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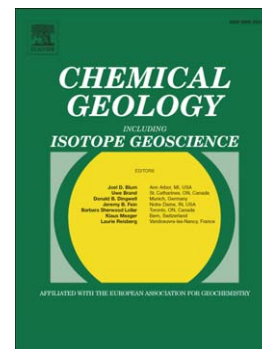
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Molybdenum isotope variations in magmatic rocks.

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Abstract

The application of Mo isotopes to study geodynamic processes is a rather new development that has gained considerable momentum over the past few years. Its redox-sensitivity causes significant mass-dependent isotope variability in low-temperature environments – mainly during weathering, sediment deposition and seafloor alteration. Potentially, these fractionated Mo isotope characteristics of surface materials could be used to identify recycled crustal components in mantle sources. Here we provide an overview of the first studies on mass-dependent isotope variations of Mo in igneous rocks and the Mo isotopic characteristics of major geochemical reservoirs before assessing the potential of Mo isotope variations as a new tracer in mantle geochemistry.

Mass-dependent Mo isotope variations induced by magmatic differentiation are in general muted owing to the incompatibility of Mo in common igneous minerals. However, fractionation of Mo isotopes by hydrous silicate mineral phases has been suggested. Sulphide fractionation can potentially have a marked influence on the Mo isotope composition of evolving magmatic systems but does not appear to be a major influence due to the limited modal abundance of sulphide phases precipitated during differentiation. The largest Mo isotope variations in igneous systems reported so far are found in arc-related rocks. Currently available data suggest that the $\delta^{98/95}\text{Mo}$ values (i.e. the $^{98}\text{Mo}/^{95}\text{Mo}$ ratio relative to the reference material NIST SRM 3134) measured in arc basalts are higher than those of the upper mantle. This offset appears to be linked to the addition of isotopically heavy slab-derived fluid to the arc melts, whereby heavier Mo isotopes become enriched in the fluid as a result of the slab-dehydration. In contrast, lighter $\delta^{98/95}\text{Mo}$ compositions found in some arc-related lavas could be linked to geochemical tracers commonly associated with sediment melt contribution. Overall, mass balance considerations suggest that the recycled crustal material has a Mo isotope composition equal to or most likely lighter than that of fresh oceanic crust.

Chondritic meteorites display a remarkably homogeneous $\delta^{98/95}\text{Mo}$ of $-0.16 \pm 0.02\%$ suggesting a similar bulk composition for the inner solar system and thus the Earth. Residual Mo in the mantle after core formation is expected to be isotopically heavy but for temperatures in excess of 2500K, typically proposed for core-mantle equilibration, the difference in $\delta^{98/95}\text{Mo}$ of the mantle relative to chondrite is $<0.1\%$. Analyses of Mo isotopes in mid-ocean ridge basalts suggest a slightly sub-chondritic composition of the depleted mantle ($\delta^{98/95}\text{Mo} = -0.21 \pm 0.02\%$). Similarly, late Archean komatiites yield slightly sub-chondritic chondritic $\delta^{98/95}\text{Mo}$ of ca. $-0.21 \pm 0.06\%$ suggesting that the mantle may have maintained a similar Mo isotope composition throughout the post-Archean. The Mo isotope composition of the continental crust is currently the least well-constrained value of major geochemical reservoirs. A preliminary estimate available for maximum value for the upper continental crust yields a super-chondritic $\delta^{98/95}\text{Mo}$ of ca. $+0.15\%$. The value of the bulk continental crust remains unknown but is likely to be lower. Assuming a chondritic bulk silicate Earth differentiates solely into

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