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Significance of tridymite distribution during cooling and vapor-phase alteration of ignimbrites

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Abstract

Thick sequences of silicic ignimbrites contain complex emplacement and cooling histories, often masking contacts between ignimbrite flow packages. Mineralogical and textural variations in these sequences are primarily a function of emplacement temperature and cooling time. Here, we focus on the use of the silica polymorph tridymite to understand the association of vapor-phase crystallization and devitrification within ignimbrite flow packages. As opposed to the common occurrence of cristobalite, the restricted domains in which we observe tridymite may provide more relevant constraints for interpreting post-emplacement devitrification and vapor-phase alteration. This study examines sections through the Whakamaru (New Zealand), Bishop (U.S.A.), and Grey's Landing (U.S.A.) ignimbrites by combining textural observations with measurements of density, groundmass crystallinity, and the distribution and proportion of tridymite to cristobalite. The rheomorphic Grey's Landing ignimbrite represents a high-temperature end-member scenario, with widely distributed tridymite (up to 20%) resulting from a high-magmatic temperature and rapid devitrification in a low-porosity deposit. In the welded Whakamaru and Bishop ignimbrites, metastable tridymite (up to 13%) is concentrated along boundaries between flow packages. Here tridymite is interpreted to crystallize in transient permeable zones, forming during vapor-phase alteration prior to compaction, where upper denser-welded flow materials serve as vapor seals. Our results suggest that tridymite may link the initial cooling and welding history of ignimbrites to vapor-phase alteration and devitrification, and may serve as a potential mineralogical fingerprint of depositional contacts, important for consideration of lateral transport of fluids in geothermal reservoirs.

Keywords: Tridymite, cristobalite, crystallization, devitrification, vapor-phase alteration, Whakamaru ignimbrite, Bishop Tuff, Grey's Landing ignimbrite