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A tale of two diamond hosts - Kimozero and Dachine

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The Palaeoproterozoic Kimozero (Karelia, Russia) and Dachine (French Guiana) ultramafic volcaniclastics present a contrasting story in diamond origin and upward transporting medium.

Kimozero is emplaced within the Onega inter-cratonic depression filled with a supercrustal Palaeoproterozoic sequence of volcanic and sedimentary formations within the broader Archean Karelian Craton (Ushkov, 2001; Ustinov et al., 2009).

Amphibolitisation and carbonatisation at Kimozero is widespread. Nevertheless, textures reveal pseudomorphed large olivine macrocrysts and phlogopite, and a second generation of former groundmass olivine. Accessory minerals include mantle-derived magnesiochromite, minor pyrope, chrome-diopside and diamond. Whole rock trace element chemistry for Kimozero shows kimberlite patterns of enhancements in ultramafic elements, e.g. Mg, Ni, Cr, combined with elevated incompatibles such as Nb, Zr, REE.

Kimozero diamonds are mainly octahedra with minor macles and aggregates. FTIR studies show the plastically-deformed diamonds to be N-free type II. Inclusions in the diamonds of Mg-rich orthopyroxene and pentlandite suggest a peridotitic lithospheric mantle derivation. Os data for sulphide inclusions give an unradiogenic Os/Os ratio of 0.109 indicating a late Archean mantle source or older. Kimozero therefore is a conventional kimberlite source of peridotitic lithospheric mantle-derived diamonds.

At Dachine the diamondiferous unit is a greenschist to amphibolite facies metamorphosed pyroclastic ultramafic intercalated within the 2.11 Ga Lower Paramaca metavolcanics in the southern greenstone belt of French Guiana (Bailey, 1999; Capdevila et al., 1999). This is an island arc setting. Pseudomorphed relict olivine crystals and chromite are recognisable, and accessory magnesiochromite and lherzolitic- and minor harzburgitic-Cr pyrope are derived from lithospheric mantle. Whole rock/trace element patterns identify the Dachine host rock as a low-Al komatiite. Komatiites are usually associated with very high temperatures and lack of volatiles, unfavourable conditions for diamond survival during transport to surface.

Diamonds from Dachine are 0.5-1mm in size. ~85% of them are polycentric octahedrons/intergrowths of pale yellow, grey or brown colour and ~15% are cubo-octahedral and cube monocrystals. Broken stones and fragments are common. CL imagery reveals irregular, complicated, blocky but still octahedral internal zonation. These features indicate a high speed of formation resulting from multiple diamond seed nucleation from a carbon-saturated environment. The diamonds are intensely deformed with abundant slip planes testifying to post-crystallisation stress under rigid conditions. They contain abundant primary inclusions of Fe-sulphide, together with minor omphacite (cf. eclogitic diamond inclusion paragenesis?) and unusual spessartine-grossular-almandine-pyrope garnets. The diamonds have low to medium nitrogen content and aggregation type 1b-1aA; the low aggregation suggests short mantle residence time (Cartigny, 2007; 2008). Carbon isotope composition of the diamonds varies from -31.9 to +0.15‰ with an average of -24.4‰ (Cartigny, 2007) similar to that of carbonado. The overwhelming dominance of pyrrhotite inclusions implies a sulphide paragenesis growth medium, and the association with Mn garnet is reminiscent of Broken Hill type sulphide mineralization. A possible reaction for diamond formation, 2FeS + CO2 = 2FeO + S2 + C (diamond), requires 4.3-5 GPa and 1050 - 1350ºC (Marx, 1972).

We suggest that at Dachine sulphide-rich fluids and C from which diamond formed were released from a subducting hydrated slab which interacted with rising komatiitic melt. Hydration of the komatiite lowered its temperature, increased its buoyancy and assisted in rapid upward transportation of the melt, thus preserving diamond. The resultant melt further interacted on its upward passage with Cr-pyrope-bearing mantle peridotite, but as yet we have no evidence of diamond derived from peridotitic lithosphere.