

"The origin and history of the still active Volcanic Province of western Victoria"

Ray Cas

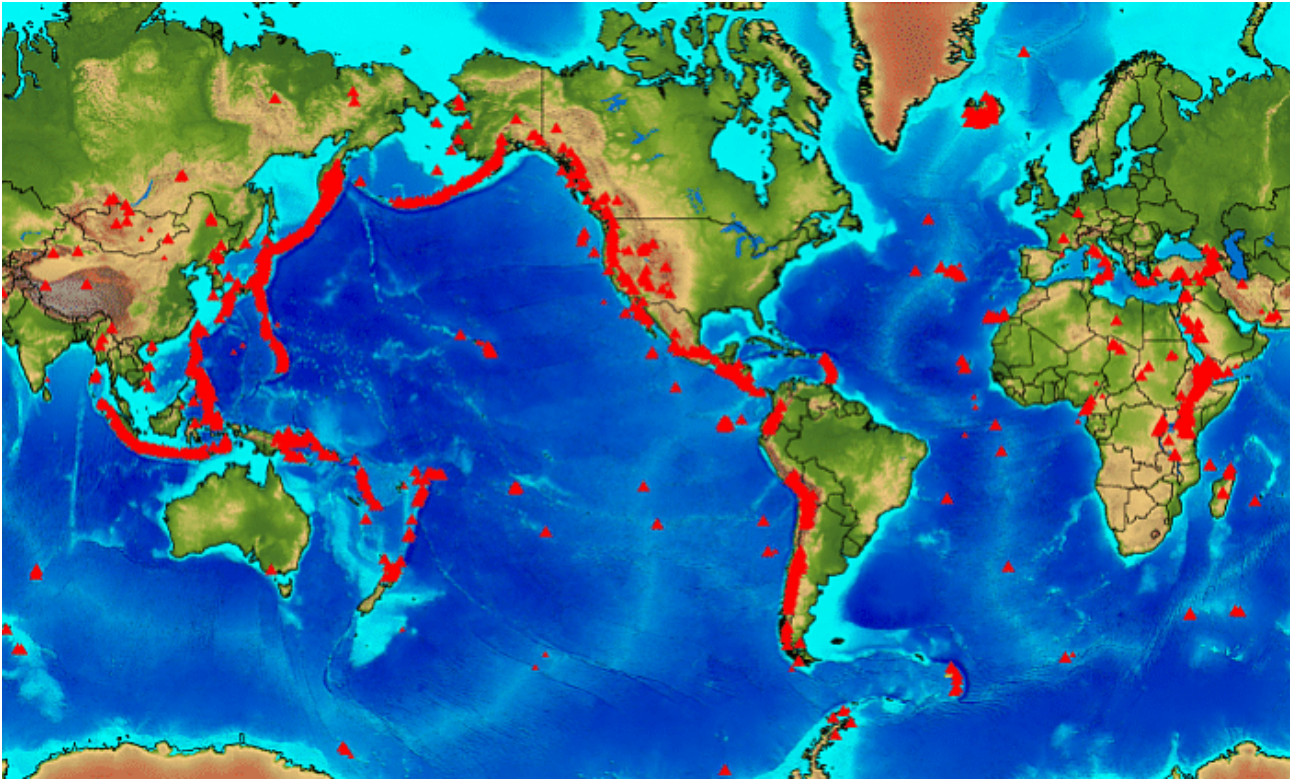
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INTRODUCTION

- We associate large volcanoes with the Pacific Ring of Fire



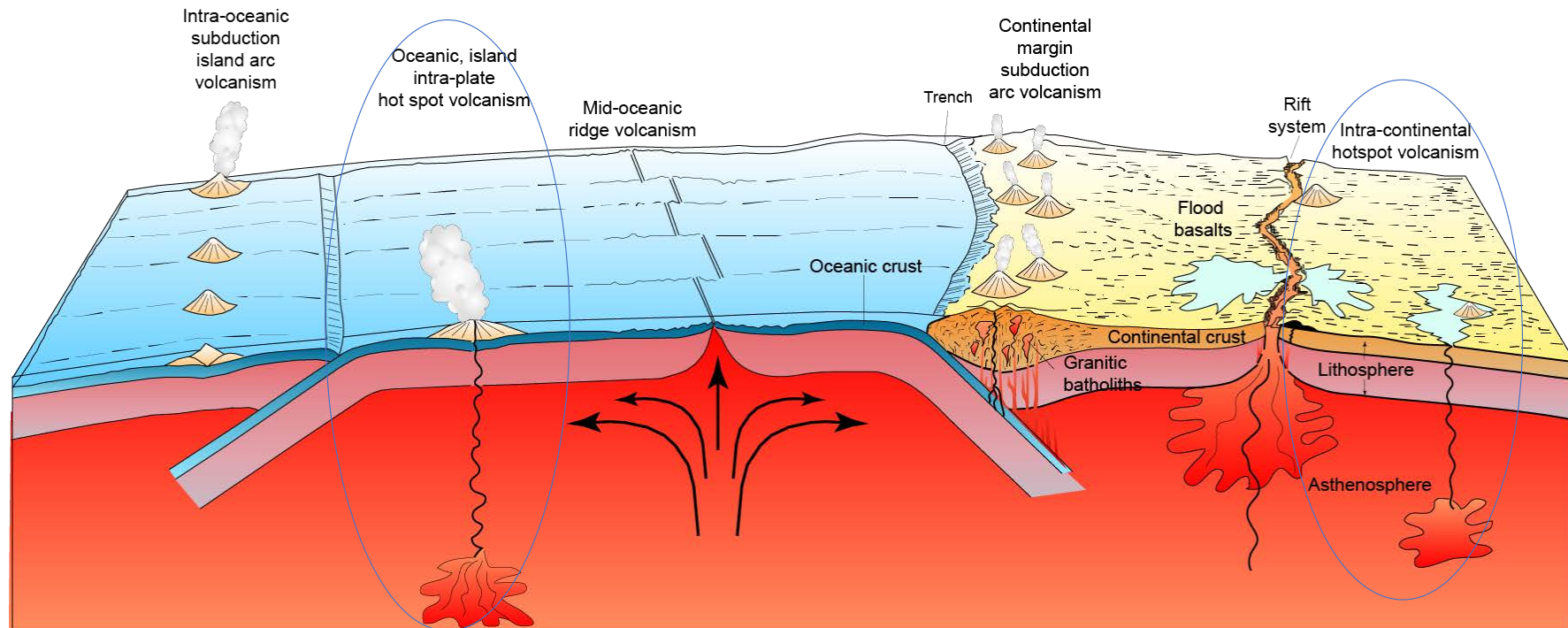
e.g. Tongariro, Ngauruhoe, Ruapehu, N Zealand



e.g. Mt Fuji, Japan

INTRODUCTION

- The Ring of Fire volcanoes defines where oceanic lithospheric plates sink back into the Earth's interior
- However, “Monogenetic” *intra-plate* continental basaltic volcanic provinces (ICBVPs) can form away from these plate margins, where the Earth's interior is anomalously hot



INTRODUCTION

- ICBVPs are very widespread, complex, multi-volcano, long lived, volcanic systems
 - Consist of multiple, widely dispersed, largely *monogenetic* volcanoes
- Erupted magma volumes of ICBVPs is comparable to large polygenetic volcanoes (e.g. explosive calderas, stratovolcanoes)
 - $\sim \pm 1,000 \text{ km}^3$
- But,
 - ICBVPs lack a single central magma source/conduit, and can be longer lived
 - Erupted volumes from single volcanoes $\ll 1 \text{ km}^3$
- ICBVPs are NOT flood basalt provinces

INTRODUCTION

- What we DON'T understand very well about ICBVPs:
 - Why they form where they do
 - What causes them to form
 - Where and when the volcanoes in these provinces erupt
 - are there systematic patterns of volcanism in space and time?
 - Their eruption frequency

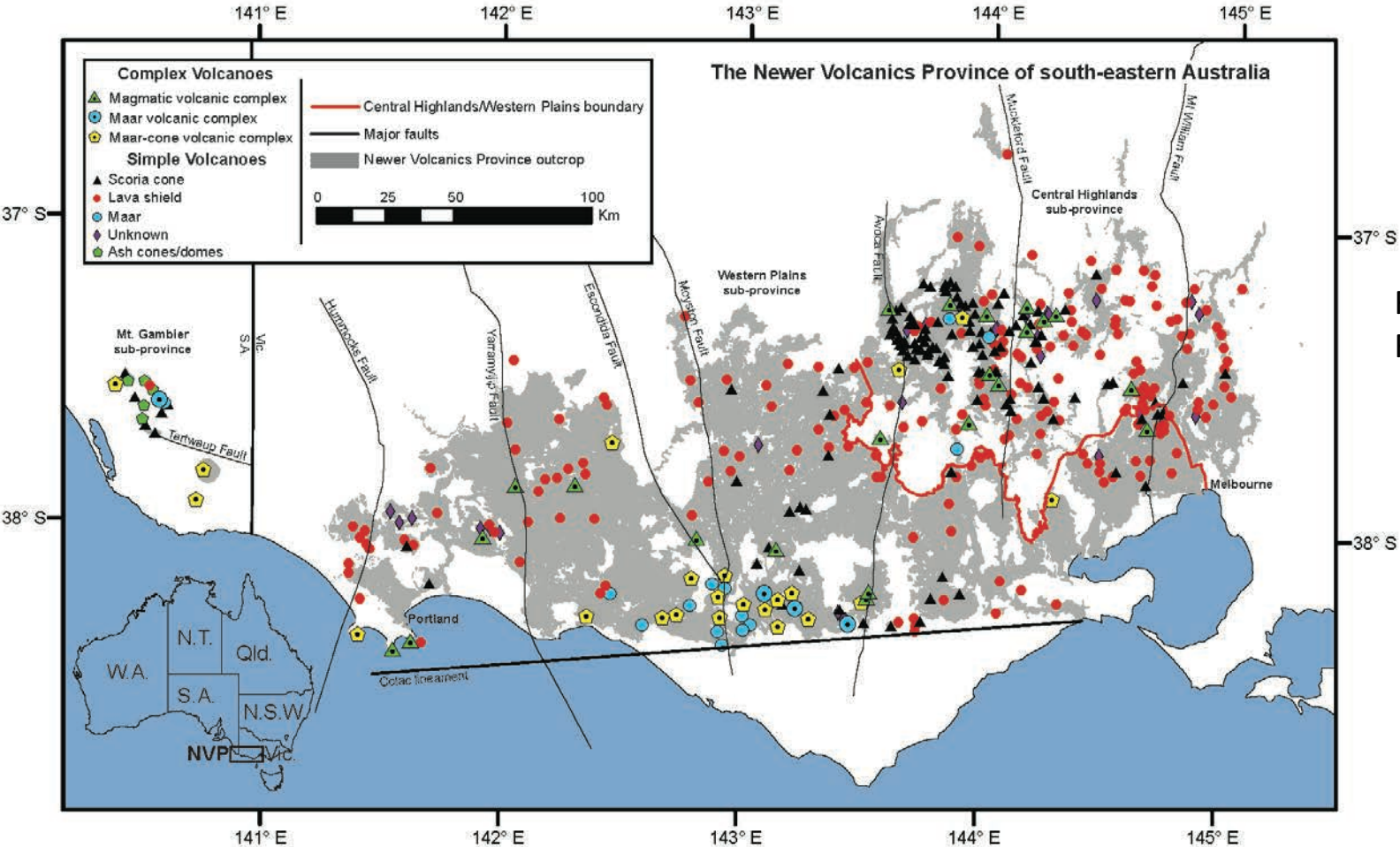
AIMS – Summarise what we know about the Newer Volcanics Province

- Use multiple tools, including
 - Volcanology
 - Geophysics
 - Geochemistry
 - Geochronology
- Reflect on some hazards from future eruptions in the NVP

NEWER VOLCANICS PROVINCE

- Australia's only active volcanic province ?
- Area >23,000 kms²
- One of the largest ICBVPs on Earth
- Erupted volume of magma (DRE) < 886 km³
- Consists of plains forming basalt lavas, and over 400 volcanoes, extending from
- Melbourne (pop. ~ 4 million) lies on the eastern margin, to Mt Gambier in southeastern South Australia
- Canberra, Sydney, Wellington and Auckland lie "downwind"

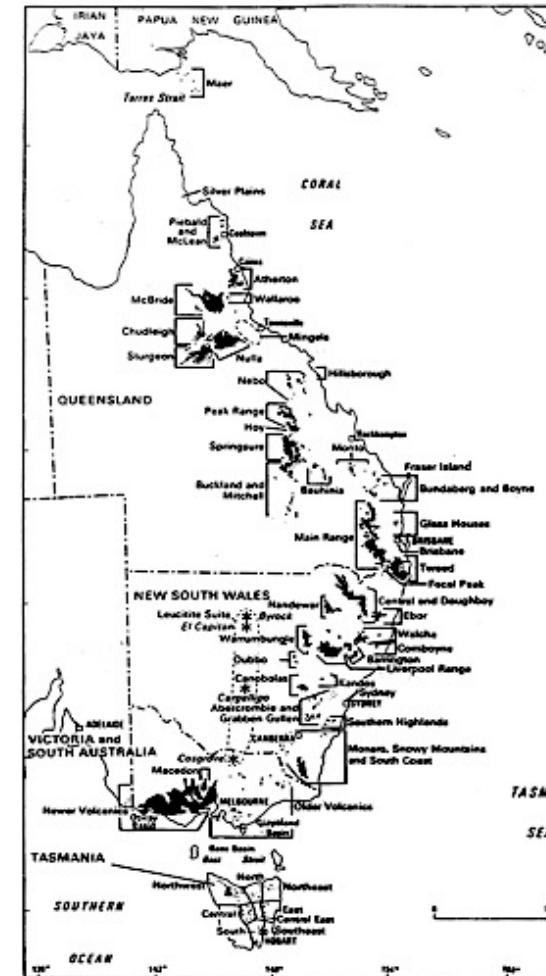
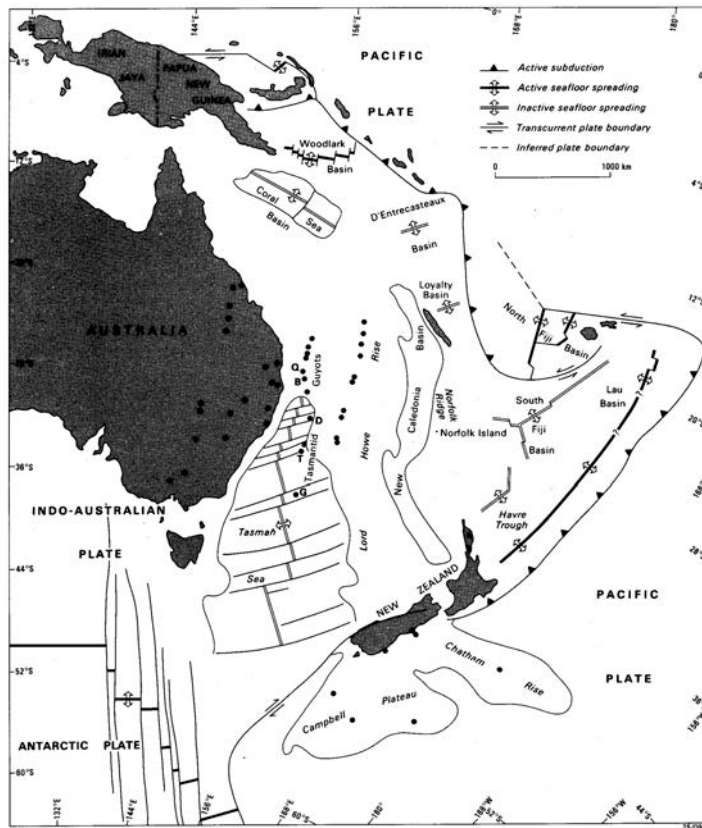
NEWER VOLCANICS PROVINCE



From Boyce 2013, Fig. 1, after Joyce 1975

Eastern Australia Volcanism in the last 90 Ma

- Volcanism began along Australia's eastern seaboard after the break-up of the supercontinent Gondwana
- Not related to tectonic plate margins such as the Ring of Fire



NEWER VOLCANICS PROVINCE

- Eruption activity began ~ 6 - 8 Ma (Edwards et al., 2004; Cayley et al. 1995),
- There are 400+ volcanoes in the NVP
- Eruption frequency
 - ~ 50 per 1 million years., or
 - ~ 5 per 100,000 years, or
 - ~ an eruption about every 20 – 15 kyr**
 - Last eruption ~ 5,000 years ago, at Mt Gambier
 - **-> dormant but still active volcanic province**

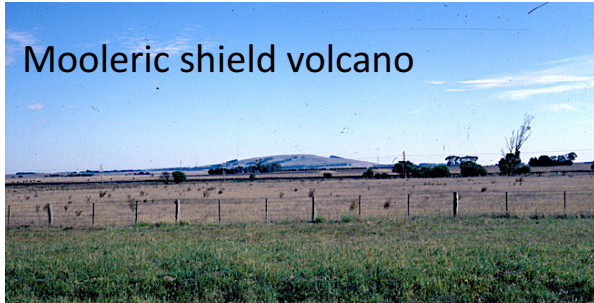
[Ages of some local volcanoes:

- Mt Napier: ~ 46 ka
- Mt Eccles, Tyrendarra: ~ 55 ka
- Mt Rouse: ~ 283 ka
- Source: Oostingh et al. (2017)]

NVP VOLCANOES & ERUPTION STYLES

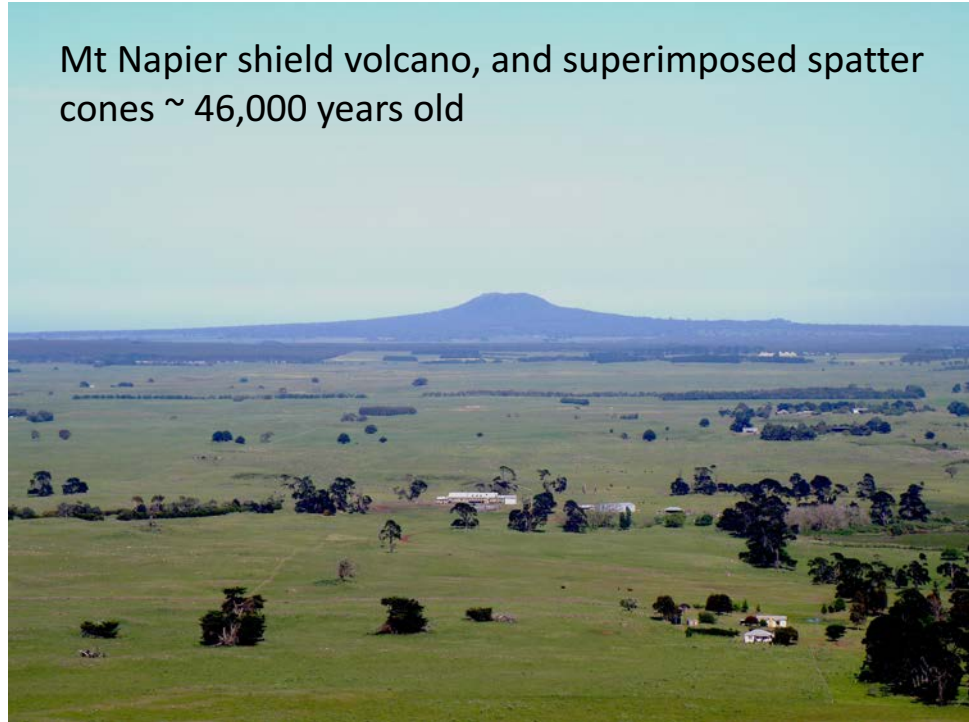
Small lava shield and cone volcanoes and relatively small lava flows (< 60 kms long)

Mooleric shield volcano



1969-1970 Mauna Ulu shield volcano and lava flow, Hawai'i

Mt Napier shield volcano, and superimposed spatter cones ~ 46,000 years old



NVP VOLCANOES & ERUPTION STYLES

Small lava shield and cone volcanoes and relatively small lava flows (< 60 kms long)

- Result of magmatic effusive and fire fountaining eruptions (e.g. Hawai'i)



Pu'u O'o volcano eruption, Hawai'i, 1983-1984

NVP VOLCANOES & ERUPTION STYLES

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Pahoia lava flow, Pu'u O'o volcano eruption, Hawai'i, 2014

NVP VOLCANOES & ERUPTION STYLES

Small lava shield and cone volcanoes and relatively small lava flows (< 60 kms long)

- Some lavas are sheets, some are valley confined



Sheet plains lava flow east of Camperdown



Valley confined 46 ka Harman Valley lava flow, Port Fairy Rd lookout

Features of the NVP lava flows: lava channels and levees

- As lava flows from the vent, the margins cool, solidify and become natural levees that confine the active lava channel



Open lava channel, with cooled natural levees,
1973 Heimay eruption, Iceland



Levees, 46 ka Harman Valley lava flow,
Wallacedale



~ 133 ka Mt Eccles lava channel
and levees

Features of the NVP lava flows: lava tubes, caves and skylights

- On lower slopes the surface of the lava cools, forms a solid crust
- This insulates the lava in the underlying roofed over lava tube from losing heat
- When the eruption stops lava drains downslope in the tube forming caves, the roofs of which can collapse



Lava tube and skylight,
1970 Mauna Ulu lava flow,
Hawai'i

Byaduk lava caves,
46 ka Harman Valley lava flow



Features of the NVP lava flows: tumuli

- Sometimes the pressure in the lava inside an enclosed lava tube can cause the roof crust to bulge upwards forming blister like features called tumuli



Tumuli, 1970 Mauna Ulu lava flow,
Hawai'i



Tumuli, 46 ka Harman Valley lava flow,
Wallacedale

Two types of basalt lava: pahoehoe and a'a



Pahoehoe

Hawai'i



Pahoehoe

46 ka Harman Valley lava flow, Wallacedale



A'a



Boral quarry, Mt Napier
A'a



When the 55 ka Tyrendarra lava flow from Mt Eccles and the 284 ka lava flow from Mt Rouse entered the sea at Port Fairy



Pu'u O'o lava flow,
2013, Hawai'i

NVP VOLCANOES & ERUPTION STYLES

Magmatic or Hawai'ian fire fountaining producing spatter cones and deposits

- Sustained fountaining of fluidal magma produces aggregates of “spatter” that build up around the vent forming a spatter cone and may also feed lava flows



Pu'u O'o spatter cone forming eruption, 1984, Hawai'i

NVP VOLCANOES & ERUPTION STYLES

Magmatic or Hawai'ian fire fountaining producing spatter cones and deposits



Remains of spatter cone and deposits, Tower Hill volcano, Warrnambool

NVP VOLCANOES & ERUPTION STYLES

Magmatic or Hawai'ian fire fountaining producing spatter cones and deposits



Remains of spatter cones and deposits, ~ 5 ka Mt Schank, South Australia

NVP VOLCANOES & ERUPTION STYLES

Magmatic explosive eruptions producing scoria cones and deposits

- Driven by magmatic gases (H_2O , CO_2)
- Build massive scoria cones around the vent

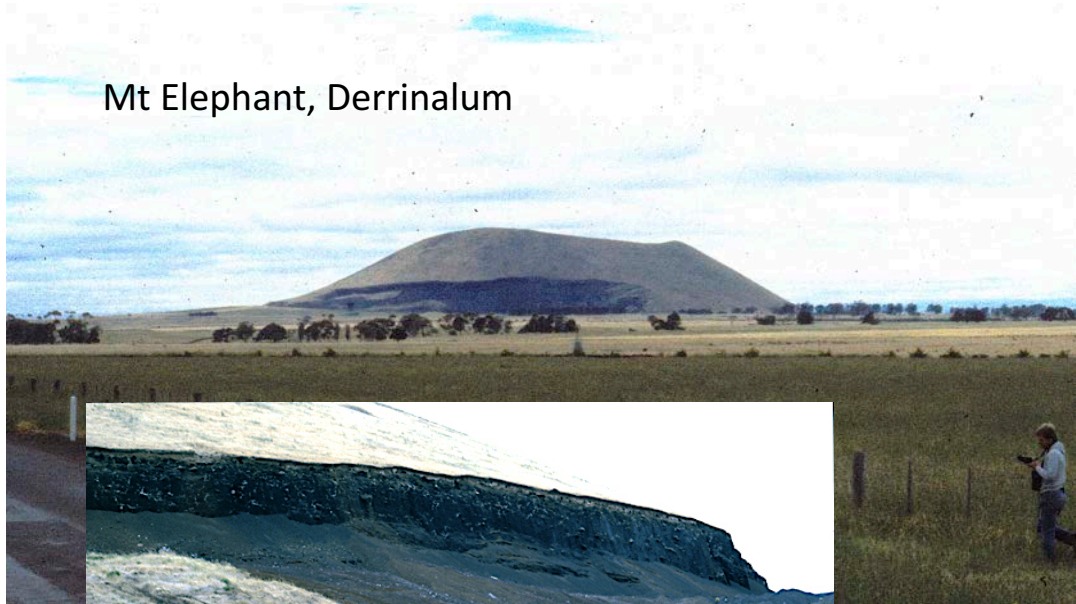


1973 eruption on Heimay, Iceland

NVP VOLCANOES & ERUPTION STYLES

Magmatic explosive eruptions producing scoria cones and deposits

Mt Elephant, Derrinalum



Mt Rouse



Gas bubble rich
Scoria deposit,
Tower Hill volcano

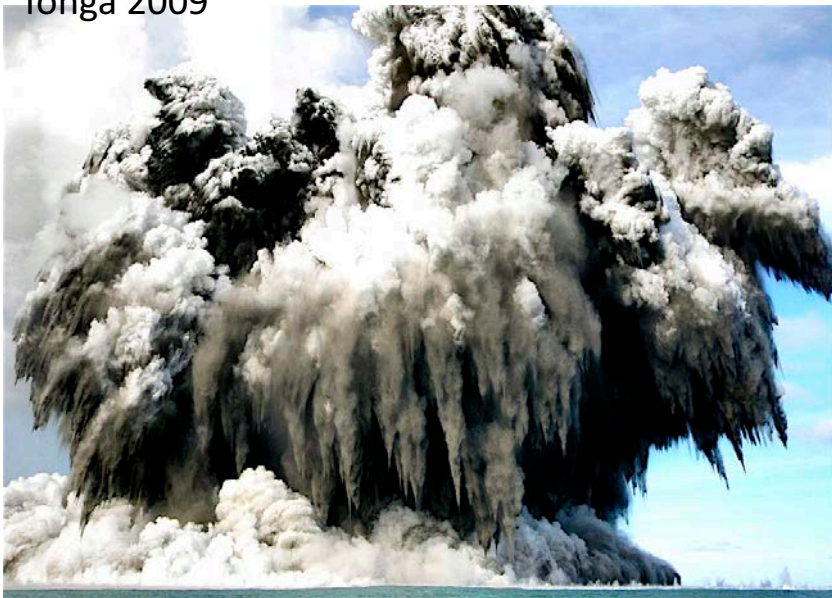


NVP VOLCANOES & ERUPTION STYLES

Phreato-magmatic explosive eruptions producing maar volcanoes and widely dispersed ash deposits

- Driven by explosive superheating of external water by the heat of erupting magma at 800°C to 1200°C

Tonga 2009



Eyjafjallajokull, Iceland 2010



NVP VOLCANOES & ERUPTION STYLES

Phreato-magmatic explosive eruptions producing maar volcanoes and widely dispersed ash deposits

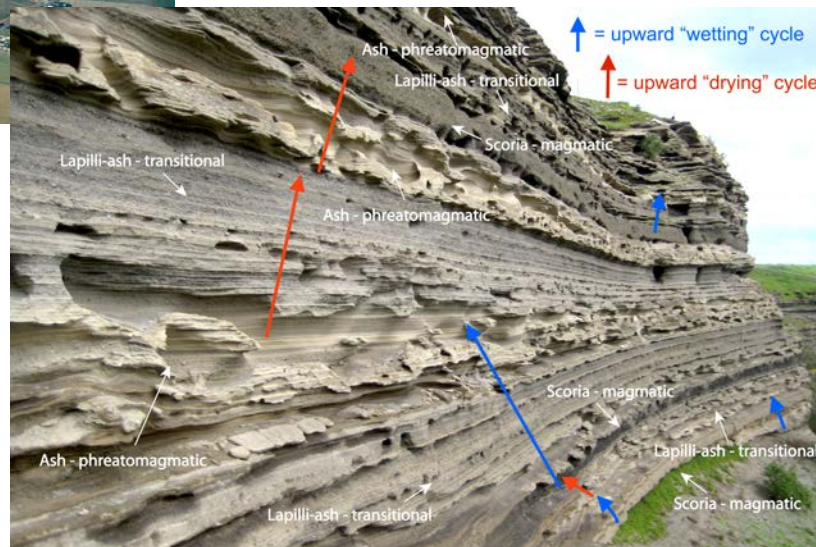


~ 35 ka Tower Hill,
Maar volcano,
Warrnambool



~ 5 ka Mt Gambier maar complex,
South Australia

Maar volcanoes occur mostly in the southern half of the NVP, where it is underlain by aquifers in the Otway Basin



Thinly bedded ash and minor scoria deposits,
Tower Hill maar volcano

NVP VOLCANOES & ERUPTION STYLES

Phreato-magmatic explosive eruptions producing maar volcanoes and widely dispersed ash deposits



Base surge deposits from Purumbete maar volcano

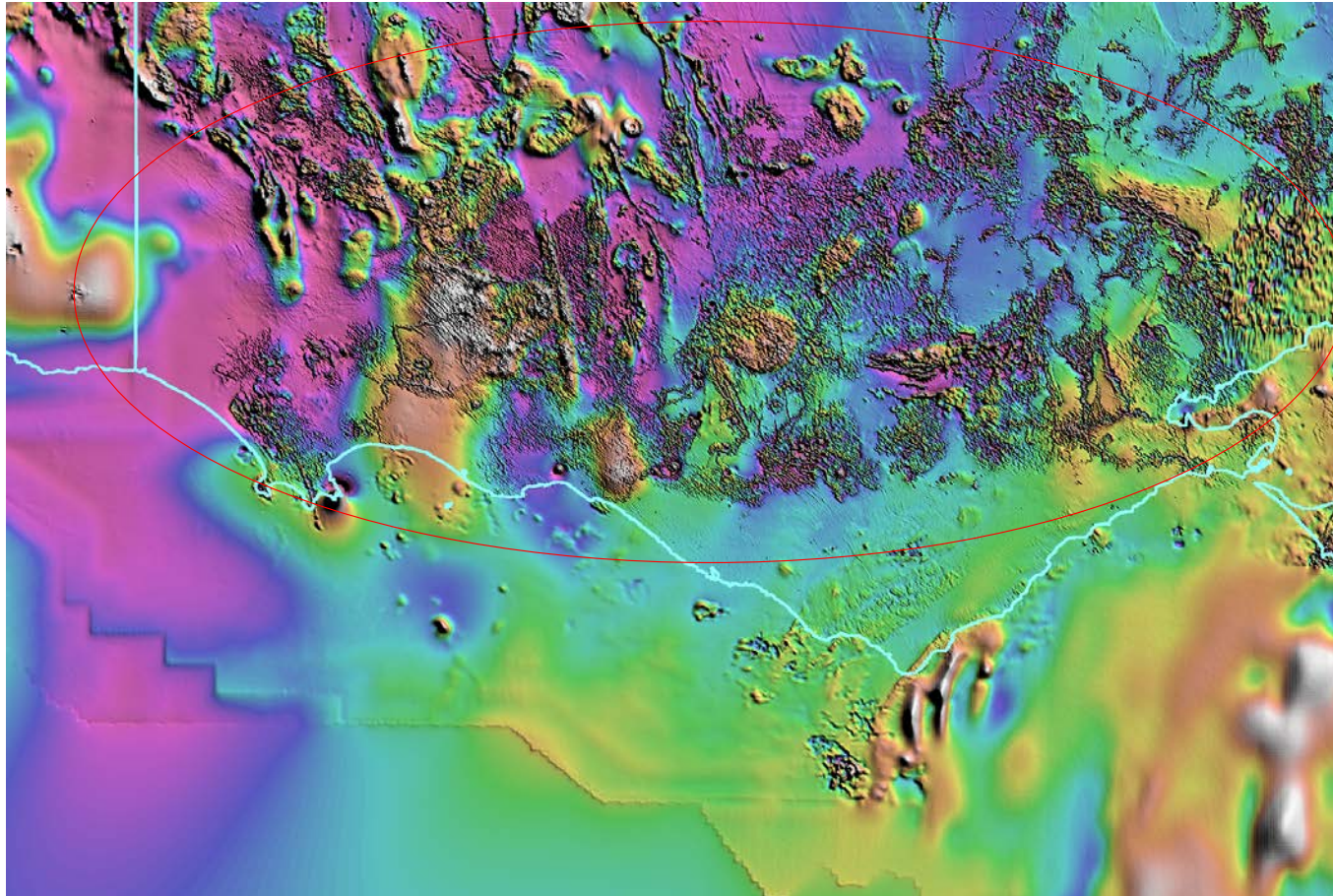


~ 5 ka Mt Mt Schank maar base surge deposits
- ALAS they are no more !

APPLYING GEOPHYSICS TO THE NVP

- Regional geophysics – mapping lava flows and cones
 - Aeromagnetics
 - Radiometrics
 - LiDar
- Regional geophysics – probing the mantle source region
 - Heat flow
 - Seismic tomography and magneto-tellurics
- Local geophysics – focus on individual volcanoes
 - LiDAR maps volcanoes and provides relative stratigraphy
 - High resolution ground magnetics and gravity
 - Decipher the subsurface structure of volcanoes

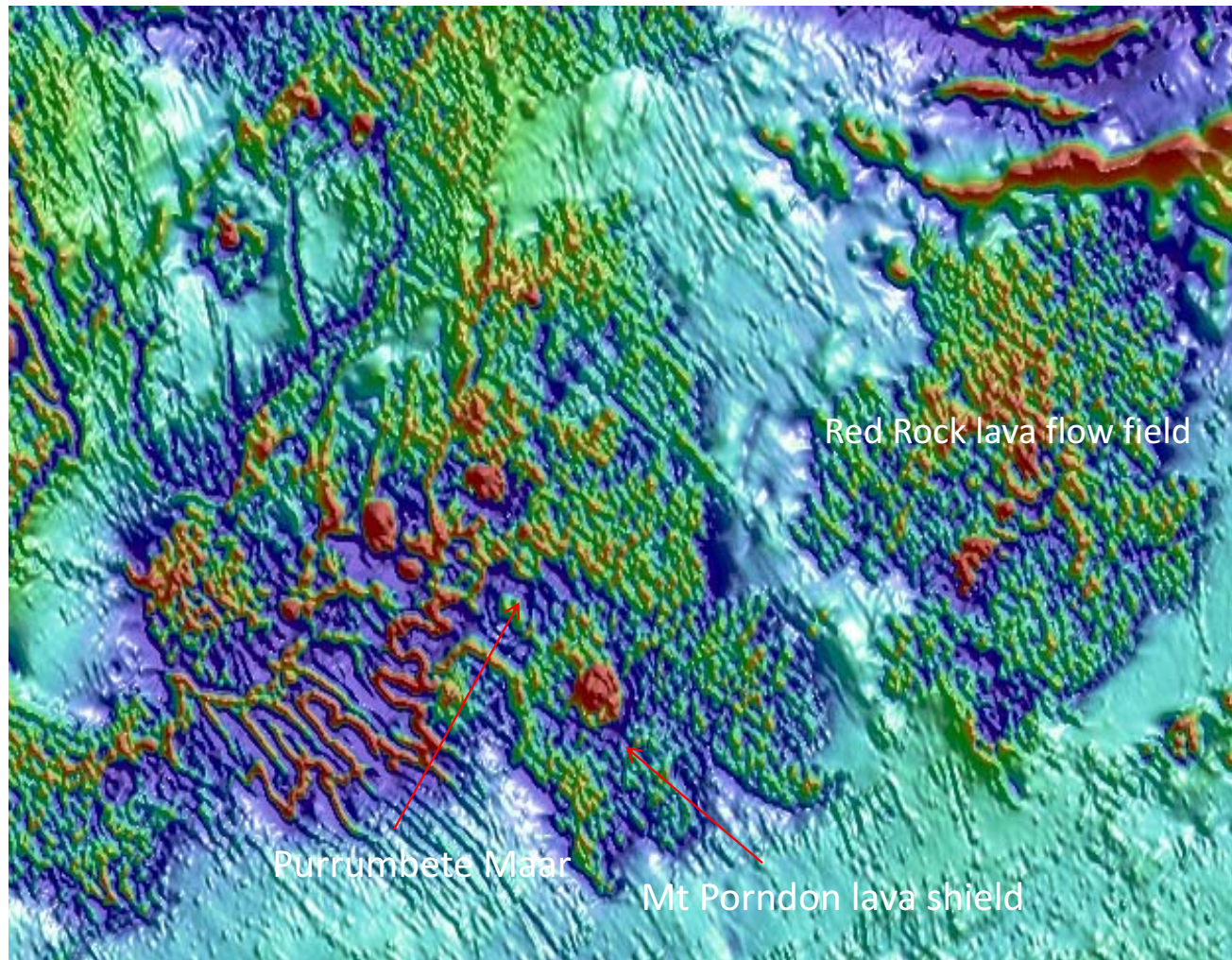
Aeromagnetics: defining the extent of lavas



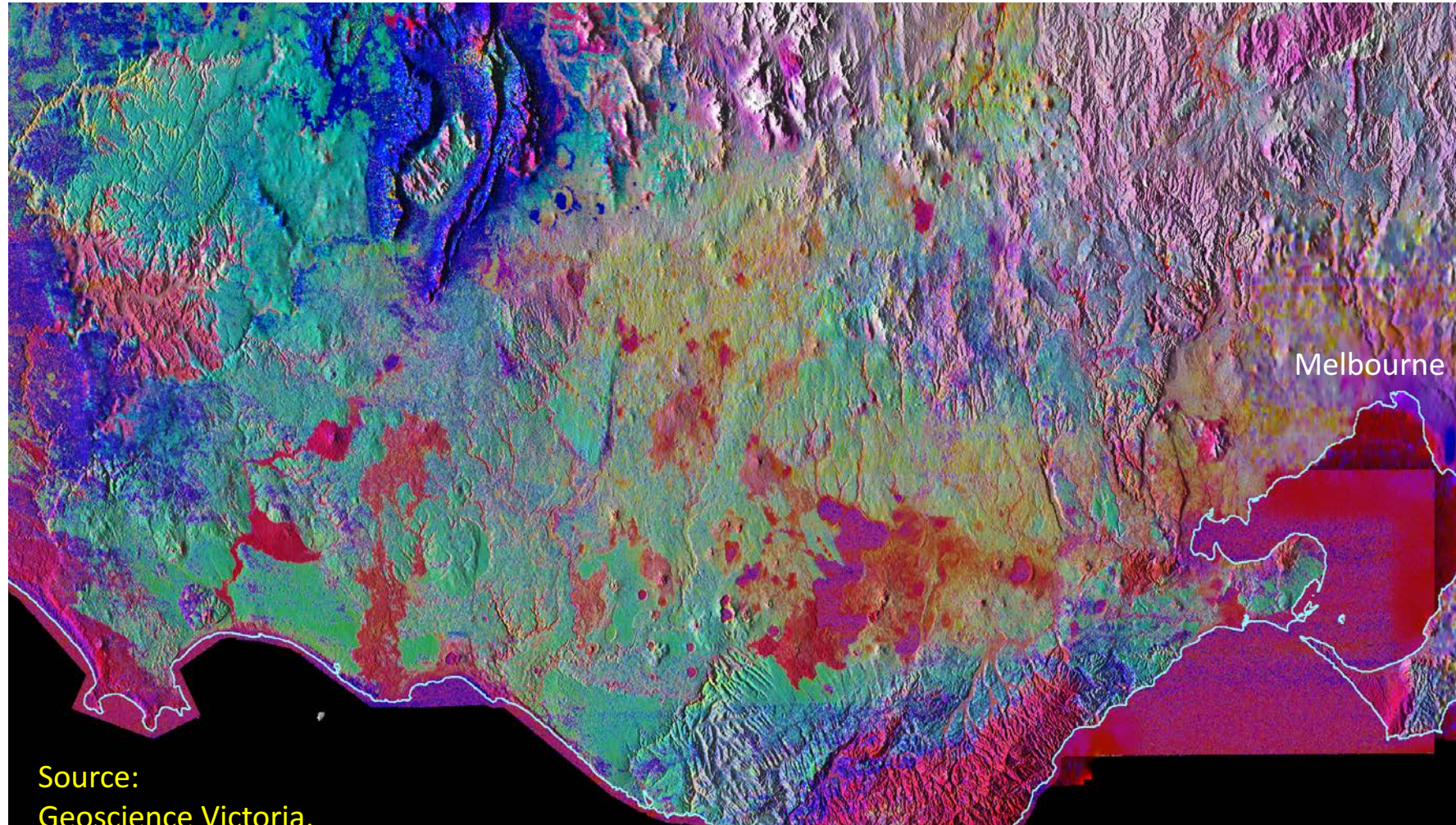
Speckled
pattern
= lavas

Source:
Geoscience Victoria,
VIMP data,
D. Moore.

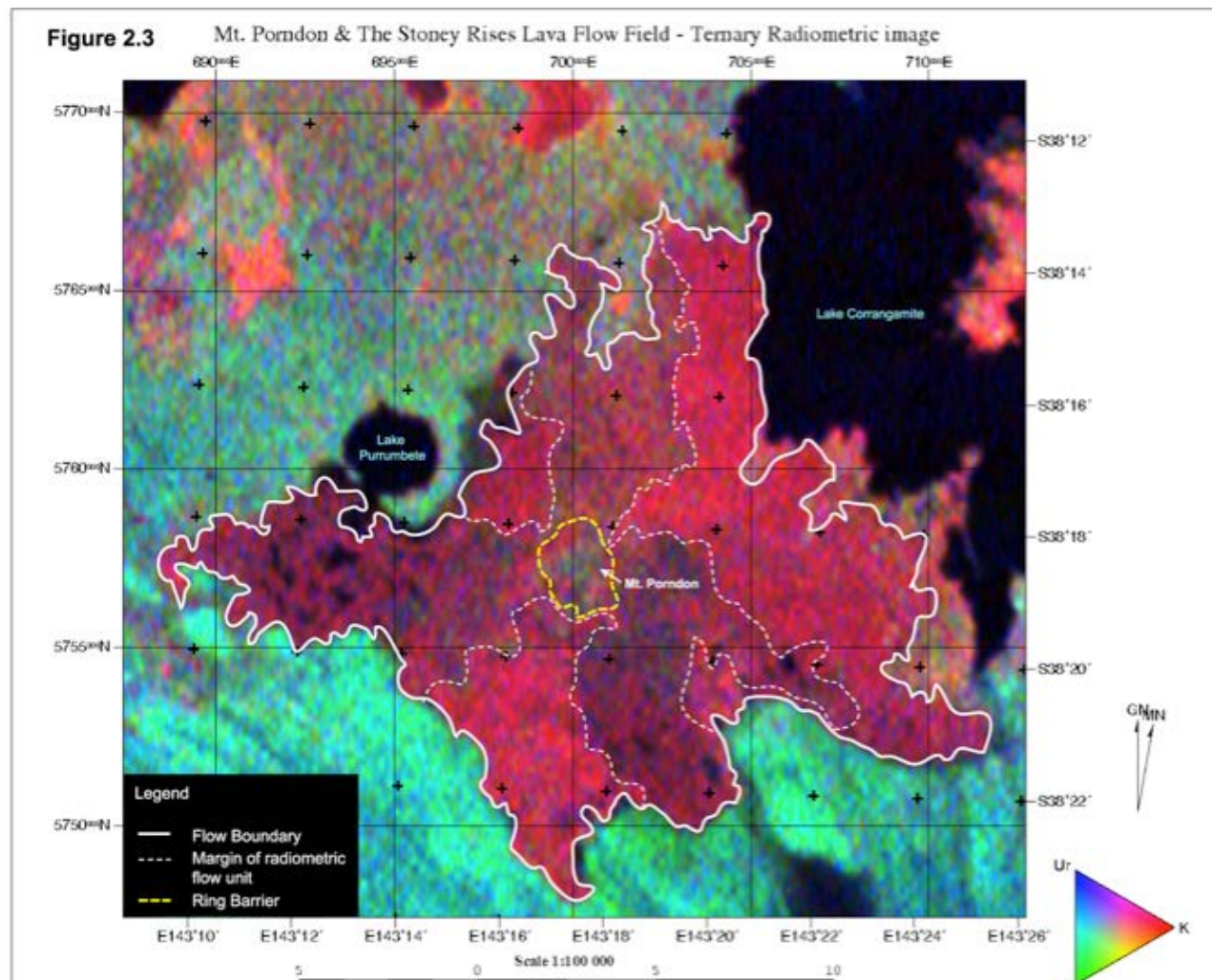
Aeromagnetics, Mt Porndon



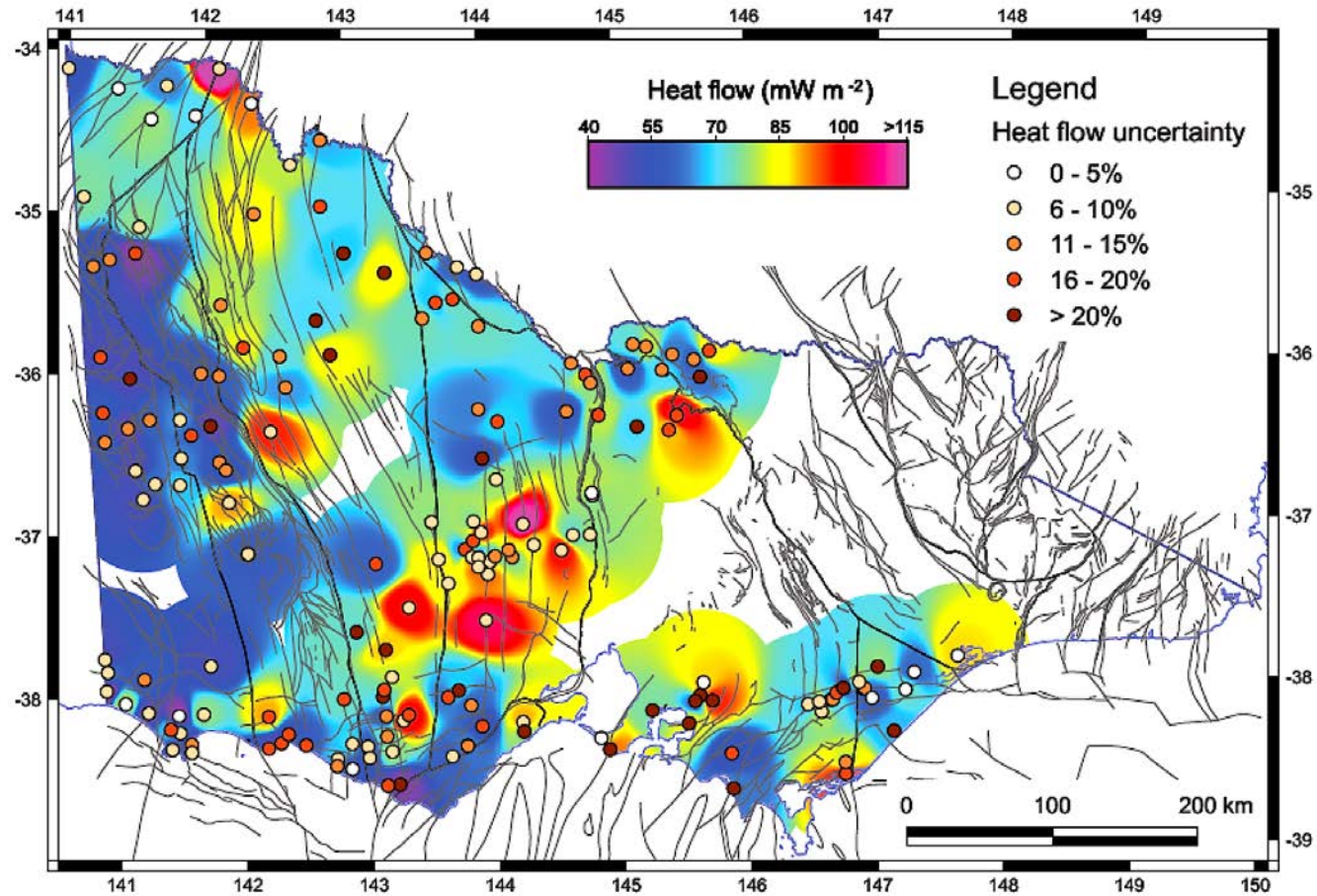
Radiometric data image
- highlights the most radiogenic basalts



Radiometrics – Mt Porndon

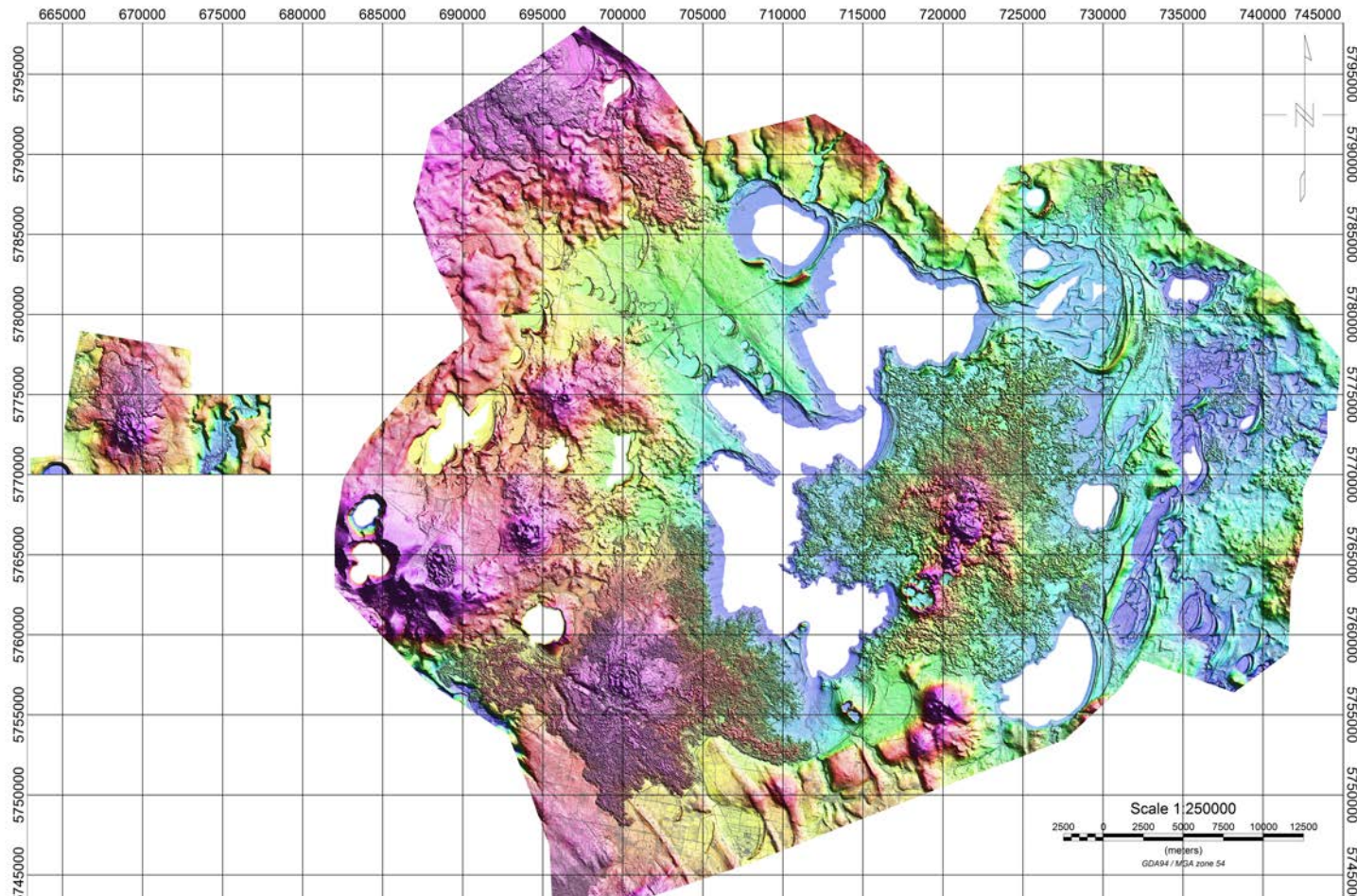


Heat Flow

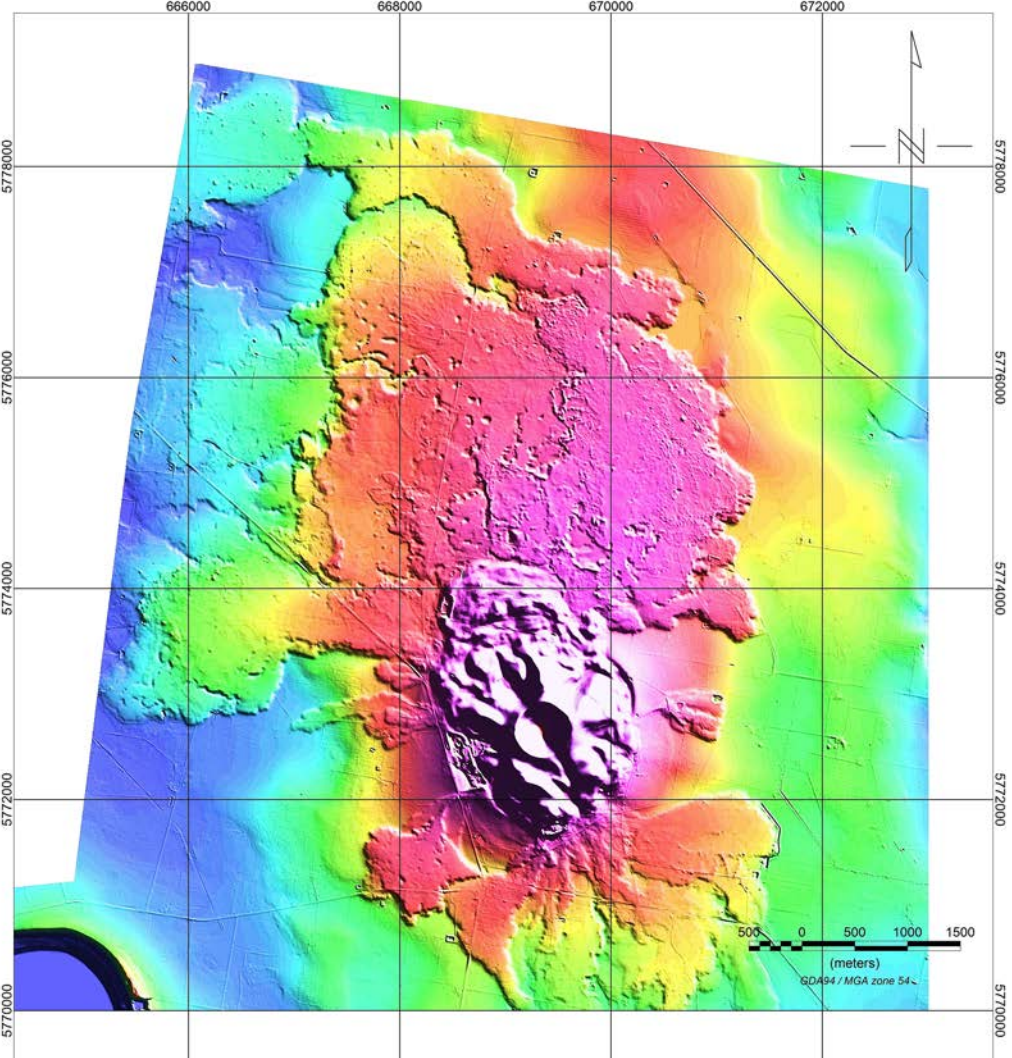


From Mather et al. 2018

Airborne Light Detection and Ranging (LiDAR): Digital Elevation Model (DEMs) - Corangamite Shire



LiDAR – Mt Noorat lava flow field and cone

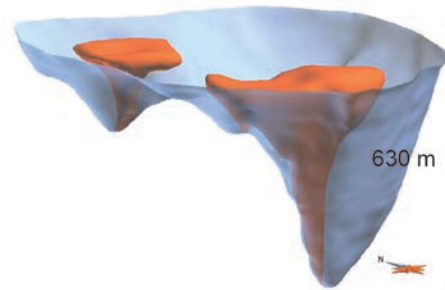


Geochemistry

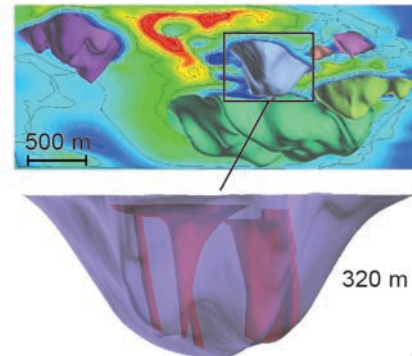
- By analysing minerals, lavas and scoria fragments from volcanic eruptions we can work out the depth in the crust and mantle that melting occurred and the magma temperature
- Geochemistry of NVP samples tells us:
 - There is not a single “mother-lode” of magma sitting under the NVP
 - Each volcano was sourced from a discrete relatively small volume batch of magma
 - These have formed frequently over ~ 8 Million years.

Using high resolution ground magnetics and gravity to investigate vent geometries: maars

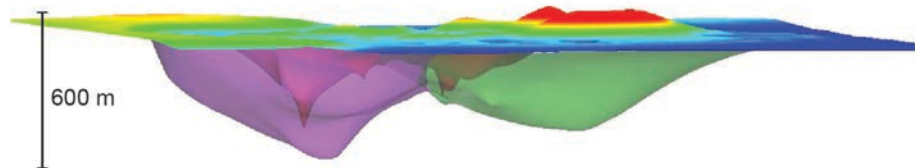
(a) Ecklin Maar



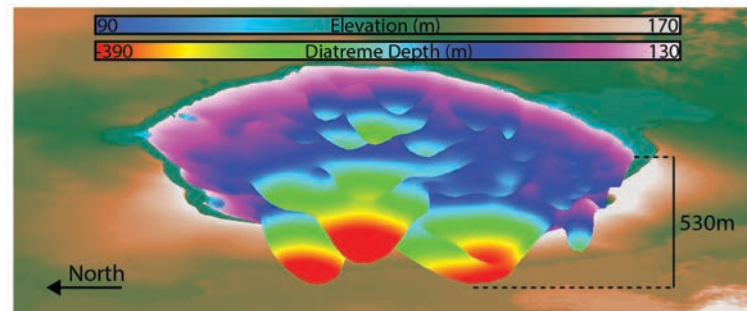
(b) Red Rock Volcanic Complex



(c) Mount Leura Volcanic Complex



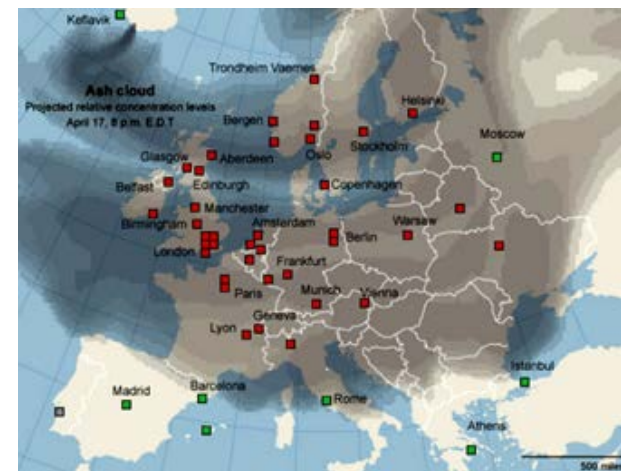
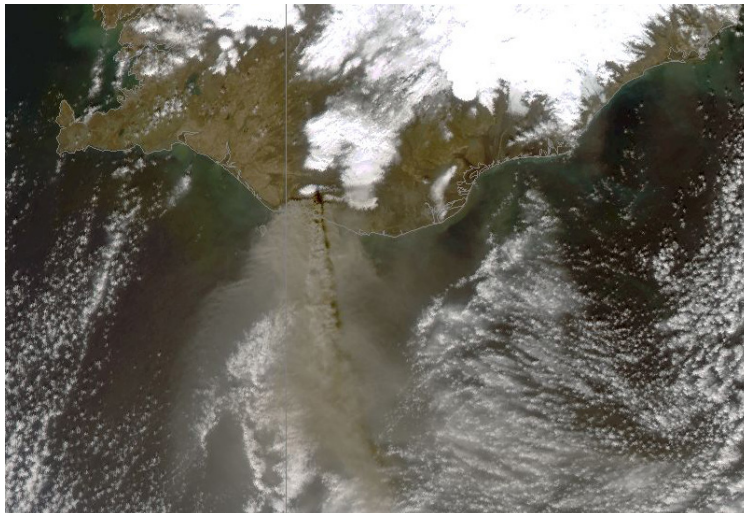
(d) Lake Purrumbete Maar



Why Should We Care?

- Volcanic Hazards from future possible eruptions in the Newer Volcanic Province
- From experiences in Hawai'i and before the Eyjafallajökull eruption, Iceland, 2010, eruptions from ICBVP volcanoes were considered to have relatively small volcanic risks
 - Eyja was small in magnitude (0.18km³, VEI~3), but had far reaching effects
 - Phreatomagmatic ash forming
- However, the erupted volume is comparable to large monogenetic maar volcano eruptions in the NVP
 - E.g. Mt Gambier, Tower Hill, Purumbete maars in NVP

Eyjafallajökull eruption, Iceland, 2010



Why Should We Care?

- *The next **magmatic** eruption in the NVP will do this*

This isn't so bad!





..... Or is it?



Why Should We Care?

- *The next **phreatomagmatic** maar forming eruption in the NVP, will do this*

Armageddon!!!!



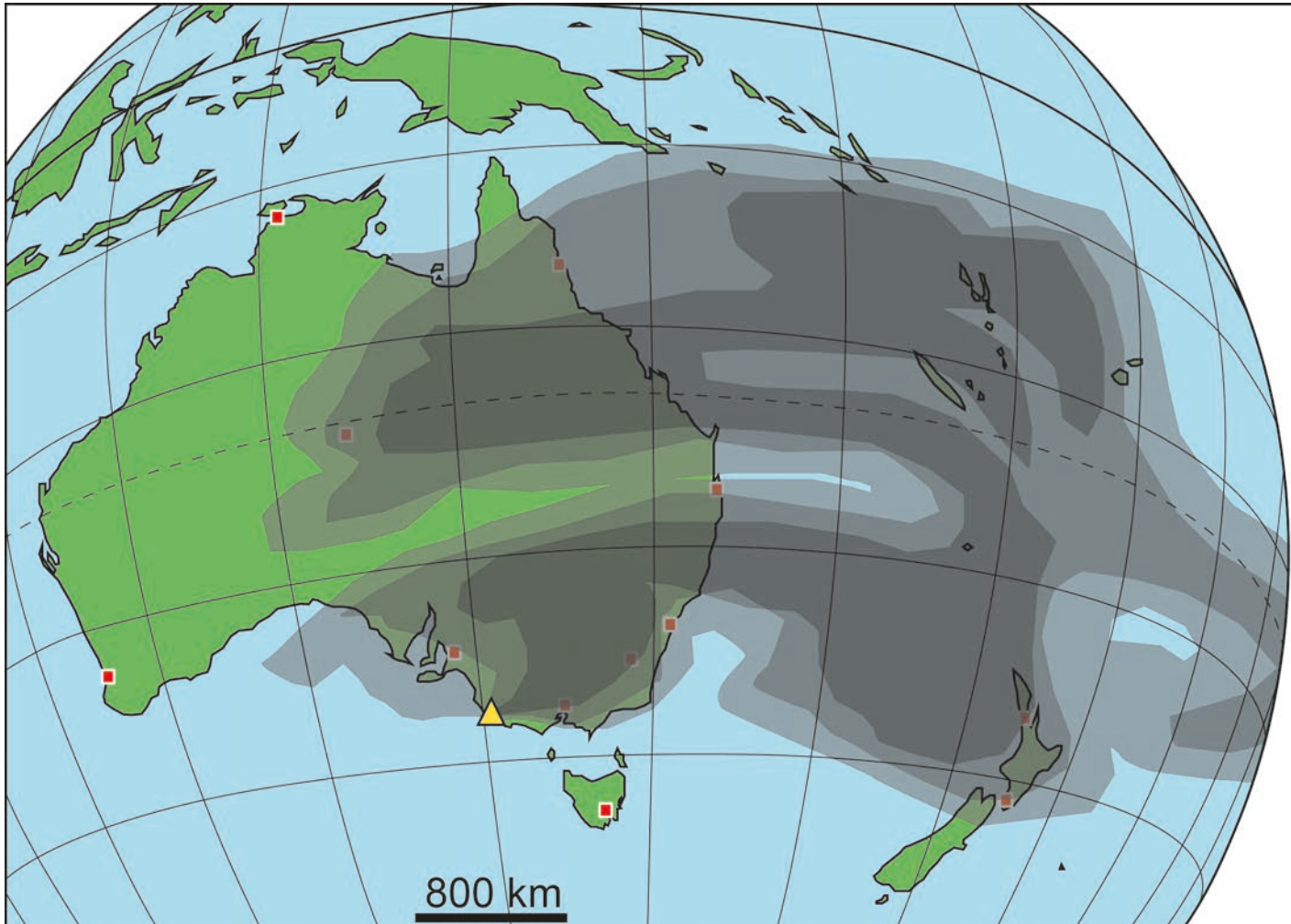
Princes Highway near Colac
or Mt Gambier

Farmers in Colac defending their farms

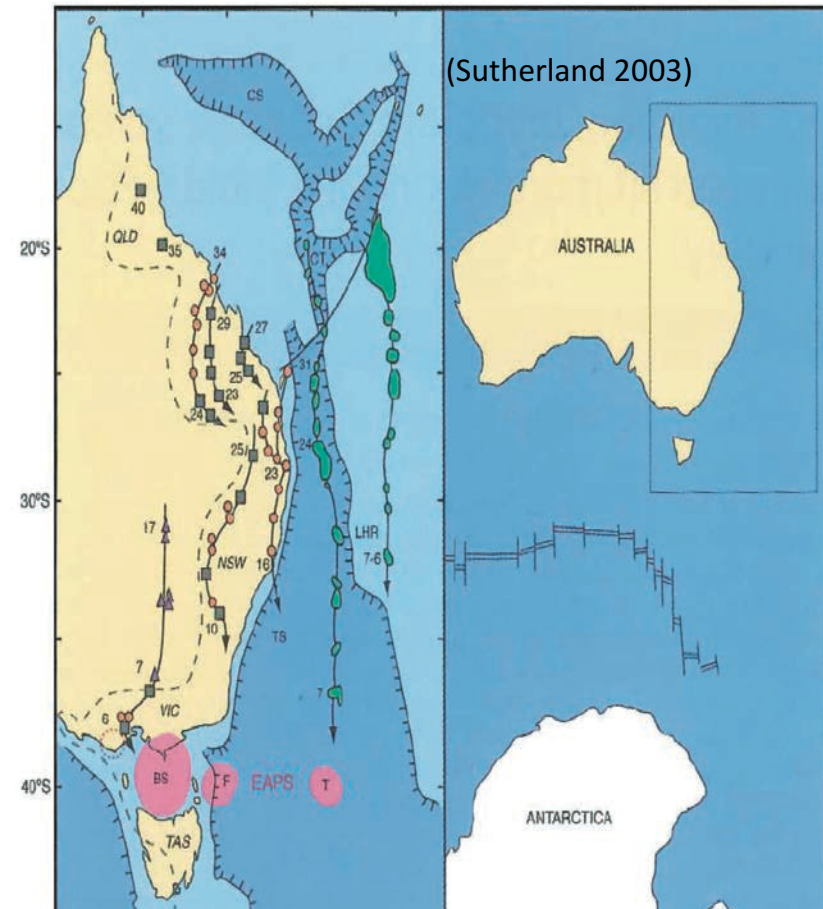
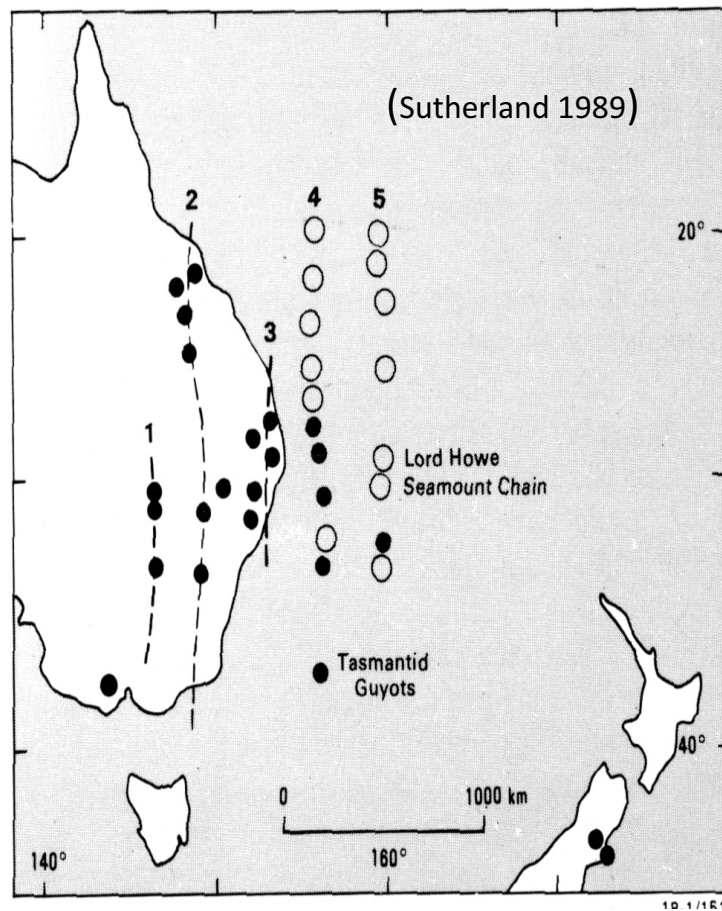


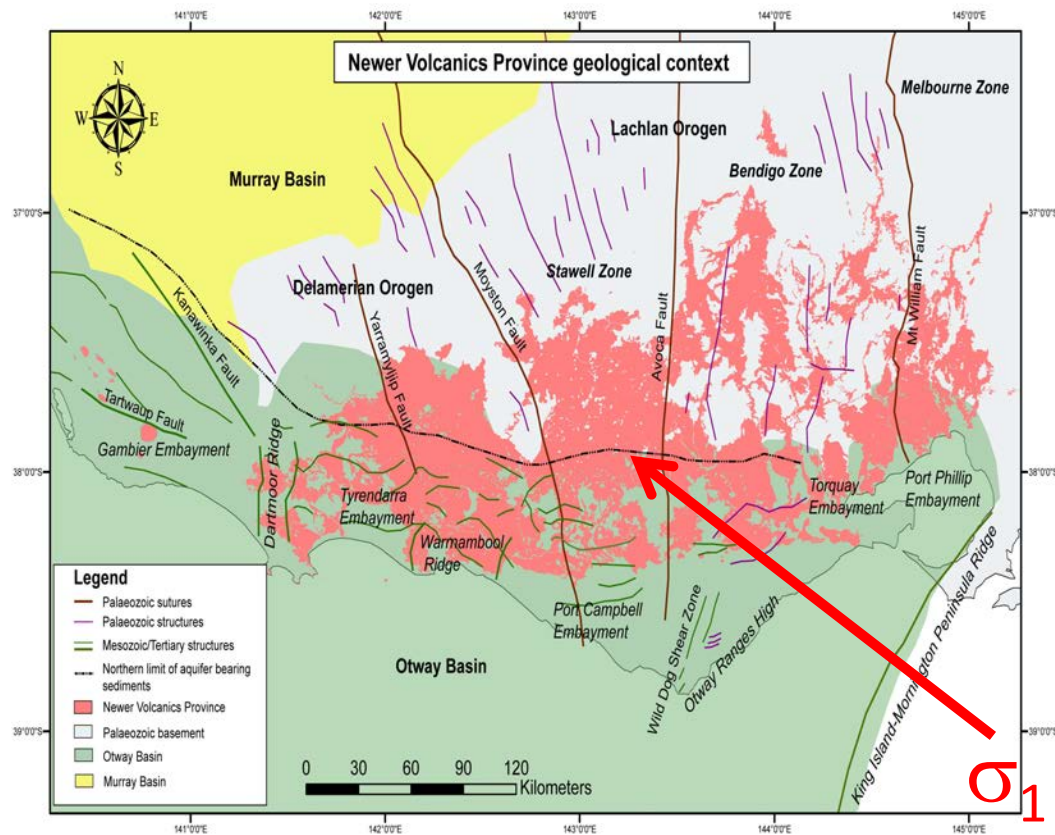
Damn, I forgot to buy the milk!

And Not flying anywhere soon Thank you



Suggested Causes of Intraplate Basaltic Volcanism





(from transpressional NZ Alps)

