Interpretation of granophyre mineral texture from rocks exhumed from volcanic eruptions, TVZ, New Zealand

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The Taupō Volcanic Zone (TVZ), is an active volcanic region in the North Island of New Zealand caused by rifting and subduction between the Pacific and the Australian plate (Wilson et al. 1995). This study focuses on granitic rock samples found within the Ohakuri ignimbrite (a pyroclastic flow deposit) from an explosive eruption 240,000 years ago (Gravley et al. 2016). Based on research I conducted with colleagues at the University of Canterbury, Christchurch, New Zealand, the samples are believed to be magma mush, a portion of the magma chamber that is in a semi-solid state.

Four of the samples contained a texture called granophyric intergrowth. Granophyre is defined as "fine-grained intergrowths, ranging from submicroscopic to millimeter scale, of quartz and alkali feldspar" (Barker, 1970). My summer research focuses on understanding the thermodynamic conditions that caused the intergrowth to form. The research questions I aimed to answer were: How and why does the granophyre vary within samples? How does the chemical composition of the granophyre vary? What were the pressure and temperature conditions during granophyre formation? In order to answer these questions I used a petrographic optical microscope, and a Scanning Electron Microscope where I collected Backscatter Electron (BSE) images and compositional data using Energy Dispersive X-Ray Spectrometry (EDS).

Granophyre is an intriguing texture under the optical microscope (Fig. 1A). Several extinction domains can be observed, where the minerals are in optical continuity with the phenocryst (larger crystal) they nucleated from. Chemical composition data revealed the intergrowth is composed of SiO_2 (quartz) and $(K,Na)AlSi_3O_8$ (alkali feldspar) where the K and Na proportions are on average 50-50. However, some areas revealed stains with high Na contents (Fig. 1B).

Granophyric intergrowth forms due to the degree of undercooling (ΔT), he degree to which the cooling of a melt falls below the true crystallization temperature of a mineral (Winter, 2010) Because the intergrowths begin coarse and fine with distance from nucleation points, the degree of undercooling must have increased with time. Additionally, granophyric intergrowths form when the melt composition is near the melting minimum in the Albite-Orthoclase-Quartz ($NaAlSiO_3O_8$-$KAlSiO_3O_8$-SiO_2) ternary phase system (Smith, 1974). Although Na-rich spots were observed, their irregularity suggests they are diffusion stains occurring after the granophyre formed, and not a third phase in the intergrowth. Therefore, the granophyre formed below the cotectic line between the quartz and alkali feldspar where the alkali feldspar is in a state of solid solution (a single phase forms, not two separate feldspar phases). This occurs in either a dry system (no H_2O) or in a wet system (H_2O in the melt) but at low pressures (Philpotts, 1990). Because the rocks contain biotite, a mineral that requires H_2O to form, I interpret that the granophyre formed in a wet low-pressure system, where the undercooling rate increased with time. These interpretations are in line with the fact that the rocks are plutonic (formed within the earth) and erupted violently (they were found in a pyroclastic flow deposit) experiencing rapid and dramatic changes in temperature and pressure.

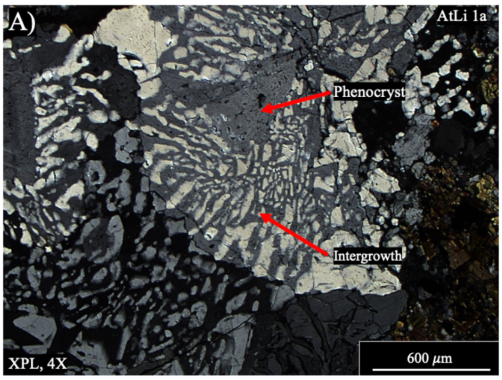

Fig.1A: Photo of different granophyric intergrowth extinction domains under an optical microscope

Fig. 1B: Photo of a SEM-EDS compositional map showing K, Si and Na contents. Pink areas are quartz, yellow areas are alkali feldspar, and orange areas are Na-rich stains.

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