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Constraining Andesitic Magma Storage and Evolution at White Island (Whakaari) Volcano, New Zealand: Insights from Experimental and Rhyolite-MELTS Modelling Results

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White Island (Whakaari) is a juvenile andesite-dacite stratovolcano 48 km offshore of the North Island of New Zealand. It is a highly active and hazardous volcano with lively hydrothermal activities for more than 10,000 years (Hedenquist et al., 1993). Combined with petrology, mineralogy, and melt inclusion geochemistry from 1977-2000 Strombolian ejecta, it has been suggested that a transcrustal pluming magmatic system existed between 2 and 9 kilometres below the surface (Cole et al., 2000; Kilgour et al., 2021; Mandon et al., 2021). However, the magma evolutionary history of the 1977-2000 eruption remains unclear.

This study employed both experimental and thermodynamic modelling approaches to constrain the magma evolution. Preliminary piston-cylinder experiments were run between 1200°C to 1000°C with addition of 2 and 10 wt.% H_2O at 5 kbar (500 MPa) without buffering fO_2. The starting materials are fine-grained rock powders and quenched glass powders of the most primitive bulk rock (P41600). The drier runs successfully reproduced the natural mineral assemblages (melt + olivine + two pyroxene + plagioclase), whereas the wetter cases cannot (melt + olivine + two pyroxene + amphibole + magnetite). However, the path of the liquid line of descent (LLD) poorly fits the natural trend defined by matrix glass compositions. Thermodynamic modelling based on Rhyolite-MELTS and Magma Chamber Simulator was also carried out to estimate the conditions under lower pressure, different water content and oxygen fugacity and distinct magmatic processes including fractional crystallization (FC), equilibrium crystallization (EC), assimilation-FC (AFC), and recharge-AFC (RAFC). It appears that White Island dacites are likely generated by basaltic andesite through an AFC or RAFC process at relatively low pressure (≤ 2 kbar) with low water content (≤ 2 wt.%) (Fig. 1). Wall-rock assimilation is also important to reconcile Pb-Nd-Sr isotopic composition of White Island andesites and dacites (Fig. 2). However, the scattered melt inclusion compositions may be indicative of varying degrees of magma-mush interaction in the mid-crust magma chamber. The next step is to run experiments at lower pressure to verify the modelling results.