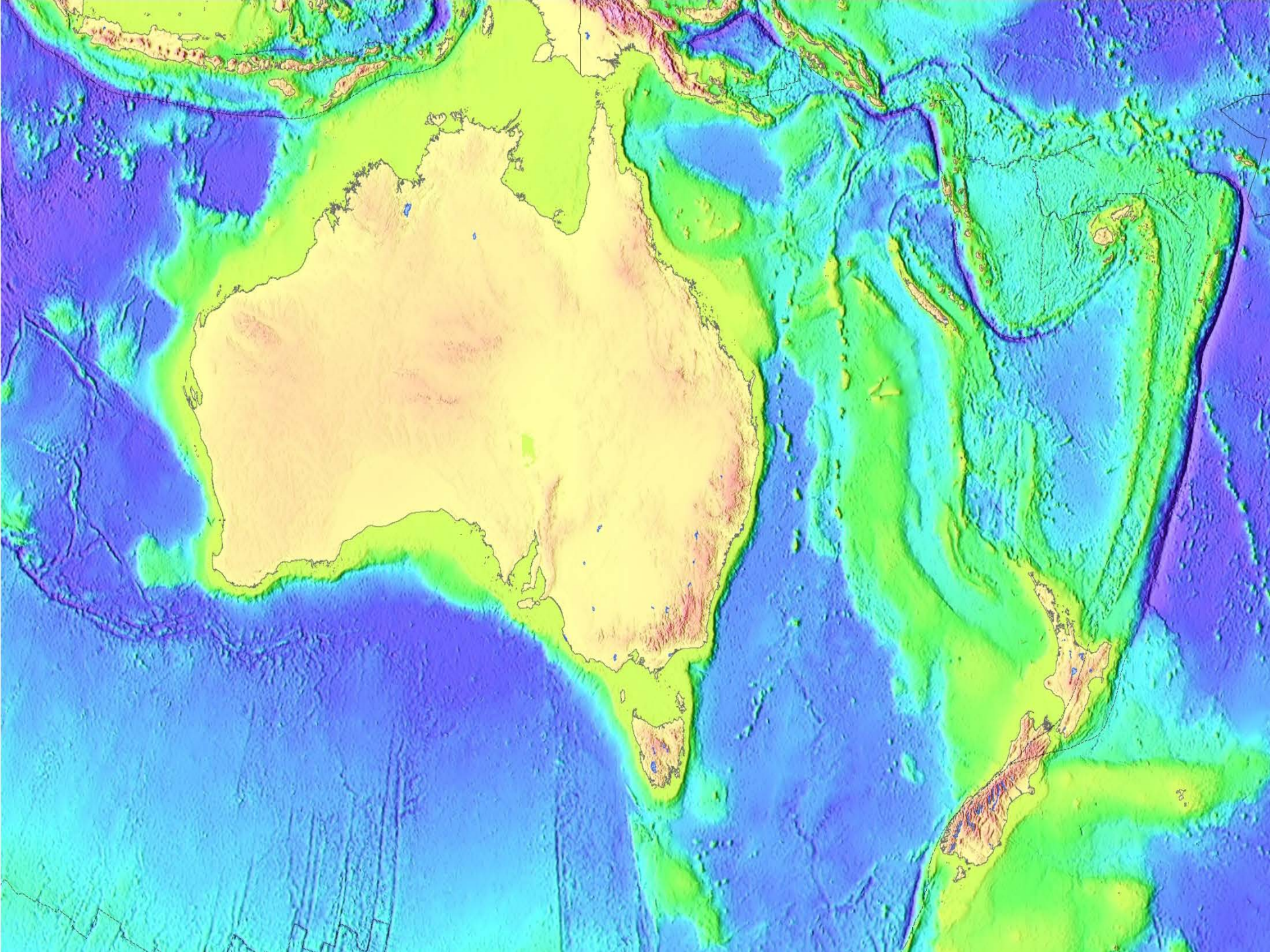
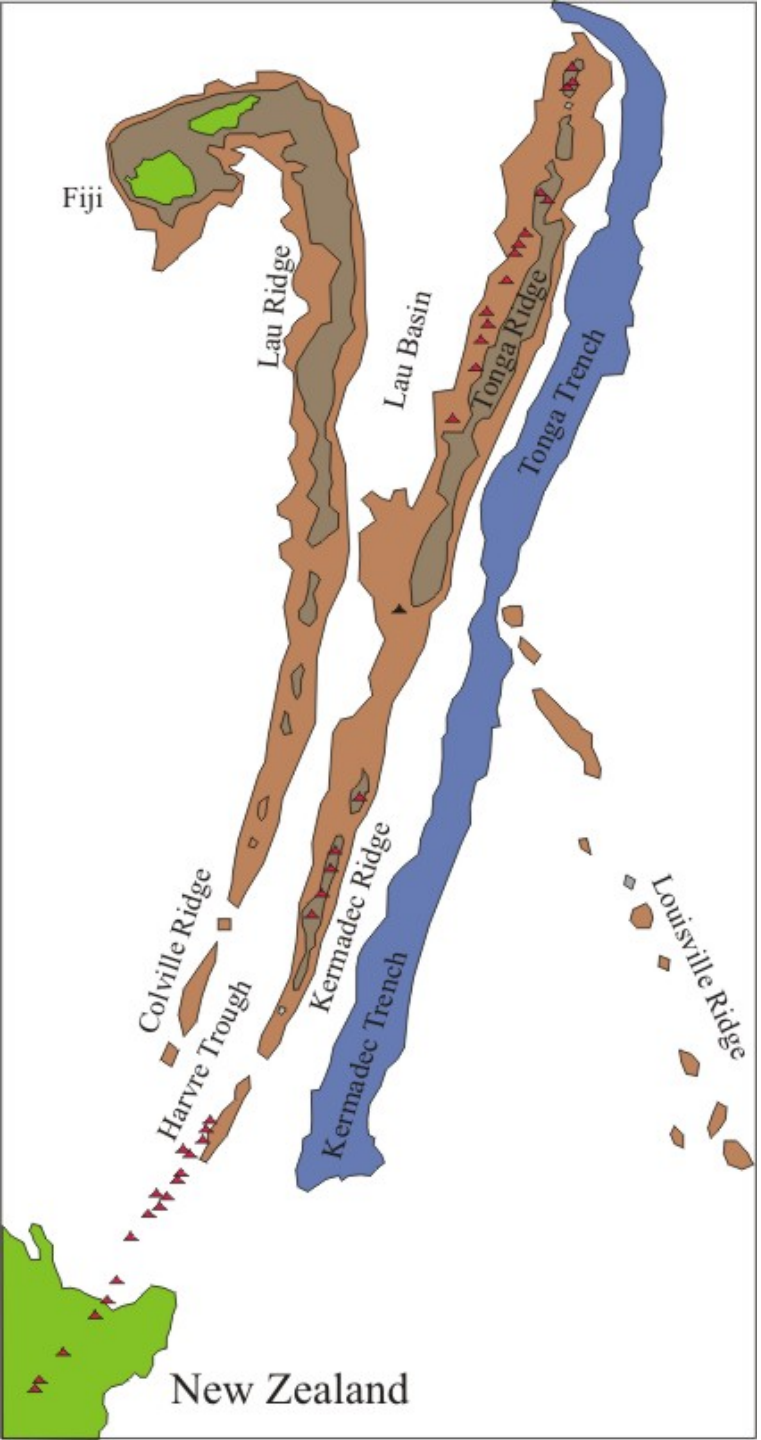
Overview of the KAHT system

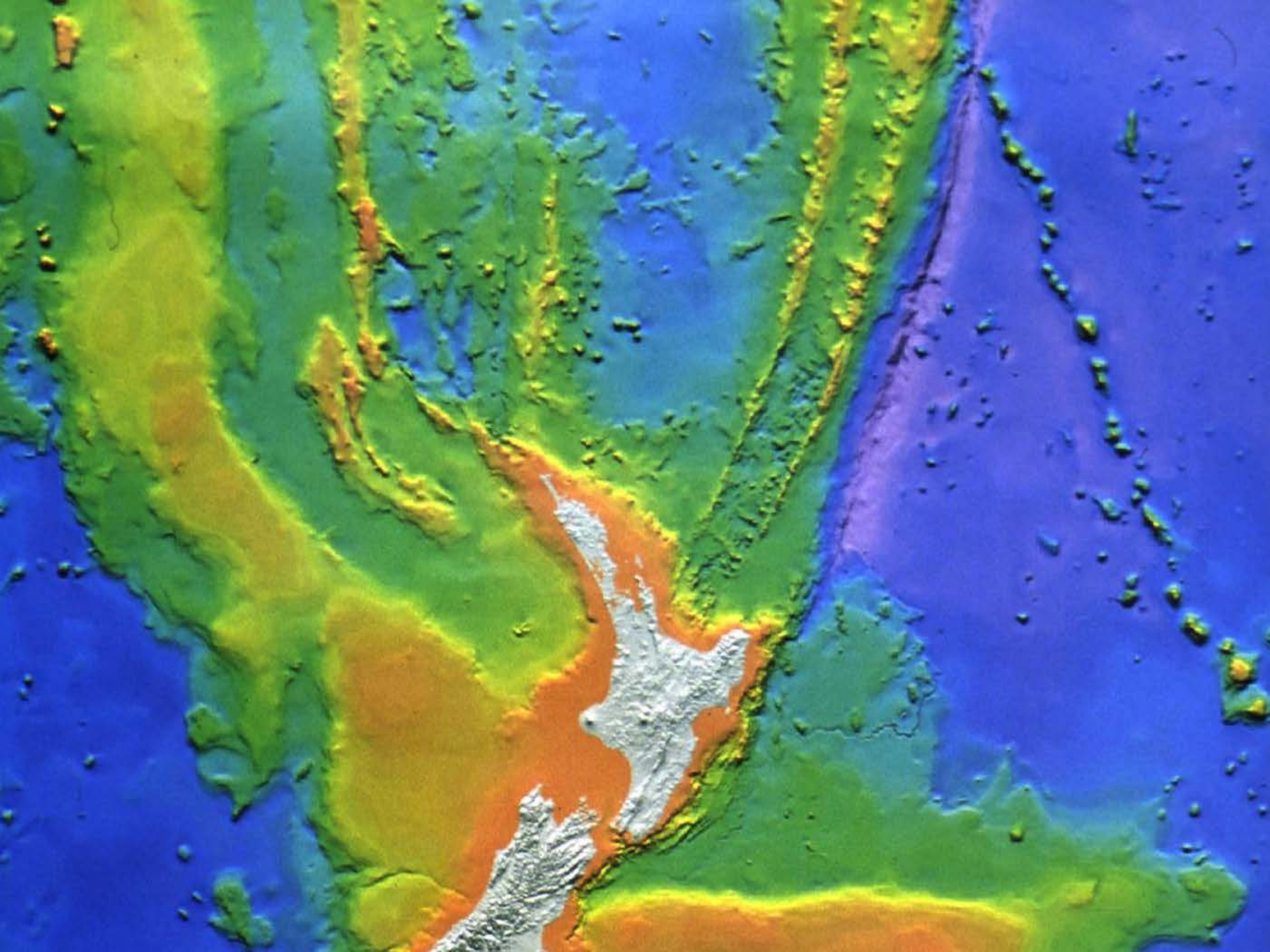
Ian E.M. Smith,
School of Environment,
University of Auckland

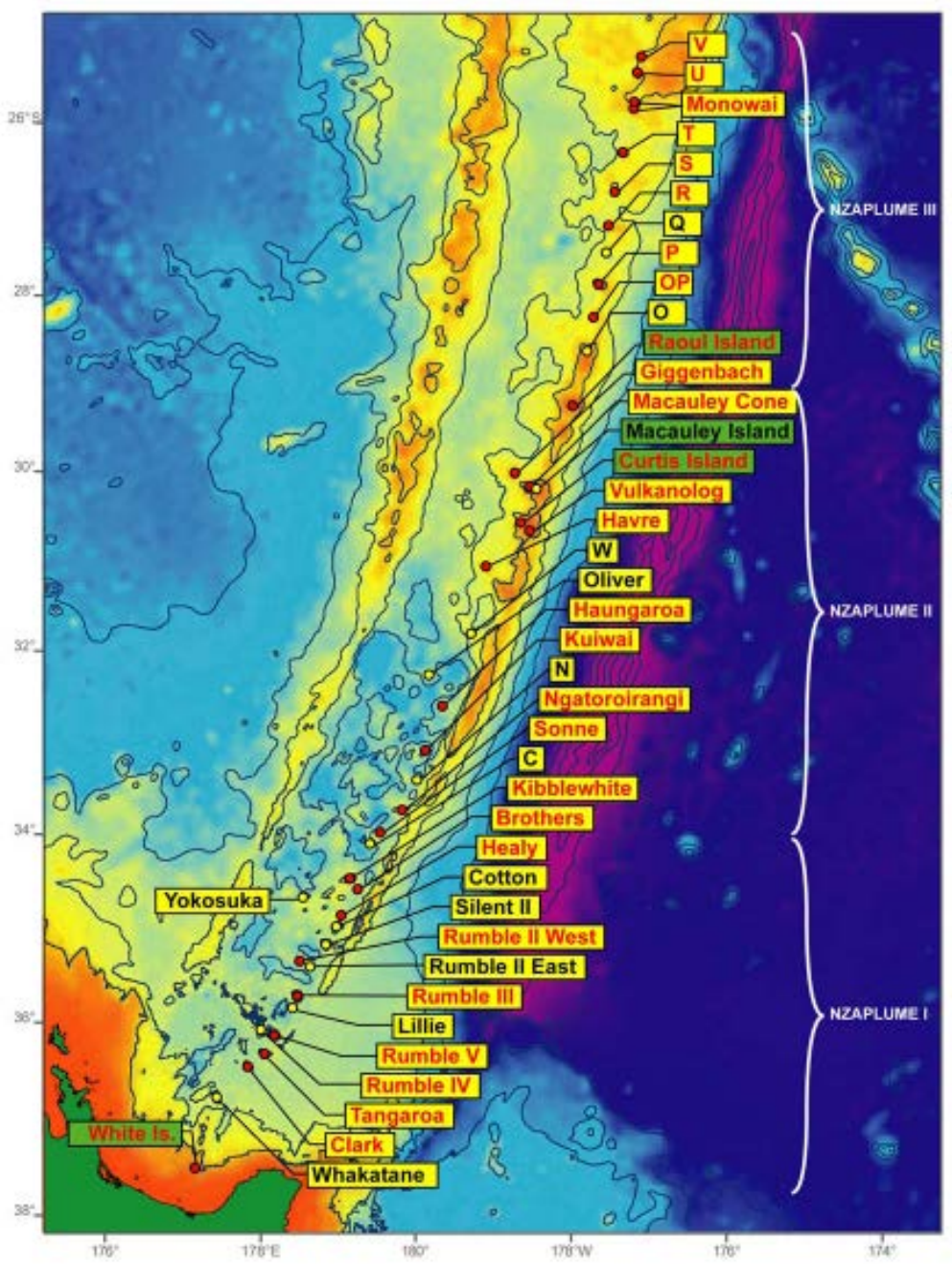




Tonga-Kermadec-New Zealand Arc

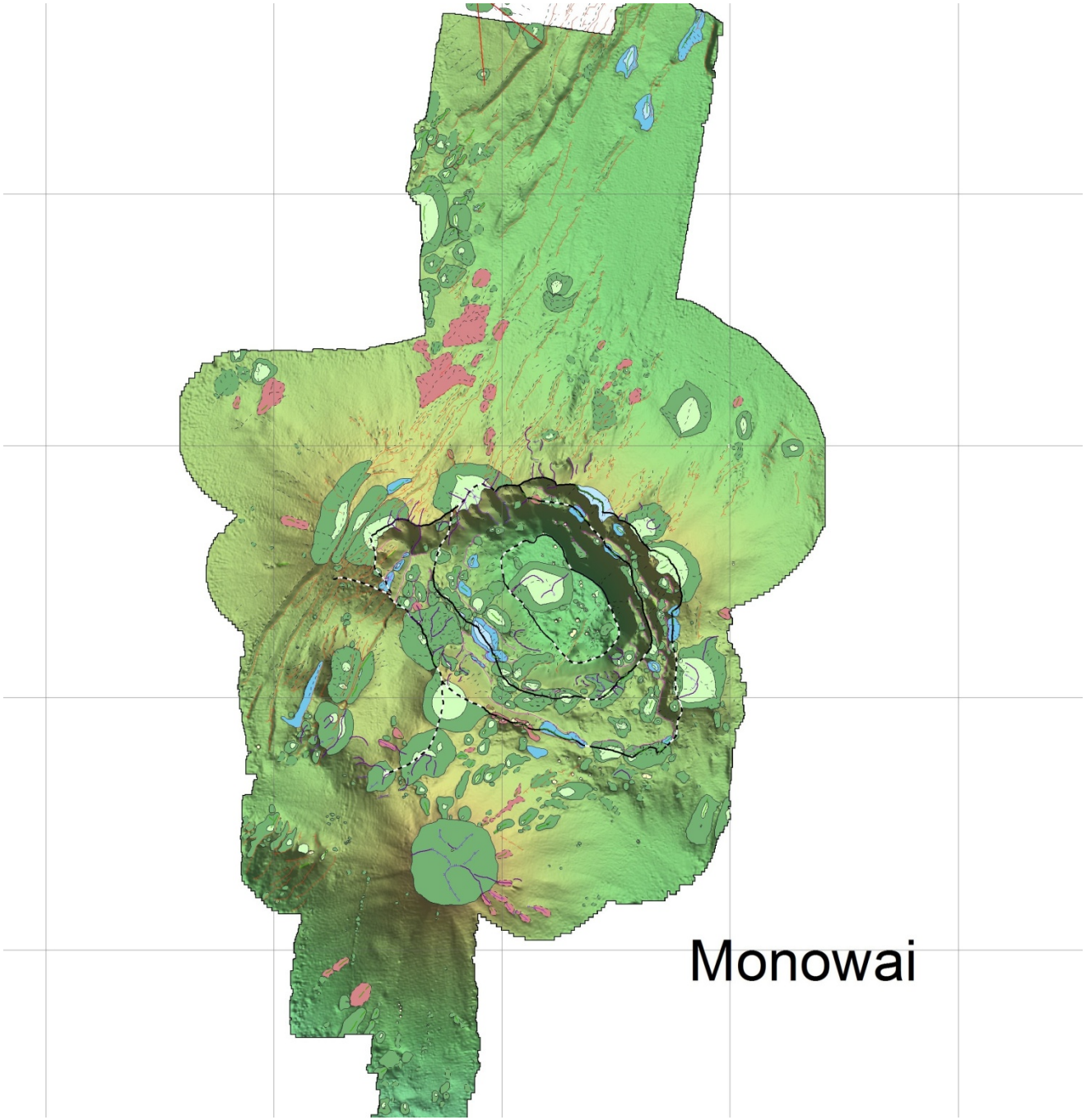
- Developed on the Pacific - Australian convergent margin
- Mainly intraoceanic except for the southern extremity
- The rock association is dominated by basaltic andesite with subordinate basalt minor andesite
- However felsic rocks (dacite to rhyolite) are widespread

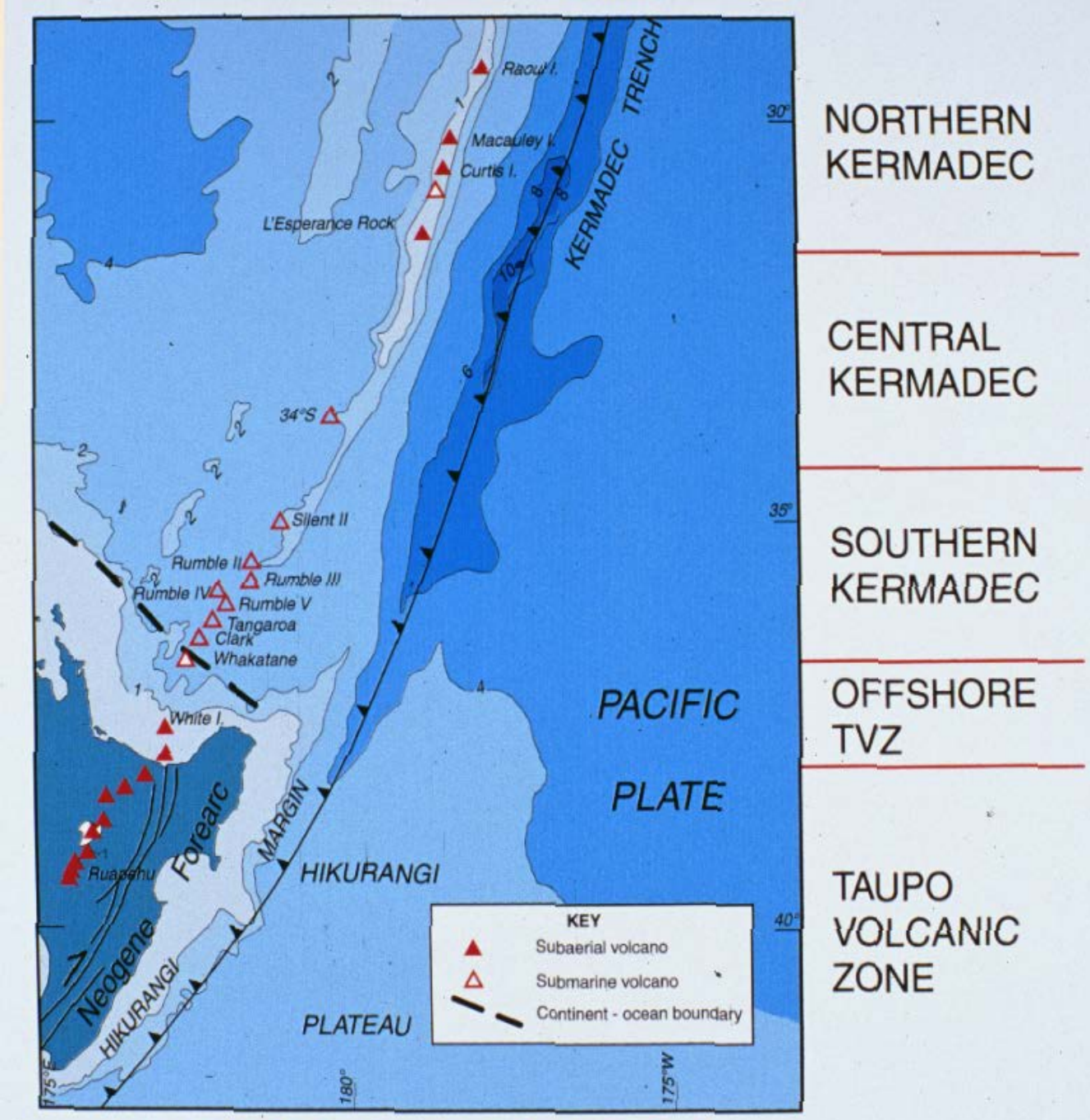




Many new volcanoes discovered in the past 10 years

- NZPLUME expeditions (NZ-USA)


Monowai



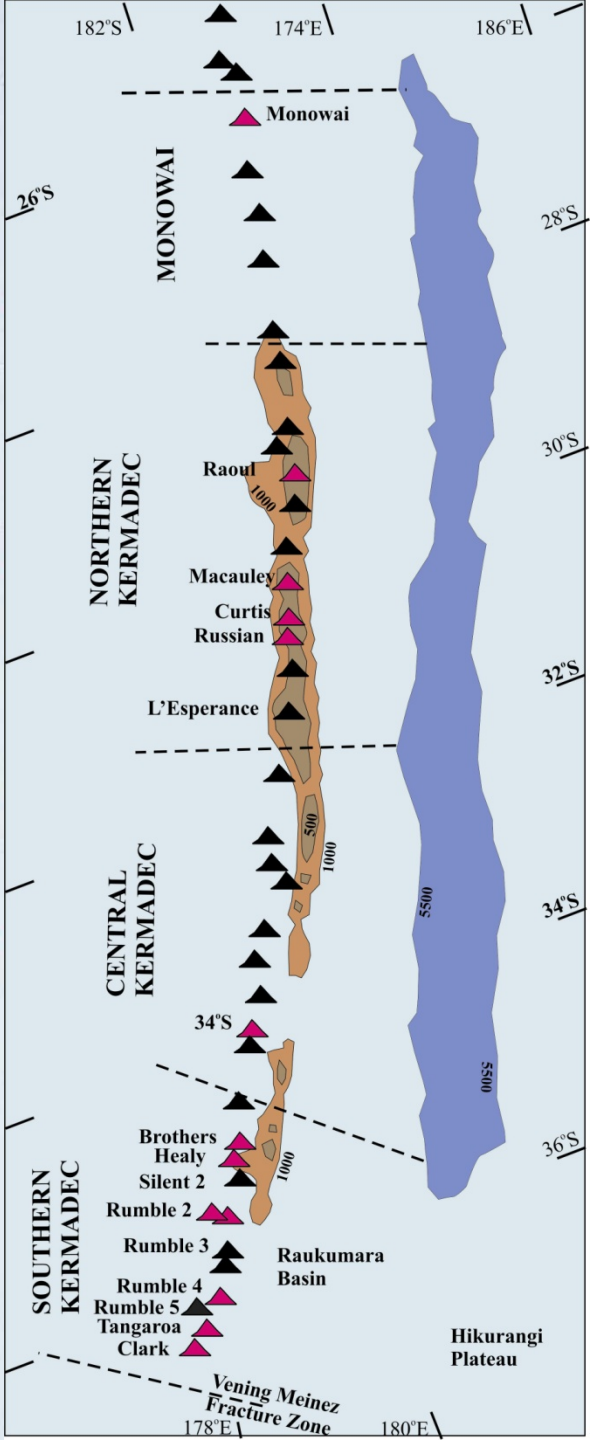
NORTHERN KERMADEC

CENTRAL KERMADEC

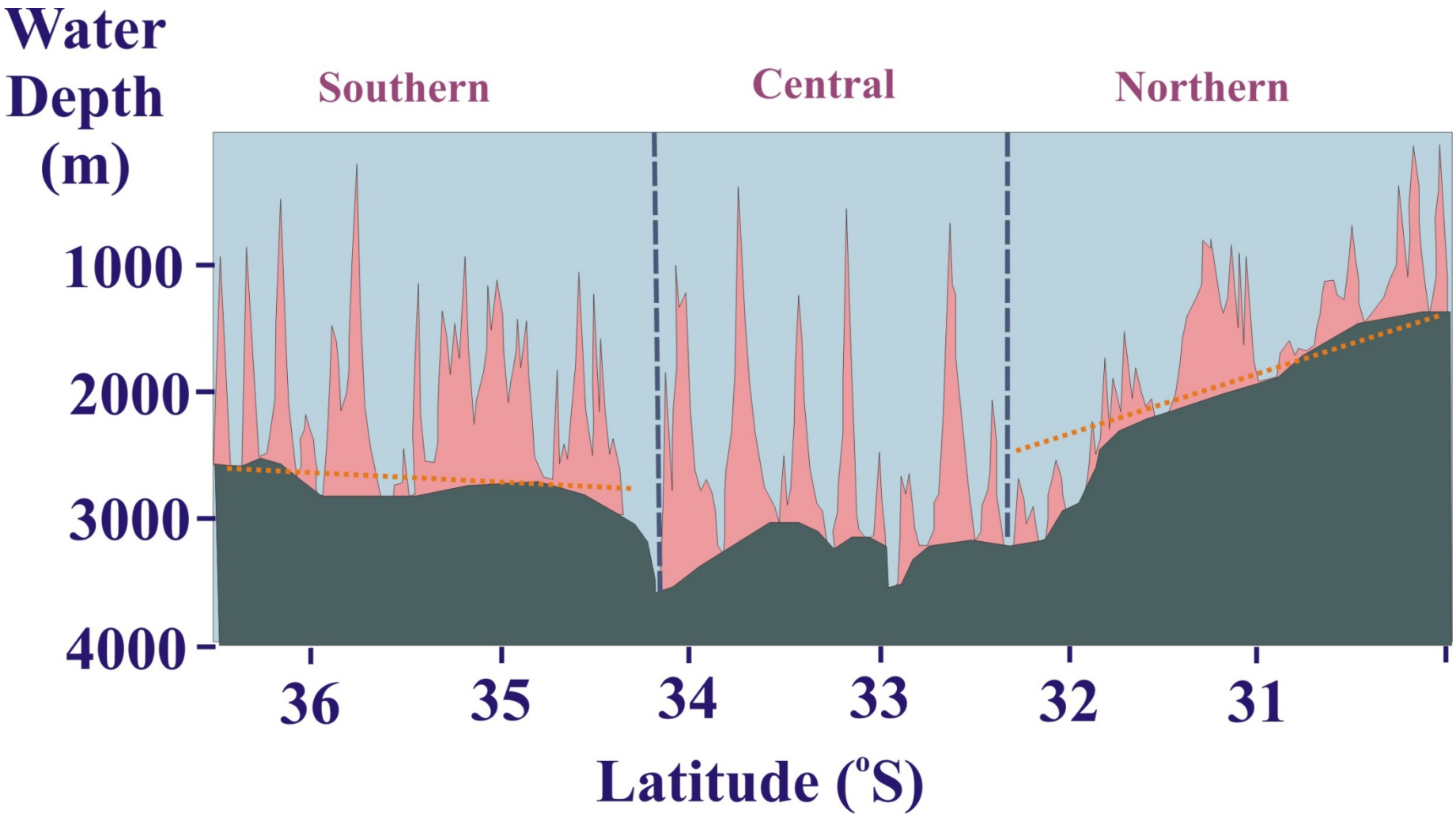
SOUTHERN KERMADEC

OFFSHORE TVZ

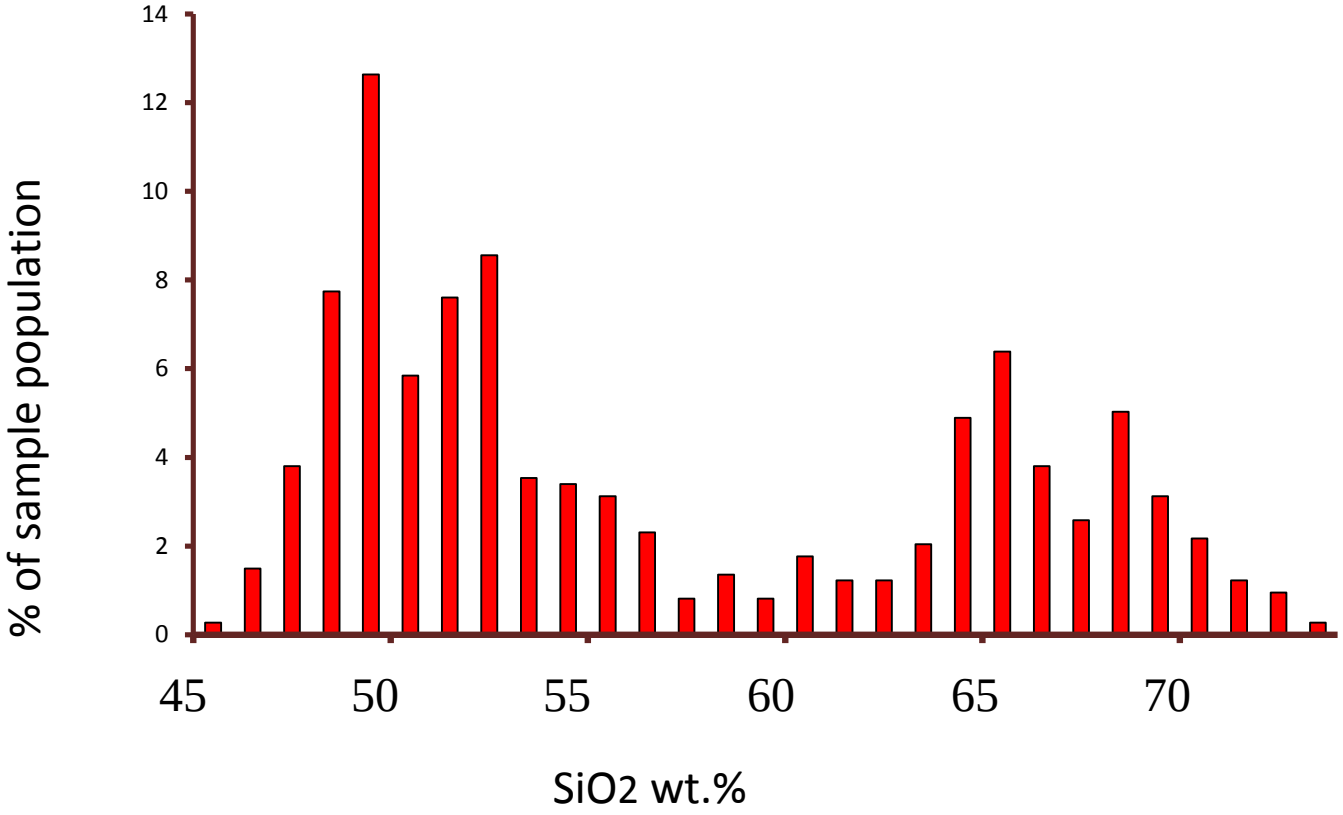
TAUPO VOLCANIC ZONE



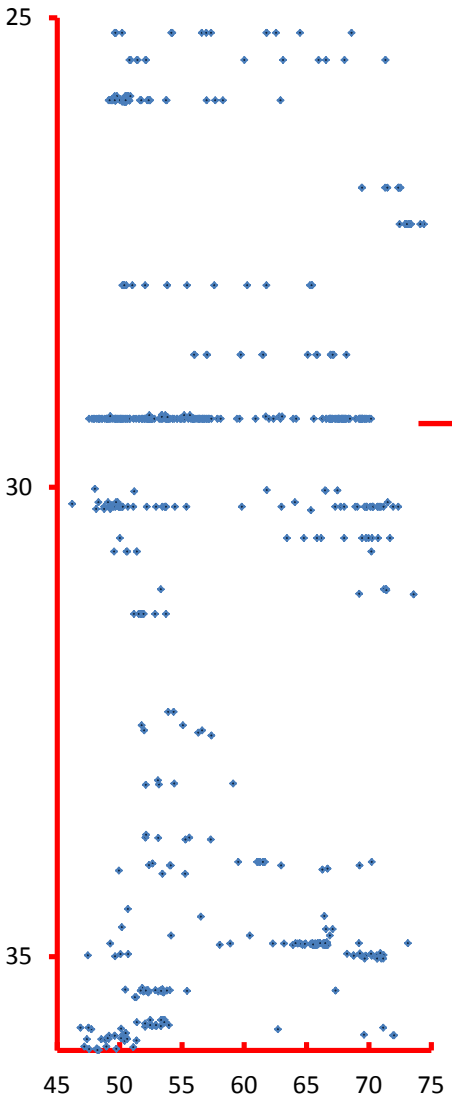
KERMADEC - NEW ZEALAND ARC



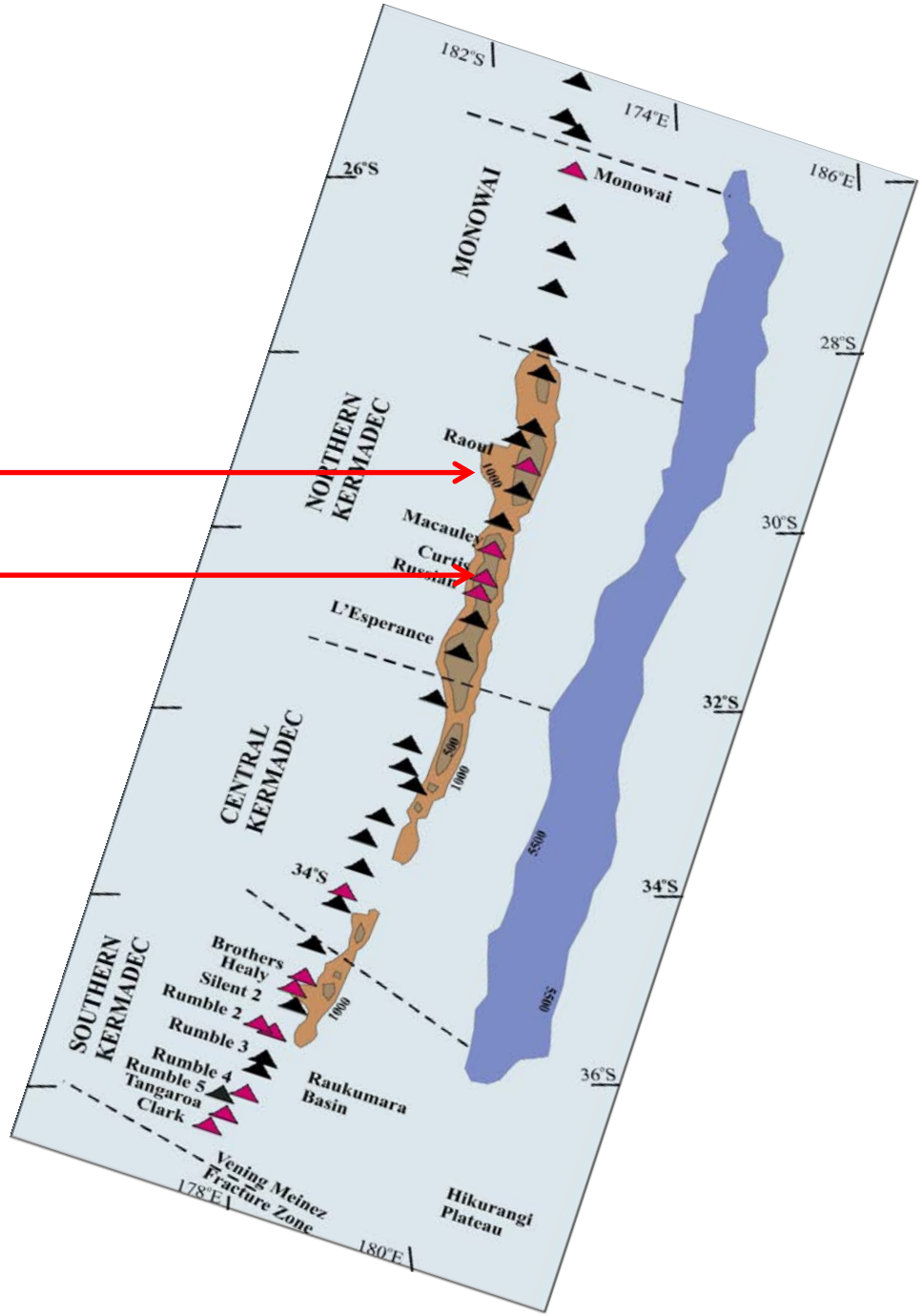
Wright et al.
JVGR 2006



The unexpected feature is the abundance of rocks with SiO2 >65 wt %

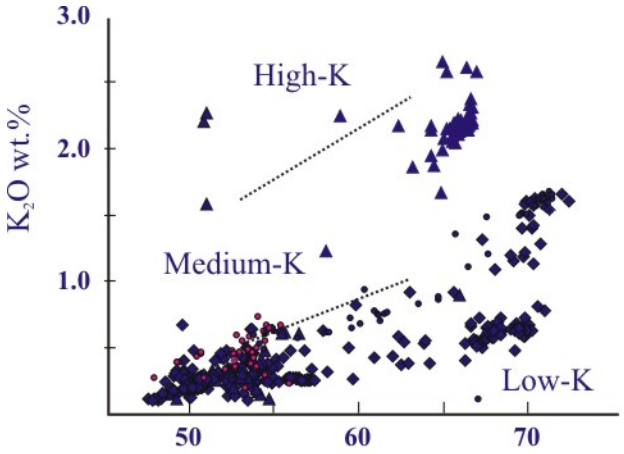

25
30
35
45
50
55
60
65
70
75

SiO2

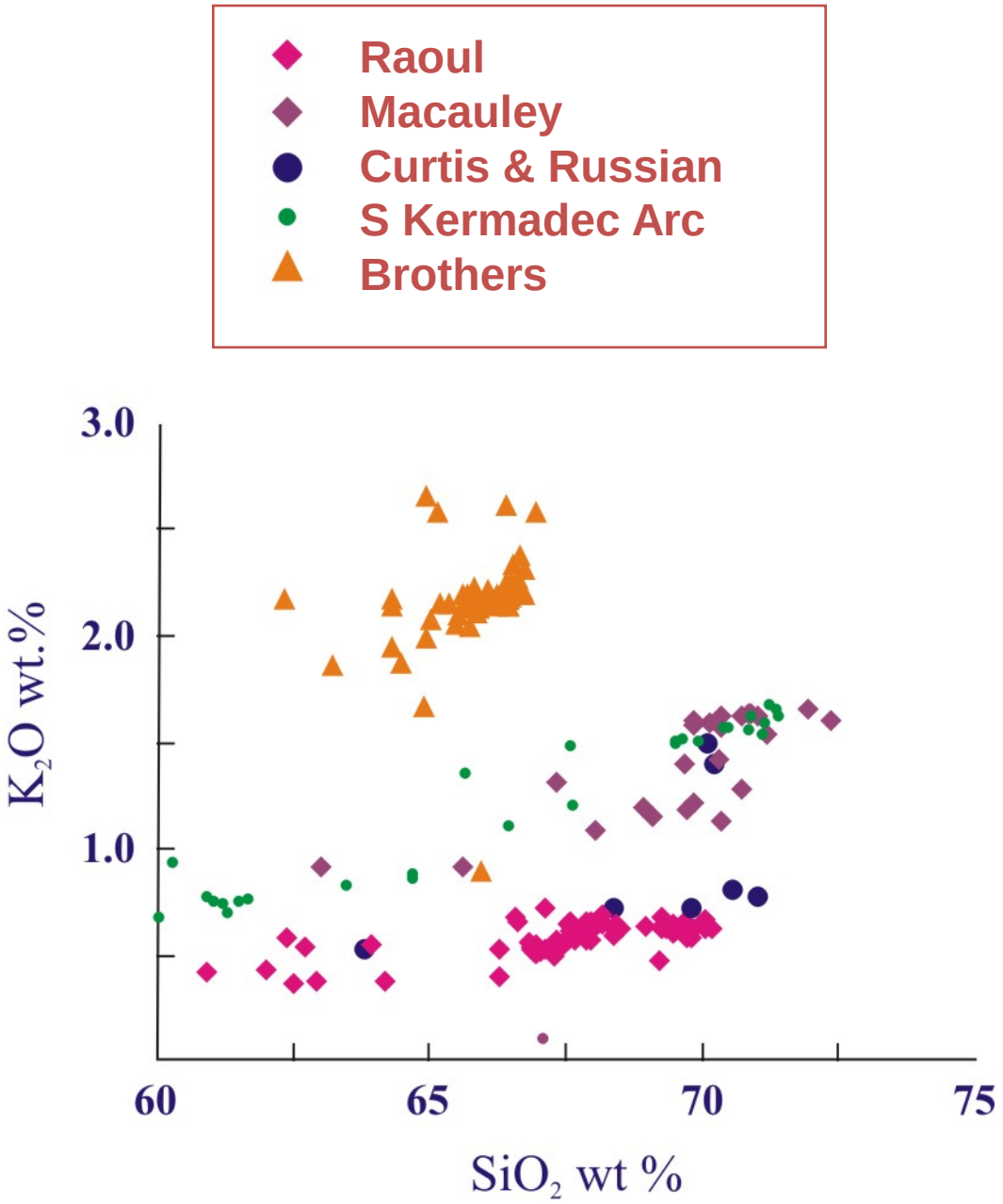

182°S
174°E
186°E
26°S
28°S
30°S
32°S
34°S
36°S
178°E
180°E
MONOWAI
Monowai
NORTHERN KERMADEC
Raoul
Macauley
Curtis
L'Esperance
CENTRAL KERMADEC
SOUTHERN KERMADEC
Brothers
Healy
Silent 2
Rumble 2
Rumble 3
Rumble 4
Rumble 5
Tangaroa
Clark
Raukumara Basin
Vening Meinez Fracture Zone
Hikurangi Plateau
1000
500
1000
5500
5500
1000


Raoul
Island
Two calderas
16 eruptions since 3,700 years ago
8 silicic, two andesitic, 6 phreatic

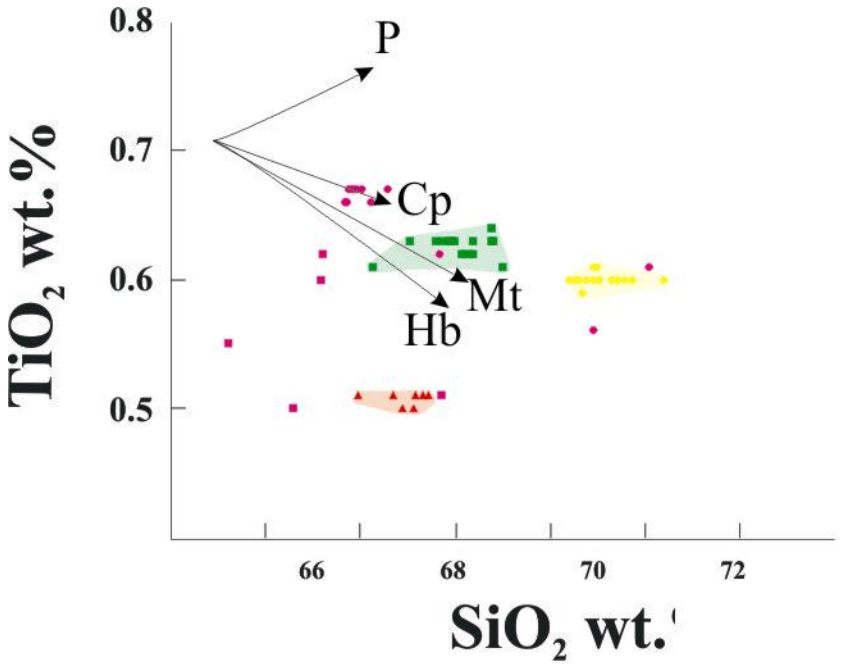
Raoul Island
Large pumice dominated fall and flow pyroclastic deposits

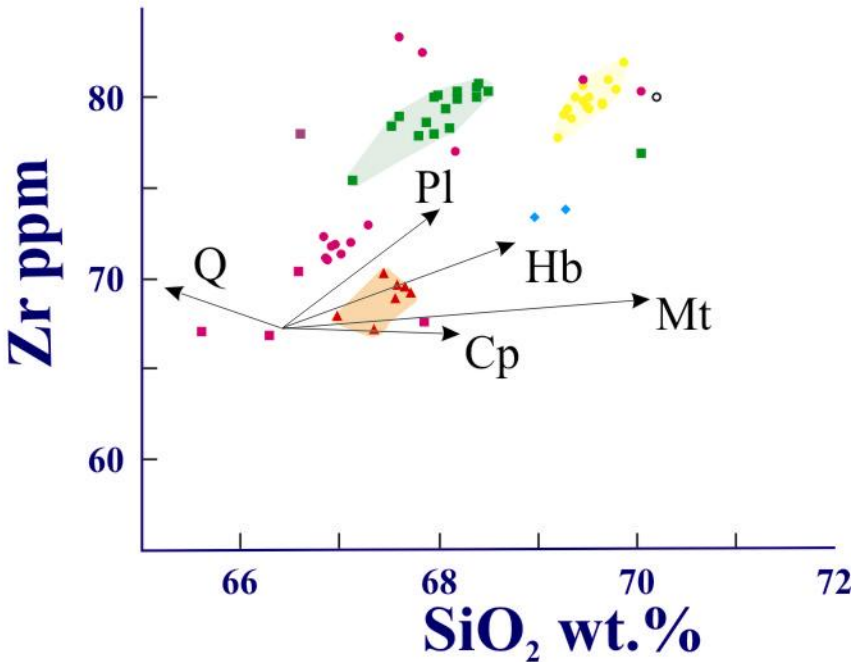


- Intermediate compositions are not common
- Basalts and basaltic andesites are almost entirely low-K
- Felsic rocks show a wide variety of compositions



Raoul Island

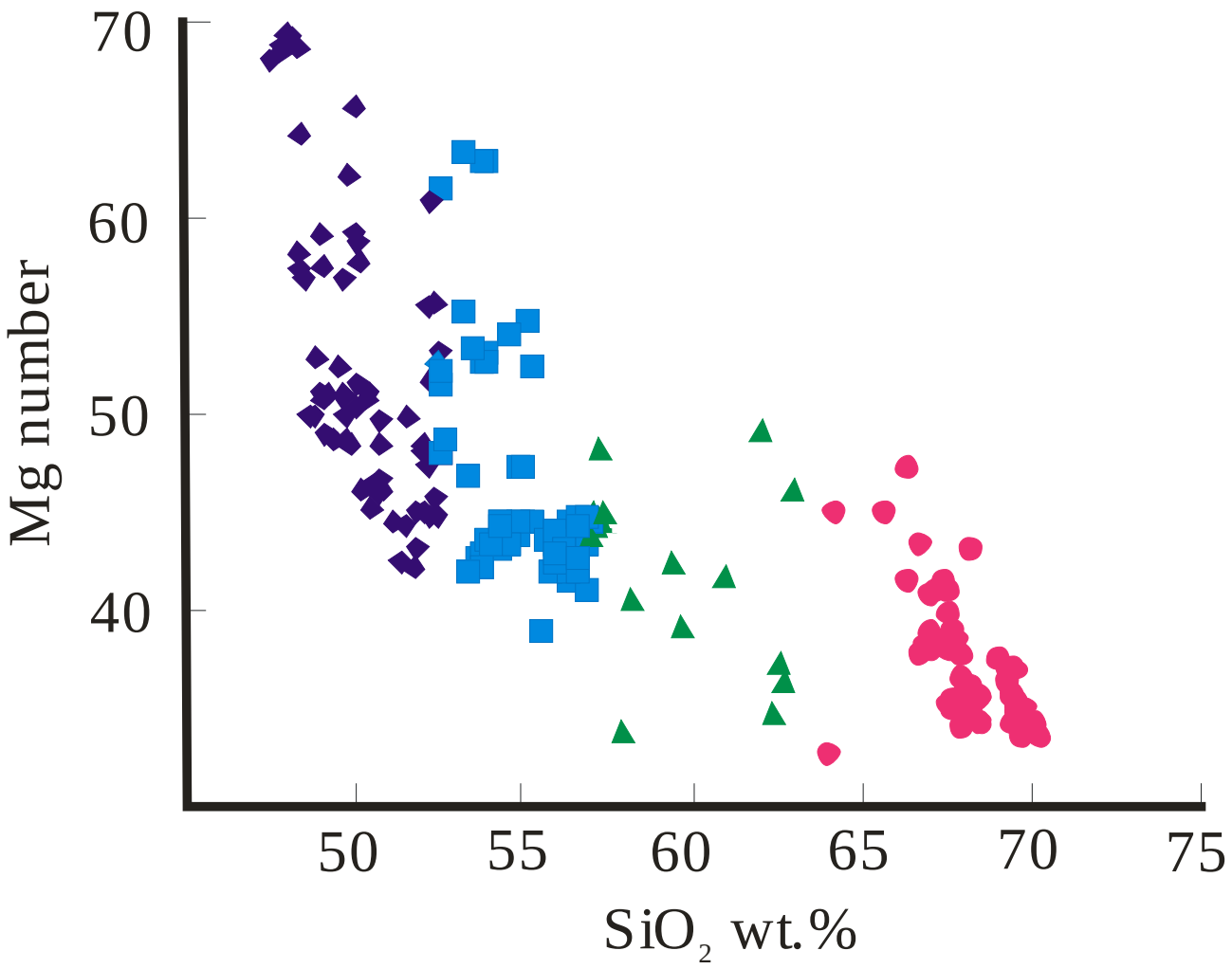




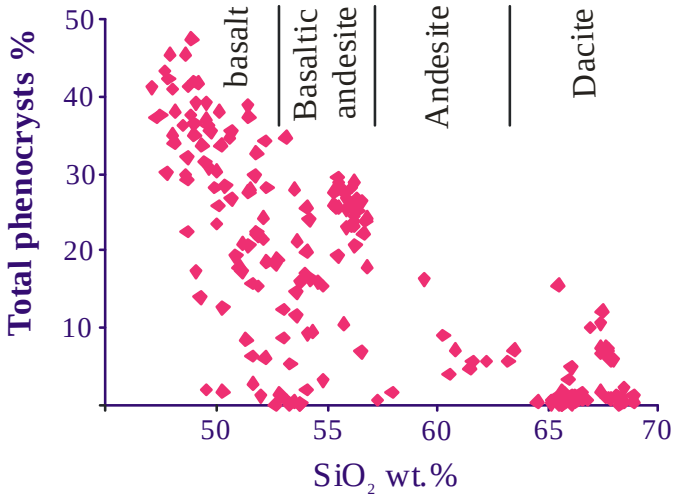
Individual felsic eruptions form discrete trends

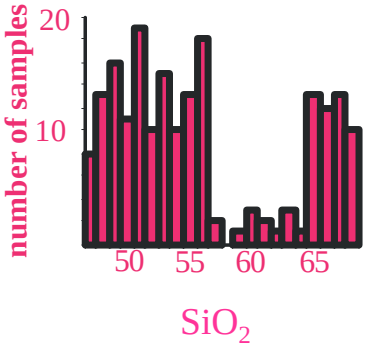
Not possible to relate these to a common fractionation scheme

Best explanation is that they developed as discrete batches

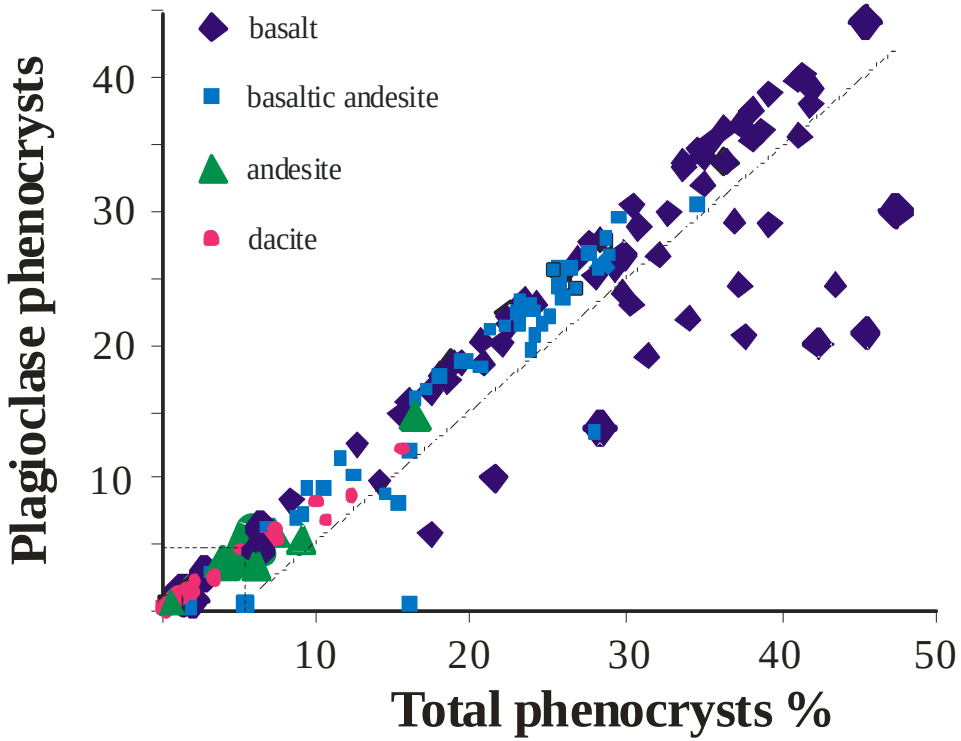


Smith et al 2009
JVGR

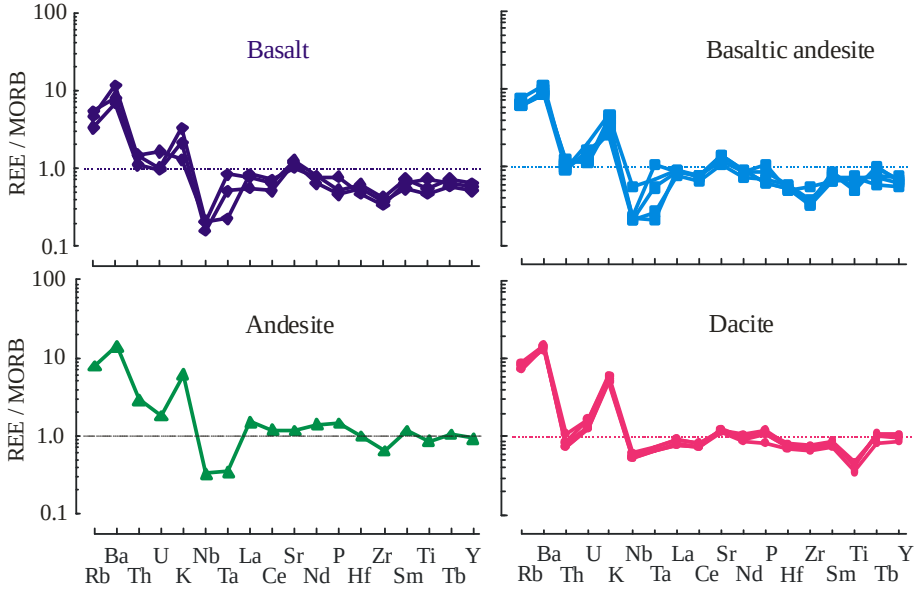




Raoul Volcano
Phenocryst proportions

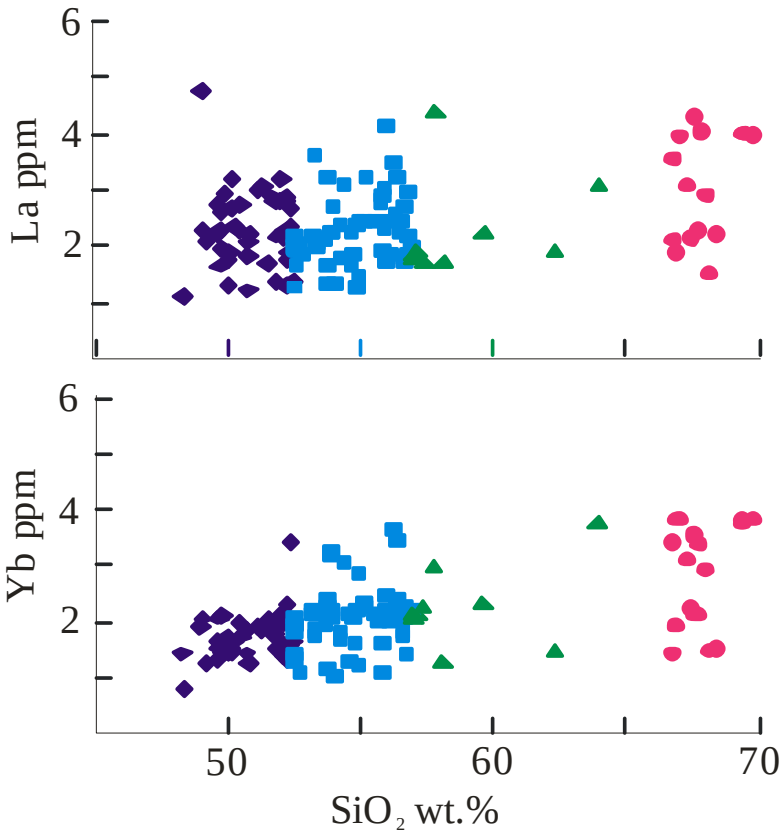


Smith et al 2009
JVGR



And what do trace element abundances tell us?

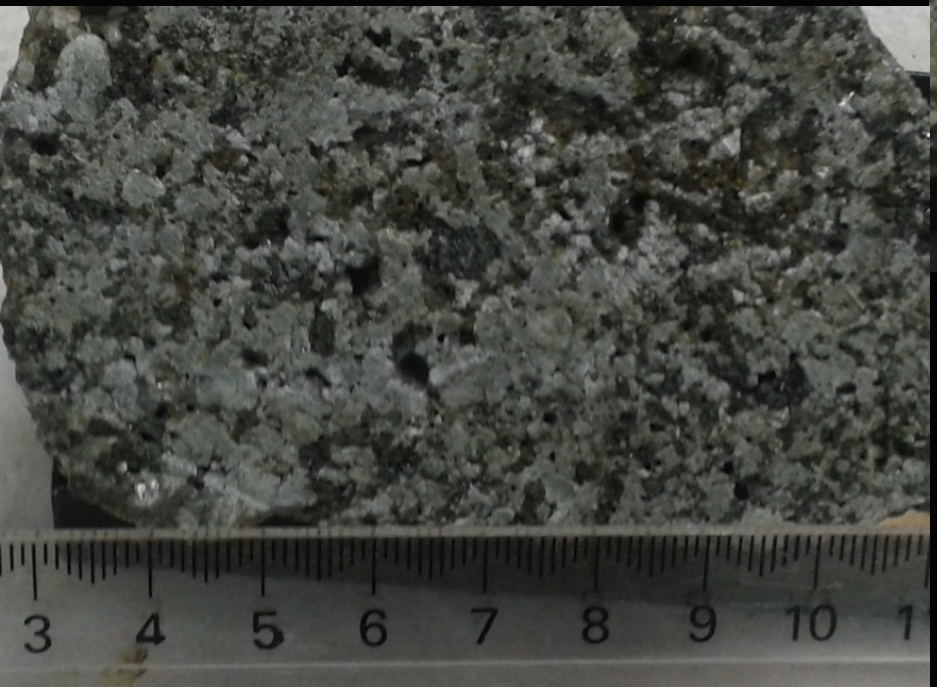
- Little sign of evolution in trace element abundances
- Development of +ve Eu anomalies and minor development of –ve Eu anomalies point to plagioclase additions and subtractions

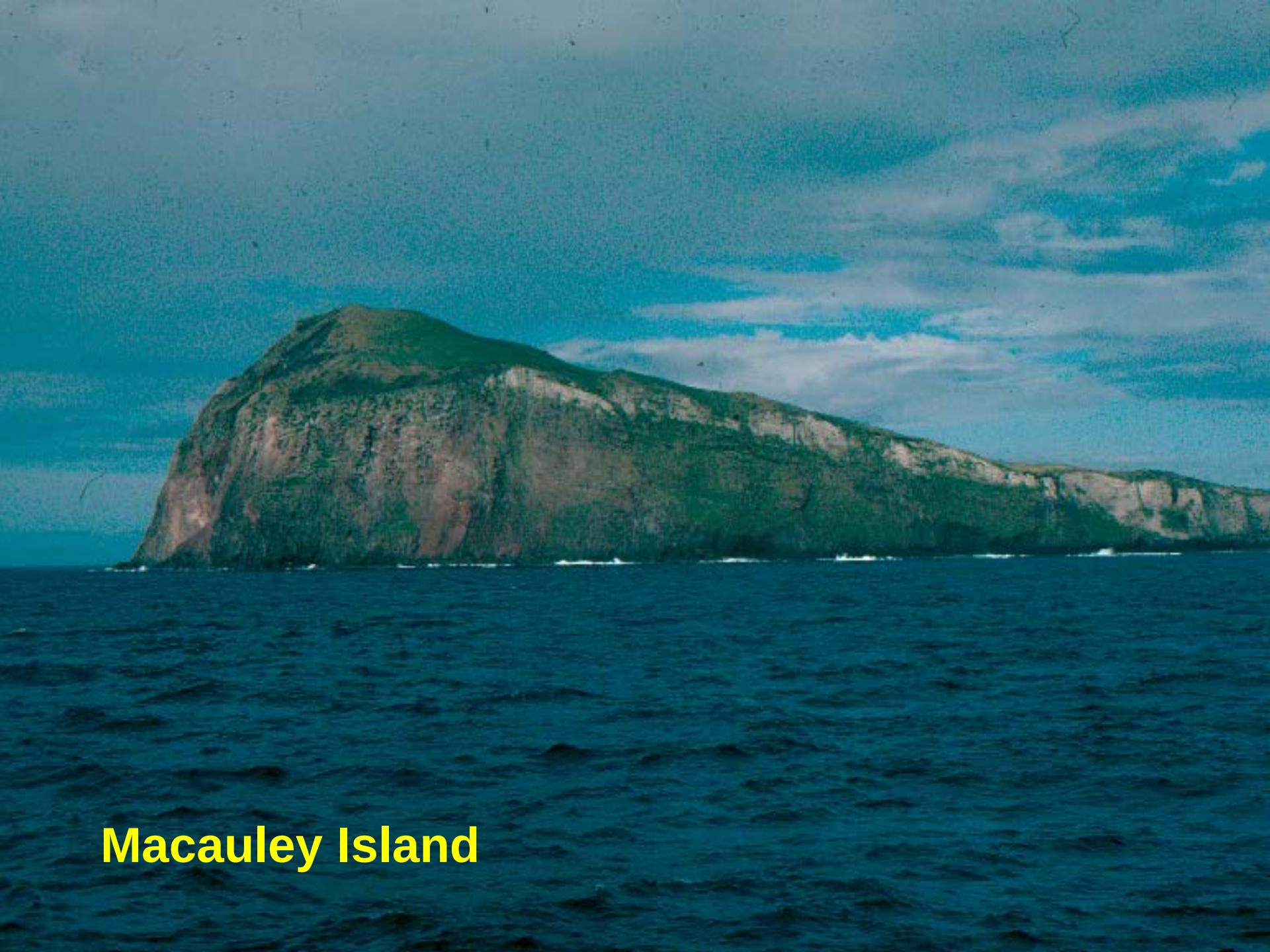


Smith et al 2009
JVGR


2 3 4 5 6 7 8 9 10 11


1 2 3 4 5 6 7 8 9


3 4 5 6 7 8 9 10

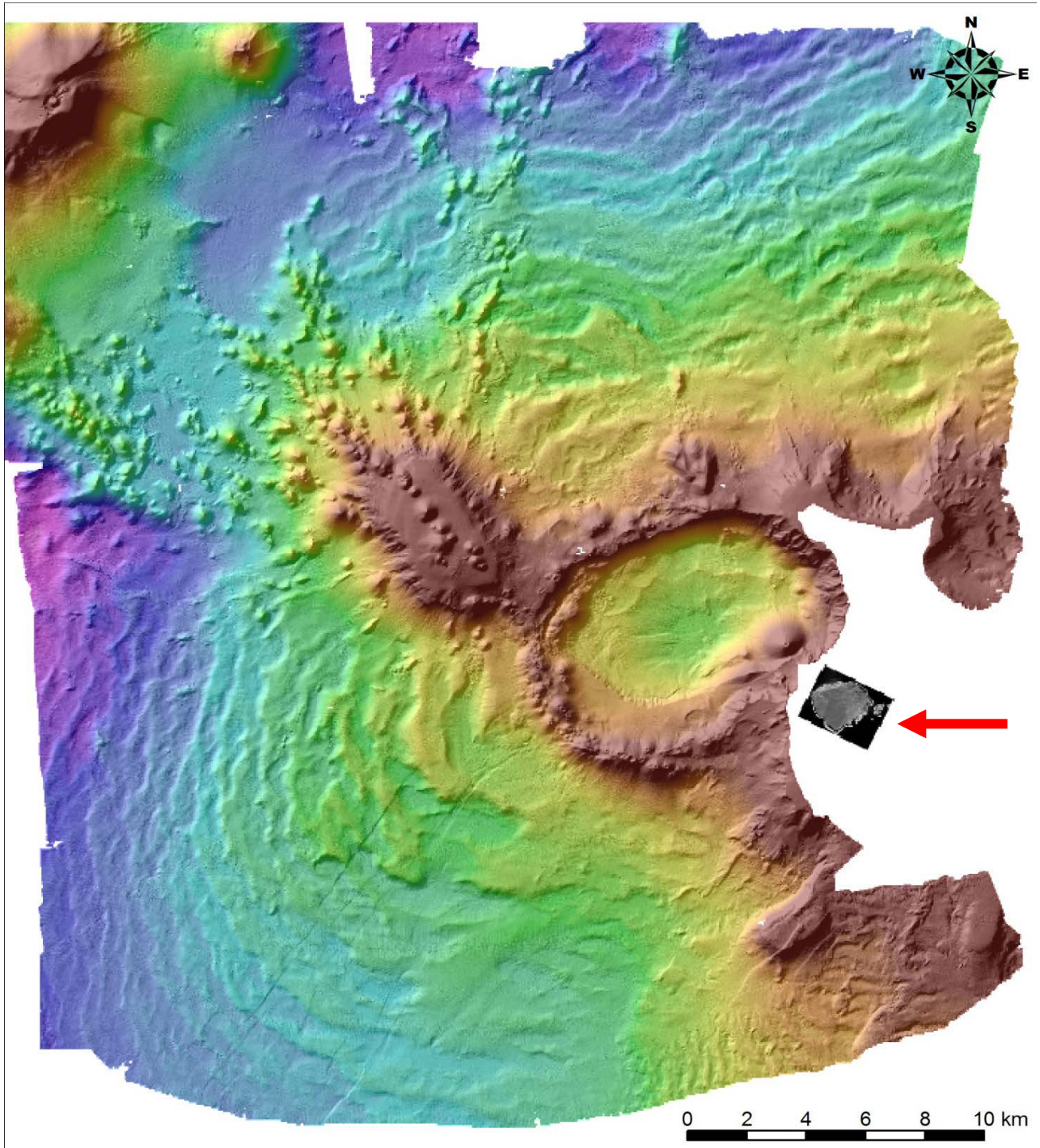

Macauley Island

Macauley Island

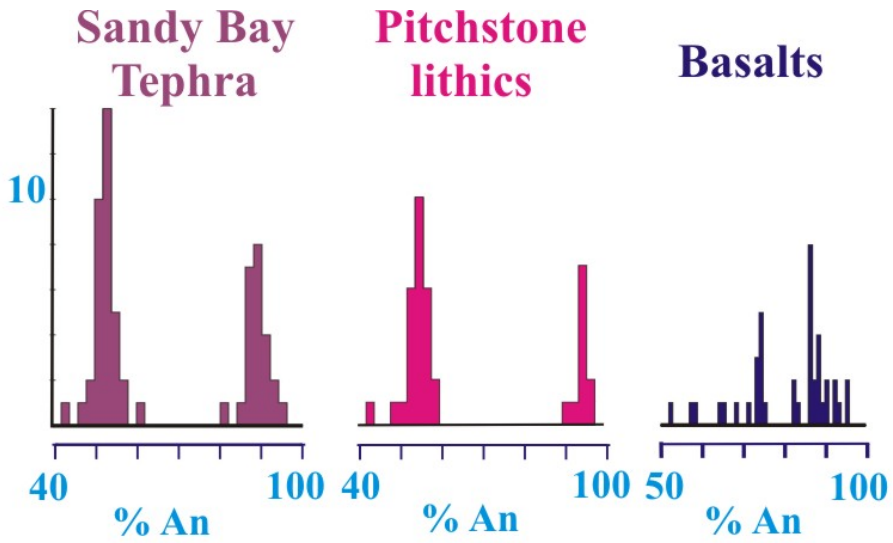
- A small subaerial fragment (3km^2) of the rim of Macauley Caldera
- Alternating basaltic and felsic eruptions

Sandy Bay Tuff

- A moderate sized felsic eruption
- Estimated volume 1-5 km^3
- 6310±190 years BP
- One of 2 known felsic eruptions from Macauley



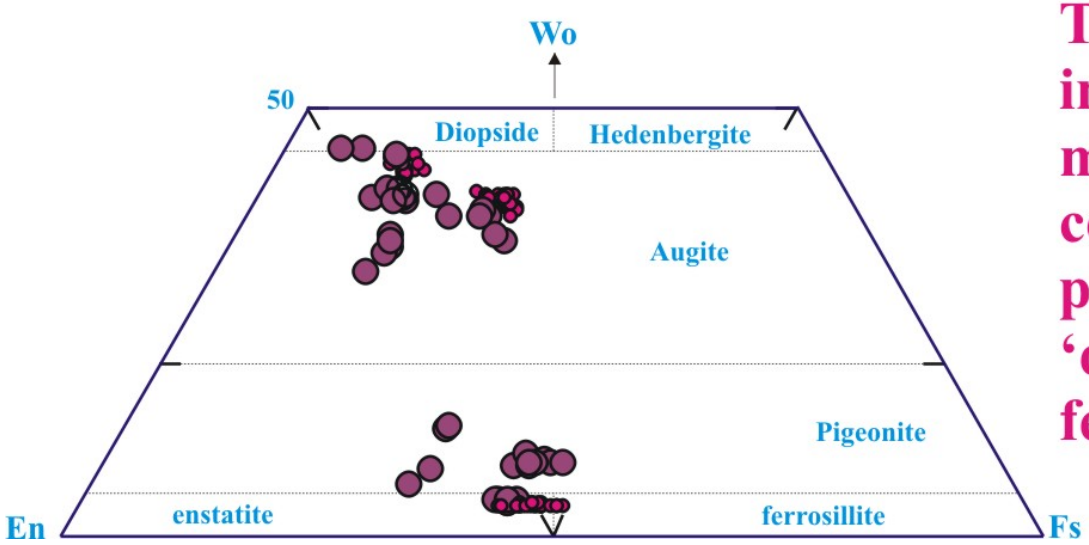
Macauley caldera 12 km diameter and up to 1.1km deep



Macauley Island

Plagioclase
- bimodal distribution of An in felsic units

Pyroxene
- bimodal distribution in terms Mg/Fe ratios



These petrographic features indicate involvement of basaltic magma in an open system. A conclusion supported by the presence of mm sized basaltic 'drops' as a distinct phase in felsic pumice

Observations

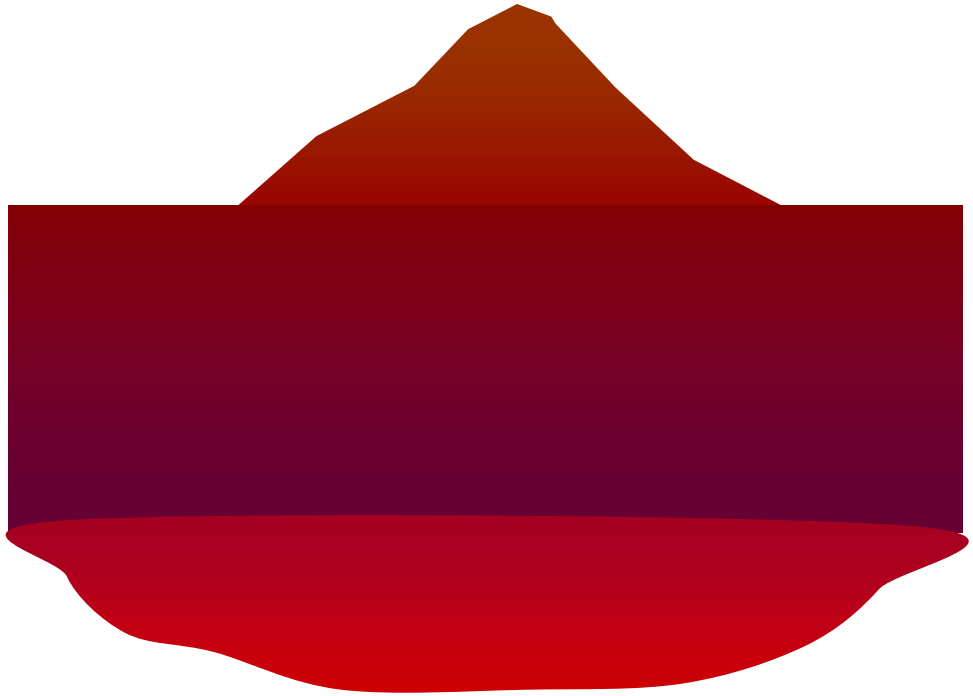
- **Frequent felsic eruptions throughout the Tonga Kermadec arc in the last 10,000 years**
- **Felsic magmas occur as compositionally discrete batches**
- **Felsic magmas are crystal poor and relatively hot**

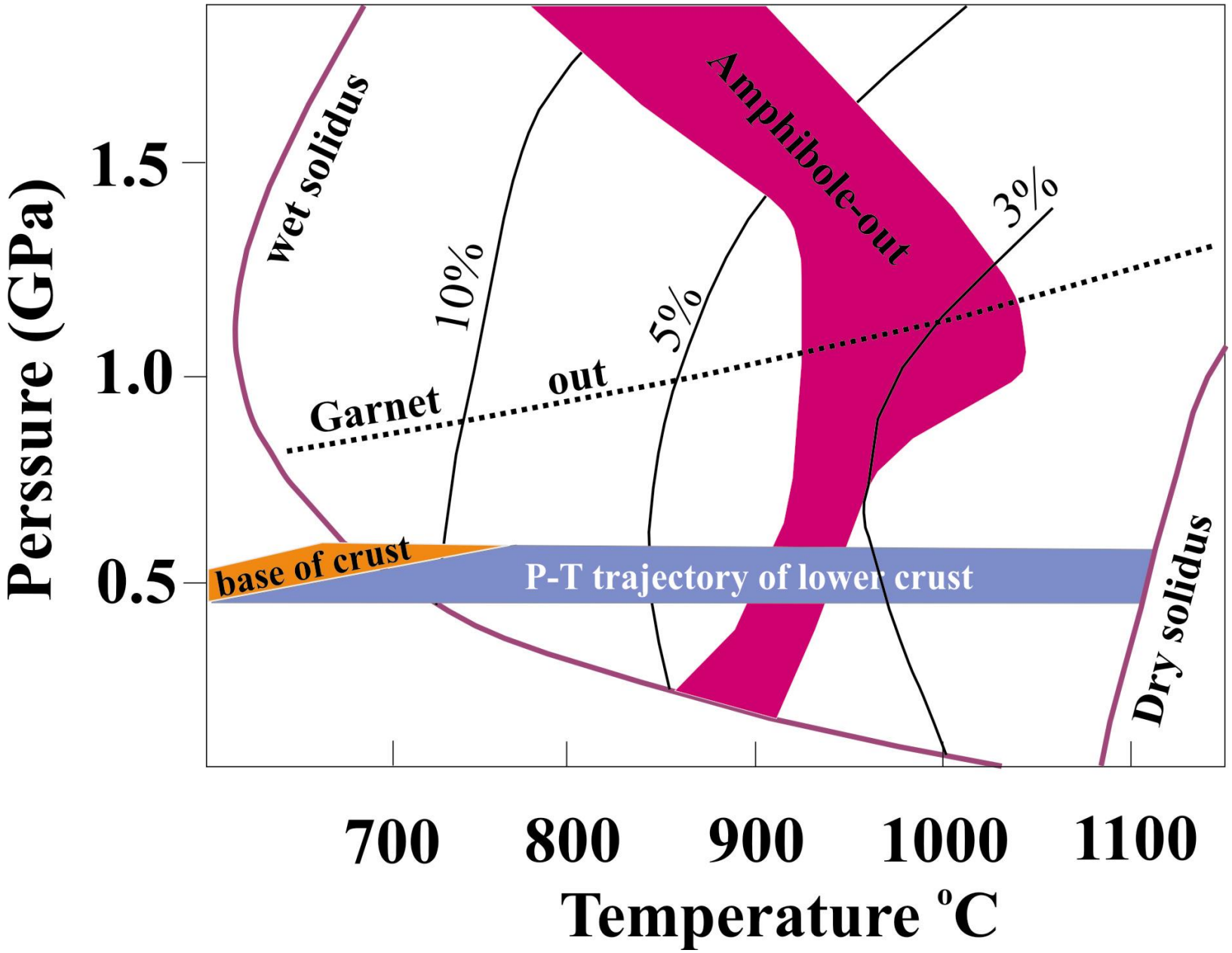
Hypotheses

- Fractional crystallisation of basaltic parent
- Crustal anatexis

The sub-arc crust

- Oceanic crust ~10 km
- Volcanic edifice ~2-3km
- Underplate ~3-5km

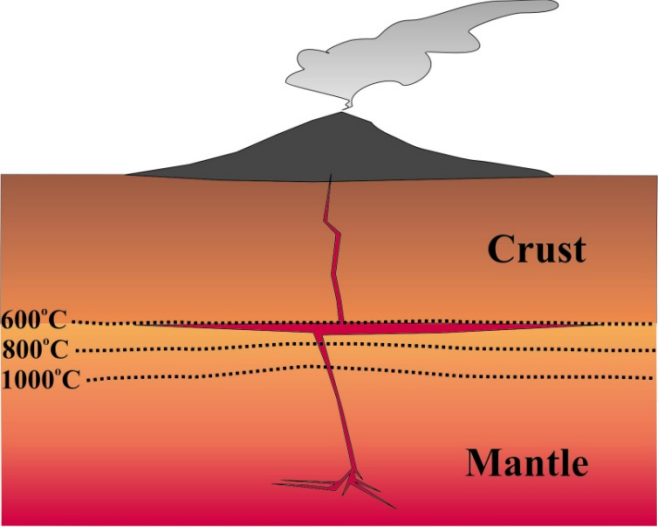



Perssure (GPa)
1.5
1.0
0.5
wet solidus
10%
5%
3%
Amphibole-out
Garnet
out
base of crust
P-T trajectory of lower crust
Dry solidus
700
800
900
1000
1100
Temperature °C

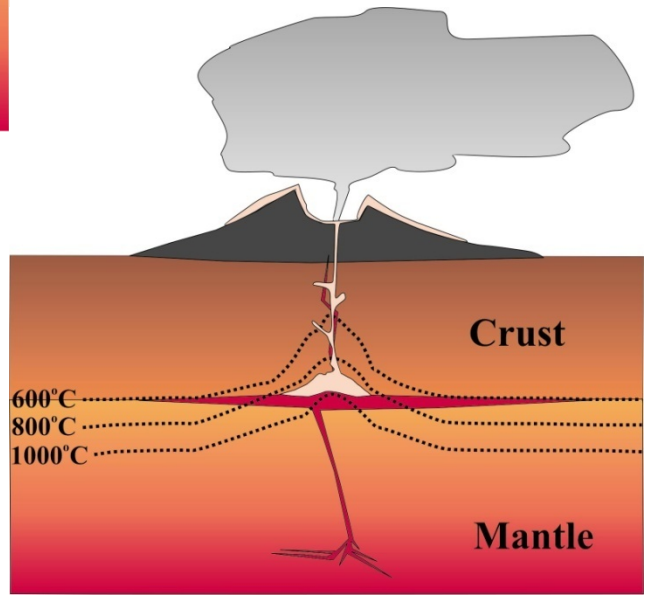
Heat required to generate a crustal melt = 2.06 pJ

Heat available to heat the crust = 28.44 pJ

- Magma flux = 3×10^{-4} km^3/year
- Time = 1.0 million years

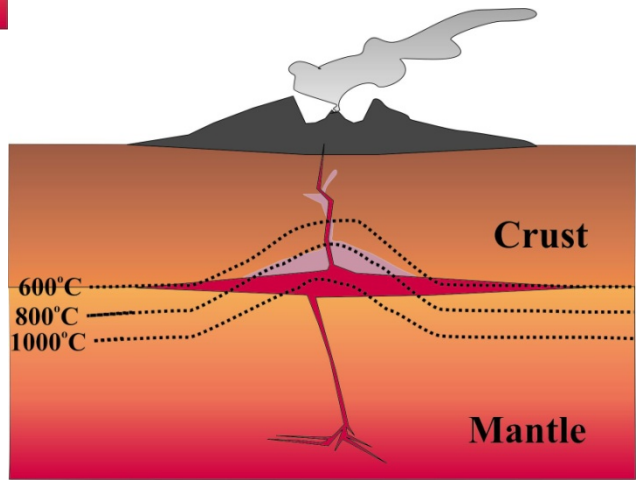


1. Infancy, heat transferred by convection as the arc is underplated

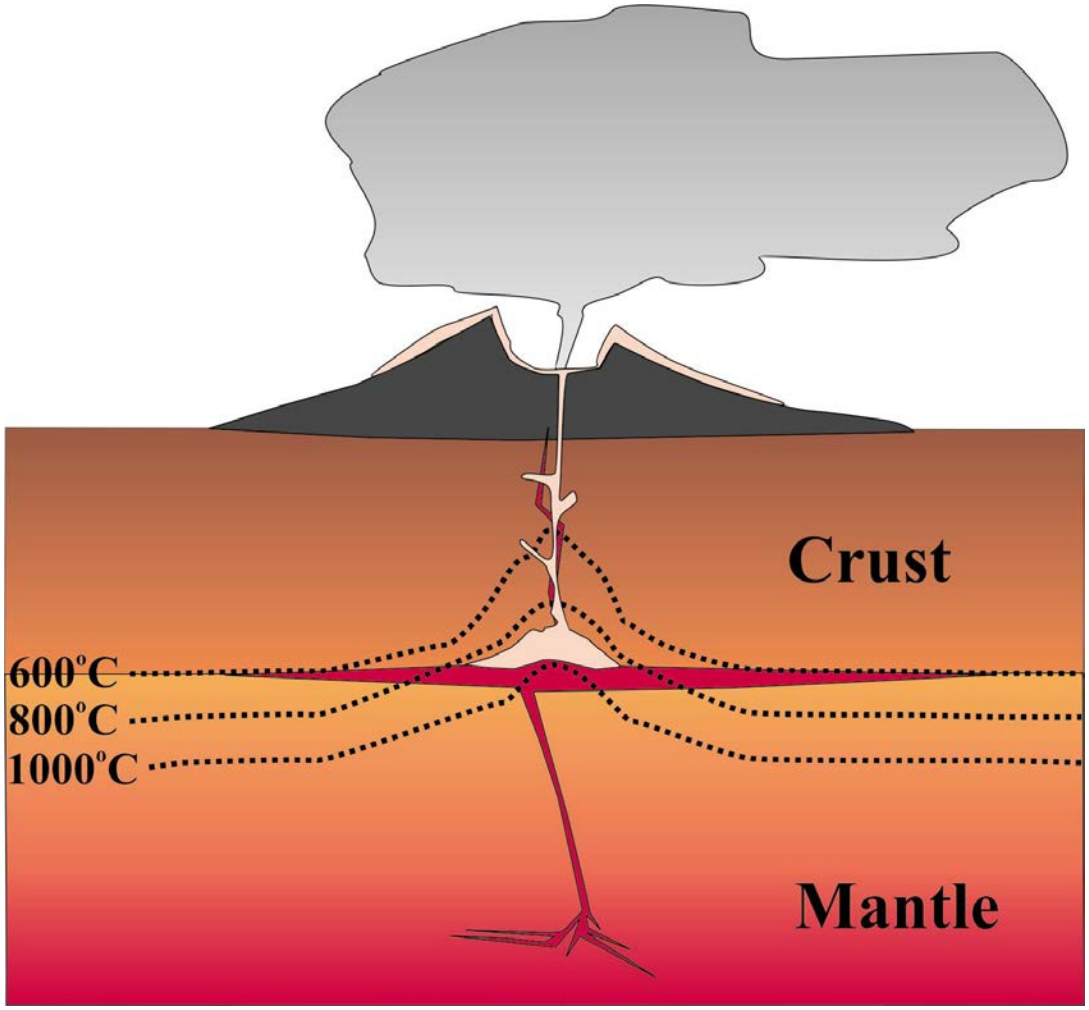


2 Adolescence felsic magmatism initiated by dehydration melting when amphibole stability exceeded

3. Arc maturity, basaltic magmatism continues but the lower crust is now depleted in felsic components



The adolescent arc



- Melting commences as the temperature approaches the amphibole-saturated liquidus at 850-950°C
- Dehydration melting fluxes the crust and felsic melts are rapidly generated
- 20-30% melt segregates from a granulitic residue
- Felsic magmatism may be interspersed with ‘normal’ mafic magmatism

Questions

- Do felsic magmas only appear ~ 1.0 ma after arc inception (observation?)

- Is felsic magmatism a transient (adolescent) stage in intraoceanic arc evolution (hypothesis)