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Fossil karst in the Jurassic of the Kościuszko Mound in Kraków (southern Poland): discussion

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INTRODUCTION

The paper by Wójcik et al. (2015) deals with the sediments encountered in drill cores from four boreholes completed in the vicinity of the Kościuszko Mound in Kraków and interpreted by the authors as infillings of karst cavities in the Upper Jurassic limestones. At the beginning it is worth mentioning the erroneous title of the article. The article describes the "fossil karst in the Jurassic of the Kościuszko Mound". The Kościuszko Mound was piled in the years 1820–1823 in honour of the national hero Tadeusz Kościuszko.

CITED REFERENCES *VERSUS* CURRENT STATE OF KNOWLEDGE

Although Wójcik et al. (2015) refer to the fossil karst, the location of these karst features in the Upper Jurassic limestones implies that the rocks in question should be characterized with reference to published details of their stratigraphic position and lithology. Of special importance are descriptions of Upper Jurassic strata from the close neighborhood of boreholes completed on the Sowiniec Horst, cores from which were studied by Wójcik et al. (2015).

Wójcik et al. (2015) wrote: "...there are only a few geological data concerning the nearest area to the Kościuszko Mound". Respecting the unquestionable rights of the authors to select the used literature, the Reader must be surprised that even publications directly addressed to "geological data nearest to the area of the Kościuszko Mound" have not been cited by the authors.

We must turn the authors' attention first to the paper by Kleczkowski and Myszka (1989) who described the tectonics of the Sowiniec Horst and the St. Bronisława Hill. That paper includes two geological cross-sections: (1) E–W trending, cutting through the Kościuszko Mound and (2) N–S trending, located some hundreds of metres west from the mound.

Another missing paper is Matyszkiewicz (1996) who studied Upper Jurassic sediments from the Sikornik Quarry located at the foot of the Kościuszko Mound, several hundreds of metres from the boreholes investigated by Wójcik et al. (2015). Matyszkiewicz (1996) provided a detailed macroscopic description of strata found in the quarry (originating from the Oxfordian/Kimmeridgian break) together with microfacies analysis and the list of identified species of Upper Jurassic foraminifers. The Sikornik Quarry is one of the three exposures in the vicinity of Kraków (along with the village of Ujazd and the Wielkanoc Hill in Tyniec) where classic, Upper Jurassic calciturbidites were encountered, covered by debris-flow sediments. Moreover, Matyszkiewicz (1996) gave some important references to stratigraphy of the topmost part of the Upper Jurassic succession in the Kraków region and to the Late Jurassic synsedimentary tectonics. Up to date, this is the only paper describing the development of Upper Jurassic sediments in the vicinity of the Kościuszko Mound.

Unfortunately, neither Kleczkowski and Myszka (1989) nor Matyszkiewicz (1996) are cited by Wójcik et al. (2015). Instead, they refer to the paper on deposition of Quaternary loess by Łanczont et al. (2013), which has rather moderate value for the objectives of their publication.

In the first two sentences of chapter "Interpretation and discussion", Wójcik et al. (2015) wrote: "The Upper Jurassic limestones from the area of the Kościuszko Mound were deposited in a shallow, warm sea on the northern shelf of the Thethys Ocean (Trammer, 1982). These were good conditions for developing cyanobacteria-sponge bioherms (Dżułyński, 1952; Matyszkiewicz, 1989; Heliasz, 1996)." Among the four publications cited in this fragment, only Dżułyński (1952) is unquestionably applicable as this is a fundamental paper that should be referenced to in any publication on Upper Jurassic limestones from the Kraków region (even only due to historic reasons). The remaining three publications either touch the problems unrelated directly to Upper Jurassic strata from the Kraków region or do not contain the matter imputed by Wójcik et al. (2015).

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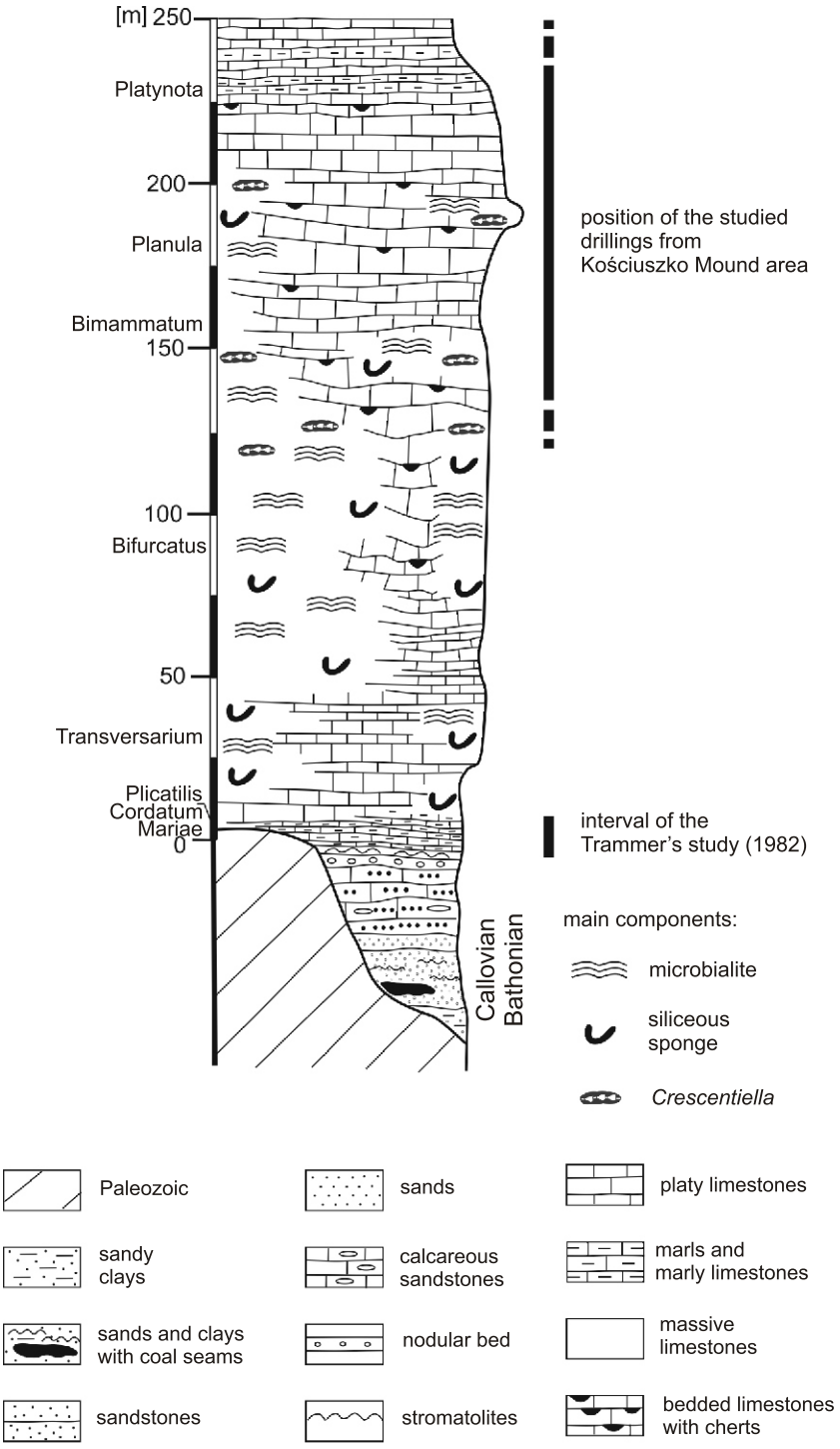

Fig. 1. Lithostratigraphy of Upper Jurassic sediments from the Kraków region (after Krajewski et al., 2011, simplified) with marked position of the Jasna Góra Beds (after Trammer, 1982) and approximate position of boreholes studied by Wójcik et al. (2015)

Trammer (1982) described sponges referred to the development of the Jasna Góra Beds, i.e., the bottommost part of the Upper Jurassic succession. Among the exposures described by this author, the closest to the Kościuszko Mound are those in Zalas and Nowa Krystyna near Krzeszowice, i.e., located over 15 km north-west from the mound. In these exposures, however, the Upper Jurassic succession includes only the Lower and Middle Oxfordian (Cordatum and Plicatilis zones; Fig. 1) represented by marls and marl-limestone alternations. A shallow-marine sedimentary environment of the Upper Jurassic limestones from the Kościuszko Mound area, imputed by Wójcik et al. (2015) to Trammer (1982), is an obvious misunderstanding. Trammer (1982) described the Lower to Middle Oxfordian Jasna Góra Beds, which do not crop out in the vicinity of the Kościuszko Mound and which certainly have not been drilled through even 100 metres, as indicated by the lack of the above-mentioned marls and marl-limestone alternations (see below in remarks on stratigraphy). Moreover, Trammer (1982:

15) stated that the Jasna Góra Beds formed "...at the depth not smaller than 150–200 m", which can hardly be regarded as a shallow-marine environment.

The paper by Matyszkiewicz (1989) contains a microfacies analysis of Upper Oxfordian limestones from Piekary near Kraków, i.e., not far from the Kościuszko Mound. However, we must emphasize that, since the late 1980s, the state-of-the-art in microfacies development, depositional conditions and precision of age determination of Upper Jurassic limestones from the Kraków area have significantly progressed and been even partly revised due to new findings of ammonites that are essential for the stratigraphy of Upper Jurassic sediments. Current stratigraphy of the Upper Jurassic strata can be found, e.g., in Krajewski et al. (2011), whereas their depositional environment was discussed in Matyszkiewicz et al. (2012) and in Kochman and Matyszkiewicz (2013) (and in references therein).

A stunning surprise for the readers is the reference to the paper by Heliasz (1996) in a publication on Upper Jurassic sediments from the vicinity of the Kościuszko Mound. Undoubtedly, Dr. Zygmunt Heliasz has contributed decisively to our knowledge of Upper Jurassic strata from the Częstochowa region as a pioneer of modern microfacies studies on these rocks. Unfortunately, his important publication was printed in materials from the XVIth Field School of Geologists of the Silesian University in Sosnowiec and now is hardly accessible for Polish authors, and practically unavailable for foreign specialists. Also, its value for studies on carbonate buildups from the Kraków region is dubious, first – because it presents the state of knowledge from before nearly 20 years, and second – because it does not apply directly to the massive limestones from the Kraków region due to distinct differences in the development of this facies in the Kraków and Częstochowa regions. Consistently with its title, the paper by Heliasz (1996) is more a history of studies on massive limestones with the special attention paid to the Częstochowa region, not to the Kraków one as that author has never worked in the Kraków region.

Summing up so far, referring to Heliasz (1996) to characterise massive limestones from the Kraków region, and ignoring several recent and easily accessible papers (mostly indexed in the Journal Citation Reports) that are directly relevant to the Kraków region, it seems that, unfortunately, Wójcik et al. (2015) did not recognise the basic literature on the region they describe.

In the first sentence of chapter "Geological setting", Wójcik et al. (2015) wrote: "The dominant role in the geological structure of the southern part of the Kraków Upland is played by Upper Jurassic limestones (up to 200 m thick; Rutkowski, 1993)." However, we must emphasize that: (1) in this 20 years old paper, the thickness of Upper Jurassic strata is, in fact, quoted as "up to 230 m"(Rutkowski, 1993: 11) whereas the new data (see e.g., Krajewski et al., 2011) indicate a thickness of up to 250 m, and (2) the author of descriptions of Upper Jurassic rocks included in the "Explanations to the Kraków sheet of the 1:50,000 Detailed Geological Map of Poland" is J. Matyszkiewicz, not J. Rutkowski (Rutkowski, 1993: 3).

REMARKS ON STRATIGRAPHY

In the abstract, Wójcik et al. (2015) mentioned the sediment-filled karst cavities which "...formed in the Middle Oxfordian limestones". In fact, ammonite fauna (which is essential for Upper Jurassic stratigraphy) has not been found in either the exposures of Upper Jurassic strata from the close vicinity of the boreholes or the drill cores themselves. Nevertheless, we are in opinion that such statement is groundless. If the

Stages	Substages	Zones	Substages	Zones
	after Kutek (1994)		after Matyja and Wierzbowski (2004)	
Kimmeridgian (part)	Lower (part)	Hypselocyclum Platynota	Lower	Hypselocyclum Platynota
Oxfordian	Upper	Planula Bimammatum	Upper	Planula Bimammatum Bifurcatus
	Middle	Bifurcatus Transversarium Plicatilis	Middle	Transversarium Plicatilis
	Lower	Cordatum Mariae	Lower	Cordatum Mariae

Fig. 2. Subdivision of the Oxfordian in the Sub-Mediterranean province, after Kutek (1994) and Matyja and Wierzbowski (2004)

term "Middle Oxfordian" is quoted the user must clearly address to the existing stratigraphy of the Oxfordian (Fig. 2), which differs in details (Fig. 1). In the older, but sometimes still used subdivisions, the Middle Oxfordian includes the Plicatilis, Transversarium and Bifurcatus zones (see e.g., Kutek, 1994; Fig. 2), whereas in more modern ones the Middle Oxfordian comprises only the Plicatilis and Transversarium zones (Matyja and Wierzbowski, 2004; Fig. 2).

We are in opinion that the stratigraphic columns of boreholes described by Wójcik et al. (2015) represent the Planula and Bimammatum zones, and do not extend down to the uppermost part of the Bifurcatus Zone. Hence, in accordance with subdivisions of Kutek (1994) and Matyja and Wierzbowski (2004), these are the Upper Oxfordian strata. Our viewpoint about the Upper Oxfordian (and, maybe, the Lower Kimmeridgian) age of rocks in question is based upon the analysis of stratigraphic position and thickness relationships of rocks described by Wójcik et al. (2015) from their boreholes, and referred to detailed stratigraphy of Jurassic sediments in the Kraków region, which has been published in many papers (e.g., recently by Krajewski et al., 2011).

In a 250 m thick Upper Jurassic succession from the Kraków region (Fig. 1), the several metres thick Lower Oxfordian sediments are overlain by Middle Oxfordian strata (identified as Plicatilis and Transversarium zones), which form a 20–30 m thick sequence dominated in its lower part by marl-limestone alternations and so-called "platy-like" limestones. If we assume that the Middle Oxfordian includes also the Bifurcatus Zone, the thickness of so defined Middle Oxfordian is about 90–110 m.

The exposures of Upper Jurassic strata in the Sowiniec Horst represent a fragment of stratigraphic column located about 200 m above the Oxfordian base, which undoubtedly points to the Upper Oxfordian (Planula Zone) and, maybe, even to the lowermost Kimmeridgian (cf. Matyszkiewicz, 1996; Krajewski, 2001; Ziółkowski, 2007, Krajewski et al., 2011). Therefore, in the Sowiniec Horst, the Upper Oxfordian strata (Planula and Bimammatum zones) should extend down to 100 m depth. The upper part of this succession corresponds in age to rocks known from the Zakrzówek sequence, located

about 1.5 km south-east from the Kościuszko Mound. The latter were described and dated with ammonite fauna at the Uppermost Oxfordian (Planula Zone) (see Krajewski, 2001). Moreover, in chapter "Results", Wójcik et al. (2015) mention the presence of dark limestones in the studied drill cores. Such limestones were described by Dżułyński and Żabiński (1954) who identified them at the same level as dolomitic limestones – the rock found exclusively in the uppermost part of the Jurassic succession in the Kraków area. Dark limestones are common in the vicinity of the Sowiniec Horst: in Podgórki Tynieckie, Pychowice and Zakrzówek, and their occurrence is always limited to the uppermost part of the Jurassic succession in the Kraków region, as demonstrated by, e.g., Alexandrowicz (1960) and Matyszkiewicz (1987).

The arguments presented above confirm our opinion that the rocks described by Wójcik et al. (2015) from the drill cores are of Upper Oxfordian age and, maybe, even Kimmeridgian sediments may appear in the topmost part of the succession. Consequently, we regard as highly improbable the presence of Upper Jurassic Bifurcatus Zone sediments at the bottom of the boreholes. We fully respect the rights of A. Wójcik and co-workers to present their own opinions but, simultaneously, we are confident that such opinions must refer to already published data and that they cannot be based solely upon undocumented ideas, paying no attention to the basic literature.

In the second paragraph of chapter "Results", the readers find for the first time (apart from Abstract) the information that the studied Upper Jurassic limestones belong to the Oxfordian. This is supported by determination of "The Oxfordian foraminifera assemblage", which "was found in the 3G borehole at the depth of 26.5 m". In table 1, which shows the results of microfauna identification, we encountered an assemblage containing *Crescentiella morronensis*, *Spirillina* sp. and *Terebella lapilloides* (polychaet) together with some fragments of bivalve shells in the 26.5 m depth sample from the 3G well. Hence, to our confusion, "The Oxfordian foraminifera assemblage" includes a single (sic!) "foram" identified at the genus level (in fact, the genus known since the Carboniferous) and a single, enigmatic Jurassic–Cretaceous microfossil *Crescentiella morronensis* (previous name *Tubiphytes*, cf. Senowbari-Daryan et al., 2008). No comment.

REMARKS ON DESCRIPTIONS OF THE LIMESTONES

The quality of descriptions of Upper Jurassic rocks presented in Wójcik et al. (2015) is highly unsatisfactory. They revealed that the boreholes were "fully cored". If so, the lithologic types of studied limestones should be easily recognized even without more advanced research, and their categorization should be made, e.g., using the basic Dunham's classification, so useful in macroscopic observations of limestones. Unfortunately, the descriptions of limestones (chapter "Results") are reduced mostly to their colours: "In all cases, white, creamy and creamy-greyish thick-bedded and massive limestones" (first paragraph of chapter "Materials and methods") or "The limestones from the lower part of the boreholes are darker, creamy-grey and less weathered" (first paragraph of chapter "Results"). Such accounts do not meet any standards of drill-core description, even if written during field work. Furthermore, it is difficult to recognise the morphology of walls of the cavities developed in the limestones because the notice: "Caverns are frequently filled with calcite crystals" does not provide any valuable information. We must remind here that "calcite crystals" can also be micrite grains, up to 4 m in diameter. However, even such an extremely poor description of limestones includes unclear fragments, e.g.: "Numerous point precipitations or dendrites of manganese hydroxides and sutural joints (stylolites) occur locally within the limestones" (first paragraph in chapter "Results").

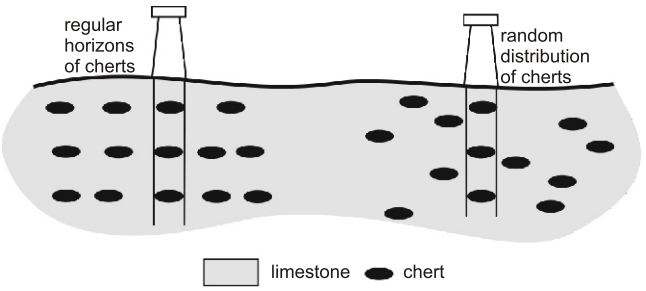

Fig. 3. Interpreted distribution of cherts in limestones based upon data from boreholes

The appearance of cherts in drill cores does not evidence their distribution either in horizons parallel to the bedding planes (left) or randomly within the rock mass (right)

The statement: "Chert concretions coated by a white porous crust are randomly distributed in the limestone (Fig. 3)", found in chapter "Results", is inconsistent. The true distribution of cherts can be concluded only from observations of outcrops, not from drill cores, even if 10 cm in diameter. The presence of single cherts in stratigraphic columns of wells never determines their distribution, neither in regular horizons nor randomly scattered within the rock mass (Fig. 3).

Another statement concerning the random distribution of cherts is not true either. Wójcik et al. (2015) wrote: "Irregular distribution of cherts in the non-bedded limestone from some sections of drill cores may be due to drilling through the transition zone between the bedded limestone with cherts and the massive limestone. Such transitions are visible in many places of the Kraków Upland (e.g., Piekary Quarry and Jeziorzany)". The Piekary site has been described by, e.g., Alexandrowicz (1955) and Matyszkiewicz (1989). The latter paper contains a drawing that illustrates the distribution of cherts in the transitional zone, and a comment: "The cherts are arranged here in horizons parallel to the bedding…" (Matyszkiewicz, 1989: 205). In the Jeziorzany outcrop, Vierek et al. (2011) found that cherts are: "…distributed parallelly to the bedding or, less commonly, chaotically scattered." (Vierek et al., 2011: 24), but they do not unambiguously linked such chaotic arrangement to the transition zone between the massive and the bedded limestones.

Concluding so far, we must consider groundless the interpretation of distribution and range of the "limestone with cherts" facies shown in the cross-section through the Sowiniec Horst (Wójcik et al., 2015: fig. 3).

SUMMARY

The paper by Wójcik et al. (2015) contains a number of errors and imperfections. Unfortunately, the description of Upper Jurassic limestones, in which infilled karst cavities occur, and the knowledge of literature relevant to the objectives of the paper are far from acceptable standards. The references list does not reflect the recent state of knowledge of Upper Jurassic sediments from the Kraków region because many important new publications have been neglected.

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