Plagioclase crystallization kinetics in basalts by high-T viscosity measurements

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In this study we explore the effect of undercooling and stirring on the crystallization kinetics of remelted basaltic material from Stromboli (pumice from the 15th March 2007 paroxysmal eruption) and Etna (1992 lava flow). Isothermal crystallization experiments were conducted at different degrees of undercooling and different applied strain rate (T=1157-1187 °C and strain rate = 4.26 s⁻¹ for Stromboli; T=1131-1182 °C and strain rate = 0.53 s⁻¹ for Etna). Melt viscosity increased due to decreasing temperature and increasing crystal content and achieved a steady value after 10^4 - 10^5 s. The mineralogical assemblage comprises sp + plg (dominant) ± cpx with an overall crystal fraction between 0.06 and 0.27, increasing with undercooling and flow.

Both degree of undercooling and deformation rate deeply affect the kinetic of the crystallization process. Plagioclase nucleation incubation time strongly decreases with increasing ΔT and flow. Plagioclase growth rates G display relative small variation with Stromboli samples (high strain rate) showing higher values (G=10^{-7.7} m s⁻¹) compared to G values from Etna samples (low strain rate; G=10^{-8.5} m s⁻¹).

G values obtained in this study are generally one or two order of magnitude higher compared to those obtained in literature for equivalent undercooling conditions. Stirring of the melt, simulating flow or convective conditions, facilitates nucleation and growth of crystals via mechanical transportation of matter, resulting in the growth rates observed. Any modeling pertaining to magma dynamics in the conduit (e.g. ascent rate) and lava flow emplacement (e.g flow rate, pahoehoe - 'a'a transition) should therefore take the effects of dynamic cristallization into account.

Fast hydration of volcanic glass at low temperatures

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During volcanic eruptions, magma loses most of its volatiles and cools below the glass transition temperature. However, natural volcanic glass is often oversaturated in water. The water often is distributed inhomogeneously and local increases can be observed around textural features such as bubbles, crystals and cracks. The origin of these heterogeneities can either be redistribution of magmatic water or dissolution of meteoric water. However, the processes of dissolution of water in a solid glass and in a silicate melt at elevated temperatures vary significantly and the quantities, timescales and speciation of water dissolution and diffusion remain poorly constrained.

We present preliminary results of water measurements on naturally hydrated volcanic glass and experimentally hydrated silicate glasses. Water heterogeneities in natural, volcanic rhyolitic glass around cracks, bubbles and spherulitic crystals as well as flow banding show increases of up to ~0.2 wt. % above the general water concentrations of ~0.045 to 0.1 wt. %. Textural and numerical proxies based on bulk water diffusion indicate timescales of hydration from hours to months. We propose to adapt these models to consider water speciation and variation with temperature.

To estimate timescales and quantities of hydration, we rapidly hydrated natural and synthetic (Fe-free) glass in a water vapor saturated Argon atmosphere at temperatures below the glass transition while recording enthalpy and gravimetric changes in a simultaneous thermal analysis. Preliminary data shows that a weight gain of 0.15 wt. % in hydration can be reached over 10 h at 400°C.

We evaluate the possibility for glass to physically intrude nanopores and chemically diffuse into the structure. Therefore common models of water dissolution, speciation, and distribution in silicate glasses need to be revised for low temperatures and further experimental and analytical work is needed to create reliable quantitative models.