

A general approach to quantify phase equilibria and silicate mineral stability fields in calc-alkaline basaltic systems

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Despite recent developments, the influence of chemical and physical parameters on magmatic phase equilibria still requires further research to understand igneous processes. As the "in-situ" study of magmatic processes is only possible to a limited extent at active volcanoes, igneous petrology predominantly relies on the analysis and interpretation of solidified magmatic products and their crystal cargo. As a consequence, a huge variety of petrological tools has been developed over the last years that have been widely applied to igneous rocks to reconstruct magmatic processes (e.g. thermobarometers). However, resultant data are frequently of only limited validity due to significant uncertainties. Moreover, such models are often interdependent meaning that the derivation of individual parameters is challenging, which further complicates their application to natural rocks.

The prediction of phase equilibria is particularly complex for calc-alkaline systems, because water and oxygen fugacity vary over wide ranges. This contribution is an attempt to fill this gap by providing new experimental data exploring systematically the effects of temperature, pressure, magma composition, H_2O , and fO_2 on phase equilibria in calc-alkaline basaltic systems. We extended existing high-pressure experimental datasets on a high-Mg basalt from the Adamello Batholith (Italy) and a high-Al basalt from the Cascades (U.S.) to upper crustal pressures. Experiments were run in internally heated pressure vessels (IHPV) at 200 and 400 MPa and varying H_2O contents (0-9 wt.%) with fO_2 conditions buffered between NNO+1 and NNO+2.3.

Beside changes in mineral assemblages, we established the role of crystallisation parameters on silicate mineral chemistry (e.g. for olivine, clinopyroxene, orthopyroxene, and plagioclase). We combined our results with high-quality experimental data from literature to formulate empirical mineral saturation models for olivine, plagioclase, and clinopyroxene predicting the saturation of these phases as a function of bulk system composition, pressure, temperature, H_2O , and fO_2 . Furthermore, employing our data compilation, we test existing mineral-based thermobarometers to provide some general insight on the limitations of these petrological tools and present some recommendations on their application to natural rocks.