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The curious case of the Mt. Mica pegmatite: experimental and theoretical quartz and feldspar nucleation delay in a common peraluminous pegmatite

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Peraluminous pegmatites are common in nature and are mainly composed of sodic plagioclase, K-feldspar, and quartz. It was therefore surprising when crystallization experiments performed on a peraluminous granite composition (Mt. Mica pegmatite composition from Maine, USA with ASI = 1.45) were unable to nucleate quartz and feldspar. Crystallization experiments were performed in a piston cylinder apparatus at 630 MPa by first melting a glass powder (made from the rock) with 4.5 wt% H_2O at 1100 °C for 24 h then cooling to temperatures between 700 and 1000 °C and holding the samples at those conditions for 5 to 211 hours. Experimental run products were investigated by SEM microscopy, with EDS analyses of crystalline and quenched liquid phases, and compared to a theoretical nucleation delay model based on classical nucleation theory (CNT) equations from Fokin et al. (2006, [1]). These crystallization experiments failed to produce quartz and feldspar despite the experiment conditions being well within the stability field of these minerals as shown by melting experiments on the natural rock powder, as predicted by MELTS and by the CNT model. These results contrast with those of Rusiecka et al. (2020, [2]) who performed experiments on a metaluminous granitic composition (Lake County obsidian composition from Oregon, USA with ASI = 0.96) where quartz and plagioclase nucleated within 24 hours at similar undercoolings to those used here. The nucleation delays for peraluminous melts therefore appear to be longer than for metaluminous melts. We attribute these differences in timescales to the difference in composition, namely, the presence of a higher concentration of aluminum and lower concentration of potassium in the Mt. Mica pegmatite compared to the Lake County obsidian.

[1] Fokin, V.M., Zanotto, E.D., Yuritsyn, N.S., and Schmelzer, J.W. (2006) Homogeneous crystal nucleation in silicate glasses: A 40 years perspective. Journal of Non-Crystalline Solids, 352, 2681–2714.

[2] Rusiecka MK, Bilodeau M, Baker DR (2020) Quantification of nucleation delay in magmatic systems: Experimental and theoretical approach. Contributions to Mineralogy and Petrology.