Mineral facies and source materials for lower mantle inclusions in diamonds from Sao Luiz, Brazil

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Diamonds from alluvial deposits on the Sao Luiz river, near the Aripuena kimberlite province, Brazil, contain mineral inclusions with compositions indicating derivation from the mantle transition zone and lower mantle. Table 1 lists the associations of inclusions which have been found within single diamonds and correspond to lower mantle mineral assemblages. In addition to the associations shown in Table 1, diamonds occur with inclusions of only one mineral, and these include both Mg-rich and Fe-rich (Mg,Fe)O compositions. Note that phases are identified on the basis of mineral composition rather than crystal structure, and in many cases the structure is believed to have changed to that of a low pressure polymorph. TAPP refers to a tetragonal almandine-pyrope phase (Harris *et al.*, 1997), which may be a primary lower mantle crystal structure or represent a pyrope-rich garnet with some Fe (almandine molecule) but virtually no Ca.

Mineral facies of silicate-bearing assemblages

The occurrence of (Mg,Fe)O, $(Mg,Fe)SiO_3$ and $CaSiO_3$ accords with generally expected lower mantle mineral assemblages. In detail, the above associations of Mg-Fe oxide and silicate phases are summarised in Fig. 1 and correspond well with relationships predicted by experimental data (e.g. Fei *et al.*, 1996) in the MgO-FeO-SiO_2 system. MgSiPvk is restricted to relatively magnesian compositions, bounded on the Fe-rich side by the occurrence of quartz together with fPer and MgSiPvk having $Fe^{2+}/(Fe^{2+} + Mg)$ ratios of 0.30 and 0.11 respectively. The phase relationships also correspond well to those found experimentally in the $MgSiO_3$–Al_2O_3 system (e.g. Irifune *et al.*, 1996) if the majoritic garnet of the experiments is replaced by TAPP or pyrope-rich garnet (Harte *et al.*, submitted). The low-Al and high-Al MgSiPvk assemblages respectively indicate

TABLE 1. Lower Mantle mineral associations in Sao Luiz diamonds

Mineral association	Approximate composition	No. found	$Fe^{2+}/(Fe^{2+}+Mg)$ of associated fPer
fPer + MgSiPvk (low-Al)	$(Mg,Fe)O + (Mg,Fe)SiO_3$	2	0.15 to 0.30
fPer + MgSiPvk (high-Al)	$(Mg,Fe)O + (Mg,Fe)_{0.9}Al_{0.2}Si_{0.9}O_3$	1	0.18
fPer + CaSiPvk	$(Mg,Fe)O + CaSiO_3$	1	0.19
fPer + Sti	$(Mg,Fe)O + SiO_2$	1	0.30
fPer + TAPP	$(Mg,Fe)O + (Mg,Fe)_3Al_2Si_3O_{12}$	3	0.17 to 0.30
fPer + MgSiPvk + TAPP	$(Mg,Fe)O + (Mg,Fe)SiO_3 + (Mg,Fe)_3Al_2Si_3O_{12}$	1	0.30

fPer - ferropericlase; MgSiPvk - MgSi perovskite; CaSiPvk - CaSi perovskite; Sti - stishovite; TAPP - phase with pyrope-rich garnet composition.

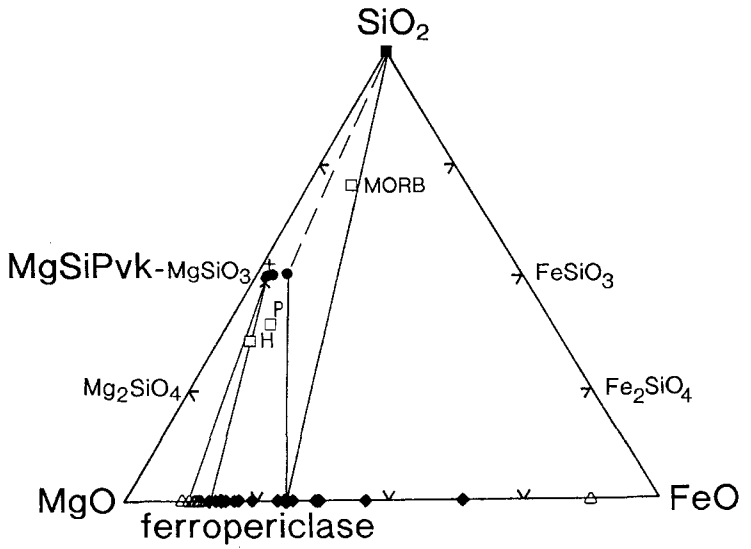

FIG. 1. Mineral compositions plotted in MgO–FeO–SiO_2 triangle. Solid symbols are data from Sao Luiz, and + is Sao Luiz high-Al MgSiPvk. Open triangles and x are inclusions from other localities. H, P and MORB refer to depleted harzburgite, pyrolite, and primitive mid-ocean ridge basalt bulk compositions respectively.

mineral facies where a garnet-like phase is first of all stable and then becomes unstable at greater depth (where Al becomes accommodated by solid solution in MgSiPvk). Experimental data indicate that the phase relationships found are appropriate to conditions of approximately 24 to 28 GPa and 1500–2000°C, corresponding approximately to the uppermost 100kms of the lower mantle (660 to 760 kms depth).

Source materials

The rock compositions indicated by the silicate-bearing mineral associations correspond to those of expected ultrabasic and basic rocks (Fig. 1). But an important point is that CaSiPvk inclusions, which contain most of the trace elements (Harte and Harris, 1994), show positive Eu anomalies suggestive of derivation from subducted originally plagioclase-bearing rocks. On the other hand, the extremely wide range of (Mg,Fe)O oxide compositions found as single inclusions in Sao Luiz diamonds (Fig.1) include Fe-rich compositions well beyond those expected for even differentiated basic rock compositions (Harte *et al.*, submitted), and a possible origin from the D@ layer must be contemplated. With the exception of a single very Fe-rich inclusion from Monastery Mine (South Africa), Sao Luiz is the only locality showing such Fe-rich compositions. The simultaneous occurrence of these potential D@ Fe-rich compositions, together with CaSiPvk containing a crustal geochemical signature, and mineral assemblages from adjacent to the upper/lower mantle boundary, make it tempting to speculate that diverse source materials have met and become encapsulated in diamond near the upper/lower mantle boundary, as a consequence of layered mantle convection.

References

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