Hydrothermal Alteration Revealed by Apatite Luminescence and Chemistry: An Indicator for Covered Porphyry Copper Deposits

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Apatite is a common resistate mineral occurring across a range of host-rocks and alteration assemblages. Study of several porphyry copper deposits in British Columbia indicates that the unique physical and compositional characteristics of apatite can be used as marker to evaluate chemical condition of rock formation or associated hydrothermal alteration. Apatite under visible light and SEM shows no notable differences between fresh and altered varieties but cathodoluminescence reveals significant differences. Apatite in fresh rocks displays yellow, yellow-brown and brown luminescence, whereas in K-silicate altered rock displays characteristic green luminescence. The green-luminescent apatite replaces yellow or brown-luminescent apatite and locally overgrows it. Apatite occuring with muscovite alteration displays characteristic grey luminescence.

The chemistry of apatite from electron microprobe and laser ICP-MS analyses reflects its alteration and luminescence. The yellow-luminescent apatite has high concentrations of Mn (0.3-0.5%) and high Mn:Fe (>1), while the brown-luminescent apatite has low Mn, but higher concentrations of Cl, S and REE. The green luminescence is caused by lower Mn:Fe ratio (ca. 1). Other trace elements such as Cl, S, and Na were also depleted during K-silicate alteration. Grey-luminescent apatite occuring with muscovite alteration results from significant Mn and trace element loss (Mn:Fe of <0.3) during low pH phyllic alteration in calc-alkalic porphyry deposits.

The correlation between apatite texture, luminescence and composition with the degree and intensity of porphyry alteration offers a fast and effective method to utilize it as indicator for porphyry mineralization in glacial, fluvial and regolith terrains. These findings indicate that knowledge from apatite and other porphyry indicator minerals can be more fully developed to understand the link between ore deposits and sedimentary cover and to improve exploration decision-making similar to the contributions that accessory minerals and G10 garnets made to diamond exploration.