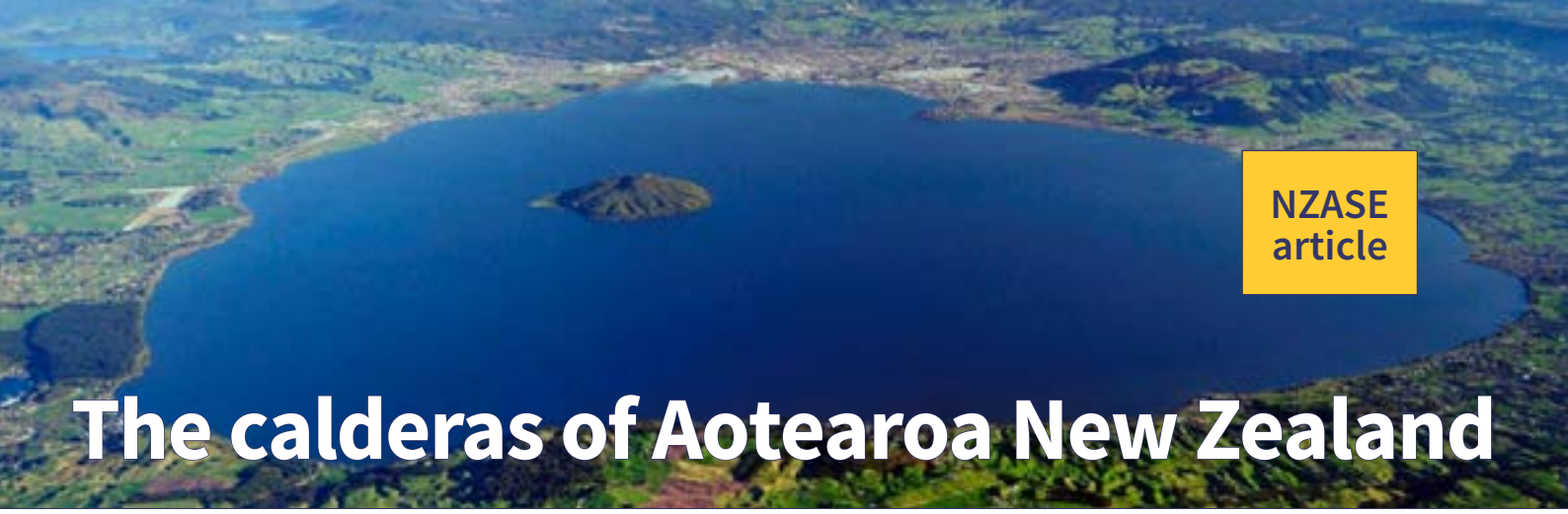


NZASE article

The calderas of Aotearoa New Zealand

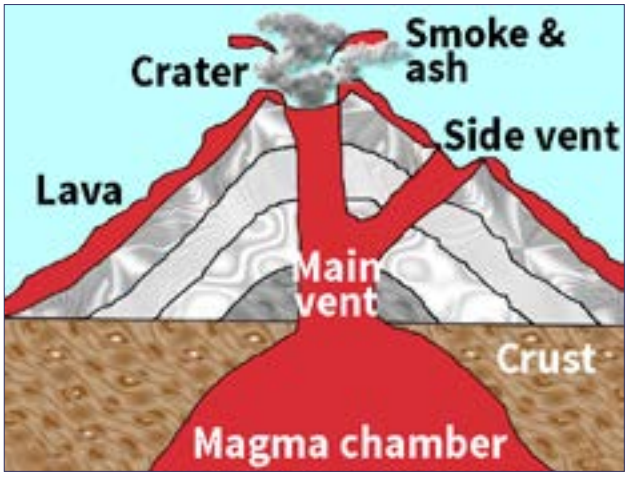
*NZASE Science Communicator **Mike Stone** describes the volcanic activity that creates calderas around our islands.*

Tectonic plates

It is no wonder our islands are geologically active, as they are positioned on the collision zone of two tectonic plates. We have had two sizable eruptions and three major earthquake sequences in the last 10 years alone. The latest seismic or volcanic activity can be seen on Geonet.

These huge plates under oceans and continents move very slowly. New oceanic crust forms from erupted molten rock at mid-ocean ridges, moves away, and eventually dives into the mantle at subduction zones. The subducting plate carries with it lots of water and CO_2 from carbonate-rich sediment (CO_2 increases the amount of gas, and sediment increases the amount of silica in the resulting magma), which is released into the mantle above the subducting plate. This causes rock to melt and rise, sometimes staying below the surface, sometimes being erupted.

Our islands have many dormant volcanoes and 11 active ones. Most eruptions have occurred in the Taupo Volcanic Zone (TVZ) from three cone volcanoes (Ruapehu, Tongariro/Ngauruhoe, and Whakaari/White Island) and two calderas (Okataina and Taupo). These active subduction volcanoes form a part of the Pacific Ring of Fire, a line of volcanic and earthquake activity circling the Pacific Ocean at the edge of tectonic plates.



Parts of a volcano. Image: Ms Shapiro's Technology Blog

Rotorua caldera. Lava domes are clearly visible at Mokoia Island, and in the bush-clad hills of Ngongotahā (top right) and Hamurana (bottom left). Photo: D. Townsend, GNS.

Types of magma

Volcanoes produce different types of magma.

1. **Rhyolitic magma** is high in silica and gas, and viscous (sticky like treacle). The gas becomes trapped at high pressure in the thick magma and so produces violent ash eruptions when that pressure is released.
2. **Intermediate magma** has medium silica levels and viscosity, producing eruptions of lava and ash resulting in steep-sided cones.
3. **Basaltic magma** is low in silica, so has low viscosity, making it runny like water. It erupts lava and results in low cones with long, gentle slopes, also called shield volcanoes.

Calderas

Calderas are collapsed craters which develop after eruptions that eject huge amounts of magma. When the shallow magma chamber empties, the volcano above it can collapse, leaving an enormous ring-shaped depression. In some places the walls of the caldera may be visible as steep cliffs, but these can be obscured when the crater fills with erupted material or water.

Some calderas are remnants of the most violent rhyolitic eruptions. Others form from

basaltic magma, when the magma chamber is shallow and subsidence is gradual. Most calderas in Aotearoa/New Zealand are rhyolitic, but three are basaltic.

The violence of rhyolitic eruptions can also throw huge amounts of pumice, ash and gas into the atmosphere, which later falls. Lighter particles can be thrown into the stratosphere 50km above the caldera – too high to fall back to earth. It can spread around the world, affecting the global climate for years, as happened in past Taupo eruptions.

As well as erupting upwards, a hurricane of hot pumice, ash, and gas explodes in all directions along the surface. These pyroclastic flows can travel large distances at up to 700km/hr, leaving behind debris up to 100m deep.

After the eruption when the gas is exhausted, any magma remaining in the chamber will ooze, as rhyolite is highly viscous. The molten rock piles up around the vent forming lava domes such as Mokoia Island and Mt Ngongotahā within the Rotorua caldera.

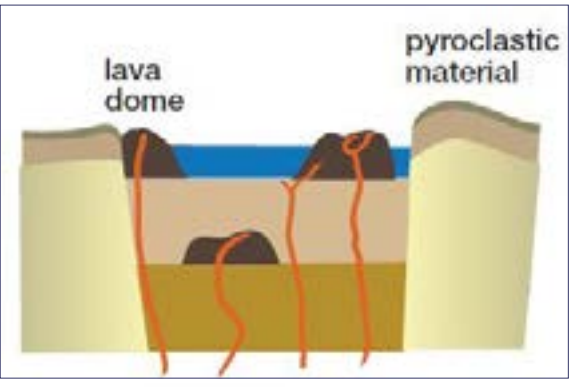
The calderas within the Taupo volcanic zone are the most productive and frequently active rhyolite caldera volcanoes on earth. Because of the size of the eruptions they collectively form a super volcano complex.

Ten calderas of Aotearoa

In case of further events, geologists take GPS readings at many of these sites (map next page) and monitor water and gas chemistry, seismic activity, and, where present, lake levels.

Taupo is fully named Taupo-nui-a–Tia/ the great cloak of Tia, after the discoverer of the roto. Lake Taupo lies in the caldera of an active volcano, covering several separate vents. The biggest of its many eruptions was 27,000 years ago, with another violent eruption in 230 AD. Both of these were huge by world standards, leaving small ash deposits across the whole country and deep pyroclastic flows nearby.

Lakes and lava domes are often formed in caldera basins. Image: LEARNZ



Banks Peninsula, with the high caleras walls of Lyttleton Harbour (top) and Akaroa Harbour. Google Earth.

Smaller eruptions created lava domes like Mt Tauhara.

The **Okataina** caldera contains the Tarawera volcano (last erupted in 1886) with six older calderas nearby - Maroa, Mangakino, Kapenga, Whakamaru, Reporoa and Rotorua. Large explosive eruptions from this group of rhyolite volcanoes produced a huge volume of material which buried older vents and formed extensive flat ignimbrite plateaus flanking the eastern and western sides of the TVZ.

Tuhua/Mayor Island is the visible portion of a basaltic shield volcano 700m high and 15km wide, which has erupted many times over 130,000 years. After the most recent events, 36,000 and 6,000 years ago, the ground gradually subsided, leaving overlapping caldera craters. Mayor Island is treasured for its high quality obsidian.

Raoul Island is the largest and most northern Kermadec island, and one of the most explosive; an eruption killed a DoC worker in 2006. It has two caldera craters; the biggest is 6km wide with three small lakes.

The **Macauley Caldera** is a submarine volcano within 100km of Raoul Island. Its crater is 50km across, about the size of Wellington Harbour, with steep walls and numerous hydrothermal vents. Giant sand waves radiate from it for many kilometres.

Healy volcano is a large submarine Kermadec volcano with active hydrothermal vents. It has a sizable caldera, with a basin 400m below the rim. Pumice deposits cover the caldera – the same material covers parts of the North and Chatham Islands.

Brothers is another submarine volcano in the Kermadecs. The volcano itself is three times bigger than White Island and is topped by a caldera with steep walls up to 500m high.

NZASE's new map of volcanoes and volcanic fields in Aotearoa/NZ and our waters.

The Kermadec Islands, about 1,000 km north of Whakatane, are part of New Zealand territory. As well as visible volcanic islands, undersea surveys have found about 50 wholly underwater (submarine) volcanoes. Evidence of their eruptions includes pumice rafts, water discolouration, gas bubbling as well as rumbling noises and seismic activity. Several have hydrothermal vents (black smokers).

A dome rises from one side of the caldera floor. Numerous hydrothermal vents are seen on the dome and caldera

Monowai Seamount is one of the most active submarine volcanoes in the Kermadec group, and its height can grow very quickly – currently it is only 100m below the surface. Its caldera is 11km wide and 1,500m deep, with small parasitic cones and hydrothermal vents on its flanks.

The **Akaroa and Lyttleton Harbours** on Banks Peninsula are in the remnants of two large basalt shield volcanoes, active nine to six million years ago. Huge eruptions led to a subsidence crater, much like the caldera on Kīlauea in Hawai'i. Subsequent erosion of valleys created two long harbours. Like the Auckland field, these volcanoes did not form at plate margins but over hot-spots in the mantle.

Within the Auckland volcanic field there are 13 crater remnants of volcanoes, including Lake Pupuke, Orakei and Panmure basins. However, these are maars rather than calderas, because they were not caused by the ground sinking, but by explosive eruptions when lava interacted with water. Such explosions leave a crater at the vent, surrounded by a 'ring' of ejected material, often subsequently forming a lake. Maar craters are also smaller than calderas, typically 2-8 km across.

Calderas are a significant feature of the NZ volcanic landscape and can also have a global impact.

Sources

GNS volcanoes; GNS landforms; GNS factsheets

Jacobson, H. (1914). Tales of Banks Peninsula, Akaroa Mail Office.

NZ Geographic: The power of Taupo; Auckland volcanoes

QUORA: Maar and caldera

Stipp, J. & McDougall, I. (1968). Geochronology of the Banks Peninsula Volcanoes, New Zealand. *N.Z. Journal of Geological Geophysics 11*, 1239-60

Te Ara: Volcanoes

Volcano Discovery: Healy

Wikipedia: Calderas of New Zealand; Raoul Island; Healy.

Ngā Kupu

Pahu – Erupt, explode
Pahūtanga – Eruption
Puia – Volcano
Roto – Lake
Rūaumoko – God of earthquakes and volcanoes
Tahepuia – Lava
Tawhā – Caldera
Tokarewa – Magma

From Te Aka Maori Dictionary and Paekupu