Magmatic and linked hydrothermal processes fractionate Mo isotopes

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Molybdenum isotope ratios in the marine sedimentary record are a valuable tool for reconstructing the evolution of atmospheric oxygen and paleo-redox conditions of the oceans. However, mass-balance models are highly dependent on the characterization of the (terrestrial) Mo sources. Recent results on the Mo isotope composition of terrestrial igneous rocks [1] and molybdenites [2] show a Mo isotope variability that is larger than previously suspected for crustal rocks and minerals. Therefore, two geochemically well-understood systems, the Kos Island Arc volcano (Greece) and the porphyry Questa Mo deposit (New Mexico, USA), were investigated systematically. The magmatic evolution of the igneous rock suite from Kos was predominantly controlled by fractional crystallization. The molybdenites from the porphyry Questa Mo deposit were produced during two distinct mineralization stages, related to two hydrothermal fluid exsolutions from an increasingly fractionated magma [3].

The magma evolution from basalt to dacite on Kos is characterized by increasing δ^{98}Mo (total δ^{98}Mo range = 0.3‰) along with increasing Mo concentrations, as expected for a highly incompatible element. The δ^{98}Mo of the molybdenites from the Questa deposit ranges from -0.48‰ to +0.40‰, with a median at -0.06‰. The median δ^{98}Mo increases from first stage (-0.17‰) to late stage molybdenites (0.21‰). Based on these results we recognize three different processes that produce systematic Mo isotope fractionation between 700 and 350°C in igneous and hydrothermal environments: (a) fractional crystallization, (b) magmatic-hydrothermal fluid exsolution and (c) molybdenite precipitation.

All these processes lead to the enrichment of heavy Mo isotopes in the more evolved magma or fluid phase. This indicates that the mean Mo isotope composition of all molybdenites (δ^{98}Mo ≈ 0.4‰; [2]) reflects a maximum value for Earth`s upper crustal signature.

[1] Voegelin *et al*. (2012) *Geochim Cosmochim Acta,* **86**, 150–165. [2] Greber *et al*. (2011) *Geochim Cosmochim Acta,* **75**(21), 6600–6609. [3] Klemm *et al*. (2008) *Miner Deposita,* **43**, 533-552.

Multiple generations of TTG gneisses host Eoarchean supracrustals in the Innukjuak domain (Québec, Canada)

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The ca. 3750-3780 Ma Nuvvuagittuq supracrustal belt (NSB) in northern Québec is the best known of a dozen or so km-scale supracrustal belts (or "enclaves") which are part of the Innukjuak domain of the northwest Superior province in Canada [1,2]. Dominantly (mafic) amphibolites and minor paragneisses in these supracrustal belts are surrounded and intruded by several generations of tonalite-trondhjemite-granodiorite (TTG) gneisses; these imparted metamorphic overprints on the enclaves beginning at ca. 3750 Ma. Previous work also documented a ca. 3650 Ma tonalitic gneiss in the core of the NSB fold belt [2; referred to here as the central tonalitic gneiss (CTG)] as well as rocks of the "Boizard suite" (Aboi), a terrane of ca. 2700 Ma granitoid gneisses that volumetrically dominate the Innukjuak domain [3]. New geochemical and U-Pb zircon geochronological data are presented for these gneisses coupled with data from a previously undated but locally significant pale granodioritic gneiss enveloping the NSB, the "Voizel suite" (Avoi; [2]).

We find that most Aboi zircons are up to ca. 3700 Ma inherited cores from multiple generations with ca. 2700 Ma igneous overgrowths. The CTG hosts mainly ca. 3650 Ma igneous cores with narrow rims. Younger zircons typically have spongy textures attributable to hydrothermal growth. Outside the NSB, Avoi rocks are the principal host for various Innukjuak domain supracrustal enclaves. Most Avoi igneous zircon cores from these localities cluster about 3550 Ma with younger metamorphic rims. Younger Avoi ages tend to be discordant. A tonalitic gniess cross-cutting amphibolites from a supracrustal belt northeast of the NSB, and within Avoi, yielded a maximum concordant zircon age of 3653±8 Ma; it may be cogenetic with the CTG. The previously unrecognized 3550 Ma Avoi igneous event is recorded as metamorphic zircon growth within many of the NSB lithologies [4], particularly in metasedimentary units and the CTG.

[1] Cates & Mojzsis (2007) *EPSL* **255** 9-21. [2] David *et al.* (2009) *GCA* **121**, 150-163. [3] Simard *et al.* (2003) Ministère des resources Naturelles, Québec, vol. 2002/10 [4] Cates & Mojzsis (2009) *Chem Geol* **261**, 99-114.

DOI:10.1180/minmag.2013.077.5.7