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Cristobalite formation in synthetic and volcanic glasses: Insights from hydrothermal experiments and textural characterisation

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Cristobalite is ubiquitous in volcanic systems, and yet often occurs outside its stability field and commonly hosts Al, Na, K substitutions in its crystal structure. Cristobalite may form by (i) vapour-phase deposition (from a Si-saturated vapour transported locally or distally) and/or (ii) devitrification (local crystallisation within glassy groundmass). We combine hydrothermal vapour-glass interaction experiments with solution chemistry and microtextural characterisation to constrain when systems favour glass dissolution versus silica deposition, and to develop compositional criteria for distinguishing mechanisms of cristobalite formation.

We reacted simplified synthetic glasses (80 wt.% SiO_2, 13 wt.% Al_2O_3; variable Na:K) and a natural rhyolitic glass (SiO_2 76.0 wt%, Al_2O_3 13.0, Na_2O 4.0, K_2O 4.8; Fe_2O_3 0.83, CaO 0.65; others ≤0.15; LOI 0.28; total 99.87) n closed batch vessels where glass powder was suspended above aqueous solutions—representing pure water, acidic (0.1 M HCl) and alkaline (0.1 NaOH) environments—enabling interaction with a vapour phase at high temperature. Experiments were run for up to 22 weeks at 200 °C (17 bar) and 300 °C (87 bar). Dissolved Si and alkalis were monitored by ICP-OES; solids were characterised by SEM, EMPA, and Raman spectroscopy.

At 200 °C, solution chemistry indicates progressive glass dissolution with silica and alkali mobilisation through time in all systems. By 11 weeks, SEM revealed etch pits on glass grains and the appearance of Si and Al - rich nanoscale crystallites on altered glass surfaces. In experiments at 300 °C with H_2O vapour, pervasive vapour-phase deposition occurs with opal, cristobalite, quartz and nepheline precipitation on vessel walls. Ongoing work is extending this framework to acidic and alkaline vapours to quantify pH control on silica transport, dissolution and precipitation kinetics, and the assessment of Al - Na - K impurity signatures as possible discriminators for cristobalite formation mechanisms in natural volcanic settings.

These experiments represent the low-temperature and low-pressure boundary of alteration within the very upper volcanic edifice and constrain the minimum conditions under which cristobalite can form as a secondary mineral in these systems.