

In Situ S Isotope and Trace Element Composition of Apatite from the Gaspé Copper Porphyry-Skarn Cu-Mo Deposit

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Magmatic apatite incorporates abundant trace elements and volatiles (Cl, F, OH), including S. Previous in situ $\delta^{34}\text{S}$ measurements in apatite from arc magmas and porphyry systems show a range of $\sim 0\text{--}10\text{‰}$, attributed to fluid saturation or sulfate/sulfide crystallization, which are key controls on porphyry Cu fertility. In this study, we performed in situ SIMS $\delta^{34}\text{S}$ coupled with EPMA and LA-ICP-MS measurements in matrix-hosted apatite from polyphase porphyry intrusions at the Gaspé Copper porphyry-skarn Cu-Mo deposit to investigate the controls on the S isotope signature in apatite. The Gaspé Copper deposit has two intrusive centers: Copper Mountain (CM) and Porphyry Mountain (PM). Apatite at CM and PM displays $\delta^{34}\text{S}$ values with a range of $\sim 1.5\text{--}8\text{‰}$, means of $\sim 4.7\text{‰}$, and some intra-grain variations exceeding 5‰ , with no specific $\delta^{34}\text{S}$ values associated with the pre-, syn-, and post-mineralization intrusions. In some syn- and post-mineralization intrusions, apatite volatile chemistry (F, Cl, OH) indicates fluid saturation, which has no or limited impact on the apatite $\delta^{34}\text{S}$ values. Only a small fraction of apatite at CM exhibits a core-to-rim increase in $\delta^{34}\text{S}$ values (up to 5.7‰) correlating with decreasing Cl content. This pattern may be consistent with S isotope fractionation driven by exsolution of SO_2 -bearing fluids in oxidized melts. However, most investigated grains from intrusions at CM and PM, also show a large range in $\delta^{34}\text{S}$ values without systematic relationship with volatile and trace element compositions. This suggests a minor effect of fluid exsolution on the observed range of apatite $\delta^{34}\text{S}$ values. Apatite S isotope signature is likely controlled by magmatic replenishment and crystallization/redissolution of anhydrite during apatite crystallization. While the $\delta^{34}\text{S}$ values in apatite provide only limited evidence of fluid exsolution and mineralization at the Gaspé Copper deposit, the results illustrate the complex dynamics of S in a long-lived oxidized magmatic system.