The origin of fertile enstatite by deep-seated carbonatite metasomatism

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Interaction of Mg- and Si-rich carbonatite magmas with mantle peridotite is shown to be responsible for the formation of fertile enstatite, providing a possible solution to the long-standing enigma of the unusually enstatite-rich nature of some Archean lithospheres.

The process is evidenced by a rare mantle-derived peridotite xenolith from Canada's Slave craton in which trapped inclusions of carbonatite melt have reacted with both diopside and depleted enstatite (low Al, Cr and Ca), to form fertile enstatite (high Al, Cr and Ca), with no associated change in enstatite mg#.

The interaction of Mg-rich carbonatite melt with diopside at high pressure to produce residual dolomitic carbonatite melt and enstatite has been predicted theoretically and is well-supported by experimental phase-equilibrium studies. However, with the exception of the current sample, this reaction has not been observed in upper mantle rocks. This type of carbonatite metasomatism is the reverse of Ca-rich carbonatite metasomatism common at lower pressures, where a dolomitic carbonatite melt reacts with mantle wall-rock to convert enstatite to diopside.

A compilation of enstatite compositions in kimberlite-borne xenoliths and xenocrysts from South Africa's Kaapvaal craton provides evidence for this style of metasomatism in the Kaapvaal lithosphere, which by implication may have been responsible for both its enstatite-rich nature as well as the origin of many (but not all) garnet lherzolites due to the subsequent exsolution of garnet and diopside from fertile enstatite.