

Carbon isotope systematics during carbonated silicate melting under upper mantle conditions

MADHUSOODHAN, Satish-kumar^{1*} ; MIZUTANI, Shogo² ; YOSHINO, Takashi³
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¹Niigata University, ²Shizuoka University, ³Okayama University

¹Niigata University, ²Shizuoka University, ³Okayama University

Carbon isotope fractionation between graphite and carbonated silicate melt was determined at 5 GPa and in the temperature range between 1400 and 1900 °C. High pressure experiments were carried out in the carbon-saturated model harzbergite system (Enstatite-Magnesite-Olivine-Graphite), where carbonated silicate melt and graphite were the two stable carbon-bearing phases in the run products. Carbonated silicate melting resulted in an isotopic fractionation between graphite and carbon in the silicate melt, where the carbon in the melt is ¹³C enriched than co-existing graphite (Mizutani et al., 2014). ¹³C enrichment in carbonate melt were further confirmed in experiments where redox melting between olivine and graphite produced carbonate melt as well as carbonate reduction experiments to form graphite.

According to the results of carbon isotope fractionation obtained in this study between graphite and carbonated silicate melt, heavier carbon will be selectively partitioned to the melt and graphite will be lighter than the melt in the order of 1 to 2 permil. If locally oxidative or reductive domains are present or melt extraction and a Rayleigh fractionation process dominate in the upper mantle, then carbonate silicate melt-graphite carbon isotope partitioning at upper mantle conditions will have larger effect on carbon isotopic composition. It is possible that carbonate melt will progressively enrich in carbon isotopes, which corresponds to the primary igneous carbonatite values (-5 to -8 permil) and even rare carbonatites having the more enriched ¹³C (-2 to -5 permil) may be explainable in term of the existence of more reductive environment. Conversely, the graphite coexisting with such melts will have delta13C values corresponding to main mantle carbon reservoir. Recent experiments have shown that carbonate melts can be a medium for the efficient crystallization of diamonds in Earth's mantle. Therefore, redox reaction at lower upper mantle is likely to yield the range of carbon isotope variation of mantle derived diamond. Moreover, carbonated mantle melting according to redox melting at upwelling mantle can be an alternative explanation for the formation of ¹²C enriched diamonds in the deep mantle

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