Volcanoes of the Waikato

Science research article

Active volcanoes in Aotearoa/NZ are found in the Taupō Volcanic Zone (TVZ), and result from subduction at the plate boundary. About 2.5 million years ago (MYA) when the TVZ was just beginning to form, magma created by this plate boundary was being erupted further to the west in the central Waikato region. University of Waikato volcanologist Dr Marlena Prentice and NZASE Science Communicator Mike Stone explain.

Context of Waikato volcanism

Volcanic arcs are chains of volcanoes up to thousands of km long, which form near the boundary where one tectonic plate is subducted under another.

Arc volcanoes in Aotearoa New Zealand first appeared in Te Tai Tokerau/Northland around 25 MYA, when the Pacific Plate began to be subducted below the Australian plate. These volcanoes form part of a continuous chain that extended northwards towards Tonga.

Since then, the position of these arc-related volcanoes and the plate boundary has migrated SE. It is marked by the undersea Colville-Lau Ridge and volcanoes along the Coromandel Peninsula, known as the Coromandel Volcanic Zone (CVZ).

The Waikato region is situated west of the arc volcanoes, in the area known as the back-arc. The region is dominated by the wide Hamilton Basin, made up of lowland areas separated by hill ranges that have been uplifted along faults. Many of the Waikato volcanic maunga are located over or near these faults, which act as a pathway for magma to reach the surface.

Parallel to the Hamilton Basin lies the Hauraki Rift, which has separated the volcanic cones in the east from those in the Coromandel Peninsula. Beginning about 7 MYA, this rift is now 20-40 km wide and extends 250 km into the Firth of Thames.

Waikato volcanoes

Kakepuku and Te Kawa from the south. By Johnragla, Wikipedia, CC BY-SA 4.0.

The maunga of the Waikato region are places of inherent mana (spiritual power), steeped in tapu (sacredness), and taonga tuku iho (treasures passed down for future generations).

They are central to the whakapapa of all Māori, helping to define tūrangawaewae (one's place of standing or belonging), and linking the descendants of the Tainui waka (who still live around Pirongia and Karioi) to the patupaiarehe (ancient people) already living on several maunga when the waka arrived.

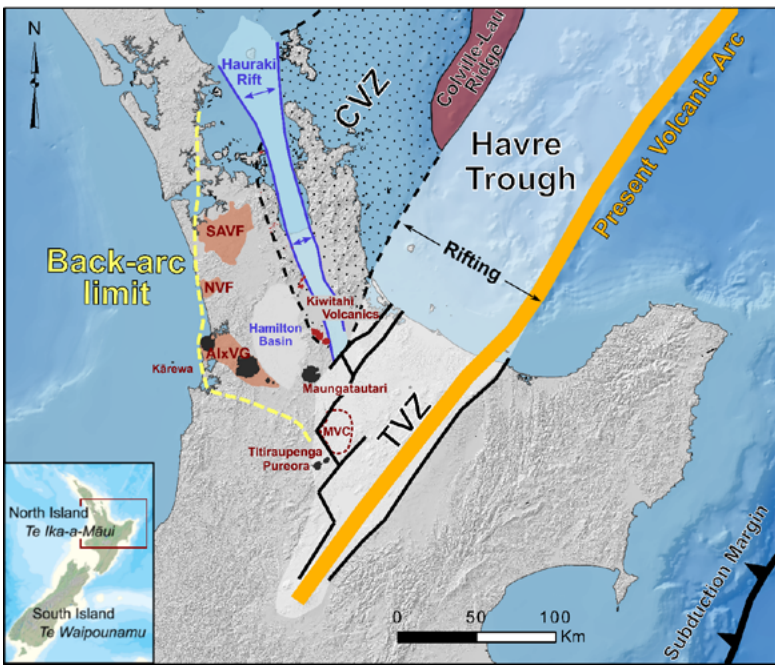
Through these whakapapa strands, the tangata whenua maintain roles as kaitiaki (protectors) of the large Waikato maunga, and smaller volcanoes. These can be subdivided into five distinct groups.

1 Kiwitahi volcanics

The first group, a chain of highly eroded stratovolcanoes and volcanic deposits, stretches 120 km from Waiheke (16 MYA) to Te Tāpui (around 6 MYA) near Cambridge.

Erupted lavas commonly have low to

Map of central North Island showing location of Waikato volcanoes and other geologic features. Marlena Prentice.



Pirongia volcano. Photo by University of Waikato.

intermediate silica content, typical of arc volcanism. Three of the youngest centres are located in the Waikato between the lowlands of the Hamilton Basin and the Hauraki Rift:

- ***Tahuna*** – Remains of large boulders of basaltic andesite lava flows strewn over greywacke basement rock.
- ***Maungatapu*** – This rounded hill is an eroded volcanic cone, the youngest of the Kiwitahi volcanoes. The remains of basaltic andesite lava flows are visible across the surface.
- ***Ruru, Maungakawa, Te Tāpui*** – These three symmetrical cones are about 500m high, lie in a distinct line and erupted about 6 MYA. Deeply eroded andesitic boulders left from lava flows are strewn over all three cones.

These volcanoes are much older than the others discussed below, and are believed to be CVZ volcanoes separated from those on the Coromandel Peninsula by the expanding Hauraki Rift.

2 Alexandra Volcanic Group

The second group is a chain of large basaltic stratovolcanoes and smaller cones, which form a 60 km line along the western edge of the Hamilton Basin. The cones extend inland from near Raglan and include the maunga of Karioi, Pirongia (the largest), then Kakepuku, Te Kawa and Tokanui.

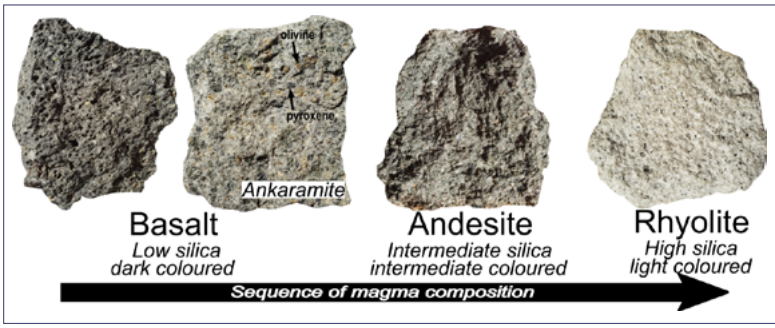
Located between and around these larger volcanoes is the Okete Volcanic Field where at least 50 individual vents represent single eruption events. Together, these volcanoes form the Alexandra Volcanic Group (AlxVG).

The AlxVG group erupted around 50 km^3 of basaltic lava over 1,000 km^2, between 2.7–1.6 MYA. This is about half of all basalt erupted in the North Island in the last 17 MY.

Smaller amounts of andesitic lava also erupted periodically throughout the eruptive lifespan of Karioi and Pirongia. Magmas can be classified as either subduction-related (arc-type basalts and andesites), or intraplate basalts. The AlxVC is one of only a few sites in the world where these two types of basalt have erupted from the same vents over time.

The arc-related basalts contain unusually large crystals of olivine and pyroxene, and are the only example of this rock type (ankaramite) found in Aotearoa/NZ. The viscous nature of this lava creates the steep angled cones (~15-20°) of the Alexandra group.

Intraplate lavas contain similar crystals to those found in ankaramite. However, the crystals are much smaller and the chemistry of the rocks is different, forming the smaller cones of the Okete Volcanic Field.



Compositional range of Waikato volcanic rocks. Image by Marlena Prentice.

The 60 km line of volcanoes is described in pūrākau (ancient Maori stories), which tell us that Pirongia and Karioi are sisters and the island Kārewa (to the west of the AlxVC in p1 map) was Karioi's lover.

Eventually, Karioi fled west and Kārewa followed, later to be sent offshore. The children of Karioi and Kārewa are spread between them, represented by the small volcanoes surrounding Karioi, and those submerged offshore towards Kārewa.

Another pūrākau states that Kakepuku won the love of Te Kawa, and the two now stand together in eternity near Te Awamutu.

3 Monogenetic volcanic fields

Monogenetic volcanic fields have numerous vent sites where smaller eruptions (< 1 km^3) have occurred over a wide geographic area and are spaced over long periods of time (ie, 10,000-100,000+ years).

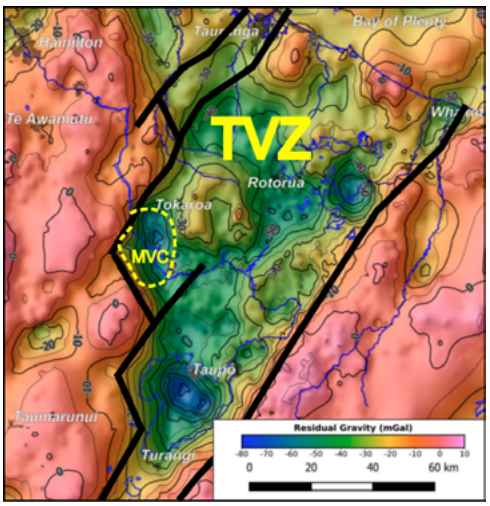
Each eruption represents a single episode,

Maungatautari volcano, by Sanctuary Mountain Maungatautari.

where magmas, usually of basaltic composition, are erupted over weeks to decades to build a single new volcano or volcano complex, never to erupt again.

The earliest appearance of a monogenetic field in this region is the Okete Volcanic Field (2.7 to 1.8 MYA; see above). Since then, this intra-plate volcanism has migrated northwards, forming the volcanic fields of Ngatutura (NVF) which erupted around 1.7 MYA, followed by the South Auckland (SAVF) between 1.5M and 500,000 years ago, and the currently active Auckland Volcanic Field.

These fields largely contain scoria cones and associated lava flows. Magma-water (phreatomagmatic) interaction during eruptive events is represented by maars and tuff rings, the largest of which is the Onewhero tuff ring in south Auckland.



Gravity anomaly map of the TVZ, redrawn by Marlena from Stagpoole et al., 2021. The blue areas of negative values mark the large calderas of the TVZ.

4 Isolated stratovolcanoes

The fourth group is made up of three extinct stratovolcanoes, aged between 1.9 and 1.6 MYA, south of the Hamilton Basin. The northernmost is the circular cone of Maungatautari, almost 800 m high, and ~8 km in diameter at its base.

Exposures of mostly andesite lava occur across the mountain, along with pumice deposits that record more explosive eruption events. A large horseshoe-shaped scar on the NW slopes is from a partial collapse of the cone after the volcano stopped erupting.

South of Maungatautari are Mounts Pureora and Titīraupenga, on the south-west margin of the Mangakino caldera (see map). Both these stratovolcanoes erupted low silica basaltic andesite lavas. Pureora is the larger cone, 450 m high and 5 km in diameter.

The lavas have been dated with K-Ar (potassium-argon) methods, and Pureora, at 1.6 MYA, is slightly younger than the other two. In contrast, Titīraupenga is the smallest cone, reaching only 350 m high with a 4 km diameter.

These volcanoes were actively erupting during the early stages of the TVZ formation. Maungatautari is part of the volcanic arc, and a similar relationship is inferred for the cones of Pureora and Titīraupenga.

5 Mangakino Volcanic Centre

The fifth group is the Mangakino Volcanic Centre, the westernmost and amongst the oldest of the extinct caldera volcanoes in the TVZ. This grouping was active several times 1.6-0.9 MYA, including two super-eruptions and other large explosive eruptions.

Ngā Kupu

Mātai puia – Volcanology
Maunga – Mountain, peak
Pae maunga – Mountain range
Puhanga puia – Volcanic plume
Puia – Volcano, geyser, hot spring
Puia koeko – Cone-shaped volcano
Puia kōpuku – Dome volcano
Puia korehāhā – Extinct volcano
Puia moe – Dormant volcano
Puia oho – Active volcano
Puia pākai – Shield volcano
Pūrākau – Ancient Māori stories
Toka puia – Volcanic rock.

From Te Aka Maori Dictionary

These eruptions frequently produced pyroclastic flows – clouds of hot pumice, rock fragments, ash and gas which flowed laterally away from the vent at high speed.

When the material comes to rest, it forms a rock often known as ignimbrite. The two largest eruptions are represented by the Ongatiti and Kidnappers ignimbrites, which both travelled up to 200 km from the caldera.

Today the caldera is buried by hundreds of metres of lake sediments and ignimbrites from younger TVZ calderas, but its location is known because of the rhyolite lava domes erupted around its edges, and a major negative gravity anomaly commonly used to define calderas in the TVZ.

Ignimbrite exposed in the Hinuera Quarry, where it is over 35 m thick. From Pittari, 2021.

A sea stack at Ngatutura Point, part of the monogenetic, Ngatutara Volcanic Field. Photo by by A. Pittari, University of Waikato.

Reference

Pittari, A., et al., 2021, Inception of the modern North Island (NZ) volcanic setting: Spatio-temporal patterns of volcanism between 3.0 and 0.9 Ma. *NZ Journal of Geology & Geophysics, 64*(2-3), 250-272.

If you cannot access the full article, it is available by emailing Marlena.

Useful resources

Magma drillers save planet earth (online game).

Email Jessica Smith of the University of Waikato for school visits on environmental & earth science topics.

Email Annette Rodgers at the University of Waikato to borrow or buy rock sets ($60 + GST).

Teachers can email Marlena if they would like to work together to develop field trips suitable for all student levels.

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