Composition and evolution of the SCLM, and the origin of its diamonds

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Recent developments in seismic tomography and the integrated modeling of geophysical and petrological data have stimulated a major re-evaluation of the original composition and present extent of Archean subcontinental lithospheric mantle (A-SCLM). Analyses of seismic and gravity data, and consideration of relationships in exposed Archean peridotite massifs, suggest that the primitive A-SCLM probably was a highly depleted, moderately oxidised dunite-harzburgite, formed by high-degree melting at high T and P. Seismic tomography of cratons at regional and local scales shows "knobs" of high-Vs material that can be modeled as primitive A-SCLM, surrounded by zones of lower Vs. Kimberlites preferentially intrude these low-Vs belts, bringing up xenolith suites dominated by garnet lherzolites. By analogy with Archean peridotite massifs, these less-depleted rocks are interpreted as the result of metasomatic refertilisation, with progressive addition of cpx and garnet, and lowering of Mg#, in the peridotites. Within individual kimberlite fields, there is a direct correlation between this refertilisation process and the presence of diamonds of the peridotitic paragenesis [1]. A strong correlation between subcalcic garnets and diamonds suggests a model in which diamonds are deposited as CH_4-rich fluids are oxidized by the SCLM, producing carbonate-rich, hydrous fluids.

EMP and FTIR analyses of μm-sized fluid inclusions in "fibrous" diamonds have identified a more complex suite of high-density fluids (HDF), ranging from carbonatitic melts to "hydrosilicic" fluids and super-saline brines. LAM-ICPMS analysis of such diamonds [2] yields trace-element patterns similar to kimberlites and carbonatites, with high LREE/HREE, and high contents of alkali elements (Na, K, Rb, Cs, Ba) and HFSE (Ti, Zr, Nb…). Within single localities, carbonatitic, hydro-silicic and saline fluids have broadly similar trace-element patterns. The different types of HDF may reflect complex interactions between low-volume (mostly carbonatitic) melts, saline brines and different wall rocks (peridotitic vs eclogitic, refractory vs metasomatised).

In contrast to the fibrous diamonds, most monocrystalline diamonds have REE patterns that are either are essentially flat, or are depleted in LREE relative to HREE. They also are depleted in the alkali elements relative to the LREE, and many show strong negative anomalies in Y and Sr. These fluids and those that form fibrous diamonds may be related through carbonate/silicate melt immiscibility; the transition between them has been observed in single stones. In the Diavik mines, some monocrystalline diamonds and their fibrous/granular coats appear to have grown from the same type(s) of fluid.

If most peridotitic diamonds are related to the metasomatic modification of the dunitic Archean SCLM, then progressive metasomatism of the SCLM through time should decrease its overall prospectivity for diamonds. However, in tectonothermally younger terrains, diamonds are commonly hosted primarily in eclogites. In the absence of oxidized dunites, these mafic rocks may provide the redox environment required to deposit diamonds. Metasomatism is an ongoing process, and it is not obvious that diamonds necessarily are ancient; some may be quite „modern."

[1] Malkovets, V. et al. (2007) *Geology*, **35**, 339-342. [2] Rege, S. et al. (2005) *J. Anal. Atom. Spectrom.*, **20**, 601-611.