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How do granites solidify? Information from quantitative textural studies using cathodoluminescence and other techniques

Michael Higgins
Sciences Appliquées, Université du Québec à Chicoutimi, Chicoutimi, Canada (mhiggins@uqac.ca)

The qualitative and quantitative study of granitic textures (microstructures) has been somewhat neglected, as compared to mafic rocks. Certainly some granite samples are not readily susceptible to textural analysis, particularly if they are altered, but many acidic rocks can be examined in the same way as mafic rocks, using the same techniques. The earliest studies were of K-feldspar megacrysts in granitoids, a component that can be easily quantified by direct measurement in the field and image analysis of stained slabs. However, analysis of thin sections requires other techniques. Although the main components of granites, plagioclase, K-feldspar and quartz, can be readily distinguished in thin section by experienced petrographers, they cannot be quantified readily from optical images using automatic or semi-automatic image analysis methods. An alternative approach is to use cold-cathode cathodoluminescence (CL). This microscope-based method easily distinguishes these three phases and can also identify alteration. Minor colour differences and zonation in CL can sometimes reveal the presence of different crystal populations. Apatite, zircon and other minor phases are also imaged, but all silicate minerals that contain iron do not luminesce. A combination of CL and unpolarised light can be used to classify a thin section into almost all significant phases. In these phase maps adjoining crystals of the same phase are amalgamated. Segmenting the phase maps into crystal maps requires the addition of a cross-polarised image and manual crystal tracing, but provides much richer data.
CL images of unaltered granites can reveal a wealth of different textures which will be illustrated with granitoid samples from the Illapel Plutonic suite, Chile and elsewhere. The overall goal is to understand the solidification process. CL was used to select the least altered samples and a mosaic of about half a thin section was produced for each sample. Plagioclase is always the earliest phase and commonly forms a network of euhedral crystals. Despite the apparent simplicity CL shows that there may be different populations of crystals. Quartz can be sub-euhedral or interstitial and there is considerable variation in the clustering of the crystals. The greatest textural variation is shown by K-feldspar. In all these samples it is interstitial, but can be distributed evenly, in clusters of crystals or as oikocrysts. In some cases the phase appears to spread out along grain boundaries and may pseudomorph the last liquid. CL images show that apatite, and perhaps zircon, are closely associated with amphibole. The same behaviour has been seen in dacite lavas, but at the moment there is no obvious explanation for this.