

Application of techniques to enlarge meltpools and crystals in crystallization experiments: A case study in an andesitic system from the Pacific-Antarctic Rise

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Dredged lavas from the Pacific-Antarctic Rise (PAR) reveal beside basalts a significant number of silicic lavas with andesitic to dacitic composition [1]. In order to understand the formation of felsic melts in a fast-spreading mid-ocean ridge environment, we performed crystallization experiments to experimentally simulate differentiation/fractional crystallization processes proceeded during the magmatic accretion of the PAR. For this, phase relations and phase compositions in a typical andesitic system have been obtained, using a natural glass from the PAR with andesitic composition as starting material (SiO₂ 61.95 wt%, MgO 1.57 wt%; sample SO157-3DS1).

Here, we present the results of the phase equilibria study at temperatures between 910 and 1030°C, a pressure of 200 MPa, two redox conditions ($\Delta QFM_{nominal}+1$ and $+3.2$ at $a_{H_2O}=1$) and with different a_{H_2O} ($0_{initial}$ to $1_{initial}$), performed in internally heated pressure vessels (IHPV). Considering the variations of a_{H_2O} , f_{O_2} of our experiments vary between $\Delta QFM-1$ and $\Delta QFM+3.2$. The stability and composition of magnetite is highly redox-sensitive. It is liquidus phase for the more oxidizing experiments ($>990^\circ C$, $a_{H_2O}=1$). In contrast, the stabilities of the other crystallizing phases are less redox sensitive. Clinopyroxene is the most common phase next to FeTi-oxides and stable at each temperature with low a_{H_2O} and at $\leq 950^\circ C$ also for $a_{H_2O}=1$. Plagioclase is stable at $a_{H_2O} \leq 0.8$, orthopyroxene at $a_{H_2O} \leq 0.5$. Quartz occurs at low temperature ($\leq 950^\circ C$) and low a_{H_2O} (≤ 0.4). As accessory phase, we observed apatite. Amphibole is expected at lower temperatures and high water activity. The corresponding experiments close to the solidus (down to 830°C), using cold seal pressure vessels (CSPV), are in progress.

Our experimental data will be directly applied to results on natural data from the PAR, obtained by [2], especially on modeling the magmatic evolution of the PAR basaltic-andesitic-dacitic suite and on providing well-suited distribution coefficients between crystallized minerals and melt to be extracted from our phase equilibria experiments. The latter are essential for the exact modeling of differentiation and contamination processes in the axial magma chambers of fast-spreading ridges, since suitable distribution coefficients in relevant, volatile-bearing systems at shallow pressures are not available. For this, it is necessary to increase the size of the experimental phases of the low temperature runs to be measurable by an in-situ trace element method (20 to 30 μm).

Therefore, we applied thermal cycling techniques for coarsening of crystals and melt pools [3] in combination with the diamond trap technique [4] for the first time for a hydrous andesitic system. In a systematic study, we tested the different parameter of thermal cycling (peak amplitude, wave period, total duration) to improve the technique with the result, that sizes of clinopyroxene crystals increased ~ 5 times and sizes for plagioclase crystals even ~ 10 times in comparison to static experiments. Moreover, most of the tiniest crystals residing in the matrix in static experiments have been dissolved and melt pools have been enlarged up to 10 μm in diameter. Due to the dissolution of the tiniest crystals, the diamond trap technique can be used to separate the melt from the crystals, since the potential for tiniest minerals to escape into the pores of the trap is minimized. Now, only the pure melt is separated and application of in-situ trace element analyses is possible.

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