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**Understanding the Holocene explosive
eruption record of the Tongariro
Volcanic Centre, New Zealand**

**A thesis presented in partial fulfilment of the requirements
for the degree of**

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in

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Anja Moebis

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This thesis is dedicated to my partner and best friend
Gert Lube



Ngauruhoe viewed from the west

Abstract

The Tongariro Volcanic Centre has experienced many VEI 1-4 eruptions over the last 12 000 cal. yrs. B.P., dominantly from Ruapehu, Ngauruhoe and Red Crater. The historic record of 150 years alone is insufficient to provide a robust understanding of future volcanic hazard, necessitating a quantification of eruption parameters from the geological record. The major obstacle to this is untangling a complex sequence of interdigitating, fine-grained and poorly distinguishable tephras from the three source volcanoes. With detailed mapping and using volcanic glass chemistry, tephras from the three sources were discriminated. This has led to a revision of the age of Ngauruhoe to be at least 6500 cal. yrs. B.P., around 4000 years earlier than previously thought. It also provides the most detailed explosive eruption frequency and magnitude record from the area since 12 000 cal. yrs. B.P. Ruapehu and Ngauruhoe tephras were characterised by initial phreatomagmatic explosions that transformed into dry magmatic (strombolian) phases. Magma-water interaction is shown by basal layers of pale-brownish-grey fine ash, containing blocky glass shards with small isolated spherical vesicles, and exhibiting surface conchoidal and step-like fractures. The magmatic phase ash is microlite-rich, with dark glass containing elongate vesicles with thin bubble walls and irregular surfaces. The largest eruption recognised from Ngauruhoe, produced a distinct dark purple tephra, with a well-constrained volume of $26.6 \times 10^6 \text{ m}^3$, and a probable eruption column height of about 15 km. The total tephra volume from Ngauruhoe is estimated to be $952 \times 10^6 \text{ m}^3$, around 50% of the known lava volume. A climactic eruption period of Ngauruhoe occurred between ~ 2900 and 2700 cal. yrs. B.P., during which 64% of its known explosive eruptions occurred, including its largest known events. This phase, representing 3% of the volcano's lifespan, produced 57% of its pyroclastic output. Over the last 12 000 cal. yrs. B.P., the frequency of Ruapehu eruptions appears to have increased about 2000 yrs B.P., but this may reflect better preservation and exposure of the more recent tephras. Bursts in Ruapehu explosive activity have occurred out of phase with those from Ngauruhoe. The minor pyroclastic cone of Red Crater represents an eruption site that was active for at least ~ 4000 cal. yrs. B.P. and has mainly been characterised by effusive events. Since around 900 cal. yrs. B.P. minor explosive events have occurred from this location, increasing in magnitude from 400 cal. yrs. B.P.

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List of Abbreviations

cpx	Clinopyroxene
DP	dark purple
EMPA	Electron microprobe analyses
F. or Form.	Formation
hb	Hornblende
hyp	Hypersthene
LPA	Laser Particle Analysis
MtF	Mangatawai Formation
MF	Mangamate Formation
NF	Ngauruhoe Formation
Ng	Ngauruhoe
ol	olivine
opx	orthopyroxene
OVC	Okataina Volcanic Centre
Ox	oxides
PF	Papakai Formation
PP	pale purple
plg	plagioclase
px	pyroxene
Rua	Ruapehu
RC	Red Crater
SEM	Scanning electron microscope
TgVC	Tongariro Volcanic Centre
tm	Titanomagnetite
TNP	Tongariro National Park
TTF	Tufa Trig Formation
TVC	Taupo Volcanic Centre
TVZ	Taupo Volcanic Zone