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The Toarcian Oceanic Anoxic Event: a shallow-water perspective

Stephane Bodin (1), Francois-Nicolas Krencker (1), Lahcen Kabiri (2), and Adrian Immenhauser (1)

(1) Ruhr-Universität Bochum, Institute for Geology, Mineralogy and Geophysics, Germany, (2) Faculty of Science and Techniques Errachidia, University of Moulay Ismaïl, Boutalamine-Errachidia, Morocco

The Toarcian ocean anoxic event (T-OAE, ca. 183 Ma) corresponds to a major perturbation of the carbon cycle as reflected by a marked decrease (2 to 7 per mil) in carbon-isotope ratios of various carbonate and organic matter phases. Severe environmental perturbations and biotic turnovers are accompanying the unfolding of the T-OAE, which is thought to be initiated by the activity of the Karoo-Ferrar large igneous province. Most of the studies dedicated to the T-OAE were however undertaken in mud-rich, deep-water setting, leaving vast uncertainties about its shallow-water expression and accompanying sea-level fluctuations.

Here we present an extensive sedimentological dataset of the shallow-water record of the T-OAE within the Central High Atlas Basin of Morocco. The combination of ammonite and brachiopod biostratigraphy, together with carbon-isotope chemostratigraphy (on both carbonate and organic matter) allows a precise location of the T-OAE in the studied shallow-water sections. Thanks to well-exposed and thick successions, relative sea-level variations were reconstructed on a high-resolution scale, highlighting several important facts.

Firstly, the T-OAE interval is preceded by a 50 meters-deep incised valley, observed within the uppermost Polymorphum ammonite zone. Similar observations have been reported from Euro-boreal basins and, together with published evidences of coeval occurrence of relatively cool seawater temperature and low atmospheric pCO_2, we postulate that this forced regression is driven by glacio-eustasy. This points at the occurrence of a "cold snap" event just prior to the onset of the T-OAE. Secondly, the inception of the T-OAE is marked by the demise of the Lithiotid-dominated neritic carbonate factory, replaced by siliciclastic-dominated sedimentation during the T-OAE negative carbon isotope shift. Thirdly, an important progradation of oo-biodetritic shoal occurs during the negative carbon isotope plateau, underlying that the renewal of carbonate production occurred already during the T-OAE. Fourthly, a second-order maximum flooding interval is reported from the uppermost Levisoni ammonite zone, within the interval of return to pre-excursion carbon-isotope values. Finally, the ubiquitous presence of storm-related features within the T-OAE, as well as a marked seaward expansion of the storm-influenced zone, points at an increase of hurricane intensity associated with the T-OAE hyperthermal.

Altogether, the observations help to better understand the dramatic environmental changes having occurred during the unfolding of the T-OAE, as well as their consequences on, and interaction with, the neritic carbonate factory.