

Apatite Insights Into the Volatile Evolution of Gold-fertile Alkaline Magmatic Systems

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The volatile evolution of magmatic systems is critical for magmatic-hydrothermal ore formation. Apatite records changes in magmatic volatile contents by incorporating water, halogens (F, Cl) and sulfur into its crystal structure. While apatite geochemistry has been widely applied to of calc-alkaline magmas related to porphyry copper deposits, apatite from alkaline magmatic centers related to epithermal gold deposits received less attention.

Here, we compare apatite compositions from three gold deposits related to alkaline magmatism: Kışladağ (Turkey), Ladolam (Lihir Island, Papua New Guinea), and Cripple Creek (Colorado, USA), to assess similarities and differences in their magmatic evolution. In all three localities, apatite occurs as inclusions in various silicates and oxides as well as (micro-)phenocrysts. Apatite inclusions are typically euhedral, acicular to prismatic and oscillatory zoned, whereas apatite phenocrysts are either oscillatory zoned or exhibit patchy or no zonation. Apatite compositions were analyzed by EPMA and LA-ICP-MS and show elevated Si and Fe concentrations as well as steep chondrite-normalized REE patterns, consistent with a magmatic origin. Except for Kışladağ, apatite inclusions have higher OH contents than phenocrysts, which are more enriched in fluorine, suggesting crystallization from fluid-saturated magmas. Chlorine concentrations are uniform within each deposit but vary between them: < 0.2 wt.% (Cripple Creek), 0.5-1.0 wt.% (Lihir Island), and > 1 wt.% (Kışladağ). These notable differences possibly reflect variations in geological settings (continental rift vs. post-collisional subduction zone) and magma affinities (strongly vs mildly alkaline) or the depth of magma emplacement and hence fluid exsolution. Sulfur concentrations in apatite from all three deposits vary between 0.1 to 0.5 wt.%, indicating oxidized magmatic systems.

Future geochemical modelling in combination with melt-inclusion data and comparison to apatite from other locations will refine interpretations of apatite geochemistry from alkaline magmas and its link to ore fertility for the formation of gold epithermal and porphyry deposits.