

## Intermittent ascent of aphyric andesitic melts revealed by cryptic micro-antecryst textures

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Crystal cargoes transported by arc magmas upon eruption often consist of complexly zoned phenocrysts with diverse histories. While these crystals record the early stage of magma formation and evolution, they are not ideal recorders of ascent processes, which are the keys to useful constraints for adequate volcano monitoring. Conversely, microlites and micro-phenocrysts, frequently associated with decompression-induced degassing or cooling, are relevant recorders of late-stage ascent processes. Our study focusses on the active Tongariro Volcanic Centre (TgVC), located at the southern end of the Taupo Volcanic Zone; an active volcanic complex that has produced a wide range of explosive eruption styles fed by intermediate magmas. Scoriae from these volcanoes contain glassy and nearly-aphyric tephras, carrying microlites of plagioclase and pyroxene (mostly orthopyroxene). Major element analyses, combined with textural information, are used to assess equilibrium between the microlites/micro-phenocrysts and the groundmass glass. Chemical disequilibrium of some plagioclase and pyroxene crystals with the surrounding glass is common in most tephras. To investigate this further, we mapped plagioclase and pyroxene phenocrysts, micro-phenocrysts and microlites at submicron resolution for major and trace element distributions via chemical mapping and SIMS-SCAPS imaging. From a total of 105 images, six plagioclase textural patterns are noted: resorption and overgrowth, oscillatory zoning, single compositional jump, sieve textures, fractures, and strontium zonation; while in pyroxene microlites the following textures are found: resorption and overgrowth, calcium-rich rims, magnesian core and calcic rims, fractures, and aluminium zonation. Microlite textures are observed down to  $<30 \mu\text{m}$  in most tephras from TgVC, and interpreted in the context of an interplay of magmatic processes involving multiple events of magma recharge/mixing, pressure fluctuations, fracturing, and rapid cooling and crystal growth. Since TgVC is located in an extensional tectonic setting, we envision a vertically oriented magma plumbing system, where short-lived and nearly-aphyric magma pulses accommodate crustal extension through dyking. Explosive eruptions occur when a hot magma batch fractures through previous intrusions, recycling a variety of small crystals grown under diverse physico-chemical conditions and stored in rapidly cooled, previously intruded dykes. Thus, textures cryptic to conventional imaging indicate that a significant proportion of the microlitic and micro-phenocrystic mineral cargo is of antecrystic origin (i.e. hence referred as “micro-antecrysts”) and cannot be attributed to late-stage nucleation and growth at the onset of volcanic eruptions.

Keywords: microlites, micro-phenocrysts, zonations, Tongariro Volcanic Centre, magma ascent

Some textures and zonations observed in plagioclase microlites, micro-phenocrysts and phenocrysts of the Tongariro Volcanic Centre andesitic tephras: (a) sieve textures resulting from rapid decompression; (b) fracture (and overgrowth) triggered by entrainment of crystals from a crystal-mush-like environment; (c) strontium zonation associated with a negative correlation with An suggesting recycling of old crystals. Ca, Si, Sr, Na, BSE and An respectively stand for calcium, silica, strontium, sodium, back-scattered electron and

	TEXTURE	DESCRIPTION	INTERPRETATION
(a) Sieve textures		<ul style="list-style-type: none"> <li>• Within resorbed cores but also appears as a continuous layer between two stages of growth</li> <li>• Observed in phenocrysts only</li> </ul>	
(b) Fracture (and overgrowth)		<ul style="list-style-type: none"> <li>• Fractures are preferential along the cleavages</li> <li>• Overgrowth occurs after fracturing, different from late-stage fracturing processes such as fragmentation, sampling or sample preparation</li> <li>• Cryptic in BSE image</li> <li>• Observed in microlites and microphe-nocrysts</li> </ul>	
(c) Strontium zonation		<ul style="list-style-type: none"> <li>• Sr is enriched where Ca is depleted</li> <li>• Negative correlation of Sr and An profiles</li> <li>• Observed in micro-phenocrysts and phenocrysts</li> </ul>	