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Oxfordian and Kimmeridgian of the northeastern margin of the Holy Cross Mountains, Central Poland

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In Late Jurassic the area of Central Poland was a part of the northern Tethyan shelf which developed in the margins of the East European Craton. The present day NE margin of the Holy Cross Mountains was situated in a proximal part of this shelf. The Oxfordian sedimentation began with open shelf, sponge-algal mudstones of the *mariae*, *cordatum*, and *plicatilis* Zones. During the latest *transversarium* and *bifurcatus* Chrons, shallow water biogenic and oncolitic facies developed. They were, in turn, replaced during the Late Oxfordian and the Early Kimmeridgian by oolitic-bioclastic grainstones and laminites. During the *divisum* Chron and the Late Kimmeridgian oyster shellbeds and clays were deposited. Within the studied sequence thirteen lithostratigraphic units are established and described. The collected ammonite fauna document the following ammonite zones: *mariae*, *cordatum*, *plicatilis*, *transversarium*, *bifurcatus*, *planula*, *hypselocyclum* and *divisum*.

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INTRODUCTION

The Upper Jurassic deposits in the NE margin of the Holy Cross Mountains (Fig. 1) are exposed from beneath the Quaternary and/or Tertiary cover only in a few isolated regions (see E. Rühle, 1947; J. Czarnocki, 1948). The exposures are situated, coming from NW to SE, between Dobrut and Wierzbica, in the vicinity of Iłża, in the Kamienna river valley from Przepaść to Skarbka, and in two localities on the Vistula river near Zawichost and Rachów (Fig. 2).

In the Wierzbica region, the Upper Jurassic strata are a part of a gently (6–8 degrees) dipping monocline whereas in the SE part of the investigated area they form several asymmetric folds running from NW to SE (J. Samsonowicz, 1934; W. Pożaryski, 1948; W. Jaroszewski, 1972) which include the following structures: Magonie–Folwarczysko Syncline, Stoki Anticline, Lemiesze Syncline, Bałtów Anticline, Sienno Anticline, Dębowe Pole Anticline and Błaziny Anticline. The marginal flexures of the Mid-Polish Anticlinorium (W. Pożaryski, 1948, 1976) i.e. Grabowiec–Dębowe Pole–Chwałowice flexure, Sienno–Ożarów flexure and Wisła flexure appear also in this area (Fig. 2). All the mentioned tectonic deformations originated in result of the inversion of the Mid-Polish Trough during latest Cretaceous and earliest Palaeocene (J. Kutek, J. Głazek, 1972; J. Kutek, 1994).

The Upper Jurassic sequence in the investigated area has been studied since the beginning of 19th century by G. G. Pusch (1836), A. Michalski (1884, 1888), J. Siemiradzki (1909), J. Siemiradzki (*fide* J. Siemiradzki, E. Dunikowski, 1891), J. Lewiński (1902), J. Samsonowicz (1923, 1925, 1926, 1927, 1932, 1934), A. Łuniewski (1923), S. Z. Różycki (1939) and W. Pożaryski (1948). More recent studies dealt with stratigraphy of the Dobrut–Śniadków area (J. Dembowska, 1953), vicinity of Iłża (Z. Dąbrowska, 1953, 1957, 1983*a*, *b*; J. Kutek, 1983) and vicinity of Bałtów (J. Liszkowski, 1962, 1976; W. Brochwicz-Lewiński, J. Liszkowski, 1976). The Lower Oxfordian strata yield relatively abundant ammonite collection described by L. Malinowska (1965, 1970). In contrast, in the Middle–Upper Oxfordian section only single ammonite specimens have been found (W. Brochwicz-Lewiński, J. Liszkowski, 1976; J. Kutek, 1983; Z. Dąbrowska, 1983*b*). Some palaeontological studies dealt with corals (E. Roniewicz, 1966), diceratids (L. Karczewski, 1969), oysters (A. Seilacher *et al.*, 1985; M. Machalski, 1989, 1993), neri-

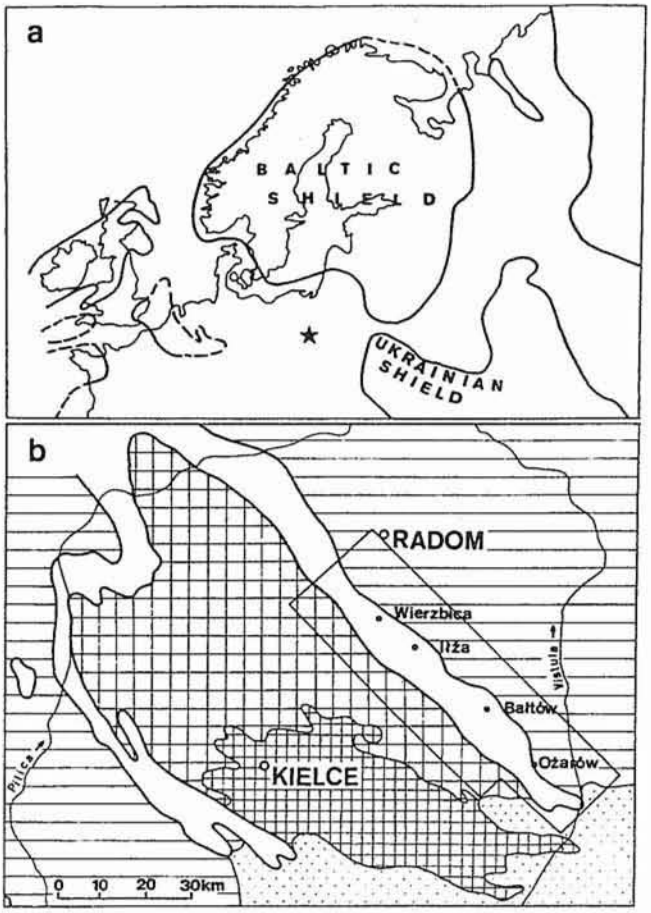


Fig. 1. Location of the studied area: a — palaeogeographic setting of the epicontinental basin of Central Poland (star), b — geological map of the Holy Cross Mts.; boxed is the area enlarged in Fig. 2
1 — Palaeozoic (dense box-work), 2 — Mesozoic older than Upper Jurassic (loose box-work), 3 — Upper Jurassic (blank), 4 — Cretaceous (horizontal ruling), 5 — Miocene of the Carpathian Foredeep (dotted)

Położenie terenu badań: a — paleogeograficzne usytuowanie epikontynentalnego basenu centralnej Polski (gwiazdka), b — mapa geologiczna Gór Świętokrzyskich; konturem zaznaczono obszar przedstawiony na fig. 2
1 — paleozoik (gęsta kratka), 2 — mezozoik starszy od górnej jury (rzadka kratka), 3 — jura (białe), 4 — kreda (poziome kreski), 5 — miocen zapadliska karpackiego (kropki)

neids (L. Karczewski, 1969; J. Wieczorek, 1979) and brachiopods (W. Barczyk, 1965, 1970; J. Dzik, 1979).

This paper presents an approach to litho- and biostratigraphy of the whole NE margin of the Holy Cross Mts. based on field studies done in 1985–1989 and described in the author's Ph. D. thesis (J. Gutowski, 1992) which includes detailed geological sections, correlation analysis, interpretation of sedimentary environment and reference list.

LITHOSTRATIGRAPHY

The Upper Jurassic deposits, approximately 400–600 m thick, are underlain by the Callovian gaizes and siliceous sandstones with rare belemnites and ammonites of the genus *Macrocephalites*. The Callovian/Oxfordian transition beds are exposed only in the Wyszmontów–Ożarów railway cut. Following are the descriptions of informal lithostratigraphic units which have been recognized within the Upper Jurassic (Fig. 3).

WYSZMONTÓW SPONGE LIMESTONES (*Wsl*)

The unit is formed of medium-bedded micrites, less commonly biomicrites or pelmicrites which are characterized by numerous siliceous sponge mummies, brachiopods, trochites, belemnites, ammonites and single bivalves of the genus *Lima*. The sponges are usually dispersed in layers or form only small lens-shaped bioherms. The total thickness of the unit is about 30 m. It is exposed in the railway-cut at Wyszmontów–Ożarów and in Podgrodzie.

PRZEPAŚĆ MASSIVE LIMESTONES (*Pml*)

This unit appears above the *Wsl* unit in the railway-cut at Wyszmontów–Ożarów. The sponge bioherms are characteristic for this unit and were described from Przepaść by L. Malinowska (1965). The biolithites, which are the main component of the unit, are formed of mummies of siliceous sponges and serpulids. Accompanying fauna is composed of brachiopods, bivalves, gastropods, bryozoans, crinoids and regular echinoids. Ammonites and belemnites are quite numerous as well. The bioherms are up to 10 m thick and they pass laterally into bedded limestones. In the upper part of the unit, sponges are often replaced by lammellar coral colonies of the genus *Microsolena*. The maximum thickness of the unit in the Podgrodzie–Przepaść zone can be approximated as 70 m.

Both the *Wsl* and *Pml* units are locally dolomitized and silicified.

WOLA LIPIENICKA SPONGE LIMESTONES (*WLsl*)

The unit is a stratigraphic equivalent of the *Wsl* and *Pml* units in the NW part of the investigated area. It is nowhere exposed now and it can be characterized only on the base of well-core descriptions and archival descriptions of previously existing outcrops. The unit is built of yellowish or white micrites or biomicrites, usually medium-bedded, which yield relatively abundant siliceous sponge mummies, bivalves, brachiopods, trochites, echinoid spines and also ammonites. Corals appear locally in the uppermost part of the unit (Tychów Nowy well). Supposedly, the unit can at least partly include

sponge bioherm complexes, which are, however, not unequivocally documented yet. Deposits of the unit are commonly dolomitized, silicified and karstified. The maximum documented thickness of this unit reaches 120 m (Wymysłów well) but the total thickness can be approximated as 170–200 m.

BAŁTÓW PLATY LIMESTONES (*Bpl*)

This unit is built of medium, rarely thick-bedded, yellowish, slightly marly micritic limestones. They appear above the *Wsl* unit and contact laterally with the *Pml* unit. The unit reaches its maximum thickness of about 100 m (Magonie and Bałtów wells: documented incomplete thickness 76 m) in the zone where massive limestones of the *Bpl* unit are absent. In contrast, in the zones of maximum sponge buildups development the thickness of the *Bpl* unit is decreasing, and, in extremal situation, the unit is missing completely. The unit is exposed at Bałtów and Stoki. In the Wierzbica–Iłża region there are no sufficient field data to confirm the presence of this unit. Benthic fauna appears in these monotonous micritic limestones only in accumulations on surfaces of particular isolated layers. Such faunal accumulations are characterized mainly by bivalves: *Gryphaea*, *Isognomon*, *Nanogyra*, *Liostrea*, *Trigonia*, *Pholadomya* and brachiopods. Trochites, decapod claws, and ammonites appear less frequently.

BAŁTÓW CORAL LIMESTONES (*Bcl*)

The unit is well exposed only in the Kamienna river valley near Bałtów, Zarzecze, Lemiesze and Stoki (E. Roniewicz, P. Roniewicz, 1971). It is composed of extremely diversified, thick-bedded or massive bioclastic and/or oncolitic grainstones or biolithites. They overlay the *Bpl* unit and the *Pml* unit (Fig. 3). The unit is characterized by very diversified coral assemblage (E. Roniewicz, 1966). The corals are a main component of bioherms, common especially in the lower part of the unit. The corals are accompanied by oysters, brachiopods, nerineids, calcareous sponges, regular echinoids, serpulids, crinoids and red algae of the genus *Solenopora*. Oncoids are often up to 7 cm in diameter. These are mainly coral fragments coated by thin blue-green algae envelope (Mumienkalk type). Upper part of the unit is dolomitized and it contains often brown cherts. Maximum thickness of the unit is 25 m.

ONCOLITE CHALKY LIMESTONES (*Oncl*)

The limestones which build the unit are very rich in CaO (50–55%), porous and poorly bedded. Lithology is rather diversified but oncolitic limestones are most characteristic. Microoncoids prevail generally in the unit but sometimes there appear also larger oncoids up to 3 cm in diameter. Other carbonate grains like bioclasts, pellets, ooids are less common. Thick micritic intercalations are relatively often. Diceratids and nerineids appear in the unit in monospecific or slightly taxonomically diversified assemblages within the biostromes intercalated with micritic limestones (L. Karczewski, 1969; J. Wieczorek, 1979). Corals can be found sporadically. They form isolated, spherical *patch reefs* up to 1.5 m in diameter.

The thickness of the unit ranges from 30–35 m in the Bałtów region to more than 50 m in the Wierzbica–Iłża region. In the vicinity of Iłża one can observe the *banded chert level* near the top of the unit. The level continues to the SE direction and can be correlated in several sections in the Bałtów–Ożarów region (*cf.* W. Pożaryski, 1948; J. Gutowski, 1992).

BŁAZINY OOLITE LIMESTONES (*Bol*)

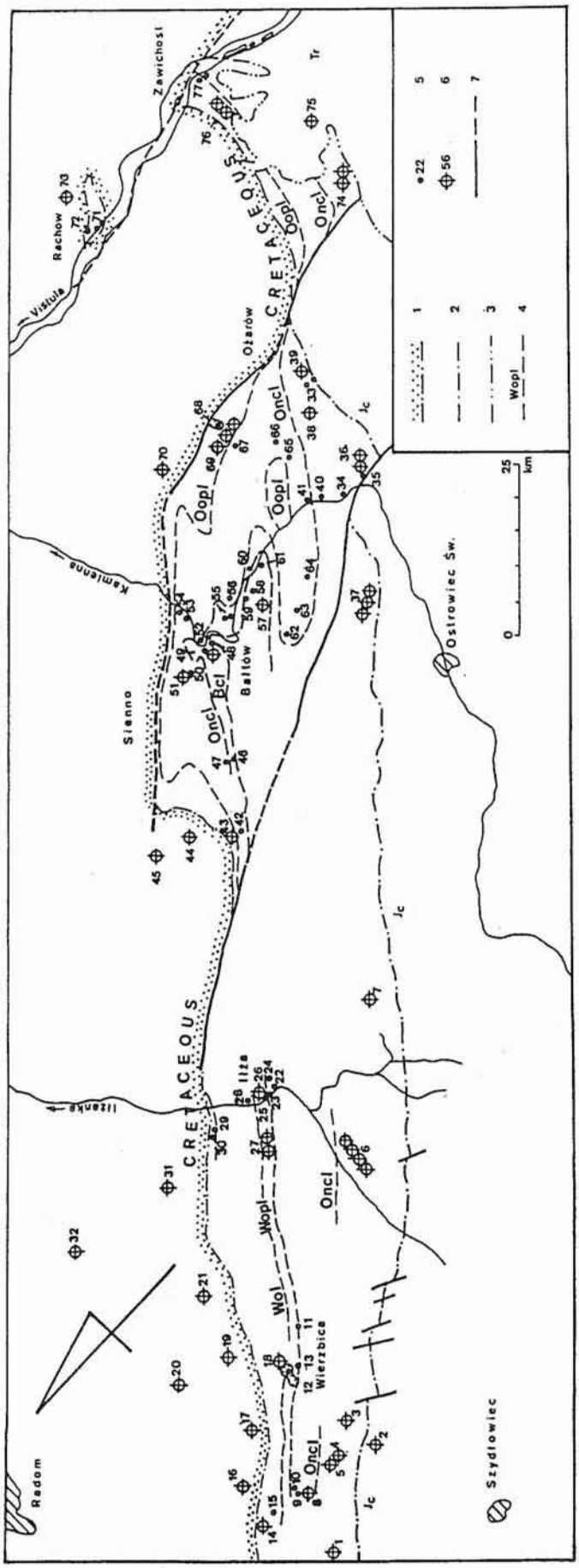
The unit is exposed in the vicinity of Błaziny and Iłża. It is mainly composed of CaO rich (up to 56%), fine-grained oolitic limestones without fauna. They are commonly cross-bedded, and sometimes they are intercalated with laminites bearing fenestral and teepee structures. In the upper part of the unit there appear also fine bioclastic grainstones and micrites with fauna of nerineids, bivalves and rynchonellids. The top of the unit is underlined by regional sedimentary discontinuity characterized by a hardground and *chocolate chert level* situated directly below the hardground. The total thickness of the unit is 35–40 m.

SKARBKA OOLITE LIMESTONES (*Sol*)

The unit is exposed in the vicinity of Skarbka, Gliniany and Krzemionki Opatowskie. Its thickness attains about 90–110 m. In the lowermost part of the unit, in Lipniki and Wólka Bałtowska, abundant remains of coalified plant remains appear in oolitic, bioclastic and/or micritic limestones (J. Liszkowski, 1972, 1976). Very delicate leaves and branches are often well preserved. Above the level with plant remains, one can observe micritic limestones intercalated with cross-bedded oolites (Śródborze, Sachalin, Krzemionki Opatowskie) in which the *banded chert level* appears (Krzemionki Opatowskie, Skarbka, Śródborze). The *Sol* unit is in its upper part similar to the *Bol* unit. Cross-bedded oolitic limestones without fauna are typical for this part of the section (Skarbka). They are sometimes intercalated with laminites bearing fenestral and teepee structures. In the uppermost part of the unit bioclastic and micritic limestones with nerineids, bivalves and brachiopods are more common (Gliniany). The top of the unit is characterized by the hardground associated with *chocolate chert level* (Ożarów) which can be observed also in the top of *Bol* unit near Iłża, Wierzbica and Marylin–Śniadków.

WIERZBICA OOLITE AND PLATY LIMESTONES (*Wopl*) AND OŻARÓW OOLITE AND PLATY LIMESTONES (*Oopl*)

These units are very similar and are established in the Wierzbica–Iłża and Bałtów–Ożarów regions, respectively. They both are exposed in large quarries of the cement works in Wierzbica and Ożarów (see Fig. 3) and in the classic outcrops of the Zamkowa Hill in Iłża.



The section of both the units begins with a layer of bioclastic packstone which is about 2 m thick and can be observed in Wierzbica, Wymysłów–Marianów and Ożarów. The layer contains abundant bivalves of the genus *Pholadomya* which are preserved in their life position. The section continues with micritic limestones and marls (Wierzbica) and oolitic-bioclastic grainstones which are often cross-bedded. They pass often laterally into micritic limestones and/or micritic limestones with thin intercalations of oolites which are lenticular or flaser-bedded (Wierzbica, Ożarów, Iłża). Overlying are thin-bedded micritic limestones of the lithographic type, often intercalated with thin bioclastic laminae which are flaser-bedded. Thicker intercalations of such a type appear occasionally in a form of lenses up to 1.5 m thick. They are usually cross-bedded and green due to glauconite content. Additionally, they also contain common remains of coalified flora and even large trunks of *Cycadaceae* (Wierzbica). The top of the *Wopl* unit represents a regional discontinuity expressed by hardground which is sometimes cut by erosional scours and channels up to 1.5 m deep (Wierzbica). In Ożarów, erosional structures are less distinct. A bioclastic packstone with corals appears in the top of *Oopl* unit (Ożarów, Fig. 3).

Both the *Wopl* and *Oopl* units have a similar thickness ranging between 60.0–61.5 m in Wierzbica and 57.5–58 m in Ożarów. In comparison to the older units like *Bol* and *Sol* units the discussed deposits are definitely more marly (average CaO content 40%) and thus they can be easily recognized in the field. The base of the discussed units was traditionally interpreted as the Astartian/Kimmeridgian boundary (J. Samsonowicz, 1934). Discussed lithological change is also connected with a distinct change in composition of benthic assemblages. The assemblage dominated by diceratids and rynchonellids is here rapidly replaced by oyster, terebratulid and myid dominated assemblage. Oolitic limestones which belong to the discussed younger units are always enriched in, mainly oyster derived, bioclasts which are, in turn, almost completely absent in oolites of the *Bol* and *Sol* units.

WIERZBICA OYSTER LUMACHELLE (*Wol*)

The unit consists of alternation of marls or micritic limestones and bioclastic packstones composed mainly of shells of the oyster *Nanogyra*. In the lower part of the unit very characteristic *Lopha* bed appears (Wierzbica). The bed is of a biostromal nature and it abounds in diversified

Fig. 2. Geological map of the NE margin of the Holy Cross Mts.
1 — base of the Cretaceous; 2 — base of the Upper Jurassic; 3 — northern limit of the Miocene of the Carpathian Foredeep; 4 — base of the lithostratigraphic units described in text; 5 — exposure; 6 — well; 7 — major flexures and faults; Tr — Tertiary; Jc — Callovian

Mapa geologiczna północno-wschodniego obrzeżenia Gór Świętokrzyskich
1 — spąg kredy; 2 — spąg jury górnej; 3 — północny zasięg miocenu zapadliska przedkarpackiego; 4 — spąg jednostek litostratygraficznych opisanych w tekście; 5 — odsłonięcia; 6 — otwory wiertnicze; 7 — główne fleksury i uskoki; Tr — trzeciorzęd; Jc — kelowej

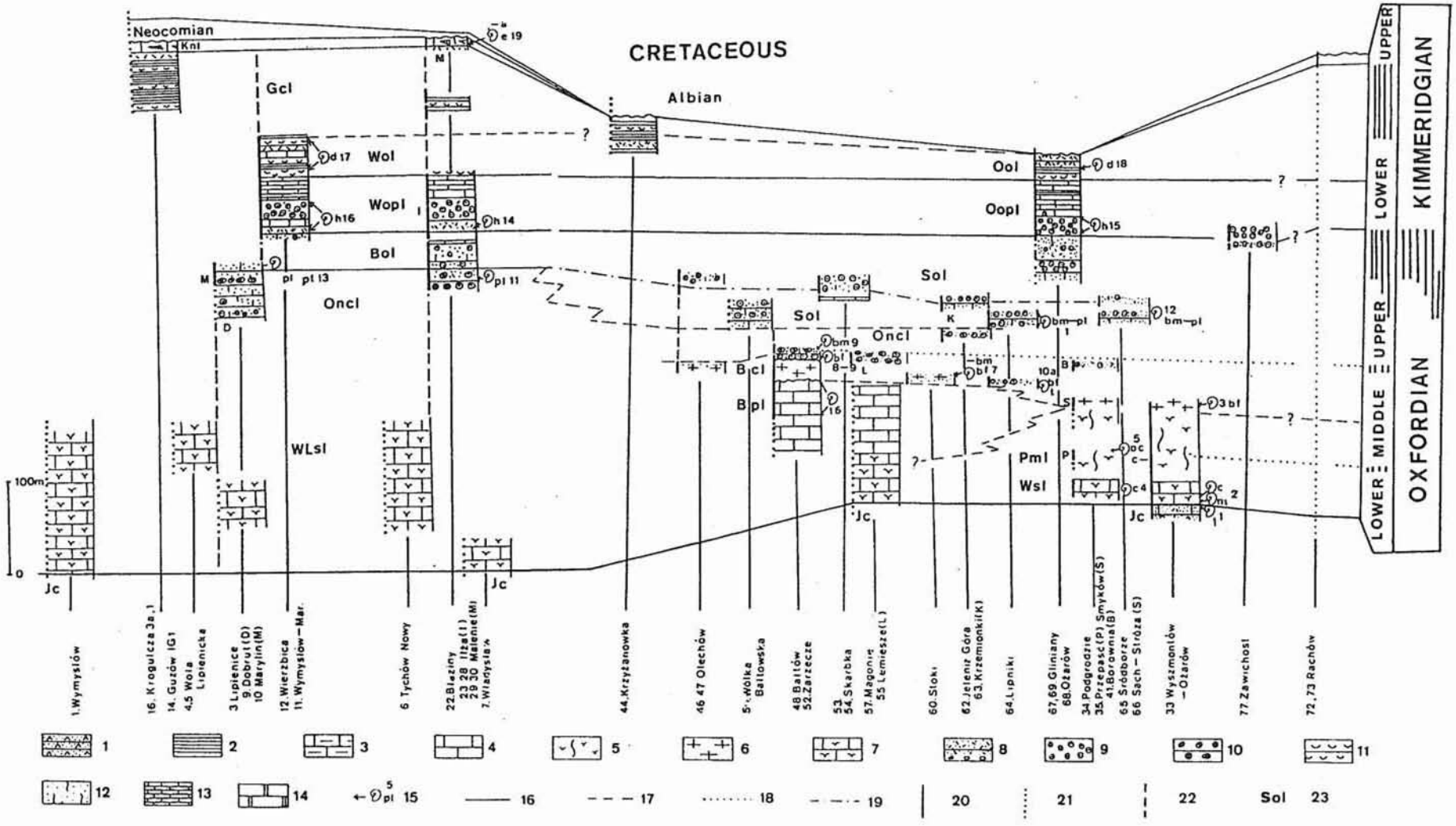


Fig. 3. Correlation of the Upper Jurassic stratigraphic sections in the NE margin of the Holy Cross Mts.
1 — gaizes, 2 — clays and marls, 3 — marly limestones, 4 — micritic limestones, 5 — sponge-algal bioherms, 6 — coral bioherms, 7 — sponge bedded limestones, 8 — biogenic and intraclastic grainstones and packstones, 9 — oolites, 10 — oncolites, 11 — oyster shell-beds, 12 — chalky limestones, 13 — laminites, 14 — dolomites, 15 — ammonite locality discussed in text, 16 — time correlation lines (boundaries of the sedimentary sequences and both chronostratigraphic and lithostratigraphic units), 17 — boundaries of the lithostratigraphic units, 18 — biostratigraphic correlations, 19 — *banded chert level*, 20 — outcrops, 21 — well-logs, 22 — thickness measured using width of exposure, 23 — names of the lithostratigraphic units described in text; ammonite zones: m — *mariae*, c — *cordatum*, pc — *plicatilis*, t — *transversarium*, bf — *bifurcatus*, bm — *bimammatum*, pl — *planula*, pt — *platynota*, h — *hypselocyclum*, d — *divisum*, e — *eudoxus*, a — *autissiodorensis*
Korelacja profili jury górnej północno-wschodniego obrzeżenia Gór Świętokrzyskich
1 — gezy, 2 — iły i margle, 3 — wapienie margliste, 4 — wapienie mikrytowe, 5 — biohermy gąbkowo-glonowe, 6 — biohermy koralowe, 7 — uławicone wapienie gąbkowe, 8 — wapienie z intraklastami i organodetrytyczne, 9 — oolity, 10 — onkolity, 11 — muszlowce ostrygowe, 12 — wapienie kredowate, 13 — laminity, 14 — dolomity, 15 — stanowiska amonitów omówione w tekście, 16 — izochroniczne linie korelacyjne (granice sekwencji sedymentacyjnych oraz jednostek chronostratygraficznych i litostratygraficznych), 18 — korelacje biostratygraficzne, 19 — poziom krzemieni pasiastych, 20 — odsłonięcia, 21 — profile otworów wiertniczych, 22 — miąższość mierzona z szerokości wychodni, 23 — jednostki litostratygraficzne opisane w tekście; poziomy amonitowe — patrz tekst angielski

bivalves and brachiopods (A. Seilacher *et al.*, 1985; M. Machalski, 1993) among which *Lopha gregarea* (Sowerby) is most characteristic. The *Lopha* bed is a good stratigraphic marker and it can be correlated between Wierzbica and Iłża sections (J. Kutek, 1983). Overlying are bioclastic packstones which are often glauconite-rich. In the upper part of the unit, one can observe a level of *Nanogyra virgula* (Defrance) lumachelle which is about 2.5 m thick (Wierzbica). The total thickness of the unit is 31–33 m in the Wierzbica cement works quarry.

OŻARÓW OYSTER LUMACHELLE (*Ool*)

This unit attains 30 m of thickness. Its top is erosionally cut and it is overlain by the Albian sandstones. In Ożarów, the lowermost part of the unit is composed of a characteristic bed with terebratulids, rynchonellids and oysters of the genus *Nanogyra*. Higher up in the section, cross-bedded oyster lumachelle (bioclastic grainstone) with glauconite is dominating. It is sometimes intercalated with marls.

GUZÓW CLAYS AND LUMACHELLES (*Gcl*)

The lowermost part of this unit is exposed above the *Wol* unit in the Wierzbica quarry. In the Guzów IG 1 well they have reached not complete thickness of 50 m. These are grey or ash-grey marly clays with thin, usually no more than 10 cm thick intercalations of lumachelles with *Nanogyra virgula* (Defrance). On the upper surface of such layers, accumulations of flat oysters of the genus *Deltoideum* appear. Such accumulations can be also observed in the uppermost part of the *Wol* unit in the Wierzbica quarry (M. Machalski, 1989). In the clays, thin shelled bivalves *Nicaniella*, large oysters *Gryphaea* and fragments of ammonites are relatively abundant. In the uppermost part of this unit, a bioclastic oyster lumachelle level is exposed in Malenie. This lumachelle contains abundant quartz grains, glauconite and pebbles of black cherts (Z. Dąbrowska, 1983*a*). Discussed level attains its maximum thickness of 15–20 m in Malenie and in the wells near Krogulcza. It is thinning in the NW direction down to a few centimetres in wells of the Przytyk–Dęba region (W. Pożaryski *et al.*, 1958).

KRZYŻANOWICE NERINEID LIMESTONE (*Knl*)

The unit overlies the *Gcl* unit between Krogulcza and Krzyżanowice–Malenie and it is also present in the Annopol Anticline. It is composed of yellowish bioclastic packstones-grainstones which contain a rich nerineid fauna (L. Karczewski, 1960; J. Wieczorek, 1979) and intercalations of yellowish marls. Top of the unit contacts erosionally with the Cretaceous deposits (Fig. 4). The observed thickness reaches 8 m in the vicinity of Krzyżanowice and 6 m in Rachów. The unit is replaced in the NW direction by marls of the Przytyk–Dęba region (W. Pożaryski *et al.*, 1958).

BIOSTRATIGRAPHY

Application of the Submediterranean zonal scheme of E. Cariou *et al.* (1971) was discussed and accepted for the Upper Jurassic sequence of Central Poland (A. Wierzbowski, 1966; J. Kutek, 1968; J. Kutek *et al.*, 1974; W. Brochwicz-Lewiński, 1976; B. A. Matyja, 1977; B. A. Matyja *et al.*, 1989). It is also accepted in this paper.

The Lower Oxfordian and lower part of the Middle Oxfordian strata are relatively well documented by ammonite record. In turn, upper parts of the Upper Jurassic section, especially in the case of Upper Oxfordian and Upper Kimmeridgian strata, have very poor ammonite record. Thus, the zones' boundaries can be only approximated in many cases (Fig. 3).

LOWER OXFORDIAN AND LOWER PART OF THE MIDDLE OXFORDIAN

The oldest Oxfordian ammonite fauna has been collected from layers up to the level 3.5 m above the top of gaizes (ammonite locality 1 in Fig. 3). This fauna is dominated by perisphinctids. Oppellids are less frequent and, surprisingly, cardioceratids are rather rare. These ammonites represent forms characteristic for the *mariae* Zone. A specimen of *Rursiceras* sp., typical for higher part of this zone, have been found 3.5 m above the top of gaizes. The *cordatum* Zone comprises at least the strata of the Wyszmontów sponge limestones unit (*Wsl*) occurring in the interval from 3 to about 45 m above the top of gaizes. This is confirmed by finding such forms as *Peltoceratoides* sp. and *Parawedekindia* sp. (ammonite locality 2 in Fig. 3) which are known from the *Bukowskii* and *Costicardia* Subzones (*cf.* B. A. Matyja, 1977).

Higher up in the section of the *Pml* unit (ammonite locality 5 in Fig. 3) there occur ammonites of the genus *Cardioceras*, the characteristics of which are typical rather for late forms of the genus (B. A. Matyja, personal com.). L. Malinowska (1965) illustrated from Przepaść *Glochiceras distortum* (Bukowski) and *Scaphitoides paucirugatus* (Bukowski) which are also typical for the both mentioned subzones. Representatives of the genera *Peltoceratoides* and *Parawedekindia*, which are common in older strata, have not been found in the discussed interval of the section. This suggests that the fauna from Przepaść represents, most probably, higher part of the *cordatum* or *tenuicostatum* Subzones of the *plicatilis* Zone of the Middle Oxfordian.

TRANSVERSARIUM AND *BIFURCATUS* ZONES

The fauna from the *Bpl* unit (ammonite locality 6 in Fig. 3) is dominated by perisphinctids, among which representatives of *Perisphinctes* (*Dichotomosphinctes*) ex. gr *wartae* (Siemiradzki) can be identified. Additionally, *Ochetoceras canaliculatum* (Buch) and *Subdiscosphinctes* (*Aureimontanites*) sp. have been found. L. Malinowska (1967, tabl. 2, fig. 6a, b) illustrated *Taramelliceras anar* (Oppel) that was found in Bałtów. Most diagnostic among the listed forms are the perisphinctids, which are known only from the *transversarium* Zone (R. Enay, 1966). Absence of any older forms like *P.* (*Dichotomosphinctes*) *antecedens* suggests rather a higher part of this Zone. The other listed ammonites occur also in the *plicatilis* Zone, and in the case of the two mentioned species, also in the lower part of the *bifurcatus* Zone. It can be concluded, in agreement with the opinion of W. Brochwicz-Lewiński and J. Liszkowski (1976), that the 30 m thick upper part of the *Bpl* unit, which is exposed in Bałtów, belongs to the *transversarium* Zone. The boundary between the *plicatilis* and *transversarium* Zones runs, therefore, below these deposits, and not in the top of the *Bpl* unit as it was suggested by J. Liszkowski (1976). The *transversarium* Zone has not been documented in the *Pml* unit. In the uppermost part of this unit, in Wyszmontów–Ożarów (ammonite locality 3 in Fig. 3), a poorly preserved specimen of *Perisphinctes* (*Dichotomoceras*) sp. has been found. It is indicative of the *bifurcatus* Zone (*cf.* R. Enay, 1966; W. Brochwicz-Lewiński, 1976). Deposits of the *Bcl* unit at Zarzecze yielded *Perisphinctes* (*Perisphinctes*) cf. *panthieri* Enay (Pl. II, Fig. 1). The following ammonites have been listed form this locality: *P.* (*Dichotomoceras*) *bifurcatus* (W. Brochwicz-Lewiński, J. Liszkowski, 1976), *Nebrodites* (*Passendorferia*) sp. (W. Brochwicz-Lewiński, Z. Różak, 1976, pl. 34, fig. 1; pl. 35, fig. 1). All these forms are representative for the *bifurcatus* Zone.

J. Liszkowski found in Bałtów within the section of *Bcl* unit: *Subdiscosphinctes* (*Subdiscosphinctes*) ex. gr *mindowekreutzi* (Siemiradzki), *S.* (*Aureimontanites*) sp., and within the lower part of the *Oncl* unit: *Microbiplices microbiplex* (Quenstedt) (Pl. I, Fig. 2). Both these ammonites of the genus *Subdiscosphinctes* are known from the higher part of the *transversarium* and *bifurcatus* Zones (W. Brochwicz-Lewiński, 1975) whereas the genus *Microbiplices microbiplex* (Quenstedt) occurs in the *hypselum* Subzone of the *bimammatum* Zone (R. Enay, 1966; A. Wierzbowski, 1978). The species *Taramelliceras* (*Strebliticeras*) *externnodosum* (Dorn) (Pl. I, Fig. 7) found in Stoki (ammonite locality 7 in Fig. 3) is known from the *bifurcatus* Zone and also the lower part of the *bimammatum* Zone. The ammonites found by J. Liszkowski in the abandoned and recently filled quarry of the Ostrowiec Świętokrzyski steel-works called "Lipniki" (ammonite locality 10a in Fig. 3) can be assigned to *P.* (*Dichotomoceras*) *bifurcatoides* Enay (Pl. II, Fig.5). One specimen of *Perisphinctes* (*Dichotomosphinctes*) ex. gr *wartae* (Siemiradzki) comes also from this locality. In the neighbouring, still existing quarry (ammonite locality 10 in Fig. 3) the present author collected badly preserved specimens of *Orthosphinctes* (*Orthosphinctes*) cf. *freybergi* (Geyer) and *O.* (*Lithacosphinctes*) sp. These ammonites indicate that the lower part of the Lipniki section belongs to the upper part of the *transversarium* Zone and to the *bifurcatus* Zone whereas the higher part of the section, that exposed in the recently existing Lipniki quarry, belongs most probably to the *bimammatum* Zone.

The fauna from ammonite localities 3, 7, 8, 9, 10 and 10a allows to delimit the upper boundaries of the *transversarium* and *bifurcatus* Zones. The upper boundary of the *transversarium* Zone runs in the vicinity of Bałtów between the ammonite localities 6 and 8, while in the Wyszmontów–Ożarów area it runs somewhere below the ammonite locality 3 and within the locality 10a.

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The lower boundary of the *bimammatum* Zone runs in Bałtów somewhere from 10 to 20 m above the base of the *Oncl* unit and it is indicated by the appearance of *Microbiplices microbiplex* (Quenstedt). The presence of the *bimammatum* Zone is also documented by the fauna from ammonite locality 10 (Lipniki).

The higher part of the Upper Oxfordian is not unequivocally documented in the Bałtów–Ożarów region. The ammonite *Orthosphinctes* (*Pseudorthosphinctes*) sp. (Pl. II, Fig. 3) found in the ammonite locality 12 has been recorded from the *bimammatum* and lower part of the *planula* Zone (F. Atrops, 1982). In the Wierzbica–Iłża region, the *planula* Zone is documented by the appearance of *Idoceras* (*Subnebrodites*) sp. (*cf.* B. A. Matyja *et al.*, 1989 and references cited therein) in the ammonite locality 11 (Pl. I, Fig. 1).

LOWER KIMMERIDGIAN

In the uppermost part of the *Oncl* unit (ammonite locality 13 in Fig. 3) and in the lowermost part of the *Wopl* unit (ammonite locality 16 in Fig. 3) the representatives of the genus *Rasenia* (*Eurasenia*) have been found. The last locality also yield *Ataxioceras* sp. Specimens of *Rasenia* (*Eurasenia*) have been also illustrated by Z. Dąbrowska (1983*b*, pl. 1 and 2) from Iłża (ammonite locality 14 in Fig. 3). The ammonites of the subgenus *Eurasenia* are known from the uppermost part of the *planula* Zone (A. Wierzbowski, 1978) and from the whole Lower Kimmeridgian but their most common appearance is observed within the *platynota* and *hypselocyclum* Zone (O. F. Geyer, 1961). The genus *Ataxioceras* occurs in the *hypselocyclum* Zone and rarely in the upper part of the *platynota* Zone (F. Atrops, 1982). Therefore, the boundary between the *planula* and *platynota* Zones runs in the Wierzbica–Iłża region somewhere above the ammonite locality 11 and near the ammonite locality 13. This boundary can not be indicated in the Bałtów–Ożarów region. The *hypselocyclum* Zone is documented by the following ammonite findings: *Ataxioceras* sp., *Rasenia* (*Eurasenia*) sp., *R.* (*Pachypictonia*) sp. (ammonite locality 16 in Fig 3; Pl. II, Fig. 2) and *R.* (*Pachypictonia*) sp., *Orthosphinctes* (*Ardescia*) sp. and *Orthosphinctes* (*Lithacosphinctes*) sp. (ammonite locality 18 in Fig. 3). The fauna from these two localities is similar to that

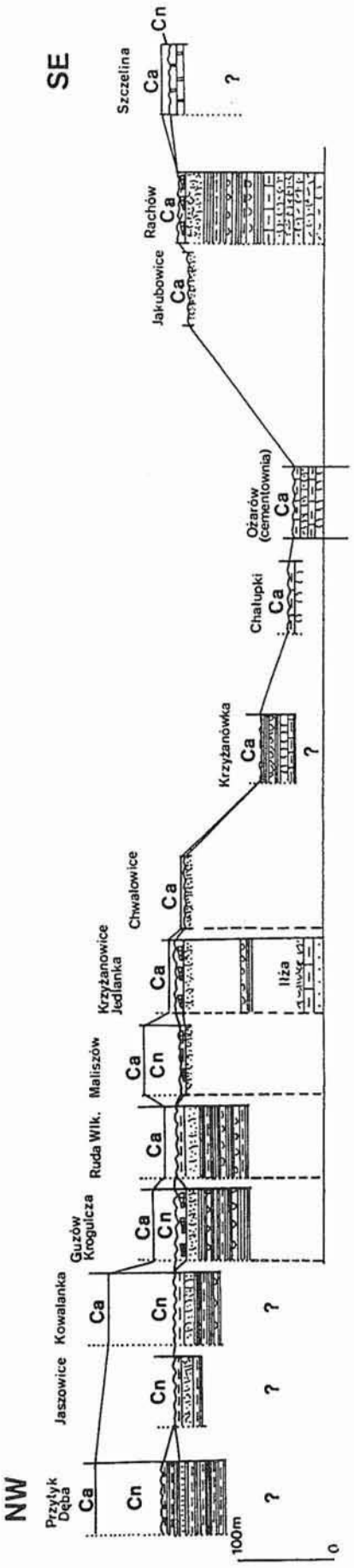

Fig. 4. Neocimmerian erosional gap
Ca — Albian, Cn — Neocomian; bottom line indicates a base of the *Wol* and *Ool* lithostratigraphic units; other explanations as in Fig. 3

Neokimeryjskie ścięcie erozyjne
Ca — alb, Cn — neokom; linia u podstawy oznacza spąg jednostek *Wol* i *Ool*; pozostałe objaśnienia jak na fig. 3

described from the *hypselocyclum* Zone of the SW margin of the Holy Cross Mts. (J. Kutek, 1968). Lower boundary of the *hypselocyclum* Zone runs somewhere below the discussed ammonite localities.

The lowermost part of the *Wol* unit yield in the Wierzbica quarry the following specimens (ammonite locality 17 in Fig. 3): *Ataxioceras* (*Ataxioceras*) *hypselocyclum hypselocyclum* (Fontannes) (Pl. I, Figs. 3, 4) — 4 m above the top of the *Lopha* bed (Fig. 3) and *Crussoliceras* sp. — 1.5 m above the top of the *Lopha* bed. These genera occur together in the Submediterranean province only in the *semistriatum* Zone of the *lothari* Subzone, that is in the uppermost part of the *hypselocyclum* Zone *sensu* F. Atrops (1982). This horizon should be included into the *divisum* Zone *sensu* O. F. Geyer (1961) (*cf.* J. Kutek, 1968). The lower boundary of the *divisum* Zone was defined by O. F. Geyer (1961) by first appearance of the representatives of the genus *Crussoliceras*. This definition is also accepted in this paper. Consequently, the lower boundary of the *divisum* Zone runs directly below the ammonite locality 17. Higher up in the section of the Wierzbica quarry (ammonite locality 17 in Fig. 3), only representatives of the genera *Crussoliceras* and *Garnierisphinctes* occur (Pl. II, Fig. 4; Pl. I, Fig. 6). One specimen, assigned as *Crussoliceras* sp. was also found about 20 m above the top of the *Ool* unit in Ożarów (ammonite locality 18 in Fig. 3). Therefore, it can be concluded that the lower boundary of the *divisum* Zone runs in the whole investigated area somewhere around the base of the *Wol* and *Ool* units.

UPPER KIMMERIDGIAN

Indistinguishable fragments of ammonites bearing perisphinctid ribbing have only been found in the uppermost part of the *Wol* unit and within the *Gcl* unit. Z. Dąbrowska (1957) listed a specimen of *Amoeboceras (Nannocardiceras)* cf. *anglicum* (Salfeld) from the *Knl* unit (ammonite locality 19 in Fig. 3). This species indicates a Late Kimmeridgian age, excluding upper part of the *autissiodorensis* Zone (Z. Dąbrowska, 1983*a*; J. Kutek, 1983) and most probably also the *mutabilis* Zone.

CONTACT OF UPPER JURASSIC AND CRETACEOUS

The original thickness of the Upper Jurassic deposits has been reduced due to the Neocimmerian erosion (Fig. 4). Most complete section can be observed in the NW and SE margins of the investigated area. In the boreholes of the Przytyk–Dęba region the Neocomian clays overlie the Lower Volgian clays (W. Pożaryski *et al.*, 1958). In the borehole of Szczelina (near Zaklików, Lublin Upland) the Neocomian deposits (S. Cieśliński, W. Pożaryski, 1970) contact with the dolomites of the Urzędów Formation which is of the Late Kimmeridgian age (T. Niemczycka, 1976*a*, *b*). The Early Cretaceous erosion reached its maximum in the Ożarów region (*cf.* W. Pożaryski, 1948) and resulted in maximum Neocimmerian erosional gap.

The Albian sandstones overlie here the oyster lumachelle which belongs to the *divisum* Zone of the Lower Kimmeridgian. To the NW and SE the Jurassic section gradually becomes to be more complete (Fig. 4). The contact of Lower Kimmeridgian oolites and Albian sandstones observed in Zawada in southern part of Tarłów Graben (A. Łuniewski, 1923; W. Pożaryski, 1948) is distinctly of a tectonic nature (J. Samsonowicz, 1932).

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OKSFORD I KIMERYD PÓŁNOCNO-WSCHODNIEGO OBRZEŻENIA GÓR ŚWIĘTOKRZYSKICH

Streszczenie

Opracowanie przedstawia syntezę lito- i biostratygrafii utworów górnojurajskich północno-wschodniego obrzeżenia Gór Świętokrzyskich (fig. 1), odsłaniających się między Dobrutem i Wierzbicą, w okolicach Iłży, w dolinie Kamiennej od Przepaści, przez Bałtów po Skarbkę oraz nad Wisłą w Zawichoście i Rachowie. Na podstawie 76 profili z odsłonięć i otworów wiertniczych (fig. 2) wyróżniono 13 nieformalnych jednostek stratygraficznych. Obejmują one zarówno osady dolnego i niższej części środkowego oksfordu (fig. 3), wykształcone w facji gąbkowej i mikrytowej otwartego szelfu, jak i utwory płytkowodnej facji platformy węglanowej, tworzone od przełomu poziomów *transversarium* i *bifurcatus*, a wykształcone początkowo jako wapienie biogeniczne z koralami, a następnie wapienie onkolitowe, oolitowe oraz laminity i wreszcie (od poziomu *divisum*) — muszlowce ostrygowe i margle. Na podstawie kolekcji amonitów obejmującej 94 okazy udokumentowano następujące poziomy amonitowe: *mariae*, *cordatum*, *plicatilis*, *transversarium*, *bifurcatus*, *planula*, *hypselocyclum* oraz *divisum* (fig. 3). W wyniku neokimeryjskiego ścięcia erozyjnego utwory neokomu lub albu kontaktują z różnymi ogniwami górnej jury (fig. 4). Najgłębiej neokimeryjska erozja sięgnęła w rejonie Ożarowa, gdzie piaskowce albu kontaktują bezpośrednio z muszlowcami ostrygowymi poziomu *divisum*.

EXPLANATIONS OF PLATES

PLATE I

Fig. 1. *Idoceras* (*Subnebrodites*) sp.
Ammonite locality 11, exposure 22-Błaziny, *planula* Zone

Fig. 2. *Microbiplices microbiplex* (Quenstedt)
Ammonite locality 9, exposure 48-Bałtów, *bimammatum* Zone

Figs. 3, 4. *Ataxioceras* (*Ataxioceras*) *hypselocyclum hypselocyclum* (Fontannes)
Ammonite locality 17, exposure 12-Wierzbica, *divisum* Zone

Fig. 5. *Rasenia* (*Eurasenia*) cf. *vernacula* Schneid
Ammonite locality 13, exposure Marylin–Śniadków, *planula* or *platynota* Zone

Fig. 6. *Garnierisphinctes semigarnieri* (Geyer)
Ammonite locality 17, exposure 12-Wierzbica, *divisum* Zone

Fig. 7. *Taramelliceras* (*Strebliticeras*) *externnodosum* (Dorn)
Ammonite locality 7, exposure 60-Stoki, *bifurcatus* Zone

PLATE II

Fig. 1. *Perisphinctes* (*Perisphinctes*) cf. *panthieri* Enay
Ammonite locality 8, exposure 52-Zarzecze, *bifurcatus* Zone, x 0.32

Fig. 2. *Rasenia* (*Pachypictonia*) sp.
Ammonite locality 15, exposure 68-Ożarów, *hypselocyclum* Zone, x 0.32

Fig. 3. *Orthosphinctes* (*Pseudorthosphinctes*) sp.
Ammonite locality 12, exposure 66-Sachalin–Stróża, *bimammatum* or *planula* Zone, x 0.32

Fig. 4. *Crussoliceras atavum* (Schneid)
Ammonite locality 17, exposure 12-Wierzbica, *divisum* Zone, x 0.63

Fig. 5. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* Enay
Ammonite locality 10a, exposure Lipniki, *bifurcatus* Zone, x 0.63

All photos taken by S. Kolanowski

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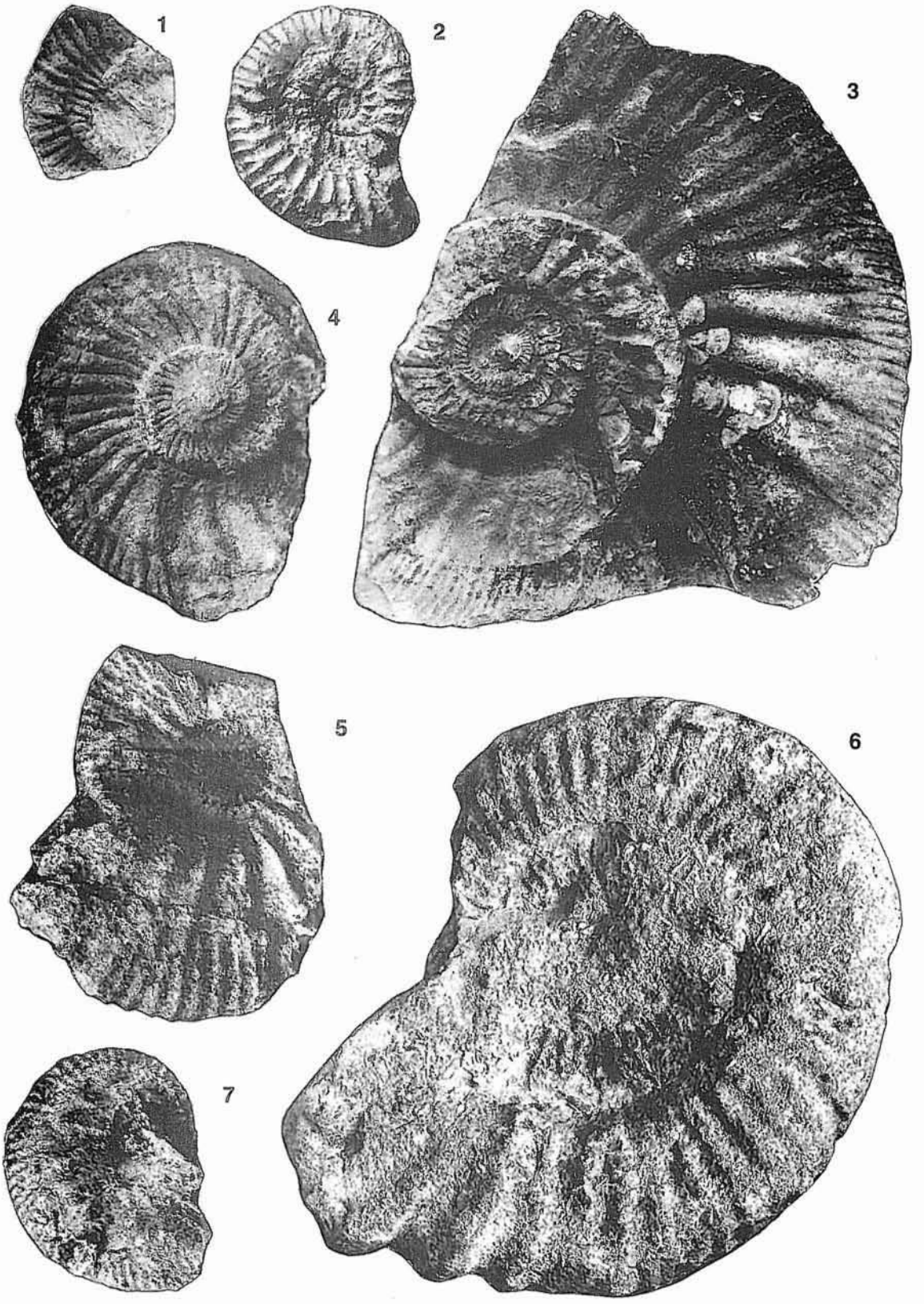
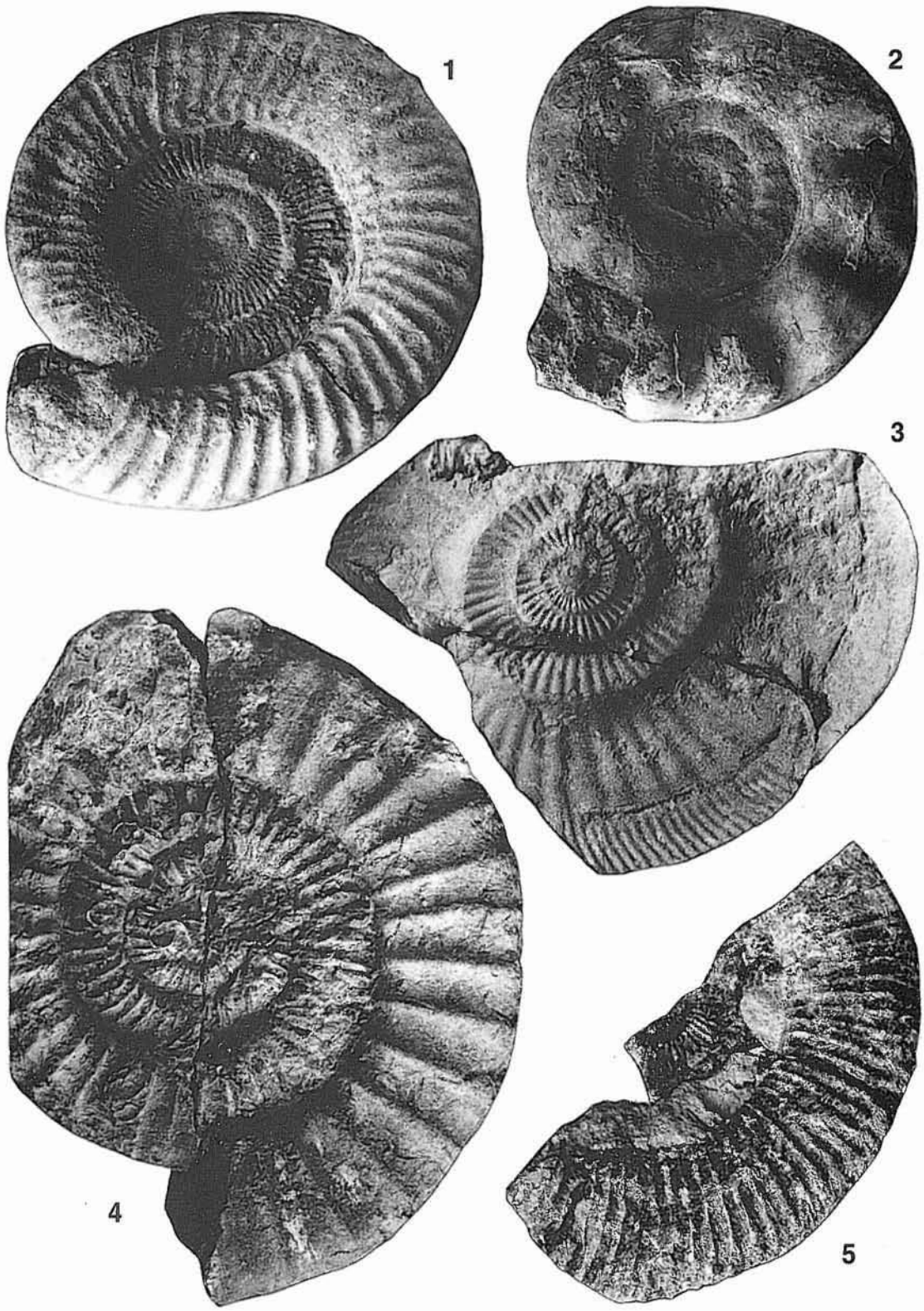


Jacek GUTOWSKI — Oxfordian and Kimmeridgian of the northeastern margin of the Holy Cross Mountains, Central Poland



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