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The shallow water carbonate record of Early Jurassic Mass extinctions, Oceanic Anoxic Events, and major palaeoenvironmental changes

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Extreme palaeoenvironmental perturbations have profoundly affected the history of life on Earth as well as the sedimentary record. There is a crucial need to understand how ecosystems respond to these events (e.g., ocean warming, acidification, and decreased oxygenation) in order to predict and mitigate the changes associated with modern environmental degradation. Several ancient carbon cycle perturbations, such as the Toarcian Oceanic Anoxic Event (T-OAE) in the Early Jurassic, have been identified as good analogues for modern ecological changes. Although there is a great deal of work on the T-OAE record from deeper water settings (e.g., anoxic rift basins, deep shelf environments), there remains a significant gap in our knowledge about the shallow-water record of extreme palaeoenvironmental events in the Early Jurassic events (specifically the Pliensbachian-Toarcian boundary and the T-OAE).

This research combines geochemical and palaeontological data from two shallow-water Early Jurassic records: the Dinaric Carbonate Platform (Slovenia) and the High Atlas Mountains (Morocco). The Dinaric Carbonate Platform contains Pleinsbachian lithiotid (bivalve) biostromes, coral bioherms, and a diverse assemblage of carbonate producing fauna. Our work at this site focuses on documenting the geochemical (C, Sr, and O isotopic data as well as major and trace element data) and sedimentological signature of the T-OAE in a shallow water carbonate setting. Our paired litho- and chemostratigraphy show that reduced sedimentation rates and hiatal surfaces on the outer Dinaric carbonate platform developed as a result of a diminished carbonate factory. Based on our benthic faunal patterns and geochemical data, the carbonate production crisis is posited to have been a result of the combination of eutrophication, episodic anoxia, and ocean acidification coincident with large igneous province activity (recorded in mercury concentrations). The deteriorated palaeoenvironment led to long-term sedimentological expressions of a stressed ecosystem on this carbonate platform.

The Moroccan High Atlas Mountains provide another excellent shallow-water record of the T-OAE, with a thick carbonate mixed carbonate-siliciclastic shelf-to-ramp setting preserved through the entire Early Jurassic interval. Several key observations can be made in Morocco: there is no evidence for anoxia in this shallow-water locality; the carbonate factory collapses at the Pliensbachian-Toarcian stage boundary as well as the T-OAE; and the reef communities, particularly the lithiotid biostromes, persist across the stage boundary through to the T-OAE. The Moroccan Atlas Mountains also record the oldest corals reefs to recover from the T-OAE, indicating that these shallow-water carbonate environments may be more hospitable to reef ecosystems and shallow-water marine communities. These data will allow us to build a more nuanced understanding of the palaeoenvironmental conditions during the T-OAE, connect the basinal and shallower-water records of the OAE, as well as document the collapse and recovery of the shallow-water community during this extinction.