Subduction of altered basalts and serpentinites into the transition zone and the lower mantle recorded in the chemical and Li-isotopic features of inclusions in diamonds from Juina, Brazil

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Summary
The mineral inclusion suite in alluvial diamonds from Juina (Mato Grosso, Brazil) is unusual in that it shows a predominance of ferropericlase and an overabundance of various kinds of Ca-phases. The Li isotopic composition of the ferropericlases ranges from -3.9 to +9.6‰ within the range of ocean floor serpentinites and altered ocean floor basalts. These rock types together with ophicarbonates, rodingites and a variety of carbonates form a melange at subduction zones. If subducted into the transition zone and the lower mantle such a melange will be metamorphosed to the inclusion minerals in the diamonds as suggested by high pressure phase relationships. The diamonds themselves may be formed from the subducted material by redox reactions.

Approach
The inclusion suite in alluvial diamonds from Juina (Mato Grosso, Brazil) is unusual in that it shows a predominance of ferropericlase [with Mg-values between 35 – 83 (Harte et al. 1999; Kaminsky et al. 2001)] and an overabundance (compared to other transition zone and lower mantle minerals) of various kinds of Ca-phases: walstromite-structured $CaSiO_3$, larnite (ß-Ca_2SiO_4), perovskite ($CaTiO_3$, where Ti is replaced by Si to various extents), $CaCO_3$ and possibly dolomite (Harte et al. 1999; Kaminsky et al. 2001; Brenker et al. 2007; Hayman et al. 2005). The coexistence of Mg-rich ferropericlase with MgSi-perovskite assigns these diamonds to an origin from the transition zone or lower mantle. The very Fe-rich nature of some of the ferropericlases led Harte et al. (1999) to suggest an origin from the D'' layer while Brey et al. (2004) interpreted them as high pressure phases from hybrid lithologies of peridotite mixed with eclogite/sediment (or their melt derivatives). Further unusual chemical features are the high Mn content in ilmenites and overall high to very high abundances of Ni, Cr, Mn and Li in the ferropericlases [Kaminsky et al. (2001) reported Li-concentrations between 2 and 23 ppm]. Ferropericlase is almost the sole Li-bearing phase in transition zone and lower mantle peridotitic lithologies. The high concentrations open the possibility to determine the isotopic composition of lithium by solution MC ICP MS. Isotopic ratios and the abundances of trace elements of the inclusions in diamond are indicative of the nature and chemical composition of the source rocks and will give clues to the precursor rocks.

Results and Discussion

Ten diamonds with ferropericlase inclusions with variable Mg-values were available to us. Four contained single and six multiple inclusions. Four diamonds contained sufficient ferropericlase to determine the Li isotopic composition by MC ICP MS; the Li-contents were determined by SIMS for all other diamonds; all other elements were measured by electron microprobe. The Li isotopic composition (δ^7Li) of the ferropericlases from the four diamonds ranges from -3.9 to +9.6‰ with no correlation with the Li content or the Mg-values. This range lies within the range of ocean floor serpentinites and altered ocean floor basalts. Altered ocean floor also consists of ophicarbonates, rodingites and a variety of carbonates. A melange of such rock types exists in subduction zones. The multiplicity of phases with “olivine”, MgSi-perovskites, TAPP (tetragonal almandine-pyrope phase), CaSi-perovskites, magnetite, ilmenite, Cr-Ti spinel, SiO_2, majoritic garnet, CaTi-perovskite, sphene, rutile, corundum, native Fe and Ni, the overabundance of Ca-phases, the chemical variability of the ferropericlases and the Mn-rich nature brings such a melange as precursor rocks of the inclusions in diamonds and of the diamonds from Juina into mind. We therefore suggest that the diamonds from Juina and their inclusions crystallized in the transition zone and lower mantle by fluid-induced redox reactions from subducted ocean floor precursor rock types.

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