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Redox changes across the Triassic-Jurassic boundary: From anoxic to euxinic black shale deposition

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The Triassic-Jurassic boundary (T-J; 201.6 Ma) marks one of the so called Big Five mass-extinction events that may have led to the extinction of more than 80% of all marine invertebrates. The extinction of marine and terrestrial biota is increasingly linked to the outgassing of large volumes of CO2 and SO2 during the emplacement of the Central Atlantic Magmatic Province. Here, we present multi-disciplinary data, including organic geochemical proxies, isotope (C, N), and palynological data, from cores in Luxemburg (Rosswinkel), and northern (Mariental) and southern Germany (Mingolsheim) that provide evidence for changes in type of black shale deposition that reflect major environmental perturbations across the T-J boundary. Prior to the T-J extinction, the Uppermost Rhaetian in Germany contains black shales that are rich in dinoflagellate cysts, and show high amplitude nitrogen isotope excursions. No biomarker evidence for photic zone euxinia was found in the Rhaetian. Because cyst-building dinoflagellates require oxygenated bottom waters, Rhaetian organic-rich sediments were deposited through high-productivity in well mixed shallow marine basins. Following the major overturn of terrestrial vegetation (fern spike) and the marine extinction level, black shales in the lowermost Hettangian reveal extremely low dinoflagellate cyst abundance, but high abundance of prasinophyte green algae and acritarchs. These black shales also show elevated quantities of the biomarker isorenieratane. Isorenieratane derives from the brown strains of photosynthetic green sulphur bacteria (Chlorobiaceae) that require both light and free hydrogen sulfide in the water column. The presence of abundant aryl isoprenoids (isorenieratane and its diagenetic products) in Luxemburg and N Germany suggests that marginal marine basins in NW Europe became salinity stratified and developed intense Photic Zone Euxinia (PZE) after the mass extinction event. This change in low oxygen conditions is consistent with the long-term effects of CO2 release, greenhouse warming and post-extinction productivity breakdown. Isorenieratane occurs repeatedly in Hettangian and Sinemurian organic rich sediments. Hence, repeated PZE in epicontinental seas bordering the Tethys Ocean may have contributed to the slow recovery of shallow marine ecosystems after the Triassic-Jurassic boundary.