Tracing processes in the deep mantle by nickel stable isotopes

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The isotope system of nickel (Ni) has recently achieved some attention as a possible tracer for low-temperature processes [1]. However, although Ni is a ubiquitous element in the mantle the behaviour of Ni isotopes in high-temperature environments is yet to be investigated. In this study we have measured the mass-dependant isotope composition of Ni ($\delta^{60/58}$Ni, relative to the Ni metal standard NIST-SRM986) in a variety of mantle derived rock samples by MC-ICPMS using double-spike correction (long-term external reproducibility on silicate samples < 0.07‰) [2].

MORB glasses from different ocean ridges (Mid-Atlantic Ridge, Indian Ocean Ridge, and East Pacific Rise) and of different spreading rates were analysed for their Ni isotope compositions. The samples from the faster-spreading East Pacific Rise are heavier on average than those from the slower Mid-Atlantic and Indian Ocean Ridges, although all samples are significantly lighter (up to –0.4‰, δ^{60}Ni) in their isotope composition relative to peridotite samples. It is therefore possible that partial melting of the upper mantle cause fractionation of Ni isotopes, with the lighter isotopes being preferably extracted into the melt.

The Ni isotopic compositions of intraplate basalt (OIB) samples from widely different locations were also measured. Although the δ^{60}Ni-values for these basalt samples were spread over ~0.2‰, the values are within error of the isotopic composition of peridotites and Tertiary komatiites, which indicates that there is essentially no isotopic fractionation between mantle rocks and intraplate basalts. These preliminary results suggest that basalts may have small differences in their Ni isotopic composition depending on their origin, with MORBs appearing lighter than intraplate basalts.

Whether these results depend on differences in degree of partial melting between the MORB and OIB samples, or if their differences are due to the source's original chemical composition is difficult to say without further analyses. However, if partial melting causes fractionation of Ni isotopes between solid and melt in the mantle to the same extent in both OIBs and MORBs, resulting in the melt being slightly lighter than the residual solid, then the deep mantle may contain an undepleted reservoir of heavier δ^{60}Ni than measured in peridotite and komatiite samples.

[1] Cameron et. al. (2009) ***PNAS*** 106, 10944-10948.
[2] Gall et. al. (2012) ***JAAS*** 27, 137-145.

Supergene Evolution of Granitic Waste Rock Piles around U-mines in the Saint-Sylvestre Area (French Massif Central)

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The French National Plan on the Management of Radioactive Materials and Waste launched a survey of some former uranium mines, worked in France between 1948 and 2001 to detect potential effects on the environment. We present preliminary data on the supergene evolution of waste rock piles generated during mining operations in the Saint-Sylvestre leucogranite complex (northwestern Limousin, French Massif Central) a granite intruded at 324 ± 4 Ma. This two-mica granite hosts an important U-ore mineralization deposited at 270-280 Ma, due to sustained hydrothermal circulation. In the Bellezane area, later lamprophyre dykes also cut the granite and suffered extensive low-T alteration. Mining operations have generated waste rock piles of granitic rocks, exposed to meteoritical weathering since the mining time. Biotites are a useful indicator of the type and intensity of alteration, showing chloritic or kaolinitic evolution. Low-T weathering is indicate by the presence of smectites. Fe-migration gives rise to the formation of Fe^{3+}-phosphates and sulphates. Primary U-minerals mostly consist of pechblende and coffinite. Primary and secondary phosphates consist of monazite and crandalite, sometimes intergrown. is frequently observed. Secondary phases such as autunite of U-bearing smectite contribute to decrease U-mobility during meteoritic weathering.