Tectonic and climatic constraints on the West-Tethyan mid-Carnian Event

Thomas Hornung[1], Leopold Krystyn[2], Michael M. Joachimski[3], Rainer Brandner[1] & Christoph Spötl[1]

1 Leopold Franzens University of Innsbruck, Institute of Geology & Paleontology, Innrain 52, 6020 Innsbruck, Austria (Email: thomas.hornung@uibk.ac.at; rainer.brandner@uibk.ac.at; christoph.spoetl@uibk.ac.at)
2 University of Vienna, Department of Palaeontology, Althanstrasse 14, 1090 Vienna, Austria (Email: leopold.krystyn@univie.ac.at)
3 University of Erlangen, Institute of Geology, Schlossgarten 5, 91054 Erlangen, Germany (Email: Joachimski@geol.uni-erlangen.de)

The oxygen isotope composition from conodont apatite of three Carnian sections (Northern Calcareous Alps) was measured in order to unravel potential variations in marine palaeotemperature during the Mid-Carnian extinction event. Carbon and oxygen isotope record based on 150 whole rock samples of twelve sections sited within the central and eastern Northern Calcareous Alps (Longobardian 1 to Lacian 2) contributed complementary information concerning bioproductivity and organic carbon burial rate. Platform and ramiform conodont elements (CAI = 1.0; 1 mg samples or circa 100 to 150 platform conodonts) were derived from variegated limestones (Freygutweg; Hallein, Salzkammergut) and red limestones (Feuerkogel; Bad Aussee, Styria) of the Hallstatt Limestone Facies as well as from calcisiltites of the Pötschen Facies (Sandiger Höllgraben; Gosau / Upper Austria). The $\delta^{18}O_{phos}$-data reveal a significant negative excursion at the Julian / Tuvalian boundary showing an overall-amplitude of 2.5 ‰: conodonts of both bedded grey limestones of the Longobardian 1 (*hungaricus* Zone) and bedded light-coloured limestones of the Lacian 1-2 (*primitius* Zone) show low average $\delta^{18}O_{phos}$-values ranging between of 22.5 ± 0.3 ‰ and 22.3 ± 0.3 ‰ (VSMOW), respectively, whereas conodonts from red limestones of the Tuvalian 1 and 2 (*polygnathiformis* Zone) range at 20.0 ± 0.3 ‰. A very rapid end-Julian decline in $\delta^{18}O_{phos}$ (1.0 ‰) can be observed in the uppermost *austriacum* Zone translating into a short temperature rise of 4.5 ± 0.5°C. The overall warming from Longobardian 1 to the Julian/Tuvalian boundary amounts to 10 ± 1°C within a time period of approximately 5 Myrs.
Relatively high Ladinian $\delta^{13}C_{carb}$-values (3.5 ‰, VPDB) start to decrease rapidly in Longobardian 2 reaching lowest values of 1,8 ‰ within the *carnicus* Zone (Julian 1/IIc). Both the $\delta^{13}C_{carb}$- and the $\delta^{18}O_{phos}$-minima, however, follow circa 2 Myrs delayed at the end of the *austriacum* Zone and are connected two mid-Carnian biotic events affecting different types of biota:

a) Demise of carbonate platforms (Julian 1/IIc): The $\delta^{13}C_{carb}$-minimum corresponds to a demise of carbonate platforms at the onset of Reingraben Shales, traceable throughout the Tethyan realm. A potential trigger for this degradation is the Tethyan-wide mid-Carnian regression related to the Eo-Cimmerian collision and continental uplift in Eurasia: decelerated and stopped tectonic subsidence at the NW' Tethyan margin caused widespread emersion, loss of shallow-marine habitats and demise of reefal organisms and growth. Concomitant changes in plate configuration and/or atmospheric circulation patterns may have enforced the already existing mega-monsoon leading to an exceedingly wet climate (e.g. Simms and Ruffel, 1989; Parrish, 1999). The $\delta^{13}C_{carb}$-minimum can be thus explained by a) weathering and riverine influx that might have lowered the carbon isotope composition of dissolved inorganic carbon of shallow marine surface waters and by b) the absence of biomass deposition due to widely degraded carbonate factories.
b) Julian/Tuvalian-extinction event: The $\delta^{18}O_{phos}$-minimum parallels a $\delta^{13}C_{carb}$-maximum and a major extinction event that affected mainly marine nektonic biota such as conodonts and ammonoids, but also terrestrial organisms. The coincidence of the rapid End-Julian drop of $\delta^{18}O_{phos}$- and the $\delta^{13}C_{carb}$-maximum (4.0 ‰, VPDB) denotes the climax of siliciclastic input during wet climate (Schilfsandstein Member and Lunz Formation) and thus rapidly enhanced planktic marine bioproductivity without renewed reef flourishing. Indeed, the constantly high temperatures (as deduced from the oxygen composition of conodont apatite) during Tuvalian 1 and 2 correspond to evaporates of the Germanic Basin (Oberer Gipskeuper) and Lunz Facies (Opponitz Formation) translating into a temperature rise in marine (basinal) shelf areas but also on the continental hinterland, that, finally, led to significant extinction events: gladigondolellid conodonts and trachyceratid ammonoids dominating Lower Carnian strata disappeared at the end of the *austriacum* Zone. The monospecific occurrence of the conodont species *Metapolygnathus polygnathiformis* in the basal Tuvalian 1 may reflect well-adapted, euryhaline forms. Concerning the hinterland, labyrinthodonts got extinct and tetrapodes suffered a major decline (Simms and Ruffel, 1989).
In summary, we interpret the mid-Carnian event as a result of a climatic turning point in Triassic history, triggered by widespread plate tectonic change affecting both W' Eurasia and the NW' Tethyan margin. Both the $\delta^{13}C_{carb}$ and the $\delta^{18}O_{phos}$ data predict this climate change long before the event. The system remained perturbed since Lacian 1. Then, $\delta^{18}O_{phos}$-ratio rose and, accordingly, temperatures fell again to values as they persisted during Upper Ladinian and Lower Carnian. Reefs underwent flourishing. The $\delta^{13}C_{carb}$-ratio (3.4 ‰, VPDB) and thus bioproductivity remained constantly high up to Lacian 2. Then, and this has to be examined further studies, isotope data predicted a second Upper Triassic warming event, eventually being the precursor of the End-Triassic mass extinction.

Parrish, J.T. (1999): Pangaea und das Klima der Trias. – In: Hauschke, N., Wilde, V. (Eds.): Trias – eine ganz andere Welt: 37-42, Pfeil Verlag, München.

Simms, M.J., Ruffel, A.H., 1989: Synchroneity of climate change and extinctions in the Late Triassic. – *Geology* 17: 265-268.