Heaviest Precambrian shale U isotopes to date: Oxygenation in the ~2.0 Ga Zaonega Formation, Russia

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The initial rise of oxygen in the Paleoproterozoic was followed by a massive positive C isotope excursion known as the Lomagundi Event (LE), ~2.3–2.05 Ga. A widely-accepted explanation for the LE invokes an elevated organic C to carbonate C burial ratio, which would have additionally resulted in the release of vast amounts of free O_2 [1]. Yet, this implies unlikely levels of bioproduction and very few organic-rich deposits are known from the time.

To test this mechanism, we study U, Mo, and Cr isotopes in immediately post-LE (~2.0 Ga) shales of the Zaonega Formation (ZF), Russia [2]. If organic carbon burial was responsible for the LE, O_2 production was likely to have lessened by the time of ZF deposition. Yet, we find $\delta^{238}U$ values up to 0.79±0.09‰ in the ZF, the highest reported to date from Precambrian shales. This is significant because even with maximum fractionation from seawater to sediments, such values require a marine U pool at nearly the modern $\delta^{238}U$ composition of ~−0.4‰. This suggests a limited extent of ocean anoxia, as anoxic sediments preferentially scavenge ^{238}U from seawater, leaving the residual pool ^{238}U-depleted.

These data, combined with fractionated Cr isotopic ratios and high Mo, U, and Cr abundance, suggest highly oxidized global oceans at the time of ZF deposition. Since our data come from firmly post-LE strata, this contradicts the idea that O_2 production decreased rapidly following the end of the LE, indicating against organic carbon burial as a driver of the LE carbon isotope excursion. Instead, alternative explanations are needed for these profound perturbations in the Paleoproterozoic O_2 and C cycles.

[1] Karhu & Holland (1996) *Geology* **14**, 867-870. [2] Mänd *et al*. (accepted) *Nat. Geosci*.