Growth of giant magmatic crystals: Insights from experiments

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Giant crystals[1] in internally-zoned granitic pegmatites can exceed 10 m in length (e.g., spodumene, Black Hills, USA) and may hold clues about unique mechanisms of self-assembly of condensed matter. The self-scaling of crystal sizes in undercooled pegmatite liquids with "the size of the container" has been previously postulated[2]. However, 1) the relation between crystal-growth rates and the width of the available liquid and 2) the variation of growth rates with time have not been investigated systematically. We simulated pegmatite texture in crystallization runs in diamond-anvil cell (DAC) experiments with variable sample diameter for H_2O-undersaturated Li-B haplogranitic melt undercooled by 100-200 °C below its liquidus at ~2-4 kbars.

We used time-lapse photography to quantify the growth of unobstructed crystals with lengths reaching a fraction $X \geq 0.1$ of the diameter of the DAC. Consistently, the largest crystals developed with a constant 3D growth rate, but with a nonlinear (cubic-root) 1D growth rate function of time. The power function $G_{24h}=b \cdot W^a$ that best-fitted 1D growth-rates at 24h after nucleation against the width of the container (W) for DAC runs and published experiments, was extrapolated from the 0.170 – 3 mm scale of experiments to 10^{-2} – 10^2 m scale of igneous bodies. The modelled crystal-growth times for K-feldspar with $X \cong 0.45$ varied from 21 days in a 0.08 m pegmatite vein (Praia da Gelfa, Portugal) to ~45 years in a 17 m thick dike (Evje-Iveland, Norway). These growth times are similar, although generally longer, than melt-longevity estimates from conductive-cooling computations. However, our modelled growth times are 1-2 orders of magnitude shorter and more realistic than growth times calculated applying the same experimental growth rates to natural pegmatites. The self-scaling of growth rates to the size of the available space in undercooled systems such as pegmatites implies a commensurate scaling of 3D fluxes.

[1] Jahns, R.H. (1953) *Am Mineral* **38**, 563-598
[2] London, D. (2008) *Can Mineral Spec Pub* **10**