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Multiphase Mineral Inclusions in Diamonds from Fuxian and Mengyin Kimberlites, Eastern China

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Multiphase mineral inclusions have been recovered from 20 diamonds collected from Pipe 50, Fuxian kimberlites and Pipe Shengli 1, Mengyin kimberlites. These inclusions (up to 1 mm) are much larger than the normal discrete ones in Chinese as well as worldwide diamonds. Backscattered images and electron microprobe analyses demonstrate that the mineralogy and mineral chemistry of these inclusions are quite similar whilst the diamonds are collected from different localities. These minerals are mainly olivine (serpentine now), phlogopite, and calcite with baritite and other opaque minerals (spinel, perovskite, magnetite) found in individual samples. Such a mineral assemblage is very similar to that of epigenetic inclusions from Sloan kimberlite, Colorado (Meyer and McCallum, 1986).

The host diamonds are dominantly colourless, irregular fragments or octahedral crystals, and 1-4 mm in size. Some have amber - brown in colour and tetra-hexahedron in shape. Occasionally they have visible micro-crack and triangular growth striation on the surface. One diamond has very elaborated cathodoluminescent picture, showing extremely complicated history of its growth. The EA-IRMS (Isotope Ratio Mass Spectrometry connected with Elemental Analyser) analyses for 14 inclusion-bearing diamonds, as well as 49 inclusion-free diamonds of same localities, show that $\delta^{13}C$ for the Fuxian and Mengyin diamonds fall in the range of 0.5 to 6.5 and the majority in the range of 1.5 to 5.5 with an average at 3.5 (Zhang, unpublished). Such an isotope nature is consistent with the fact that peridotite-paragneissic assemblage dominates in Chinese diamond inclusions (Meyer et al., 1994; Harris et al., 1994) and with the observation of $\delta^{13}C$ of the peridotitic affinity (0 - 10) from worldwide diamonds.

Phlogopite only occurs in Fuxian diamonds and has euhedral crystallography. The composition of phlogopite inclusions is very similar to those from Finsch and Sloan diamonds with the exception that Fuxian inclusion phlogopite contains trace amount of P_2O_5. In a plot of Mg/(Mg+Fe) ratio versus TiO_2 (Figure 1), Fuxian phlogopite inclusions and megacrystic phlogopites fall within the same field which contrasts remarkably with the groundmass phlogopite (TiO_2 >1.5wt%) and glimmeritic phlogopite (Mg/(Mg+Fe) <0.87) from Fuxian kimberlite. If the megacrystic phlogopite represents the mantle metasomatised phase or the early fractionally-crystallized products of kimberlitic melts, thus phlogopite inclusion may have a metasomatic origin at mantle depth. This conclusion is also supported by the Si+Al cations occupying tetrahedral sites in phlogopite, phlogopite inclusion and megacrystic phlogopite have very identical Si+Al close to 8, but the Si+Al in groundmass phlogopite and glimmeritic phlogopite are very low (<<8).

Serpentine that is considered to be altered from original olivine has relatively low Al_2O_3 and variable FeO content. One large serpentine (400µm) has compositional zonation. Five analyses for this zoned serpentine shows systematic composition variations. From centre to margin the content of SiO_2 and MgO obviously decreases and Al_2O_3 and CaO increases. This may indicate that the process responsible for the formation of serpentine is involved in the removal of Mg and Si from olivine, and the addition of Al and Ca to serpentine from the fluid. Therefore, all serpentines are considered to be epigenetic. The depth at which serpentine begin to crystallize depends on the revised reaction: *3* Mg_2SiO_4 (olivine) + (SiO_2+$4H_2O$) (kimberlitic melt) $\leftrightarrow$ $2Mg_3Si_2O_5(OH)_2$ (serpentine). According to Tatsumi (1989), this reaction is approximately isothermal (600ºC) and pressure-dependant. Serpentine can be stable up to 40 kb, that means serpentine replacing olivine can reach up to 120 km.

Thus the majority of the epigenetic minerals in Chinese diamonds may be the products of extensive alteration of primary inclusions by mantle metasomatism in the lithospheric mantle in which the proto-kimberlite fluid was infiltrated into diamonds along micro-cracks or micro-fracture. Considering that the mineral assemblage of the epigenetic inclusions is comparable to that of kimberlite groundmass except for phlogopite compositions, we conclude that at least some secondary inclusions were affected by host kimberlite fluids during kimberlite emplacement.