



Progress in integrated Late Triassic carbon isotopic stratigraphy of the Northern Calcareous Alps

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During the Late Triassic, despite new important originations a general decline in biodiversity was marked by a series of steps between the Carnian and the Rhaetian, with the T-J boundary event as final strike. The Reingraben Event and the Julian-Tuvalian boundary are two first massive turnovers; the Carnian-Norian boundary records a major vertebrate turnover, the early to middle Norian boundary comes up with a turnover in both the reefal and pelagic fauna and the most dramatic loss (70%) in biodiversity among Late Triassic molluscs. Around the Norian-Rhaetian boundary, the pelagic fauna of higher trophic level starts declining, whereas the reefs experience a blooming time. A refined stratigraphy and a construction of a well-calibrated carbon isotope reference curve are necessary to decipher between gradual environmental changes and abrupt or even catastrophic events during the Late Triassic.

Improvement in the Upper Triassic $\delta^{13}\text{C}_{\text{carb}}$ curve shows that after a gentle increase until the base of the Carnian, the early Carnian records three negative excursions of 2 to 3‰ amplitude. The two first excursions rebound to previous values, whereas the third negative excursion, at the Julian-Tuvalian boundary, is followed by a positive excursion up to +5‰. The remaining Upper Carnian displays stable values around 2‰. The Carnian-Norian boundary interval is marked by a minor increase of less than 1‰. The Early to Middle Norian crisis is marked by a turning point from Early Norian slowly increasing carbon isotope values (up to 3.5‰ to gradually decreasing ones until 1.8‰ at the base of the Rhaetian. This Norian decrease display two accelerated steps, one in the middle Norian and the other one just after the Norian-Rhaetian Boundary. This last 1‰ decrease corresponds however to an important change in lithology. The values show then a small increase during the early Rhaetian, with a maximum in the middle Rhaetian (at 2.4‰). The isotopic record remains constant until the top of the Rhaetian with its significant negative shift identified in a number of marine sections in close proximity to the extinction event. The general stability of the curve even through the Norian-Rhaetian boundary crisis event describes a stable oceanic structure prior the mass extinction. From an isotopic point of view, only the two Lower Carnian excursions, the Early Late-Upper Carnian Boundary and the Triassic-Jurassic 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 carbon isotopic composition of seawater.