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A novel protocol for resolving feldspar crystals in synchrotron X-ray microtomographic images of crystallized natural magmas and synthetic analogs

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Abstract

X-ray computed microtomography is a non-destructive imaging technique recognized in the geosciences as a powerful tool to investigate rock textures directly in three dimensions (3D) at the micrometer and sub-micrometer scale. The quantitative morphological and textural analysis of images requires segmentation and characterization of phases in the reconstructed volume based upon their gray levels (related to their relative X-ray attenuation) and/or morphological aspects. Often the differences in X-ray attenuation of some phases are so small that no contrast is observed in the reconstructed slices or, although the human eye can discern the differences between these phases, it is difficult, or sometimes impossible, to reliably segment and separately analyze these phases. Facing this challenge, we propose an experimental and computational procedure that allows the segmentation of phases with small density variations in geomaterials. By using an experimental protocol based on phase-contrast synchrotron X-ray microtomography combined with a customized 3D image processing procedure, we successfully segmented feldspar from the glassy matrix in both a natural volcanic sample and a synthetic analog. Our results demonstrate that crystallized natural volcanic rocks and synthetic analogs can be characterized by synchrotron X-ray phase-contrast microtomography and that phase-retrieval processing is an invaluable tool for the reconstruction of 3D multiphase textures.

Keywords: Synchrotron X-ray microtomography, phase-contrast X-ray imaging, phase-retrieval, 3D rock textures, crystallization, feldspars