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Isotopic Characterization of Diamond Growth in Fluids

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Trapping inclusions in diamonds has been used as a diagnostic to constrain diamond growth media (e.g. Navon et al., 1994; Weiss et al., 2015) in the Earth's upper mantle. Experimental works now generate inclusion-bearing diamonds from seeds in mixtures of carbonates, graphite, and silicates in the presence of excess of pure water or saline fluids (H_2O-NaCl) and investigate in more details the conditions of natural diamond growth (Bureau et al., 2012; 2016). Experiments were carried at conditions compatible with the Earth's geotherm between 6-7 GPa (1300-1675°C) in multi-anvil presses at the Bayerisches Geoinstitut, Bayreuth from a few hours two a few days. Results show that within the timescale of the experiments diamond growth occurs on seeds if water and alkali-bearing carbonates are present. We show that water promotes fast diamond growth, which is favorable to the formation of inclusions. Thin sections of a few diamond seeds containing exposed inclusions were prepared using a Focus Ion Beam (about 2 to 5 µm thickness). These sections were deposited on silicon wafers and gold coated for micron-scale determination of the delta ^{13}C isotopic compositions using the NanoSIMS 50 installed at the Muséum National d'Histoire Naturelle, Paris.

Carbon isotope measurement with NanoSIMS were calibrated against a natural Ia and a synthetic IIa diamond used for diamond anvil cells, whose compositions were determined by gas-source mass spectrometry at IPGP at 3.6±0.1‰ and -20.9±0.1‰, respectively (Pinti et al., 2016). All the starting materials used for the experiments were also characterized for their delta ^{13}C by the same technique at GEOTOP, Montréal.

The isotopic composition of the new diamond grown areas were measured close to the inclusions. They exhibit a different isotopic signature than that of the starting seeds (starting diamond composition: -29.6 to -30.4±1.4‰). The new diamond signatures are falling into the range of signatures of the starting carbonates used for the experiments (- 4.8±0.1 to -16.2±0.1‰) when they are far away from the composition of the starting graphite (-26.4±0.1‰). This shows that the carbon source for diamond growth must be the carbonates present either as CO_3^{2-} ions dissolved in the melt or as carbon dioxide species CO_2 in the aqueous fluid and that diamond growth occurred from carbonate reduction rather that from graphite dissolved in the melt.

We suggest that the presence of small discrete or isolated volumes of water-carbonate-rich fluids are necessary to grow inclusion-bearing peridotitic, eclogitic, fibrous, cloudy and coated diamonds, and may also be involved in the growth of ultrahigh pressure metamorphic diamonds.

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