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Integrative stratigraphy during extreme environmental changes and biotic recovery time: The Early Triassic in Indian Himalaya

Sylvain Richoz (1), Leopold Krystyn (2), Thomas Algeo (3), and Om Bhargava (4)

(1) Institute of Earth Sciences, University of Graz, Heinrichstraße 26, 8010 Graz, Austria (sylvain.richoz@uni-graz.at), (2) Institute of Paleontology, University of Vienna, Althanstrasse 14, 1090 Vienna, Austria (leopold.krystyn@univie.ac.at), (3) Dept. of Geology, University of Cincinnati, Cincinnati, Ohio 45221-0013 U.S.A. (algeot@ucmail.uc.edu), (4) 103, Sector 7, Panchkula 134109, Haryana, India (onbhargava@gmail.com)

The understanding of extreme environmental changes as major extinction events, perturbations of global biogeochemical cycles or rapid climate shifts is based on a precise timing of the different events. But especially in such moving environments exact correlations are difficult to establish what underlines the necessity of an integrated stratigraphy by using all tools at disposition.

A Lower Triassic section at Mud in the Spiti Valley (Western Himalaya, India) is a candidate section for the GSSP of the Induan-Olenekian Boundary (IOB). The succession was deposited in a deep-shelf setting on the southern margin of the Neotethys Ocean. The section contains abundant fossils allowing a very precise regional biostratigraphy and displays no signs of sedimentary breaks. Analysis of pelagic faunas proves a significant, two-step radiation phase in ammonoids and conodonts close to the Induan-Olenekian boundary. These diversifications are coupled with a short-termed positive $\delta^{13}C_{carb}$ excursion of global evidence. The Spiti $\delta^{13}C_{carb}$ excursion displays, however, different amplitude and biostratigraphic position than in other relevant sections for this time interval. In this study, we analyzed $\delta^{13}C_{carb}$, $\delta^{13}C_{org}$, and $\delta^{15}N_{org}$ as well as major, trace, and REE concentrations for a 16-m-thick interval spanning the mid-Griesbachian to early Spathian substages, to better constrains the chain of events. Prior to the first radiation step, high difference gradient between the $\delta^{13}C_{carb}$ values of tempestite beds with shallow carbonate and carbonate originated in deeper water is interpreted as a sign of a stratified water column. This effect disappears with the onset of better oxygenated conditions at the time of the ammonoid-conodont radiation, which correspond as well to $\delta^{13}C_{carb}$, $\delta^{13}C_{org}$ and $\delta^{15}N_{org}$ positive excursions. A decrease in Mo and U concentrations occurring at the same point suggests a shift toward locally less reducing conditions. The second step coincided with the change from terrigenous to almost pure carbonate sedimentation. This new set of data demonstrates from on hand the rapidity of radiation of the pelagic fauna in the aftermath of the Permian-Triassic extinction as soon as environmental conditions were favourable again. On the other hand, it demonstrates that bathymetry, for example, but also other local factors, could have had a significant impact in the timing of these radiations and may hamper solid worldwide correlations.