Quantifying OAE2 marine oxygen levels from coupled Mo and U isotopes: A Tethyan perspective

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U and Mo isotopes are promising geochemical proxies for globally averaged ocean redox conditions in deep time. Because the Mo and U isotope compositions of seawater are controlled primarily by variation in ocean redox conditions, coupled Mo and U isotope records can be used to reconstruct variation in the relative sizes of oxic/suboxic, anoxic and euxinic sinks over geological time. The different sensitivities of Mo and U to anoxic and euxinic conditions creates a situation in which joint evaluation of the Mo and U isotope records provide greater constraints on variation in ocean redox conditions than either proxy can in isolation.

Here we report new and published Mo- and U-isotope data from shallow and deep marine black shales spanning the OAE2 along the subtropical Western Tethys. These data are used to infer the evolution of the seawater Mo and U isotope compositions and to investigate changes in marine oxygen levels during this interval. Because the incorporation of Mo and U isotopes into organic rich sediments is influenced by local bottom water redox conditions, we also report Fe speciation data from which oxygen levels in the marine substrate were determined in a sample-by-sample basis. Our Fe speciation data suggest expansion of the Oxygen Minimum Zones (OMZs) into the shallow western Tethys ocean waters; as well as the presence of an oxygenated deep Tethys ocean. These differences in bottom water redox conditions explain observed heterogeneities on black shale Mo-isotope compositions within the Western Tethys. Box modeling of the seawater coupled Mo- and U- isotope system suggest that anoxic and euxinic bottom water redox conditions occupied approximately 40 % and 15 % of the marine substrate respectively. These estimates are in accordance with previous estimates based on U-isotopes. The similar evolution of the seawater Mo, U and C isotope compositions suggest enhanced shallow marine anoxia as an important mechanism controlling the C-cycle during the OAE2. The observed heterogeneities in ocean bottom water redox conditions may explain the differences on the degree of affection of marine life during the OAE2.