

DIAMONDITES AND CARBONATITIC FLUIDS: SIGNALS FROM TRACE ELEMENTS IN GARNETS AND CLINOPYROXENES AND FROM C ISOTOPE ABUNDANCES

by

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Diamondites are fine- (< 100 µm) to coarse-grained (> 1 mm) rocks consisting of diamonds and occasionally some silicates and oxides [1]. They are usually porous rocks with abundant open and mostly interconnected cavities. The walls of the open cavities are covered by euhedral diamond crystals (druses). Silicates (mostly garnets) are present preferentially interstitially or fill the space in cavities and often contain inclusions of euhedral diamonds.

Silicates from 10 diamondites have been analyzed for trace element contents by laser ablation ICP-MS [2]. Four diamondites contain lilac "peridotitic" garnets with low CaO contents (3.6 - 5.7 wt.%), high Mg-numbers (0.83 - 0.84) and high Cr₂O₃ contents (3.9 - 6.4 wt.%). Occasionally, they are accompanied by Cr-diopside. "Peridotitic" garnets have heavy rare earth element (HREE)-enriched and light rare earth element (LREE)-depleted chondrite-normalized patterns, commonly with a small hump at Eu and Sm (Fig. 1). The remaining 6 diamondites contain orange "eclogitic" garnets with low Cr₂O₃ contents (< 1 wt.%). These "eclogitic" garnets can be divided into two subgroups: E-I garnets have high Mg-numbers (0.84 - 0.85, as high as those of the "peridotitic" garnets) and higher Cr₂O₃ and TiO₂ and lower HREE contents than the E-II garnets (Fig. 1).

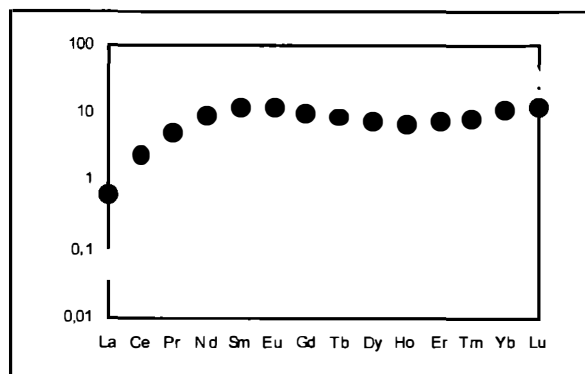


Fig. 1
Chondrite-normalized REE abundances in garnets from diamondites. Solid circles: "peridotitic"; open squares: "eclogitic" I; open triangle: "eclogitic" II.

The chondrite-normalized trace element patterns of the two subgroups of "eclogitic" garnets are all depleted in LREE with respect to the HREE and have significant positive anomalies of Zr and Hf. "Eclogitic" garnets are more depleted in highly incompatible elements (LREE, Nb and Ta) than the "peridotitic" garnets.

Diamondites and their silicates very likely are the product of a fluid phase. The hypothetical fluids in equilibrium with the "peridotitic" garnets have trace element abundances which are similar to those in kimberlitic and carbonatitic liquids. Therefore, diamondites very likely formed from a highly alkaline fluid/liquid in the presence of carbonates. A predominantly alkali carbonatitic fluid/melt could provide the proper environment for mobilization of incompatible elements and precipitation of diamond [e.g., 3]. Hypothetical melts in equilibrium with "eclogitic" garnets are highly magnesian but depleted in LREE and other highly incompatible elements relative to the typical kimberlitic, lamproitic or carbonatitic liquids. This is surprising as eclogites should be richer in trace elements than peridotites, as should be the fluids in equilibrium with these rocks. The differences in trace element contents of fluids which precipitated, beside diamonds, "peridotitic" and "eclogitic" garnets, respectively, therefore, must be the result of different properties of these fluids rather than of different source rocks [1].

Diamonds (117 samples) from 35 diamondites have been analyzed for C isotope abundances (Fig. 2). Delta ^{13}C values vary between and within diamondites with a total range from -3.24 to -24.36 ‰ for 13 "peridotitic" diamondites, from -18.30 to -23.59 ‰ for 4 which in addition to garnet also contain clinopyroxene and from -5.27 to -22.22 ‰ for 19 "eclogitic" diamondites. Three diamondites without silicates have a range in $\delta^{13}\text{C}$ from -5.44 to -27.87 ‰.

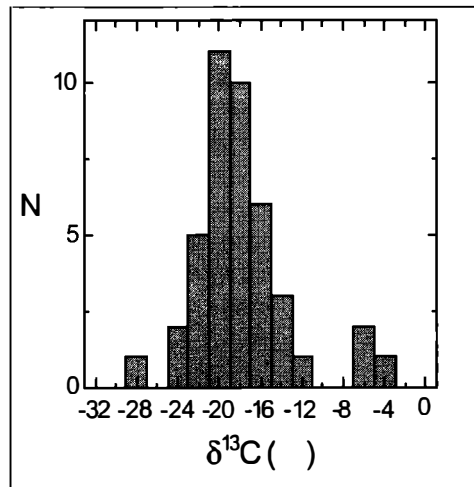


Fig. 2

Carbon isotope composition of diamondite diamonds.

Carbon in our diamondites is clearly lighter than that previously reported from diamond crystals [e.g., 4] and polycrystalline diamonds from Yakutia ($\delta^{13}\text{C}$: -6.1 to -2.6 ‰, [5]) but similar to that reported for polycrystalline diamonds from South Africa [6, 7]. Surprisingly, only 3 out of 35 diamondites have C isotope abundances that are compatible with unfractionated upper mantle C [see 5] and they represent all three types of silicate-bearing diamondites. The C isotope abundances are apparently not correlated with the type of garnet ("eclogitic" or "peridotitic") present, nor with the absence of silicates. The dominantly light C is probably the product of mass fractionation between oxidized (CO_2) and reduced (CH_4) carbon [e.g., 8] indicating diamond precipitation via CH_4 , probably at fairly low temperatures. The degree to which mass fractionation occurred could simply reflect the mass ratio of reduced to oxidized C in the local environment. Variable isotopic compositions of C within diamondites (up to almost 4 ‰ $\delta^{13}\text{C}$!) likely reflect changing conditions during diamond growth. The few diamondites with upper mantle C isotope composition could indicate precipitation of diamond directly from carbonates [e.g., 3].

In conclusion, diamondites seem to be the product of large scale mass transfers taking place in the Earth's mantle. Carbonatitic fluids/melts appear to be the main vehicle for major, minor and trace element transfers, transfers of heat and of C, presumably from the deeper to the shallower mantle. Depending on local conditions in the mantle, some of the mobilized elements react with mantle rocks they invade (e.g., carbonatitic metasomatism) or are precipitated into the space created by the moving fluids/melts (e.g., diamondites). As the main mass of the mobilisates continues to migrate, highly fractionated products are left behind, the most common of which seem to be pyroxenites, olivinites, garnetites and diamondites.

Acknowledgements

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