POTENTIAL IMPACTS FROM A SUPERVOLCANO: Taupō Volcanic Centre

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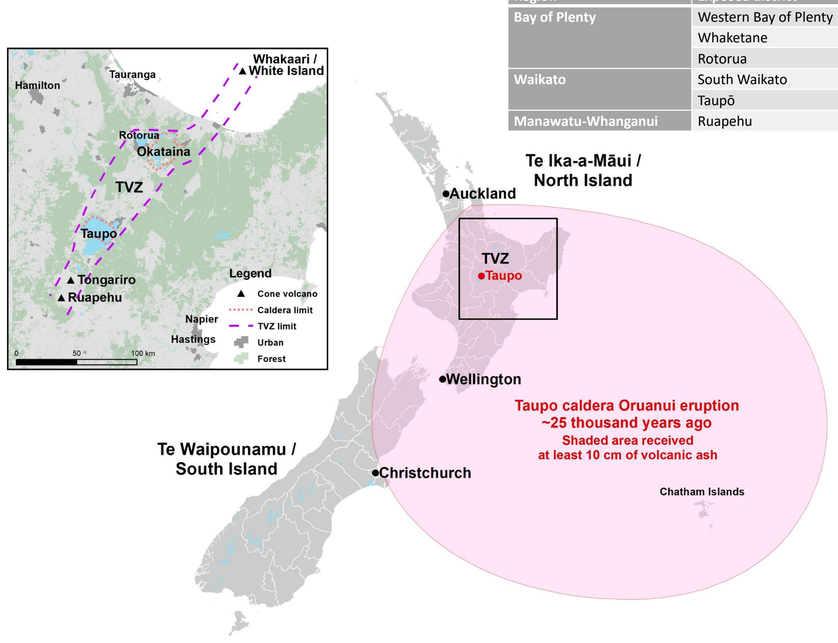
Caldera volcanoes are **large, extended, and complex** volcanic systems, and their formation is usually related to high explosive eruptions collapsing the roof of magma chambers (Lockwood, 2017). On a global scale, Taupō Volcanic Zone (TVZ) in Aotearoa - New Zealand is the most active caldera volcanic system, and it includes two well-established caldera volcanoes: **Taupō Volcanic Centre (TVC)** and Okataina volcanic Centre (OVC). From these calderas, the TVC hosted the last identified **supereruption** (over 1000 km^3 of erupted material) known as Oruanui, which occurs ~25.5 ka ago (Wilson, 2001; Barker, 2020). Its last explosive event was known as the Taupō event in the 232 CE, with ~45 km^3 of total erupted material. Oruanui and Taupō events were associated with large Pyroclastic Density Currents (PDCs), among other volcanic processes, devastating a vast land portion. However, **a new eruption in the TVZ is highly unlikely** with just a <0.1% annual probability (Wilson, 2001).

Region	Exposed district	Inhabitants	%Māori
Bay of Plenty	Western Bay of Plenty	51,321	19%
	Whaketane	35,700	47%
	Rotorua	71,877	40%
Waikato	South Waikato	24,042	35%
	Taupō	37,203	30%
Manawatu-Whanganui	Ruapehu	12,309	43%



POTENTIAL IMPACTS

From natural hazard, two types of impacts could be defined, **intensive** impact associated with high-severity, but low-frequency processes and **extensive** impact referred to low-severity, but high-frequency events related mainly, but not exclusively to highly localized hazards (UNDRR, 2015). The potential impact is calculated through the following simple formula:

$$Pi = H \times E \quad (1)$$

Pi= Potential impact

H = Hazard

E = Exposure

Prospective scenarios for TVC activity were developed under the umbrella of an Endeavour fund research programme from the Ministry of Business, Innovation and Employment (MBIE) called **ECLIPSE: Eruption of Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions.** From those, main results show that scenarios are useful, usable and desirable inputs for the development of risk management strategies in caldera volcanoes (Campbell, 2020). Also, in case of occurrence, the scenarios allow defining potential impacts to exposed populations and the critical infrastructure they rely on. Some recognized hazards are summarized in the next table:

Caldera system	Scenario	Volcanic process	Impact type
Taupo Volcanic Centre	Caldera unrest	Earthquake	Intensive
		Earthquake swarm	Intensive/Extensive
		Thermal heat	Intensive
		Ground deformation	Intensive/Extensive
	Caldera eruption	Earthquake swarm	Intensive/Extensive
		Ground deformation	Intensive/Extensive
		Thermal heat	Intensive
		Phreatomagmatic explosion	Intensive
		Ash emission	Intensive
		Ashfall	Extensive
		Pyroclastic density Current	intensive
		Gas emission	Intensive/Extensive
		Lahar	Intensive

References

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Potter, S. H., Scott, B. J., & Jolly, G. E. (2012). *Caldera Unrest Management Sourcebook. GNS Science Report 2012/12. 73 p.*

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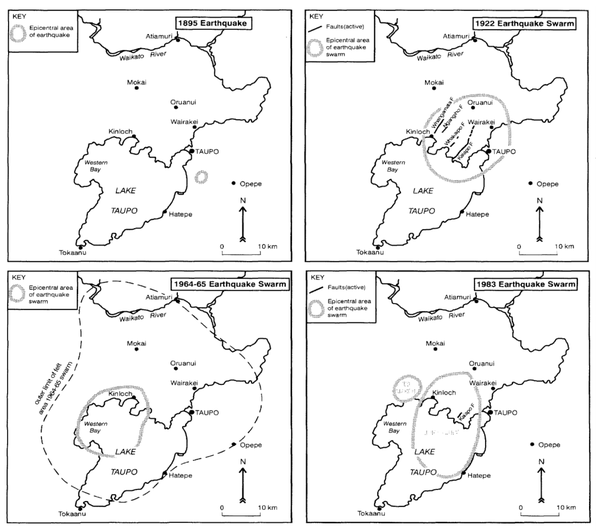
On the other hand, **caldera unrest** without led any eruption is a more frequent phenomenon, and multiple episodes were recorded in historical times for both TVC and OVC (Johnston, 2002). Caldera unrest may include **earthquakes, ground deformation, thermal and chemical changes,** among other processes, in which occurrence can result in hazards (Newhall & Dzurisin, 1988; Johnston, 2002). Some OVC's relevant episodes are hydrothermal eruptions with two fatalities and a guest house destroyed in 1917, and earthquake activity with losses of over USD 29,000 in 1983USD. For TVC, earthquake swarms' episodes were associated with ground deformation in 1922, and high public anxiety was reported despite minor damage. Similar episodes occurred in 1964-65 but with less interest from media coverage (Johnston, 2002; Potter, 2012).



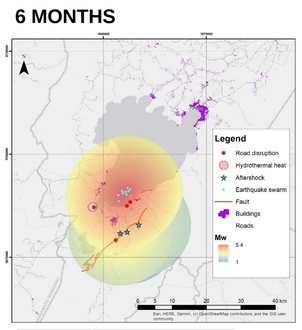
(Figure from Johnston, 2002)

Date	Caldera unrest description	Associated impacts
1895 3 to 6 weeks	Earthquake about Mw 6 followed by an aftershock sequence	Chimney collapsed, crockery and glassware smashed Roads blocked by landslides around the lake
1922 10 months	Earthquake swarms of about Mw 5-5.4 Subsidence of 3.7 m in the northwestern part of Taupō lake Fault rupture over an area of about 70 km2	Several chimneys collapsed in the north Minor damage to crockery and bottles Residents reported a "state of great anxiety." Uncertainty created many rumors
1964-65 1 year	Earthquake swarms' episodes followed by an isolated earthquake of Mw 4.6 Over 1100 earthquakes were felt in two months with a recurrence of 140 events per day Possible uplift of 99 mm near Horomatangui reef	Only a few earthquakes were felt Less interest from media coverage
1983-84 2 years (25 months)	Uplift of 55 mm was followed by equivalent subsidence in Kaiapo fault Hydrothermal eruptions occurred in geothermal fields near Taupō	Minor damage by earthquakes such as cracked chimneys and fallen ornaments

PRELIMINARY RESULTS

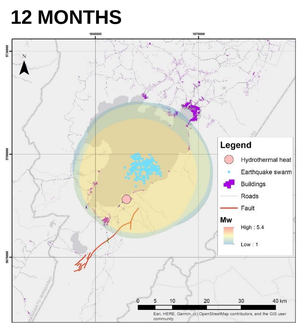
As part of the Ph.D. called 'Risk management for caldera volcanoes in Taupo Volcanic Zone' is proposed the calculation of potential impacts from caldera volcanic activity in TVC. Through a simplification of the ECLIPSE Scenarios for caldera unrest activity, three activity stages were defined associated with numbers of exposed buildings to earthquake shaking (with a total of 29 months of disruptive activity) :

6 MONTHS



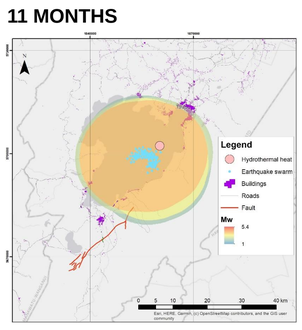
Mw	Building exposure
2 to 3	159
3 to 4	536
4 to 5	7072
Over 5	472

12 MONTHS



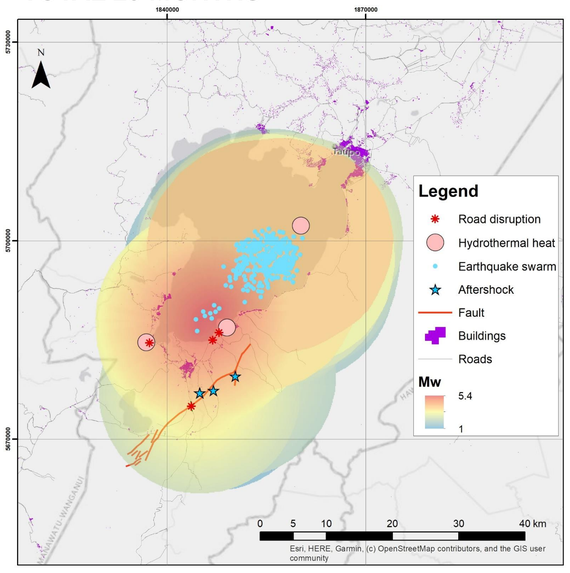
Mw	Building exposure
2 to 3	3244
3 to 4	7457

11 MONTHS



Mw	Building exposure
2 to 3	5953
3 to 4	8177

TOTAL 29 MONTHS



Mw	Building exposure
2 to 3	5683
3 to 4	5971
4 to 5	7072
Over 5	472

FURTHER STEPS

- **Numerical modeling of volcanic processes included in ECLIPSE Scenarios.**
- **Calculation of population exposure through LandScan database (2019) and Census 2018.**
- **Identification of main critical infrastructure and lifeline networks exposed to volcanic processes for volcanic unrest and eruption in TVC.**
- **Calculation of potential impact levels (1) for the total exposed area.**