Geological Quarterly, 2019, **63** (1): 212–214
DOI: http://dx.doi.org/10.7306/gq.1463

The Early Kimmeridgian succession at Kodrąb (Radomsko elevation, central Poland) and its palaeogeographical and palaeotectonic implications – reply

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Wierzbowski, A., Głowniak, E., 2019. The Early Kimmeridgian succession at Kodrąb (Radomsko elevation, central Poland) and its palaeogeographical and palaeotectonic implications – reply. Geological Quarterly, **63** (1): 212–214, doi: 10.7306/gq.1463

Associate editor: Anna Wysocka

This reply refers to the critical discussion by Olchowy and Krajewski (2019) on our paper which has recently been published (Wierzbowski and Głowniak, 2018). The Early Kimmeridgian deposits we described crop out in the Rogaszyn Quarry at Kodrąb (Radomsko elevation) and were chronostratigraphicaly interpreted based on collected ammonites, and correlated with coeval deposits of the neighbouring areas. The authors of the critical discussion consider, however, our study as containing "*...incorrectly prepared Kimmeridgian profile, and incomplete and unprecise documentation...*" which "*...cannot be the source of regional correlations… and cannot provide conclusions concerning the synsedimentary tectonics...*" (Olchowy and Krajewski, 2019). Our reply will concentrate in its first part on the sedimentary succession at the Rogaszyn Quarry, and then on its general interpretation in the palaeogeographical and palaeotectonic context.

We studied the Rogaszyn Quarry in 1989 (E.G.) when it was actively working, and then, after time of its decline when it was nearly fully overgrown, during 2015–2017 (A.W.), when some parts of the quarry were re-cleaned by the new owner. These observations resulted in collecting the materials not only showing the depositional succession that cropped out in those times, but also providing a fairly large collection of ammonites. Some of them were found *in situ*, and some in the rubble, but according to the position of the findings and characteristic lithology of the matrix they are easily located in the succession. The same section was also studied by Kutek (1968) who gave the general outline of the succession of the deposits and collected some ammonites preserved in the Museum of the Faculty of Geology, University of Warsaw. He showed that the succession at Kodrąb differs markedly from that of the SW margin of the Holy Cross Mts., and introduced some local lithostratigraphic units. Our study is the continuation of the study of Kutek (1968), enriched in newly obtained biostratigraphical and lithostratigraphical data. The given section shows some generalizations resulting partly from the existence of some still not unequivocally recognized parts of the succession. The study has been prepared mostly for showing the differences in lithological development between the study area and the neighbouring areas to present some wider palaeogeographical and palaeotectonic interpretations.

The oldest deposits in the Rogaszyn Quarry are oolitic limestones discussed by Olchowy and Krajewski (2019). These had been well-known before, not only to us (we can present relevant photos from the Rogaszyn Quarry taken in 1989 when the deposits were exposed even better than today) but also to other students of the section. However, **these deposits were not the subject of our study**. They represent a part of the "chalky limestone member" of Kutek (1968), cropping out most completely in the old quarry at Smotryszów, whose deposits have not yielded any ammonites so far. The "chalky limestone member" at Smotryszów contained part a thin oolitic body in its middle, as well as showed some share of oolites in its upper part (Kutek 1968; see also Jaworowski, 1962). Unfortunately, the detailed correlation of these deposits between the Smotryszów Quarry and the Rogaszyn Quarry is difficult at the present state of availability of the lithological succession. It was thus the reason that we did not study the discussed oolitic limestones in the lower part of the Rogaszyn Quarry, and we concentrated on the younger deposits of the "platy-onkolite member" of Kutek (1968), well-dated by ammonites and overlying along a sharp boundary the "chalky limestone member" in the Smotryszów Quarry. It should be remembered that the oolites from the "chalky limestone member" cannot be treated as the equivalent of the "Oolite of Smotryszów" of Kutek (1968: 526, fig. 11), which represents a much younger rock unit, well-dated by ammonites. Olchowy and Krajewski (2019) put together these two oolitic units evidently erroneously, and placed the oolites only in the lowermost part of the succession in the quarry, concluding that the position of the upper oolitic limestone (corresponding to unit

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Received: January 4, 2018; accepted: February 14, 2019; first published online: March 22, 2019

11 of Wierzbowski and Głowniak, 2018 – "Oolite of Smotryszów") in the sedimentary succession "is incorrect".

Thus, the whole succession described by us in the Rogaszyn Quarry begins from the top of the oncolite limestone unit (our unit 1) because of the plausible correlation with the neighbouring section of the Smotryszów Quarry described by Jaworowski (1962) and Kutek (1968). The most probable correlation between these two sections assumes that the top of the oncolite limestones and the base of the overlying marls and micritic limestones in both sections are isochronous or nearly isochronous. Such interpretation is based on the similarity of the lithological successions and their ammonite faunas, indicating a very narrow chronostratigraphical interval of the discussed oncolite limestones, corresponding to the lower part of the Platynota Zone. Olchowy and Krajewski (2019) consider such a correlation doubtful "*...despite of findings two ammonites...*" – because of the "*...2 km distance between the quarries...*", "*...their location at the same elevation...*", and "*...the distinct dip of the strata...*" at the quarries. These arguments may be easily questioned: the stability in lithology and thickness of the only one oncolite limestone bed, which yielded one of the above-discussed ammonites, may be traced over a distance of at least up to 3 km (see Kutek, 1969: 264), whereas the dips of the strata in the northeastern limb of the Smotryszów Anticline are not stable but strongly oscillate in their values, which is due to the presence of fault structures (see e.g., Czubla, 1988).

The stratigraphical succession studied by us in the Rogaszyn Quarry includes several small-scale rock units (units 2–6) composed of micritic limestones and marls. We specified the thicknesses of the particular units, but these data are questioned by Olchowy and Krajewski (2018) who additionally did not recognize our units 5 and 6 (possibly because of the poor state of the outcrop). They used the small-scale photograph published in our study to indicate that our measurements were done wrong. In fact, the numbers for beds 4 and possibly 5 in our figure 3A were located incorrectly – i.e. too low in the succession (numbers for beds 5 and 6 are given properly in our fig. 3B), but it does not mean that our measurements given in the text should be neglected. Additionally, Olchowy and Krajewski (2019) question our interpretation of the presumable local occurrence of beds 7 and 8. These were recognized in 1989 by one of us (E.G.) directly below the omission surface in the part of the quarry completely covered nowadays. However, the beds seem to be absent in another part of the quarry studied in 2015–2017 (AW), where the omission surface in similar stratigraphic position (i.e. close to the base of unit 9 – see fig. 2 in Wierzbowski and Głowniak, 2018) – is developed at the top of bed 6. According to the interpretation provided by Wierzbowski and Głowniak (2018: 514) "*...it is difficult to prove…., if the omission surface at the top of the unit 6 is the same surface as that of unit 8, but such an assumption seems very likely...*" – and this has been accepted in our figure 2. Another solution is that there occur two closely placed omission surfaces in the succession; however, this very slightly changes the general stratigraphical interpretation of the deposits. In any way, such a consideration does not provide any premise for stating by Olchowy and Krajewski (2019) that our "*...conclusions based upon insufficiently documented succession are much too far-reachin*g...".

The last comment of these authors is related to the occurrence of the youngest deposits, poorly exposed in the southeastern part of the quarry, and referred by us to unit 12. The deposits are well-bedded micritic limestones and marls seen only in the rubble. They have been correlated with "*...platy limestones and underlying clays of Dmenin...*" of Kutek (1968), recorded by him near Smotryszów. Their lithology in the section is given in our figure 2, thus, with some approximation and without recognition of any particular rock-units. These deposits yielded the ammonite indicative of the upper part of the Hypselocyclum Zone, which results in placing of unit 12 well above our unit 11 ("Oolite of Smotryszów").

In relation to our palaeogeographical and palaeotectonic interpretation of the Rogaszyn Quarry succession, Olchowy and Krajewski (2019) discuss some problems related to the correlation of the main marly units between the Radomsko elevation, the Wieluń Upland and the NW margin of the Holy Cross Mts. They notice that Unit D_3 from the latter area, originally compared with the so-called lowermost Marly Unit of Kutek (1968) by Matyja and Wierzbowski (2014), is correlated in our study with the Kiełczygłów Marl Member of Wierzbowski and Głowniak (2018) from the Wieluń Upland. It is, however, the normal consequence of findings of new data, especially ammonites, which change the former interpretation, and these suggest additionally that the lowermost Marly Unit in fact correlates better with Unit D_2 from the NW margin of the Holy Cross Mts. When constructing the correlation chart (Wierzbowski and Głowniak, 2018: tab. 1) we used materials from the sections well-known to us. This was the reason we presented the borehole of the Bełchatów Geo-2a drilled in 1959 in the close proximity of the Radomsko elevation area, which has been studied personally by one of us (AW). On the other hand, the other sections, e.g. those studied by Mrozek (1975) and Barwicz-Piskorz (1995, in which older studies of this author are summarized) have not been "ignored" by us, but we found some objective difficulties in using the presented there data. The cores described by Mrozek (1975) come from boreholes located much towards the north, beyond the study area. Of the core sections described by Barwicz-Piskorz (1995), undoubtedly the most interesting is the composite core section from Kodrąb. However, it is presented at a very general scale, does not contain detailed description of the lithology, and is interpreted in terms of stratigraphical classification proposed by Kutek (1968) for the SW border of the Holy Cross Mts. Nevertheless, it may be suggested that the middle part of the Kodrąb section by Barwicz-Piskorz (1995) corresponds approximately to the succession discussed by us. The occurrence of two omission horizons (Barwicz-Piskorz, 1995: fig. 5) may appear important for the correlation, but such a study needs detailed core descriptions which have not been, however, provided by that author.

We do not agree with suggestions of Olchowy and Krajewski (2019) that the lack of references to their studies (namely Krajewski et al., 2014, 2016, 2017) does not allow the proper recognition of the activity of the Holy Cross lineament during the Late Jurassic. In fact, their two papers (Krajewski et al., 2014, 2017) were focused on the hardground sequence from the Sobków Quarry in the SW margin of the Holy Cross Mts., and its relation with the activity of the Holy Cross lineament and the study area in the proximity of the Radomsko elevation is obviously distant. The third paper (Krajewski et al., 2016) refers to the Złoczew Graben, east of the Kleszczów Graben, and proves synsedimentary activity marked by the presence of gravity-flow deposits, but "unfortunately poor biostratigraphical dating of the Upper Jurassic deposits makes difficult the precise reconstruction between the particular facies types" (see Wierzbowski, 2017: 64, including also other critical comments on the paper in question). Thus, we preferred citing the study by Matyja and Wierzbowski (2014), where the activity of the lineament is given on the firm basis of facies development and precise chronostratigraphical correlations.

Summarizing our reply, we would like to notice that we do not agree with the critical comments given by Olchowy and Krajewski (2019). These resulted from incorrect interpretation of our study and distorted interpretation of our stratigraphical framework. The separate paper concerning the Kodrąb succession, as planned by P. Olchowy and M. Krajewski, could contribute to the discussion (especially by providing the basis for detailed comparison between their and our interpretation of the succession in the quarry for the persons not familiar with detail of it), but it should contain also chronostratigraphical correlation with the neighbouring areas. The latter is especially important because the differences between the sedimentary evolution of the area at Kodrąb, when compared with that of other areas during the latest Planula to the earliest Hypselocyclum chrons of the Early Kimmeridgian, have been one of the main results of our study.

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