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Muth (Spiti, Indian Himalaya) – A Candidate Global Stratigraphic Section and Point (GSSP) for the Base of the Olenekian Stage.

Leopold Krystyn[1], Om N. Bhargava[2] and Devendra K. Bhatt[3]

[1] Department of Palaeontology, Vienna University, A-1090 Vienna, Althanstrasse 14, Austria; leopold.krystyn@univie.ac.at

[2] 103, Sector 7, Panchkula 134 109, Haryana, India

[3] 57 Clay Square, Lucknow 226 024, Uttar Pradesh, India

Southern Tibet and the High Himalayan Range are now located in the Tibetan Zone known as the highest tectonic element of the Himalayan orogen. During the Lower Triassic time this zone was part of the tropical Indian Gondwana margin and formed a large deeper-neritic basin close to or below storm wave base with long-term stable environmental conditions. In this basin, pelagic fossils such as ammonoids, specific bivalves and conodonts were widespread deposited in fine-grained carbonates (distal tempestites or bioclastic wackestones). These are now found in prolifically in many places of northern India, Nepal and Tibet. The original low palaeolatitude, a high preservation potential and good fossil extractability are the fundamentals of an extraordinary pelagic faunal diversity record (Diener, 1897, Krafft & Diener, 1909, Waterhouse, 1996, Bhatt et al., 1999) and underline the past and present importance of the region for the chronostratigraphic subdivision of the Lower Triassic and for high-resolution fossil zonations. Waterhouse has recently proposed a new detailed ammonoid subdivision of the entire Lower Triassic for Nepal, and Spiti data with special reference to the Induan-Olenekian boundary are presented herein. A more recent geological monograph of Spiti has been published by Bhargava and Bassi, 1998.

The Muth section is situated in Lahul & Spiti district, northern Himachal Pradesh State of India in the Western Himalayas and is formerly proposed as candidate GSSP for the Induan-Olenekian boundary (Lower Triassic). It is reachable from Shimla (or Manali) through the main road along the Sutlej and Spiti valleys till Lingti and, from there up the Pin valley road up to the village of Muth (3800 m). Due to high altitude, access to the outcrop may be hindered by snowfall during the winter months but is principally unrestricted all year long. The travel to Spiti and Muth is open to persons of all nationalities.

Sediments representing the Lower Triassic in Spiti are found in the Mikin Formation (formerly Tamba Kurkur Fm.), subdivided recently into three members (Bhargava et al., 2004). Varying lithologies within the middle member allow discrimination of three intervals named for their diagnostic ammonoids from base to top as: 1) two to three meters thick *Gyronites* beds (the former *Meekoceras* beds of Krafft), 2) two meters thick *Flemingites* beds and 3) up to 10 m thick *Parahedenstroemia* beds. As for the

underlying lower member (*Otoceras* beds), the intervals can be traced along the Pin and Lingti rivers over tens of kilometres across strike and seem to constitute identical time-equivalent rock units. Faunistic studies of the I-O boundary interval so far have been concentrated in Muth section where board and lodging is available. The village itself rests on the Mikin Formation that extends from Muth towards northwest along a tributary valley for several kilometers to the crest between the Pin and Parahio valleys. Extensive continuous exposures on the northern valley slope provide excellent conditions for measuring and sampling of the sequence at many places between 3900 m and 5000 m altitude (see fig. 1 in Krystyn et al., 2004). For logistic reasons, work was concentrated at two sites, one 100 m above the village called as M 03 and another, newly sampled in 2004, named as M 04. The latter is more difficult to reach as it is located at 4200m in altitude, though extensive outcrop weathering provides better conditions for megafossil collection. Both places show identical rock sequences and can be correlated bed-by-bed. This allows a comprehensive data set presentation within one composite section (fig. 1) where the conodont file is equally known from both places whereas the ammonoid data are mostly derived from M 04.

The *Flemingites* beds constitute a monofacial succession of: (1) in the lower part approximately 1dm- and (2) in the upper third c. 5 cm-bedded, dark grey limestones. Fifteen layers, numbered as 12A to 12C, 13A to C, 14A to C, 15A to C and 16A to C record a sequence of four ammonoid as well as conodont zones, some of them with corresponding boundaries. From the base to the top the following ammonoid zones with their conodont counterparts are discriminated: 1) a "*Gyronites*" sp. Zone containing ammonoids of typical Induan affinity time-equivalent to the *nepalensis* Zone, 2) the *Rohillites rohilla* Zone equivalent to the *eowaageni* respectively *N. waageni* n. subsp. A Zone sensu Zhao Laishi et al., 2004, 3) the *Flemingites griesbachi* Zone coeval to the *elongata* = *N. waageni* n. subsp. B Zone and 4) the *Euflemingites* Zone corresponding to the top of the *elongata* and the (lower) *N. w.* w*aageni* Zone.

The new ammonoid sequence is presently recorded only from Muth, but counterparts of at least the *griesbachi* Zone may be found widespread in the eastern Tethys (Salt Range, Nepal, Tibet, Timor, China). The Muth zonal scheme gives way to three I-O boundary options: 1) the FO (or FA) of R*ohillites rohilla* in bed 13C: it marks the entry of flemingitids or typical Olenekian (Smithian) ammonoids (= O 1). The contemporaneous appearance of kashmiritids and of *Pseudohedenstroemia himalayica* strengthens the event; the latter may indicate apparent synchronicity with the appearance of *Hedenstroemia* in the Boreal; 2) the FO/FA of *Flemingites griesbachi* (and of *Flemingites* s. str.) in bed 14B (= O 2) and 3) the FO of

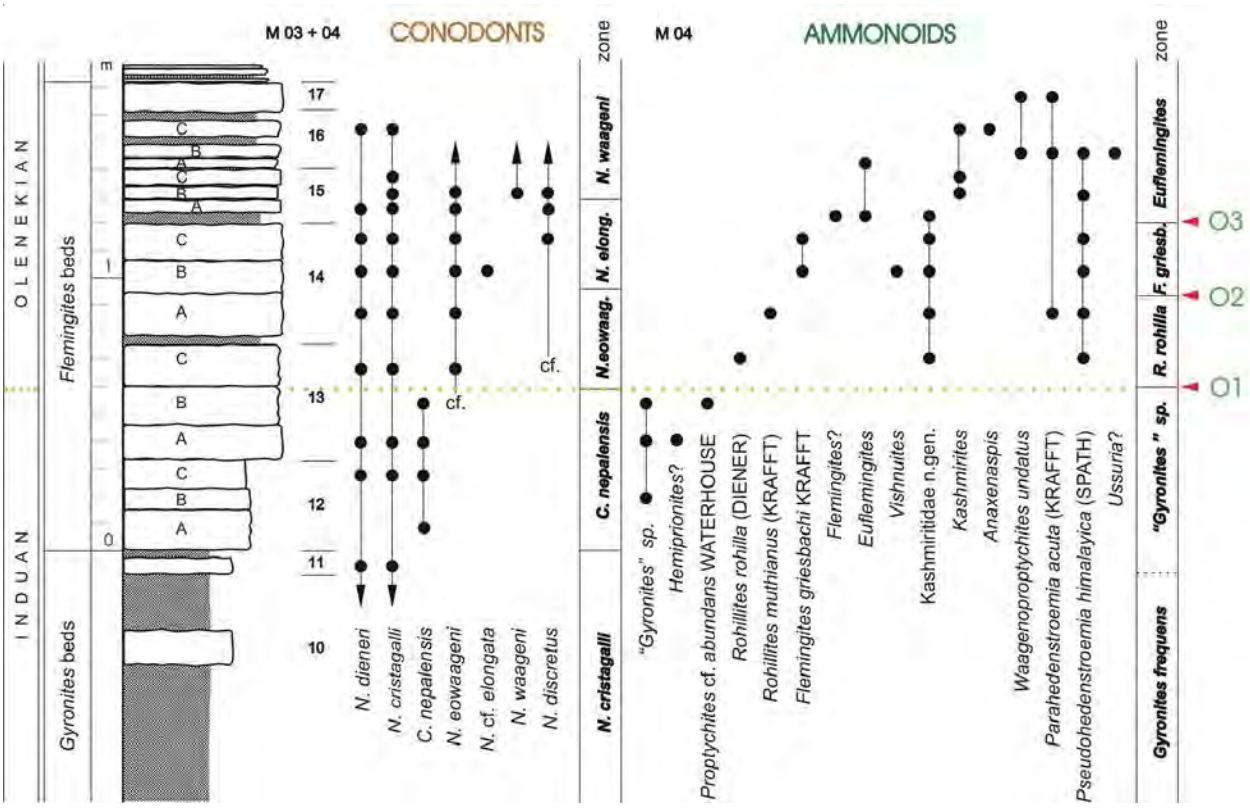

Figure 1. Ammonoid and conodont biochronology of the proposed Induan-Olenekian boundary candidate GSSP at Muth, Spiti.

Euflemingites in bed 15A (= O 3). Option 1 represents the most distinct ammonoid boundary, which seems to correlate with the onset of the *N. waageni* group also in Chaohu, China (Tong et al., 2003), a datum preferred by the Subcommission on Triassic Stratigraphy. It may be recognizable by conodonts in the Boreal realm through disappearance of *C. nepalensis*. Options 2 and 3 are less distinctive ammonoid boundaries despite the fact that the pandemic genus *Euflemingites* may represent the only direct stratigraphic link between low and high palaeolatitudes faunas within the whole time interval.

From a biochronological viewpoint, Muth is an obviously superior site compared to Chaohu, the other presently proposed candidate (Tong et al., 2003). The Chaohu sections have a) fewer macrofaunal elements, confined to an interval above the proposed boundary, and b) miss *C. nepalensis* as a complementary boundary proxy. Muth on contrary shows a reduced sediment accumulation rate reaching only half of the boundary beds thickness of Chaohu. Demonstration of sedimentary completeness and stratigraphic continuity is thus fundamental in Muth and is provided by the described successive appearance data of phylogeneticly related ammonoid and conodont taxa. A severe handicap of Muth section is a regional thermal overprint (CAI 3,5) that precludes a reliable magnetostratigraphy. A meaningful chemostratigraphy, however, is still possible (Atudorei, pers. comm.) and scheduled for 2005.

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A revised Lower Triassic intercalibrated ammonoid-conodont time scale of the eastern Tethys Realm based on Himalayan data.

Leopold Krystyn

Department of Palaeontology, Vienna University, Althanstrasse 14 – 1090 Vienna, Austria

The Himalayas are known since long as host of large and diverse Lower Triassic faunas, most of which unfortunately lack precise stratigraphic distribution data in the rock record. Useless from viewpoint of modern biochronological standards they otherwise are of great importance for their substantial historic contribution to the chronostratigraphic subdivision of the Lower Triassic stages and substages. Bearing that in mind a thorough reinvestigation of sections in Spiti from where a major part of the fauna was derived, has been started within recent years (Krystyn et al., 2004).

Results of the study lead to a considerable improvement of the (eastern) Tethyan ammonoid zonal scheme with the introduction of new zones around the Gangetian (=Griesbachian) – Brahmanian (=Dienerian) and the Dienerian – Smithian boundary (fig. 1). Correlated on a regional scale with other schemes established in the eastern Tethys (Salt Range, Tibet, southern China) as well as on a long distance scale with those from western Panthalassa (Primoriye) and from the Arctic (Canada, Siberia) the actual superiority of the Himalayan faunal sequence will be demonstrated and discussed. In the light of the presented data a reinstallation of parts of the classical stage and/or substage terminology of Mojsisovics et al., 1895 against younger and less adequate subdivisions (i.e. Induan, Griesbachian, Dienerian) is highly recommended and should be considered

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