

Volatile contents of historical eruptions at Mt. Ruapehu, New Zealand

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Introduction

Mt. Ruapehu is a large, andesite stratovolcano located at the southern end of the Taupo Volcanic Zone (TVZ), North Island, New Zealand. Eruptions are common, with short repose periods (months to years) making Ruapehu one of the most active volcanoes in New Zealand. Most of the eruptions recorded since 1945 involved very small volumes of magma ($\ll 0.1 \text{ km}^3$) and the warning period before each eruption was short; in some cases as little as 9 min [1].

We used the volatile contents (H_2O , CO_2 , F, Li, B, Be, Cl) from both melt inclusions and groundmass glasses to determine the magma storage conditions and degassing history at Ruapehu from scoria erupted in 1945, 1969, 1971, 1977, 1995, and 1996. These samples allowed us to investigate whether the magmatic system has changed over a fifty year period. These are the first volatile data obtained from Ruapehu or from any other andesite in the TVZ.

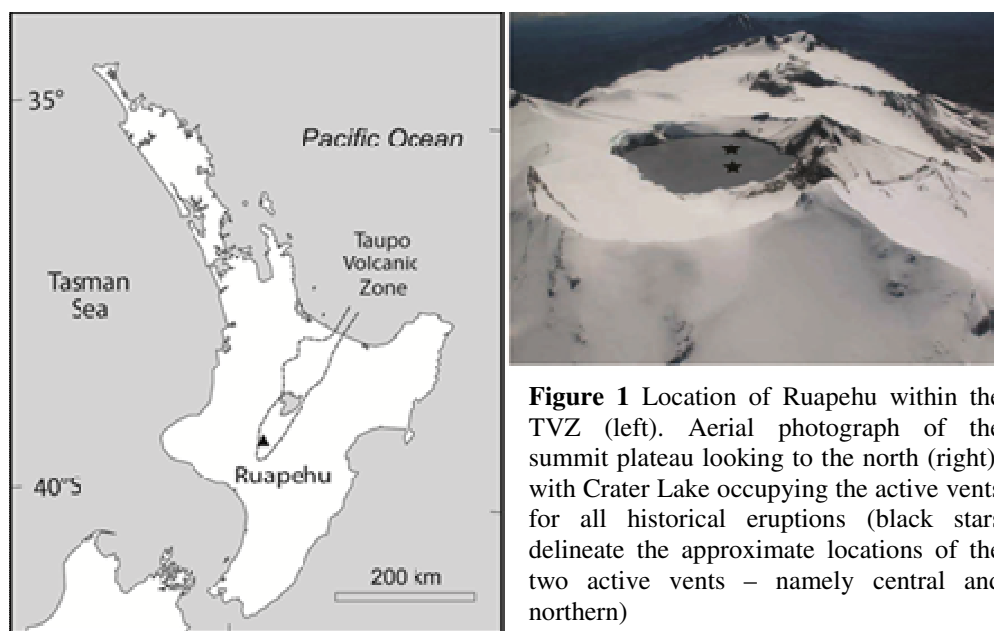


Figure 1 Location of Ruapehu within the TVZ (left). Aerial photograph of the summit plateau looking to the north (right), with Crater Lake occupying the active vents for all historical eruptions (black stars delineate the approximate locations of the two active vents – namely central and northern)

Methods

We prepared crystal separate thin sections of the historical scoria for SIMS analysis, which minimized the carbon background from excess epoxy. We followed the procedure of [2], by analysing glass standards with known H_2O and CO_2 contents, and by building working curves of $^1\text{H}/^{30}\text{Si}$ vs. H_2O and $^{12}\text{C}/^{30}\text{Si}$ vs. CO_2 . A total of nine glass standards were run, covering a range of 0.15–4.1 wt % H_2O and 0–2860 ppm CO_2 . Standards were run at three periods during each day to account for any drift in the analyses. EPMA on the melt inclusions was completed after SIMS, for major element chemistry.

Results

A total of ~ 130 analyses (melt inclusion and groundmass glass) were completed over two separate weeks on the SIMS. Melt inclusions in orthopyroxene, clinopyroxene and plagioclase were analysed. Ruapehu melt inclusions are relatively H_2O -poor and CO_2 -rich compared to andesites and dacites in other arc settings [3]. Melt inclusions contain ~ 1.5 wt % H_2O and between 30 and 1000 ppm CO_2 , with no discernible differences between eruptions. Of the other elements analysed in the melt

inclusions, F (up to 2000 ppm) and Cl (up to 1300 ppm) are marginally higher than other arc andesites. A maximum pressure of ~2 kb is calculated using [4], equating to ~6 km depth. This agrees well with magnetotelluric [5] and seismic tomography [6] surveys, which both show a low resistivity anomaly and low velocity zone from ~6 to ~10 km depth, marginally east of Crater Lake.

In combination with the SIMS data, major element chemistry of groundmass glasses show distinct clusters in most binary chemistry plots. Although some overlap exists, each eruption was possibly fed by a distinct magma batch. For the melt inclusions, a significant proportion of the inclusions appear to be distinct from the groundmass glass. This suggests that some of the inclusions and therefore phenocrysts are antecrysts.

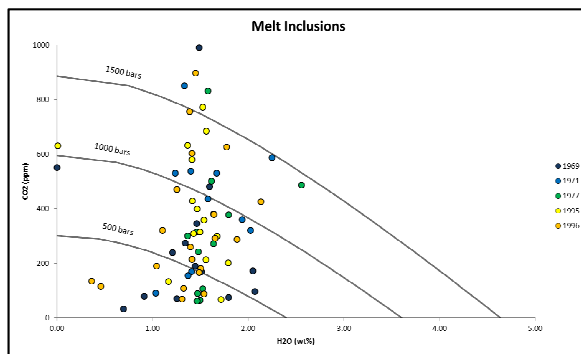


Figure 2 H₂O vs CO₂ contents of clinopyroxene-hosted melt inclusions from a range of eruptions at Ruapehu. Isobars are drawn using [4] based on a magmatic temperature of 950 °C and 1.5 wt % H₂O.

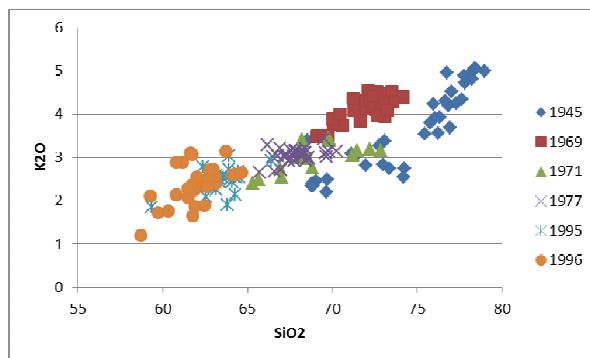
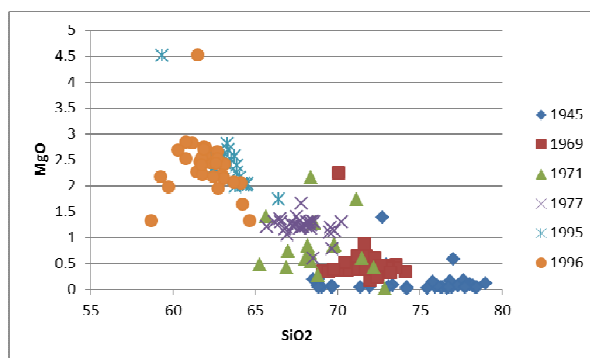


Figure 3 Major element chemistry plots of the groundmass glass from Ruapehu scoria. Note the distinction between each eruption. This implies that a separate magma fed each event.



Discussion

Historical eruptions at Ruapehu were fed by distinct magma batches that had occupied a similar depth range. This suggests that a series of sills existed (and still exist) at ~6 to 10 km depth, which would account for the geophysical anomalies at this depth. These separate and small volume magmas interacted with crystal mush zone/s at depth, periodically entraining foreign crystals into the ascending magma. The small magma volumes that are often erupted at Ruapehu provide a very sensitive record of magma mixing and crystal mush interaction that may otherwise be masked in larger magmas. These data will significantly aid in producing a realistic magmatic-hydrothermal system model for the volcano

References

- [1] G.N. Kilgour et al. (2010) *Journal of Volcanology and Geothermal Research* **191**, 1-14
- [2] J. Blundy and K. Cashman (2008) *Reviews in Mineralogy and Geochemistry* **69**, 179-239
- [3] P. Wallace (2005) *Journal of Volcanology and Geothermal Research* **140**, 217-240
- [4] S. Newman, J.B. Lowenstern (2002) *Computers and Geoscience* **28**,597-604
- [5] M.R. Ingham et al. (2009) *Geophysical Journal International* **179**, 887-904
- [6] D.P. Rowlands et al. (2005) *Geophysical Journal International* **163**, 1180–1194