Tracing magma chambers in the lab: A case study on Lascar volcano

A. STECHERN[1]*, M. BANASZAK[2], R.E. BOTCHARNIKOV[1], F. HOLTZ[1] AND G. WÖRNER[2]

[1]Institute for Mineralogy, Leibniz University of Hannover, Germany (*correspondence: a.stechern@mineralogie.uni-hannover.de)
[2]Geowissenschaftliches Centrum Göttingen, Abt. Geochemie, Göttingen, Germany

Lascar volcano is a calc-alkaline stratovolcano located in the Central Volcanic Zone (CVZ), Northern Chile and represents the most active volcano in this area. The activity of Lascar is characterized by extensive lava flows, domes, and pyroclastic deposits such as the most recent eruption in 1993. Present activity is restricted by vigorous degassing from the open vents. The composition of erupted rocks of Lascar range from poorly porphyritic mafic andesites to dacites.

In this study we combine geochemical analyses with high P-T experiments to investigate possible depth of storage from the pre-eruptive conditions of crystallization on the one hand, as well as the role of magma-mixing and differentiation during magma ascent on the other.

Well-established geo-thermo- and barometers were used to characterize the crystallization conditions of the recent 1993 eruption. Results give evidence for a large temperature interval of crystallization from ~ 850 to 1050°C and pressures between 400 to 500 MPa. Oxygen fugacity was in the range of 1.0 to 2.0 log units above the Ni/NiO oxygen buffer. The analyses of melt inclusions are dacitic to rhyolitic in compositions with rather small concentrations of chlorine, fluorine and sulfur, indicating that the evolved magma was largely degassed.

The major element compositions of Lascar lavas indicate significant changes in the magmatic processes with the alternation of mixing- and fractionation-dominated stages. The compositional variation of deeper magmas (~ 1.3 ± 0.3 GPa) can be reconciled with magma mixing models. The compositional variations of most lavas erupted in 1993 and of a few older samples correspond to crystal fractionation trends, which have been reproduced experimentally at 300 to 500 MPa. Experimental data, geochemical trends and thermo-barometric data indicate that the pre-eruptive depth of the youngest magmas (< 7.1 ka) is rather shallow (~ 500 ± 200 MPa). A possible interpretation of these results is that magma storage in upper crustal levels is mostly dominated by fractional-crystallization whereas deeper magma chambers show clear evidence for magma-mixing processes.

Upscaling pore scale carbonate precipitation rates to the continuum scale

C.I. STEEFEL[1]*, C. NOIRIEL[2], L. YANG[1] AND J. AJO-FRANKLIN[1]

[1]Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, CA 94720, USA (*correspondence: CISteefel@lbl.gov)
[2]Université de Lille, France (catherine.noiriel@univ-lille1.fr)

An integrated approach combining experimental reactive flow columns and continuum-scale reactive transport modeling has been used to compare microscopic and bulk (upscaled) rates of carbonate mineral precipitation. The experiments consisted of the injection of supersaturated, carbonate-rich solutions into calcite packs. Bulk rates of precipitation based on the change in chemistry over the length of the column were compared with spatially resolved determinations of carbonate precipitation using X-ray synchrotron imaging at the micron scale. These data are supplemented by well-stirred reactor experiments to evaluate the rate of precipitation as a function of solution supersaturation in the absence of transport effects. Results indicate good agreement between rates determined with fluid chemistry and with microtomography. The distribution of calcite precipitates shows a nonlinear spatial profile, with the greatest accumulation near the column inlet. Precipitation is greatest on Iceland spar seeds, with crystal morphology of the new precipitates suggesting growth via a 2D heterogeneous nucleation mechanism.

Using the rates of precipitation as a function of supersaturation determined in the well-stirred flowthrough reactors, it is possible to match the spatially-resolved microtomographic data with a continuum reactive transport model *if the generation of new reactive surface area is accounted for*. The experimentally-determined value of 0.90 m^2/g for the specific surface area of the neoformed calcite, added to the initial calcite surface area of 0.012 m^2/g, results in good agreement with the continuum model. The approach used here also demonstrates that it is possible to determine upscaled reactive surface area in porous media if the intrinsic rate (per unit surface area mineral) is known.