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An argument for compositional crystal size distributions

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Crystal size distribution (CSD) measurements have long been used to quantify the crystal content of igneous samples and, by extension, the crystal residence time in magmatic systems. In the simplest systems, crystals nucleate and grow continuously and resulting CSDs produce log linear distributions that can be used to determine the dominant crystal size and total crystal number. Most magmatic systems are not simple, however, and most measured CSDs are not linear. Instead CSDs are commonly curved, with steep linear segments denoting the smallest (groundmass) crystals and flatter linear-to-curved segments recording the larger crystal population. Several explanations have been given for this pattern. There is growing evidence, however, that many crystals are inherited from other parts of the magmatic system (antecrysts); for this reason, measured CSDs are commonly interpreted by fitting the curve with two separate linear trends that, in turn, are used to infer conditions of both pre-eruptive (antecrysts) and syn-eruptive (groundmass) magma storage. There is a problem with this interpretation, however, as many antecrysts have overgrown rims that reflect growth from the transporting melt, growth that was probably synchronous with formation of the groundmass population. Moreover, the rims can contribute substantially to the overall volume of the inherited crystals. From this perspective, the CSD segment representing the large crystal population cannot be interpreted as a single crystallization event, but instead records the combined size of inherited core and overgrown rim. At the same time, both the magnitude and the kinetics of the crystallization event that caused the groundmass crystallization are underestimated when the rims of the large crystals are not included as part of this late-stage event. Here we use examples from both crystallization experiments and natural samples to illustrate the effects of rim growth on CSD form and interpretation. In the case of plagioclase, in particular, we demonstrate that these composition-based CSDs are easily constructed from commonly obtained backscattered electron (BSE) images. More sophisticated composition-based CSD analysis is possible from xray maps (e.g. QEMSEM images).