Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20113

Segmentation of zoned plagioclase to assess similarities and differences in the magmatic environment feeding eruptions through time at an oceanic arc volcano.

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In oceanic arcs, such as the Lesser Antilles in the Eastern Caribbean, the fractionation of magmatic melts is strongly influenced by the crystallisation of plagioclase throughout the crustal column. Consequently, the chemical-textural information recorded by zoned plagioclase offers an opportunity to understand the environments in which the melts feeding volcanic eruptions are generated. To accurately capture the textural variability within individual samples we have designed an image-segmentation approach using 2-dimensional geochemical maps of thin sections. This approach is fundamentally based on the principle of superpixels, such that crystals are classified into spatially coherent zones. The algorithm has been designed to account for complexities associated with geochemical variability that may not reflect discrete changes in state, but rather continuous changes associated with growth and diffusion processes at the crystal boundary. The method is largely unsupervised, meaning that convergence of the segmentation algorithm is defined by minimising entropy and that the number of zones in each crystal is not estimated a priori. The result is a chemical map in which the zoning of individual plagioclase crystals is texturally segmented, retaining the spatial information from the sample. We apply this method to three stratigraphic sequences on the volcanic island of St. Kitts in the Eastern Caribbean, which consist of between three and seven eruptive units. For each eruptive unit we segment plagioclase crystals, and then correlate these zones between units based on their chemical-textural fingerprint. The results show that individual stratigraphic sequences are associated with distinguishable crystal textures, but all erupted magmas show some repeatable magmatic processes. By exploring how zonation varies within and between different eruptive units, we identify the imprint of fundamental chemical processes, and explore how this is influenced by the storage, evolution, and transport pathway of magma through the crust.