Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.21960

Contrasting molybdenum isotope behavior in two paleo-subduction systems

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Studies of molybdenum (Mo) isotopes in arc rocks have repeatedly reported compositions isotopically heavier than subducting slab components and the upper mantle, leading to the hypothesis that Mo is isotopically fractionated during slab dehydration. In this model, fluids preferentially remove isotopically heavy Mo from the slab and carry it to the mantle wedge, leaving the residual slab with an isotopically light composition. Studies of eclogites have supported this idea, and here we summarize recent work on high-P metasedimentary rocks representing subducted sediment in two paleo-subduction zones.

The Schistes Lustrés and related units from the western Alps were metamorphosed under "normal" cold subduction conditions and show a huge range of d^{98}Mo values, spanning a total of ~3 per mil. Variation in Mo isotope composition appears to chiefly reflect the heterogeneity of the sedimentary protolith, such as the differing proportion of terrigenous sediment, pelagic sediment, and carbonate. The effects of metamorphism on isotopic variability are subtle and difficult to disentangle from the protolith effects. A much different record is provided by the Catalina Schist of California, in which the higher-grade units experienced metamorphism and more extensive devolatilization under relatively warm subduction conditions. Mo isotope composition of metasedimentary samples varies more coherently with increasing metamorphic grade, and there is a general correlation between [Mo] and Mo/Ce and d^{98}Mo, consistent with progressive lightening of Mo isotope composition as Mo is lost from the system. Other lithologies from the Catalina Schist, such as mélange and metasomatized clasts within it, show consistently light Mo isotope compositions reflecting loss of isotopically heavy Mo to fluids.

While protolith heterogeneity of the Schistes Lustrés makes it difficult to evaluate metamorphic effects, the Catalina Schist provides clear evidence of both the extreme mobility of Mo in fluids under high-P/T conditions and the tendency of those fluids to preferentially carry away heavier isotopes of Mo, consistent with current models for Mo isotopes in arc systems.