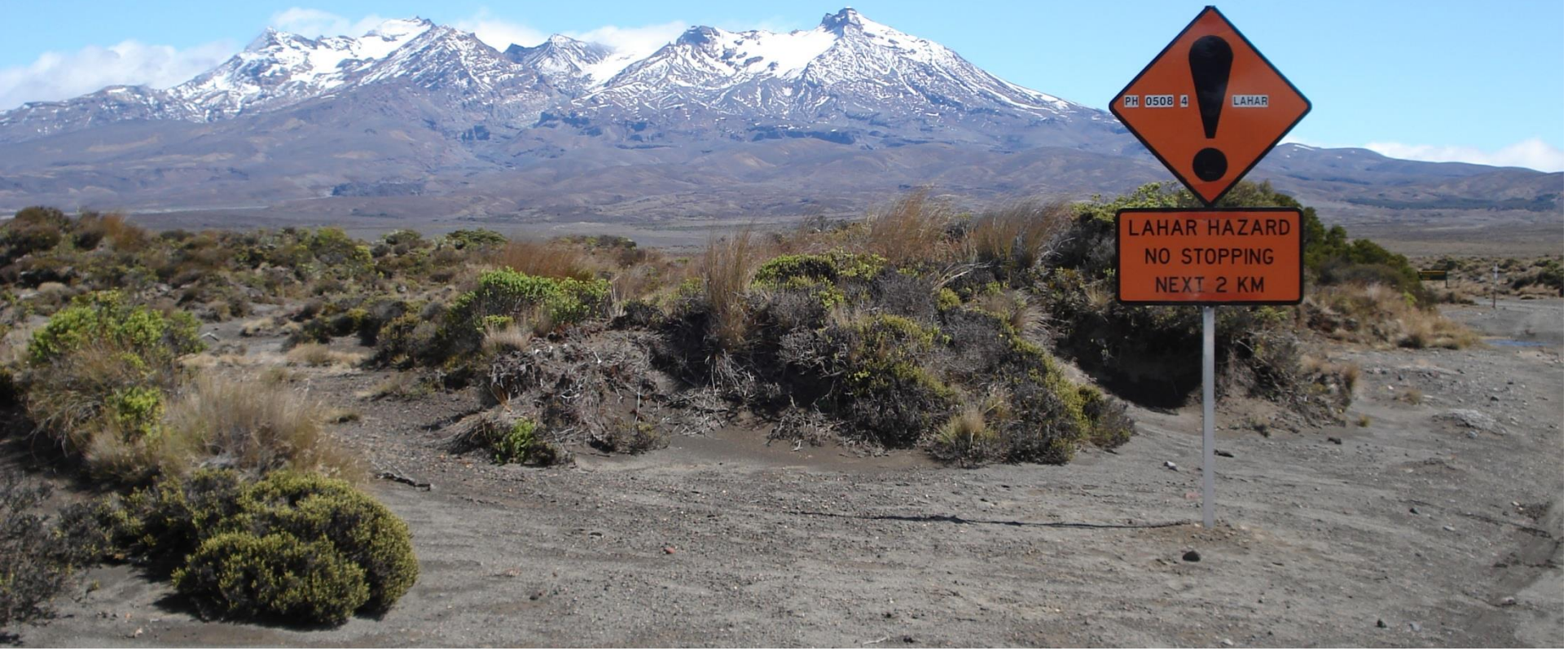
He haerenga mōrearea

Volcanic *(Hazards) and Mātauranga Māori*

Jonathan Procter



Mātauranga Māori
Te Ika a Maui
TVZ

Mātauranga – a - iwi

Taranaki

Hazard scenarios

Ruapehu

Hazard mapping

Tongariro/Ruapehu
Probabilities
Monitoring

Ruapehu
Tohu/Indicators
Forecasting

The Future

Massey University

Landcare Research
Manaaki Whenua

Ngāti Rangi Trust
Te Kāhui o Paerangi

Te Whare Wānanga o Awanuiārangi

RESILIENCE TO NATURE'S CHALLENGES
Kia manawaroa – Ngā Ākina o Te Ao Tūroa

VOLCANIC RISK SOLUTIONS
volcanic.massey.ac.nz

Social Science Motivation - Science/Engineering told us

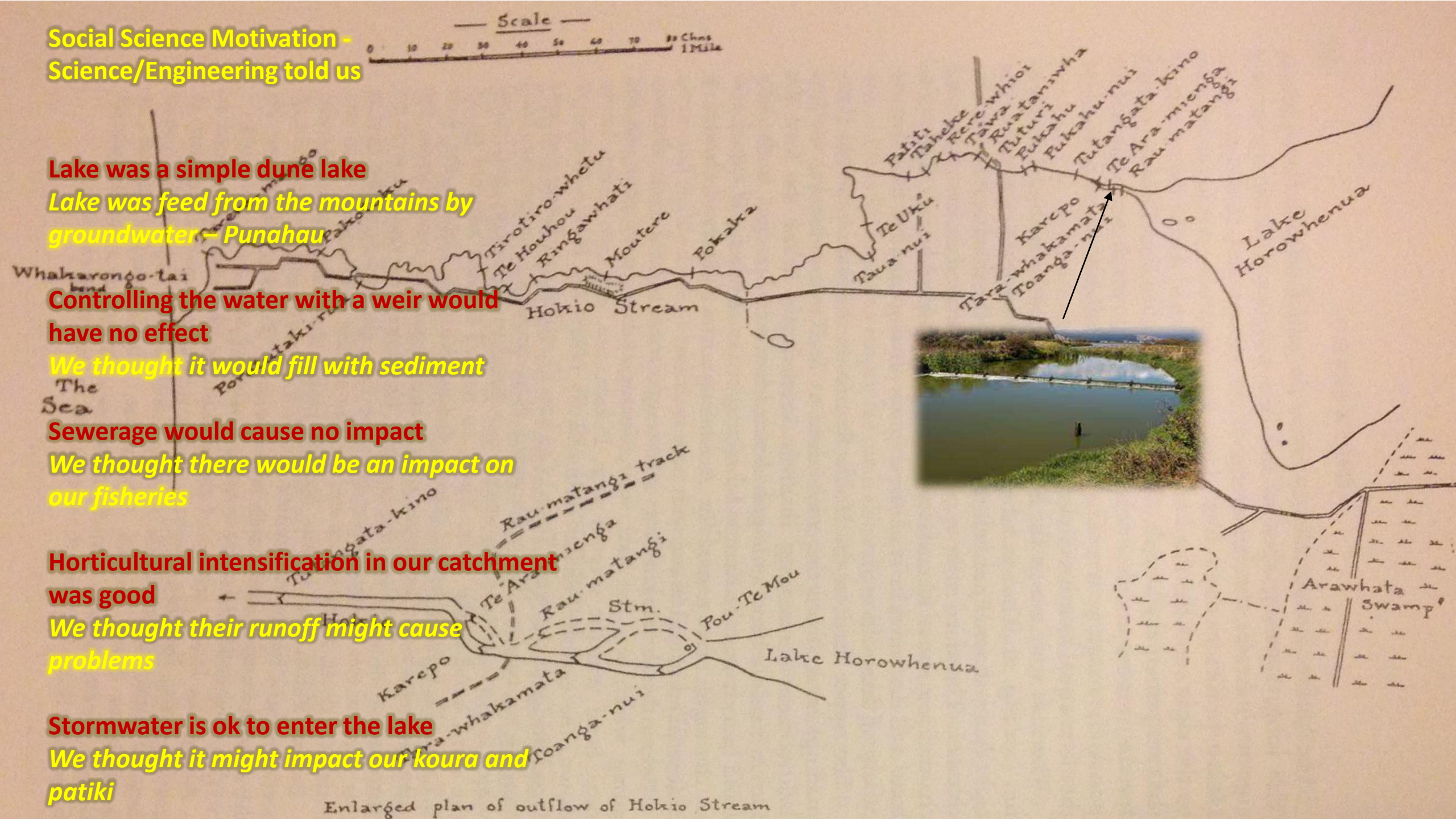
Lake was a simple dune lake
Lake was feed from the mountains by groundwater – Punahau

Controlling the water with a weir would have no effect
We thought it would fill with sediment

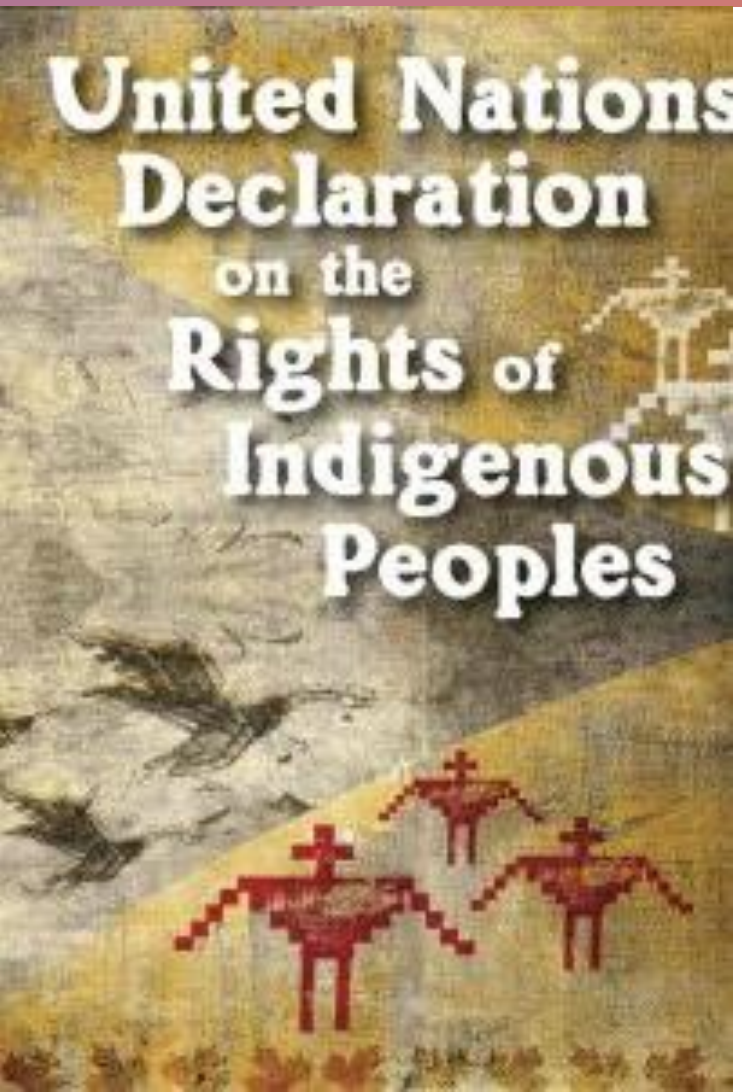
Sewerage would cause no impact
We thought there would be an impact on our fisheries

Horticultural intensification in our catchment was good
We thought their runoff might cause problems

Stormwater is ok to enter the lake
We thought it might impact our koura and patiki



Can we really compare science and indigenous knowledge?



Science

- Ancient Greece, Egypt – Euro Centric 3000 – 1200 BC
- Mathematics, Astronomy, Medicine.
- 14-16th Century Science to explain o… gravity, further advances mathemat… away from the Church as determinin… to adopting a standard methods to e… nature
- 19th Century move away from science in… technology

Humans are separate to the world around them

Indigenous Knowledge

- Global but locally focused 10 000 BC
- …aterials processing, Tools, Agriculture.
- …ks between natural world and people's …being
- …fied locally but adapted to different …tions over time
- …pansion across the Pacific from 4000 BC …~1200 yrs ago
- Understanding cycles in Earth, Oceans and Sky

Humans are part of the world

Smith et al (2016)

specialists in particular forms of knowledge, and ***developed their knowledge through a range of formal and informal instruction****, apprenticeships, and mentoring, and even being sent to live in another tribe for further instruction. There were different knowledge requirements for the specialisms; for example, a navigator needed to know how to read the sea and the stars, a weaver needed to know how to source materials, how to dye fabric and how to create garments. Each of these* ***speciality areas developed their own methodologies*** *within the wider philosophies and world views of their communities.*

Durie et al (2012)

Mātauranga Māori is about an evolving knowledge. What students of Mātauranga Māori should come away with is a sense that ***knowledge is always changing****, and that there are different approaches to it. The values might be derived from long ago, but knowledge changes. There is a* ***difference between discovering, developing, and being excited by new knowledge, and simply being told the old knowledge****… But when you look back on ancient times, Mātauranga Māori was an evolving form of knowledge. You didn't survive otherwise.* ***You had to adapt to new situations all the time.***

Mead (2012)

Mātauranga Māori is a lot more complex. It is a part of Māori culture and, over time, much of the knowledge was lost …. Mātauranga Māori is … ***linked to Māori identity and forms part of the unique features*** *which make up that identity. Because this is so, it also means that Mātauranga Māori is a unique part of the identity of all New Zealand citizens.*

Mātauranga Māori

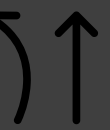
- Polynesian origins where knowledge elements include **observation, experimentation**, mythology, imaginative, innovative
- Māori ways of knowing
- The body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices
- **Is an epistemology, that is transferred and transferrable through different methods over many generations**

Mātauranga Maori is different from Science
Prof. Mason Durie

MĀTAURANGA MĀORI	SCIENCE
Holistic	Analytical
Accepted truths	Skeptical
Based on environmental encounters	Measurement & replication
Centrifugal thinking	**Centripetal thinking**
Highlights similarities	Highlights differences
Practitioners older	Practitioners younger
Time enhances knowledge	Time ages science
Steadily evolving	Knowledge constantly changing

How do we operate with two different knowledge systems?

One advances and the other is diverted



Intertwined, woven together

Merged equally

One is subsumed by the other

Parallel development

Different pathways of development

Mātauranga - Solutions Focused

(what skills do we want our children to have? *Problem-solvers of future challenges*)

- Long term
- Powerful at predictions - locally
- Holistic
- Focused on people's wellbeing
- Nonhierarchical
- Nonlinear

Te Roro o Taitearikiki

Agglutinate

New Vent already recognized by iwi

Te Reo for Kohatu and Whenua
Classification based on textural properties, hardness and usage

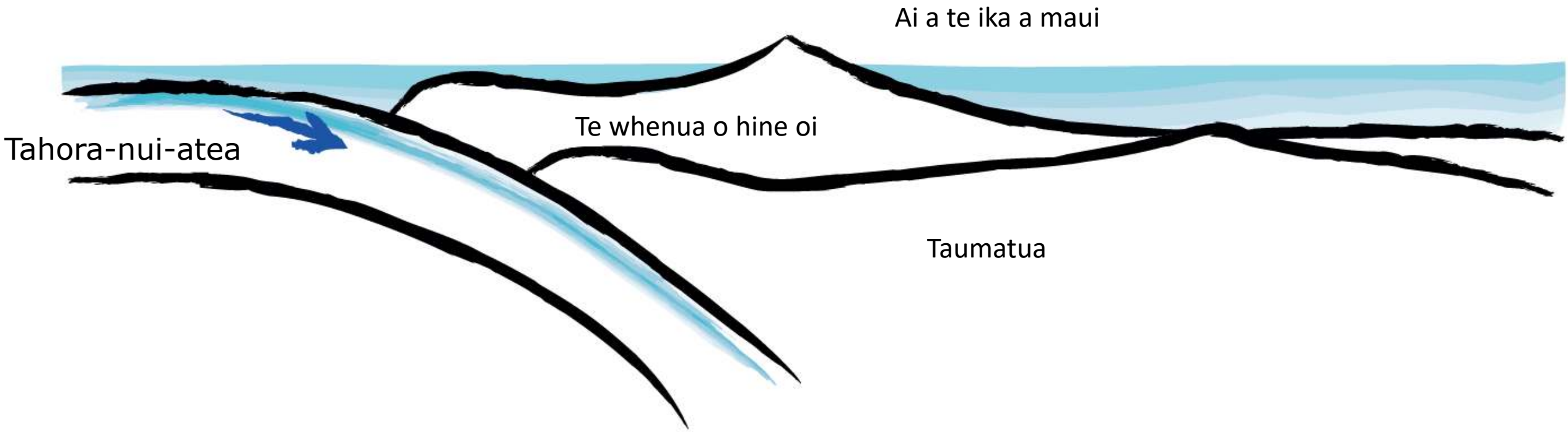
- **Rehu – Flint**
- **Mata one – Andesite/dome forming**
- **Mataa – Quartz Flint**
- **Onewa – Auckland Basalt**
- **Karaa – Fine grained Basalt (Tuhoe)**
- **Tuapaka - Limestone**
- **Kurutai - Gabbro**
- **Makahua – Sandstone**
- **Papa – Mudstone**
- **Pakohe – Argillite**
- **Pari Whero/Rangitoto– Jasper (greywacke)**
- **Kaihau – Scoria**
- **Kohurau – Quartzite**
- **Manutea - Marble**

Hamoamoa	clay	**Kowatukara**	limestone	**Pahu**	a sonorous stone; a bell
Haupapa	ledge of rocks	**Kowatukura**	a red stone	**Pakeho**	limestone
Hinangakore	green stone	**Kupapahi**	pyrites	**Papa**	a ledge of rock
Hinangarewa	green stone	**Kurutai**	green whinstone	**Pararahi**	a flat stone
Hinangatuhi	green stone	**Kurutongarerewa**	green stone	**Parataua**	green stone; a bad kind
Hohanga	sandstone. Syn. with Onetai	**Makahuri**	a stone	**Parau-umu**	black soil
Hohapa	green stone	**Makowa**	indurated sand	**Paru**	mud
Horete	a stone. Syn. with Ngahu	**Manatuna**	a whinstone	**Paru-ma**	pipe-clay
Ihu	swamp mud	**Mata**	obsidian	**Piaronga**	iron
Kahurangi	finest kind of green stone	**Moa**	a layer of stone; iron pyrites; ironstone	**Piauau**	iron
Kamaka	a rock	**Mokehu**	a white stone	**Pikiki**	
Kamuka		**Nehu**	dust	**Pora**	iron. Syn. with Piauau
Kapiti Kowatu	a stone cliff or precipice	**Ngahu**	a stone. Syn. with Horete	**Pounamu**	green stone
Kapowai	petrified wood	**Nganga**	a stone	**Puehu**	dust. Syn. with Nehu
Kara	a basaltic stone	**Ngarahu**	charcoal	**Pungapunga**	pumice stone
Karakatau	round pebbles; used as shot for pigeons	**Ngawa**	sulphur	**Pungarehu**	ashes
Kawakawa	green stone	**Ohanga**		**Pungawerawera**	brimstone
Kawakawaaumoana	green stone	**Okehu**	pipe-clay rock	**Pungawera**	pumice stone
Kawakawarewa	green stone	**Oneone**	earth	**Rahoto**	a scoriaceous stone
Kawakawatongarerewa	green stone; very fine	**Oneharuru**	good soil	**Rangitoto**	lava
Kawakawawatumu	bad kind of green stone	**Onekeretu**	stiff clay	**Rino**	iron. Syn. with Pora
Keretu	clay	**Onekotai**	swampy soil	**Tahoata**	pumice stone
Kerewenua	yellow clay	**Onekura**	red earth; volcanic table land	**Tangiwai**	green stone
Kerikeri	gravel	**Onemangu**	black or bog soil	**Teko**	a soft red stone
Kiripaka	flint stone	**Onematua**	(Fatherland); strong marly valley	**Toka**	a stone; a rock in the sea
Kokowai	red ochre	**Onepu**	sea sand	**Totoeka**	green tone
Koma	basaltic stone	**Onetai**	sandstone. Syn. with Hohanga	**Tuhua**	obsidian
Kotiatia	a boulder	**Onetaipu**	light sandy alluvial loams	**Tungaherehere**	green stone; bad
Kotore	steatite	**Oneware**	waxy soil; rich greasy soil	**Wanariki**	brimstone
Koropungapunga	pumice-stone	**Onoke**	pipe-clay rock. Syn. with Okehu	**Waro**	coal

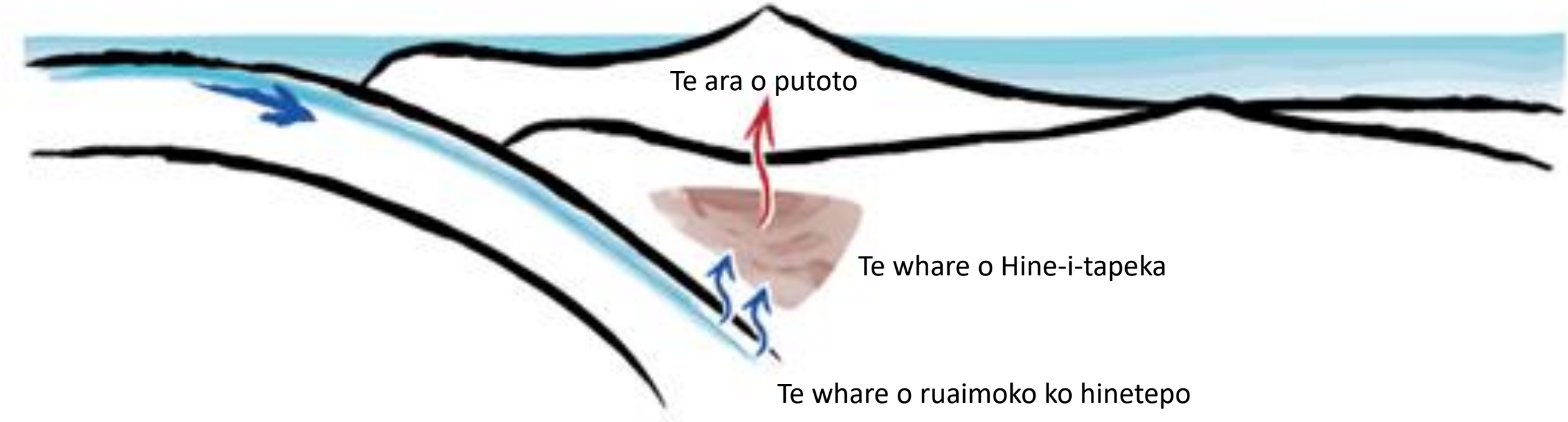
Poutiriao and tipua that exist to explain formation of rock and surface processes

Rakahore	Associated with all forms of rock
Papakura	Origin of volcanic rock
Hinetuakirikiri	Creation of gravel in rivers
Hine-one	Creation of sand
Whauaho	Formation of greywacke
Hine-uku	How clay was created
Hine-tūāpapa	Greenstone
Hine-aroaro-te-pari	Cliffs
Hine-i-te-repo	Swamps, wetlands
Parawhenuamea	Land/soils

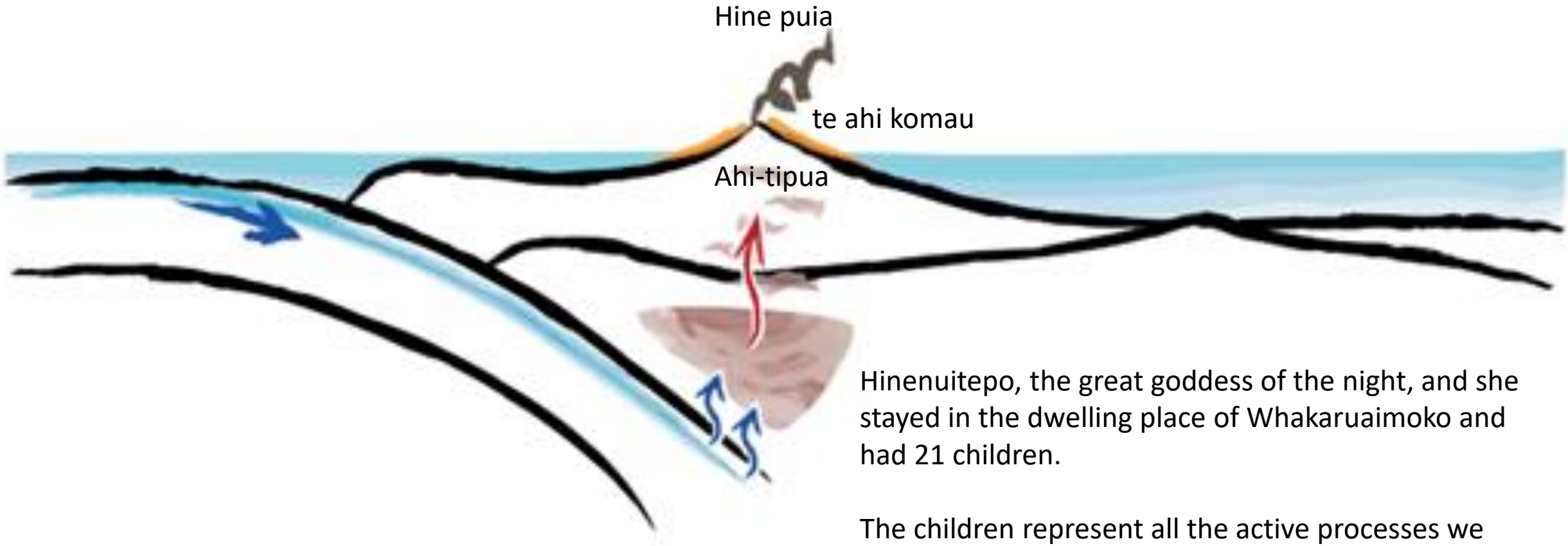
General mātauranga Māori Observations recognizing different land masses



General mātauranga Māori to explain volcanism.



Earthquakes and volcanism were the drivers of geomorphic change.

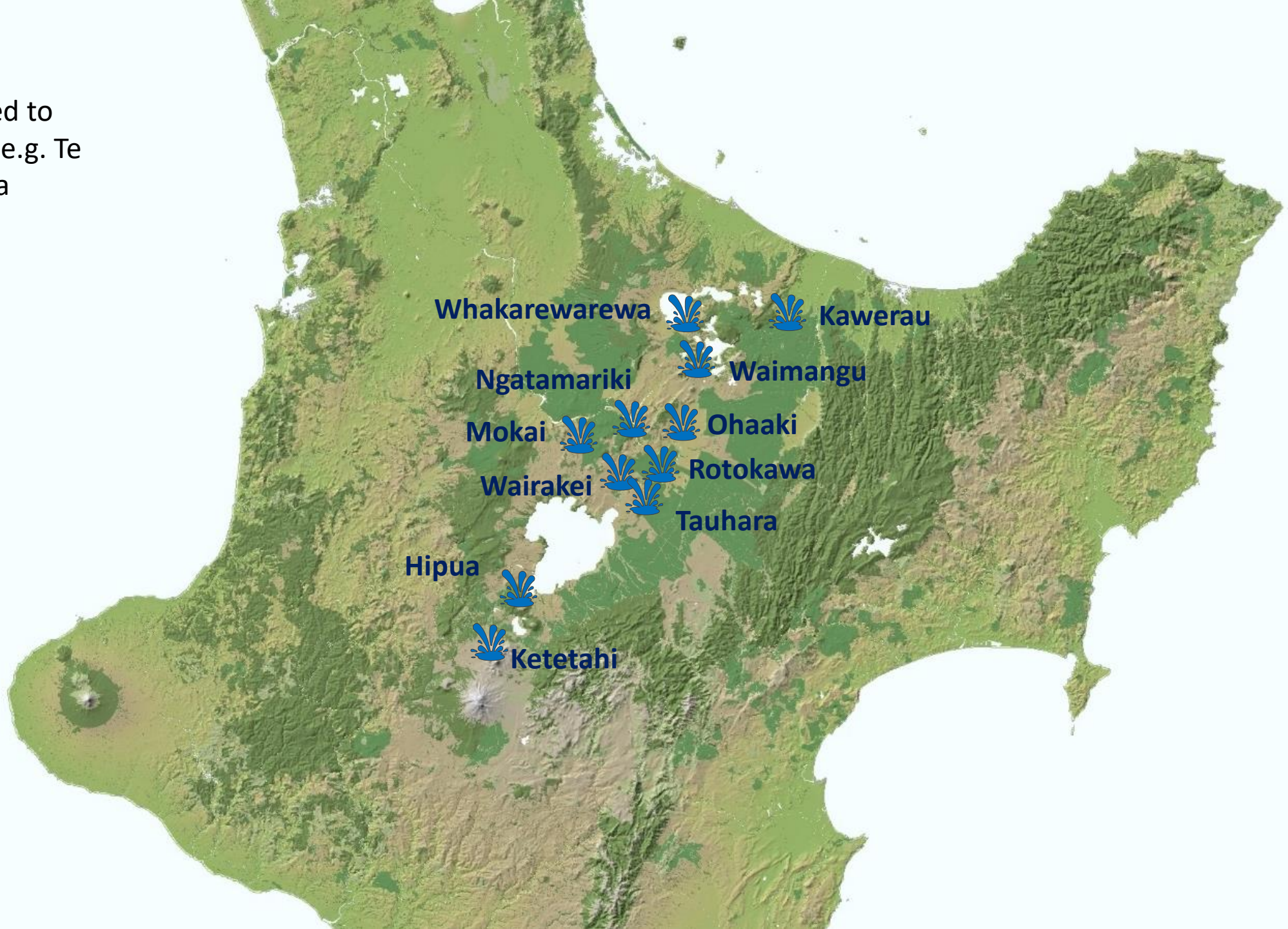


Hinenuitepo, the great goddess of the night, and she stayed in the dwelling place of Whakaruaimoko and had 21 children.

The children represent all the active processes we observe at the surface.

Knowledge recorded from 1865 by Hoani Te Whatahoro through wananga with Tohunga – Hector's Geology Map 1865

Ruaumoko
Other Tipua related to geothermal areas e.g. Te Pupu and Te Hoata

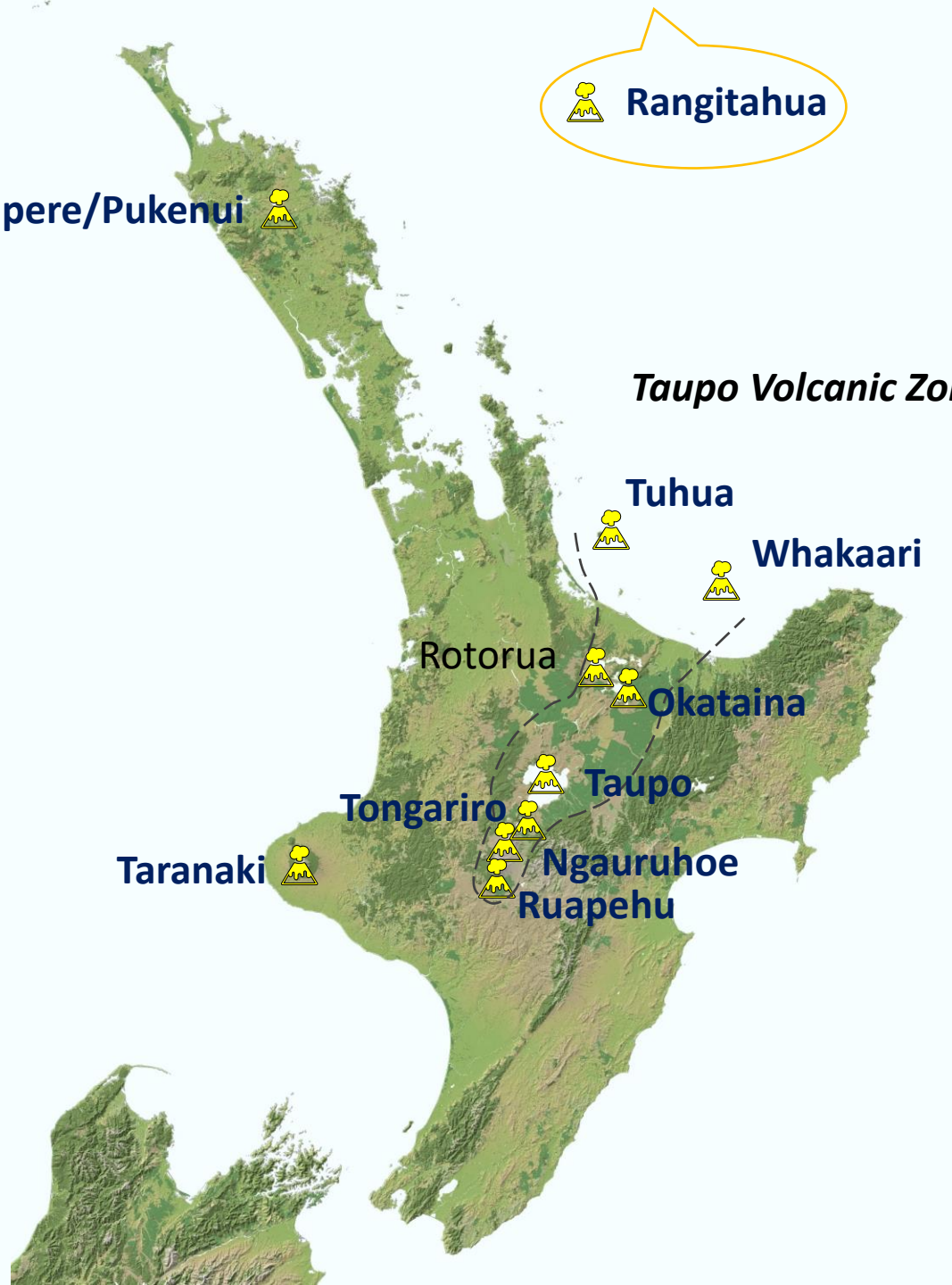


Connections to eruptions

- Rangitahua eruption clouds guiding Waka to Aotearoa 1000 yrs ago

- Ngatoroirangi defeating Tamaohoi to stop the Kaharoa/Tarawera eruption 700 yrs ago

- Ngatoroirangi calling for fire while on ngauruhoe 700 yrs ago



Taupo Volcanic Zone - Te Ahi Tipua

Taupo Volcanic Zone

Many explanations …

- *Top knot of Papatūānuku with strands connected through the land to the pacific ring of fire.*
- *Handprint of Maui*
- *Volcanoes represent blow-hole of the fish*
- *Lake Taupo "stomach" connecting to umbilical cord*

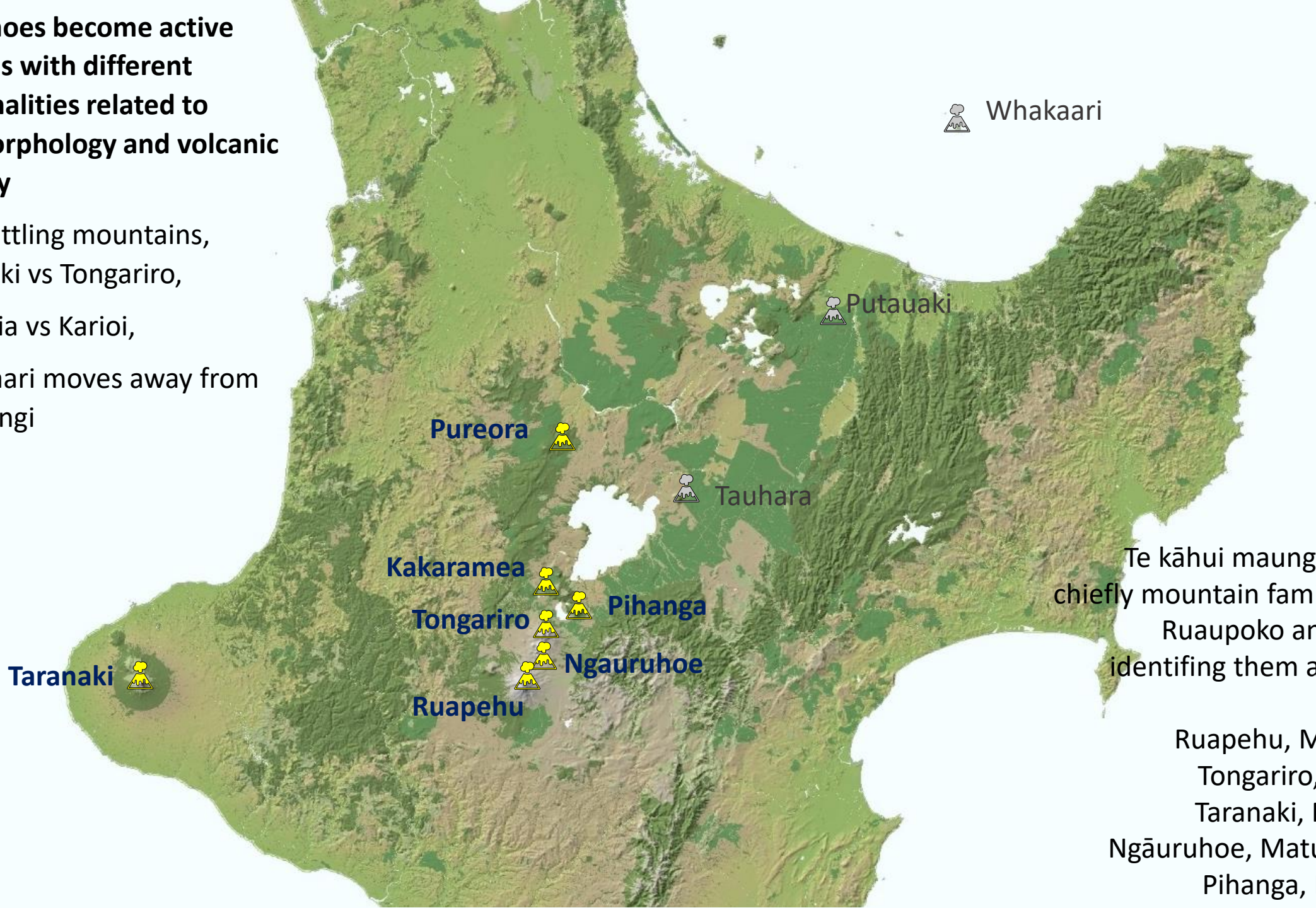
Various explanations much like our geochemists…

Volcanoes become active entities with different personalities related to geomorphology and volcanic activity

e.g. Battling mountains, Taranaki vs Tongariro,

Pirongia vs Karioi,

Whakaari moves away from Hikurangi



Te kāhui maunga tangata (the chiefly mountain family) created by Ruaupoko and given mana identifing them as individually;

Ruapehu, Matua te mana
Tongariro, Matua te toa
Taranaki, Matua te tapu
Ngāuruhoe, Matua te pononga
Pihanga, Matua te hine

Matauranga – a – iwi
stories of tapu, retribution, respect of the local environment

Horomatangi is said to be an old man and as red as fire. Thus the natives assert to have seen him. He lives in a cave on the island Motutaiko in the lake.

Ngaati Awa decide to maroon Te Tahi o te Rangi on Whakaari, an island In the Bay of Plenty which is an active volcano and is now known as White Island. But when Ngaati Awa have abandoned Te Tahi on the island and are paddling back to the mainland, the tohunga summons up a taniwha that carries him across the sea.

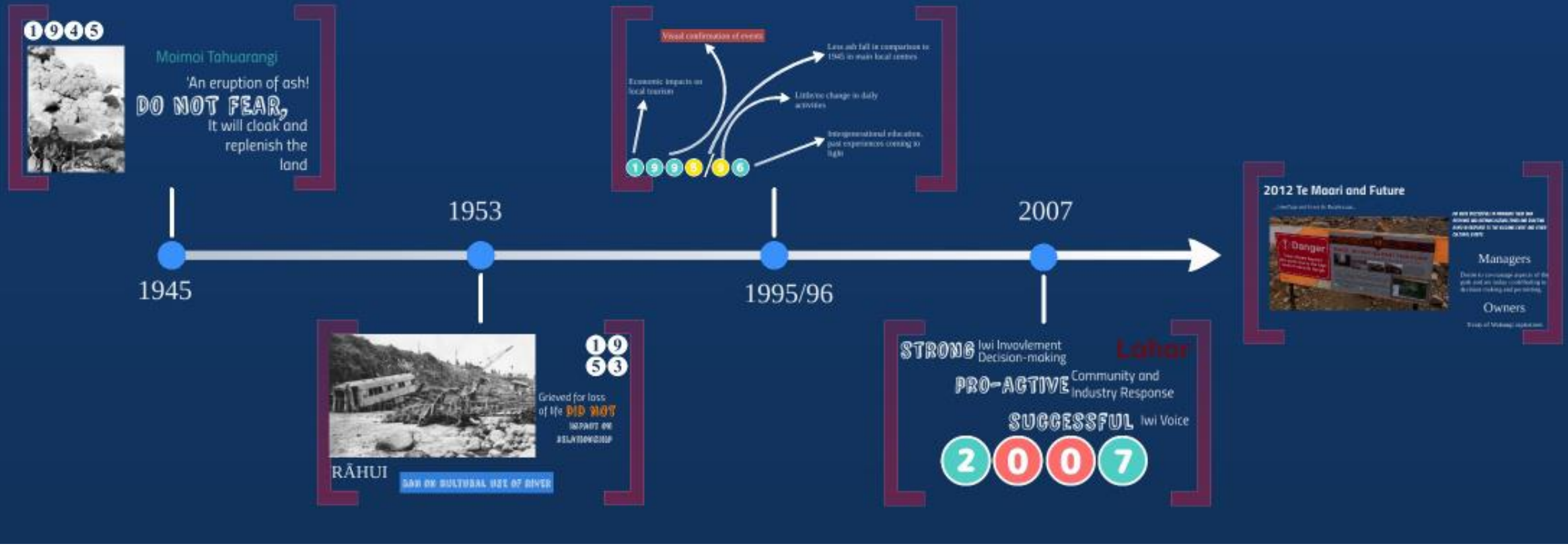
ko nga maunga nga mea e whakanuia ana e te tangata. E hau ana te rongo o ia maunga, o ia maunga ; ... e moiri-tahi ana te maunga, me te tangata ; e puta ana ki tawhiti, a, waihotia iho hei whakatauaki. Mountains are something that are revered by man. Each mountain is renowned ; ... a mountain and a person (chief) become associated together and known throughout by a proverbial saying.

The Māori state that because Tongariro mountain is tapu, they do not approve of Europeans going to that place

Mango-huruhuru now built a large house at that place, which was used by him and his people as a dwelling. Its name was Te Tapere-o-tutahi.

the old man that he would exercise his powers and bring some sands from Hawaiki, to improve his new home.

A dark cloud appears on the horizon, rapidly advancing towards the reciter, charged with a heavy burden of sand, with lightning flashing and thunders rolling.



Ngāti Rangi Paerangi – i – Te Whare Toka

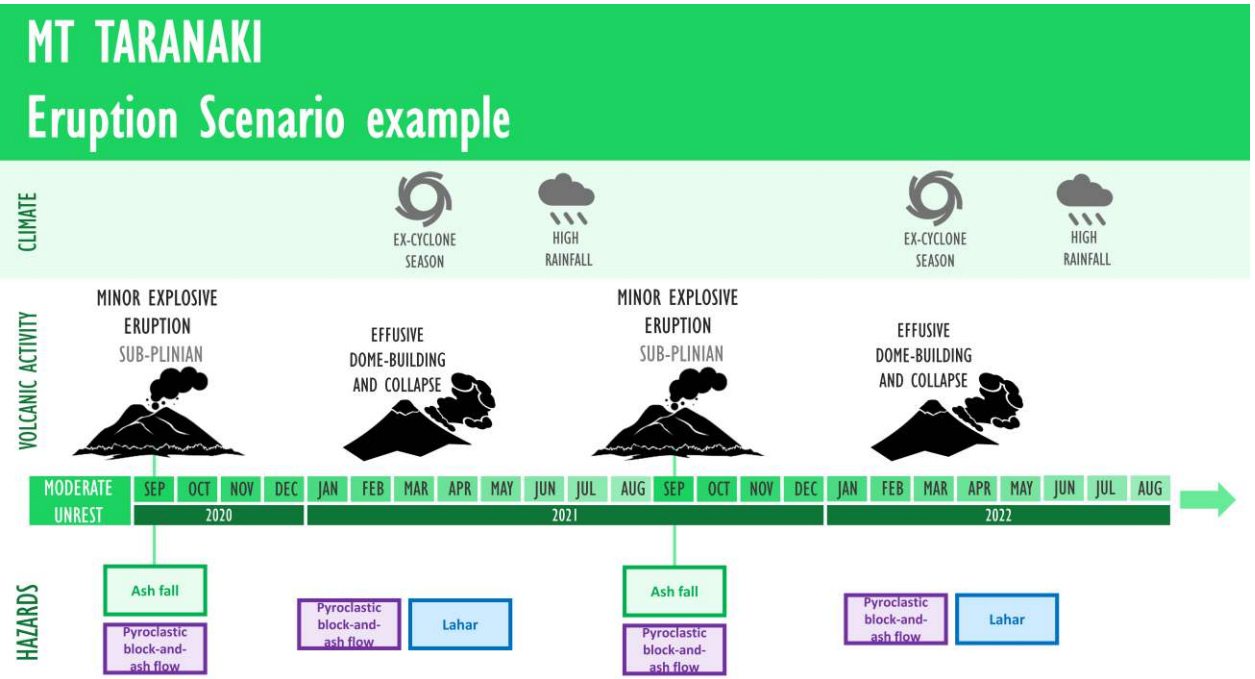
Te Matua o Te Mana

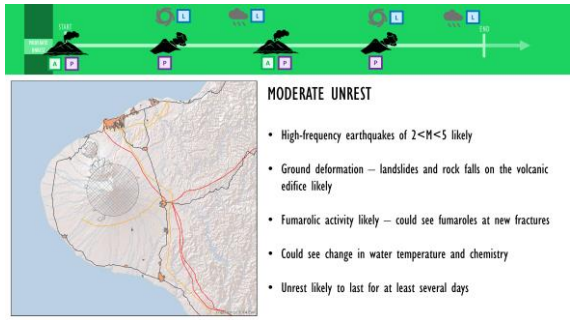
Our ancestor is not a volcanic ~~HAZARD~~

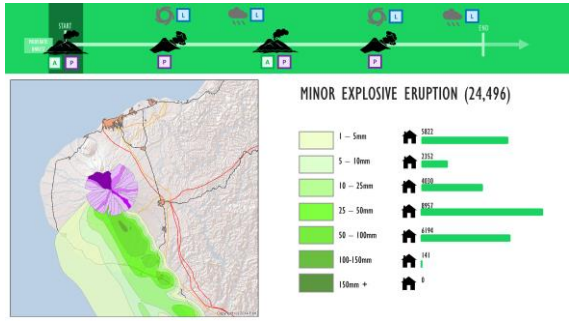
A living memory of responding and recovering to events

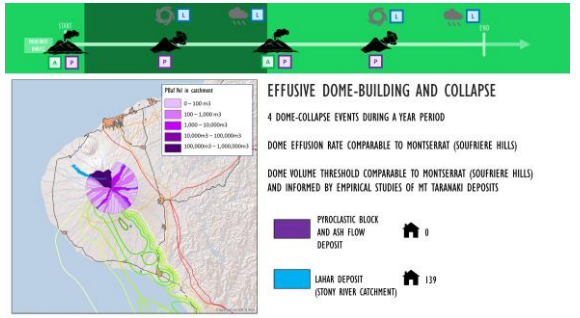
Taranaki

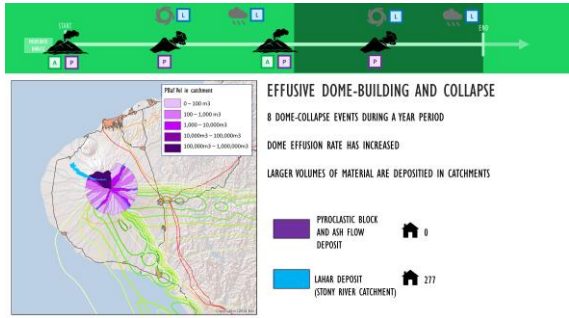
Scenario Modelling for Risk/Impact

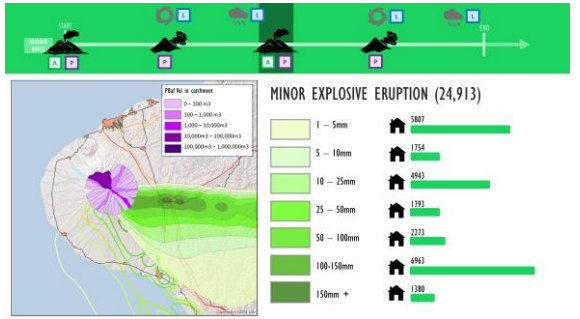


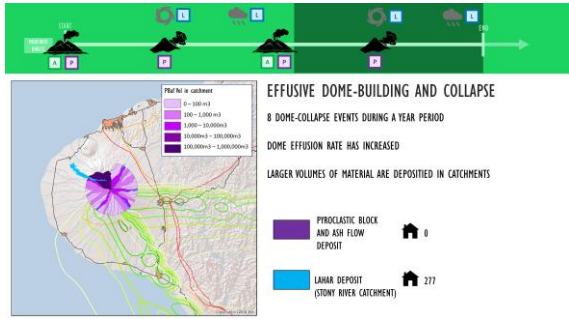








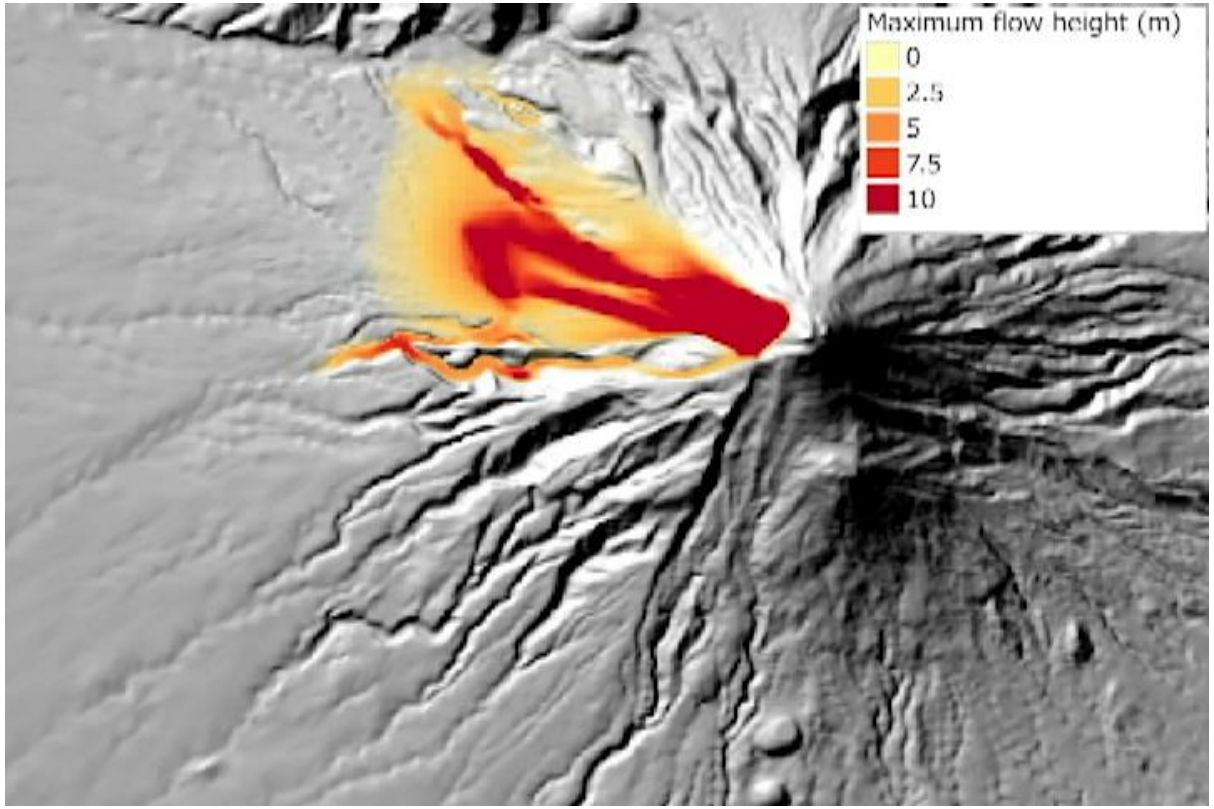




Alana Weir and Stuart Mead

Probabilistic modelling for Taranaki

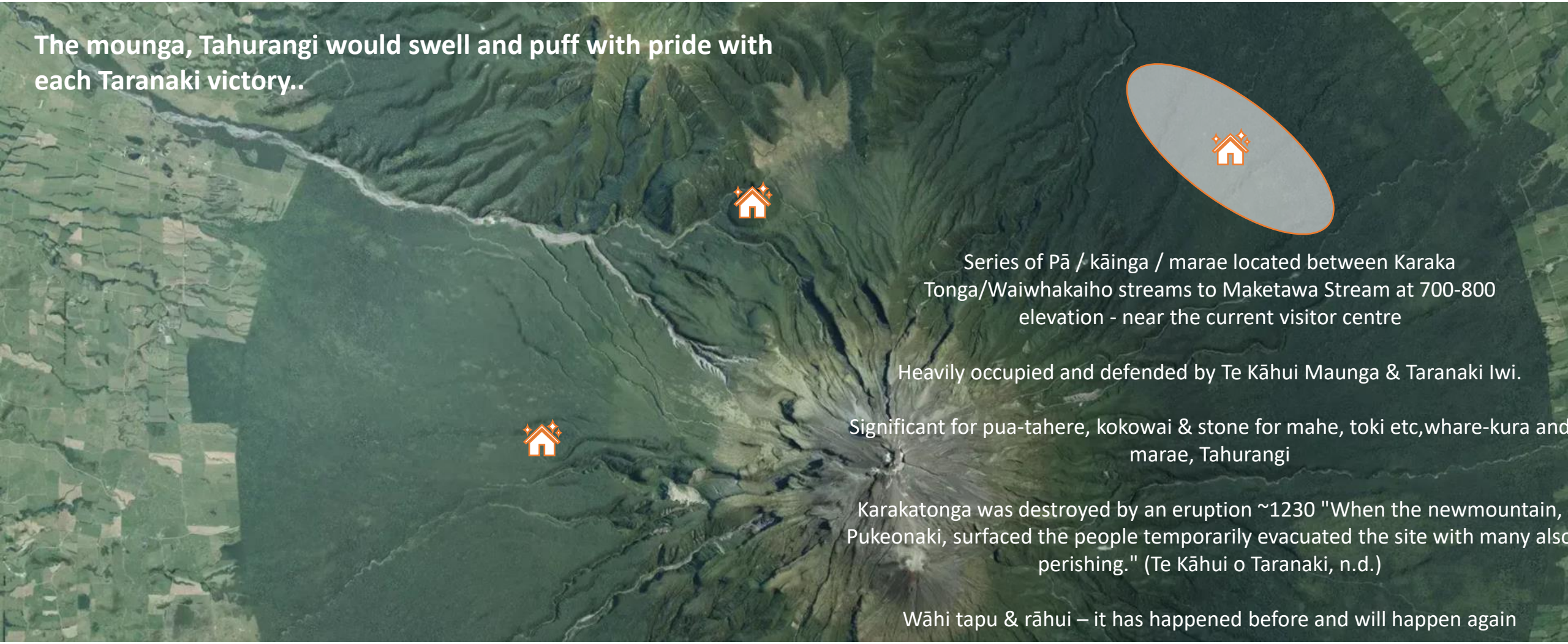
- Egmont NP hazard is ultimately conditional on an eruption (~35-38% chance of 1 or more in next 50 years)
- Following an eruption, hazardous phenomena is likely within ~900 m contour. Vulnerability is most probably binary.
- Monitoring and decision making will be essential in unrest.



Event	Estimated probability	Comments
One or more eruption of Mt. Taranaki in the next 50 years.	0.35 – 0.38	Expert elicitation suggests the most likely next eruption size is VEI 3.
Ashfall affecting North Egmont Visitors Centre requiring moderate repair to replacement.	0.4 following an eruption	Assuming moderate damage begins at ~100 mm of ashfall.
Debris avalanche at Mt. Taranaki	0.00018 per year 0.03 – 0.3 following a VEI4 or larger eruption.	
Debris avalanche affecting North Egmont Visitors Centre.	~ 0.238 if a debris avalanche is triggered.	
Pyroclastic flow travelling further than North Egmont Visitors Centre	0.58 following a VEI 2 eruption 0.90 following a VEI 3 eruption >0.95 following a VEI≥4 eruption	
Pyroclastic flow affecting North Egmont Visitors Centre	≥ 0.41 given an eruption and pyroclastic flow	Topographic position suggests damage to non-structural elements and wood-framed buildings
Block-and-ash flows near North Egmont Visitors Centre	0.6 for flow heights ≥2 m following an eruption and dome collapse (current configuration) ~0.1 for flow heights ≥4 m following an eruption and new dome growth episode	Probability of a dome growth episode is ~0.73 (Ogburn et al., 2015; Procter et al., 2019) Topographic position suggests damage to non-structural elements and wood-framed buildings.

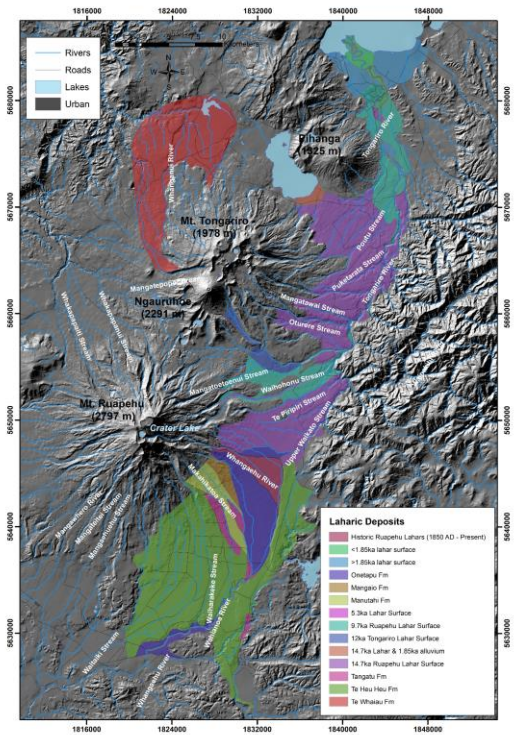
Taranaki

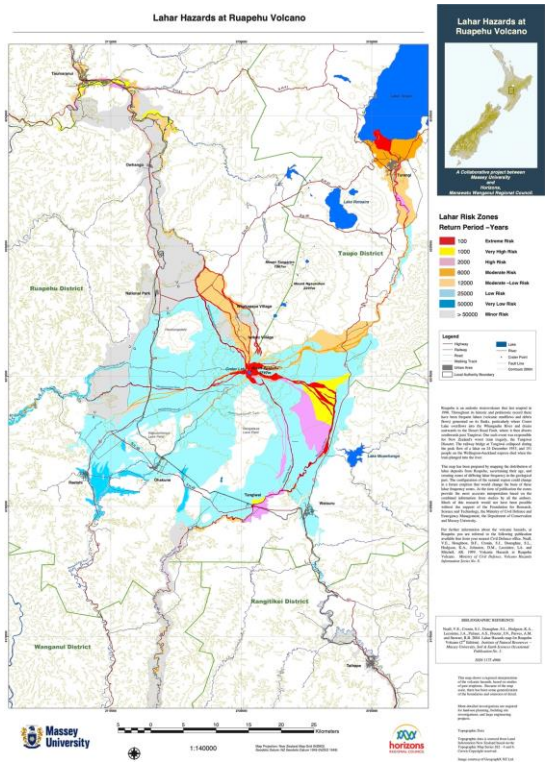
A tahu atu koe te ahi a Tahu-rangi Whakautu i runga rāka ngangana i te rangi, nā-ī. Spark of immortal fire, thou shalt fan ***That flame vulcanian, Tahurangi' fire When heavenward shoots its radiant columned plan*** **(Stowell 1911:155-157)**



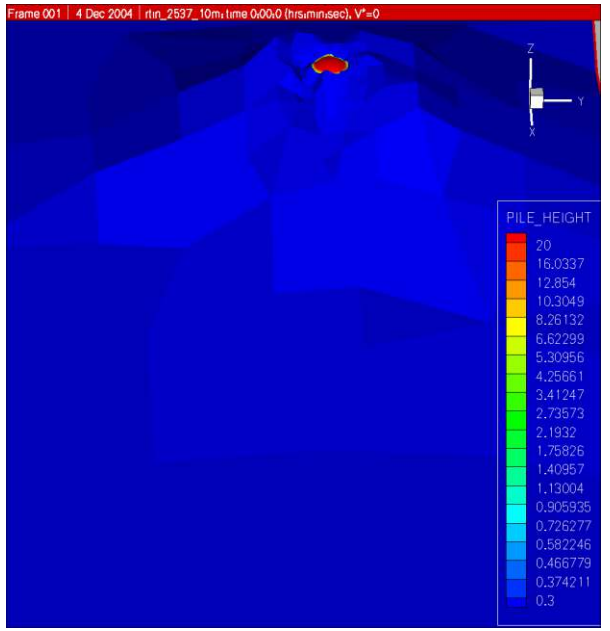
Ruapehu Hazard Zones

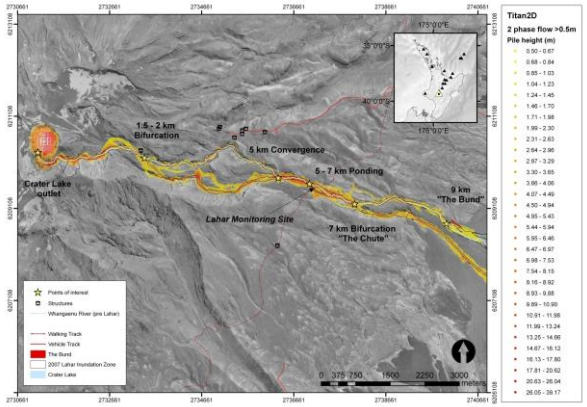
Observing the lithologies





Simulation of different events/building scenarios of activity





Determining Frequency/Magnitude

Ruapehu

The mountains also had kaitiaki and tipua. Stories about the guardians of the mountains – Te Ririo (ruler of the patupaiarehe), Takakā, Tarapikau, Taunapiki, and Rangitaiki

Series of Pā / kāinga / marae that acted as traditional astromical and volcanological observatories by matakite

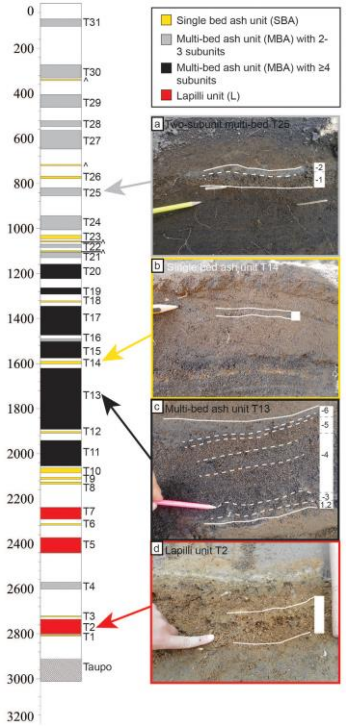
Recognition of a number of different volcanic phenomena and manifestations in the environment that were monitored by tangata tiaki

Te Wai a Moe, the sweat gland of Koro

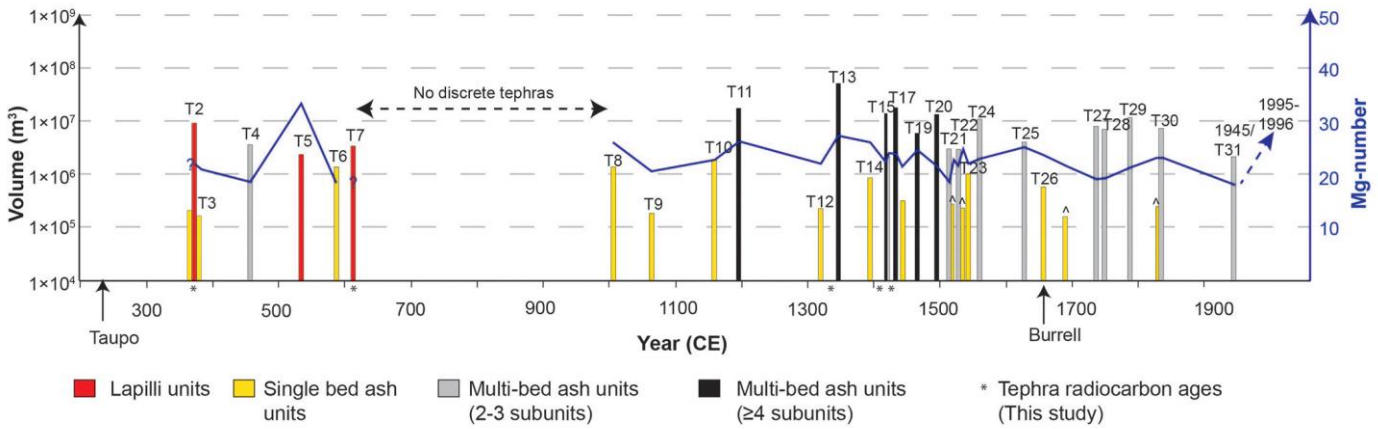
Traditional practice of have tohunga to guide you across recognised hazardous zones e.g. Te One Tapu – guided at certain times, no fires, eyes sheltered by kawakawa leaves, moved through areas quickly

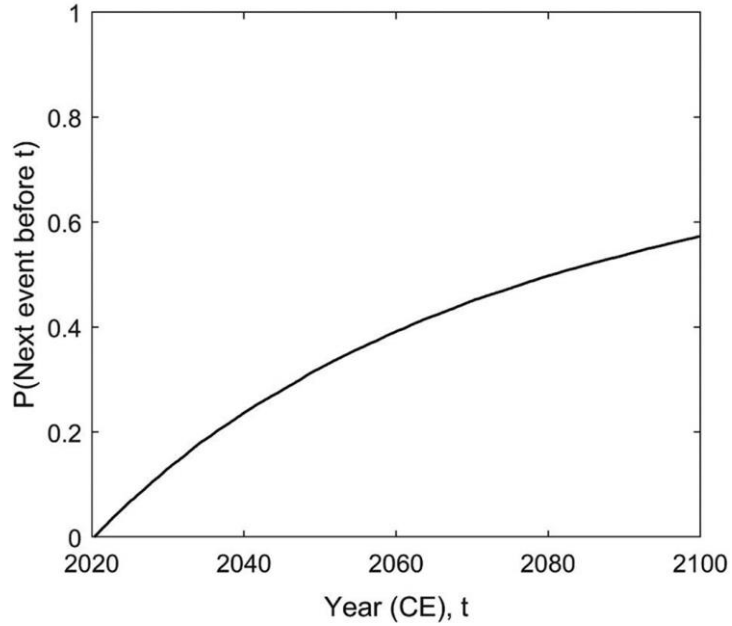
Rāhui regularly applied to lahars, volcanic activity pre and post event

Time-varying multi-hazard forecasting:
Develop new models to forecast the long-term time-varying multi-phase multi-hazards of NZ's cone volcanoes.



Mt. Ruapehu – the last 2000 yrs





- The current regime is most likely a medium rate state with one eruption every ~40 years.
- The next eruption with a magnitude equal or larger than those preserved in the Tufa Trig Formation has a median forecast date of 2079 CE.
- For Mt. Ruapehu, the probability of another phase following any current phase is approximately 54%.
- Intra-sequence models show that eruption volumes increase with eruption progression.

➢ **Informing new risk assessments for Tongariro National Park**

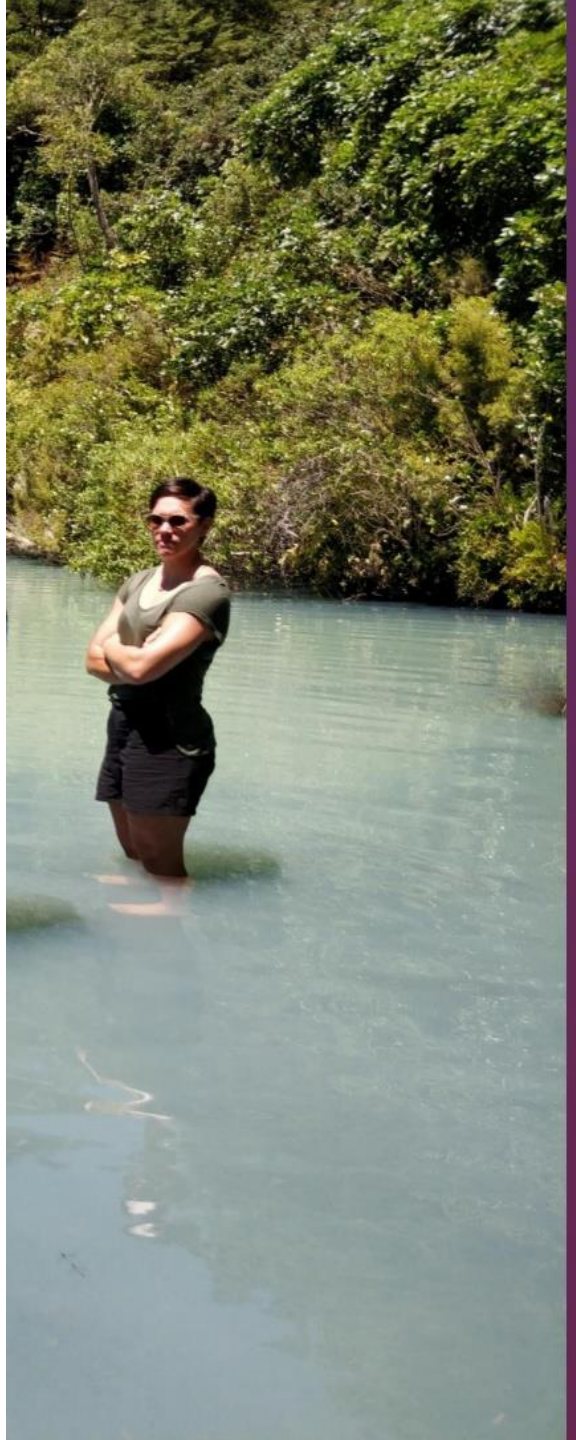
Understanding cycles of eruptions for Tongariro & Ruapehu

- Understanding of Te Maari eruptions as being related to generations of leaders
  - Te Maari/Ketetahi Erupts everytime one of our Ariki passes away.

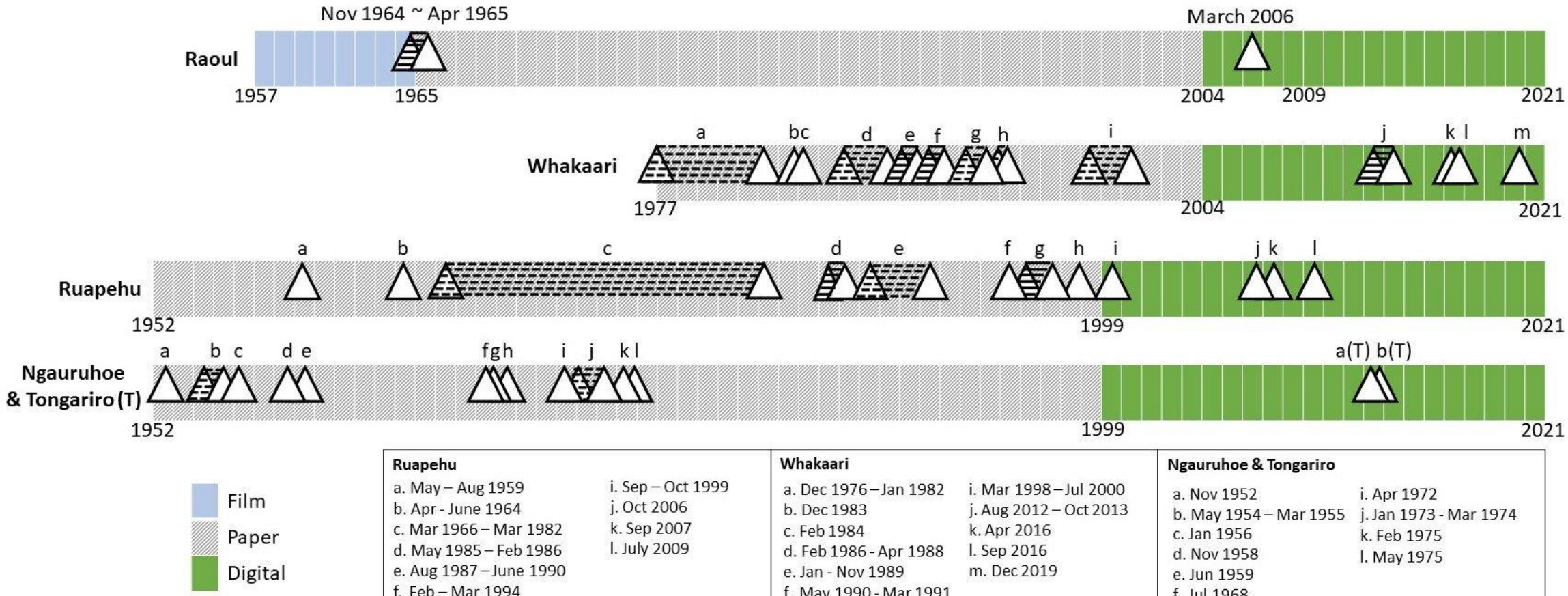
- Ruapehu 1945 “Do Not Fear – The land will be nurtured and fertile.”
  - Eruptions related to fertile land – crop rotations, 7-10 year cycles?

- Te Wai Moe – Larger eruptive processes related to Tohunga/Rangatira being placed in Crater Lake?

Ruapehu Tohu



Seismic data yet to be exploited



Ruapehu		Whakaari		Ngauruhoe & Tongariro	
a. May – Aug 1959	i. Sep – Oct 1999	a. Dec 1976 – Jan 1982	i. Mar 1998 – Jul 2000	a. Nov 1952	i. Apr 1972
b. Apr - June 1964	j. Oct 2006	b. Dec 1983	j. Aug 2012 – Oct 2013	b. May 1954 – Mar 1955	j. Jan 1973 - Mar 1974
c. Mar 1966 – Mar 1982	k. Sep 2007	c. Feb 1984	k. Apr 2016	c. Jan 1956	k. Feb 1975
d. May 1985 – Feb 1986	l. July 2009	d. Feb 1986 - Apr 1988	l. Sep 2016	d. Nov 1958	l. May 1975
e. Aug 1987 – June 1990		e. Jan - Nov 1989	m. Dec 2019	e. Jun 1959	
f. Feb – Mar 1994		f. May 1990 - Mar 1991		f. Jul 1968	
g. Jan 95 – Sep 1996		g. Feb 1992 - Apr 1993		g. Dec 1968	a(T). Aug 2012 (Tongariro)
h. Oct 97 – Jan 1998		h. Oct 1993 – Mar 1994		h. Jul 1969	b(T). Nov 2012 (Tongariro)

Eruption records

Ra: Christenson et al. (2013)

Ru: Scott (2013)

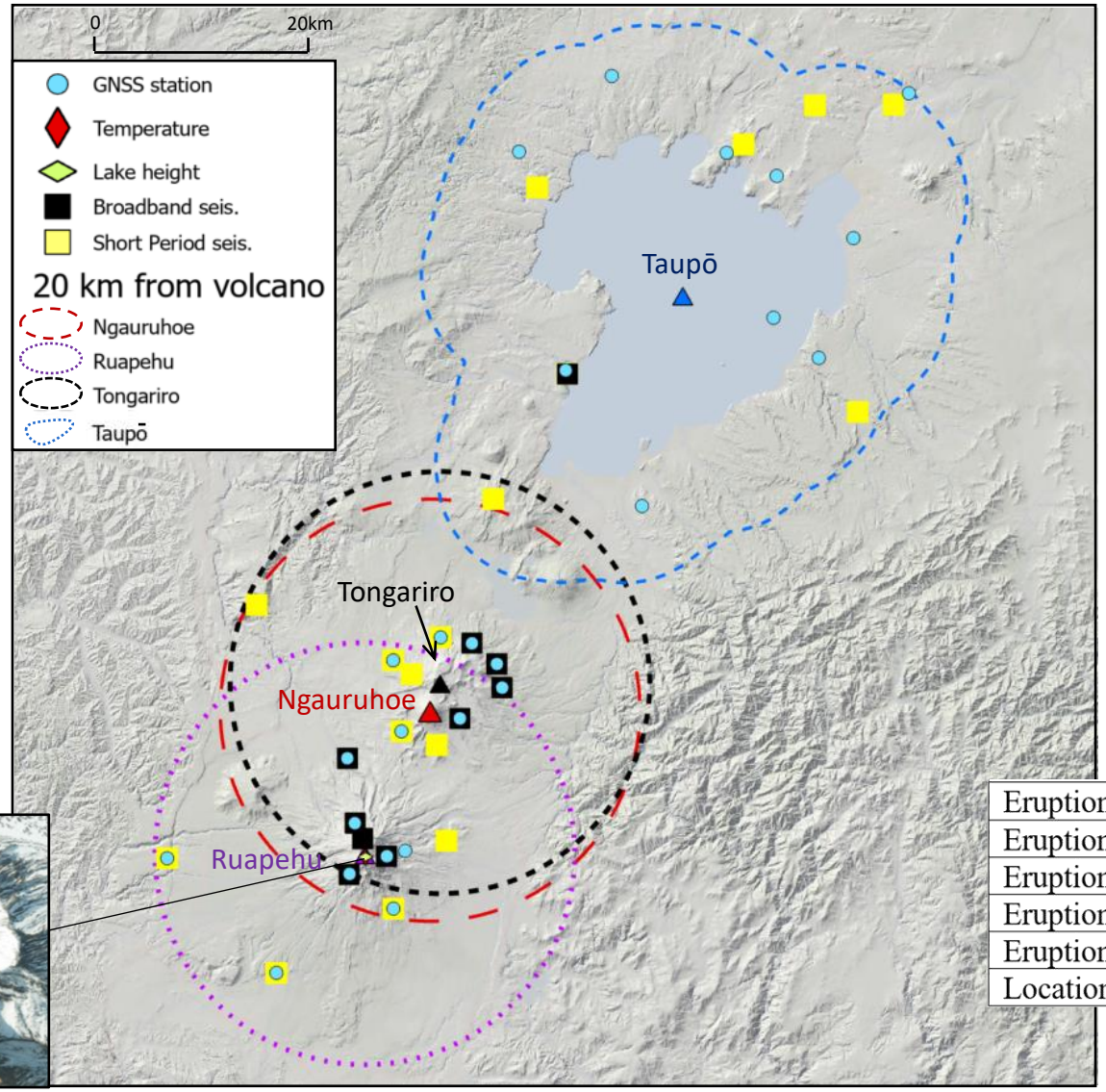
Ng: Latter et al. (1985), Hobden et al. (2002)

To: Scott and Potter (2014)

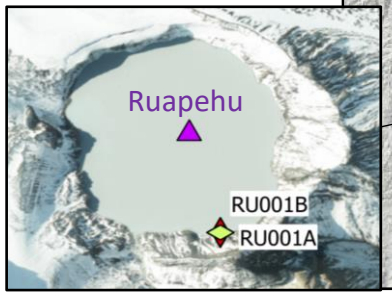
Wh: Kilgour et al. (2021)

Whitehead, M. G., Bebbington, M. S., Procter, J. N., Irwin, M. E., & Viskovic, G. P. D. (2022). **An initial assessment of short-term eruption forecasting options in New Zealand.** *New Zealand Journal of Geology and Geophysics*, 1-18.

Ruapehu Volcano



10 GNSS station
Temperature
Lake height
6 Broadband seis.
7 Short Period seis.



Sufficient seismic stations (> 6 broadband) suggests relative ease of application of but data longevity is a limiting factor.

	Expert Interpretation	Event Trees	Belief Networks	Belief Networks with training	Failure Forecasting	Process/Source based	Machine Learning
Eruption onset time							
Eruption size							
Eruption style/type							
Eruption duration							
Eruption specific hazards							
Location specific parameters							

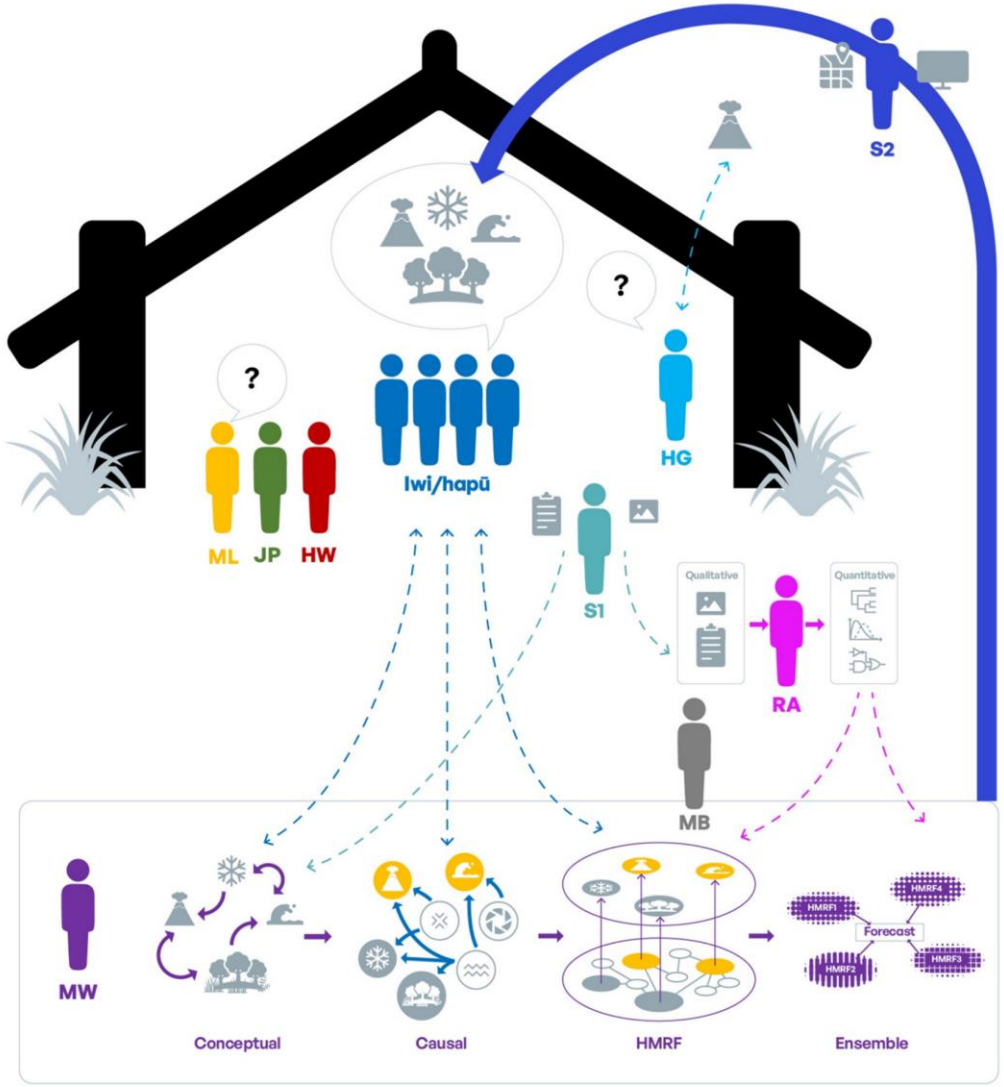
Negligible effort/time | Medium effort/time | Significant effort/time
Some effort/time | Not currently feasible

The Future…

Matatuhi

Unlocking the forecasting potential of environmental tohu via ensemble systems models

Tohu and tohunga/matakite driven expert elicitation



Research Plan and Team

Key Concepts for Māori…

maybe for Earth Science?

- **Whakapapa**
  - We are all connected
- **Ahi Kaa**
  - We are connected to place that are part of our whakapapa and that connection will never be broken
- **Kaitiaki/Atua**
  - There is an element of respecting and balancing all entities in the environment
- **Whakapaparanga** *(Generational Outcomes)*
  - Thinking, decisions and plans are longer term with outcomes benefiting the next generations; wise use of resources
- **Matatau** *(Survival/Endurance/Adaption)*
  - There is no concept of hazard and risk, paramount is for the next generation to thrive and flourish

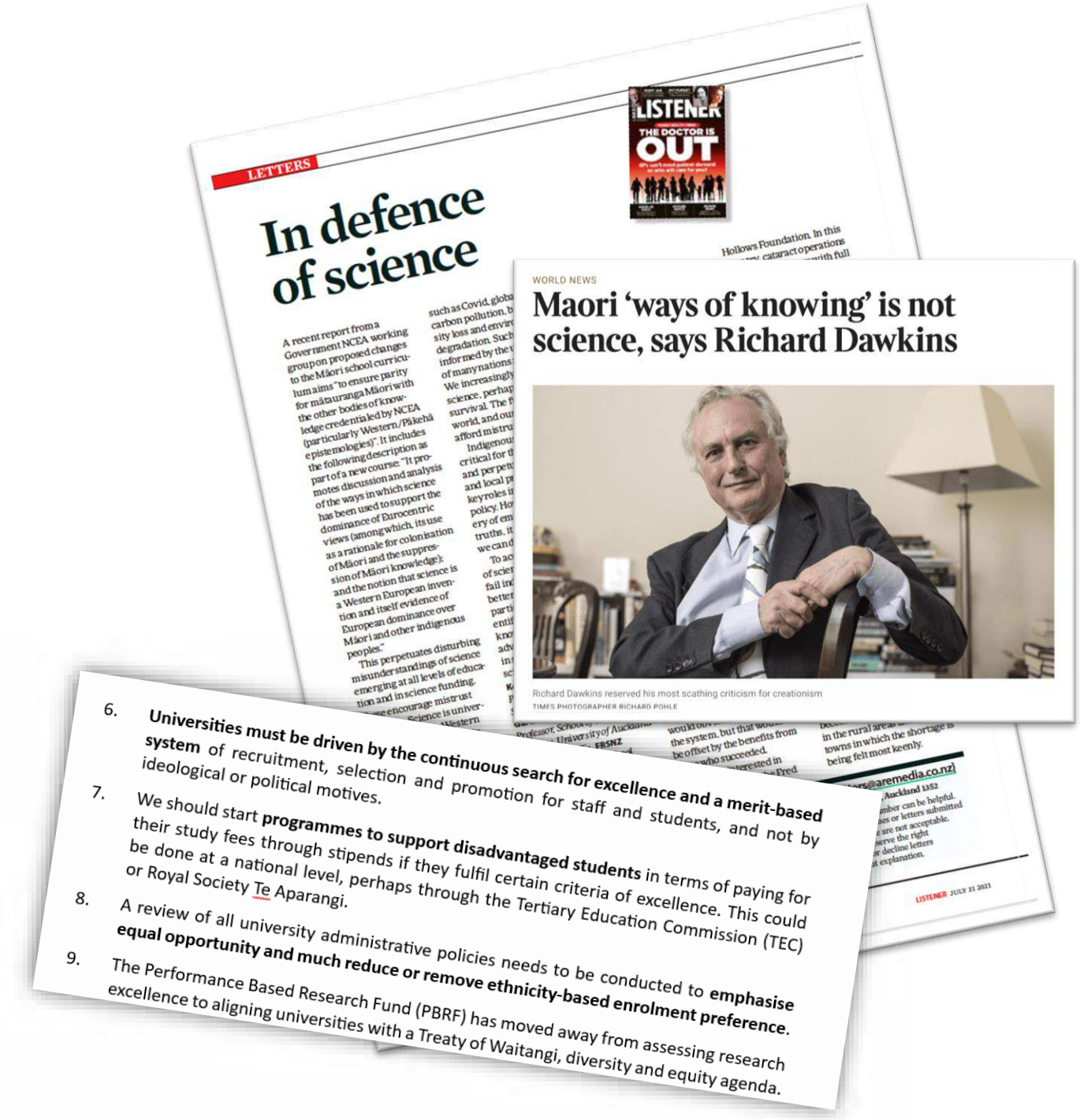
- *Wairua /Hauora – elements of caring for the wellbeing of all*
- *Te Ao Turoa – need to understand the world around us*

Problems for Earth Science in NZ- the real issues

- Caught in political cross-fire
- Played out in the Media
- Associated to mining/oil/gas industry
- Perceived as "*stamp collectors*" not problem solvers

- Our children are not engaging in STEM
- Māori and Pacifica are disproportionally affected

- Earth Science Curriculum will contain Mātauranga Māori and focus on Space, Observation/analysis and People/climate



The share of children who are Māori is projected to increase from 27 percent in 2018 to 33 percent (about 1 in 3 children) in 2043.

You have to adapt to new situations all the time.

(Durie et al, 2012)