# A numerical model for apatite Cl-OH-F evolution and quantitative interpretation of magmatic processes

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The presence and behaviour of volatile species are among the most important factors affecting the differentiation, ascent and eruption of magmas. Exsolution of volatiles into bubbles marks a significant change in magma density and potential explosivity. Furthermore, the concentrations of halogens and sulphur, in particular, are key to the formation of hydrothermal fluids that can transport and deposit metals. Apatite is a key magmatic accessory mineral that is well known to incorporate most volatile species of magmatic interest (Cl, F, OH, S and C) and can therefore shed light on these processes.

Here we present a numerical thermodynamic model to describe the behaviour of Cl, F and OH in apatite during fractional crystallisation and volatile exsolution. The model allows the user to explore the effects of variations in crystal-melt partitioning, fluid-melt partitioning, and temperature on the trajectories of apatite volatile compositions. This enables quantitative interpretation of the impact of volatiles on magmatic processes. We show the results of sensitivity analysis which helps to define the degree of uncertainty in parameter values and test the robustness of possible model solutions. The model shows that apatite can be used to discriminate volatile-undersaturated and volatile-saturated conditions, particularly when the fluid-melt partition coefficient for Cl is high. We illustrate the potential of the model using examples from subduction and rift settings, including porphyry mineralisation environments.