The deep cratonic mantle roots beneath the Canadian craton: Mantle xenolith evidence from Somerset Island kimberlites

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The nature and origin of the mantle roots beneath the Canadian craton are currently poorly constrained. The recently discovered Cretaceous Nikos kimberlite (Pell, 1993) on Somerset Island, in the Canadian Arctic, consists of three individual pipes and hosts an unusually well preserved suite of large (10–20 cm) mantle xenoliths dominated by garnet-peridotite (lherzolite, harzburgite, dunite) showing coarse and porphyroclastic textures, and minor occurrences of garnet-pyroxenite. The bulk compositions and mineral data for fifty-four Nikos xenoliths indicate their highly refractory nature with high olivine abundances (avg. 80 wt.%) and olivine forsterite contents (avg. Fo = 92.3). These compositions are characteristic of peridotite xenolith suites derived from the mantle underlying Archaean cratons such as the Kaapvaal and Siberian cratons (avg. olivine Fo = 92.5; Boyd *et al.*, 1997), but are clearly distinct from the trend defined by oceanic peridotites (avg. olivine Fo = 91.0; Boyd, 1989) and spinel-peridotites from the Canadian Cordillera (Shi *et al.*, in press) that represent the mantle beneath accreted post-Archaean continental terranes along the western margin of the Canadian shield.

The Nikos xenoliths yield pressures and temperatures of last equilibration between 20 to 55 kb and 650 to 1300°C, and a number of the peridotite nodules appear to have equilibrated in the diamond stability field. The pressure and temperature data define a conductive palaeogeotherm corresponding to a surface heat flow of 44 mW/m^2. Peridotite xenoliths from the central Slave province of the Canadian craton require a lower surface heat flow (~40 mW/m^2; Boyd and Canil, 1997) indicating a cooler geothermal regime than that beneath the Canadian Arctic.

Many of the kimberlite-hosted peridotites from the Kaapvaal craton in South Africa and parts of the Siberian craton are characterized by high orthopyroxene contents (avg. Kaapvaal 32 wt.%, Siberia 20 wt.%; Boyd *et al.*, 1997). The Nikos peridotites show modal mineral assemblages with moderate to low orthopyroxene contents (avg. 12 wt.%), indicating that the orthopyroxene-rich mineralogy characteristic of the Kaapvaal and Siberian cratons are not present in the subcratonic mantle beneath Somerset Island, and suggesting that the Nikos xenoliths formed by extensive partial melting of primitive mantle compositions.

The isotope results obtained to date suggest that the cratonic mantle beneath Somerset Island is heterogeneous and that the pyroxenites, lherzolites, and harzburgites may represent isotopically distinct mantle reservoirs. The Pb isotope data for the Nikos peridotites show that the harzburgites have more radiogenic Pb isotopic compositions than the lherzolites. One pyroxenite sample, in particular, gives a very unradiogenic Pb isotope composition ($^{206}Pb/^{204}Pb$ = 17.015, $^{207}Pb/^{204}Pb$ = 15.349, $^{208}Pb/^{204}Pb$ = 37.285) indicative of involvement of an old, most probably Archaean mantle component. Nd and Sr isotope results for the Nikos xenoliths ($^{143}Nd/^{144}Nd$ = 0.51257–0.51285; $^{87}Sr/^{86}Sr$ = 0.70412–0.70969) are similar to data previously reported for garnet-peridotites world wide, with the lherzolites plotting at the enriched end of the data array. Nd model age calculations for the Nikos xenoliths indicate ages between 420 and 800 Ma. A Lu-Hf isochron using garnet and clinopyroxene separates from one pyroxenite sample yields an age of 680 Ma, similar to the Nd model ages. The Hf and Nd isotope results may reflect formation ages, but more likely represent mixing between an old Archaean mantle reservoir and a younger metasomatic event possibly associated with kimberlite generation.

References

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