Causes of Molybdenum Depletion in Granites

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Molybdenum is an important trace element that serves as a proxy for atmospheric oxygen contents of early Earth. During the Great Oxidation Event (GOE), which occurred ~2.3 billion years ago, an increase in atmospheric oxygen caused redox-sensitive Mo to be removed from the crust at the onset of oxidative weathering. Mo residence in typical upper crustal rocks: Archean and Proterozoic granites from North America and South Africa, show systematic depletion of Mo relative to the LREE[1], whereas Mo in basaltic rocks has normalized concentrations similar to those of the LREE. One hypothesis to explain this depletion is that, due to their similar atomic radii, Mo^{6+} substitutes for Ti^{4+} in Fe-Ti bearing oxides during differentiation of calc-alkaline igneous rocks in arc settings.

We tested this hypothesis by measuring Mo concentrations in a calc-alkaline differentiation suite from Rindjani Volcano, Indonesia, in the western part of the east Sunda Arc[2]. LA-ICP-MS on Li-tetraborate-fused glass beads was used to determine Mo content within the suite, which ranges from relatively primitive high-Al basalts to dacite. The differentiation suite shows clear fractionation of Fe-Ti-oxides at 4.4 MgO wt%. The mafic samples exhibit low Mo concentrations (minimum 0.27 ppm), whereas the felsic samples exhibit higher Mo concentrations (maximum 6.1 ppm). Thus, Mo behaves as an incompatible element throughout the suite. When normalizing the samples to UCC values, Mo shows consistent enrichment relative to LREE. The incompatible behavior of Mo therefore suggests that significant Mo does not substitute into Ti-bearing minerals during calc-alkaline igneous differentiation. Thus, the depletion of Mo in granites may reflect removal of Mo from granitic plutons in a late-stage magmatic vapor phase. If this is the dominant process responsible for Mo removal from granites, then much of the Mo in the upper continental crust may be contained within molybdenite-bearing veins that precipitate from such vapors.

1. Greaney et al., 2018, *GCA* in revision. 2. Foden et al., 1983, *J. Petrol.*

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