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Carbon isotopes in a Juina diamond with carbonate inclusions

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Juina super-deep diamonds are formed at the transition zone, between the upper and the lower mantle. They contain numerous mineral inclusions such as carbonates. Although rare, the occurrence of carbonates in the transition zone or even the lower mantle suggests that the Earth's global CO_2-cycle has an ultra-deep extension. Some authors have pointed out carbonate inclusions as an evidence of the involvement of subduction-related fluids in the formation of these super-deep diamonds, and in general of eclogitic-type diamonds. Here we present new data obtained on three FIB-TEM prepared foils of a Juina diamond that contains a carbonate inclusion. Carbon isotopic signature (δ^{13}C in ‰) was measured together with N content in these foils and calibrated against a carbonado standard (GM02) with a δ^{13}C of -29.2 ‰, using a NanoSIMS 50 at the University of Tokyo. The δ^{13}C of a synthetic diamond used for anvil cell experiments and a natural diamond of type IA have been also measured (and conventional mass spectrometry analyses are under way) to use them as new internal standards and crosscheck the results.

A total of 14 raster analyses (1 x 1 μm) were carried out on the three foils, using a Cs^+ beam. We used 2 detectors on different 3 magnetic fields, so we could estimate and compare three $^{13}C/^{12}C$ ratios. N amount was also determined. Instrumental mass fractionation (IMF effect) was calculated using the data of GM02. Quasi-simultaneous arrival (QSA) effect was taken into account and data corrected consequently, because of the large amount of secondary ions observed (above 100,000 cps). Counting was between 35 and 80 cycles, depending to the variable thickness of the foils (ca. 150 nm) to avoid that the Cs^+ beam pierces the foil and measures C from the TEM carbon grid.

Results showed δ^{13}C values in the Juina diamond ranging from -9.1±3.8 ‰ to -0.43±2.82 ‰ with an average δ^{13}C value of -4.2 ‰ and a median value of -4.0 ‰. The diamond sample contains also a small amount of nitrogen with an average concentration of 62 ppm, similar to previously reported concentrations measured by SIMS. These results suggest a peridotitic origin for the diamond, possibly Type IaB, which is the most abundant class among the Juina diamonds. The origin of this diamond calls for alternative processes to explain the genesis of carbonate inclusions.

Keywords: Carbon cycle, Carbon isotopes, Diamonds, Carbonate, Juina, Transition zone