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LOWER MANTLE MATERIAL IN THE SOURCE OF KIMBERLITES

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Kimberlites represent mixtures of materials from many sources. Involvement of lower mantle and the transition zone is proven in the occurrence of diamonds with mineral inclusions that correspond to phase assemblages stable at sublithospheric depths. Diamonds from the lower mantle may host mineral inclusions that include the phase assemblage: Mg-rich silicate perovskite (MPv) + Ca-rich silicate perovskite (CPv) + ferropericlase (FP). The ferropericlase is the most common of these lower mantle minerals found among the inclusions in diamonds. An extensive database is available for the compositions of these ferropericlase inclusions.

Mg/(Mg+Fe) atomic ratios (Mg-numbers) of ferropericlase calculated for a pyrolite model composition, based upon the principle of mass balance, lie in the range of 0.82 – 0.88. These variations are controlled by the values of the Fe/Mg distribution coefficient between FP and MPv (Kd = (Fe/Mg)MPv / (Fe/Mg)FP), which for a pyrolite bulk composition vary with depth from 0.4 to 0.85 [1]. With the exclusion of the data for Brasilian diamonds, which contain an unusually high proportion of Fe-rich ferropericlase, 92 % of the calculated Mg-numbers for ferropericlase inclusions in diamond fall within the same range. The possible presence of a metallic phase in the lower mantle, related to the disproportion of ferrous iron [2], does not significantly affect Mg-number values, which follows from the high Ni concentrations in ferropericlase inclusions compatible with the values calculated for the lower mantle phase assemblage of a metal-free pyrolite bulk composition [3]. This confirms the conclusion that pyrolite is a reasonable model composition for the lower mantle.

The high proportion of Fe-rich ferropericlase inclusions in diamonds from Brasilian placers and kimberlites is possibly explained by the fractional crystallization of magmas generated through partial melting of material ascending within mantle plumes, present in the lower mantle.

On the whole, mineral inclusions in sublithospheric diamond demonstrate that a contribution of lower mantle to the source of kimberlites is real but quantitatively very small. Probably, the proportion of lower mantle material is of the same order of magnitude as the proportion of diamonds with inclusions of lower mantle minerals, as compared to the total amount of diamonds transported by kimberlitic magmas.

References:

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