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Mo isotopes in OAE 2 black shales

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Sedimentary rocks, especially organic-rich deposits, have the potential to track change in the oxygenation state of the ocean over geological time. Oceanic anoxic events (OAEs) correspond to periods of profound and rapid environmental change, which have led to both the widespread deposition of black shales and the development of widespread anoxia in the ocean. Understanding the variations in redox conditions during these events is of primary importance, since recent observations and modelling have shown that processes invoked to explain the origin of OAEs are being observed today as a consequence of anthropogenic change. Here, we compare redox-sensitive trace metal (RSTM) distributions and molybdenum (Mo) isotope variations during a major Cretaceous OAE (OAE 2, Bonarelli event). Whereas RSTM have the potential to provide insights regarding local depositional conditions and processes in palaeoceanographic systems, Mo-isotope data can, under certain circumstances, provide quantitative estimates of how the global extent of seawater anoxia may have fluctuated in the past. We selected for study a series sections within the western Tethys (La Contessa and Furlo, Italy) and in the northern Atlantic (DSDP site 367, Cape Verde Basin and ODP site 1276, Newfoundland Basin.

RSTM contents show similar trends through all the studied sections, characterized by low concentration below and above the OAE interval and higher concentrations within the Bonarelli interval. This suggests rapid variations in the redox conditions, from suboxic to euxinic conditions during OAE 2. The RSTM enrichment factors (EFs) indicate different depositional conditions and palaeoceanographic processes between the Tethys and the North Atlantic. Whereas the North Atlantic sites show evidence of weak watermass restriction associated with the action of a particulate shuttle within the water column, the EFs of the Tethyan sections are characteristic of unrestricted marine systems. Despite local differences in the redox conditions, δ98Mo values show similar values and trends along the sections of La Contessa and Furlo, and ODP site 1276. At the onset of OAE 2, an increasing trend in δ98Mo is observed with values ranging from -0.6 to 0.6 ‰Ḋuring the 2nd half of OAE 2, the δ98Mo curve shows a progressive shift towards more negative values. This pattern is contrasted with the Mo isotope record from DSDP site 367. Before the OAE 2 interval, the δ^{98}Mo values fluctuate between 0.15 and 0.48‰Ḋuring OAE 2, an increase in δ^{98}Mo is observed, ranging from 0.15 to 1.15 ‰Ṫhen, the Mo isotopes show two rapid fluctuations towards lower values ($\sim$0.70 ‰) and increase again to relatively constant values, with values fluctuating around an average value of 1.10 ‰

Both the western Tethys and the Northern Atlantic sites show redox variations, reaching anoxic/euxinic conditions. In the western Tethys, despite evidence of strongly reducing conditions, the relatively light δ^{98}Mo values suggest that redox conditions may not have been fully euxinic. The light δ^{98}Mo values may thus be related to non-quantitative removal of Mo from the water column. At site 367, the Mo isotope variations and the RSTE concentrations suggest fully euxinic conditions and the sediments deposited during OAE 2 may have recorded the seawater signature.