"Hot Zone" development beneath a long-lived andesite stratovolcano: Temporal evolution of the Mt. Taranaki (New Zealand) magmatic system

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Mt. Taranaki (Egmont Volcano) in the western North Island of New Zealand is a high-K andesite volcano with an eruptive history extending over more than 200,000 years. Past petrological research has concentrated mainly on the post-10 ka record of the modern edifice due to poor stratigraphic control of the older deposits. The earlier history is recorded in 14 major pre-7 ka debris-avalanche deposits, which formed as a result of a catastrophic collapse of the edifice at the time. The clast assemblages of 12 of these deposits were sampled to provide insights into the chemical compositions of magmas erupted during the earlier stages of activity of the volcano and form the basis for a more complete chemo-stratigraphic analysis of the Mt. Taranaki volcanic succession.

Throughout the volcanic history of Mt. Taranaki, similar eruptive styles produced a similar range of lithologies, indicating a long-term sustainability of the volcanic system. However, sample suites from the studied debris-avalanche deposits show a progressive enrichment in K_2O and LILE, reflecting a gradual evolution to high-K andesite. The early (pre-100 ka) magmatic system produced a wide range of compositions, including relatively primitive basalts and basaltic andesites with a more distinct mantle signature. These rocks contain phenocryst assemblages that indicate crystallisation within the lower crust or mantle, including a broad range of clinopyroxene compositions, high-Al_2O_3 hornblende, olivine and phlogopite. The compositional variation observed for the more primitive compositions also reflect a heterogeneous mantle source for primary Taranaki magmas. A higher proportion of high-silica compositions in the younger sample suites and the appearance of late-stage low-pressure mineral phases, such as high-TiO_2 hornblende, biotite and Fe-rich orthopyroxene, reflect a gradual shift to more evolved magmas with time.

These results are interpreted to reflect a multi-stage origin for Taranaki andesites. Parental magmas were generated within a lower crustal "hot zone", which formed as a result of repeated intrusions of primitive melts into the lower crust. The geochemical and mineralogical evidence indicates that prior to 100 ka this zone was relatively thin and cold, allowing primitive magmas to rise rapidly through the crust without significant interaction and modification. As the hot zone evolved, larger proportions of intruded and underplated mafic material were partially remelted, and interaction of these melts with fractionating mantle-derived magmas generated progressively more K- and LILE-enriched compositions. A complex and dispersed magma assembly and storage system developed in the upper crust where the hot-zone melts were further modified by fractional crystallisation and magma mixing and mingling.