Mantle metasomatism: constraints from surface features on diamonds from nature and etched in experiments

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The footprints of mantle metasomatism on dissolved diamonds capture the latest diamond-destructive event. Natural diamonds (total 603 stones) from Ekati kimberlites, Canada, are proposed to be classified into kimberlite- induced (e.g., ditrigonal outlines of {111} faces and trigonal etching pits) and mantle-derived (e.g., trigonal shape of {111} faces and hexagonal pits) groups in terms of surface features. To examine mantle fluids using diamond resorption morphology, we conducted experiments to investigate silica activity (a_{SiO2}), pressure (P) and temperature (T) effect on diamond dissolution in H_2O and CO_2 fluids, and applied our results to the natural diamond.

Experiments were conducted in piston-cylinder apparatus using natural octahedral diamonds and synthetic systems H_2O ± CO_2 - MgO ± SiO_2 and CO_2 - CaO - SiO_2 ± H_2O at 1–3 GPa and 1150–1400 °C. The products were examined using Field-Emission Scanning Electron Microscopy and Atomic Force Microscopy. Fluid compositions were monitored by synthesizing fluid inclusions in olivine and quartz, and inclusion isochores pass through the P-T conditions of the runs, confirming trapping conditions. In the aqueous system, we found: (1) formation of circular and negative trigonal etch pits on {110} and ditrigonal {111} faces, individually; (2) the suppressing effect of silica activity and pressure on circular pits; (3) positive correlation of diamond dissolution rates with T and negative with P; and (4) the accelerating effect of P on diamond morphology transformation from octahedron to dodecahedron. $CO_2/(CO_2 + H_2O)$ molar ratio increasing from 50 to 100% is accompanied by the development of hexagonal etch pits on {111} faces switching from ditrigonal to trigonal shape. Similarly, P increase from 1 to 3 GPa at constant $CO_2/(CO_2 + H_2O)$ molar ratio changes ditrigonal to trigonal outline of {111} faces. At $CO_2/(CO_2 + H_2O)$ =50 mol.%, diamonds while showing apparent H_2O-style resorption, still bear typical irregular hexagonal pits.

Comparison of our experimental results with natural diamonds from Ekati kimberlites shows that dissolution features of diamond in H_2O- and CO_2- dominated environments are comparable to the most rounded natural diamond in the kimberlite-induced group and to natural diamonds with mantle-derived resorption, respectively. The analogous results confirm the possibility of using diamond resorption features to probe the composition of the diamond dissolution medium. Our data show that presence of circular pits only on fragmented diamond faces indicates a latest H_2O-dominated aqueous fluid regime with maximum $aSiO_2$ buffered by olivine in kimberlites, and the $CO_2/(CO_2 + H_2O)$ ratio was >50 mol. % in diamond-destroying mantle metasomatism to create hexagonal etching pits.

Atlantic Geology, 2014, Volume 50, Number 1
Atlantic Geoscience Society Abstracts: 40th Annual Colloquium & Annual General Meeting 2014
doi: 10.4138/atlgeol.2014003