Journal of Conference Abstracts
Volume 5(2), 890

Lu-Hf Isotope Systematics for Peridotite Xenoliths from Somerset Island Kimberlites: Evidence for Archean Lithosphere beneath Arctic Canada

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The timing of the stabilization of the mantle roots beneath Archean cratons is currently poorly constrained because of the effects of later metasomatism. Lu-Hf isotope systematics of peridotite xenoliths, however, may provide a way of seeing through such metasomatic events in order to gain insights into the origin and early formational history of the subcontinental mantle. The Cretaceous Nikos kimberlite on Somerset Island in the Canadian Arctic hosts a suite of garnet-harzburgites and garnet-lherzolites, with minor occurrences of garnet-pyroxenite (1). These peridotite xenoliths have a refractory mineralogy with high magnesium numbers and are depleted in fusible major elements, but are enriched in incompatible trace elements, such as large ion lithophile (LILE) and light rare earth elements (LREE).

Clinopyroxene/garnet REE partitioning in high temperature peridotites (1200 to 1400 ºC and 50 to 60 kb) reflect equilibrium in the deep portion of the subcontinental lithosphere beneath Somerset Island (2). High LREE abundances in clinopyroxene and disequilibrium REE partitioning between garnet and clinopyroxene in the low temperature xenoliths (900 to 1100 ºC and 30 to 50 kb) appear to reflect a metasomatic event in the shallow mantle (<150 km) beneath Arctic Canada (2). The observed incompatible trace element disequilibrium is not likely to have persisted for an extended period of time (>10^6 years) at mantle temperatures and pressures (3). Thus this metasomatic event is probably not significantly older than the kimberlite that brought the xenoliths to the surface at 100 Ma ago.

Quantitative mass balance calculations using modal abundances of clinopyroxene and garnet and their respective REE contents yield calculated whole rock compositions with LREE abundances that are up to 99% lower than those of the analyzed whole rocks, but matching heavy rare earth element (HREE) contents. Unlike the analyzed whole rocks, the calculated LREE abundances for the majority of the whole rocks are depleted compared to chondrite, and their REE patterns are those expected for refractory mantle having experienced large degree of partial melting. These results suggest that much of the LREE budget of these xenoliths is contained in metasomatically introduced interstitial accessory phases, while the HREE are little affected by metasomatism.

Hf isotopic data were obtained using an Isoprobe MC-ICP-MS from Micromass coupled to an ARIDUS micro-concentric nebuliser. Nine garnet-peridotites are characterized by ε_{Hf} values ranging between -15 to +37 at 100 Ma ago. An analysis of one sample of the host kimberlite indicates that it is much more radiogenic (ε_{Hf} = +126) than the peridotite xenoliths. The Hf isotopic compositions of the peridotites do not correlate with their Nd-Sr-Pb systematics. ε_{Nd} values for the xenoliths have a much more restricted range (-0.3 to +5) and cluster around CHUR. Nd model ages (T_{DM}) range from 500 to 1000 Ma, with the exception of a porphyroclastic high temperature peridotite that yields an age of 2.4 Ga.

A Lu-Hf whole rock isochron for the low temperature peridotites (n = 3) and one high temperature peridotite (Nd model age = 2.4 Ga) yields an Archean age of 2.5 Ga (R^2 = 0.992). The initial Hf isotope ratio for this isochron ($^{176}Hf/^{177}Hf$ (t) = 0.28116) indicates an age of formation of 2.5 Ga relative to a chondritic reservoir. These Hf results suggest that the shallow lithospheric mantle beneath the Canadian Arctic stabilized at the end of the Archean, while almost all of the Nd model ages reflect a younger metasomatic event. The Lu-Hf isotopic systematics appear to be much less affected by mantle metasomatic events.

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