

Apatite in Cu-sulfide ore from the Mount Polley alkalic porphyry, BC Canada

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The role of sulfur in the development of porphyry-Cu deposits is poorly understood, despite the fact that ore minerals are principally sulfides. One of the greatest difficulties associated with understanding the role of S within magmatic and hydrothermal systems is that sulfate phases are soluble in groundwater and are therefore often missing from the geological record. One solution to this problem is to study sulfate inclusions that are trapped and preserved within phases that crystallized from ore-bearing fluids/melt. An example of this can be found within the Late Triassic Mount Polley alkalic porphyry-Cu-Au deposit in British Columbia where large (up to 5mm long) euhedral to subhedral apatite crystals hosted within bornite-chalcopyrite cemented breccias make up to 30% of the Cu-sulfide matrix. Apatite crystals include numerous different types of primary and secondary inclusions, such as Ca-sulfate (45%), Cu-sulfide ± silicate material (25%), phlogopite (10%), globular orthoclase (5%) and composite inclusions (15%), which include variable proportions of Cu-sulfide, Ca-sulfate, silicate, anhydrite and calcite. Inclusions range in size from <5 to 300µm, are elongate to spherical. Elongate inclusions commonly have negative hexagonal crystal-shapes and are orientated so that their long axis is parallel to the c-axis of the host apatite. In certain cases negative crystal-shaped Ca-sulfate inclusions form a network of inclusions that branch out from microfractures and are therefore secondary. Cu-sulfide inclusions are also observed along the same microfractures, as are composite inclusions of Ca-sulfate + Cu-sulfide, which demonstrate that the melt/fluid was sulfate saturated at the time of trapping.

Apatite crystals show examples of fractured inclusion-rich cores and fracture-free inclusion-poor rims. Cores are comparatively enriched in S (4000-5500ppm) compared to crystal rims (2000-3500ppm), which reflects change in the solubility of S into apatite. A decrease in the solubility of S into apatite may be in response to; 1) fluids/melt becoming more reduced, 2) decrease in pressure, 3) increase in temperature and/or 4) decrease of S within the melt/fluids.