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Application of multiple isotope proxies to reconstruct the paleoredox evolution of the oceans and oceanic basins

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Traditional and non-traditional isotope proxies have become a widely used tool to reconstruct the redox evolution of the oceans throughout Earth history [1, 2, 3]. Analytical improvements of MC-ICP-MS techniques now allow the measurement of essentially all transition metals, including U isotopes [4], at high precision for use in such investigations. All of these isotope proxies have in common that they are based on redox-related isotope fractionation. Mo and U isotopes appear to be particularly suitable to characterize distinct periods with global perturbations in the oceanic oxygen evolution (e.g. [5, 6, 7]). However, the proper use of these isotope proxies requires detailed knowledge of the isotopic mass balance and fractionation mechanisms of the respective elements. Here we present new constrains on the recently developed U isotope proxy that are based on experimental [8] and natural observations.

Paleoredox investigations usually rely on records preserved in sedimentary deposits, however our knowledge of the paleo-environmental situation is frequently incomplete. Some environmental parameters, such as basin structures and local redox shifts, may produce local isotope effects (e.g. [9]). To gain complementary information, we therefore apply a multi-proxy approach, including Mo-, U- (and S) isotopes, as well as trace element signatures, to characterize and quantify the extent of seafloor anoxia during some important Mesozoic oceanic anoxic events (OAE). Our results indicate a global increase of oceanic anoxic conditions during and around the Cretaceous OAE-2 and also during and before the early Jurassic T-OAE. However, isotope (particularly S and U) and trace element signatures of samples deposited during the T-OAE are likely dominated by basin isolation (due to regression), resulting in a coupled draw down of redox-sensitive elements from the water column. Post T-OAE isotope signatures indicate connection of the basins to the open ocean and a global decrease of seafloor anoxia close to present day levels.

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