Diamond Interactions with Nitrogen-Bearing Carbonate Fluids at Mantle Conditions

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Natural diamonds that form in the Earth's mantle are almost exclusively composed of pure carbon. Nitrogen is the most abundant trace element found in diamonds and can be present at concentrations as high as ~3800ppm. There are currently two models used to describe the behaviour of nitrogen in diamonds; in the first, nitrogen is incompatible and significant incorporation of nitrogen into the diamond structure is only possible when equilibrium partitioning is disrupted by rapid diamond growth. In the second model, nitrogen is a compatible element that preferentially fractionates into the growing diamond relative to the coexisting fluid under equilibrium conditions. As a first step in exploring these models, we investigated the conditions under which diamond could grow in N-bearing fluids. We took nitrogen-bearing carbonate ± graphite fluids and seed diamonds to 6 GPa and 1420ºC, well within the diamond stability field. We varied the molar proportions of carbon and nitrogen in the fluid. The diamonds were weighed and imaged using a scanning electron microscope before and after each experiment to determine any mass or structural changes that had occurred. The experiments showed that increasing the amount of graphite while maintaining a constant C/N caused the percent mass change to transition from negative to more positive values, whereas decreasing the C/N caused the reverse. We suggest that nitrogen is incompatible and increasing concentrations of nitrogen negatively affects the growth and stability of diamonds. Studying the interactions between nitrogen and diamond can help constrain the concentration of nitrogen in the mantle and enhance our understanding of the mantle part of the nitrogen geochemical cycle.