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An atomic force microscopy study of diamond dissolution features: The effect of H_2O and CO_2 in the fluid on diamond morphology

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Abstract

Experimental data demonstrates that the resorption morphology of diamond greatly depends on the composition of the reacting fluid and can be used to constrain the composition of mantle fluids in diamond source areas and magmatic fluid in kimberlite magma. This requires a model that describes how different fluids interact with the diamond surface. This study uses atomic force microscopy (AFM) to quantitatively characterize the crystallographic orientation of micro-faces that form individual etch pits on diamond surfaces produced naturally in a kimberlite magma and experimentally in H_2O-rich and CO_2-rich fluids at 1150, 1250, and 1350 °C and 1 GPa. Dissolution features were examined on {111} diamond faces with the AFM scan areas ranging from 30×30 to 1×1 μm. The study shows that the extremely different resorption features developed on diamond surface during dissolution in H_2O- and CO_2-rich fluids, are formed by the same set of micro-faces with angles ~7, 11, 16, and 22°, corresponding to the {433}, {322}, {221}, and {321} faces, respectively. This suggests that diamond has similar dissolution rates in the same directions of the diamond lattice in both H_2O- and CO_2-rich fluid but that the mechanism of material removal is different. Reaction with H_2O-rich fluid develops regular features due to layer-by-layer carbon removal. In CO_2-rich fluid, deep etch pits with irregular walls form when dissolution is focused around the outcropping dislocations. The size and shape of the etch pits and their association with the outcropping dislocations depend on temperature and could be used to constrain the crystallization conditions of kimberlite magma. Natural kimberlite-induced resorption features indicate high $H_2O:CO_2$ ratios in kimberlitic fluid.

Keywords: Diamond resorption, H_2O and CO_2 fluid, atomic force microscopy, mechanism of diamond dissolution, etch pits