towards the venter. The ribbing is fairly dense in the inner whorls (PR = 35–39 at D = 20–30 mm), becoming more distant at larger diameters (PR = 29–32 at D = 50–70 mm, and PR = 24–25 at D = 90–120 mm; see Fig. 15), the rib division is low and fairly irregular, often polyplocoidal in the inner whorls with commonly occurring constrictions; on the outer whorl of the phragmocone the ribbing is represented only by sparsely placed and swollen primary ribs at the umbilicus, whereas the rest of the whorl side and the ventral side become smooth. These specimens (Pl. 2: 5; Pl. 5: 7) may be accommodated in the species *Ataxioceras* (*Ataxioceras*) *eudiscinum* Schneid, which is based on a large specimen represented by its phragmocone and described by Schneid (1944, p. 18, pl. 4:1), subsequently designated as the lectotype of the species by Atrops (1982, p. 236–237). The species is clearly a macroconch, and it may be treated as the dimorphic counterpart of late representatives of the subgenus *Schneidia*, possibly *Ataxioceras* (*Schneidia*) *lussasense* Atrops.

The ammonites coming from the marly limestones of the lowermost part of the Burzenin Formation, at the base of the Kiełczygłów Marl Member (locality 83 at Kule in: Wierzbowski, 1966), are represented by small, densely ribbed specimens (Fig. 15) with the common polyplocoid subdivision of ribs. They were previously referred to as *Ataxioceras*

(*Ataxioceras*) sp. by Wierzbowski (1966); but they are microconchs (Pl. 5: 5) closely comparable with *Ataxioceras* (*Schneidia*) *lussasense* Atrops (see Atrops, 1982, p. 177, with given synonymy). The same species is represented in the Premik (1926) collection from Szałe near Kalisz: the specimen is about 80 mm in diameter and shows involute coiling and very dense ribbing (Pl. 6: 5).

Some comments may be given also on the specimens recognized in the Premik (1926) collection from the Trojanów in the Kalisz area. The microconchs are represented by specimens (Pl. 7: 4) showing marked similarity to the subgenus *Schneidia* in having a lower point of division of ribs on the body chamber, and generally rather thin and sharp ribbing. The specimens are similar to some specimens of *Ataxioceras* (*Schneidia*) *lussasense* Atrops, such as that of Atrops (1982, pl. 33: 3), but differ from the bulk of the specimens of the type-series of that species in having generally less dense ribbing (PR = 25 at D = 74–85 mm), and weakly involute to weakly evolute coiling of the last whorl (at D = 74–87 mm: Wh = 34.5–39.0, Ud = 34–39). The unequivocal interpretation of these specimens at the species level is difficult, and they are referred to as *Ataxioceras* (*Schneidia*) aff. *lussasense* Atrops, but possibly represent a new species. The corresponding macroconchs (Pl. 8: 1) attain at least up to about 140 mm in diameter, and show involute coiling in the phragmocone and the initial part of the body-chamber (at D = 83–117 mm: Wh = 42.5–47.0, Ud = 24.5–30.5), and are characterized by distant and massive primary ribs especially at larger diameters (PR = 20–22 at D = 85–110 mm; PR = 17 at D = 120 mm), but even at smaller diameters (PR = 30–35 mm at D = 50 mm; PR = 28 at D = 60 mm). These specimens show a large similarity to the species *Ataxioceras* (*Ataxioceras*) *suberinum* (von Ammon) as described by Geyer (1961, p. 62, pl. 13: 1, 2, with given synonymy).

A few ammonites have come from the outcrops of the Burzenin Fm., and the Majaczewice Mbr., at Burzenin. Of the specimens collected by Kowalski (1958, p. 35) special attention should be paid to those described as "*Ataxioceras lothari* (Oppel)" and "*Ataxioceras inconditum* Fontannes" from the Brzyków Oncolite Bed. The former is represented by a fragment of the body-chamber with the peristome preserved, and an adjoining piece of the phragmocone of the specimen of about 100 mm in diameter; the ribs are massive showing polyplocoidal subdivision on the body-chamber, and triplicate – polygyrate ribbing on the phragmocone which indicates that the specimen (Pl. 5: 6) may be referred to as *Ataxioceras* (*Parataxioceras*) *evolutum* Atrops. The latter is a fragment of the body-chamber with rather loosely spaced ribs showing triplicate and biplicate subdivision with some intercalatory ribs; the whorl section is rounded: this specimen may be referred to as *Orthosphinctes* (*Ardescia*) cf. *inconditus* (Fontannes). Still another specimen referred by Kowalski (1958, p. 35) to "*Ataxioceras inconditum* Font." is an adult specimen with the peristome preserved, about 100 mm in diameter. This specimen (Pl. 6: 1) shows evolute coiling (at D = 98 mm, Wh = 29, Ud = 42.3) and rather dense ribbing (at D = 100 mm, PR = 36) which shows the polyplocoidal subdivision of the ribs appearing rather late, at about 75 mm diameter – on the body-chamber. The specimen seems to be closely related to *Ataxioceras* (*Parataxioceras*) *hippolytense* Atrops, especially its densely ribbed variant (see Atrops, 1982, pl. 7: 7).

A single specimen (Pl. 6: 2) collected by the present author in the outcrop at Majaczewice (Majaczewice Mbr. of the Burzenin Fm.) near Burzenin is represented by the phragmocone and a piece of the body-chamber beginning at 135 mm diameter. The coiling is evolute (at D = 114 mm, Wh = 32.4, Ud = 43.8; at D = 140 mm, Wh = 30.7, Ud = 43.6). The ribbing is stout and moderately dense (at D = 45–65 mm, PR = 32–33; at D = 100–140, PR = 30–29); the ribs show polyplocoidal subdivision at the end of the phragmocone, with a high secondary / primary ribs ratio (about 5.0 at D = 130 mm); the ornamentation on the ventral side of whorl on the body-chamber tends to fade after a deep constriction at D = 130 mm. The specimen may be compared with *Ataxioceras* (*Ataxioceras*) *cardoti* Atrops (see Atrops, 1982, pp. 238–242, pl. 9: 1 – holotype; pl. 31: 1 and 36: 2 – paratypes). It differs from the holotype and the two paratypes of this species in its more evolute coiling resembling somewhat in that feature the closely related *Orthosphinctes* (*Lithacosphinctes*) *dawidi* Atrops. The specimen studied shows, however, the polyplocoidal subdivision of its ribs – a feature typical of the genus *Ataxioceras.* The character of the rib-curve (Fig. 15) is of the "archaic" type characteristic of *A. cardoti* which resembles also very much that of *Orthosphinctes* (*Lithacosphinctes*), and differs markedly from the rib-curves of typical *Ataxioceras* like *Ataxioceras* (*Ataxioceras*) *illibatum* Schneid (see Atrops, 1982, fig. 46).

Some specimens coming from the middle part of the Burzenin Fm. are known from boreholes in the brown-coal field at Szczerców. Very characteristic is a specimen from unit G corresponding here to a lower part of the Majaczewice Mbr., in borehole KT 9 (at depth 256.5 m). This specimen is possibly adult, attaining about 75 mm in diameter, and shows evolute coling (at D = 72.5 mm, Wh = 31.7, Ud = 40); the ribbing (Fig. 15) is very dense on the inner whorls (at D = 40mm, PR = 48), and loosely spaced thereafter (at D = 42 mm, PR = 42; at D = 75 mm, PR = 37), and it is rather irregular on the body-chamber. This specimen (Pl. 7: 1) can be recognized as *Ataxioceras* (*Parataxioceras*) *effrenatum* (Fontannes) as revised by Atrops (1982, p. 210–213, pl. 9: 2–3 – refigured holotype, and pl, 10:10), who placed in the species specimens of rather a small size, densely ribbed on inner whorls, very close to its holotype.

Some ammonites of the genus *Ataxioceras* were described by Wierzbowski (1966) from the deposits representing the upper part of the "oolitic" fm., and the overlying Burzenin Formation in boreholes at Dubidze and Błota Kruplińskie in the eastern border of the Wieluń Upland. The ammonite described as *Ataxioceras* (*Parataxioceras*) sp. (Wierzbowski, 1966, p. 184. pl. 4: 2) represents a fragment of the body-chamber with the loosely spaced ribs showing an indistinct polyplocoid subdivision fairly high on the whorl side. Because of this, and the very evolute coiling, it may be referred to as *Ataxioceras* (*Parataxioceras*) cf. *evolutum* Atrops (*cf.* Atrops, 1982, p. 215–219). Another specimen described as *Ataxioceras* (*Ataxioceras*) sp. by Wierzbowski (1966, p. 185, pl. 6: 1; see Pl. 6: 3) shows involute coiling with the very well developed polyplocoidal subdivision of ribs already at the middle of the whorl height; the inner whorls of the specimen represent a fragment of the phragmocone, whereas the preserved part of the outer whorl is a fragment of the body-chamber, which suggests generally a rather small final size of the specimen in question (up to 100 mm in diameter). All these features indicate that the specimen can be safely accommodated in the subspecies *Ataxioceras* (*Ataxioceras*) *hypselocyclum hypselocyclum* (Fontannes).

Several specimens were found in the Majaczewice Mbr. of the Burzenin Formation in boreholes at Kiełczygłów, and boreholes from the brown-coal field and outcrop of Szczerców, on the northern border of the Wieluń Upland. The specimens from the borehole at Kule (J 10 at 30.6 m) are from about 60 mm to about 70–80 mm in diameter, representing the phragmocone with a part of the body chamber, or only a fragments of the body-chamber. They show typical polyplocoidal subdivision of the ribs which begins fairly low on the whorl height, and may be interpreted as (Fig. 11; Pl. 7: 2, 3) *Ataxioceras* (*Parataxioceras*) *lothari lothari* (Oppel) and *A.* (*P.*) cf. *lothari* (Oppel). A fragment of the body-chamber of a larger specimen found in the same borehole at 32 m shows the typical polyplocoidal subdivision of ribs on the middle of the whorl height, and may be referred to (Pl. 7: 5) as *Ataxioceras* (*Ataxioceras*) cf. *hypselocyclum* (Fontannes).

Similar specimens were found in corresponding deposits in the boreholes from the brown-coal field at Szczerców. The most common here are specimens of *Ataxioceras lothari lothari* (Oppel), as well as some fragmentarily preserved ones referred to the subspecies as cf. Some specimens like the one from borehole PD20B (depth 175–176 m) represented by the phragmocone with a part of the body-chamber shows weakly evolute coiling at the beginning of the body chamber (at D = 66 mm, Wh = 36.4, Ud = 40.9); the ribbing (Fig. 15) is moderately dense (at D = 40 mm, PR = 40; at D = 80 mm, PR is about 30) with the well developed polyplocoidal subdivision of ribs; the specimen is close to the holotype of the species (Oppel, 1863, pl. 67: 6), and variant B of the subspecies of Atrops (1982, p. 200). Another specimen (Pl. 6: 4) from borehole PW 408 (depth 149.5 m) shows very evolute coiling (at D = 74 mm, Wh = 29.7, Ud = 43.2), very strong and distant ornamentation on the body-chamber (at D = 75 mm, PR = 22), and a high secondary/primary ribs ratio (at D = 75 mm, SR/PR = 5.6); it is very similar to "*Ataxioceras nudocrassatum* Geyer", and especially to the paratype of that form (see Geyer, 1961, pl. 14: 5), recognized as a very heavily ornamented variant of *A. lothari lothari* (Oppel) by Atrops (1982, p. 201).

A very characteristic specimen (Fig. 11; Pl. 8: 2) has been found in unit G (Majaczewice Mbr.) of the Burzenin Fm. in borehole 37/13.5 m (depth 81 m) from the Szczerców brown-coal field. It is about 75 mm in diameter and shows the body-chamber. The ornamentation is characterized by the very irregular subdivision of ribs, and the commonly occurring constrictions, whereas the coiling is very evolute (at D = 75 mm, Wh = 34.6, Ud = 44.6). These features indicate close affinity with *Ataxioceras* (*Parataxioceras*) *planulatum* (Quenstedt) – see Atrops (1982, p. 220–223, pl. 43: 4–7).

Of other ammonites of the genus *Ataxioceras* from the Majaczewice Mbr. of the Burzenin Fm., at Burzenin, worth noting is the specimen of *Ataxioceras hypselocyclum semistriatum* Schneid coming from locality 51 of Kowalski (1958, p. 40). The specimen (Pl. 7: 6) is represented by a phragmocone, about 70 mm in diameter showing very involute coiling (at D = 65.5 mm, Wh = 45.8; Ud = 23.6), the dense ribbing (at D = 70 mm, PR = 32) with a very high secondary/primary rib ratio (about 4.5) and the double polyplocoidal subdivion of ribs – the features indicative of the subspecies (see Atrops, 1982, p. 258).

Genus ***Crussoliceras* Enay, 1959** and genus ***Garnierisphinctes* Enay, 1959**. Representatives of these two genera were encountered in the Majaczewice Member of the Burzenin Formation near Burzenin. They are mostly incomplete, and small but showing typical features of the two subgenera. The representative of the former (Pl. 7: 8) shows the low oval whorl section, strongly evolute coiling, and sparsely placed ribs with a high point of bifurcation suggestive of a relation with *Crussoliceras divisum* (Quenstedt); the specimens of the latter show a compressed whorl section, moderately evolute coiling, strongly prorsiradiate primary ribs with a lower point of bifurcation, and the common occurrence of narrow constrictions bordered by strongly developed single ribs – these may be compared with *Garnierisphinctes semigarnieri* (Geyer) (Pl. 8: 4) and *G. championneti* (Fontannes) (Pl. 8: 3) (see Geyer, 1961; Enay *et al.*, 2014).

Family Perisphinctidae Steinmann, 1890

Genus ***Trenerites* Sarti, 1993**. This Mediterranean genus founded on the basis of *Trenerites evolutus* (Gemmelaro) by Sarti (1993, 2002) includes a single specimen referred previously to as " *Idoceras planula* (Hehl)" (see Wierzbowski, 1966, pl. 8: 1) from the Pajęczno section of the Kuchary Chalky Limestone Member (Prusicko Fm.). This specimen representing mostly the phragmocone with a fragment of the body-chamber preserved shows very involute coiling (at D = 117 mm, Wh = 26, Ud = 56; at D = 86 mm, Wh = 23, Ud = 57.5), and moderately dense ribbing (PR = 36 at D = 50–90 mm). The ribs are stout, slightly arcuate with a very high point of rib bifurcation, but not covered by the next whorl. These features make possible comparison of the specimen studied with *Trenerites enayi* Sarti (see Sarti, 1993, p. 107–109, pl. 21: 1a, b; pl. 22: 2a–d). It should be remembered that the specimen differs markedly from all the representatives of *Subnebrodites* because of its very evolute coiling and high point of the rib division.

Family Aulacostephanidae Spath, 1924

Several groups of ammonites of the family representing the separate lineages are recognized in the material studied. The most common in the lower part of the succession are ammonites of the genus ***Vielunia* Wierzbowski et Głowniak, 2010** (macroconchs and corresponding microconchs of the genus ***Prorasenia* Schindewolf, 1925**). The macroconchs placed in the genus *Vielunia* were in the past commonly referred to the genus *Ringsteadia* (*e.g.*, Wierzbowski, 1970, 1978), but their full proper taxonomic interpretation was given rather recently (Wierzbowski *et al.*, 2010). The two species – *Vielunia flexuoides* (Quenstedt) and *Vielunia limosa* (Quenstedt) are known in the lower part of the succession in the area of study. They differ mostly in the density of ribbing and the type of coiling with more densely ribbed and more involute specimens representing the former species.

Vielunia flexuoides was described by Wierzbowski (1970, p. 273–275, pl. 1: 1–3; pl. 2: 1, 2) from the Niwiska Dolne section (massive limestones of the Częstochowa Sponge Limestone Fm.) and from the Latosówka section (Wolbrom Limestone Member of the Pilica Fm.); in addition to the same species belong *Ringsteadia* (*Ringsteadia*) sp. indet. of Wierzbowski (1966, p. 188, pl. 9: 1) and possibly *Ringsteadia* (*Vineta*) sp. (p. 188, pl. 9: 2) from the Wolbrom Limestone Member at Wólka Prusicka near Prusicko and at Gajęcice Stare near Pajęczno. Moreover, two specimens attributed to the species "*Ringsteadia* (*Ringsteadia*) *caliginosa* (Schneid)" [= *Vielunia caliginosa* (Schneid)] by Wiśniewska-Żelichowska (1971, p. 37–40, pl. 23–25) from massive limestones of the Częstochowa Sponge Limestone Fm. at Rudniki (Lipówka section) show the density of ribbing and the type of coiling similar to those of *Vielunia flexuoides* (Quenstedt). It should be remembered that although *Vielunia caliginosa* is undoubtedly closely related to *V. flexuoides*, it shows less dense ribbing and somewhat less involute coiling, and it occurs in somewhat younger deposits (see Geyer, 1961, p. 127; Wierzbowski *et al.*, 2015, p. 82).

Another ammonite species recognized is *Vielunia limosa* (Quenstedt). The specimens which may be placed in the synonymy of this species have been originally described by Wierzbowski (1970, p. 277, 278, pl. 4: 1, 2) as "*Ringsteadia* sp. indet."; some are additionally illustrated herein (Pl. 9: 5). All of them come from massive limestones of the Częstochowa Sponge Limestone Fm., mostly of the Niwiska Dolne section. These specimens represent the inner whorls comparable with those of the holotype of *Vielunia limosa* (Quenstedt), and differ from specimens of the older *Vielunia dzalosinensis* Wierzbowski and Głowniak (Wierzbowski *et al*., 2010, p. 71) in the less dense ribbing and the more involute coiling. It should be noted that some specimens described originally as *V. limosa* (see Wierzbowski, 1970, p. 275, 276, pl. 3) have been included later into the synonymy of the new species *V. dzalosinensis* (Wierzbowski *et al*., 2010, p. 70, 71).

Younger representative of *Vielunia* include the large specimen of "*Ringsteadia* (*Ringsteadia*) *tenuiplexa* (Quenstedt)" described by Wierzbowski (1970, p. 278, 279, pl. 6) from the Kuchary Chalky Limestone Member of the Prusicko Formation of the Kuchary section. This specimen shows moderately involute coiling of the inner whorls, and rather massive, distant ribs. A very similar coarsely ribbed specimen represented by a phragmocone about 170 mm in diameter comes from deposits of possibly the same lithostratigraphic unit cropping out at Gawłów near Pajęczno. Additional specimens, but referred to that species with reservation, came from somewhat older deposits of the Częstochowa Sponge Limestone Fm. in the Niwiska Dolne section (Matyja, Wierzbowski, 1997, p. 86, 89). The interpretation of the species "*R. tenuiplexa*" was given by Geyer (1961, p. 126), but there exist in the literature a number of similar heavily ribbed forms with long primary ribs of the *Vielunia* type – some of them even placed in the subgenus *Eurasenia* Geyer, 1961. Such is the case with "*Rasenia* (*Eurasenia*) *conspicua* (Schneid)" (see Geyer, 1961, p. 97, pl. 22: 7), which has been based on a specimen of " *Ringsteadia conspicua* Schneid" (Schneid, 1939, p. 171, pl. 14: 1 and some other strictly related forms referred therein to the genus "*Ringsteadia*"), but which fit better to the genus *Vielunia*.

Two specimens in the material studied have been previously attributed to *Eurasenia* by Wierzbowski (1964,

p. 162–163, pl. 1: 2; 1978, p. 321, pl. 3: 5), and tentatively compared with the strongly involute *E. vernacula* (Schneid) and *Eurasenia* sp.: *E. engeli* Geyer or *E. gothica* (Schneid). Both the specimens (Pl. 10: 1, 2) coming from the Kuchary Chalky Member of the Prusicko Fm. attain about 55 mm in diameter, show strongly involute coiling (Wh = 44.5–45.3, Ud = 25.5–27.2) and rather distant primary ribs (PR = 20–23 at D = 55 mm) with a fairly high secondary/primary ribs ratio (SR/PR=3.6–3.8 at D = 55 mm). The specimens differ from typical representatives of the genus *Eurasenia* in the presence of long primary ribs which resemble those of the genus *Vielunia.* Although the difference between the late representatives of *Vielunia* and the earliest representatives of *Eurasenia* is relatively small, and the transition between them is gradual – the specimens discussed seem to represent late forms of the genus *Vielunia* and may be compared with "*Ringsteadia gothiciformis* Schneid" (see Schneid, 1939, p. 169, pl. 13: 12) = *Vielunia gothiciformis* (Schneid) as interpreted herein.

The material studied shows that there existed possibly two separate lineages of *Vielunia* (see also Wierzbowski, 2017b). One of them is represented by the more heavily ornamented and the moderately involute forms leading from such forms as *Vielunia limosa* (Quenstedt) (and earlier occurring *V. dzalosinensis* Wierzbowski, Głowniak) to forms similar to *Vielunia tenuiplexa* (Quenstedt) and then to the moderately involute to weakly evolute representatives of the genus *Eurasenia.* The second lineage possibly lead from forms close to *Vielunia flexuoides* (Quenstedt), following the closely related *V. caliginosa* (Schneid), to the strongly involute forms at the transition between *Vielunia* and *Eurasenia* [*V. gothiciformis* (Schneid) and *E. vernacula* (Schneid) – *E. gothica* (Schneid], and then to representatives of the genus *Involuticeras* Salfeld, 1917 (see Geyer, 1961, p. 92; Wierzbowski *et al*., 2016, p. 32).

The ammonites of the genus *Prorasenia* being the counterparts of *Vielunia* are generally less well-known in the material studied. From the oldest *Prorasenia crenata* (Quenstedt) representing the microconch of *V. dzalosinensis* (Wierzbowski *et al*., 2010) there should be a transition to the younger *Prorasenia quenstedti* Schindewolf. This latter species is recognized in the Prusicko Formation – in the Kuchary Chalky Limestone Member at Pajęczno and the younger Skowronów Limestone Member at Prusicko (see Wierzbowski, 1966, p. 187, pl. 8: 3, 4). These specimens may represent both the microconchs of late forms of *Vielunia*, as well as of early forms of *Eurasenia.*

Some rare ammonite macroconchs may be compared with the genus ***Pictonia* Bayle, 1878** (subgenus ***Pictonites* Mesehnikov, 1969**) and the corresponding microconchs of the genus ***Prorasenia* Schindewolf, 1925**. The older macroconchs are two poorly preserved specimens, both coming from the massive limestones of the Częstochowa Sponge Limestone Fm., in the sections at Rudniki (Lipówka section) and Niwiska Dolne. The specimens are about 50–60 mm in diameter and show weakly evolute coiling with irregular ornamentation of the inner whorls, and loosely placed ribbing on the outer whorl; the primaries on the outer whorl are short, and somewhat swollen, and the secondaries appear about the mid-height of the whorl (Pl. 9: 3). The specimens are similar to the holotype of *Pictonia perisphinctoides* from southern Germany as illustrated by Wegele [1929, p. 81, pl. 10: 2a, b; see also Schneid (1940, p. 88, pl. 7: 2) and Geyer (1961), p. 116, pl. 21: 7], and are referred herein to as *Pictonia* cf. *perisphinctoides* (Wegele). It should be remembered that the specimen of larger diameter originally described as "*Rasenia dacquei* " by Wegele (1929, p. 80, pl. 1a, b) with coarse triplicate ribs seems to represent the outer whorls of *P. perisphinctoides* (see Schweigert and Callomon, 1997, p. 45). Similarly, the younger *Pictonia* – *P. kuyaviensis* Matyja et Wierzbowski from northern Poland was described mainly from fairly small specimens, but along with a single larger specimen of "*Rasenia* aff. *dacquei*", showing coarse primary ribs and representing possibly the outer whorl of this species (see Matyja, Wierzbowski, 2002, pl. 1: 4–11 and 12, respectively). Such a character is also seen in a fragment of the whorl of a large specimen, revealing the evolute coiling and the presence of massive triplicate ribs, coming from the middle part of the Latosówka Marl Member of the Prusicko Fm. in core 2B (depth 35–40 m; locality 54 of Wierzbowski, 1966) at Ważne Młyny near Prusicko. This specimen, previously referred to as *Eurasenia* or *Pachypictonia*, may be thus rather safely interpreted as a fragment of the outer whorl of *Pictonia* similar to the forms described above (Pl. 9: 2).

It results from the aforegoing that the Submediterranean ammonites of the genus *Pictonia* like *P. perisphinctoides* and *P. kuyaviensis* show the development of strong ribbing at larger diameters, in which they differ markedly from the typical Subboreal representatives of the genus *Pictonia* from NW Europe. Thus, they deserve a separate subgenus name – and the name *Pictonites* with the type species *Pictonia* (*Pictonites*) *perisphinctoides* (Wegele), proposed by Mesezhnikov (1969, p. 103) for the evolute forms from southern Germany, showing fairly regular ornamentatation which continues on the outer whorls, seems here the most appropriate. On the other hand, the interpretation given by Geyer (1961, p. 118) according to which the name "*Rasenia dacquei*" of Wegele (1929) has been treated as an older synonym of *Pictonia indicatoria* Schneid (1940, p. 90, pl. 8: 1–4), the type species of the subgenus *Pachypictonia* Schneid 1940, is inappropriate (*cf.* also Schweigert, Callomon, 1997, p. 44). The inner whorls of *P. indicatoria* show already at a small diameter the presence of the thick swollen primary ribs of the *Rasenia* type completely different from those occurring at a comparable size in *Pictonia perisphinctoides* and other representatives of the subgenus *Pictonites.*

The youngest specimen in the material studied which may be compared with *Pictonia* (*Pictonites*) comes from the Kule Chalky Member of the Prusicko Formation at Kule in the northern border of the Wieluń Upland. This specimen (Pl. 9: 1 a, b) about 150 mm in diameter is represented by a half of the phragmocone (at least up to 120 mm diameter), and a fragment of the body-chamber. The coiling is weakly involute in the inner whorls (at about 60 mm diameter, Wh = 39, Ud = 33.3), but soon becomes evolute (at D = 80 mm, Wh = 32, Ud = 40). The ribbing is rather sparse (PR is about 22 at D = 50 mm, and PR/2 equals 14 at about 120 mm). The primary ribs are short, fairly thick, and the point of appearance of the secondary ribs is somewhat below the middle of the whorl side. The primary ribs become markedly swollen directly above the umbilicus and the ribbing tends to fade on the higher part of the whorl, in the preserved fragment of the body-chamber. The specimen can be closely compared with *Pictonia constricta* Schneid, and the very close, possibly conspecific *P. tereticornis* Schneid from southern Germany (see Schneid, 1940, p. 105, pl. 14, 1–3, and p. 106, pl. 13: 3, pl. 14: 4; see also Geyer, 1961, p. 115). Another specimen of this rare species was described by Kutek (1968, p. 559, pl. 1: 3) from central Poland. On the other hand, the specimen described as *Pictonia* (*Pictonia*) *constricta* by Geyer (1961, p. 115, pl. 22: 2) possibly does not belong to that species but is rather a late representative of *Vielunia* as shown by the fairly long primary ribs, and the oval whorl section. The species *P. constricta* is undoubtedly very close to older *P. perisphinctoides* and *P. kuyaviensis*, representing possibly the end-member of the *Pictonites* lineage. It may be noticed, that the primary ribs in *Pictonia constricta* are, however, shorter and more swollen than in older species, and the whorl section is more narrow, tapering to the ventral side. These features indicate some similarity to early representatives of the genus *Rasenia* from Subboreal Province, especially *Rasenia inconstans* Spath, as interpreted by Birkelund and Callomon (1985, p. 33–35, pl. 12: 1–4; pl. 13: 1–5; pl. 14: 1–4; with given synonymy), but the main difference becomes the more dense ribbing, and the less evolute coiling of the inner whorls of the species in question. It should be remembered, that *R. inconstans* shows a marked "horizontal" variability, ranging from the less heavily ribbed forms, morphologically being closer to *Pictonia*, up to the more heavily ribbed forms closer to typical *Rasenia* (Birekelund, Callomon, 1985), the feature which may be considered also for the end of the *Pictonites* lineage, as discussed herein.

The microconchs of the genus *Pictonia* can also be found in some representatives of *Prorasenia.* The most obvious similarity of the specimens studied is to *Prorasenia hardyi* Spath. Such an opinion in relation to specimens from southern Germany and Poland was expressed earlier by Schweigert and Callomon (1997, p. 22) as well as by Matyja and Wierzbowski (1997, p. 89). This is the case also with a specimen referred to here as *Prorasenia* cf. *hardyi* Spath (Pl. 9: 4) from the Kuchary Chalky Limestone Member of the Prusicko Fm. at Kuchary. This was referred to as *Prorasenia* n.sp. in Geyer (1961) by Wierzbowski (1964). The specimen is about 25 mm in diameter, showing the flat whorl-sides and the weakly involute to weakly evolute coiling and the low point of rib division on the inner whorls, as well as the characteristically densely placed ribs with their high division point on the outer whorl.

Some specimens found in the youngest deposits studied – in the Burzenin Formation – in the northern border of the Wieluń Upland, and at Burzenin represent another group of aulcostephanids, showing generally stronger ornamentation of the rasenoidal type. Here belong representatives of the genera ***Eurasenia* Geyer, 1961**, and ***Involuticeras* Schneid, 1917**.

A well-preserved ammonite, about 130 mm in diameter, from the Burzenin area (Brzyków Oncolite Bed at Brzyków), is represented by the phragmocone with a large part of the body-chamber (about ¾ whorl long) preserved (Pl. 9: 6). The coiling is markedly involute (at D = 110 mm, Wh = 43.6, Ud = 28.1); the ribbing is strong with short swollen, and loosely placed primaries (at D = 115–130 mm, PR = 18–17), and a fairly high secondary/primary ribs ratio (SR/PR = 4.0 at D = 130 mm). The specimen corresponds closely to the holotype of *Eurasenia vernacula* (Schneid) (see Schneid, 1939, pl. 13: 1; see also Geyer, 1961). Another smaller specimen (Pl. 10: 3) represented by the phragmocone, and referred to as "*Rasenia frischlini* (Oppel)" by Kowalski (1958, p. 35) shows involute coiling (at D = 61 mm, Wh = 44.2, Ud = 27.8), the distant and stout character of ribbing (at D = 60 mm, PR = 14), and a low-trapezoidal whorl section. It may be referred to *Eurasenia trimera* (Oppel) according to the interpretation of this species by Geyer (1961, p. 99, 100).

A fragment of a body chamber (about 50 mm in height) recognized in a borehole (J 10, at 32 m) at Kule in the northern border of the Wieluń Upland, may be easily interpreted as belonging to the genus *Involuticeras.* The specimen (Pl. 8: 5) shows a steep umbilical wall, strongly developed, swollen primary ribs, and wide secondary ribs near the ventral side, whereas the large part of the whorl height is smooth. Because of the fragmentary preservation, unequivocal ascribing of the specimen to the particular species is difficult – but most probably its interpretation is either *Involuticeras involutum* (Quenstedt) or *I. limbatum* (Schneid) (see descriptions in Geyer, 1961, p. 102, 105, and relevant illustration including those in Schneid, 1939). Quite commonly representatives of the genus *Involuticeras* were encountered in the Burzenin area – especially in the Brzyków Oncolite Bed; these include *Involuticeras* cf. *involutum* (Quenstedt) and *I.* cf. *crassicostatum* (Geyer) (Pl. 10: 6), differing mostly in the density and strength of the ribbing (see Geyer, 1961). Other specimens commonly cited from that locality by Kowalski (1958) as "*Involuticeras glabellum* (Schneid", "*I. cinctellum* Schneid", and "*I. limbatum* (Schneid)" by Kowalski (1958, p. 35) are accommodated in *Involuticeras limbatum* (Schneid) (Pl. 10: 5) according to the interpretation of this species by Geyer (1961, p. 105).

Another group of ammonites of the family Aulacostephanidae are rare forms of the genus ***Vineta* Dohm, 1925** (both micro- and macroconchs). The specimens were encountered in the massive limestones of the Częstochowa Limestone Fm., as well as in the micritic limestones of the Wolbrom Limestone Member at Rudniki (Lipówka section), and at Latosówka. The single macroconch is a small specimen about 42 mm in diameter showing very involute coiling (Wh = 50, Ud = 16.5) and very dense prorsiradiate ribs with their irregular subdivision (SR/PR ratio is about 3.6 at D = 40 mm). The specimen (Pl. 10: 7) is very close to *Vineta striatula* (Schneid) (*cf.* Schneid, 1939, pl. 16: 5; Geyer, 1961, pl. 22: 1). The only microconch specimen is about 32 mm in diameter and shows thin dense ribbing with prorsiradiate primaries, and rectiradiate secondaries both on inner and outer whorls, and the peristome with lappet (Pl. 10: 8). It is very similar to the microconchs of *Vineta* described by Wierzbowski *et al.* (2010, p. 70, pl. 6: 6, 7). The *Vineta* microconchs resemble very much earlier *Microbiplices* microconchs of the *M. procedens* group (Wierzbowski *et al*., 2016, p. 29).

The genus ***Balticeras* Dohm, 1925** is still poorly known since its establishment by Dohm (1925, p. 34). The characteristic features of the genus (and the type species *B. pommerania* Dohm) are: the large size, very involute coiling, narrow umbilicus with a very steep umbilical wall, and poorly recognized, but generally weak ornamentation especially in the dorsolateral part of the whorls, as well as a discoidal whorl section with the tendency to be oxycone (Dohm, 1925; Arkell *et al.*, 1957; Gygi, 2003). Also the relation of *Balticeras* to other genera has been the subject of different interpretations – from its treatment as a subgenus of *Ringsteadia* (see Arkell *et al*., 1957), or the indication of its rather unclear position within the aulacostephanoid lineage (Geyer, 1961), but with possible relations to *Vineta*, *Involuticeras* and even *Semirasenia* (*i.e*. with *Rasenioides*; see also Wierzbowski, 2017b). Hence, the occurrence of the specimens in the Burzenin area, in the Brzyków Oncolite Bed described as "*Balticeras pommerania* Dohm var. *samsonowiczi* Kowalski n.var." by Kowalski (1958) is of special interest. However, the failure of Kowalski to give any indication of a type specimen has so far precluded its formal use of the proposed name for this form. Nonetheless the specimens found in the Kowalski's collection are recognized herein as representing the new species *Balticeras samsonowiczi* sp. nov. with preservation of the originally proposed name, and the distinguishing of the holotype and the paratype of the species.

Balticeras samsonowiczi sp. nov.
(Pl. 10: 9; Pl. 11: 1 a–c)

1958. *Balticeras pommerania* Dohm var. *samsonowiczi* Kowalski, p. 35, without description and illustrations.

Type material. – Holotype (no. MWG UW ZI/83/08; Pl. 11: 1a–c), paratype (no. MWG UW ZI/83/09, Pl. 10: 9).

Type area and locality. – Burzenin area, Brzyków (locality 52 in Kowalski (1958).

Type horizon. – Brzyków Oncolite Bed of the Majaczewice Member of the Burzenin Fm., Lower Kimmeridgian, the upper part of the Hippolytense Subzone of the Hypselocyclum Zone.

Derivation of the name. – In memory of Prof. Jan Samsonowicz – the eminent Polish geologist, and the student of the Mesozoic deposits of the Łódź Synclinorium; the name is introduced according to the original proposal of W.C. Kowalski (1958) in his stratigraphical interpretation of the ammonite fauna collected at Burzenin.

Diagnosis. – Macroconchs of moderate size, showing very involute coiling and a high discoidal whorl section with a narrow umbilicus and a very steep umbilical wall; the ribbing is weaker in the dorsolateral, and stronger in the ventrolateral part of the whorls with a general tendency to lowering of the point of division of ribs with growing diameter.

Material. – Two specimens represented by the body-chamber with the last part of the phragmocone (holotype), and the phragmocone, with partly preserved body-chamber (paratype).

Description. – Specimens attain about 100 mm in diameter; the character of coiling indicates they are fully grown. The coiling is very involute (in holotype at D = 93 mm, Wh = 52.6, Ud = 17.2; in paratype at D = 63 mm, Wh = 54, Ud = 15.9; at D = 98 mm, Wh = 52, Ud = 22.4). Umbilicus deep with a very steep umbilical whorl but without the umbilical edge; the umbilical wall becomes gentle near the aperature. Whorl section trapezoidal tapering towards the ventral side which is narrow and rounded. The ribbing in the phragmocone consists of weak primary ribs and much stronger secondary ribs appearing near the middle of the whorl height; on the body-chamber the primary ribs are poorly developed – but tending to shorten, whereas the secondary ribs appear lower on the whorl side, showing an indistinct tendency to join the primary rib at about one third of the whorl height.

Discussion. – The specimens seem the most close to *Balticeras pommerania* Dohm, but they possibly attain a much smaller final size when compared with specimens of this species as described by Dohm (1925, pl. 5: 1, phragmocone, nearly 200 mm in diameter) or Gygi (2003, fig. 153, phragmocone, 390 mm in diameter). Although the outer whorls of these giant specimens are completely smooth, the ornamentation of the inner whorls of some of these larger specimens (see Gygi, 2003, fig. 156) is similar to that observed on the body-chamber of *Balticeras samsonowiczi* sp. nov. as marked by presence of the short primary ribs in the umbilicus. The character of the ribbing of the inner whorls (phragmocone) of *B. samsonowiczi* indicates also some similarity to that of much older representatives of the genus *Vineta* (see Wierzbowski *et al.*, 2010, p. 67, pl. 7). Both the specimens of *Balticeras samsonowiczi*, as well as at least some of the large specimens of *B. pommerania*, *e.g.*, that of Gygi (2003, fig. 153 with adhering *Ataxioceras* (*Parataxioceras*) *evolutum* Atrops), come from a similar stratigraphic level – *i.e.* from the upper part of the Hippolytense-lowermost Lothari Subzone of the Hypselocyclum Zone.

Genus ***Rasenioides*** **Schindewolf, 1925**. The genus is represented by two specimens found in the vicinity of Burzenin. One of them coming from the Brzyków Oncolite Bed is a small fully grown microconch, 31 mm in diameter, with the final peristome with lappet preserved (Pl. 10: 10); the primary ribs are loosely spaced (at D = 25 mm, PR = 15; at D = 30 mm, PR = 18); the number of secondary ribs is somewhat reduced at the end of the body-chamber (from SR/PR = 3.6 at D = 25 mm to SR/PR = 3.0 at D = 30 mm). The reduction of the secondary ribs with growing diameter is recognized as diagnostic of *Rasenioides paralepidulus* (Schneid), which results in the somewhat isolated position of the species within the microconchs of the genus *Rasenioides* (see Geyer, 1961, p. 114).

Another species is a very large macroconch, about 250 mm in diameter. It shows very specific features distinguishing it from all the known macroconchs of the genus *Rasenioides.* Because of these, and its importance for the phylogeny of the genus, it is distinguished herein as the new species *Rasenioides glazeki* sp. nov.

Rasenioides glazeki sp. nov. (Pl. 12)

Type material. – Single specimen (no. MWG UW ZI/84/010) designated as the holotype.

Type area and locality. – Burzenin area, quarry at Majaczewice.

Type horizon. – Lower part of the Majaczewice Member of the Burzenin Fm., Lower Kimmeridgian, at the boundary of the Hippolytense Subzone and the Lothari Subzone of the Hypselocyclum Zone.

Derivation of the name. – In memory of Prof. Jerzy Głazek – the eminent Polish geologist, and the student of the karst processes and tectonics of the Wieluń Upland.

Material. – One specimen about 250 mm in diameter recognized as the holotype of the new species.

Description. – The specimen consists of the phragmocone and the initial part of the body chamber. The coiling is strongly involute (at D = 180 mm, Wh = 47.2, Ud = 19.5), and the whorl section is high-oval tapering towards the ventral side. The umbilicus is deep with a steep umbilical wall. The inner whorls are not visible, and the ornamentation is seen from about 100 mm diameter, when there appear short swollen primary ribs at the umbilicus. The primary ribs are loosely spaced (about 20 primary ribs), they continue up to about a quarter of the whorl height where they split into numerous thin secondary ribs: there are about 8–10 secondary ribs per primary. The ornamentation disappears at about 180 mm diameter, and the outer whorl becomes smooth except for thin ribblets in the periumbilical part of the whorl and sporadically occurring, narrow, weak constrictions.

Discussion. – The new species is the oldest known so far macroconch of the genus *Rasenioides.* It shows marked similarities in its shell growth (type of coiling, character of umbilicus) to *Balticeras pommerania* Dohm which may be treated as its phylogenetic forerunner. Also the development of the ornamentation as observed in the inner whorls of *B. pommerania* (see Gygi, 2003, fig. 156), and in the specimens described herein as *B. samsonowiczi* sp. nov., seems to be related to that found in the allied new species *R. glazeki* sp. nov.

The new species differs from stratigraphically younger species of the genus, such as *R. askeptus* (Ziegler) mostly in its larger size, very involute coiling, and steeper umbilical wall, but the number of primary ribs, and the SR/PR ratio in the two species seem similar (*cf.* Ziegler, 1963; Hantzpergue, 1989). More involute coiling somewhat similar to that of *R. glazeki* sp. nov. is observed in the youngest species of the genus *Rasenioides* such as *R. discoides* Hantzpergue and *R. ecolisnus* Hantzpergue (*cf.* Hantzpergue, 1989).

It is highly probable that the microconch *Rasenioides paralepidus* (Schneid) is the dimorphic counterpart of *R. glazeki.*

Family Aspidoceratidae Zittel, 1895

The ammonites of the family are represented by the genera ***Aspidoceras*** **Zittel, 1865**, ***Epaspidoceras*** **Spath, 1931,** and ***Pseudhimalayaites*** **Spath, 1925**. The genus *Aspidoceras* is represented by rare specimens mostly corresponding to the species *Aspidoceras binodum* (Oppel), found in almost the whole interval studied of the Lower Kimmeridgian from the Kuchary Chalky Limestone Mbr, of the Prusicko Fm. (*e.g.*, Wierzbowski, 1978, pl. 10: 4), up to the Majaczewice Mbr. (mostly Brzyków Oncolite Bd.) of the Burzenin Fm. – where they become more common. The specimens of the genus *Epaspidoceras* were found only in the uppermost part of the Częstochowa Sponge Limestone Fm. in the Szczyty Interbiohermal Basin and adjoining areas, in the NW part of the Wieluń Upland, in the uppermost part of the Planula Zone. Here belongs the specimen referred to "*Paraspidoceras*" *mamillanum* (Quenstedt) by Wierzbowski (1978, p. 328), as well as several specimens not studied in detail from the quarry at Lisowice (locality Pj 110 in Matyja and Wierzbowski, 1997). The genus *Pseudhimalayites* as discussed recently by Schweigert (1997) includes the specimens of *Pseudhimalayites uhlandi* (Oppel) for a long time attributed to the genus *Orthaspidoceras.* The specimens studied coming from the uppermost part of the Burzenin Fm. at Burzenin, and collected by Kowalski (1958) are two large phragmocones of about 130 mm and about 170 mm in diameter (Pl. 11: 2a, b). The specimens show strongly developed nodes in the middle part of the whorl height (about 15 per whorl), and strong outer ribs stretching from the nodes and passing across the wide venter.

PLATE 1

Fig. 1. *Taramelliceras* cf. *rigidum* (Wegele); external mould; Prusicko, Skowronów Limestone Mbr., Prusicko Fm., Platynota Zone; specimen MWG UW ZI/84/080; × 2

Fig. 2. *Taramelliceras* cf. *kobyi wegelei* Schairer; Pajęczno, core O-5 (depth 47.3 m), Skowronów Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/081; × 2

Fig. 3. *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke); Rudniki: Lipówka quarry, Częstochowa Sponge Limestone Fm., Planula Zone; MWG UW ZI/84/053

Fig. 4. *Orthosphinctes* (*Lithacosphinctes*) *evolutus* (Quenstedt); inner whorls-phragmocone; a part of the outer whorl preserved – body-chamber; Pajęczno: "Na Targowicy" quarry, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/044

Fig. 5. *Orthosphinctes* (*Lithacosphinctes*) *freybergi* (Geyer); Latosówka quarry, Wolbrom Limestone Mbr., Pilica Fm., Planula Zone; MWG UW ZI/84/052

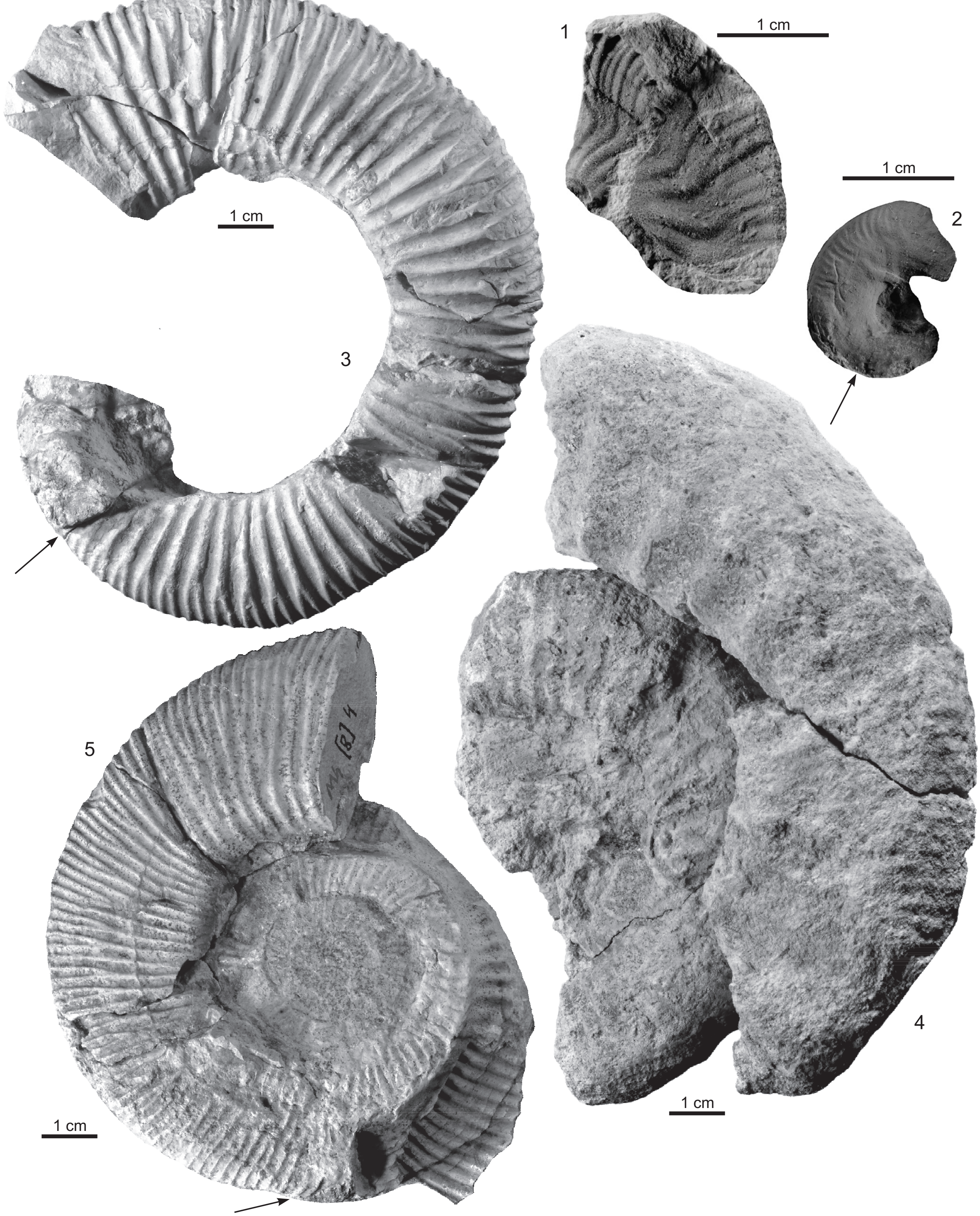


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PLATE 2

Fig. 1. *Orthosphinctes* (*Lithacosphinctes*) *gidoni* Atrops; Kuchary, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/030

Fig. 2. *Subnebrodites planula* (Hehl); Rudniki: Lipówka quarry, Częstochowa Sponge Limestone Fm., Planula Zone; MWG UW ZI/84/061

Fig. 3. *Subnebrodites minutum* (Dieterich); external mould; Rudniki: Lipówka quarry, Wolbrom Limestone Mbr., Pilica Fm., Planula Zone; MWG UW ZI/84/064

Fig. 4. *Subnebrodites minutum* (Dieterich); a half of the outer whorl preserved is the body-chamber; Szczerców brown-coal field, core 120G-1P (depth 266.5 m), Wolbrom Limestone Mbr., Pilica Fm., Planula Zone; MWG UW ZI/84/017

Fig. 5. *Ataxioceras* (*Ataxioceras*) *eudiscinum* Schneid; phragmocone; Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone-basal part; MWG UW ZI/84/098


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PLATE 3

Fig. 1. *Orthosphinctes* (*Lithacosphinctes*) *gidoni* Atrops; inner whorls – phragmocone; a part of the outer whorl preserved – body-chamber; Kuchary, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/019

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PLATE 4

Fig. 1. *Orthosphinctes* (*Ardescia*) *enayi* Atrops; Kuchary, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/016

Fig. 2. *Orthosphinctes* (*Lithacosphinctes*) cf. *pseudoachilles* (Wegele); Pajęczno: "New Urban" quarry, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; MWG UW ZI/84/042

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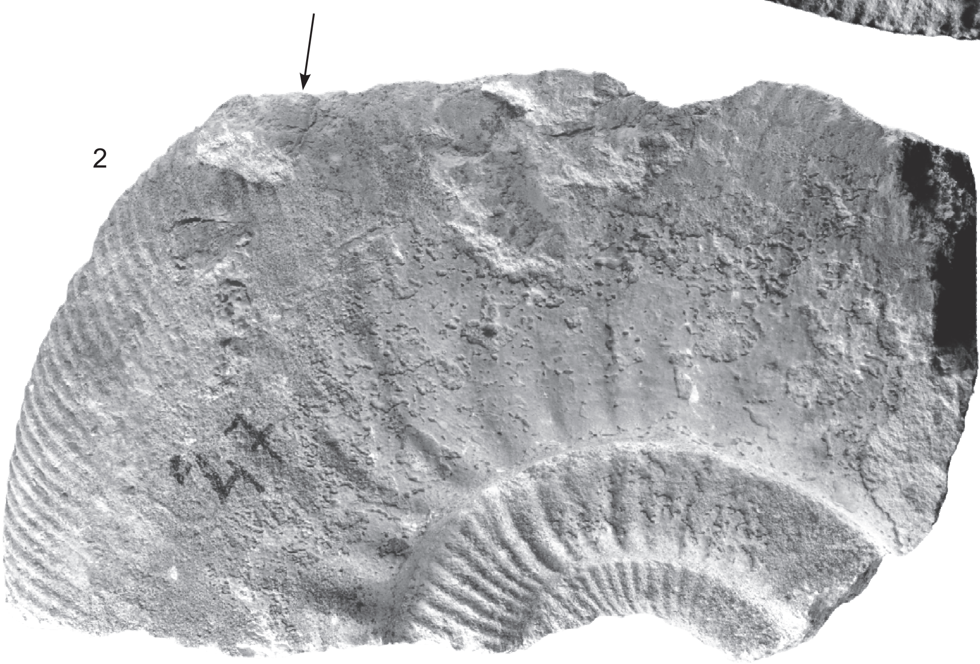

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PLATE 5

Fig. 1. *Subnebrodites* sp.; external mould; Mstów, Latosówka Marl Mbr., Pilica Fm., Planula Zone; MWG UW ZI/84/063

Fig. 2. *Ataxioceras* (*Parataxioceras*) *homalinum* Schneid – *connatum* Schneid; Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone-basal part; MWG UW ZI/84/096

Fig. 3. *Ataxioceras* (*Parataxioceras*) *homalinum* Schneid (*A. hoelderi* Geyer in: Wierzbowski, 1966, pl. 5: 2); Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone-basal part; IGP UW/A/7/7

Fig. 4. *Ataxioceras* (*Parataxioceras*) *lautum* Schneid (= *A. effrenatum* (Font.) in: Wierzbowski, 1966, pl. 5:1); Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone-basal part; IGP UW/A/7/6

Fig. 5. *Ataxioceras* (*Schneidia*) *lussasense* Atrops; external mould; Kule, Kiełczygłów Marl Mbr., Burzenin Fm., Hypselocyclum Zone – basal part; MWG UW/ZI/84/101

Fig. 6. *Ataxioceras* (*Parataxioceras*) *evolutum* Atrops; body-chamber; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MWG UW ZI/83/01

Fig. 7. *Ataxioceras* (*Ataxioceras*) *eudiscinum* Schneid; inner whorls – phragmocone; a part of the outer whorl preserved is the body-chamber; Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone-basal part; MWG UW ZI/84/103

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PLATE 6

Fig. 1. *Ataxioceras* (*Parataxioceras*) *hippolytense* Atrops; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MUZ PIG 1817.II.2

Fig. 2. *Ataxioceras* (*Ataxioceras*) *cardoti* Atrops; Majaczewice, Majaczewice Mbr., Burzenin Fm., Lothari Subzone-basal part, Hypselocyclum Zone; MWG UW ZI/84/001

Fig. 3. *Ataxioceras* (*Ataxioceras*) *hypselocyclum hypselocyclum* (Fontannes) (= *A.* sp. in: Wierzbowski, 1966, pl. 6: 1); Dubidze, core W-6 (depth 66.8-68.1 m), Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; IGPUW A/7/8

Fig. 4. *Ataxioceras* (*Parataxioceras*) *lothari lothari* (Oppel); Szczerców brown coal-field, core PW 408 (depth 149.5 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW ZI/84/115

Fig. 5. *Ataxioceras* (*Schneidia*) *lussasense* Atrops; Szałe near Kalisz, ? Pilica Fm., Hypselocyclum Zone – basal part; MUZ PIG.239.II.92

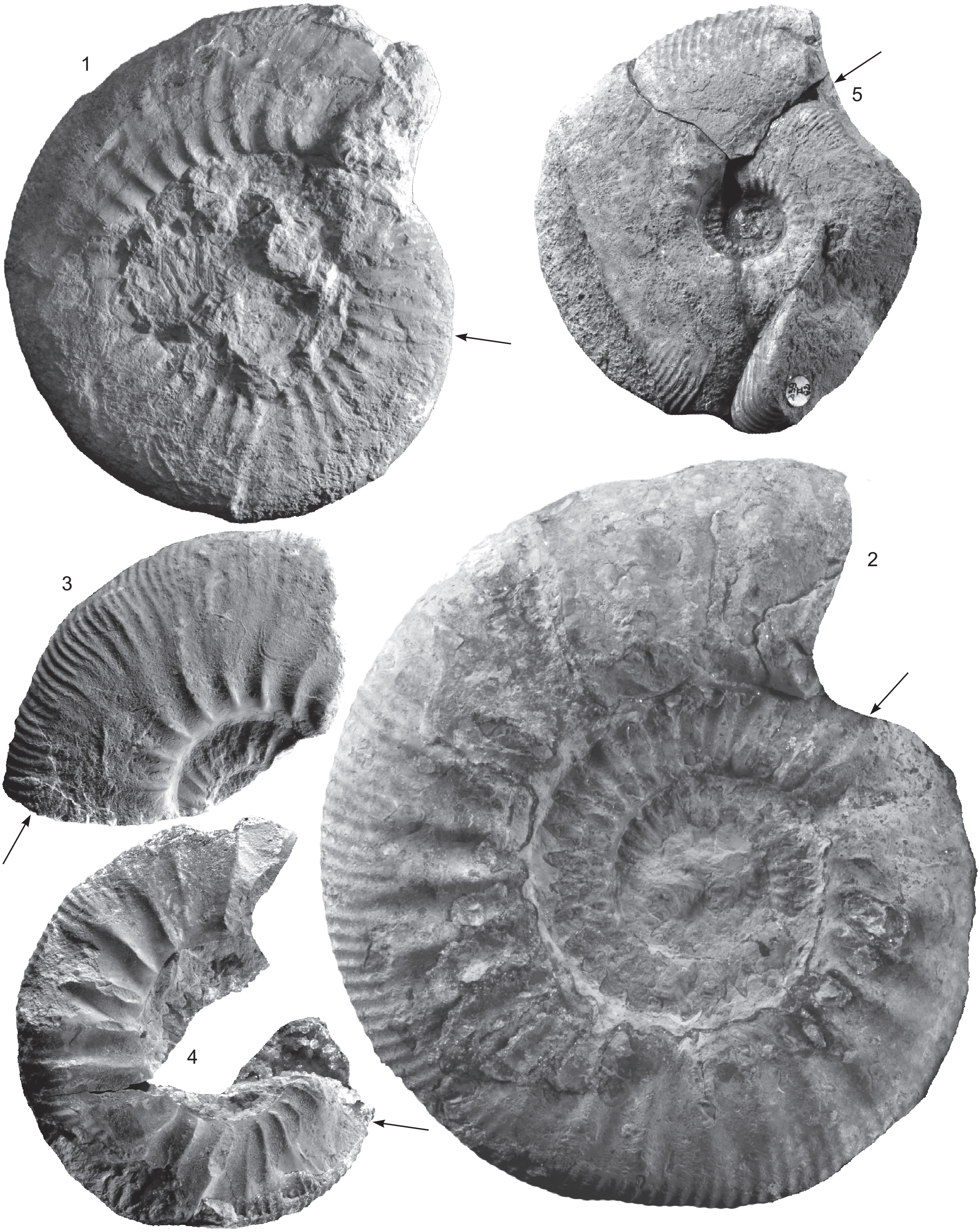
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PLATE 7

Fig. 1. *Ataxioceras* (*Parataxioceras*) *effrenatum* (Fontannes); Bełchatów brown-coal field, core KT 109 (depth 256.5 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW ZI/84/113

Fig. 2. *Ataxioceras* (*Parataxioceras*) cf. *lothari* (Oppel); body-chamber; Kiełczygłów, core J-10 (depth 30.6 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW/ZI/84/109

Fig. 3. *Ataxioceras* (*Parataxioceras*) *lothari lothari* (Oppel); Kiełczygłów, core J-10 (depth 30.6 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW/ZI/84/108

Fig. 4. *Ataxioceras* (*Schneidia*) aff. *lussasense* Atrops; Trojanów near Kalisz, Majaczewice Mbr., Burzenin Fm., Hypselocyclum Zone; MUZ PIG 239.II.68

Fig. 5. *Ataxioceras* (*Ataxioceras*) cf. *hypselocyclum* (Fontannes); body-chamber; Kiełczygłów, core J-10 (depth 32 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW/ZI/84/111

Fig. 6. *Ataxioceras* (*Ataxioceras*) *hypselocyclum semistriatum* Schneid; phragmocone; kol. Brzyków at Burzenin (locality 51), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MUZ PIG 1817.II.1

Fig. 7. *Orthosphinctes* (*Ardescia*) cf. *perayensis* Atrops; Burzenin area, unknown locality (? 48 or 51), Majaczewice Mbr., Burzenin Fm., Lothari Subzone – uppermost part, Hypselocyclum Zone; MWG UW ZI/83/12

Fig. 8. *Crussoliceras* cf. *divisum* (Quenstedt); Burzenin area, Majaczewice (locality 48), Majaczewice Mbr. or Sarnów Gastropod Limestone Mbr., Burzenin Fm., Crussoliensis Subzone, Divisum Zone; MWG UW ZI/83/13


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PLATE 8

Fig. 1. *Ataxioceras* (*Ataxioceras*) *suberinum* (von Ammon); Trojanów near Kalisz, Majaczewice Mbr., Burzenin Fm., Hypselocyclum Zone; MUZ PIG 239.II.67

Fig. 2. *Ataxioceras* (*Parataxioceras*) *planulatum* (Quenstedt); Szczerców brown coal-field, core 37/13.5 (depth 81 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW ZI/84/121

Fig. 3. *Garnierisphinctes championneti* (Fontannes); phragmocone; Burzenin area, kol. Brzyków (locality 51), Majaczewice Mbr. or Sarnów Gastropod Limestone Mbr., Burzenin Fm., Crussoliensis Subzone, Divisum Zone; MUZ PIG 1817.II.4

Fig. 4. *Garnierisphinctes* cf. *semigarnieri* (Geyer); body-chamber; Burzenin area, Majaczewice (locality 48), Majaczewice Mbr. or Sarnów Gastropod Limestone Mbr., Burzenin Fm., Crussoliensis Subzone, Divisum Zone; MWG UW ZI/83/15

Fig. 5. *Involuticeras involutum* (Quenstedt) or *I. limbatum* (Schneid); body-chamber; Kiełczygłów, core J-10 (depth 32 m), Majaczewice Mbr., Burzenin Fm., Lothari Subzone, Hypselocyclum Zone; MWG UW ZI/84/112

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PLATE 9

Fig. 1. *Pictonia* (*Pictonites*) *constricta* Schneid: a – middle and outer whorls: middle whorls – phragmocone, outer whorl – body-chamber, b – inner whorls of the same specimen; Kule, Kule Chalky Limestone Mbr., Prusicko Fm., Hypselocyclum Zone – basal part; MWG UW ZI/84/099

Fig. 2. *Pictonia* (*Pictonites*) sp.; phragmocone; Ważne Młyny, core 2B (depth 35–40 m), Latosówka Marl Mbr., Pilica Fm., Planula Zone; MWG UW ZI/84/092

Fig. 3. *Pictonia* (*Pictonites*) cf. *perisphinctoides* (Wegele); phragmocone; Rudniki: Lipówka quarry, Częstochowa Sponge Limestone Fm., Planula Zone; MWG UW ZI/84/082

Fig. 4. *Prorasenia* cf. *hardyi* Spath; Kuchary, Kuchary Chalky Limestone Fm., Prusicko Fm., Platynota Zone; MWG UW ZI/84/050

Fig. 5. *Vielunia* cf. *limosa* (Quenstedt); phragmocone; Niwiska Dolne, Częstochowa Sponge Limestone Fm., Planula Zone; MWG UW ZI/84/094

Fig. 6. *Eurasenia vernacula* (Schneid); phragmocone; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MWG UW ZI/83/04

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PLATE 10

Fig. 1. *Vielunia gothiciformis* (Schneid) (= *R.* (*Eurasenia*) cf. *vernacula* Schneid in: Wierzbowski, 1964, pl. 1: 2); Kuchary, Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; IGPUW/A/6/5

Fig. 2. *Vielunia gothiciformis* (Schneid) (= *R.* (*Eurasenia*) sp. in: Wierzbowski, 1978, pl. 3: 5); Pajęczno: „New Urban" quarry; Kuchary Chalky Limestone Mbr., Prusicko Fm., Platynota Zone; IGPUW/A/10/336

Fig. 3. *Eurasenia trimera* (Oppel); phragmocone; Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MUZ PIG 1817.II.3

Fig. 4. *Prorasenia* cf. *quenstedti* Schindewolf; Szczerców coal-mine outcrop, unit D, "oolitic" fm., Hypselocyclum Zone; MWG UW ZI/84/008

Fig. 5. *Involuticeras limbatum* (Schneid); phragmocone; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MUZ PIG 1817.II.5

Fig. 6. *Involuticeras* cf. *crassicostatum* (Geyer); outer mould; Majaczewice, Majaczewice Mbr., Burzenin Fm., Lothari Subzone - basal part, Hypselocyclum Zone; MWG UW ZI/84/004

Fig. 7. *Vineta* cf. *striatula* (Schneid); ? phragmocone; Rudniki quarry, Częstochowa Sponge Limestone Fm., Planula Zone; MWG UW ZI/84/085

Fig. 8. *Vineta* sp. (m); external mould; Rudniki: Lipówka quarry, Wolbrom Limestone Mbr., Pilica Fm., MWG UW ZI/84/084

Fig. 9. *Balticeras samsonowiczi* sp. nov., paratype; phragmocone; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MWG UW ZI/83/09

Fig. 10. *Rasenioides paralepidulus* (Schneid); Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MWG UW ZI/83/05


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PLATE 11

Fig. 1. *Balticeras samsonowiczi* sp. nov., holotype, a, b – lateral views, and c – ventral view; Brzyków, Brzyków Oncolite Bd., Burzenin Fm., Hippolytense Subzone, Hypselocyclum Zone; MWG UW ZI/83/08

Fig. 2. *Pseudhimalayites uhlandi* (Oppel); phragmocone; lateral and ventral view, Burzenin (locality 47), Sarnów Gastropod Limestone Mbr., Burzenin Fm., Uhlandi Subzone, Divisum Zone; MWG UW ZI/83/17

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PLATE 12

Fig. 1. *Rasenioides glazeki* sp. nov., holotype; Majaczewice, Majaczewice Mbr., Burzenin Fm., Lothari Subzone – basal part, Hypselocyclum Zone; MWG UW ZI/84/010

All specimens in natural size if not indicated otherwise. The phragmocone/body chamber boundary is arrowed

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Appendix II

DESCRIPTION OF THE NEWLY ESTABLISHED FORMAL LITHOSTRATIGRAPHICAL UNITS

PRUSICKO FORMATION

Name. – After Prusicko village on the Warta river in the northern part of the Polish Jura Polish name: *formacja z Prusicka*).

Type area. – North-eastern part of the Wieluń Upland and its borders, the area between Zapole, Prusicko, Zakrzówek Szlachecki and Brzeźnica where the deposits of the formation have been studied in outcrops and cores (Figs 4, 8A; Wierzbowski, 1966, figs 4, 5).

Reference sections. – Sections at Kule village, north of Kiełczygłów (Wierzbowski *et al.*, 1983, fig. 2; see also Fig. 8C herein; sections between Latosówka hamlet – Kuchary village, at Mokrzesz village, and at Skowronów-Piasek villages, east of Częstochowa (Wierzbowski, 1964).

Subdivision. – The Formation is subdivided into five members (Figs 4, 13): the Kuchary Chalky Limestone Member, the Mstów Limestone Member, the Skowronów Limestone Member, the Góry Marl Member, and the Kule Chalky Limestone Member.

Thickness. – Up to about 150–220 m.

Lithology. – Bedded chalky limestones with cherts, rich in benthic fauna (sponges – both calcareous and siliceous, sometimes hermatypic corals, brachiopods) forming flat biostromal bodies, as well as well as thick units of bedded micritic limestones (mudstones) with a very poor fauna, marly limestones and marls.

Boundaries. – Lower boundary marked by appearance of chalky limestones (Kuchary Chalky Limestone Member) or the bedded micritic limestones (mudstones) of the Mstów Limestone Member; upper boundary at the top of the chalky limestones of the Kule Chalky Limestone Member.

Geological age. – Lower Kimmeridgian (Platynota Zone to lowermost Hypselocyclum Zone).

Distribution. – The formation is fully developed in the northern part of the Polish Jura (Wieluń Upland) and adjoining areas, but its lowermost part occurs fairly far towards the south (at least down to the Skowronów Interbiohermal Basin in the Częstochowa Upland; see Figs 2, 3).

Equivalents. – Several informal rock units which have been distinguished in the past are included into the Prusicko Formation; they represent a set of synonyms corresponding to particular members of the Formation: lower marly unit (Polish name: *dolny zespół marglisty*) – *pars* (Wierzbowski, 1966 – localities 50–52, only); middle platy limestones (Polish name: *środkowe wapienie płytowe*) – *pars* (Wierzbowsk*i*, 1966, 1978; Kutek *et al.*, 1977; Głazek *et al.*, 1980; Wierzbowski *et al.*, 1983); middle chalky limestones (Polish name: *środkowe wapienie kredowate* – Wierzbowski, 1966); Kuchary chalky limestones (Polish name: *wapienie kredowate z Kuchar* – Kutek *et al.*, 1977); Prusicko chalky limestones (Polish name: *wapienie kredowate z Prusicka* – Kutek *et al.*, 1977; Wierzbowski, 1978; Głazek *et al.*, 1980); Pajęczno chalky limestones (Polish name: *wapienie kredowate z Pajęczna* – Kutek *et al.*,1977; Wierzbowski, 1978; Głazek *et al.*, 1980; Wierzbowski *et al.*, 1983); middle marly unit (Polish name: *środkowy zespół marglisty* – Wierzbowski, 1966: Kutek *et al.*, 1977; Głazek *et al.*, 1980; Wierzbowski *et al.*, 1983); upper chalky limestones (Polish name: *górne wapienie kredowate* – Wierzbowski, 1966); Kule chalky limestones (Polish name: *wapienie kredowate z Kul* – Kutek *et al.*, 1977; Głazek *et al.*, 1980; Wierzbowski *et al.*, 1983).

Kuchary Chalky Limestone Member

Name. – After Kuchary village near Mstów on the Warta River, east of Częstochowa where the chalky limestones of the member were originally described and its stratigraphic position was established (Wierzbowski, 1964) (Polish name: *ogniwo wapieni kredowatych z Kuchar*).

Type area. – Between Latosówka hamlet and around Latosówka quarry – where the deposits of the unit are penetrated in cores, and towards the east to Kuchary village (including the no longer existing quarry section at the village).

Reference sections. – The sections between Skowronów and Piasek villages – south-east of Częstochowa (Matyja, Wierzbowski, 1996, fig. 4), and the sections near Prusicko and Pajęczno, in the north (Fig. 4).

Thickness. – Usually about 20–40 m, but may be larger up to 50–60 m; locally (in the central parts of the interbiohermal areas) the unit is absent, being replaced by the deposits of the Mstów Limestone Mbr.

Lithology. – Chalky limestones, usually soft and friable, but sometimes developed in a denser variety, with cherts, and with common benthic fossils (calcareous and siliceous sponges, brachiopods – rynchonellids and terebratulids, serpulids, bryozoans, less commonly hermatypic corals – especially *Microsolena*); *Tubiphytes* structures are abundant.

These are the first deposits rich in benthic fauna which accumulated in the interbioherm areas as they spread over the older poorly fossiliferous micritic limestones and marls of the Pilica Fm. in the northern part of the Polish Jura.

Boundaries. – Lower boundary with the underlying micritic limestones of the Mstów Limestone Member of the Pilica Formation placed at the level of occurrence of limestones rich in benthic fauna usually seen in boreholes (*e.g.*, Wierzbowski, 1966, locality 53 at Ważne Młyny– borehole 8B: at 23.4 m depth), upper boundary – that with overlying marls with poor fauna of the Zapole Marl Bed of the Skowronów Member (see Wierzbowski, 1966: locality 51 at Prusicko on 6.5 m of the section); sometimes, if the marls sedimented on the top of former biohermal complexes (Wierzbowski, 1966, locality 59 in Pajęczno, fig. 3, pl. 2: 1, 2) – at the top of the marly limestone bed rich in benthic fossils (Figs 4, 9).

Geological age. – The ammonites found in lowermost part of the member indicate the Galar Subzone, or its approximate equivalent the "*Idoceras planula – Prorasenia quenstedti* horizon" of Wierzbowski (1978; see also Wierzbowski, 1966). A younger ammonite fauna being best recognized in the Kuchary village section occurs about 25–30 meters above the base of the member and it is indicative of the Platynota Zone at the boundary of its lower and middle parts, indicating stratigraphical condensation (see chapter on stratigraphy; *cf.* also Wierzbowski, 1964; Atrops, Wierzbowski, 1994). Thus, the member corresponds to the lower and the lowermost middle Platynota Zone of the Lower Kimmeridgian.

Distribution. – The Member is known from northern part of the Polish Jura down to the Pilica Interbiohermal Basin in the Częstochowa Upland to the south.

Equivalents. – The Kuchary Chalky Limestone Member strictly corresponds to some informal lithostratigraphic units distinguished in the past: the middle chalky limestones (Polish name: *środkowe wapienie kredowate* – Wierzbowski, 1966, fig. 4, p. 171), the Kuchary chalky limestones (Polish name: *wapienie kredowate z Kuchar* – Kutek *et al.*, 1977, fig. 2); the Prusicko chalky limestones (Polish name: *wapienie kredowate z Prusicka* – Kutek *et al.*, 1977, fig. 2; Wierzbowski, 1978, fig. 2, p. 304, 305; Głazek *et al.*, 1980, figs 31, 32, p. 240); the Pajęczno chalky limestones (Polish name: *wapienie kredowate z Pajęczna* – Kutek *et al.*, 1977, fig. 2; Wierzbowski, 1978, fig. 2, p. 305; Głazek *et al.*, 1980, figs 31, 32, p. 240; Wierzbowski *et al.*, 1983, fig. 2, p. 523). It should be remembered that location of the "Prusicko chalky limestones" below the "Kuchary chalky limestones" (= Kuchary Chalky Limestone Member) in the succession, as interpreted previously (*e.g.*, Kutek *et al.*, 1977, fig. 2; *cf*. Wierzbowski, 1978, fig. 2) was erroneous. The lithostratigraphical unit distinguished as the "*Schichten mit Rhynchonella astieriana*" of Roemer (1870), and the "chalky limestones" (Polish name: *wapienie kredowate*) with *Septaliphoria astieriana* of Różycki (1948, 1953, 1960) partly corresponds to the Kuchary Chalky Limestone Member.

Mstów Limestone Member

Name. – After Mstów town east of Częstochowa, where the deposits of the unit are accessible in natural outcrops at the edge of the Warta river valley (Polish name: *ogniwo wapieni z Mstowa*).

Type section. – At Mstów town.

Reference section. – Boreholes at Pajęczno (borehole J-6: 14.0–21.5 m; Ł-9: 7.8–10.0 m; O-5: 91.5–97.9 m; see Wierzbowski *et al.*, 1983, fig. 3; see also Fig. 4) – in the northern part of the Wieluń Upland; at Rudniki near Częstochowa – in Lipówka quarry (Premik, 1934; Wierzbowski, 1965); Latosówka quarry (Chrzanowska *et al.*, 1960, figs 9, 10); Skowronów village (Matyja, Wierzbowski, 1996, fig. 4).

Thickness. – From a few meters up to 20–30 meters.

Lithology. – Grey-blue (yellow if weathered) thin bedded limestones and marly limestones with marl intercalations with a poor benthic fauna.

Boundaries. – Lower boundary with Latosówka Marl Member of the Pilica Fm. placed at the level where soft marls are replaced by hard limestones; upper boundary placed either at the base of the chalky limestones with abundant benthic fauna (Kuchary Chalky Limestone Member), or in the case where the Kuchary Chalky Limestone Member is missing – at the base of marls corresponding to the Zapole Marl Bed of the Skowronów Limestone Member (Fig. 13).

Geological age. – Lower part of the Platynota Zone in northern part of the Polish Jura.

Distribution. – The member occurs in the interbiohermal basins from the northernmost part of the Polish Jura down to the Pilica Interbiohermal Basin and the Wolbrom Interbiohermal Basin to the south.

Equivalents. – Middle platy limestones (Polish name: *środkowe wapienie płytowe*) – *pars*, *i.e.* corresponding to deposits occurring below the chalky limestones (*cf.* Wierzbowski, 1966; see also Kutek *et al.*, 1977, fig. 2; Wierzbowski, 1978, fig. 2; Głazek *et al.*, 1980, fig. 32; Wierzbowski *et al.*, 1983, fig. 2).

Skowronów Limestone Member

Name. – After Skowronów village, south-east of Częstochowa where the deposits of the member crop out (Polish name: *ogniwo wapieni ze Skowronowa*).

Type section. – At Skowronów village (Figs 2, 3).

Reference sections. – Prusicko village (locality 70 at Prusicko-Góry – borehole 5B: 27.2–50.2 m); Brzeźnica Stara village (locality 71 – borehole BP IV: 91.25–103.20 m) and Dworszowice Kościelne (locality 72 – borehole K 14: 33.6–44.4 m) (Fig. 4; see Wierzbowski, 1966, p. 153–155, fig. 5).

Thickness. – Up to 25–35 meters.

Lithology. – Thin bedded micritic limestones (mudstones) with marly intercalations, with poor benthic fauna; in the lowermost part of the member is an easily recognizable marly unit – Zapole Marl Bed.

Boundaries. – Lower boundary at the base of the Zapole Marl Bed, upper boundary with the Góry Marl Member.

Geological age. – Platynota Zone of the Lower Kimmeridgian (Wierzbowski, 1966).

Distribution. – The member is known from the northern part of the Polish Jura down (at least) to the Skowronów Interbiohermal Basin in the Częstochowa Upland (Figs 2, 3).

Equivalents. – Middle platy limestones (Polish name: *środkowe wapienie płytowe*) – *pars*, *i.e.* corresponding to deposits occurring above the chalky limestones (*cf.* Wierzbowski, 1966; see also Kutek *et al.*, 1977, fig. 2; Wierzbowski, 1978, fig. 2; Głazek *et al.*, 1980, fig. 32; Wierzbowski *et al.*, 1983, fig. 2).

Zapole Marl Bed

Name. – After Zapole village where the deposits of the member were encountered (Polish name: *warstwa margli z Zapola*).

Type section. – Zapole village (see locality 50 in Wierzbowski, 1966).

Reference sections. – At Prusicko village in the north-eastern border of the Wieluń Upland, and at Skowronów village south-east of Częstochowa.

Thickness. – About 5 m at Prusicko and Zapole villages; 3.6 m in core O-5 at Łężce east of Pajęczno (Fig. 4).

Lithology. – Grey-blue to yellow (if weathered) marls and marly limestones with poor benthic fauna.

Boundaries. – Lower boundary with the Kuchary Chalky Limestone Member or if the unit does not occur as happens in central parts of the interbiohermal basins – with the Mstów Limestone Member, upper boundary at the base of overlying micritic limestones of the Skowronów Limestone Member.

Geological age. – Platynota Zone of the Lower Kimmeridgian.

Distribution. – The member is known from the northern part of the Polish Jura down (at least) to the Skowronów Interbiohermal Basin in the Częstochowa Upland.

Equivalents. – The deposits of the Zapole Marl Member were originally (see Wierzbowski 1966, fig. 4, localities 50, 51 and 52 at Zapole and Prusicko villages; *cf.* also Kutek *et al.*, 1977, fig. 2) placed in the lower marly unit (*i.e.* the Latosówka Marl Member of the Pilica Formation as recognized herein). This erroneous stratigraphical correlation resulted not only in the omission of the Zapole Marl Member in the stratigraphical chart as a separate lithostratigraphic unit, but also in misinterpretation of the Prusicko chalky limestones, as a separate lithostratigraphic unit independent of the Kuchary chalky limestones (see Kutek *et al.*, 1977; Wierzbowski, 1978; Głazek *et al.*, 1980).

Góry Marl Member

Name. – After Góry hamlet near Prusicko village where the deposits crop out (Wierzbowski, 1966) (Polish name: *ogniwo margli z Gór*).

Type section. – Prusicko-Góry section (locality 70 – borehole 5B: 20.2–27.2 m; see also locality 69: 0.5–6.5 m, in: Wierzbowski, 1966, p. 153, 154, fig. 5; see also Fig. 4).

Reference sections. – Boreholes between Brzeźnica Stara, Dworszowice Kościelne and Zakrzówek Szlachecki (locality 71 – borehole BP IV: 78.0–91.2 m; locality 72 – borehole 14K: 27.0-33.6 m; locality 73 – borehole 10B: 69.2–86.1 m; locality 74 – borehole 4B: 65.0–74.2 m; locality 75 – borehole 9B: 67.6–68.6 m) (Figs 4, 8A; see Wierzbowski, 1966, fig. 5).

Thickness. – Up to 30 meters.

Lithology. – The member in the area of occurrence is threefold: a lower part about 5–7 m thick consists of grey-blue marls with subordinate intercalations of marly limestones with a poor benthic fauna; a middle part, about 2.5 m in thickness is represented by micritic limestones with an abundant and diversified bivalve (*Pholadomya*, *Pleuromya*, *Gervillia*, *Pteroperna*, *Mytilus*, *Inoperna*, *Pinna*, *Camptonectes*, *Nanogyra*) and brachiopod (terebratulids) fauna, and an upper part, about 17–20 m in thickness, which is composed of blue-grey marls with poor benthic fauna (Wierzbowski, 1966, fig. 5).

Boundaries. – Lower boundary with limestones of the Skowronów Limestone Member, the upper boundary with chalky limestones with an abundant benthic fauna of the Kule Chalky Limestone Member (Figs 4, 13).

Geological age. – Lower Kimmeridgian – upper part of the Platynota Zone.

Distribution. – The member is known only in the northern part of the Polish Jura (north-eastern border of the Wieluń Upland) (Fig. 2).

Equivalents. – Middle marly unit (Polish name: *środkowy zespół marglisty*) – (Wierzbowski, 1966, fig. 5: Kutek *et al.*, 1977, fig. 2; Głazek *et al.*, 1980, figs 31, 32; Wierzbowski *et al.*, 1983, fig. 2).

Kule Chalky Limestone Member

Name. – After Kule village near Kiełczygłów in the northern border of the Wieluń Upland where the deposits of the member crop out (Polish name: *ogniwo wapieni kredowatych z Kul*).

Type section. – At Kule village (Fig. 8C).

Reference sections. – At Zakrzówek Szlachecki and Brzeźnica Nowa and Dubidze where the deposits of the member were cored (locality 73 – borehole 10B: 65.9–69.2 m; locality 74 – borehole 4B: 49–65 m; locality 75 – borehole 9B: 46.5–67.6 m; locality 76 – borehole 2K: 58.0–94.5 m; locality 77 – borehole 1K: 57.5–88.5 m; see Wierzbowski (1966, p. 155, 156; see Figs 4, 8A herein); moreover in the area of Kiełczygłów – at Kule village where the deposits of the member are more than 120 m thick in core J-1, and attain at least 65 m in thickness in core A-4 (Figs 6, 8C; Wierzbowski *et. al.*, 1983, fig. 2).

Thickness. – From several tens of meters (at least about 40 m) up to more than 100 meters (Wierzbowski *et al.*, 1983, p. 524, fig. 2).

Lithology. – The deposits are mostly bedded chalky limestones with an abundant benthic fauna and cherts; locally a more dense variety may occur; oncolites sometimes occur. The fauna usually is represented by siliceous and calcareous sponges, serpulids, brachiopods, bryozoans and bivalves; less commonly by gastropods, crinoids, and hermatypic corals (mostly *Microsolena*) – such deposits are encountered at Zakrzówek Szlachecki; hermatypic corals may occur more commonly (*Microsolena*) in some areas, as at Kule village near Kiełczygłów, but some transitional deposits to the Częstochowa Sponge Limestone Fm. with commonly occurring siliceous sponges and cherts are also known (cores A-10 near Kiełczygłów, and core Ł-1 near Pajęczno; see Figs 4, 6).

Boundaries. – Lower boundary with marls of the Góry Marl Member; upper boundary at the appearance of the micritic limestones and/or marls of deposits overlying the Prusicko Formation which were distinguished by Wierzbowski (1966) as the upper platy limestones (Polish name: *górne wapienie płytowe*) and the upper marly unit (Polish name: *górny zespół marglisty*) (see also Wierzbowski *et al.*, 1983, fig. 2), and correspond to the lowermost part of the Kiełczygłów Member of the Burzenin Formation (Figs 5, 6, 9).

Geological age. – Uppermost part of the Platynota Zone – to lowermost part of the Hypselocyclum Zone of the Lower Kimmeridgian (Wierzbowski, 1966).

Distribution. – The member is known only at the eastern and northern borders of the Wieluń Upland: from the Brzeźnica area in the south up to the Kiełczygłów area to the north.

Equivalents. – Upper chalky limestones (Polish name: *górne wapienie kredowate* – Wierzbowski, 1966, fig. 5); Kule chalky limestones (Polish name: *wapienie kredowate z Kul* – Kutek *et al.*, 1977, fig. 2; Głazek *et al.*, 1980, fig. 32; Wierzbowski *et al.*, 1983, fig. 2). The member is the lateral and age equivalent of the unit A (chalky limestones with corals) of the "oolitic" fm. in the northern border of the Wieluń Upland (Figs 5, 13).

BURZENIN FORMATION

Name. – After Burzenin town on the Warta river in the south-western border of the Łódź Synclinorium, north of the Wieluń Upland (Polish name: *formacja z Burzenina*).

Type area. – Vicinity of Burzenin, between Burzenin, Majaczewice, Wielka Wieś and Brzyków, sections at Burzenin, Majaczewice and Brzyków (Kowalski, 1958, localities 47–52) and cores (Wierzbowski *et al.*, 1983) (Figs 7, 8D); the formation is recognized also in the boreholes in the adjoining areas north-east and north of the Wieluń Upland – in the vicinity of Dubidze, the Bełchatów and Szczerców brown-coal fields, and to the west in the vicinity of Kiełczygłów (Figs 4–6); it is known also in the south-western border of the Łódź Synclinorium at Kalisz north-west of Burzenin.

Reference sections. – In boreholes in the Kiełczygłów area (Figs 6, 8C; Wierzbowski *et al.*, 1983, fig. 2) and the Bełchatów and Szczerców brown-coal fields (Figs 5, 8B); sections in cores from the north-eastern borders of the Wieluń Upland (Wierzbowski, 1966, localities 78–80 at Dubidze and Błota Kruplinskie; see also Figs 4, 8A, herein).

Subdivision. – The formation is subdivided into three members; these are formally distinguished herein as the Kiełczygłów Marl Member, the Majaczewice Member, and the Sarnów Gastropod Limestone Member (Fig. 13). The smaller-rank informal units distinguished herein in the Szczerców brown-coal field at the northern borders of the Wieluń Upland include units G and H corresponding to the upper part of the Majaczewice Member, and unit I corresponding to the Sarnów Gastropod Limestone Member (Fig. 5).

Thickness. – About 90–100 meters in the type area at Burzenin where the formation is fully developed (Fig. 7); more than 30–50 m (the upper parts were not enountered in the cores) in the area of Kiełczygłów (Fig. 6), and about 110 m in the adjoining brown-coal field of Szczerców (core PD 20B; Fig. 7), and markedly less in the north-eastern borders of the Wieluń Upland (Fig. 4, when some upper parts may be missing due to pre-Albian erosion) – in all these latter areas the deposits attributed to the Burzenin Fm. are the age equivalent of the upper part of the formation in its type area.

Lithology. – Micritic limestones and marly limestones locally with common infaunal and semiinfaunal bivalves, locally oncolitic limestones, and marls forming thicker unit at the base and at the top of the formation.

Boundaries. – The lower boundary is marked by the appearance of a thick marly unit (Kiełczygłów Marl Member) which directly overlies either the chalky limestones (Kule Chalky Limestone Member of the Prusicko Fm., north of Kiełczygłów in the northern border of the Wieluń Upland; Fig. 6), or the Częstochowa Sponge Limestone Formation and the Pilica Formation in the Burzenin area (Fig. 7); in the brown-coal fields of Bełchatów and Szczerców, and near Kiełczygłów, in the northern border of the Wieluń Upland, the lower boundary of the Burzenin Fm., due to lateral facies changes, is placed stratigraphically higher, at the base of unit G correlated with the Majaczewice Mbr., represented by marly limestones with infaunal bivalves and common ammonites (directly above the F – oncolite unit of the "oolitic" fm.; Fig. 5). The upper boundary of the Burzenin Fm. is placed everywhere within the marly limestones at the base of the first intercalation of oyster (*Nanogyra*) coquina (corresponding to the base of the"coquina" fm.) in the Burzenin area and in the cores in the Szczerców brown-coal field (Figs 5, 7).

Geological age. – Lower Kimmeridgian (Hypselocyclum and Divisum zones).

Distribution. – The formation occurs at the north-eastern and northern borders of the Polish Jura (Wieluń Upland); it is fully developed in the area of Burzenin and further north (*e.g.*, environs of Kalisz).

Equivalents. – The deposits of the newly distinguished formation partly correspond to the "limestone-marly-lumachelle" formation (formation no. V of Dembowska, 1979). The deposits of "limestone-marly-lumachelle" character were described as the succession of marls and marly limestones with intercalations of coquina beds built mainly of shell-hash of oysters especially of the genus *Nanogyra* in the western border of the Holy Cross Mts and some adjoining parts of the Łódź and Miechów synclinoriums. The deposits were placed in the "coquina" formation (*e.g.*, Kutek, Zeiss, 1997), but also recognized as the "Stobnica beds" (Kutek, 1962b), and the Stobnica Coquina Formation (Matyja, Wierzbowski, 2014). The deposits attributed to the Burzenin Fm., differ from the typical deposits of the "coquina" formation, in being represented by limestones and marls with an abundant bivalve fauna at some intervals – but mostly of an infaunal and semiinfaunal character, whereas the oysters are not very common. The Burzenin Formation corresponds thus to a lower part of the "limestone-marly-lumachelle" formation (formation no. V of Dembowska, 1979), directly below the oyster "coquina" formation as interpreted herein. The marly-limestone unit without intercalations of the coquina beds recognized between depth of 313.5 to 174.5 m in the borehole Kcynia IG IV in the Kujawy area in northern Poland, both lithologically and stratigraphically, corresponds precisely to the Burzenin Fm. (*cf.* Matyja, Wierzbowski, 1998).

Kiełczygłów Marl Member

Name. – After Kiełczygłów town in the northern border of the Wieluń Upland where the deposits of the member were originally encountered (Polish name: *ogniwo margli z Kiełczygłowa*).

Type area. – Vicinity of Kiełczygłów (Figs 6, 8C).

Reference sections. – Outcrops at Kule near Kiełczygłów showing in the past marly limestones of the lowermost part of the member directly overlying the chalky limestones of the Prusicko Fm. (Wierzbowski, 1966, locality 83); brown-coal field (outcrop and cores) of Szczerców where the member (Figs 5, 9) is attributed herein to the "oolitic" formation, and distinguished as unit B.

Thickness. – From about 15 meters up to about 38.5 meters in the cores in the Kiełczygłów area (Fig. 6; Wierzbowski *et al*., 1983), and about 24 to 34 m in the cores in the area of Burzenin (Fig. 7); up to about 30 meters in the brown-coal mine outcrop and cores of the Szczerców brown-coal field (Fig. 5).

Lithology. – Dark grey marls and marly limestones with poor benthic fauna.

Boundaries. – Lower boundary of the member marked by the appearance of homogenous dark marls and marly limestones, and is placed either at the top of the chalky limestones of the Kule Chalky Limestone Member (Prusicko Fm.) in the northern border of the Wieluń Upland, or at the top of the micritic limestones of the Pilica Formation with bivalves in the Burzenin area (Fig. 13). Upper boundary placed at the base of the micritic limestones with bivalves in northern border of the Wieluń Upland at Kiełczygłów, or at the base of the oncolitic limestones of the Brzyków Oncolite Bed representing the lowermost part of the Majaczewice Member in the Burzenin area. When the member is distinguished within the "oolitic" formation (Fig. 5), it occurs above the chalky limestones with corals and oolites (unit A), and below the oolitic limestones sometimes replaced by the micritic limestones at the base (unit C) (Figs 9, 13).

Geological age. – Lower Kimmeridgian (Hypselocyclum Zone).

Distribution. – The member occurs in north-eastern and northern borders of the Wieluń Upland, and in the area of Burzenin.

Equivalents. – Upper marly member (Polish name: *górny zespół marglisty* – pars: Głazek *et al.*, 1980, fig. 32; Wierzbowski *et al*., 1983, fig. 2), but not of Wierzbowski (1966, fig. 5) and Kutek *et al.* (1977, fig. 2), showing the marly deposits of the younger part of the Burzenin Fm.; the lower part of the unit *wmm/m* (micritic limestones, marls and lumachelles) in fig. 2 of Wierzbowski *et al*. (1983).

Majaczewice Member

Name. – After Majaczewice village at the Warta river, south-west of Burzenin (Polish name: *ogniwo z Majaczewic*).

Type area. – The whole Burzenin area between Burzenin, Majaczewice, Wielka Wieś and Brzyków where the deposits crop out (Figs 7, 8D): section at Majaczewice in the quarry (Fig. 10), as well as several sections seen in the past in the quarries of the area (localities 48–52 of Kowalski, 1958).

Reference sections. – Sections in the cores at Kiełczygłów (Figs 6, 8C), and the Szczerców brown-coal field (Figs 5, 8B).

Thickness. – About 25 meters in the Burzenin area as recognized in the boreholes (Fig. 7; Wierzbowski *et al*., 1983), and about 60 meters in the brown-coal field of Szczerców (core PD 20B).

Lithology. – At the base represented by oncolitic limestones of the Brzyków Oncolite Bed in the Burzenin area, but the bulk of the unit is represented by micritic limestones locally with a common bivalve fauna (mostly of infaunal and semiinfaunal character), and by marly limestones and marls; at some levels ammonites are common.

Boundaries. – Lower boundary at the top of the marly deposits of the Kiełczygłów Marl Member, either directly below the Brzyków Oncolite Bed in the Burzenin area (Fig. 7), or at the top of unit F (oncolitic limestones) of the "oolitic" fm. in the Szczerców brown-coal field (Fig. 5); upper boundary with the Sarnów Gastropod Limestone Mbr., placed at the level where the first intercalations of limestones and marls with small gastropods are encountered (Figs 5, 7).

Geological age. – Lower Kimmeridgian (Hypselocyclum and Divisum zones).

Distribution. – The member occurs in the area of Burzenin, but it continues north-westward in the zone of outcrops at least to the Kalisz area (*cf.* Premik, 1926, 1931; Czermiński, 1953). The deposits corresponding to the upper part of the member from the type area are recognized also in the northern border of the Wieluń Upland, where they are informally subdivided into units G and H (Fig. 5), and locally possibly in the north-eastern border (Fig 4).

Equivalents. – The middle part of the unit *wmm/m* (micritic limestones, marls and lumachelles) in fig. 2 of Wierzbowski *et al.* (1983). The following stratigraphical units of Kowalski (1958, table 1) corresponds to the member: "conglomeratic beds", "supra-conglomeratic beds", as well as biostratigraphically defined "lower and upper parts of the *G. dentatum* zone", all of them directly below the "lumachelle-limestones with *Exogyra virgula*".

Brzyków Oncolite Bed

Name. – After Brzyków village, south-east of Burzenin (Polish name: *warstwa onkolitu z Brzykowa*).

Type area. – Brzyków village, and the area between Brzyków and Wielka Wieś where it was penetrated by the boreholes (Wierzbowski *et al*., 1983).

Reference section. – The old co-operative quarry at Brzyków (locality 52 of Kowalski, 1958), and the edge of the Warta river valley at Majaczewice (locality 49 of Kowalski, 1958).

Thickness. – About 3 m (at least) in the quarry (Kowalski, 1958, p. 17), but the full thickness of the unit as seen in the boreholes oscillated between 2.2 m and 3.6 m.

Lithology. – Alternation of limestones and marly limestones with very common oncolites (up to about 2 cm diameter) and containing oysters *Nanogyra*: there commonly occur gastropods Nerineidae, brachiopods and bivalves; at the top is a hard limestone with bivalves and ammonites (Kowalski, 1958, p. 17).

Boundaries. – Lower and upper boundaries marked by marly limestones and marls corresponding to the Kiełczygłów Marl Member (below), and the Majaczewice Member (above).

Geological age. – Lower Kimmeridgian, the upper part of the Hippolytense Subzone of the Hypselocyclum Zone.

Distribution. – The bed is recognized in the Burzenin area.

Equivalents. – The bed was described in the past as the "conglomeratic bed" (Premik, 1931; Kowalski, 1958).

Sarnów Gastropod Limestone Member

Name. – After Sarnów village at Widawka representing the only place where the deposits of the unit are still visible in the rubble of an old quarry (Fig. 1). (Polish name: *ogniwo wapieni ślimakowych z Sarnowa*).

Type area. – The south-western limb of the Łódź Synclinorium between Burzenin town and Sarnów and Korablew villages where the deposits cropped out in the past (Michalski, 1885; Premik, 1931) and/or were penetrated by boreholes (Figs 1, 7, 8D).

Reference sections. – Section in core PD 20B in the Szczerców brown-coal field at the northern border of the Wieluń Upland (Figs 5, 8B).

Thickness. – Recognized only in the boreholes – about 50 meters in the Burzenin area and the Szczerców brown-coal field area (Figs 5, 7).

Lithology. – The member is represented by marls and marly limestones with bivalves (*Astarte*, *Pholadomya*, *Thracia*, "*Pecten*", "*Ostrea*", and others), and commonly occurring tiny gastropod concentrations (*Cerithium*, *Itieria*, *Chemnitzia*, and others) – according to Premik (1931). Erosional boundaries between the beds of micritic limestone and gastropod limestone are often recognized; small clasts of micritic limestone occur commonly in the gastropod limestones in the Sarnów and Korablew area. At the top of the member, limestones with common bivalves and bioclasts are seen in core PD 20B, in the Szczerców brown-coal field.

Boundaries. – The base of the member is placed at the top of the Majaczewice Mbr. at the level of the first mass occurrence of small gastropod concentrations. The lowest limestone beds with a rich fauna of small gastropods were reported by Kowalski (1958) in his localities 48 and 51 in the Burzenin area, directly above the typical deposits of the Majaczewice Mbr. The top of the member in the Burzenin area is placed at the base of the "coquina" fm., at the lowest marly interval with common oyster (*Nanogyra*) intercalations [it is placed directly below the succession described from localities 45–46 of Kowalski (1958, p. 12–14)].

Geological age. – Lower Kimmeridgian, lower part of Divisum Zone.

Distribution. – The Sarnów Gastropod Limestone Member is known from the northern border of the Wieluń Upland to the Burzenin area.

"OOLITE" FORMATION

The deposits attributed to this formation occurs mostly in boreholes, in the northern parts of the Wieluń Upland: in the brown-coal field of Szczerców (Figs 5, 8B), at Kiełczygłów (Figs 6, 8C), as well as locally in the north-eastern border of the Wieluń Upland (Figs 4, 8A). The deposits attain more than 200 meters in thickness (brown-coal field of Szczerców) and about 220 m in the area east of Kiełczygłów. They are represented by: chalky limestones with corals and oolites (unit A), oolitic grainstones with admixture of small-sized oncolites and bioclasts, and locally underlying micritic limestones with marly intercalations sometimes with ooids (unit C), and the overlying oncolitic limestones (unit F), as well as of sandwiched in between them – a marly unit (B – which corresponds to the Kiełczygłów Marl Member of the Burzenin Fm.), and marly limestone units (D and E) (see Figs 5, 13). They are more reduced in thickness, attaining possibly a few tens of meters, and with a reduced stratigraphical range, in the north-eastern border of the Wieluń Upland (Fig. 4). The informal status of this formation results both from the not very precise definition of the "oolitic" formation by Dembowska (1979), but also from the poorly understood relation of the discussed deposits to some other "oolitic bodies" which occur east of the area of study – in the brown-coal field of Bełchatów (Mrozek, 1975) and the neighbouring Chełmo and Smotryszów anticlines (Kutek, 1968).

The "oolitic" formation corresponds to the uppermost part of the Platynota Zone, and the lower part of the Hypselocyclum Zone of the Lower Kimmeridgian in the area of study.

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