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# V and Sc Systematics in Cratonic Mantle Peridotites: A Cumulate Origin for the Excess Si in the Mantle Beneath Archean Cratons

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Archean cratons, tectonically inactive regions of continental crust, owe their stability to thick, cold, and buoyant mantle keels (Boyd, 1989). The buoyant nature of these keels is due to depletion in Ca, Fe, and Al, elements that permit stabilization of dense minerals. While such depletions can be explained by high degrees of partial melting, some mantle keels (Kaapvaal and Siberian cratons) are too rich in modal orthopyroxene (Opx), or equivalently in Si, to be simple partial melting residues (Boyd, 1989; Walter, 1998). The three main hypotheses for producing Si-enrichment are melt-rock reaction with slab-derived melts (Kelemen et al., 1998), addition of cumulate Opx, and high temperature metamorphic differentiation into olivine-rich and Opx-rich layers (Herzberg, 1999). Si-enrichment is shown here to correlate with increases in Al, Sc, V, and possibly Ca. These trends are best explained by addition of Opx with high Al, Ca, Sc, and V compared to the bulk harzburgitic residue. The inferred Mg#=Mg/(Mg+Fe), Sc, and V contents of these extraneous Opx's are too high to be in equilibrium with silicic melts derived from an eclogitic oceanic slab, as such melts have low Mg# and are impoverished in V and Sc (Drummond et al., 1996; Rapp et al., 1999), the latter of which may be partitioned into residual garnet and clinopyroxene during eclogite melting. The inferred Opx compositions are better explained if they are in equilibrium with basalts or komatiites, and are thus inconsistent with models in which Si-enrichment is caused by melt-rock reaction between a slab-derived melt and ultra-depleted mantle. Instead, they are consistent with both metamorphic differentiation and the addition of cumulate Opx. The general paucity (relative to the number of Si-enriched peridotites) of high Mg# dunites complementary to the Opx-rich harzburgites argues against the former, and thus, a model whereby cumulate Opx precipitates from an ultramafic magma and mechanically mixes with Opx-poor harzburgite to create Opx-rich harzburgite is preferred. One argument against the cumulate hypothesis is that unusual conditions, i.e. a magma ocean, would be required. However, in a global compilation of cratonic peridotites (Siberia, Tanzania, South Africa, Canada, Greenland), only South Africa and, to a lesser extent, Siberia, show significant Si-enrichment. This suggests that Si-enrichment may not be the norm, and perhaps the cratonic mantle beneath South Africa and Siberia indeed formed under unusual conditions. Interestingly, the FeO content of South African and Siberian peridotites is slightly lower than that beneath other cratons, suggesting that South African and Siberian cratonic mantle may have formed at higher pressures.

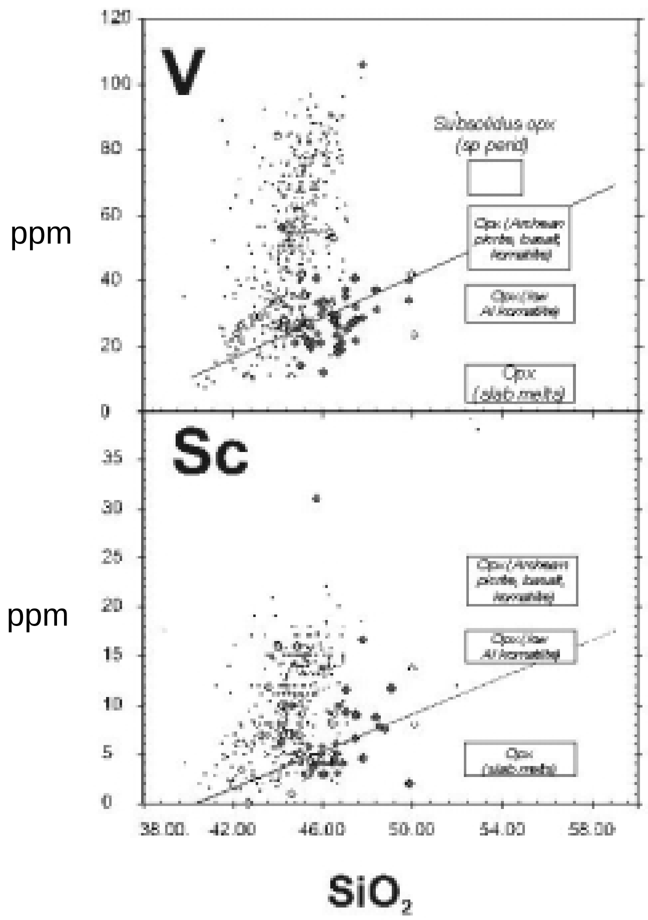


Figure1: Dots represent Phanerozoic spinel peridotites, filled diamonds represent Si-rich harzburgites from Archean cratons, and open diamonds represent peridotites from Archean cratons that are not opx-enriched (based on Mg/Si versus Mg# plots). Boxes represent estimated V and Sc (ppm) contents of Opx in equilibrium with different melts.

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