First series transition metals (Zn, Fe, Mn, Co, Sc, V) as tracers of mineralogic heterogeneities in the mantle

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Major element heterogeneities in the Earth's mantle may be inferred from peridotite samples, oceanic basalts and seismological data. It is widely believed that the Earth's mantle holds heterogeneities, because subduction transfers eclogitic material back into the mantle, lithosphere delaminates, and melt percolation affects the modal mineralogy of the peridotitic mantle. Melt-rock reaction products may range from dunite to pyroxenite, depending, for example, on whether the percolating melt is saturated or undersaturated in olivine, respectively. Oceanic basalts are also characterized by large isotopic and trace element variability that is hard to reconcile with partial melting of a pyrolite-like mantle alone.

Here we use first series transition metals, Zn, Mn, V, Sc, Co, and Fe systematics in mafic and ultramafic systems to detect mineralogical and lithological heterogeneities that deviate from pyrolite-like peridotitic mantle dominated by olivine and orthopyroxene. We suggest that those moderately incompatible elements are more robust indicators of mineralogic heterogeneities than highly incompatible elements. Exchange partition coefficients (K_D) between peridotite and melt have been estimated (1) theoretically, through mineral/mineral elemental partitioning on natural samples using LA-ICPMS combined with experimental database and (2) experimentally, by conducting mineral (olivine, orthopyroxene and clinopyroxene) /melt partitioning experiments using a piston-cylinder apparatus at temperatures and pressures relevant for the Earth's upper mantle. Particularly, we suggest that Zn/Fe is minimally fractionated during partial melting of peridotite and differentiation of primitive basalts, but highly fractionated if garnet and/or clinopyroxene are the dominant phases in the source during melting. We propose that the Zn/Fe ratios of primitive ocean island basalts (OIB) and mid ocean ridges basalts (MORB) could trace the major element and mineralogic heterogeneities of their mantle source region. The high Zn/Fe ratios of some OIB require in their source the presence of high Zn/Fe lithologies or lithologies that have bulk Zn/Fe exchange coefficients <<1. All garnet and clinopyroxene-bearing lithologies, such as eclogites and pyroxenites fit the latter requirement.

Boron isotopic geochemistry of the McMurdo Dry Valleys, Antarctica

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The boron isotopic geochemistry was investigated in the ice-covered lakes and glacial meltwater streams within Taylor and Wright Valley of McMurdo Dry Valleys (MCM), Antarctica, in order to achieve a greater understanding of the origin of solutes. MCM is the largest ice-free region in Antarctica, and has mean annual temperature of ~-20°C and annual precipitation of <5 cm per year. Even under this extremely arid climate, hydrological connectivity exists throughout the austral summer during which time ephemeral streams form from glacial meltwater and flow into ice-covered, closed basin lakes. The source of boron and the geochemical evolution of these water bodies are reconstructed by using δ^{11}B, B/Cl, and Na/Cl ratios. Concentration of B and its isotopic composition were measured by inductively coupled plasma mass spectrometry and negative thermal-ionization mass spectrometry techniques, respectively. In Taylor Valley, B/Cl ratios suggest two sources of boron to the lakes, a terrestrial weathering source and a marine source. These ratios also indicate the depletion of boron by adsorption within the higher rock-water aquatic systems of Wright Valley. δ^{11}B values span the range of 12.3‰ to 51.4‰, with the heaviest value in the hypolimnion of a highly evaporated hypersaline lake. Depending on the landscape position and history of each lake, two isotopic mixing regimes exist: marine with terrestrial-influenced meltwater and ancient evaporated seawater with marine-influenced lake water.