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Evidence for the Existence of the Low $^{176}Hf/^{177}Hf$ Component in Majorite Garnets Included in Diamonds from the Monastery Kimberlite

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A study of the Hf isotope systematics of kimberlite (Nowell et al., 1999) has identified a component with unusually low time-integrated $^{176}Hf/^{177}Hf$ isotope ratios. Nowell et al. (1999) propose that this component originated by melting in the presence of a garnet residuum, and that kimberlites form by later reaction between this component and the subcontinental lithosphere. Data from the high-silica-garnet (majorite garnet) inclusions in diamonds from the Monastery kimberlite (Moore and Gurney, 1985; Moore et al., 1991) help to identify the nature and origin of the low $^{176}Hf/^{177}Hf$ component. The rare earth contents of the garnets with modest excesses of silica can be modelled as 50% garnet residues from remelting of Archaean tonalite; and by estimating distribution coefficients for majorite-garnet by combination of garnet and orthopyroxene, the garnets with significant excess silica can similarly be modelled as residues from remelting of Archaean tonalite (Hatton, 1993). The melt extracted from Archaean tonalite has the low Lu/Hf ratio required for the low $^{176}Hf/^{177}Hf$ component. Kimberlites might then be plausibly generated by reaction between peridotite and a melt of a protolith formed during earlier melting of Archaean tonalite.

Nowell et al. (1999) considered that the low $^{176}Hf/^{177}Hf$ component could not reside in the convecting asthenosphere because the signature is not observed in asthenospheric melts. At pressures greater than 28 kilobars the eclogite thermal divide separates melts coexisting with olivine from melts derived from olivine-free protoliths. At high pressures the low $^{176}Hf/^{177}Hf$ component, existing as an olivine-free protolith of garnet-pyroxene±coesite±kyanite, generates a melt independent of peridotite, and the strong low $^{176}Hf/^{177}Hf$ signature of this melt survives the later reaction with peridotite to produce kimberlite. At pressures less than 28 kilobar the low $^{176}Hf/^{177}Hf$ component exists as an olivine-bearing protolith and cannot generate a melt independent of peridotite. Thus the low $^{176}Hf/^{177}Hf$ signature may be present in convecting asthenosphere, although its signature is clearly visible only in high pressure melts such as kimberlite and lamproite.

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