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Understanding Aspects of Andesitic Dome-forming Eruptions Through the Last 1000 yrs of Volcanism at Mt. Taranaki, New Zealand

A dissertation presented in partial fulfilment of the requirements
for the degree of
Doctor of Philosophy
in
Earth Science

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The summit of Mt. Taranaki. Photographed by G. Lube.

Dedicated to my parents,
to Katrin and my son August

Abstract

Andesitic volcanoes are notorious for their rapid and unpredictable changes in eruptive style between and during volcanic events, a feature normally attributed to shallow-crustal and intra-edifice magmatic processes. Using the example of eruptions during the last 1000 yrs at Mt. Taranaki (the Maero Eruptive Period), deposit sequences were studied to (1) understand lava dome formation and destruction, (2) interpret the causes of rapid shifts from extrusive to explosive eruption styles, and (3) to build a model of crustal magmatic processes that impact on eruption style.

A new detailed reconstruction of this period identifies at least 10 eruptive episodes characterised by extrusive, lava dome- and lava flow-producing events and one sub-Plinian eruption. To achieve this, a new evaluation procedure was developed to purge glass datasets of contaminated mineral-glass analyses by using compositional diagrams of mineral incompatible-compatible elements. Along with careful examination of particle textures, this procedure can be broadly applied to build a higher degree of resolution in any tephrostratigraphic record. Geochemical contrasts show that the products of the latest Mt. Taranaki eruption, the remnant summit dome (Pyramid Dome) was not formed during the Tahurangi eruptive episode but extruded post-AD1755. Its inferred original maximum volume of 4.9×10^6 m^3 (DRE) was formed by simultaneous endogenous and exogenous dome growth within days. Magma ascent and extrusion rates are estimated at ≥0.012 ms^{-1} and ≥6 m^3s^{-1}, respectively, based on hornblende textures. Some of the Maero-Period dome effusions were preceded by a vent-clearing phase producing layers of scattered lithic lapilli around the edifice [Newall Ash (a), Mangahume Lapilli, Pyramid Lapilli]. The type of dome failure controlled successive eruptive phases in most instances. The destruction of a pressurised dome either caused instantaneous but short-lived magmatic fragmentation (Newall and Puniho episodes), or triggered a directed blast-explosion (Newall episode), or initiated sustained magmatic fragmentation (Burrell Episode). The transition from dome effusion to a sustained, sub-Plinian eruption during the Burrell Lapilli (AD1655) episode was caused by unroofing a conduit of stalled magma, vertically segregated into three layers with different degrees of vesiculation and crystallisation. The resultant ejecta range from brown, grey and black coloured vesicular clasts to dense grey lithics. Bulk compositional variation of erupted clasts can be modelled by fractionation of hornblende, plagioclase, clinopyroxene, and Fe-Ti oxides. Pre-eruption magma ascent for the Maero Period events is assumed to begin at depths of c.9.5 km.

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I wish to thank every person who contributed to the outcome of this study.

I went back to New Zealand to study one of the most fascinating phenomena nature has to offer: volcanoes. Of the North Island volcanoes, Mount Taranaki stands out as being the most imposing, and to me the most striking. Despite its dormancy, it proved a real challenge, to climb, find samples and sections, and to draw out some of his secrets.

For the opportunity to work again on Mt. Taranaki I am indebted to my chief-supervisor Dr Shane J. Cronin. Through him I learnt much about how to observe volcanic deposits and to understand the various processes involved in generating them. His aid in my receiving a Massey University Doctoral scholarship is highly appreciated. In past years Dr Cronin supported numerous overseas trips, which offered me the opportunity to meet other scientists, either on conferences or at the institutions where my overseas supervisors are based. I also benefited from his extraordinary skills in writing and presenting ideas and thoughts.

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