

NOTE ON THE CONODONTS FROM THE INDUAN-OLENEKIAN BOUNDARY

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INTRODUCTION

A brief summary of results of studies into the Induan-Olenekian Boundary (IOB) conodont material from Waili (Guangxi Province, South China) and Mud (Spiti, Himashal Pradesh, Northern India) is presented (Goudemand et al., in prep. a, b). The latest consensus about the definition of the IOB was to use the FAD of *Neospathodus waageni* sensu lato as an index for the base of the Olenekian (IOB Working Group, as suggested by Tong et al., 2004). Up to now and until the foreseen proposal of the Nammal Gorge section, Pakistan as a GSSP candidate, only two sections have been formally proposed: the Mud section M04 in Northern India (Krystyn et al., 2007a, b), and the West Pindingshan section at Chaohu in Anhui Province, South China (Tong et al., 2003, 2004). Conodont-based correlations between these two sections remain hitherto unclear. Furthermore, new ammonoid data recently questioned the stratigraphic position of the IOB in Mud (Brühwiler et al., 2010). Our new conodont data demonstrates that the northern Indian and south Chinese conodont sequences agree better with one another and with the ammonoid data than was previously thought.

NEW DATA

In the Mud section, the presumed FO of *Neospathodus waageni* was reported in subbed 13A3 (Krystyn et al., 2007a, b). In order to re-assess in details the Mud section, intense bed-by-bed sampling of ammonoids and conodonts was performed below this proposed GSSP. It led first to a revision of the ammonoid biozonation and to the recognition that the most relevant ammonoid turnover occurred between beds 9 and 10 (Brühwiler et al., 2010), about 1m below bed 13 where the boundary was proposed in 2007 (Krystyn et al., 2007a, b). The conodont material led to surprising outcomes too, since 'typical' Smithian forms occurred also below bed 13 (Goudemand et al., in prep. a). In particular, *Ns. waageni* sensu lato was also found in bed 10 (together with the ammonoid *Flemingites bhargavai*), the middle part of which had not been sampled previously. In bed 10 of Mud section, the elements pertaining to *Ns. waageni* sensu lato (see Fig. 1.A) are similar to the specimens of "*Ns. waageni eowaageni*" that were described from beds 24-16, 24-20,

24-21 and 24-22 at Chaohu (Zhao et al., 2008a, fig. 3/ 1–4). *Neospathodus waageni* is a highly variable species that deserves further species differentiation (Goudemand et al., in prep. a, b). These early forms of "*Ns. waageni eowaageni*" were hitherto included in *Ns. waageni* sensu lato and discussed as such during earlier deliberations of the IOBWG. The fact that "*Ns. waageni eowaageni*" had not been recorded from Mud until now had actually led some people to question the completeness of the conodont record in Mud. Our results show that they do occur in Mud too and that they could be used to define the IOB. However, these early forms, which I will refer here to *Novispathodus waageni* new subspecies A, should be distinguished from true *Ns. waageni eowaageni*, a subspecies of '*Neospathodus*' *waageni* whose holotype is from higher up in the Chaohu section (bed 27 at Chaohu, Zhao et al., 2007, pl.1, fig.5; Zhao et al., 2008a, fig. 3/ 5; not pl. 1, fig. 11 from Zhao et al., 2008b, which was published later). Though the two forms are superficially similar, *Ns. waageni eowaageni* is about twice as large and its upper profile is more arcuate. I have many specimens of both forms in my collections (e.g., Waili and Mud) and *Novispathodus waageni* new subspecies A cannot be considered a juvenile form of *Ns. waageni eowaageni*.

Note also that I assign them to the genus *Novispathodus*, whose type species is *Novispathodus abruptus*, an early Spathian species. The P_1 element of *Novispathodus* is segminate and very similar to the P_1 of all neospathodids, but the other elements of the apparatus are different from those of *Neospathodus*, especially the P_2 element, which is characteristically high-bladed. In collections from both Waili and Mud, the P_1 s of *Novispathodus waageni* new subspecies A are found together with similarly denticulated, high-bladed P_2 s, which in my opinion belong also to *Novispathodus waageni* new subspecies A (see Fig. 1.B). Based on further unpublished reconstructions of its apparatus, *Ns. waageni* should be similarly re-assigned to the genus *Novispathodus* (e.g., Orchard & Zonneveld, 2009). This may apply also to all species associated with *Nv. waageni*, such as '*Neospathodus*' *pakistanensis* and '*Neospathodus*' *posterolongatus*.

At Chaohu, further elements that Zhao et al. (2008a) assigned to '*Neospathodus*' *posterolongatus* were also illustrated from the first 'Olenekian' beds containing *Novispathodus waageni* new subspecies A (Zhao et al., 2008a, beds 24-20 and 24-22, fig. 3/ 7, 8). *Novispathodus posterolongatus* was originally

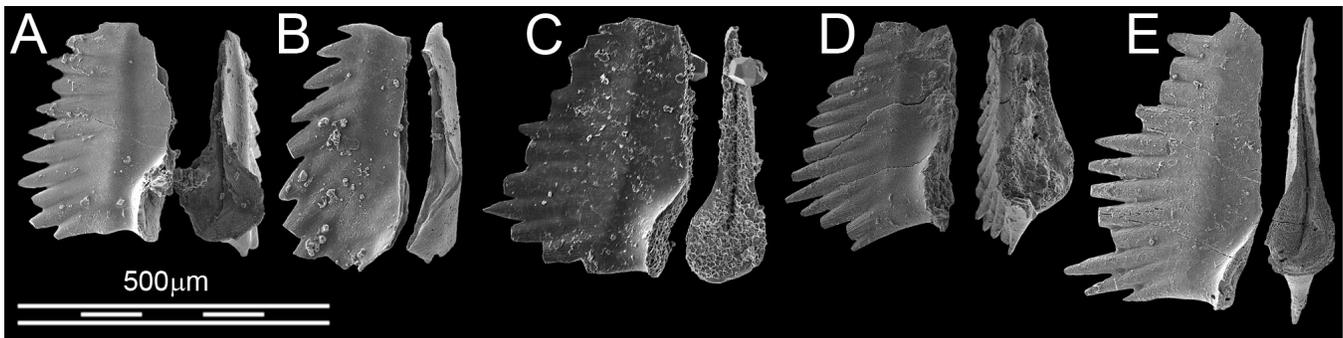


Figure 1 – **A–D**, *Novispathodus waageni* new subspecies **A**. **A**, P_1 element, Mud, bed 10. **B**, P_2 element, Mud, bed 10. **C**, **D**, P_1 elements, Waili cave section, bed W147 (=bed W235 of Galfetti et al., 2008). **E**, *Novispathodus* n. sp. **B**. P_1 element, Mud, bed 10. All SEM images, all $\times 80$. All specimens are deposited at the Paleontological Institute and Museum, University of Zurich, Switzerland.

considered a subspecies of *Nv. waageni*. It is also considered as a good secondary proxy for the IOB (IOB Working Group). *Novispathodus posterolongatus* is similar to *Nv. pakistanensis* but differs in the elongated basal cavity of its P_1 element. The holotype of *Nv. posterolongatus* comes from bed 25-25 at Chaohu (Zhao et al., 2007), where it co-occurs with *Nv. waageni waageni*. In Chaohu, Waili and Mud, the FOs of *Nv. posterolongatus* and *Nv. waageni* sensu stricto are sub-contemporaneous. In my opinion, the elements illustrated by Zhao et al. from beds 24-20 and 24-22 are not true *Nv. posterolongatus* and are better differentiated as a new taxon (Goudemand et al., in prep. a, b) that I refer here to *Novispathodus* n. sp. **B**. In all cases, the very same elements are also found to co-occur with *Novispathodus waageni* new subspecies **A** in collections from Mud and Waili (see Figs. 1.C–E) and they could also be used as an index for the IOB.

Based on these results, bed 10 in Mud correlates with the upper part of bed 24 in Chaohu (West Pingdingshan section). In accordance with the Chaohu section and the ammonoid data from Mud (Brühwiler et al., 2010), the IOB in Mud should be placed between beds 9 and 10.

The biostratigraphic sequences are very similar in Mud, Waili and Chaohu. In Mud, we find successively: *Novispathodus waageni* new subspecies **A** and *Novispathodus* n. sp. **B** (bed 10), *Borinella nepalensis* (from bed 11), *Eurygnathodus costatus* and *Eu. hamadai* (beds 12, 13), *N. waageni eowaageni* (from bed 14). In the Waili cave section in Guangxi, the same sequence is recognized: *Novispathodus waageni* new subspecies **A** is found (see Figs. 1C–D) about 1 meter below the massive ‘*Flemingites rursiradiatus*’ beds (Brayard and Bucher, 2008), *Borinella*. cf. *B. nepalensis* was found 30 cm above that, *Eu. costatus* and *Eu. hamadai* are restricted to the bed just below the *Flemingites* beds and the lowermost part of the *Flemingites* beds, and *Nv. waageni eowaageni* is found in the middle of the *Flemingites* beds. In Chaohu, and as far as one can tell from the published material, a similar sequence occurs, except that no element of *Borinella* is known. Finally, note that at Nammal section (Salt Range, Pakistan), the type locality of *Nv. waageni waageni*, P_1 and P_2 elements of *Novispathodus waageni* new subspecies **A** are also found in the earliest ‘Smithian’ strata (Goudemand et al., unpublished), much lower than the FO of *Nv. waageni* sensu stricto.

CONCLUSIONS

Based on our new data from Mud and Waili, we differentiate two new taxa (*Novispathodus waageni* new subspecies **A** and *Novispathodus* n. sp. **B**) that were previously thought to belong to *Nv. waageni eowaageni* and *Nv. posterolongatus* respectively. In Chaohu these two taxa occur in the earliest Smithian strata (sensu IOBWG). In Mud and Waili (and Nammal), they can also be used to define the base of the IOB. Such definition would be compatible with the ammonoid data from Mud. The conodont biostratigraphic sequences in Mud, Waili, and Chaohu are very similar.

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