Potassium isotope composition of mantle peridotite

DMITRI A. IONOV[1] AND KUN WANG (王昆)[2]

[1] Geosciences Montpellier, Université de Montpellier and CNRS UMR 5243, 34095 Montpellier, France (dmitri.ionov@umontpellier.fr)

[2] Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University in St. Louis, MO 63130, USA (wangkun@wustl.edu)

Potassium is highly incompatible in peridotites, the most common upper mantle rocks. Melt extraction from the Bulk Silicate Earth early in the Earth's history concentrated much of the K in the proto-crust and thus dramatically reduced its concentration in the remaining depleted asthenospheric mantle. Subsequent recurring melting of the asthenosphere left behind solid residues, even more depleted in K, which eventually accumulated to form the continental lithospheric mantle (CLM). Parts of the initially melt-depleted, hence K-poor, CLM were later metasomatized, i.e. transformed by additions of (and/or reaction with) different melts and fluids. These metasomatic media are usually enriched in incompatible elements, including K, originating from multiple sources such as the asthenosphere, mantle plumes and recycled surface materials. The sum of these processes over billions of years of the Earth's history has produced a CLM with highly heterogeneous K distribution, which is poorly constrained.

Recent advances in high-precision analysis of K isotopes suggest that K isotopes are not fractionated by high-temperature igneous processes such as partial melting and fractional crystallization. In contrast, the alteration and dehydration of subducted crustal materials would generate large K isotope fractionation between the residual slab and the released fluid. Therefore, K isotopes can be a robust tool to study K cycling between the crust and mantle, as well as a sensitive tracer for different sources of metasomatic melts and fluids.

Here, for the first time, we report high-precision K isotope compositions of a large number of xenolith peridotites. These samples include: (a) variably melt-depleted non-metasomatized peridotites; (b) whole-rock samples affected by multiple types and degrees of metasomatism; and (c) most common K-bearing metasomatic phases (amphibole, phlogopite, and quenched melt glass) separated from metasomatized peridotites. The data suggest that K isotopes are strongly fractionated in arc mantle as well as in veined and other heterogeneous mantle rocks possibly due to kinetic fractionation during fluid-rock interaction.