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TOWARDS A CARBON ISOTOPE REFERENCE CURVE OF THE UPPER TRIASSIC

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The mass extinction at the Triassic-Jurassic (T-J) boundary is one of the “Big Five” in the Phanerozoic. In marine habitats, significantly increased extinction rates at the end of the Triassic are well documented (Tanner et al., 2004). An important number of ammonoid and radiolarian families, the entire phylum of Conodonta and large numbers of species of bivalves, bryozoans, gastropods, brachiopods, echinoids and crinoids became extinct (McRoberts and Newton, 1995; Lethiers, 1998).

The presence and the amplitude of several crises (Krystyn, 2004) before the T-J boundary, however, may lead us to question its relative importance (Hallam, 2002). Strong disturbance in the environment and in the biodiversity record had already occurred at the Lower Carnian-Upper Carnian boundary and at the Lower to Middle Norian boundary with the most dramatic loss (70%) in biodiversity among Late Triassic molluscs (McRoberts and Newton, 1995). Starting in the Upper Norian (Sevatian), the pelagic fauna undergoes successive crises before the final Rhaetian-Hettangian boundary event (Krystyn and Kürschner, 2005). The relative importance of a major extinction event at the T-J boundary could thus be overestimated by the multiplication of crises during the whole Late Triassic. The continental picture is also equivocal. Catastrophic changes among vertebrates and plants have been suggested in the eastern USA (Olsen et al. 2002), but contradictory data are reported from Europe where macrofossils suggest a gradual transition in vegetation (Benton, 1994). A literature survey of palynological data shows that rates of extinctions significantly increased in the continental realm during the Late Triassic. In North America, 40% of all Late Triassic palynomorph taxa show their last appearances at the Carnian–Norian boundary, and 30% during the Norian, whereas only 20% occur at the T-J boundary (McElwain et al., 1999).

It therefore appears that despite new originations, the general decline in biodiversity was punctuated by a series of accelerated steps between the Carnian and the Rhaetian, while the T-J boundary event may have been the final strike. How these changes in the biosphere were related to oceanographic and/or geochemical changes during the known Late Triassic biotic crisis events is a question of primary importance. In order to solve this issue, two principal questions have to be addressed: (1) are these extinctions best explained by a gradual process of environmental change or by (a series of) abrupt or even catastrophic events? and (2) how do Late Triassic patterns of biotic turnover correlate and couple with oceanographic geochemistry? An expansion of a well-calibrated carbon isotope reference curve for the whole Upper Triassic is an important first step to address these questions.

While a comprehensive isotopic data set is available for the T-J boundary (Morante and Hallam, 1996; Guex et al., 2004; Kürschner et al., in press and reference therein; Pàlfy et al., in press; Ward et al., in press; Michalik et al., in press; Williford et al., in press), only a few data are available for the Upper Triassic (see Atudorei, 1999; Gawlick and Böhm, 2000; Hauser et al., 2001; Muttoni et al. 2004; Hornung and Brandner 2005; Korte et al., 2005; Hornung et al., in press for Carnian-Norian and Ward et al., 2001, 2004; Sephton et al., 2002 for the Rhaetian).

To establish a carbon isotope reference curve, several Tethyan and Peritethyan sections were measured in the Austrian Alps, Slovakia, Taurus, Oman and the Indian Himalayas. The Upper Ladinian samples record an increase in $\delta^{13}C_{carb}$ until the Lower Carnian, followed by stable values until the Upper Carnian. This stability is, however, disturbed by some small negative excursions in the isotopic signal near the Reingraben event and the Lower Carnian-Upper Carnian boundary (Spiti, Indian Himalaya; Mayerling, Austrian Alps and several sections in Taurus, this study; but see also Atudorei, 1999; Hauser et al., 2001; Hornung and Brandner, 2005 and Hornung et al, in press).

The Carnian-Norian boundary interval is marked by a minor increase in the C isotope value (less than 1‰; Gawlick and Böhm, 1999; Muttoni et al. 2004; this study). This transition is observed in Pizzo Mondello, Sicily (Muttoni et al., 2004), in Kälberstein Quarry, Austria (Gawlick and Böhm, 2000), in Bölücektasi Tepe and Erenkolu Mezarlick, Turkey, and in Silicka Brezova, Slovakia (this study), with amplitudes between 0.35‰ to 0.8‰. The isotopic values then show an increase until the Middle Norian followed by a decrease as recorded in Oman (this study), in Pizzo Mondello, Sicily (Muttoni et al., 2004) and in Kälberstein Quarry, Austria (Gawlick and Böhm, 2000). In the Upper Norian the isotopic values are relatively stable, and show no shift across the newly proposed Norian/Rhaetian boundary (Steinbergkogel, Austria and Oman, this study) before increasing again through the classical Norian/Rhaetian boundary (Oman and Oyuklu, Turkey, this study but also in British Columbia: Ward et al., 2001, 2004) into the Lower Rhaetian. Instead, Sephton et al. (2002) described a $\delta^{3}C_{org}$ peak in British Columbia at the Norian-Rhaetian boundary, which seems to be absent in the Tethyan $\delta^{13}C_{carb}$ record. The isotopic record then remains constant until the top of the Rhaetian and the famous negative double peak around the Triassic-Jurassic boundary.

The Reingraben event and the Lower Carnian-Upper Carnian boundary are apparently marked by a disturbance of the carbon cycle. The Lower to Middle Norian crisis is marked by a turning point from slowly increasing carbon isotopic values to gradually decreasing values. The Upper Norian (in the classical sense) is marked by a shift from decreasing to increasing isotope values. From an isotopic point of view, only the Reingraben event and Lower Carnian-Upper Carnian boundary can be interpreted as events, whereas other biotic crises of the Late Triassic seem to have occurred during periods of gradual changes in the isotopic composition of the marine seawater.

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