Variable redox conditions leading to Early Cambrian black shale-hosted Ni-Mo and V mineralization in South China as revealed by Mo-U isotopes

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Molybdenum and uranium isotopes are promising proxies for paleo-redox conditons of the Earth oceanic system. Both Mo and U are highly redox-sensitive elements and show variable isotope fractionation during precipitation under oxic, suboxic and euxinic conditions. Here we report the Mo and U isotope composition of Early Cambrian Ni-Mo-, V-rich black shale units and their black shale country rocks from the southeastern margin of the Yangtze Platform, South China.

Sulfide-rich samples (Ni-Mo ore) have $\delta^{238/235}$U ranging from 0 to 0.43 ‰ (mean: 0.22 ±0.14 ‰) and $\delta^{98/95}$Mo ranging from 0.25 to 1.38 ‰ (mean: 0.94 ±0.27 ‰). Comparatively, vanadium ores have variable but elevated $\delta^{238/235}$U values ranging from -0.11 to 0.68 ‰ (mean: 0.42 ±0.23 ‰) and depleted $\delta^{98/95}$Mo values ranging from -0.52 to 0.51 ‰ (mean: 0.03 ±0.36 ‰). Black shales from both Ni-Mo sulfide and vanadium mine sites have $\delta^{238/235}$U ranging from -0.51 to 0.37 ‰ (mean: -0.02 ±0.27 ‰) and $\delta^{98/95}$Mo ranging from 0.24 to 2.29 ‰ (mean: 1.31 ±0.59 ‰). Overall, the U isotope data show a negative correlation with the Mo isotope data (R^2 = 0.53). We infer that Mo and U isotopes have been fractionated due to variable redox seawater condition during Ni-Mo and V fixation. The strong U isotope fractionation of V ore from seawater may have resulted from partical removal under an open marine suboxic to anxoic setting. Whereas the moderate U isotope fractionation of Ni-Mo-rich black shale could be explained by complete U removal from seawater in a restricted basin. Such a situation has been suggested by Lehmann et al. (2007) and Xu et al. (2013). The geographically more widespread V mineralization compared to the Ni-Mo ore in the southerm margin of the Yangtze Platform indicates that suboxic seawater conditions were extensive during the Early Cambrian, and euxinic basins occurred only locally.

References:

Lehmann et al. (2007) Geology 35, 403-406.

Xu et al. (2013) Ore Geology Reviews 52, 66-84.