Magmatic evolution of High-Mg andesites and dacites at Ruapehu Volcano, New Zealand

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Abstract:

Ruapehu is a frequently active andesite-dacite stratovolcano located at the southern end of the Taupo Volcanic Zone (TVZ) in New Zealand. Samples from high-magnesian andesites and dacite (HMAD) lava flows erupted during the period from 48–36 ka (1) have been collected to define and quantify the types and timescales of processes that triggered these unusual volcanic eruptions. We present petrological data and mineral diffusion timescales for these samples to provide a case study of the sequence of events involved in the assembly and eruption of magma at continental arc stratovolcanoes. The samples are classified as HMAD based on the values of their whole-rock SiO_2 content (56.8–65.0 wt. %) and Mg#, which ranges from 60–69 (andesites) and 53–57 (dacites). The lavas form linear trends on bivariate whole-rock major and trace element plots that are distinctly elevated for MgO, Ni and Cr compared with all other lavas erupted throughout the >200 ka lifetime of Ruapehu and most other calk-alkaline andesites of the TVZ.

Various disequilibrium features and the magnesian whole-rock geochemical characteristics of the Ruapehu HMAD lavas are attributed to the influx of relatively primitive magma that entrained ultramafic xenocrysts into magma storage/mush zones of bulk dacitic composition. The magma mixing process is clearly recorded by a population of reverse-zoned clinopyroxene and orthopyroxene within the crystal cargo of these lavas. Fe-Mg inter-diffusion timescales for reverse-zoned orthopyroxenes were constrained by crystal geochemistry and orientation data collected by EPMA and EBSD. The results reveal that effusion of lavas occurred 1 day to 3 weeks after magma mixing events (80% of calculated timescales are less than 10 days), and thus indicate that mafic recharge acted as an eruption triggering process. Ruapehu HMAD lavas are important samples of high-MgO magmas collected from the global subduction zone system that were formed by crustal level magma hybridization processes rather than directly by mantle melting processes.