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3D zoning of barium in alkali feldspar

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Abstract

Interpretation of chemical zoning within igneous minerals is critical to many petrologic studies. Zoning in minerals, however, is commonly observed in thin sections or grain mounts, which are random 2D slices of a 3D system. Use of these 2D sections to infer 3D geometries requires a set of assumptions, often not directly tested, introduces several issues, and results in partial loss of zoning information. Computed X-ray microtomography (microCT) offers a way to assess 3D zoning in minerals at high resolution. To observe 3D mineral zoning using microCT, however, requires that zoning is observable as differences in X-ray attenuation. Sanidine, with its affinity for Ba in the crystal lattice, can display large, abrupt variations in Ba that are related to various magma reservoir processes. These changes in Ba also significantly change the X-ray attenuation coefficient of sanidine, allowing for discrete mineral zones to be mapped in 3D using microCT. Here we utilize microCT to show 3D chemical zoning within natural sanidines from a suite of volcanic eruptions throughout the geologic record. We also show that changes in microCT grayscale in sanidine are largely controlled by changes in Ba. Starting with 3D mineral reconstructions, we simulate thin-section making by generating random 2D slices across a mineral zone to show that slicing orientation alone can drastically change the apparent width and slope of composition transitions between different zones. Furthermore, we find that chemical zoning in sanidine can commonly occur in more complex geometries than the commonly interpreted concentric zoning patterns. Together, these findings have important implications for methodologies that rely on the interpretation of chemical zoning within minerals and align with previously published numerical models that show how chemical gradient geometries are affected by random sectioning during common sample preparation methods (e.g., thin sections and round mounts).

Keywords: Computed X-ray microtomography, mineral zoning, sanidine, barium