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Experimental study of diamond resorption during mantle metasomatism

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Many of kimberlite-derived diamonds are partially dissolved to various degree but show similar resorption style. This resorption style has been observed in experiments with aqueous fluid at the conditions corresponding to kimberlite emplacement (1-2 GPa). At the same time, each diamond population has more than ten percent of diamond crystals with several drastically different resorption styles, which have not been observed in experiments, and may represent partial dissolution of diamonds during metasomatism in different mantle domains. Metasomatic processes modify the composition of subcratonic mantle, may trigger the formation of kimberlite magma, and result in the growth and partial dissolution of diamonds. Composition of metasomatic agents as constrained from studies of the reaction rims on mantle minerals (garnet, clinopyroxene) and experimental studies vary between carbonatitic melt, aqueous silicate melt, and CHO fluid. However, complex chemical pattern of mantle minerals and estimates of redox regime in subcratonic mantle allow different interpretations. Here we explore diamond dissolution morphology as an indicator of the composition of mantle metasomatic agents. Towards this end we examine diamond dissolution morphologies developed in experiments at the conditions of mantle metasomatism in different reacting media and compare them to the mantle-derived dissolution features of natural diamonds.

The experiments were conducted in multi-anvil (Walker-Type) apparatus at 6 GPa and 1200-1500oC. Dissolution morphology of natural octahedral diamond crystals (0.5 mg) was examined in various compositions in synthetic system MgO-CaO- SiO_2-CO_2-H_2O. The runs had the following phases present: solid crystals with fluid (various ratio of H_2O-CO_2-SiO_2, and in the air), carbonate melt, carbonate-silicate melt, and carbonate melt with CHO fluid. Experiments produced three different styles of diamond resorption. In the presence of a fluid phase with variable proportions of H_2O and CO_2 diamond crystals develop ditrigonal outline of {111} faces, striation or hillocks along the edges, and shallow negatively oriented trigonal etch pits with flat or pointed bottom. Presence of SiO_2 in the fluid resulted in multi-corner morphology, layering and / or more intensive etching of {111} faces. Dissolution in carbonate melt in the absence of water produced deep stepped-wall hexagonal and trigonal etch pits with negative orientation. The three resorption styles show strong resemblance to the secondary morphology of natural diamonds. This suggests that CHO fluid, aqueous silicate melt, and carbonatatitic melt are metasomatic agents reacting with natural diamonds in subcratonic mantle. The comparison of the experimentally-induced resorption styles to those on natural diamonds show that mantle metasomatism induced by CHO fluid develop morphologies similar to those developed in kimberlite magma. This indicates that significant proportion of kimberlite-hosted diamonds may show resorption features of mantle origin. Aqueous silicate melt induces step-faced multi-corner resorption morphology, similar to natural diamonds with nitrogen aggregation corresponding to eclogitic diamonds. Dissolution in carbonatitic melt results in complex morphologies with deep hexagonal pits similar to natural diamonds with nitrogen data corresponding to peridotitic diamonds.