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# Ocean acidification and continental weathering at the Toarcian Oceanic Anoxic Event captured by boron and lithium isotopes

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Earth's geological record is marked by climate disturbances and mass extinctions, which are usually linked to rapid releases of carbon dioxide ($CO_2$), leading not only to global warming but also to ocean acidification and widespread ocean deoxygenation. Subsequent climate stabilization is typically attributed to an increase in continental weathering, which reduces $CO_2$ concentrations and counteracts ocean acidification. The Early Jurassic Toarcian Oceanic Anoxic Event (ca. 183 million years ago) marks a global mass extinction coincident with widespread ocean anoxia and rapid greenhouse warming. This was likely driven by pulses of volcanic activity and metamorphism associated with the Karoo and Ferrar large igneous provinces, which have caused a rapid input of $CO_2$ into the atmosphere–ocean system. To test if ocean acidification was an additional environmental stressor and if weathering acted as a key part of the subsequent environmental restoration process, we created a multi-isotope (Li, B, C, O, Mg, Sr) record using micrites and fossil brachiopod and oyster shells from two marine carbonate sections in SW Europe, deposited in the NW Tethys. The micrite B isotope data document an ocean acidification event during the TOAE, which was reproduced using a coupled biogeochemical (COPSE) model. These findings indicate that ocean acidification was a possible additional stressor at the beginning und and during the T-OAE, but community recovery appears to be independent of ocean pH. At the same time, stable boron isotope values of brachiopods and bivalves show no excursions, suggesting these taxa may have been able to physiologically buffer changes in ocean pH. The combined lithium, magnesium and strontium isotope ratios from micrites and fossil shells point to a change in the silicate weathering regime from incongruent to congruent during the T-OAE. This transition, marked by reduced clay and soil formation and high mineral dissolution rates, is consistent with other geochemical proxies for this interval. The onset of congruent weathering would also have drawn down atmospheric $CO_2$ and increased bicarbonate flux into the oceans. This process likely contributed to the up-regulation of oceanic pH, playing a key role in restoring the Earth system to its pre-perturbation state.