American Mineralogist, Volume 108, pages 2105–2120, 2023

An experimental crystallization of the Macusani obsidian in a thermal gradient with applications to lithium-rich granitic pegmatites

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Abstract

Drilled cores of Macusani green obsidian pebbles from Peru were hydrated and melted above their liquidus temperatures at 200 MPa to a single column ~4 cm in length and then undercooled in a thermal gradient >150 °C along the length of the cores. Despite thousands of hours at subliquidus temperatures, the crystallinity of the products ranged from ~30 to ~5 vol%. Mineral assemblages varied along the length of the cores but not in relation to the thermal gradients in all cases. Oscillations in the abundances of plagioclase, K-feldspar, and quartz were observed across the crystallization fronts and along the lengths of the cores. The originally homogeneous melts became heterogeneous in response to crystallization and to thermal gradients. Chemical gradients in the glasses included sharp boundary layer pile-up of F and B adjacent to the crystallization fronts, as well as linear gradients among several of the elements spanning the entire lengths of the melt columns. Values of molar K/(K+Na) in the glasses, plotted as K*, varied positively with Si, inversely with Al and F, and positively with the domains of K-feldspar that formed at maximum distance from the plagioclase-rich regions. Overall, the results are marked by sharply bounded textural domains, by the spatial segregation of mineral assemblages, by oscillations in mineral assemblages at multiple scales, and by monomineralic crystal aggregates that are hallmarks of pegmatite bodies. Temperatures recorded by feldspars closely approached the actual temperature gradient down to ~500 °C, and the solvus on the alkali feldspar join has been delineated for the first time by the simultaneous crystallization of feldspars from an undercooled melt.

Keywords: Experimental petrology, granite, pegmatite, feldspar, thermometry