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Evolution of the carbon cycle and seawater temperature from the Triassic-Jurassic boundary to the Early Toarcian based on brachiopod geochemistry

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The ecological crisis and extinction at the end of the Triassic coincides with several environmental perturbations such as global temperature rise, ocean acidification and carbon isotope anomalies, with a large observed negative carbon isotope excursion (CIE) in the Late Rhaetian as well. Followed by the ETE, the Early Jurassic was characterized by marked fluctuations of the global seawater temperature and carbon cycle. Carbon isotope records are showing positive and remarkable negative excursions. A particular example of these phenomena is connected to the Toarcian Oceanic Anoxic Event (TOAE). The δ13C record of the TOAE is showing a negative excursion of a high magnitude, suggesting the injection of large amount of light carbon into the ocean-atmosphere system, coinciding with rapid global warming and widespread anoxia. Beside the TOAE there are many other, smaller scale carbon isotope anomalies and environmental perturbations at the Sinemurian-Pliensbachian transition or at the Pliensbachian-Toarcian boundary.
In our study, we provide new brachiopod δ13C, δ18O, and Mg/Ca data from the time interval starting in the Rhaetian till the end of the Early Toarcian. Considering the strong resistance of brachiopod shells against diagenesis, our aim is to reconstruct seawater temperature, seawater Mg/Ca, and carbon cycle evolution based on a reliable geochemical proxy database of the studied time interval. The samples have been collected from various localities across Europe achieving a good, at least ammonite subzone scale resolution for the Rhaetian stage and for the Lower Jurassic. The geochemical preservation of the shell material have been tested by several approaches. Thin-sections were made from the shells and analyzed by electron microprobe and ICP-OES to evaluate their preservation by assessing concentrations of Fe, Mn, Sr, and their ratios (Mn/Ca, Sr/Ca). Considering the various elemental composition data of fossil and recent brachiopods published by several authors, we established thresholds as Sr/Ca > 0,46 ($\sim$ 400 ppm Sr) and Mn/Ca < 0,37 ($\sim$ 200 ppm Mn) for samples with good preservation and Sr/Ca > 0,34 ($\sim$ 300 ppm Sr) and Mn/Ca < 1 ($\sim$ 460 ppm Mn) for moderate preservation. Samples not fitting to this criteria were excluded from the data sets used in our interpretations. We find that average values of Mg/Ca measured on different species collected in the same stratigraphic level show low variability, suggesting minor species-specific effects on this ratio. High-resolution transects through shells of some species detect cyclic fluctuations in Mg/Ca that coincide with growth lines, suggesting that this ratio captures changes in temperature seasonality.