Oxygenated oceans persisted after the termination of the Lomagundi Event: Evidence from the Zaonega Formation

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Background & objectives

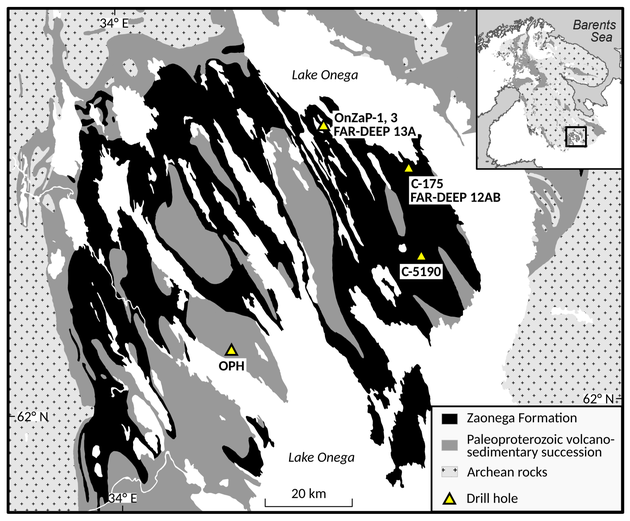
The ~2.22 to 2.05 Ga Lomagundi Event (LE), the longest-lasting carbonate C isotope excursion in Earth history, is widely believed to reflect an increased organic C burial flux that also led to high (even near-modern) concentrations of O_2 in the Paleoproterozoic atmosphere. After the end of the LE, as the organic C burial flux lessened, atmospheric O_2 is thought to have crashed to mid-Proterozoic levels [1].

The ~2.0 Ga Zaonega Formation (ZF), a post-LE section, is a lynchpin in the study of these major transformations, yet previous works have led to two opposed views on Earth's oxygenation during ZF deposition. We studied trace metal redox proxies from two coring sites in the ZF in order to shed light on post-LE redox developments.

Key findings

- The ZF contains the highest Mo, U, and Re concentrations reported to date in pre-Neoproterozoic shales (1009 μg g^{-1}, 238 μg g^{-1}, and 516 ng g^{-1}, respectively).
- In-situ elemental abundance mapping and basin-wide correlation of trace metal-enriched horizons suggest that these enrichments are primary.
- The ZF must have been connected to a large marine pool of Mo, U, and Re, which, in turn, suggests that the continental margins were predominantly oxic at ~2.0 Ga.
- If the post-LE ocean-atmospheric system remained oxidized as our data suggests, then current theories on the mechanisms behind the Lomagundi Event and the Paleoproterozoic "O_2 overshoot" should be revisited.

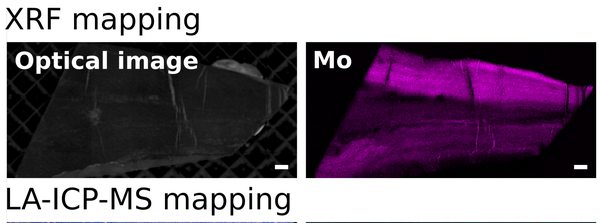
Study area



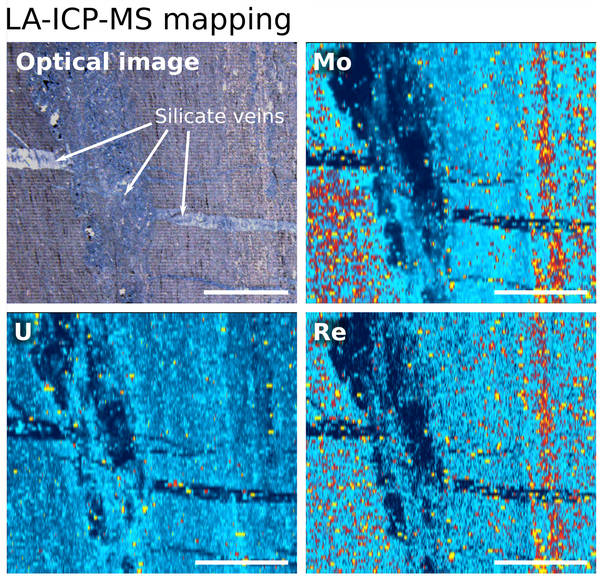
The ~2.0 Ga ZF is an organic C-rich carbonate-shale succession, interlayered with lavas and tuffs. It overlies the LE-aged Tulomozero Formation, but is itself a firmly post-LE succession, as evidenced by its carbonate C isotope record [2].

Post-depositional alteration?

XRF mapping

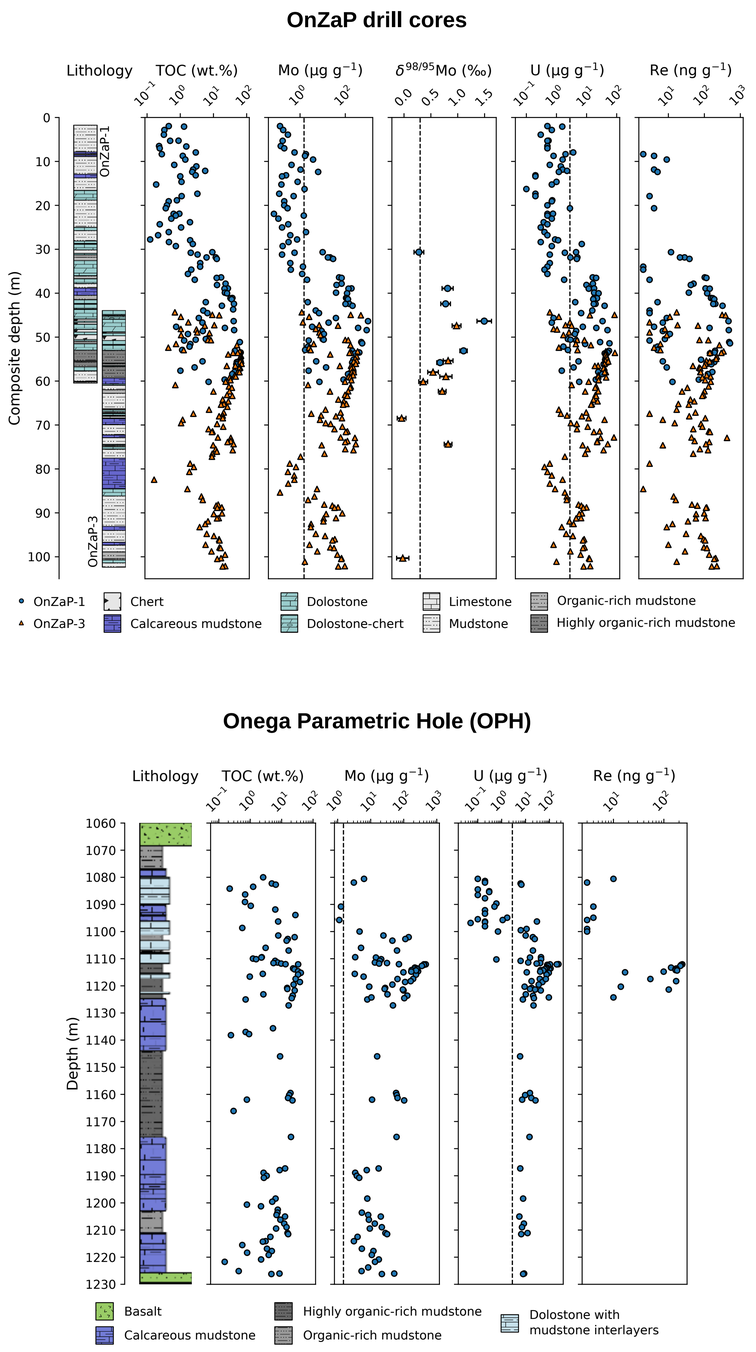


LA-ICP-MS mapping



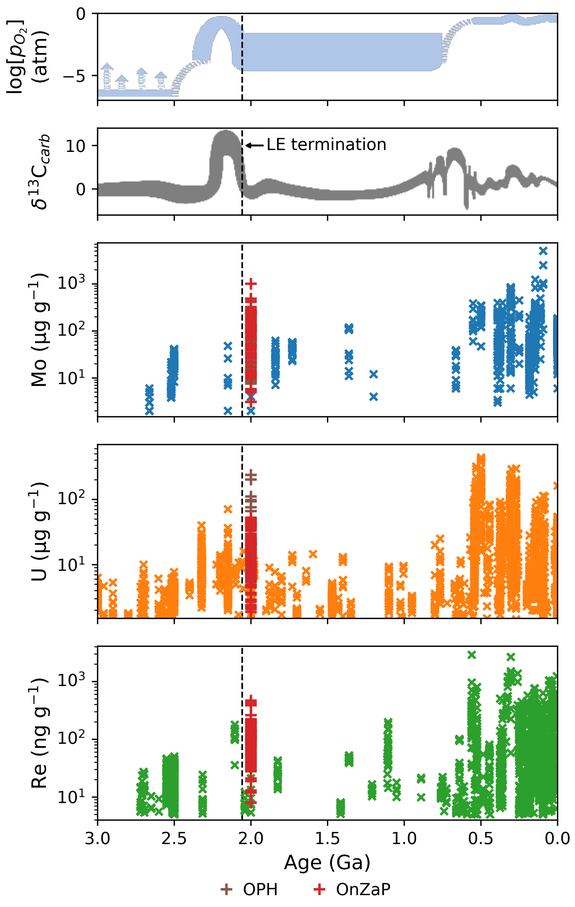
In-situ trace metal abundance maps of a black shale sample from the OnZaP drill core. Trace metals are associated with laminated, organic C-rich sediments, not hydrothermal veining, suggesting that the ZF trace metal inventory is primary. Scale bars are 2 mm.

Trace metal redox proxies



Total organic C content, trace metal abundances and Mo isotope composition in the OnZaP and OPH drill cores, upper ZF. Dashed lines represent average crustal content. Re crustal average is 0.4 ng g^{-1}. These sections are correlated lithologically, as well as through S and C isotope stratigraphy [3].

Implications



Inferred atmospheric O_2 levels [4], carbonate C isotopic composition [5] and shale trace metal abundance through Earth history [6-8]. Trace metal data from the ZF (OnZaP and OPH) supports the persistence of a large marine trace metal pool following the end of the LE.

References

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