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Decoupling of carbon isotope records between organic matter and carbonate prior to the Toarcian Oceanic Anoxic Event (Early Jurassic)

Stephane Bodin (1), Tim Kothe (1), Francois-Nicolas Krencker (1), Guillaume Suan (2), Ulrich Heimhofer (3), and Adrian Immenhauser (1)

(1) Ruhr-Universität, Bochum, Institute for Geology, Mineralogy and Geophysics, Bochum, Germany (stefbodin@gmail.com), (2) Université Lyon 1, Campus de la Doua, Bâtiment Géode, F-69622 Villeurbanne Cedex, France, (3) Institut für Geologie, Leibniz Universität Hannover, Germany

Across the Pliensbachian-Toarcian boundary (P-To, Early Jurassic), ca. 1 Myr before the Toarcian Oceanic Anoxic Event (T-OAE), an initial negative carbon isotope excursion has been documented in western Tethys sedimentary rocks. In carbonate, its amplitude (2–3 permil) is similar to the subsequent excursion recorded at the onset of the T-OAE. Being also associated with a rapid warming event, the significance of this first carbon isotope shift, in terms of paleoenvironmental interpretation and triggering mechanism, remains however elusive.
Taking advantage of expanded and rather continuous sections in the High Atlas of Morocco, several high-resolution, paired organic-inorganic carbon isotope records have been obtained across the Upper Pliensbachian - Lower Toarcian interval. At the onset of the T-OAE, an abrupt 1–2 permil negative shift is recorded in both organic and inorganic phases, succeeded by a relatively longer term 1–2 permil negative trend and a final slow return to pre-excursion conditions. In accordance with previous interpretations, this pattern indicates a perturbation of the entire exogenic carbon isotope reservoir at the onset of the T-OAE by the sudden release of isotopically light carbon into the atmosphere. By contrast, there is no negative shift in carbon isotopes for the P-To event recorded in bulk organic matter of Morocco. Given the strong dominance of terrestrial particles in the bulk organic matter fraction, this absence indicates that massive input of 12C-rich carbon into the atmosphere is not likely to have happened during the P-To event. A pronounced (2 permil) and abrupt negative shift in carbon isotope is however recorded in the bulk carbonate phase. We suggest that this decoupling between organic and inorganic phase is due to changes in the nature of the bulk carbonate phase. Indeed, the negative shift occurs at the lithological transition between Pliensbachian–lowermost Toarcian limestone-marl alternations and the Lower Toarcian marl-dominated deposits. Before the P-To event, vigorous shallow-water carbonate factories were responsible for the bulk of carbonate production and export into the basin. Being dominated by aragonite precipitation, they tend to have a more positive carbon isotope signature than carbonate produced offshore. The demise of the shallow water platforms during the P-To event has led to a drastic reduction in the amount of carbonate in the rock record (indicated by the switch from limestone-marl alternations to a marl-dominated sequence), as well as to a marked decrease in the production and export of isotopically heavy carbon, ultimately recorded by a negative shift in the isotopic signature of the bulk carbonate fraction. This study highlights the need of paired organic-inorganic carbon isotope record in order to fully distinguish regional from global perturbation in the carbon cycle.