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First V isotope data of amphibolites and serpentinites from a paleo-subduction zone

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Constraining the physical conditions of fluid–rock interaction during metamorphism and metasomatism is critical to understanding volatile cycling on both local and global scales. The isotopic ratios of redox-sensitive elements may help unravel the changing redox states of complex fluid–rock interactions. The vanadium (V) isotope system is highly promising as a redox tracer because V has four oxidation states. Furthermore, V is concentrated in oxides such as magnetite, which is produced during serpentinization. Currently, there is insufficient data to assess to what extent V isotopes respond to fluid–rock interaction and metamorphic processes.

We present the first investigation targeting the response of the V isotope system to fluid–rock interaction and metamorphism. We measured V isotope ratios in whole-rock amphibolites, and in serpentinization-generated magnetite separated from subduction-related serpentinites from the Belvidere Mountain Complex (BMC; Vermont, USA). Here, the tectonic contact between amphibolites and serpentinites is enriched in graphite, whose precipitation resulted from the confluence of fluids at different redox states [1]. The presence of graphite layers and carbonate veins within both units suggests infiltration of fluids at different redox states, making the BMC a useful case study.

We selected ten amphibolites with varying mineral assemblages, and ten serpentinites spanning serpentinization degrees of 20–100 %. These suites include both samples that are free of, and crosscut by, graphite and carbonate veins. Surprisingly, V isotope ratios show limited variations among all samples from both suites, despite clear evidence (i.e., graphite vs. carbonate veins) for interaction with fluids at different redox conditions. Our V isotope data also overlap with values of MORBs and BSE. This suggests that the primary V isotope composition of the protoliths was retained during multi-stage metamorphism and metasomatism. This has implications on our understanding of V mobility in subduction zones, hence on its availability for deep microbial life. If V is not mobilized and/or fractionated by secondary processes at different redox conditions, V isotopes may be a robust tracer for heterogeneities in Archean mantle sources.

[1] Boutier et al. (2024), GCA