High molybdenum abundance in the ~2 Ga Zaonega Formation: Implications for seawater following the Lomagundi Excursion

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Background & objective

The enrichment and isotopic composition of redox-sensitive elements (RSE) in black shales are frequently used tools for estimating local and global marine redox conditions. For instance, Mo and U enrichments in the sedimentary record have been shown to increase after the Great Oxidation Event (GOE) and the Lomagundi Excursion (2.45-2.0 Ga). A decline in O₂ levels after 2.0 Ga is inferred to have caused a drop in marine RSE abundance [1]. However, it remains unclear how such trends are affected by basinial, rather than global conditions.

We have analysed RSE concentrations and Mo isotopes in a new 100-m section of the ~2 Ga Zaonega Formation (ZF), NW-Russia, in order to assess the importance of basinial versus global signals on RSE enrichment and to re-evaluate redox development in the critical ~2 Ga time interval which links the high-O₂ post-GOE and the low-O₂ Mesoproterozoic worlds.

Take-home points

- Some of the highest Mo concentrations in the Precambrian (up to 1000 μg/l) suggest a robust marine Mo pool at ~2 Ga. This argues against a previously inferred collapse of the sulfate pool at ~2 Ga [2].
- Mo behaviour in the ZF mostly reflects open basin conditions, thus RSE cycling in the ZF likely records global marine trends.
- Lack of basinial watermass restriction w.r.t. Mo cycling, however, points to 1.11 ± 0.07% being an underestimate of marine δ²⁹⁸⁰⁸⁰⁸Mo.
- Retention of Mo in high-TOC pyritobitumen veins suggests that the majority of Mo in the ZF is bound to organic phases.

Results

Study area

- Figure 1: δ¹³Corg, total organic carbon (TOC), P, U and Mo concentrations, δ²⁹⁸⁰⁸⁰⁸Mo and XRD-based Fe distribution in the studied section. A lithology-based correlation is used to combine chromatostratigraphic data from the two cores into a continuous section.
- Figure 2: Secular trends in Mo concentrations in black shales. The ZF contains some of the highest Mo enrichments known in the Precambrian, suggesting a robust Mo pool, Modified from [1].
- Figure 3: Secular trends in Mo/TOC ratios in black shales. These ratios likewise support a robust or even increased Mo pool at 2 Ga, Modified from [4].
- Figure 4: Crossplot of Mo and U enrichment factors (EF). The majority of the data follows a trend suggestive of increasing water-column hypoxia and sulfidity under non-restricted conditions [5]. Some scattered data possibly relate to Mo depletion in episodes of basinial restriction. Lack of restriction indicates that δ²⁹⁰⁸⁰⁸Mo is likely fractionated from seawater.
- Figure 5: Crossplot of Mo concentrations versus TOC content. The strong correlation even at high TOC levels suggests the association of Mo with organic phases.

References


Acknowledgements

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