

Crystallization experiments in rhyolitic systems: The effect of temperature cycling and starting material on crystal size distribution

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ABSTRACT

One of the various problems faced in experimental petrology is the fact that most experimental products obtained by crystallization experiments are too small, making their accurate identification by electron microprobe and laser ablation analyses very difficult. This problem is magnified when a highly polymerized starting material is used for experiments at low temperature (e.g., 700–800 °C). In this study, we present the results of crystallization experiments performed using a rhyolitic starting glass in which we test the potential of temperature cycling and pre-hydrated starting material to increase crystal size and discuss the effect of those variables on the attainment of chemical equilibrium. Experiments were performed at different temperatures (725 to 815 °C) and pressures (1 and 2 kbar), under water-saturated conditions ($a_{\text{H}_2\text{O}} = 1$; with $a_{\text{H}_2\text{O}}$ being the water activity). During the experiments, temperature was either constant or cycled to ± 15 °C around the target temperature during the first half of the runs. We used either a pre-hydrated (7 wt% H₂O) rhyolitic glass or a dry rhyolitic glass to which 7 wt% H₂O was added during capsule preparation.

Our results differ between 1 and 2 kbar experiments. At 1 kbar, plagioclase and orthopyroxene were the main crystalline phases affected and temperature cycling (± 15 °C) did not increase the crystal size of these phases. In contrast, if only the nature of the starting material is considered (dry glass vs. pre-hydrated), the use of a pre-hydrated starting material successfully increased the overall crystal size and decreased the crystal number density. At 2 kbar, plagioclase and amphibole were the main phases and the largest crystals were also obtained when pre-hydrated starting material was used. Contrary to experiments at 1 kbar, temperature cycling also increased the overall crystal size. The different effects of temperature cycling at 1 and 2 kbar are attributed (1) to the different cation diffusivities at 1 and 2 kbar caused by different melt water concentrations and (2) the negligible effect of temperature cycling at 1 kbar (± 15 °C) is explained by little dissolution of phases, so that small crystals were already too large to be completely consumed by the dissolution process in the high temperature interval. The results demonstrate that temperature oscillation (depending on the amplitude) and the nature of the starting material (pre-hydrated vs. dry glass + water) are two parameters that can contribute to increase crystal sizes in experiments with rhyolitic melts. However, we also observed that the use of a pre-hydrated starting material increased the occurrence of zoned plagioclase crystals, which may indicate that chemical equilibrium was not perfectly reached.

Keywords: Crystallization experiment, temperature cycling, crystal size distribution, rhyolite