Research Article

NEWS FROM THE PERMIAN-TRIASSIC GURYUL RAVINE SECTION (KASHMIR, INDIA): A FAULT CAUSING BIOSTRATIGRAPHIC CORRELATION PROBLEMS AND REMARKS ON THE DIENERIAN CONODONT UAZs

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Abstract – Guryul Ravine (Kashmir, India) is unique in that it is the only ammonoid bearing expanded and complete Permian-Triassic boundary section along the entire southern Tethys margin. As such it may be important to note that during a field campaign in 2017 we identified a fault within the Griesbachian part of the section. Although it can be detected in aerial photographs (if searched for) it is quite difficult to be seen in the field. As this structure has not been described in previous publications we assume that it has been overlooked and thus might account for some problems in stratigraphic correlation between previous studies. Also, in a recently published study about Guryul Ravine, we identified some errors that we want to bring to attention

INTRODUCTION

The classic Guryul Ravine section in Kashmir/India has been studied for palaeontology since 1907 and 1909 by Hayden and Middlemiss, respectively. Teichert (1970) was the first to report a mixed Permo-Triassic fauna from there and a Japanese-Indian research group carried out an extensive palaeontological study (Nakazawa et al., 1970, 1975; Nakazawa and Kapoor 1981; Matsuda 1981, 1982, 1983, 1984). More recently, Algeo et al. (2007), Korte et al. (2010), Horacek et al. (2014) and Brookfield & Sun (2015) investigated the section. Baud et al. (2014) published a field guide containing a compilation of published and also new data.

Lately, following their high-resolution sampling, Brosse et al. (2017) reassessed and revised the conodont biochronology and presented a carbon isotope curve of the fifteen lowermost stratigraphical meters of the Khunamuh Formation at Guryul Ravine section, which they correlate with Member E in Nakazawa et al. (1975) above the sandstone layers of the topmost Zewan Formation (Member D of Nakazawa et al., 1975). This interval includes both the Permian-Triassic and the Griesbachian-Dienerian (lower-upper Induan) boundaries. Brosse et al. (2017) confirm the first occurrence of *Hindeodus parvus*, the index for the base of the Triassic (Yin et al., 2001), in the middle of sub-member E2 (Unit 56 of Matsuda, 1981) in bed GUR09 and characterize 11 Unitary Association Zones based on the conodont record from China and from Guryul Ravine. Brosse et al. (2017) identify the Griesbachian-Dienerian boundary (GDB) within the interval between UAZ8 and UAZ9, which corresponds in the Guryul Ravine section to the space between their bed numbers GUR310 and GUR311. Brosse et al. (2017) define the GDB by using as marker the first occurrence of *Sweetospathodus kummeli*, corresponding to the replacement of segminiplanate (here *Clarkina* and *Neoclarkina*)

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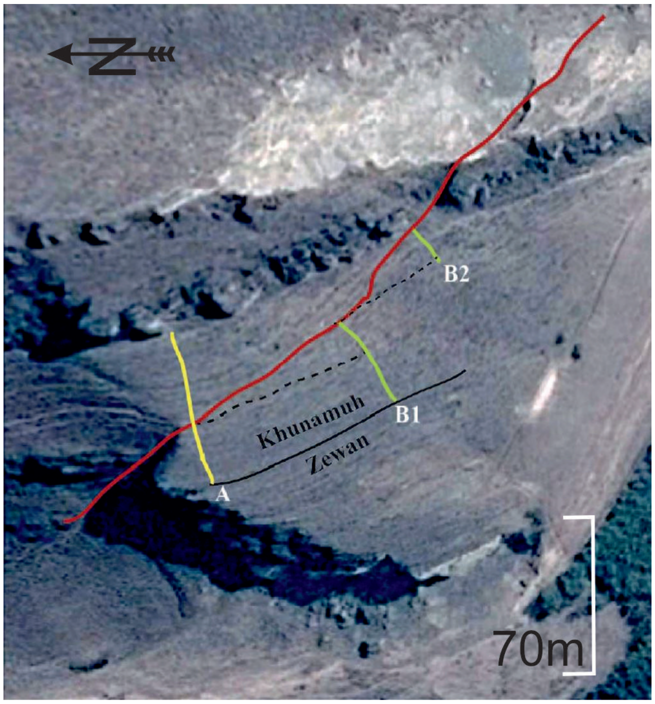

Figure 1–Aerial view of the Guryul Ravine section with indication of the fault and location of measured sections (base image from Google Earth). Red line indicates the trace of the fault, yellow line refers to the trace of the section of Brosse et al. (2017), green line indicates our section (unpublished) and probably also the Nakazawa et al. (1975) section, according to the almost perfect lithological match up to the base of F member. Black line is the boundary between the Zewan and Khunamuh Formations. Dashed lines indicate strike of beds below the fault.

by segminate (*Sweetospathodus* and *Neospathodus*) conodonts. Brosse et al. (2017, p.359) note that "this faunal turnover was possibly linked to a climate change at the Griesbachian-Dienerian transition, from a cool and dry to a hot and humid climate" and "This transition could be the trigger of the migration of neogondolellids towards high latitudes and of the radiation of neospathodids during the Dienerian." However, Brosse et al. (2017) state that a bed-by-bed correlation of their results with the log by Nakazawa et al. (1975) could not be achieved.

MATERIAL AND METHODS

After having visited the Guryul Ravine section several times in recent years we observed a high-angle fault with omission of beds at the study locality of Brosse et al. (2017) in the upper Griesbachian (Figs. 1 and 2). This fault results in a missing interval of approximately 5.5–6.0 metres (which is the upper part of the E3 member of Nakazawa et al., 1975) – nearly 40% of the Griesbachian in their section (Fig. 3) between beds 308 and 310 of Brosse et al. (2017). We believe that this unidentified fault, as a consequence, resulted in the problem to achieve a bed-by-bed correlation with Nakazawa et al. (1975) and Nakazawa and Kapoor (1981) respectively, as Brosse et al. (2017) note. When adding the missing part, a bed-by-bed sections correlation between these authors can be done (Fig. 3).

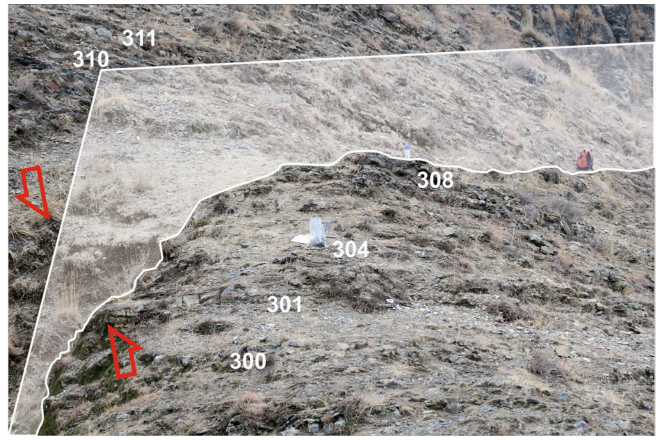

Figure 2 – Photograph of a part of the section investigated by Brosse et al. (2017). Note the bed numbers marked on the rocks in the field with the fault and its movement direction indicated.

Consequently, also the isotope curve presented by Brosse et al. (2017) has a gap that needs to be closed.

Furthermore, when comparing the section figure in Baud et al. (2014, fig. 23), which contains identical sample numbers, it is obvious that it does not fit to the figure published subsequently in Brosse et al. (2017). When comparing these two profiles of the same section (Baud et al., 2014; Brosse et al., 2017) we observe distinctive variations, e.g., a significant difference in distance between samples GUR299 and GUR300 with ca. 1m in Baud et al. (2014) and ca. 5m in Brosse et al. (2017). As this discrepancy occurs in the footwall of the fault in the section it cannot account for it. Furthermore, we could not identify such a variation in thickness between the two beds along strike over 100m distance. An explanation for these differences is required to rule out the possibility of merging samples from different parts of the section or combining disparate data (e.g., conodonts and isotopes) from only apparently identical sample numbers – however coming from different levels within the section.

RESULTS

Amending the stratigraphic log for the missing interval enables us to do a bed-by-bed correlation of Nakazawa et al. (2015) data with the detailed conodont record in Brosse et al. (2017) as noted above. Therefore, we can link the macro-fossil and sedimentological dataset of Nakazawa et al. (1975) to the conodont data set by Brosse et al. (2017). By combining the two data sets, we can correlate *Otoceras woodwardi* with *Hindeodus parvus*, *Ophiceras tibeticum* with C*larkina krystyni* and note a good agreement in the finding of *Clarkina carinata* and *Hindeodus typicalis*. We have to stress, however, that the correlation is based entirely on the published data and the conodont stratigraphy will be again significantly revised by our ongoing study.

Brosse et al. (2017, fig. 18) report conodont Unitary Assemblage Zones (UAZ) with some very strange UAZs, i.e. UAZ10 and UAZ11 where *Sweetospathodus kummeli*, having an exceptionally long duration, is co-occurring with *Neogondolella chaohuensis*, *Eurygnathodus costatus* and *Neospathodus eowaageni*.

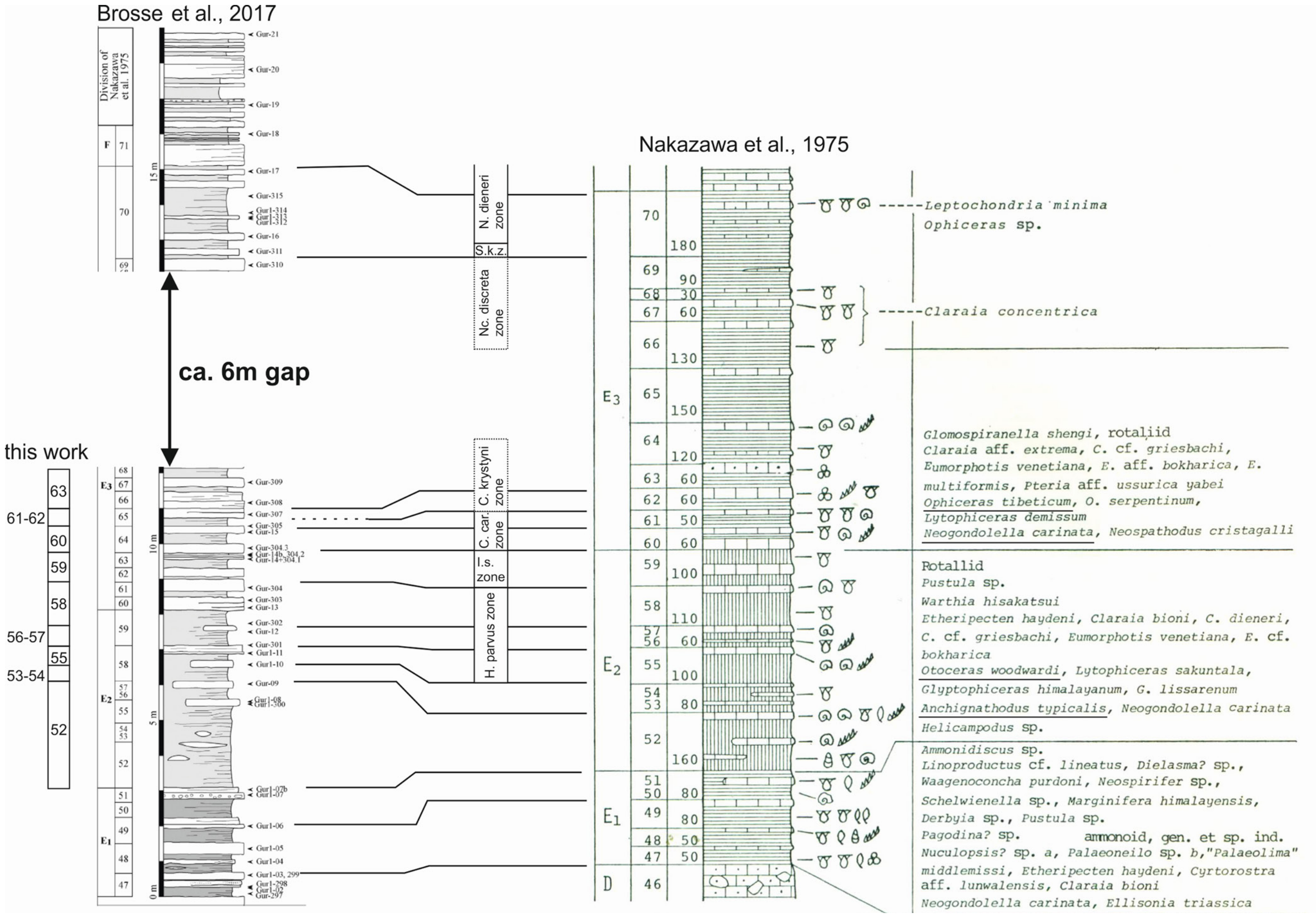

Figure 3 – Side-by-side sections data comparison between Nakazawa et al. (1975) and Brosse et al. (2017, modified), with a bed-by-bed correlation, position of the gap, and conodont zones after data of Brosse et al. (2017); fossils mentioned in text are underlined. H.= *Hindeodus*, I.s.= *Isarcicella staeschei*, C. car.= *Clarkina carinata*, C.= *Clarkina*, Nc.= *Neoclarkina*, S.k.z.= *Sweetospathodus kummeli* zone, N.= *Neospathodus*. Note, *Anchignathodus* is an old synonym for *Hindeodus*. Bed-by-bed correlation between Nakazawa et al. (1975) and Brosse et al. (2017) was achieved by lateral tracing of the individual beds between the two section lines in the field.

We are not aware of any section where these co-occurrences exist. To our experience so far and from published literature (Orchard, 2007; Chen et al., 2015; Zhang et al., 2007), *S. kummeli* only occurs over a very short interval and in association of just a few species (e.g., *Ns. dieneri*, *Nc. discreta*, *C. carinata*, *C. planata*, *C. taylorae*, *C. tulongensis*). This co-occurrence of further species in Brosse et al. (2017, fig. 18) probably points towards a confusion of species, admixture of samples, a condensed interval or something similar – to our current knowledge - or an error. On the other hand, according to Zhang et al. (2007), *S. kummeli* co-occurs with *Ns. cristagalli* and, therefore the range of *Ns. cristagalli* has to be revised in Brosse et al. (2017, fig. 18) too and in consequence also the UAZs. As we think that there are several problems and inconsistencies concerning the UAZ 9–11, we think that there is need for correction.

DISCUSSION AND CONCLUSIONS

The high-angle fault with omission of beds identified by us in the field 2017 now enables a bed-by-bed correlation of the Brosse et al. (2017) data with the results of Nakazawa et al. (1975). The correlation of the data sets produced by Nakazawa et al. (1975) and Brosse et al. (2017) allows the combination of micro- and macro-fossils identified hithero in the Guryul Ravine section. Our correlation confirms the co-existence of *Otoceras woodwardi* with *Hindeodus parvus* and *Ophiceras tibeticum* with *C. krystyni*. The correlation also shows a good agreement in the *Clarkina (Neogondolella) carinata* ranges (except that the lowermost mentioned occurrence in Member E1 by Nakazawa et al. (1975) has to be omitted). However, the reader needs to keep in mind that another revision of the conodont data will be shortly published by the authors.

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