# Lower Mantle Mineral Associations in Diamonds from São Luiz, Brazil

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**Abstract**--A suite of diamonds from the São Luiz, alluvial deposit, Brazil, shows an unprecedented abundance of (Mg,Fe)O (ferropericlase-magnesiowustite - fPer) inclusions, which under normal circumstances are most likely to be derived from the lower mantle. Furthermore, occasional colourless inclusions in the same diamonds have compositions of $(Mg,Fe)SiO_3$ and $CaSiO_3$, corresponding to those of the phases MgSi-perovskite (MgSiPvk) and CaSi-perovskite (CaSiPvk), which are also expected to occur in the common peridotitic compositions of the lower mantle. Aluminous phases in the same suite of diamonds include: (1) a phase (TAPP) of garnet composition, $(Mg,Fe)Al_2Si_3O_{12}$ but with a distinct tetragonal crystal structure; (2) an Al-rich MgSiPvk; (3) an $Al_2O_3$ phase.

Unlike the occasional and always magnesian fPer inclusions reported in diamonds from other localities, the São Luiz fPer have an extremely wide range of composition, with $Fe^{2+}/(Fe^{2+}+Mg)$ ranging from 0.14 to 0.62. In some of these fPer inclusions very fine scale exsolution of a magnesioferrite spinel phase has been detected. The $CaSiO_3$ are exceptionally restricted in major-minor element compositions, and are close to pure $CaSiO_3$. MgSiPvk inclusions have $Al_2O_3$ ranging from 1.2 to 2.7wt%, except in one case where it is 10.0%. The $Fe^{2+}/(Fe^{2+}+Mg)$ of MgSiPvk ranges from 0.02 to 0.05, so that $Fe^{2+}$ is relatively distributed in favour of fPer as expected from experimental work. However, Mossbauer spectroscopic determinations show MgSiPvk and TAPP to have significantly higher proportions of $Fe^{3+}$ than fPer, especially in the case of the high-Al MgSiPvk and TAPP. TAPP grains have $Fe^{2+}/(Fe^{2+}+Mg)$ of 0.03 to 0.06, with close to 3 Si cations in a 12 oxygen formula unit, and thus no sign of majoritic solid solution. Associations of fPer, MgSiPvk and $SiO_2$ in the same diamonds give phase relationships consistent with experimental data for lower mantle conditions. TAPP is unreported from experimental work.

Ion microprobe analysis of the inclusions for trace elements shows very low, generally less than chondritic, compositions for the fPer, MgSiPvk and TAPP. However, in CaSiPvk the REE contents are very high (ca. 200x chondrite), in agreement with previous experimental work for lower mantle assemblages. A small positive Eu anomaly is seen in the CaSiPvk inclusions analysed. A

calculated bulk pyrolite composition for the São Luiz assemblages gives trace element bulk compositions in between those of estimated primitive mantle and average OIB compositions. An ion microprobe oxygen isotope analysis on one CaSiPvk inclusion shows $\delta^{18}O$ of ca. 6 permil, consistent with expected mantle compositions. For the diamonds containing the inclusions, bulk $\delta^{13}C$ analyses yield typical mantle values.

Consideration of the inclusion associations found in the diamonds, in conjunction with ultra-high pressure experimental data, suggests that the natural mineral assemblages have come from a depth range of possibly less than 100kms in the uppermost part of the lower mantle, with TAPP largely taking the place normally assigned to garnet (majoritic) in the upper part of this depth range. The possible stability range of TAPP is probably very restricted, being replaced with increasing depth by aluminous MgSiPvk in normal ultrabasic-basic compositions, on the basis of both the inclusion and experimental evidence. Thus within the uppermost lower mantle there is a shallower Al-poor MgSiPvk mineral facies, and a deeper Al-rich MgSiPvk mineral facies. The inclusions probably became encapsulated in diamond in this depth range.

The lower mantle São Luiz inclusion suite suggests that some material has formed from other sources (protoliths) besides expected lower mantle ultrabasic/pyrolite compositions. The Eu anomaly shown by the CaSiPvk inclusions may indicate an original crustal source. On the other hand, the very wide range in Fe/(Fe+Mg) of the fPer, and in particular the high Fe compositions may result from some derivation of material from the D'' layer at the mantle-core boundary. If these origins are correct, then the São Luiz data may suggest a mixing of some material of both crustal and D'' origins with pyrolitic mantle adjacent to lower/upper mantle boundary, which argues in favour of layered mantle convection.