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Quantifying crystallization and devitrification of rhyolites by means of X-ray diffraction and electron microprobe analysis

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Abstract

Devitrification of silicic volcanic rocks is a relatively common process, resulting in the production of microcrystalline silica and feldspar components. Here we investigate how the products of pervasive devitrification may be characterized using the combined techniques of X-ray powder diffraction, electron microprobe analysis, and X-ray fluorescence analysis to provide a new calibrated approach to calculating the crystallinity and mineral modes in both glassy vitrophyre and devitrified volcanics. Using the integrated areas of the X-ray diffraction peaks associated with both the crystalline and amorphous components, the relative proportions of groundmass crystallites and amorphous material from both glassy and devitrified material can be calculated. A detailed calibration indicates a linear relationship among the ratio of the integrated counts and bulk crystallinity. Mineral proportions are also calculated from X-ray fluorescence measurements of whole-rock and groundmass separates and are well correlated to crystallinities calculated from both X-ray diffraction and electron microprobe image analysis for vitrophyre samples. Devitrification products in a pervasively devitrified sample are tridymite, quartz, sanidine, and a Ca-rich aluminosilicate component. Mineral analysis and X-ray mapping by electron microprobe analysis indicates that the Ca-rich aluminosilicate component appears to be the dominant metastable or amorphous phase in the devitrified sample with proportions calculated from X-ray mapping (~32%) in reasonable agreement with the calculated proportion of amorphous material determined by means of X-ray diffraction (~38%). These results demonstrate the robustness of this combined X-ray diffraction and electron microprobe imagery technique for quantifying and characterizing crystallization in complex samples.

Keywords: Rhyolite, devitrification, X-ray diffraction, electron microprobe analysis, tridymite, crystallinity, feldspar, amorphous