Thermal migration of AGV-1: implications for granitoid genesis and diversity in igneous rocks

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The processes producing granites and upper continental crust remain somewhat ambiguous. Our laboratory study of thermal migration [1] of andesite at pressure (0.5 GPa) suggests an alternative to emplacement of silicic magmas. AGV-1 with 4 wt.% H_2O was placed in a temperature gradient of the piston cylinder from 950°C in the hotspot down to ~380°C (based on a 2nd double thermocouple run) at the base of the piston for 66 days. The 2 cm long double capsule assembly (inner AuPd/outer Pt capsule) fully retained water during the run. We analyzed the charge by SEM, SIMS and MC-ICP-MS.

Visually, the material in the capsule has clearly chemically differentiated, producing a lighter colored polycrystalline mass at the cold end (bottom third) and a homogeneous dark glass at the hot end (top quarter) with a mineral-melt mush in between. Bulk major element contents smoothly change down temperature with a granite-like composition (70 wt% SiO_2, 12 wt% Al_2O_3, 5 wt. % K_2O and 2 wt. % Na_2O) at the bottom of the experiment. MgO, CaO and FeO reach maxima in the crystal mush middle portion of the experiment, reflecting the mineral modes (ap, mgt, amph, plag) appearing at distinct horizons (temperatures) in the capsule. The bottom third consists of a fine-grained mineral aggregate (qtz-kspar-plag-amph-bio) with no visible melt or fluid. Trace element contents also follow mineralogy: e.g., Rb increases with biotite mode and Zr-Hf-U spikes directly reflect observed zircons. The changes in composition reflect the thermal migration process with chemical transport reflecting diffusion through melt/supercritical fluid driven by chemical activity variations. Lastly, $\delta^{56/54}Fe_{IRMM}$ (by double spike MC-ICP-MS) of the hot melt is ~1.5‰ lighter than crystallized parts of the experiment.

Recent work shows 1) granitoid bodies cool on Myr timescales [2]; 2) diffusivities through supercritical H_2O are high [3]. We therefore speculate that some granitoid bodies reflect differentiation of the andesitic volcanic pile by thermal migration due to underplating of hot magmas. This hypothesis is consistent with observed changes in igneous rock's $\delta^{56/54}Fe$ with extent of differentiation [4].

References

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