Genesis mechanisms and the survival and destruction of continental lithospheric mantle

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A key characteristic of cratonic lithospheric mantle is that its major element composition can be modeled as the residue of high degrees (30-50%) of partial melting. This melting traditionally has been interpreted as occurring deep and at high-temperature, possibly in a plume that produced a komatiitic melt. The major- and some trace-element characteristics of many lithospheric peridotites, however, can only be matched by relatively shallow melting, mostly in the spinel stability field [1,2]. An alternative location for cratonic lithosphere production is a suprasubduction zone mantle wedge. In this setting, high degrees of melt extraction are caused less by high temperatures than by water fluxing. Evidence for a subduction zone setting for cratonic lithosphere production is evident in peridotites and peridotitic inclusions in diamond from the Slave craton [3] and eclogites and eclogitic inclusions from the Kaapvaal craton [4].

Evaluating the petrogenesis of xenoliths of cratonic peridotite using incompatible trace elements, and the isotopic systems based on them (Sr, Nd, Pb), is severely compromised by interaction with their host kimberlite magmas. Os and Hf isotope studies, heat flow modeling and other evidence [5], suggest that the major volume of cratonic lithospheric mantle is highly depleted in incompatible elements, including water. The depleted character of cratonic peridotites explains the general survivability of cratonic lithospheric mantle because it contributes; 1) compositional buoyancy, 2) limited heat production, and 3) increased yield strength compared to fertile, wet, mantle. These characteristics serve to increase the viscosity of cratonic mantle, which allows it to resist entrainment into the convecting mantle. Metasomatism by infiltrating melts from below lessens the compositional buoyancy caused by melt depletion and increases the abundances of heat producing elements and water in the cratonic mantle. Sufficiently extensive metasomatism can lead to the destruction of cratonic lithospheric mantle and its incorporation into general mantle circulation.

[1] – Walter, Treatise on Geochemistry, v2, p363-394, 2003.
[2] – Simon et al., J. Petrol, submitted
[3] – Westerlund et al., Cont. Min. Pet., in press
[4] – Shirey et al., Geo. Res. Lett., 28, 2509-2512, 2001.
[5] – Rudnick et al., Chem. Geol, 145, 395-411, 1998.