UPPER JURASSIC CHALKY LIMESTONES IN THE ZAKRZÓWEK 
HORST, KRAKÓW, KRAKÓW–WIELUŃ UPLAND (SOUTH POLAND)

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Abstract: Chalky limestones in the Zakrzówek Horst were laid down in small sponge-microbolite biostromes that 
provided stable foundation for the growth of extensive sponge-“Tubiphytes” biostromes forming the nodular 
limestones in the Zakrzówek area. The ammonites occurred in chalky limestones indicate that the studied deposits 
belong to the youngest palaeontologically documented Upper Jurassic limestones in the Kraków area (Planula 
zone). The vertical succession of fauna and facies characteristics indicate progressive shallowing of the 
environment at the end Oxfordian, from deeper shelf to shallower water.

Key words: Carbonate buildups, microfacies, background sedimentation rate, Upper Jurassic, Kraków, Southern 
Poland.

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INTRODUCTION

Chalky limestones are present in the Kraków Upland in 
only a few outcrops within the small tectonic element – the 
Zakrzówek Horst (Figs 1, 2). The rare occurrence of these 
limestones in the Kraków area is in clear contrast with the 
other areas of occurrence of Upper Jurassic rocks in Poland, 
where the chalky limestones are one of the dominant litho-
logical varieties.

This paper presents the description of the lithology, fa-
cies and microfacies variation of the chalky limestones and 
their adjacent sediments. An attempt is also presented at the 
interpretation of the depositional environment of the chalky 
limestones.

GEOLOGICAL BACKGROUND

The studied area lies in the southern part of the 
Kraków–Wieluń Upland and from tectonic point of view it 
is a fragment of the Carpathian Foredeep (Rutkowski, 
1993). Characteristic for the area are numerous horsts built 
mainly of Mesozoic rocks and surrounded by a system of 
faults; tectonic grabens are filled with Miocene clays (Fig. 1). The main faults in the Zakrzówek Horst are oriented 
SW–NE and NW–SE and have vertical displacements of ca. 
200 m (Rutkowski, 1993). Besides the main faults the pres-
ent author found smaller ones near Twardowski Rocks and 
Księża Hill; their amplitudes are from a few to nearly 
twenty metres (they are not shown in Figs 1, 2). Individual 
blocks between the faults are inclined at various angles, 
forming fault benches. So in the area of Twardowski Rocks 
the strata are inclined 3–5°, in the quarries Zakrzówek and 
Kapelanka they are nearly horizontal, while at Księża Hill, 
they dip at 20° SE (Gradziński, 1972). Moreover, Creta-
ceous abrasion surface and small tectonic grabens filled 
with Cretaceous marls are locally present.

The Zakrzówek Horst is built mainly of Oxfordian 
limestones which are up to 225 m thick. The limestones be-
long to the bedded facies (Dłużynski, 1952; Gradziński, 
1972) and they include numerous nodules and flat lenses of 
chert. Four main lithological types may be distinguished in 
the exposed bedded limestones: micritic, chalky, nodular 
and dolomite-bearing granular ones; all these types form 
distinctive horizons in vertical sequence and their total 
thickness is ca. 40 m (Fig. 3). A part of the limestones was 
subject to early diagenetic dolomitization (Łaptaś, 1974) 
and to epigenetic silicification (Matyszkiewicz, 1987).

Chalky limestones are a subordinate lithological variety 
in the Kraków area, they belong to the facies variety of the 
bedded limestones, hence they are scarcely reported in pub-
lications (Krobicki, 1984; Matyszkiewicz, 1987, 1993). 
These papers, dealing with outcrops situated within the 
Zakrzówek Horst, are dedicated to other topics, hence they 
do not include a thorough discussion of the origin and depo-
sitional environment of the chalky limestones. The most 
complete description of these outcrops is included in the pa-
per by Krobicki (1984) who found that the chalky lime-
Matyszewicz (1987, 1993) in short comments on the chalky limestones from Zakrzówek points to the chaotic arrangement of cherts, as contrasted with their arrangement in parallel horizons in the bedded limestones. This author also suggests that the chalky limestones could correspond to local inhomogeneities on the basin bottom, possibly related to the dense colonisation by benthos.

**METHODS AND TERMINOLOGY**

This study included field work and observation of thin sections under a polarising microscope. The field work included detailed mesoscopic study, vertically and laterally, of the chalky limestones and the compact limestones near the Jasna nad Wisłą Cave (Jasna Cave in short; name after Szelerewicz & Górny, 1986; Figs 2, 4), in Ostatnia Cliff (Figs 2, 5; name after Król & Barabasz, 1997) and the Zakrzówek Quarry (Fig. 2). The observations were also car-

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stones occur as lenses 4.0–4.5 m thick and ca. 4 m long. They are embedded in hard and compact bedded limestones. They include rich fauna, mostly sponges. Numerous are also brachiopods, small ammonites, casts of pelecypods, crabs and gastropods. The bedding partly disappears within the lenses due to the nodular nature of the limestone. Bedding is marked by horizons of chert nodules and flat lenses. Krobicki (1984) distinguished three horizons of the chalky limestones in his generalised profile and described their lithology only in the lowest horizon. The two lowest horizons lie at the altitudes 168 and 190 m above sea level (calculated from an unpublished profile by M. Krobicki, 1984). They were exposed in the Zakrzówek Quarry which is now abandoned and its lower part is now flooded, together with the exposures of the two lowest horizons of the chalky limestones. The highest of the three horizons lies at an altitude of 210–220 m and this is described here.

Fig. 1. Geological structure of the studied area (after Rutkowski, 1993, simplified)

Fig. 2. Location sketch of the study area (names of exposures after Szelerewicz & Górny, 1986 and Król & Barabasz, 1997)

Fig. 3. Synthetic section of the sediments in the Zakrzówek Horst (without the older sediments, now under water). 1 – chalky limestones; 2 – nodular limestones; 3 – dolomites; 4 – granular limestones; 5 – micritic limestones

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M. KRAJEWSKI
ried out within the massif in numerous caves whose total length attains ca. 1 km (A. Górny pers. commun., 1999). Because of the monotonous lithology of the chalky limestones and the difficult access to the outcrops, the detailed descriptions are provided only for the exposure in the Jasna Cave and in Ostatnia Cliff. A tentative name “chalky limestone horizon” has been accepted for the chalky limestones and other sediments at the same stratigraphical level. A total of 130 samples were collected and thin sections for microscopic study were made of them. The other parts of the studied outcrops were studied in detail mesoscopically. The study included also the limestones directly below and above the chalky limestones horizon. During the laboratory study, microfacies types were described according to the classification and terminology by Wright (1992) which in turn is based on that by Dunham (1962) and its later modification (Embry & Klovan, 1972).

CHALKY LIMESTONES

A total of eight exposures of chalky limestones have been found; four in the western, northwestern and southern walls of abandoned and partly drowned Zakrzówek Quarry (Fig. 2), three in abandoned Kapelanka Quarry in its fragment known as Ostatnia Ścianka (Figs 2, 5) and one at the entrance to the Jasna Cave (Figs 2, 4). All outcrops are situated at similar altitudes (210–220 m) and they make up the highest horizon of the chalky limestones.

Jasna Cave

The cave is situated in the Twardowski Rocks park, in a wall of an old quarry facing the Vistula River (Figs 2, 4). The exposed chalky limestones form a lens within hard, bedded limestones. The height and width of the lens are from a few to nearly twenty metres and its precise boundary is difficult to delineate. Laterally, the chalky limestones pass gradually into the harder, bedded limestones. They are light cream in colour; they smear fingers when touched. The bedding surfaces are not as distinct as in typical bedded limestones; they locally disappear and are marked only by the arrangement of cherts. Some of the cherts are arranged chaotically. Most of them do not exceed 8 cm in diameter. Their nuclei often include fragments of sponges and brachiopods. Fauna is abundant, represented mainly by sponges, brachiopods, gastropods, ammonites (see also section Stratigraphy) and belemnites. Among the brachiopods the most common are Dictyothyropsis cf. loricata, Sellithyris sp., Lacunosella cracoviensis (Quenstedt) and Septaliphoria cf. astieriana (d’Orbigny), (M. Krobicki, pers. commun., 1999; cf. Müller et al., 2000). The interiors of some brachiopod shells are not completely filled with sediment. Sponges occur in life position as well as redeposited. In the lower and middle parts of the lens they are hexactinellids with widely varying forms – from calices to narrow tubes. The sponge diameters vary from 2 to 10 cm. Microfacies in the lower parts of the lens are boundstone and wackestone (Figs 6, 7). The boundstone is composed of numerous pure clotted thrombolite (cf. Schmid, 1996; Leinfelder et al., 1996) encrusted with abundant serpules. Numerous growth voids and burrows are present, geopetally filled with internal sediment composed exclusively of peloids. The voids are less than 3 mm across. Fragments of siliceous sponges and echinoderm plates are also present.

Wackestone and boundstone (Figs 6, 7) predominate in the middle part of the lens. They are strongly differentiated and are mainly pure leiolite, layered leiolite (term after Braga et al., 1995; cf. Leinfelder et al., 1996; Riding, 2000) and micritic stromatolites, developed on sponge surfaces and poorly structured thrombolites. Fragments of siliceous sponges encrusted with serpules are also common.

In the upper parts of the lens, hexactinellids spoges are partly replaced by lithistids sponges, densely packed in sediment. They are accompanied by nektonic fauna, mainly ammonites and belemnite fragments. The ammonites include specimens 4–12 cm in diameter, preserved complete or in large fragments, many of them incompletely filled with sediment. The fossils do not display important deformations. All fossils are strongly lithified and embedded in soft sediment. The degree of compactness of the sediments and
the abundance and diversity of fauna increase from the assumed centre of the lens towards its margins.

Microbolites are less common in the upper part of the lens and these are mainly single pure leiolites on sponge outer surfaces. The sediment is mainly bafflestone-boundstone and wackestone-floatstone, less commonly packstone. The main components are fragments of calcareous and siliceous sponges and “Tubiphytes” morronensis (cf. Schmid, 1995, 1996) who are up to 0.8 mm across. The other components include gastropods, echinoderms, brachiopods, Terebellula lapilloides and numerous unidentifiable bioclasts.

Ostatnia Cliff

This exposure is situated at the western end of the abandoned quarry Kapelanka (Figs 2, 5). Ostatnia Cliff is 20 m high and 35 m long. The chalky limestones are exposed here in yellowish lenses a few metres thick and long. They are best visible in places from which rocks have fallen recently. In other places the chalky limestones are similar at surface to the typical hard, bedded limestones and only when struck with hammer they disintegrate into soft debris. They smear fingers upon touching, but are somewhat harder then the chalky limestones from the Jasna Cave. They include cherts only sporadically, and these do not exceed 6 cm in size. Fauna is frequent but less diversified than in the Jasna Cave.

Among the mesoscopically discernible faunal components, the most common are lithistid sponges, less common are hexactinellide sponges, brachiopods (mainly terebratulids).

The microfacies is mostly wackestone and bafflestone-boundstone. The lower parts of the lenses contain numerous poorly structured thrombolites and single pure leiolites on surfaces of numerous tuberoids built of fragmented siliceous sponges. The upper parts of the lenses include numerous “Tubiphytes” morronensis with diameters of 0.8 mm and calcareous sponges, while the numbers of leiolites and thrombolites decrease.

ENCOMPASSING SEDIMENTS OF THE CHALKY LIMESTONES

In the exposures in the Jasna Cave and in Ostatnia Cliff the chalky limestones pass laterally into compact bedded limestones (Figs 4, 5) whose microfacies is wackestone. Fauna includes small bioclasts of undetermined nature and fragments of echinoderms, brachiopods and “Tubiphytes”
UPPER JURASSIC CHALKY LIMESTONES

47

Fig. 10. Wackestone – floatstone with “Tubiphytes” morronensis; Księża Hill

Fig. 11. Wackestone – floatstone with Lithocodium aggregatum; Księża Hill

morronensis embedded in micritic matrix. “Tubiphytes” morronensis occur as branching and ovate forms, 0.5–0.8 mm across. Common are siliceous sponges up to 15 cm across and poorly structured thrombolites binding the sediment.

Below the chalky limestones horizon lies a horizon of micritic limestones with scarce fauna (cf. Peszat, 1991). They are more compact than the sediment in the chalky limestone horizon. The dominant microfacies is wackestone, sporadically mudstone built of predominant peloids, few tuberoids and less numerous boundstones, those built mainly micritic stromatolites, forming flat and dome-like forms, and of few layered leiolites.

The micritic limestones are overlain with the described chalky limestone horizon. The proportion of microbolites in the sediment increases in the transitional zone between the two horizons. These are mainly poorly structured thrombolites, less commonly micritic stromatolites. The chalky limestone horizon is 7 m thick on average and it is distinguished by the abundance of benthic and nektonic fauna. The horizon includes the chalky limestone lenses described above. The chalky limestone lenses usually pass upwards into nodular limestones (Figs 3, 8), sponge-microbolite and sponge-“Tubiphytes” morronensis, build mostly of sili-

Fig. 12. Nodular biostromes with columnar stromatolites. Księża Hill

Fig. 13. Floatstone – wackestone with scleractinian coral (fragment of colony? pers. commun. E. Morycowa, B. Kołodziej, 2001); Księża Hill

cceous and calcareous lithistid sponges successively overgrown upwards. Microfacies of the nodular limestones are mostly boundstone-bafflestone and wackestone and in most parts have the same lithology as the chalky limestones. These limestones include common peloidal stromatolites and less common micritic ones which include small growth voids and poorly structured thrombolites. Common are “Tubiphytes” morronensis 1 mm across and Terebella lapilloides, brachiopods (mostly terebratulids) and numerous unidentifiable bioclasts.

Above the horizon of nodular limestone lies a horizon built mainly of stromatolites (Fig. 9) which is ca. 1 m thick in Zakrzówek Quarry. Mesoscopically these are hard limestones with conchoidal fracture, resembling micritic limestones. The forms and internal structures of these stromatolites differ from those described earlier from Zakrzówek. In
the Zakrzówek quarry these are micritic stromatolites with darker and lighter bands. The stromatolites are up to 10 cm thick and extend laterally up to several tens of centimetres.

Above the "stromatolite" horizon, there appear numerous horizons of grainstones (packstone-grainstone-rudstone) which in some parts were partly or even completely dolomitized. The sediments between the grainstones are developed as wackestones and floatstones with numerous "Tubiphytes" morronensis up to 1.2 mm across (Fig. 10), Lithocodium aggregatum (Fig. 11; cf. Schmid & Leinfelder, 1996; Kołodziej, 1997), calcareous sponges, agglutinating and peloidal stromatolites. The stromatolites have columnar forms, up to 5 cm across and up to 15 cm high (Fig. 12). Scleractinian corals (Fig. 13; fragment of colony?; E. Morycowa, B. Kołodziej, pers. commun., 2001) occur sporadically.

The same sediments at Księża Hill include forms resembling erosional channels filled with grainstones (rudstone-grainstone), built mainly of ooids and oncoids of II and IV type (cf. Dahanayake, 1977) and intraclasts, often with graded bedding. The grainstones are in places bound by single pure leiolites.

**STRATIGRAPHY**

Biostratigraphic attribution of the studied deposits was established on the base of ammonites collected in the Jasna Cave, i.e. in the lower part of the Zakrzówek Horst section (Fig. 3), ca. 190–200 m above the base of the Oxfordian. Twenty fragments of ammonites were collected, of which four were determined as Orthosphinctes sp., Idoceras (Subnebrodites) proteron Nitzopoulos and two as Idoceras (Subnebrodites) sp. (Fig. 14). They indicate that the studied deposits belong to the Planula zone, Planula subzone, proteron horizon (B. A. Matyja, pers. commun., 1999), hence these are the youngest palaeontologically documented Upper Jurassic deposits in the Krakow area. Taking into account the minimal sedimentation rate of the chalky limestones and the stratigraphical condensation of the Upper Jurassic deposits...
in the Kraków area, relative to the areas of the Upland situated farther to the north, it seems likely that the deposits in the middle and upper parts of the Zakrzówek section belong to still younger zones of the Upper Jurassic (Krajewski & Bajda, in press; cf. Matyszkiewicz, 1997).

**DEPOSITIONAL ENVIRONMENT**

The chalky limestones differ markedly from the surrounding typical compact bedded limestones. The differences consist mainly in greater diversity of benthic and nektic fauna and lower compactness in the chalky limestones.

The described lenses of chalky limestones were laid down as small sponge-microbolite biostromes (cf. Leinfelder et al., 1996) passing upwards into sponge biostromes (autoparabiostrome - autobiotrome; cf. Kershaw, 1994; Figs 3, 4, 5) with numerous "Tubiphytes" morronensis and microbolites, forming nodular limestones in the area of Zakrzówek.

The environment of deposition of the sponge-microbolite biostromes remains open to discussion. The sponge-microbiolite bioconstruction are usually related to deep shelf environment with minimal rate of deposition, variable or small supply of nutrients in the marginal parts of the so-called "reef window" (Leinfelder et al., 1996; Leinfelder & Nose, 1999). The main components of sediments at Zakrzówek are thrombolites, subordinate are stromatolites and leiolites, siliceous and calcareous sponges and "Tubiphytes" morronensis.

The chalky limestones include a broad variety of sponges. Their frequency and diversity are at maximum in the central parts of the chalky lenses. Hexactinellids dominate in the lower parts of the lenses, gradually replaced upwards by lithistids. Calcareous sponges appear in great numbers in the upper parts. The studies in other areas indicate that such a sequence reflects a shallowing trend (cf. Trammer, 1982, 1989; Leinfelder et al., 1993, 1994, 1996; Keupp et al., 1996). The depositional environment of the biostromes made up of hexactinellids and lithistids with thrombolites was one of lower shelf, ca. 100 m deep (cf. Pratt, 1995; Leinfelder et al., 1994, 1996) or deeper (cf. Piseria, 1998).

Microbolites are common in the limestones in Zakrzówek Horst. However, they are not very useful for interpretation of depositional environment. Microbolites could form at various depths, levels of water energy, salinities and degrees of aeration. The studied sediments commonly include thrombolites and micritic stromatolites which indicate a low-energy environment with low sedimentation rate (cf. Keupp et al., 1993; Leinfelder et al., 1993, 1996; Schmid, 1995, 1996; Dupraz & Strasser, 1999; Leinfelder & Schmid, 2000; Riding, 2000).

"Tubiphytes" morronensis are common in the Zakrzówek area in the middle and upper parts of the section. They occur in various forms, mostly ovate, less commonly branching, depending on the firmness of substratum (cf. Schmid, 1995). The diameter of the outer tests of "Tubiphytes" morronensis increase in thickness upwards in the section. This indicates changes in availability of light, related to either shallowing or decreasing turbidity (cf. Leinfelder et al., 1996; Krajewski, 2000). In the case of the limestones observed at Zakrzówek both factors seem important. In the upper parts of the section "Tubiphytes" morronensis often occur together with Terebella lapilloides in the Terebella-Tubiphytes association, widely described in the literature (cf. Leinfelder et al., 1993, 1996; Schmid, 1995, 1996; Dupraz & Strasser, 1999). According to them, the occurrence of this community in shallow water setting indicates poor oxygenation. The depth of deposition of this association was probable several tens of metres (cf. Leinfelder et al., 1993, 1994, 1996) in a high mesotrophic environment (cf. Dupraz & Strasser, 1999). In the uppermost parts of the section at Zakrzówek "Tubiphytes" morronensis often occur together with Lithocodium aggregatum and the thickness of the "Tubiphytes" morronensis outer walls attains 1.2 mm, indicating low mesotrophic or oligotrophic environment of a few to less than twenty metres deep (cf. Schmid, 1995; Leinfelder et al., 1996; Schmid & Leinfelder, 1996; Dupraz & Strasser, 1999; Krajewski, 2000).

**CONCLUSION**

The basic components and their succession indicate that in the initial stage of formation of the sponge-microbolite biostromes (chalky limestones), the depth was about 100 m or more, and that at the end of their deposition the depth could be of a few tens of metres. The sediments found higher in the section could be laid down in an even shallower environment.

The occurrence of relatively infirm sponge-microbolite biostromes (chalky limestones) beneath similar in structure but more compact sponge biostromes with numerous "Tubiphytes" morronensis and microbolites (nodular limestones) reflects a change in depositional environment. The sponge-microbolite biostromes formed on deep shelf, below the storm wave base in a low-energy environment. Sponges growing loose in sediment (cf. Trammer, 1985) did not develop a rigid framework typical of carbonate biostromes in the Kraków area (Matyszkiewicz & Krajewski, 1996; Matysz kiewicz, 1997), but only an initially lithified construction. On the other hand, the sponges in the biostromes with "Tubiphytes" morronensis, growing in a shallower environment, were overgrowing one another and formed a structure resistant to erosion.

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Streszczenie

GÓRNOJURAJSKIE WAPIENIE KREDOWATE ZRĘBU ZAKRZÓWKA W KRAKOWIE, WYŻYNA KRAKOWSKO-WIELUŃSKA, POŁUDNIOWA POLSKA

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W pracy przedstawiono wyniki badań górnojurajskich wapieni kredowatych zrębu Zakrzówka (Fig. 1, 2, 3). Szczegółowe badania makroskopowe, mikrofałdowe objęły dwa stanowiska. Pierwsze stanowisko znajduje się w otworze Jaskini Jasnej nad Wisłą (w skrócie Jasnej; Fig. 2, 4). Drugie stanowisko znajduje się we fragmentach ściany o nazwie Ostatnia Scianka (Fig. 2, 5). Badania przeprowadzone zostały również w osadach sąsiadujących z wapieniami kredowatymi.

Stratygrafia została ustalona na podstawie amonitów zebra- nych w niżej części profilu Zakrzówka (Fig. 3) w jaskini Jasnej wskazujących na przynależność wapieni kredowatych do poziomu Planula, podpoziomu Planula horyzonu Protocon (Fig. 14; inf. usta B. A. Matyja, 1999).

W jaskini Jasnej (Fig. 2, 4) odsłaniające się wapienie kredowate tworzą soczewkę wśród twardych typowych wapieniu uławionych. Licznie występuje fauna, głównie gąbki, ramienionogi, ślimaki oraz amonity i belemnity. W dolnych i środkowych partiach wapieniewskich obserwuje się Hexactinellida wykazujące duże zróżnicowanie w morfologii od form w kształcie kieliszkowatych do form w kształcie wąskich rurek. W wyższych partiach soczewki Hexactinellida zastępowane są przez Lithistida. Wszystkie skamieniałości są silnie zlityfikowane i tkwią w miękkim kredowatym osadzie.

Pod względem mikrofałdowym dolne partie soczewki wykształcone są jako biolityty (boundstone) oraz waki (wackestone). W środkowych partiach soczewki dominują waki (wackestone) oraz biolityty (boundstone; Fig. 6, 7). W górnych partiach soczewki osad wykształcony jest głównie jako biolityt (bafflestone-boundstone) oraz waki (wackestone-floatstone), rzadziej jako mikrytowy zriaz hint (packstone).

Na Ostatniej Sciance (Fig. 2, 5) najczęściej obserwuje się gąbki z rodzaju Lithistida rzadziej Hexactinellida, ramienionogi głównie terebratule. Pod względem mikrofałdowym wykształcone są jako waki (wackestone), oraz biolityty (bafflestone-boundstone).

Lateralnie wapienie kredowate przechodzą płynnie w zwięzłe wapienie uławione (Fig. 4, 5). Ku górze najczęściej soczewki wapieni kredowatych jak i inne wapienie z tego poziomu zastępowane są przez gruzłowate wapienie gąbkowo-tubiphytesowe zdobywane głównie z gąbek krzemionkowych i wapiennych Lithistida (boundstone - bafflestone - wackestone; Fig. 8) i w większości partii wykazują podobne wykształcenie strukturalne jak wapienie kredowate. Ponad wapieniami gruzłowatymi występuje poziom zbudowany głównie ze stromatolitów (Fig. 9) oraz poziom zriazntów (packstone-grainstone-rudstone; Fig. 3), które w pewnych partiach uległy częściowej bądź całkowitej dolomityzacji. Pomiędzy zriazntami osady wykształcone są jako waki (wackestone-floatstone) z "Tubiphytes" morronensis i mikrytowej biolitytowej, jak w rejonie Zakrzówka wapienie gruzłowate.

Dyskusyjnym problemem jest środowisko sedimentacji biostron gąbko-mikrobialnych i biostrom gąbkowych z "Tubiphytes" morronensis w których głównymi komponentami są trombolyt, rzadziej stromatolity i leolity, gąbki krzemionkowe oraz wapienne i "Tubiphytes" morronensis. Biorąc pod uwagę sukcesję fauny oraz niewielką miąższość wapieni kredowatych, można stwierdzić, iż wapienie uławiwane (Fig. 4, 5) odgrywały swoje rolę w procesach sedimentacji zbiornika na przełomie Oksfordu i Kimerydu. Podstawowe komponenty i ich następstwo wulkanizacji wskazuje, iż w początkowej fazie tworzenia się wapieni kredowatych głębokość wynosiła około 100 m lub głębiej, a pod koniec ich sedimentacji mogła wynosić około kilkudziesięciu metrów.

Różnice w zwięzłości podobnie wykształconych kredowatych biostron gąbko-mikrobialowych i gąbkowych biostrom gruzłowatych z "Tubiphytes" morronensis prawdopodobnie mogą odzwierciedlać zmiany warunków środowiskowych. Paleomorfia wapieniewskiego zbiornika na przełomie Oksfordu i Kimerydu. Podstawowe komponenty i ich następstwo wulkanizacji wskazują, iż w początkowej fazie tworzenia się wapieni kredowatych głębokość wynosiła około 100 m lub głębiej, a pod koniec ich sedimentacji mogła wynosić około kilkudziesięciu metrów.

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