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The open shelf — carbonate platform succession at the Oxfordian/Kimmeridgian boundary in the SW margin of the Holy Cross Mts: stratigraphy, facies, and ecological implications

ABSTRACT: The material from the new quarry at Sobków-Wierzbica as well as from the neighboring boreholes, supplied new data on the uppermost Oxfordian — lowermost Kimmeridgian succession in the SW margin of the Holy Cross Mts, Central Poland. These deposits represent a part of the shoaling-upward sequence, starting from basinal micritic limestones with intercalations of grainstones (derived from the prograding carbonate platform) and with episodic benthic assemblages developed in the more distant areas (due to occasional winnowing of the soft carbonate mud), up to the shallow-water grainstones marking the progressing onlap of the carbonate platform. The succession of the faunistic assemblages reveals the successive stages in the progradation of the platform. The moderately rich ammonite fauna is composed mostly of the genera *Idoceras* and *Orthosphinctes*, indicative of the Planula Zone of the uppermost Oxfordian. These new findings throw a new light on the ammonite biogeography and on the ecological aspects of ammonite distribution during the Late Oxfordian of Central Poland.

INTRODUCTION

The Oxfordian — Lower Kimmeridgian succession in the south-western margin of the Holy Cross Mts, Central Poland (*see* Text-fig. 1) has been studied during the last twenty years (KUTEK 1968, MATYJA 1977, and references therein). This succession consists of some 1100 m of limestones, less commonly of marls, all folded in several anticlines and synclines. It is well accessible in numerous outcrops including a few big quarries, such as Wolica, Siedlce, and Sobków (*see* Text-fig. 2). The uppermost Oxfordian — lowest Kimmeridgian part of the succession remained till recently poorly known because of its lithology (soft rocks) which does not offer any natural exposures. Hence, the newly founded quarry at Sobków-Wierzbica in the southern limb of the Sobków anticline, close to the Wierzbica village, about two kilometers eastward from the old Sobków quarry (Text-fig. 2) revealed, for the first time, the full sequence of these deposits. It represents about one hundred meters of white, soft, thick-bedded micritic limestones overlain by a few meters of grainstones. The field studies on the section in 1988 yielded the material analyzed in this paper. Some additional data on the same part of the sequence and showing its lateral variability, has been obtained from the unpublished report on the boreholes drilled between Sobków-Wierzbica quarries (Czarakcziewa 1985).

The Oxfordian – Lower Kimmeridgian succession in the Holy Cross Mts represents a major, upward-shoaling carbonate sequence, and the studied section displays just the transition from the basinal to the carbonate platform facies. The present study, therefore, gives a comprehensive account on the regional stratigraphy and environment. Moreover, as the studied section has also yielded, for the first time in the Holy Cross Mts, numerous ammonites of the uppermost Oxfordian, a presentation becomes possible of wider problems of the ammonite distribution pattern in Late Oxfordian of Central Poland.

STRATIGRAPHY

The Upper Oxfordian deposits of the south-western margin of the Holy Cross Mts are divided into the following lithostratigraphic units: the Morawica Limestone Member, the Massive Limestone Member, and the Siedlce Limestone Member (Matyja 1977).

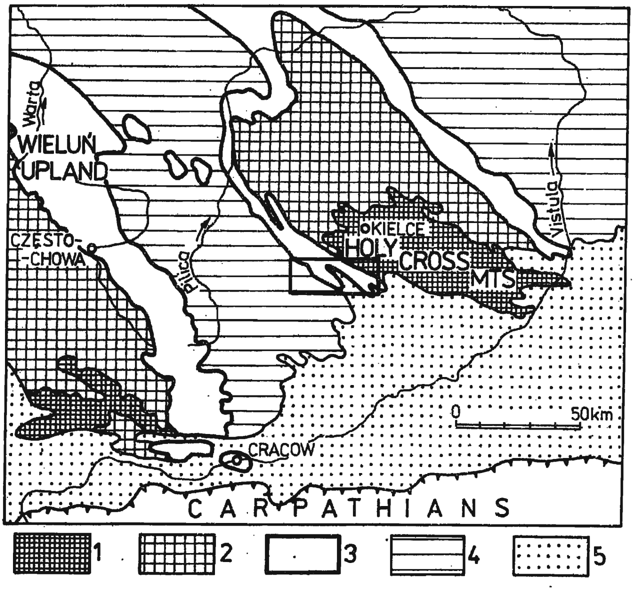

Fig. 1. Geological map of the Central Polish Uplands (*after* Znosko 1968); indicated is the area presented in Text-fig. 2

1 Paleozoic, *2* Mesozoic (older than Upper Jurassic), *3* Upper Jurassic, *4* Cretaceous, *5* Fore-Carpathian Depression (marine Middle Miocene)

The Morawica Limestone Member consists of a monotonous sequence of thick- to medium-bedded limestones abounding in siliceous sponge mummies, putroids and siliceous concretions. This Member is 137 m thick (Text-fig. 3), but only its uppermost, 30 m thick, part belongs to the Upper Oxfordian, as evidenced *i.e.* by the occurrence of *Taramelliceras externnodosum* (Dorn) and *Microbiplices microbiplex* (Quenstedt). It is the oldest Late Oxfordian fauna in the Holy Cross Mts which may be correlated with the Hypselum Subzone of the Bimammatum Zone (Matyja 1977).

The Massive Limestone Member occurs generally above the Morawica Limestone Member, but locally it interfingers with the uppermost part of the latter, as well as with the lower part of the Siedlce Limestone Member. The Massive Limestone Member is represented by huge, up to 250 m thick and several kilometers long, rock bodies related to cyanobacteria-sponge bioherm complexes. No ammonites have yet been found in the Member, but its clear spatial relation to the biostratigraphically well-defined Morawica Limestone and Siedlce Limestone members allows to determine its age between the lower part of the Bimammatum Zone (or possibly uppermost part of Bifurcatus Zone) and the lower part of the Planula Zone (Matyja 1977).

The Siedlce Limestone Member appears above the Morawica Limestone Member in areas where the Massive Limestone Member is missing. It is the case of the studied area between Wolica and Sobków villages (Text-fig. 2), which is situated just in the middle of the interbioherm zone (Matyja 1977).

In the interbioherm zone the Siedlce Limestone Member attains its maximum thickness about 535 meters. The Member is formed by thick-bedded micritic limestones (mudstones). In its lower part, siliceous sponges may still occur like in the underlying Morawica Limestone Member. Not so common are also other groups of fossils, especially the ammonites and brachiopods.

The more typical variety of the Siedlce Limestones, forming the great bulk of the Member, is composed of micritic limestones with extremely rare faunal elements like trace fossils, small-sized ammonites and bivalves. In the uppermost part of the Member in the Sobków-Wierzbica quarry there occur a few horizons very rich in fossils whereas the bulk of the rock is faunistically almost barren (Text-figs 4—5). The same part of the Member, recognized in the boreholes between the

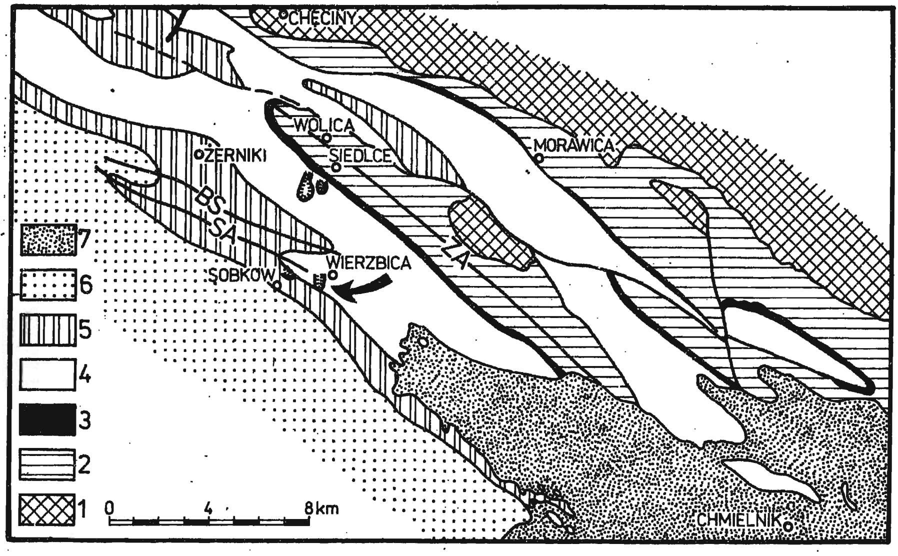

Fig. 2. Geological sketchmap of the Siedlce — Sobków area

1 Paleozoic, *2* Triassic, *3* Middle Jurassic, *4* Oxfordian, *5* Kimmeridgian, *6* Cretaceous, *7* marine Middle Miocene

Indicated are axes of: **ZA** — Zbrza anticline, **BS** — Bizorenda syncline, **SA** — Sobków anticline

Arrowed is the new exposure at the Sobków-Wierzbica quarry

Wierzbica village and the Sobków quarry, contains thin layers and thick lenses of oolitic-onkolitic-bioclastic grainstones with abundant fauna, occurring within a monotonous sequence of micritic limestones (CZARAKCZIEWA 1985).

In the lower part of the Siedlce Limestone Member there appears ammonite fauna with several Haploceratacеae, including *Taramelliceras costatum* (QUENSTEDT), the range of which extends almost through the whole interval in question, in its upper part overlapping (Text-fig. 4) with that of *Idoceras* (?) aff. *minutum* DIETERICH. The latter form, being a typical forerunner of *Idoceras* (*Subnebrodites*), is known to occur together with some allied forms in the topmost part of the Bimammatum Zone, *i.e.* in the whole Hauffianum Subzone or in its uppermost part (WIERZBOWSKI 1978). It may thus be safely assumed that this ammonite fauna corresponds to the Bimammatum Subzone and the Hauffianum Subzone of the Bimammatum Zone (*cf.* MATYJA 1977).

The newly discovered fauna from the Sobków-Wierzbica quarry (*see* Pls 1–2) occurs in the uppermost part of the Siedlce Limestone Member. It

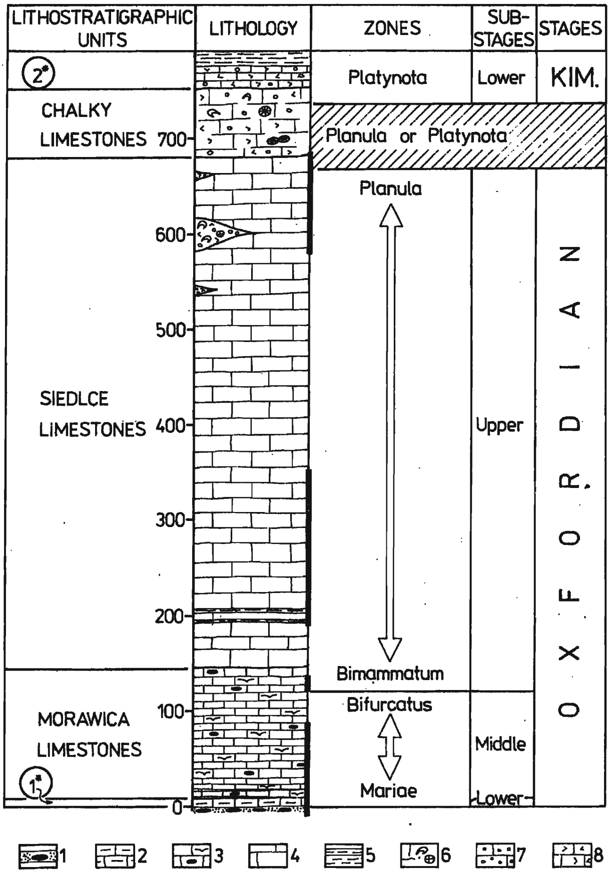

Fig. 3. Stratigraphic section of the Oxfordian in the Siedlce – Sobków-Wierzbica area
Thick lines indicate parts of the sequence accessible in the quarries
1 gaizes, *2* marly limestones, *3* limestones with sponges and siliceous concretions, *4* micritic limestones, *5* marls, *6* organogenic limestones, *7* oolites, *8* bioclastic limestones
The asterisks indicate parts of the sequence described in details: 1* – by MATYJA (1977), 2* – by KUTEK (1968)

consists of some species of *Idoceras* (*Subnebrodites*), that is *I.* (*S.*) *planula* (HEHL), *I.* (*S.*) *laxevolutum* (FONTANNES) sensu ZIEGLER (1959), *I.* (*S.*) cf. *schroederi* WEGELE, and some others of *Orthosphinctes* (*Orthosphinctes* and *Lithacosphinctes*), that is *O.* (*O.*) *polygyratus* (REINECKE), *O.* (*O.*) cf. *freybergi* (GEYER), as well as a single specimen of the Physodoceratinae which may be attributed, with reservation, to the species *Benetticeras benetti* CHECA. As it is proved by the occurrence of *Idoceras* (*Subnebrodites*), the fauna corresponds to the Planula Zone. The other ammonites are less diagnostic, as they are known from the Upper or uppermost Oxfordian and the lowermost Kimmeridgian (ATROPS 1982, CHECA 1985). The absence of *Idoceras* (*Subnebrodites*) *minutum* DIETERICH typical of the lower and middle parts of the Planula Zone (DIETERICH 1940, ZIEGLER 1959, WIERZBOWSKI 1978) is remarkable here and suggests that the fauna studied corresponds to the upper part of the Zone. The underlying sequence, about 220 m thick, representing the middle part of the Siedlce Limestone Member is unexposed, but it may be consequently attributed to some lower and middle parts of the Planula Zone.

Besides the studied fauna, the only earlier record of *Idoceras* sp. from the Holy Cross Mts was given by KUTEK (1968, Pl. 8, Fig. 2). This specimen was found at Żerniki (*see* Text-fig. 2) in the micritic limestone layer intercalated within the grainstones. The deposits are likely to be correlated with those occurring in the Sobków-Wierzbica quarry and its close neighborhood, and hence are probably of late Planula Chron. The single ammonite *Prorasenia* sp.

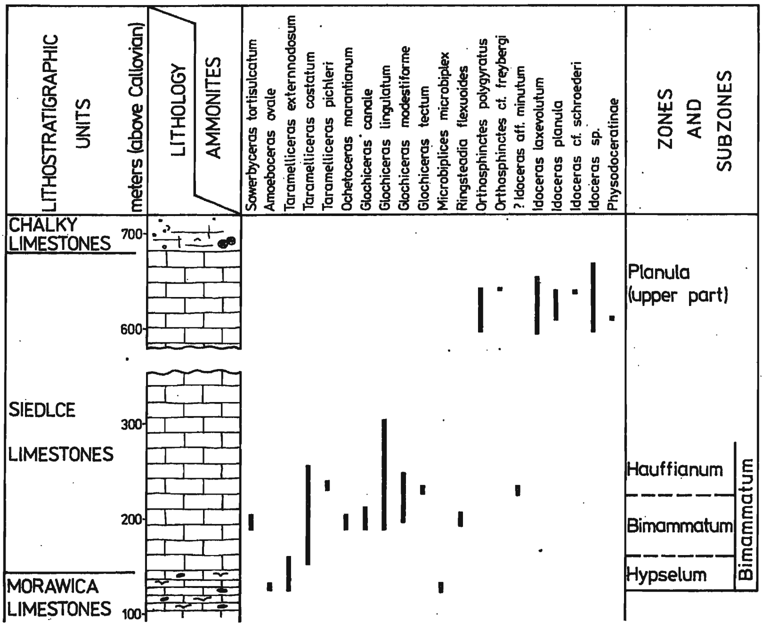

Fig. 4. Stratigraphical ranges of Upper Oxfordian ammonites in the Siedlce — Sobków area; lithology the same as in Text-fig. 3

found in the overlying grainstones of the Chalky Limestone Member, in the area between Sobków and Żerniki, may indicate still Late Oxfordian or Early Kimmeridgian age of this unit. However, as proved by the ammonite findings in some more distant areas of the Holy Cross Mts, the Chalky Limestone Member belongs, partly at least, to the Platynota Zone of the Lower Kimmeridgian (KUTEK 1968).

During the Early and Middle Oxfordian, in the investigated area of the Holy Cross region, layered limestones, mainly wackestones, with abundant siliceous sponges were commonly formed. These sediments represent open-shelf sponge facies which was widely distributed over a great area of Central and Southern Poland (*see* KUTEK, MATYJA & WIERZBOWSKI 1984, Text-fig. 1). Since the beginning of the Late Oxfordian or, possibly, since the end of the Middle Oxfordian Bifurcatus Chron, an intense growth of the cyanobacteria-sponge bioherms heavily influenced the sedimentary environment. The basin has then been divided into the hard-bottom, elevated bioherm areas and the soft-bottom, muddy, interbioherm depressions. The maximum development of the bioherms took place in the Late Bimammatum and Early Planula Chrons. At the end of the period, the growth of the bioherms created denivelations ranging up to 200 meters. Just then, the tops of the bioherms were colonized by corals of the families Latomeandridae, Microsolenidae, and Stylinidae (MATYJA 1977).

The open-shelf, *i.e.* the basinal facies joined eastward with the carbonate platform, regarded here as a zone of the shelf covered by carbonate sediments deposited above, or close to the wave base. The carbonate platform, which developed during the Middle Oxfordian in the Lublin region (NIEMCZYCKA 1976), was progressing westward and reached area of the north-eastern Holy Cross region during the Bifurcatus Chron or, possibly, during the latest Transversarium Chron (GUTOWSKI, *in prep.*). The edge of the platform was stabilized likely in the zone of the present-day north-eastern margin of the Holy Cross Mts, which then corresponded to the north-eastern margin of the Mid-Polish rift (KUTEK 1989; *cf. also* KUTEK & GŁAZEK 1972). The fact, that the thickness of the Upper Oxfordian deposits varies between 130—200 m in the NE margin of the Holy Cross Mts (GUTOWSKI, *in prep.*), ranges up to 570—620 m in the SW margin (MATYJA 1977), and decreases westwardly, is consistent with this interpretation. A strong subsidence within the rift zone stopped westward progradation and caused that the SW area of the Holy Cross region was situated during most of the Late Oxfordian in the foreland of the carbonate platform. The carbonate mudstones of the Siedlce Limestone Member, which represent a greater part of the Upper Oxfordian sequence, have initially been deposited between the bioherms but they successively spread allover the bioherm areas. As a result, the previously existing denivelations of the sea bottom have completely been buried and the bottom turned to be almost flat.

FACIES DEVELOPMENT IN THE SOBKÓW-WIERZBICA AREA

The distribution of the benthic fauna within the sequence of the micritic limestones from the uppermost part of the Siedlce Limestone Member is very irregular. Both body and trace fossils are either absent or they occur occasionally through the greater part of the sequence. Only single beds or bed sets of the sequence yield rich, especially in the number of individuals, fossil assemblages (*I – V* in Text-fig. 5). The fauna of the overlying oolitic-bioclastic grainstones of the Chalky Limestones Member (assemblages *VI – VII* in Text-fig. 5) is, in contrast, abundant and diversified. All the assemblages are characterized below in their stratigraphical succession.

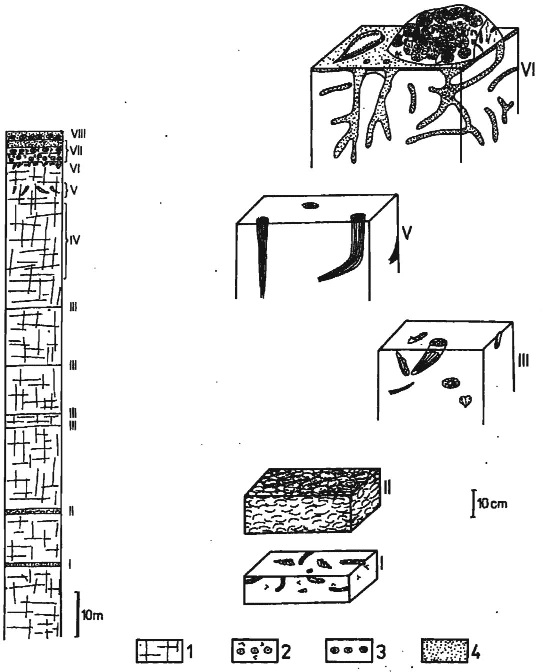

Fig. 5. Benthic assemblages within the uppermost part of the Siedlce Limestone Member (open shelf facies) and lowermost part of the Chalky Limestones Member (carbonate platform facies)
I – VIII: benthic assemblage assignations, the same as in the text
LITHOLOGY: *1* carbonate mudstones, *2* oolitic-bioclastic grainstones, *3* onkolitic-bioclastic grainstones, *4* "chalky" limestones composed mainly of small bioclasts bearing micrite

I: *Cerithium* – crustacean assemblage

This stratigraphically lowermost assemblage (*I* in Text-fig. 5) consists of gastropods, first of all *Cerithium* sp., and densely packed burrows (Pl. 3, Fig. 3), attributable to the ichnospecies *Spongelimorpha suevica* (RIETH). According to FÜRSICH (1974), the palinuran crustaceans *Glyphea* were the producers of such burrows. This is compatible with the occurrence of the carapaces of this very genus in the lower part of the Siedlce Limestone Member (FÖRSTER & MATYJA 1986).

Table 1

Cerithium — crustacean assemblage

Cerithium sp.	m	E	H
glypheoid crustaceans	m	I	DF
Trigonia verticulata	n	I	SF
aporrhaiid gastropods	r	E & Si	H
other gastropods	r	?E & Si	?H
Entolium corneolum	s	EF	SF
Nicaniella (Trautscholdia) phillis	r	I	SF
Gervillia aviculoides	s	EB	SF
Myidae	s	I	SF

Abbreviations used in Tables 1—5:
OCCURRENCE: **s** — single, **r** — rare, **n** — numerous, **m** — massy aggregated
MODE OF LIFE: **E** — epifaunal, **I** — infaunal, **EB** — epibyssate, **EC** — epifaunal cemented, **EF** — epifaunal free-living, **Si** — semiinfaunal, **IBo** — boring in hard substrate
TROPHIC CATEGORY: **SF** — suspension feeder, **DF** — deposit feeder, **H** — herbivore

The assemblage occurs within the 10 cm thick layer, which is strongly bioturbated and contains, in places, some bioclasts, mainly crinoid fragments. Single burrows, myid bivalves, and relatively numerous ammonites can also be found within the neighboring beds in the zone up to 4 meters above the cerithiid layer.

II: *Entolium* assemblage

The *Entolium corneolum* shells are aggregated in a mass (Pl. 3, Fig. 6) in the topmost part of the 14 cm thick micritic layer (*II* in Text — fig. 5). Additionally, single specimens of *Trigonia* and *Pholadomya* are also present. The latter can also be found in life position in the beds up to 2 meters below the layer with *Entolium.*

Table 2

Entolium assemblage

Entolium corneolum	m	EF	SF
Pholadomya protei	s	I	SF
Trigonia verticulata	s	I	SF
Pleuromya sp.	s	I	SF

III: *Gervillia* – solitary coral assemblage

The faunal elements do not occur in distinctly individualized layers but they are more or less regularly distributed in the 40–80 cm thick beds. However, *Gervillia* and *Pteroperna* (Pl. 4, Figs 4 and 5) shells appear together with corals in greater concentrations at several surfaces (*III* in Text-fig. 5). The corals are densely bored by lithophags and colonized by the oyster *Lopha gregarea* (Pl. 4, Fig. 3). The bivalves *Gervillia* and *Pholadomya* (Pl. 3, Fig. 2), and corals are often found in their life position.

Table 3

Gervillia – solitary coral assemblage

Gervilia aviculoides	m	EB & Si	SF
Pteroperna polyodon	m	EB	SF
solitary coral *A*	n	E	SF
Pholadomya protei	n	I	SF
Lithophaga sp.	n	IBo	SF
Entolium corneolum	n	EF	SF
Lopha gregarea	r	E & EC	SF
Nicaniella (Trautscholdia) phillis	r	I	SF
Trigonia verticulata	r	I	SF
Mytilus pectinatus	s	EB	SF
Pholadomya aequalis	s	I	SF
Goniomya sp.	s	I	SF
Pleuromya cf. *alduini*	s	I	SF
Pleuromya uniformis	s	I	SF
Nanogyra nana	s	E	SF

IV: *Gervillia* redeposited assemblage

The taxonomic composition is the same as in the assemblage *III*, except of the absence of corals. The fossils are often broken, abraded and redeposited, even in the case of deeply burrowing *Pholadomya*. There are no faunal concentrations, and the fossils are relatively rare.

V: Solitary coral assemblage

The assemblage consists only of stick-shaped corals distinctly adapted to soft, muddy substrate. The corallites (Pl. 4, Fig. 6) are often more than 40 cm long and arched due to the change in their growth direction when growing on the unstable bottom. As the corals are preserved as the external casts, a more detailed taxonomic recognition is impossible. The topmost part of the solitary corals was in some cases colonized by stylinid and/or isastreid colonies (E. RONIEWICZ, *personal information*).

Table 4

Coral assemblage

Stylosmilia sp.	n	E	SF
Calamophylliopsis sp.	n	E	SF
Comoseris sp.	n	E	SF
Heliocoenia sp.	n	E	SF
Montlivaltia sp.	n	E	SF
Solenoporaceae			
unrecognizable bioclasts of bivalves, crinoids and corals			

VI: Hardground assemblage

The contact between the carbonate mudstones and oolitic-bioclastic grainstones is featured by an omission surface which can be categorized as a soft bottom (*sensu* KAŹMIERCZAK & PSZCZÓŁKOWSKI 1968). Densely packed spongelimorphid burrows penetrate to about 1 m below the surface. The burrows are filled with grainstone, very close to that which overlies the surface. The thin cover of grainy sediment had to be deposited quickly on the omission surface as there are no borings indicative of any early lithification. Later, the bottom was colonized by large semiinfaunal pinnid *Trichites*, and the hemispherical coral colonies, mainly *Isastraea* and *Complexastraea*, attaining 30 cm in diameter (Pl. 4, Fig. 7). They are often still resting in their life position, although, always strongly abraded due to the activity of boring bivalves which were last in the ecological succession.

VII: Coral assemblage

The following sequence appears above the hardground: grainstones composed of very thin, often broken superficial ooids and bioclasts (140 cm), microonkolitic grainstone (60 cm), microonkolitic-bioclastic (mainly trochites) grainstone (210 cm). A very rich coral assemblage appears within these sediments. It is composed mostly of *Stylosmilia*, *Calamophylliopsis*, *Comoseris* and *Heliocoenia* colonies. Among the bioclasts fragments of crinoids are abundant. Associated are red algae of the superfamily Solenoporaceae.

VIII: *Diceras* — rhynchonellid assemblage

The uppermost part of the investigated sequence is composed of calciruditic bioclastic-onkolitic grainstones intercalated with chalky packstones (visible thickness about 5 meters). The diceratid biostromes are typical of that part of the section. The *Diceras* shells were aggregated almost in or near to their original life environment, as evidenced by their common articulation. The attachment area, preserved sometimes on the right valve, indicates that the diceratids cemented to the shells of other individuals or to the gravel substrate (*cf.* KARCZEWSKI 1969). The biostromes usually consist of diceratids only but the other layers, where diceratids are relatively rare, yield also other bivalves, some rhynchonellids and trochites. The observed cyclic succession probably resulted from temporal colonization of the bottom by the diceratid or crinoid-rhynchonellid community, which occupied convenient niches and migrated from place to place as the local environment had changed.

Table 5

Diceras — rhynchonellid assemblage

Diceras arietinum	m	EC & E	SF
Eodiceras sp.	n	E	SF
Septaliphoria astieriana	n	E	SF
Myidae	r	I	SF
Pentacrinus sp.	r	E	SF
other crinoids and bivalves			

DEPOSITIONAL HISTORY

The carbonate muddy sedimentation prevailing in the lowermost part of the section was extremely rigorous for the benthic organisms. Especially, the assemblage *II*, composed almost exclusively of swimming pectinid *Entolium corneolum*, suggests the importance of soft unstable substrate. According to JOHNSON (1984), *E. corneolum* may have been able to colonize in large numbers the less stable substrate, otherwise unfavorable for other suspension-feeding bivalves. The fauna appears in greater concentrations at two bed surfaces only (assemblages *I* and *II* in Text-fig. 5). This leads to the conclusion that the soupy

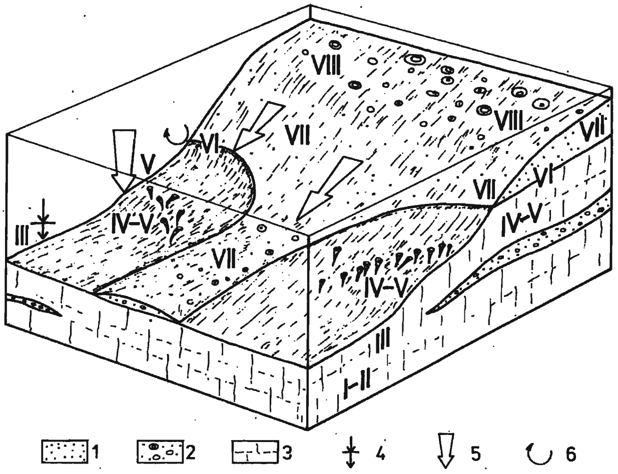

Fig. 6. Facies pattern and distribution of benthic assemblages on the slope of the prograding carbonate platform (Late Planula Chron, SW margin of the Holy Cross Mts)
I—VIII: benthic assemblage assignations, the same as in the text
LITHOLOGY: *1* oolitic-bioclastic grainstones, *2* onkolitic-bioclastic grainstones, *3* carbonate mudstones
FACTORS CONTROLLING SEDIMENTATION: *4* deposition of suspensed carbonate mud and occasional winnowing of the bottom sediment, *5* deposition of suspensed carbonate mud, *6* winnowing of the bottom sediment and development of the omission surface

ooze having made the sea bottom almost completely abiotic, was episodically transformed into a somewhat more convenient substrate. These two beds are also relatively rich in bioclasts, particularly in fragments of crinoids.

All these data suggest that the muddy sediment covering the sea bottom was temporarily partly winnowed due to a high energy (storm) events. It may have been related to the formation of the oolitic-onkolitic-bioclastic fans, found in the boreholes of the same sequence, a few hundred meters away from the discussed section in the quarry, and coming from neighboring carbonate platform (*see* Text-fig. 6). The occurrence of the bioclasts, especially of the crinoid fragments at the horizons studied and the virtual absence of other carbonate grains may be related to the differences in specific gravity. For instance, the porous microstructure of skeletal elements of crinoids considerably enhanced their longer transport (MACURDA & *al.* 1978). The high energy events temporarily slowed down the accumulation rate and involved intensive but shortly existing colonization of the bottom by simple in the taxonomic structure or even monospecific communities (assemblages *I*—*II*). Such communities seem to be typical of muddy foreland and/or slope of the Late Jurassic carbonate platforms. Similar bivalve facies is known from the Oxfordian of the Swiss Jura (Geissberg Member of GYGI & PERSOZ 1987, Text-fig. 6). The *Entolium* — *Pholadomya* assemblages are also common in slope facies of carbonate platform which prograded onto the western part of the Holy Cross region during the Hypselocyclum Chron (Early Kimmeridgian).

Upwardly in the sequence the sediment is distinctly thicker bedded and the fauna appears regularly and more frequently. On the other side, the faunal concentrations can be observed only in four levels (*III* in Text-fig. 5), what suggests a general trend to the growing up carbonate mud support. However, the mechanism of temporal relative slowing down of accumulation rate, previously described, still existed and resulted in occasional slight omission. The episodes of strong turbulence (storms) caused also redeposition of the fauna (assemblage *IV*). Bivalve communities appear more diversified (Pl. 3, Figs 1—2 and 4—5; Pl. 4, Figs 1—5). Except for eurytopic elements, like *Entolium* and *Pholadomya*, very abundant epibyssate suspension feeders colonized the bottom. However, the presence of corals seems to be more significant. This successively growing diversity and density of fauna was not caused by any change in the sediment characteristics. Moreover, the generally increasing sedimentation rate should have created more rigorous barrier for the benthic fauna than in the case of former assemblages (*I* and *II*).

The increasing rate of sedimentation was probably caused by a continuous progradation of the oolitic-onkolitic shoals. Winnowing of muddy particles from the shallow turbulent areas of the platform caused, in turn, a rapid accumulation of carbonate mud, especially in the front of grainy shoals marking the edge of the platform. Taking this into account, it is concluded that muddy foreland of the carbonate platform formed a gently inclined slope. Such bathymetric denivelations, situated between extremely shallow and deeper areas, usually establish the biotops very rich in food sources, especially in suspended organic matter which concentrates here due to the action of different sea currents. Moreover, winnowing down of the muddy particles made the water clear enough for the coral requirements. Therefore, the corals appeared more abundantly in the uppermost part of the micritic sequence, which has been deposited in a more elevated part of the slope (*see* Text-fig. 6).

The last episode of the depositional history of the micritic sequence was connected with the development of the omission surface. The omission could also resulted, as in the case of former assemblages (*I*, *II*, *III*), from occasional high turbulence events. However, the hardground must have been created as a total effect of several events, which had been more intense in more elevated parts of the slope. The regional data, moreover, suggest additionally a eustatic control of the discussed omission and accelerated shallowing of the basin. In fact, a sudden progradation of the carbonate platform facies onto the whole SW area of the Holy Cross region coincides with the replacement of the interbioherm deeper shelf sediments by chalky limestones with abundant fauna in the Polish Jura Chain during the latest Planula Chron of the latest Oxfordian/earliest Platynota Chron of the earliest Kimmeridgian (WIERZBOWSKI 1964). It can also be correlated with the sedimentary discontinuity observed in the west-European basins at the Oxfordian/Kimmeridgian boundary, whose eustatic nature has been suggested (discontinuity *1* of HANTZPERGUE 1984, 1985). Moreover, one can observe, in the considerably wide areas, similar regressive sedimentary sequences which started at the same time, as it can be evidenced by the biostratigraphic dating, *i.e.* during the latest Oxfordian (*cf.* GYGI & PERSOZ 1986, 1987; ENAY & *al.* 1988).

Finally, the sedimentation of carbonate sands spread over the area and the coral assemblage (*VII*) colonized the upper part of the platform slope. The grainy substrate was more favorable for benthic colonization, thus both density and diversity of the benthic fauna are evidently higher. The bioclastic-onkolitic calcirudites which occupy the uppermost part of the section, are connected with the diceratid assemblage (*VIII*). The absence of corals in the diceratid assemblage confirms the statement of RONIEWICZ (1966) and RONIEWICZ & RONIEWICZ (1971) that the Upper Jurassic corals were not able to build greater reefal buildups above the wave base.

The coral communities are likely to have existed in the lower slope of the carbonate platform, *i. e.* in a relatively quiet, deeper zone. The corals, therefore, usually were the main component of the pioneer community which marks, in the geological record, a transition from deeper neritic to shallow-water, higher energy sedimentary environment. In turn, the diceratid community preferred the more turbulent zone of the upper slope, close to the platform edge.

The described succession of benthic assemblages was a result of the continuous shallowing of the basin, connected with the progradation of the oolitic-bioclastic-onkolitic shoals. However, the ecological barrier between the carbonate platform (coral-diceratid) and the slope (bivalve-solitary coral) ecosystems obviously resulted from the extent of the grainy and muddy substrate respectively. The rapid change of the muddy bottom into a grainy one involved a sudden development of the platform communities. It happened even in the case of oolitic-bioclastic fans moving down from the platform area onto the foreland. The existence of these communities was, in turn, interrupted by the returns to muddy sedimentation which covered the fans again.

NOTES ON AMMONITES

The collection consists of 39 specimens housed at the Museum of Geological Faculty of the Warsaw University, and kept under the collection numbers IGPUW A/22/1 through A/22/39. The specimens are preserved as internal casts and imprints, often fragmentary and sometimes deformed. Because all the collected ammonites represent the well known species only some general comments on their taxonomy are herein presented.

Genus *Orthosphinctes*

The genus is represented by 13 specimens, the majority of which belong to the subgenus *Orthosphinctes*. The most common species is *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (REINECKE) represented by fairly typical forms (Pl. 1, Fig. 1). Some poorly preserved and hardly identifiable specimens seem to be close to this species (Pl. 1, Fig. 2). The single fragmentary specimen (Pl. 1, Fig. 3) is referred to as *Orthosphinctes* (*Orthosphinctes*) cf. *freybergi* (GEYER) differing somewhat from the typical representatives (*cf.* ATROPS 1982) of the species in a narrower umbilicus. The fragment of whorl showing thick, single primary ribs with numerous secondaries (5–6 per one primary) is attributed to the subgenus *Lithacosphinctes*, and its relation to the species *Orthosphinctes* (*Lithacosphinctes*) *evolutus* (QUENSTEDT) is suggested.

Genus *Idoceras*

The phylogenetic affinity of the Late Oxfordian ammonites placed for a long time in the genus *Idoceras* BURCKHARDT, 1906, is in fact somewhat obscure. Some authors (ATROPS 1982) treat these ammonites as a side branch of the Ataxioceratinae, derived already from an early *Orthosphinctes*, which has in turn its roots in the Passendorferiinae (ATROPS & MELENDEZ 1988). The others (ZIEGLER 1959, BROCHWICZ-LEWIŃSKI & RÓŻAK 1976) put the ammonites in question within the main stock of Idoceratinae s.l., not too far from the genus *Nebrodites*. On the other hand, as the type species of the genus *Idoceras*, i.e. *I. balderum* (OPPEL), is known from the upper part of the Lower Kimmeridgian, and as its affinity is still not clear, the direct relation of the discussed Upper Oxfordian ammonites with the genus *Idoceras* may be questioned or, at least, cannot be unequivocally proved: hence, recently, these ammonites are often placed within the genus *Subnebrodites* SPATH, 1925 (with the type species *S. planula*), whose full genus status has been restored (DONOVAN & CALLOMON 1980, PAVIA & *al.* 1987). Moreover, it may be noticed, that at the same time PAVIA & *al.* (1987) have suggested a possible origin of the genus *Idoceras* s. s. from the Late Oxfordian Passendorferiinae, through the newly erected Early Kimmeridgian subgenus *Lessiniceras* of the genus *Idoceras*, as well as the through forms being close to *Idoceras* s. s., such as *Idoceras* (? *Idoceras*) *dedaloides* (CANAVARI). This may also reflect the phylogenetic independence of

Idoceras s. s. and *Subnebrodites*. However, the appearance of the forms close to *Idoceras* s. s. in the lower part of the Lower Kimmeridgian, as shown by PAVIA & *al.* (1987), to some degree fills also the gap between the occurrence of *Subnebrodites* in the Upper Oxfordian, and *Idoceras* s. s. of the *I. balderum* group in the upper part of the Lower Kimmeridgian. This may eventually be indicative of a possible relation between *Subnebrodites* and *Idoceras*.

These problems cannot be solved in the present paper and the discussed Upper Oxfordian ammonites are placed here in the subgenus *Subnebrodites*, which is put but tentatively to the genus *Idoceras*.

The ammonites regarded as *Idoceras* (*Subnebrodites*) are the most common in the collection studied (23 specimens). The majority of the specifically determinable specimens belong to the species *Idoceras* (*Subnebrodites*) *planula* (HEHL), and *I.* (*S.*) *laxevolutum* (FONTANNES) *sensu* ZIEGLER (*see* Pl. 1., Figs 4—7 and Pl. 2, Figs 1—4). The two species differ mostly in their end-size and the character of the peristome; besides, there are some differences in the number of primary ribs per whorl with increasing diameter. The ribs in *I. planula* become loosely spaced, whereas in *I. laxevolutum* the ribs become somewhat crowded on the last whorl (*see* ZIEGLER 1959, NITZOPOULOS 1974, WIERZBOWSKI 1978). It is to be mentioned that the ammonites common in the Submediterranean uppermost Oxfordian, and ascribed to the species *I. laxevolutum* (FONTANNES) by ZIEGLER (1959), probably do not belong to the species (ENAY 1966, WIERZBOWSKI 1978). However, this suggestion needs the examination of the new material from Mt. Crussol in France where the species *Idoceras laxevolutum* has been established by FONTANNES, to evaluate the real intraspecific variability and the stratigraphic range of the species.

The four specimens of the collection differ from those of the *I. planula* — *I. laxevolutum* group in having somewhat narrower umbilicus and the higher number of secondary ribs: at D (diameter) = 35—70 mm, Ud (umbilicus diameter in D%) = 35—39, and SR/PR (the secondary to primary ribs ratio) = 2.0—2.4, whereas in *I. planula* — *I. laxevolutum* at D = 45—65 mm, Ud = 44—52, SR/PR = 1.8. These specimens (Pl. 2, Figs 5—7) are referred to as *Idoceras* (*Subnebrodites*) cf. *schroederi* WEGELE.

Subfamily Physodoceratinae

One fragmentary and deformed specimen (Pl. 2, Fig. 8) reveals sparcely placed, strong and radially elongated nodes in the dorsolateral side of the whorls, as well as the depressed whorl section, which makes it relatively close to *Benetticeras benetti* CHECA, the species recently established by CHECA (1985).

SIGNIFICANCE OF THE LATE OXFORDIAN AMMONITE FAUNAS

The ammonites collected from the discussed Upper Oxfordian deposits of the SW margin of the Holy Cross Mts may be pronouncedly interpreted in terms of biogeography and ecology.

The ammonite spectra for the Bimammatum and the Hauffianum Subzones on one hand, and the upper part of the Planula Zone on the other (Text-fig. 7, right side), indicate the overdominance of such Mediterranean-Submediterranean groups of ammonites as the Haploceratacea and some Perisphinctaceae — *Idoceras* (*Subnebrodites*) and *Orthosphinctes*, and even Phylloceratacea (*Sowerbyceras*), to the virtual exclusion of the Boreal forms. There is only stated a very scarce occurrence of the Subboreal genus *Ringsteadia* represented by the single species *R. flexuoides* (QUENSTEDT) which is possibly of the Submediterranean origin (WIERZBOWSKI 1970). Hence, there is a little doubt as to the affiliation of the studied area to the Submediterranean province (MATYJA 1977).

In other regions of the Central Polish Uplands, even in their northernmost part, *e. g.* in the Wieluń Upland where Late Oxfordian ammonite faunas are well recognized, there is a marked dominance of the Mediterranean and Submediterranean ammonites (WIERZBOWSKI 1978; *see also* Text-fig. 7, left side). Here, ammonites of the Subboreal affinities (*Ringsteadia* and various rasenoidal ammonites) are scarce, their number oscillating between 4.8%, through 8.3–11.9%, up to 23.2% of the total ammonite number for the particular parts of the succession (WIERZBOWSKI 1978, p. 306, Table 1).

The Boreal ammonites of the genus *Amoeboceras* and bivalves *Buchia*, associated with typical Submediterranean ammonites, are known to occur in a few "*Amoeboceras* beds" in the Upper Oxfordian in the Central Polish Uplands. The beds with *Amoeboceras* – *Buchia* fauna, however, are thin and separated by long intervals where the Boreal fauna is virtually absent, but the Submediterranean ammonites do occur. Of the two *Amoeboceras* beds recognized in the Upper Oxfordian, the lower one is known from the Semimam-

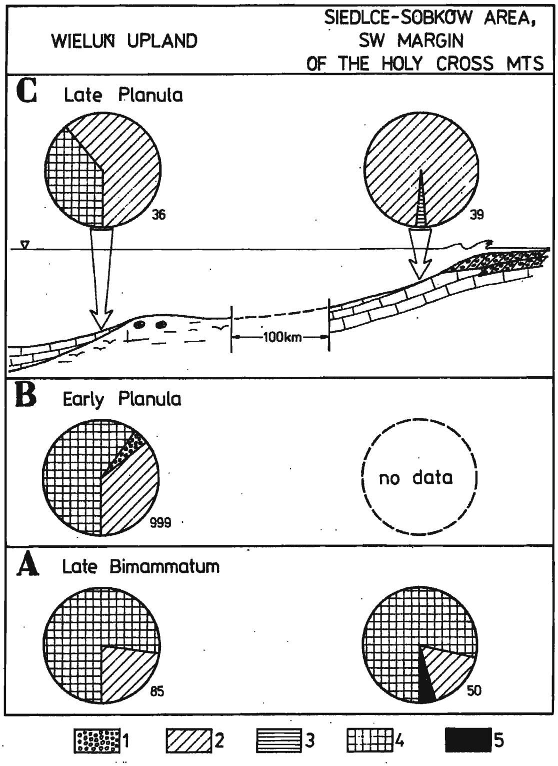

Fig. 7. Percent proportion of the total specimen number counted for the ammonite family and/or superfamily groups in the Wieluń Upland (for location *see* Text-fig. 1) and in the investigated area
1 – Cardioceratidae, **2** – Perisphinctidae, **3** – Aspidoceratidae, **4** – Haploceratаceae, **5** – Phylloceratidae

Lithology the same as in Text-fig. 3

matum Horizon of the Hypselum Subzone of the Bimammatum Zone, and the upper one is known from the lowermost part of the Planula Zone. Whereas the former has a wide extent in the Central Polish Uplands as far south as the area of Cracow and the SW margin of the Holy Cross Mts, the latter one is known only from the Wieluń Upland (*see* MATYJA & WIERZBOWSKI 1988). The "*Amoeboceras* beds" undoubtedly mark short-time, southward invasions of the Boreal fauna, and are important for the correlation of the Boreal and the Submediterranean ammonite zonal schemes. However, according to the present authors, and contrary to MALINOWSKA (1969a, b), the discussed Boreal as well as Subboreal ammonites do not in fact offer premises to distinguish the Boreal or Subboreal ammonite zones in the Central Polish Uplands. It results from the limited distribution of these ammonites in the Upper Oxfordian sequence, and/or their poor frequency. Moreover, the here occurring genus *Ringsteadia* and various rasenoidal ammonites are represented, partly at least, by the Submediterranean species and subgenera (WIERZBOWSKI 1970, 1978) whose relations with Subboreal allies are more or less distant.

On the other hand, the changes in the ammonite spectra from the Upper Oxfordian in the SW margin of the Holy Cross Mts and the Wieluń Upland (Text-fig. 7) undoubtedly resulted from the continuous westward progradation of the shallow water carbonate platform facies. The decreasing in the basin depth is well marked in the SW margin of the Holy Cross Mts where the ammonite spectrum of the Bimammatum and the Hauffianum Subzones abounds in the deeper-water Haplocerataceae, whereas that of the upper part of the Planula Zone is overdominated by the Perisphinctaceae, to the total exclusion of Haplocerataceae (*cf.* ZIEGLER 1967).

The similar succession of the ammonite faunas has also been found in the Wieluń Upland. However, the Haplocerataceae are still fairly common in micritic limestones and marls representing there a deeper water facies of the late Planula Chron. They were totally replaced by the Perisphinctaceae in the corresponding shallower-water biogenic chalky limestones, as well as in the younger deposits of the lowermost Kimmeridgian (WIERZBOWSKI 1978; *see also* Text-fig. 7).

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UTWORY PRZEDPOLA GÓRNOJURAJSKIEJ PLATFORMY WĘGLANOWEJ Z SOBKOWA-WIERZBICY W GÓRACH ŚWIĘTOKRZYSKICH

(Streszczenie)

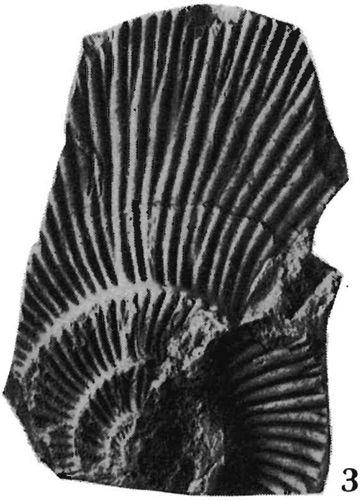
W pracy przedstawiono stratygrafię osadów i następstwo zespołów faunistycznych rozpoznanych w nowym kamieniołomie Sobków-Wierzbica na południowo-zachodnim obrzeżeniu Gór Świętokrzyskich (fig. 1—2). Odsłania się tam 100 metrowej miąższości profil uławiconych wapieni mikrytowych należących do najwyższej części ogniwa wapieni siedleckich, nadścielony kilkumetrowej miąższości wapieniami ziarnistymi należącymi już do najniższej części ogniwa wapieni kredowatych (fig. 3). Kilkadziesiąt amonitów (pl. 1—2) pochodzących z wapieni siedleckich, m. in. *Idoceras planula* (HEHL), *I. laxevolutum* (FONTANNES) oraz *I.* cf. *schroederi* WEGELE wskazuje, iż utwory te należą do wyższej części poziomu Planula. Wraz z wcześniej opisanymi amonitami z najwyższej części wapieni morawickich i najniższej części wapieni siedleckich (MATYJA 1977) przedstawiono stan rozpoznania utworów górnego oksfordu na południowo-zachodnim obrzeżeniu Gór Świętokrzyskich (fig. 3—4).

Analiza zespołów fauny nieamonitowej występujących w obrębie cienkich ławic w wapieniach siedleckich oraz w wapieniach kredowatych w profilu Sobków-Wierzbica (fig. 5; tab. 1—5 oraz pl. 3—4) wskazuje, iż utwory wapieni siedleckich tworzące się początkowo w obrębie otwartego szelfu, znalazły się w późnej dobie Planula w strefie coraz wyraźniejszego wpływu progradującej platformy węglanowej. Następstwo zespołów faunistycznych rozpoznanych w profilu Sobków-Wierzbica oddaje poszczególne stadia tej progradacji (fig. 6).

Batymetria późnojurajskiego zbiornika obszaru Polski środkowej zapisana jest także w zmianach składu submedyterańskich faun amonitowych (fig. 7). Bardzo wyraźnie zróżnicowanie batymetryczne zaznacza się w później dobie Planula, kiedy to na obszarze obecnego południowo-zachodniego obrzeżenia Gór Świętokrzyskich, w bezpośrednim sąsiedztwie platformy węglanowej, dominują przedstawiciele nadrodziny Perisphinctaceae. W tym samym czasie na obszarze dzisiejszej Wyżyny Wieluńskiej, odpowiadającej wówczas strefie otwartego szelfu, zaznacza się natomiast wyraźny udział przedstawicieli nadrodziny Haploceratаceae.

1

2



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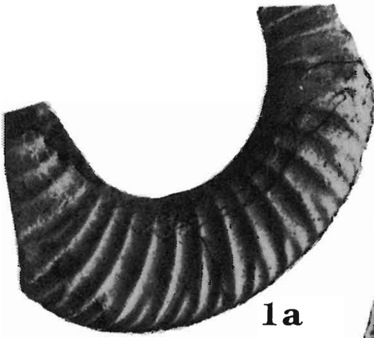
- **1** — *Orthosphinctes* (*Orthosphinctes*) *polygyratus* (Reinecke); Sobków-Wierzbica quarry, 40 m below the base of the Chalky Limestone Member, specimen IGPUW/A/22/1
- **2** — *Orthosphinctes* (*Orthosphinctes*) cf. *polygyratus* (Reinecke); ditto, at about 70—75 m, rubble, IGPUW/A/22/23
- **3** — *Orthosphinctes* (*Orthosphinctes*) cf. *freybergi* (Geyer); ditto, at 40 m, IGPUW/A/22/27
- **4-7** — *Idoceras* (*Subnebrodites*) *laxevolutum* (Fontannes) *sensu* Ziegler (1959); 4-6 — ditto, at about 40 m, rubble, specimens IGPUW/A/22/4, 5 and 3; 7 — ditto, about 25 m, IGPUW/A/22/11

All photos of natural size; taken by S. Kolanowski

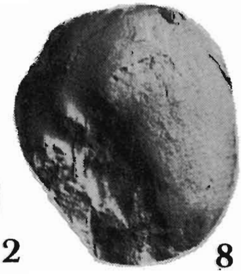

1a


1b


5


6


2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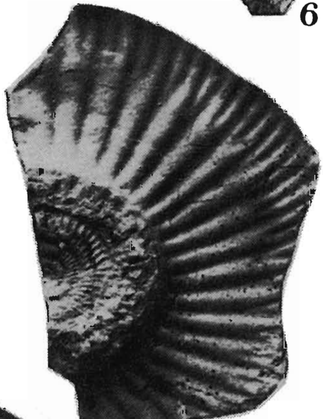
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3


4

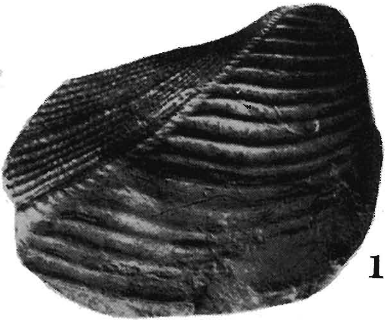
1-2 — *Idoceras* (*Subnebrodites*) *lexevolutum* (FONTANNES) *sensu* ZIEGLER (1959); 1a — internal cast of whorl, 1b — imprint of the same specimen, Sobków-Wierzbica quarry, 85 m below the base of the Chalky Limestone Member, specimen IGPUW/A/22/2; 2 — ditto, 40 m, IGPUW/A/22/6

3-4 — *Idoceras* (*Subnebrodites*) *planula* (HEHL); 3 — ditto, 71 m, IGPUW/A/22/13; 4 — ditto, 40 m, IGPUW/A/22/12

5-7 — *Idoceras* (*Subnebrodites*) cf. *schroederi* WEGELE; ditto, about 40 m, specimens IGPUW/A/22/9, 10 and 7

8 — Physodoceratinae (? *Benetticeras benetti* CHECA); ditto, at about 70 m, rubble, IGPUW/A/22/34

All photos of natural size; taken by S. KOLANOWSKI



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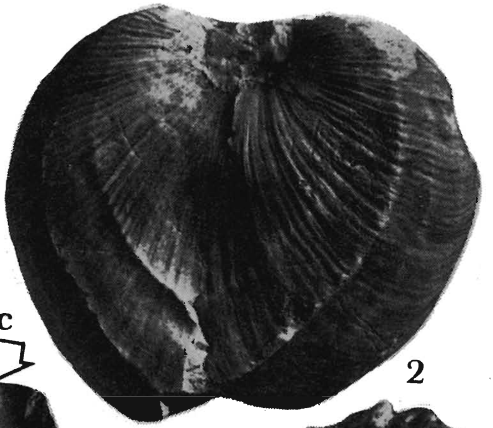

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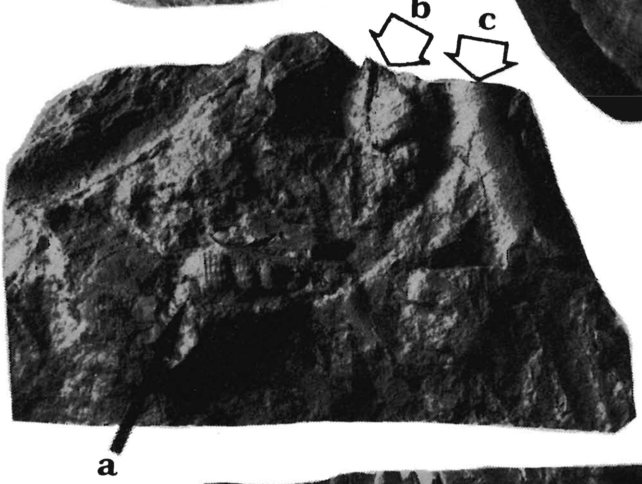

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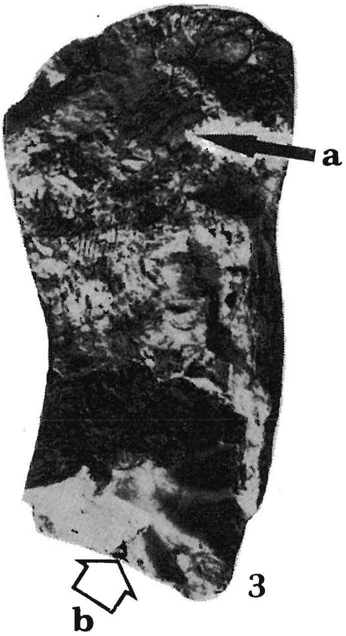
6

1 — *Trigonia verticulata* AGASSIZ, assemblage *III*
2 — *Pholadomya protei* (BRONGNIART), assemblage *III*
3 — Upper surface of the layer with aggregation of the cerithiid (**a**) and apporrhaid (**b**) gastropods, and the burrows (**c**) of the ichnospecies *Spongelimorpha suevica* (RIETH); assemblage *I*
4 — *Lopha gregarea* (SOWERBY), assemblage *III*
5 — *Goniomya* sp., assemblage *III*
6 — Upper surface of the layer with aggregation of the pectinid *Entolium corneolum* (YOUNG & BIRD); assemblage *II*, ×0.5

All photos of natural size unless otherwise indicated; taken by S. KOLANOWSKI


1


2



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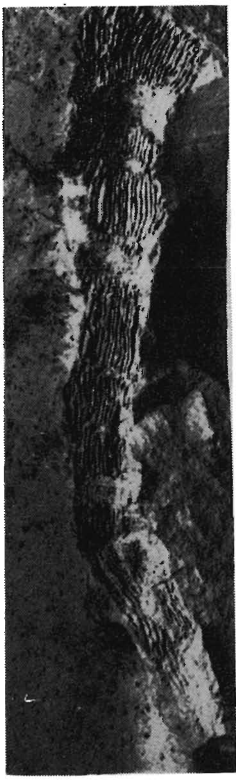
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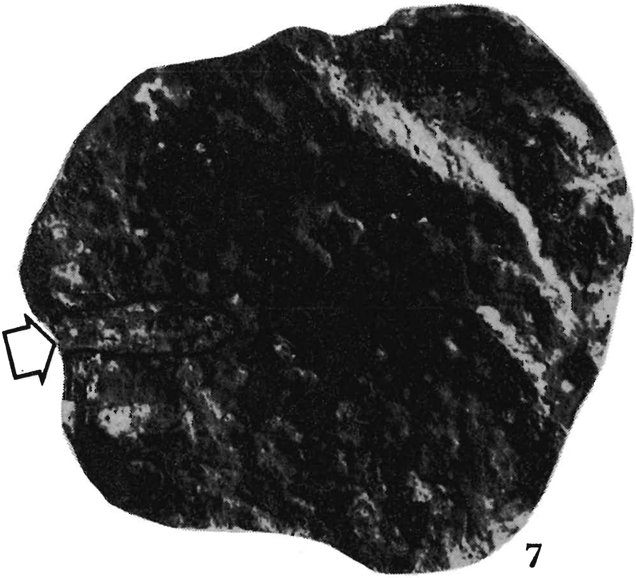
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1 — *Pleuromya* cf. *alduini* (BRONGNIART), assemblage *III*

2 — *Pleuromya uniformis* (SOWERBY), asssemblage *III*

3 — Solitary coral *A* with lithophag borings (**a**) and cemented oyster *Lopha gregarea* (**b**); assemblage *III*

4 — *Pteroperna polyodon* (BUVIGNIER), assemblage *III*

5 — *Gervillia aviculoides* (SOWERBY), assemblage *III*

6 — Solitary coral *A*, assemblage *V*

7 — Upper part of the hemispherical colony of *Complexastraea* sp. with the lithophag boring (*arrowed*); hardground assemblage (*VI*), ×0.5

All photos of natural size unless otherwise indicated; taken by S. KOLANOWSKI