Se7en: A He isotope story of the Auckland Volcanic Field

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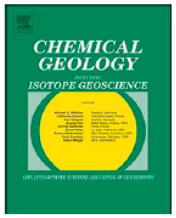

Unusually homogeneous helium isotope composition of the Auckland Volcanic Field and its implications for the underlying mantle

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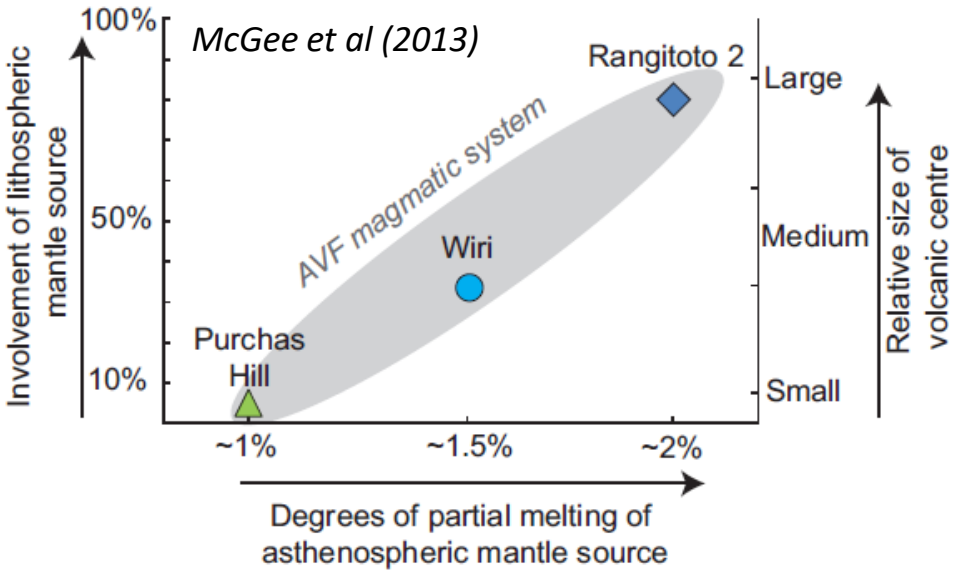
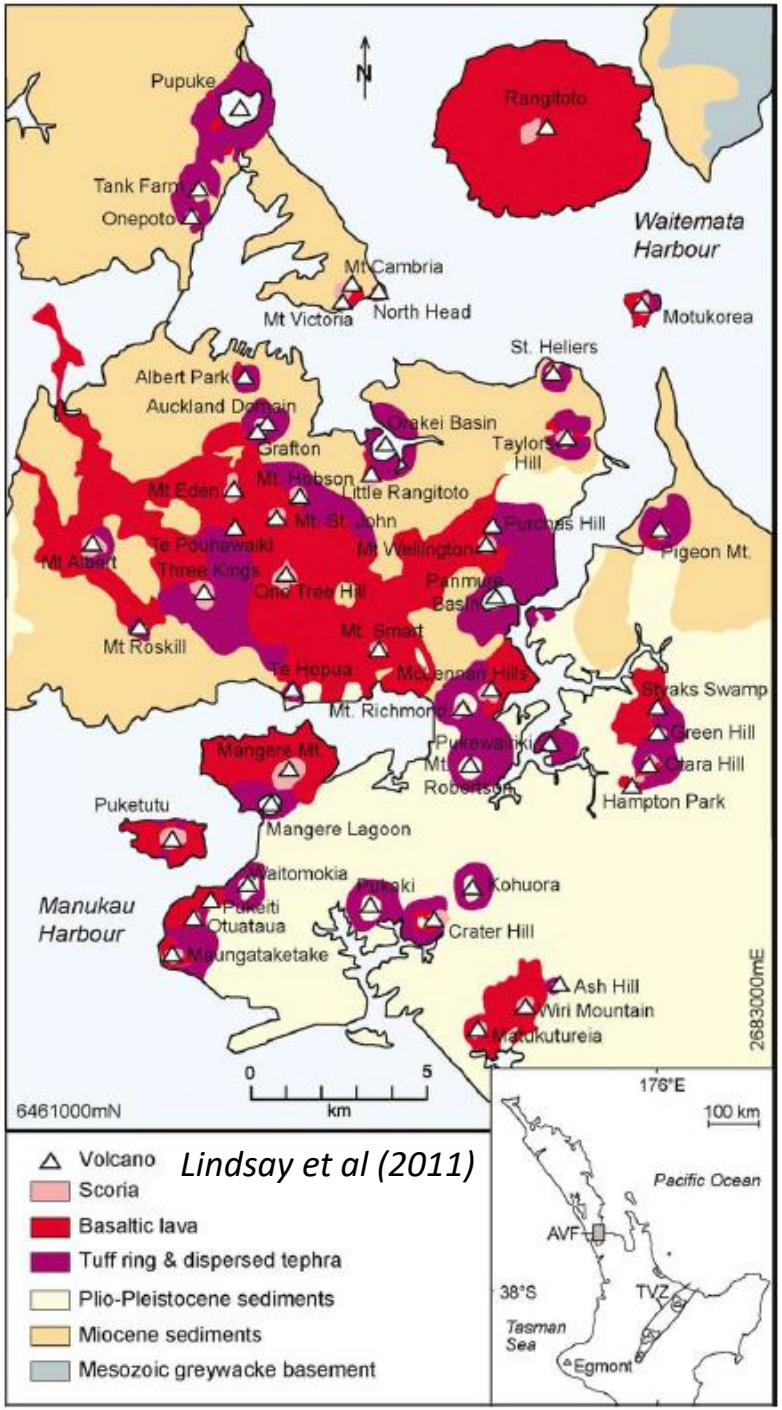
Auckland Volcanic Field

- Auckland volcanic field composed of >50 volcanic vents.

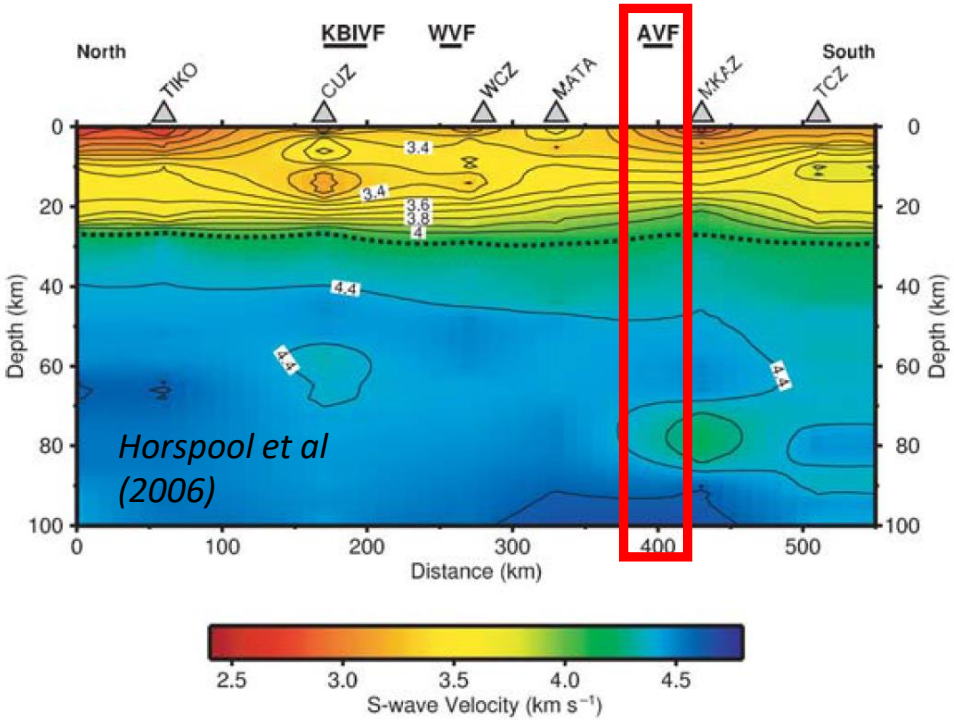
- Compositional diversity correlated to the size of the centre.

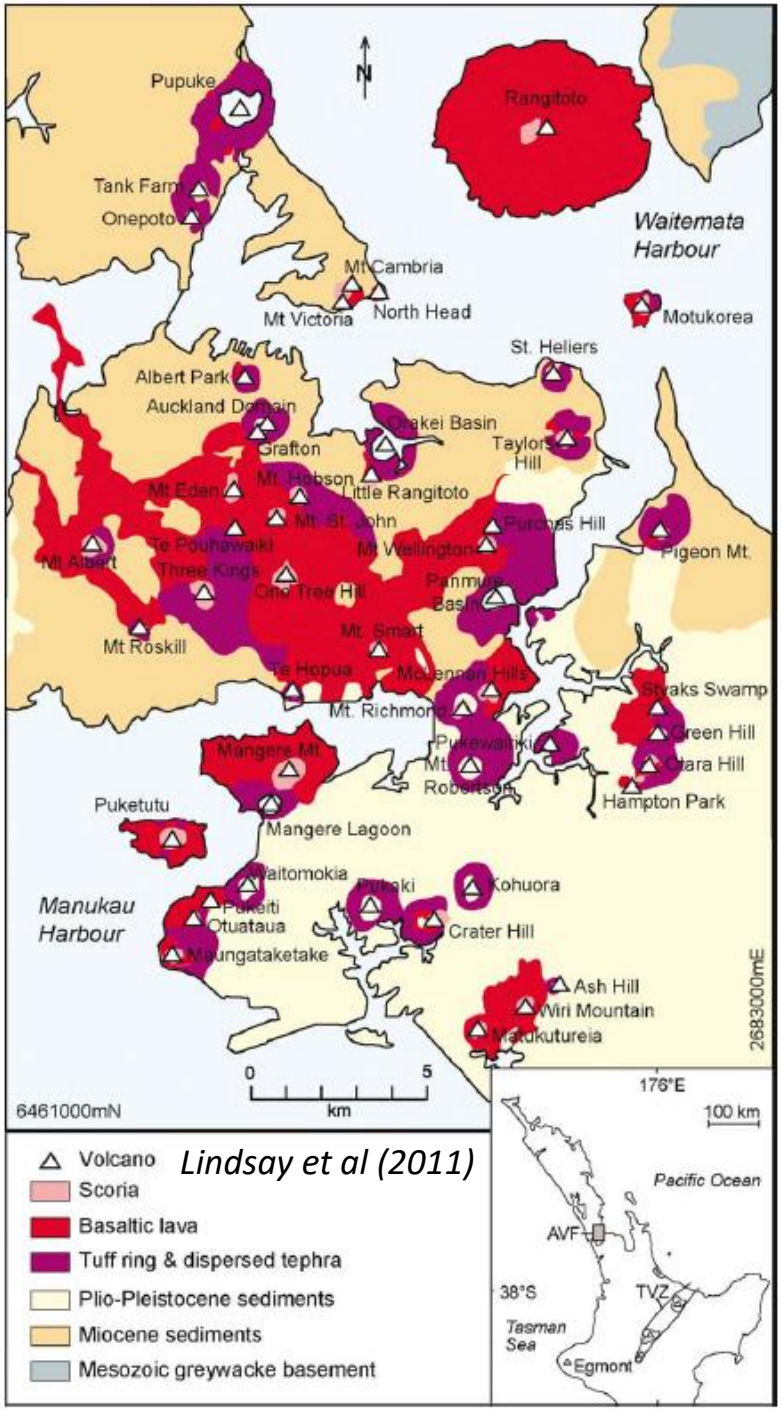




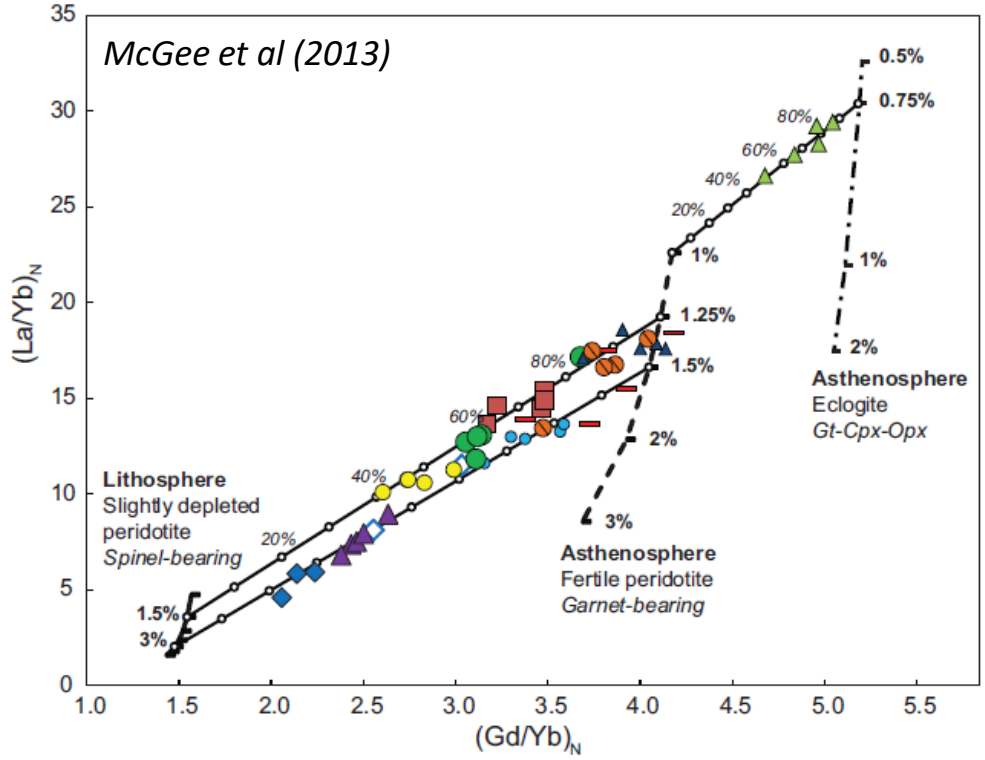
Auckland Volcanic Field

- Auckland volcanic field composed of >50 volcanic vents.
- Compositional diversity correlated to the size of the centre.
- Geobarometry and shear wave velocity structure suggest partial melt zone at 70-90 km





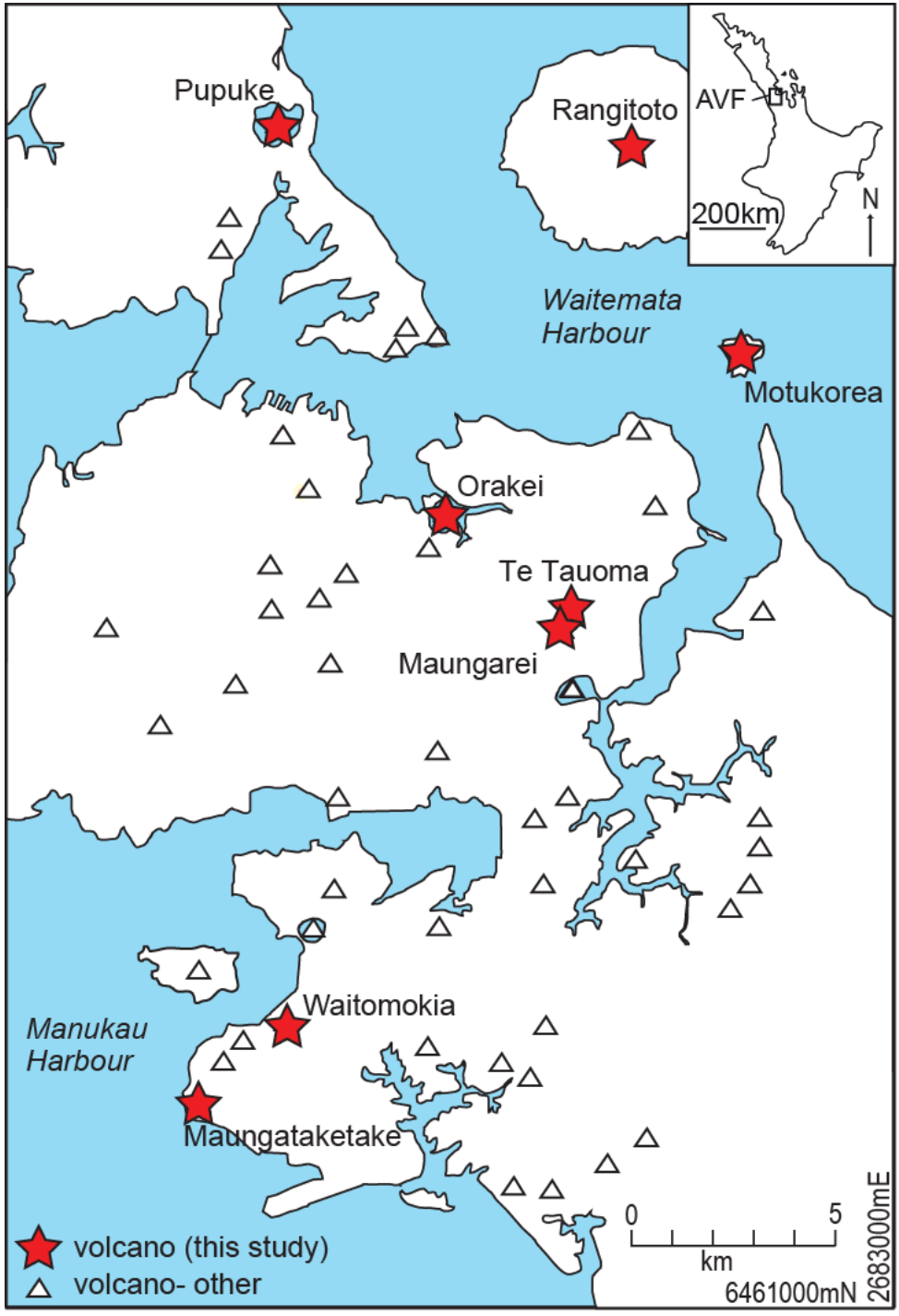
- Auckland volcanic field composed of >50 volcanic vents.
- Compositional diversity correlated to the size of the centre.
- Up to ~3 chemical endmembers have been proposed based on trace elements and radiogenic isotopes.



Compositional Diversity

- Samples for He isotope analysis chosen based on potential endmembers from McGee et al (2013).

- Prior trace element modelling suggests mixture of “lithospheric” and “asthenospheric” mantle.
  - Requires both garnet-bearing and spinel-bearing peridotite +/- enriched source.



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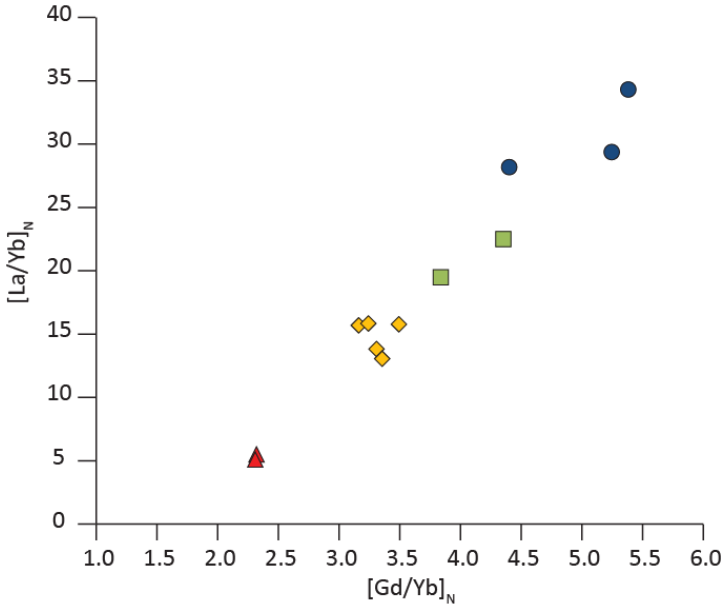
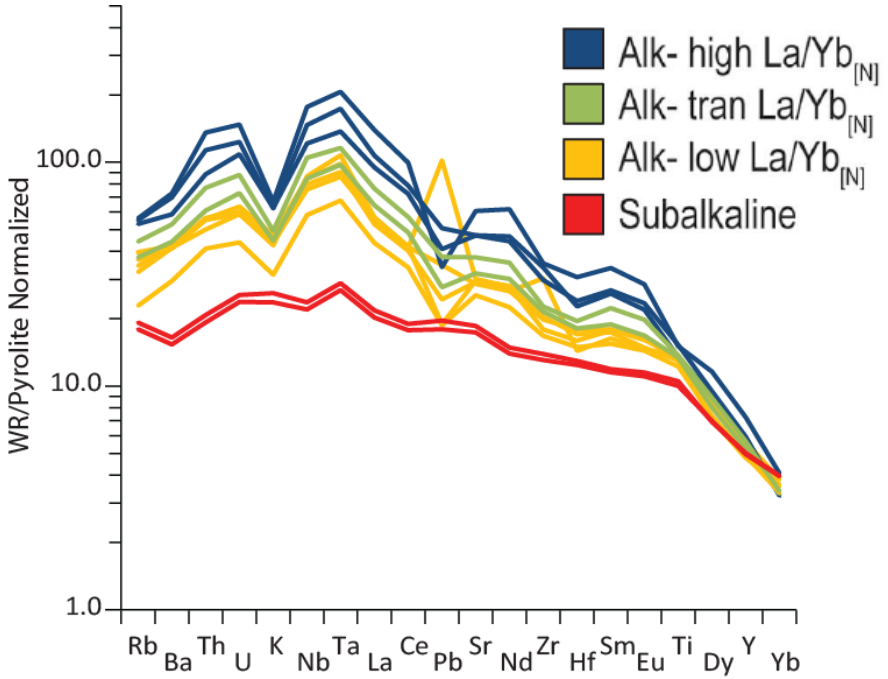
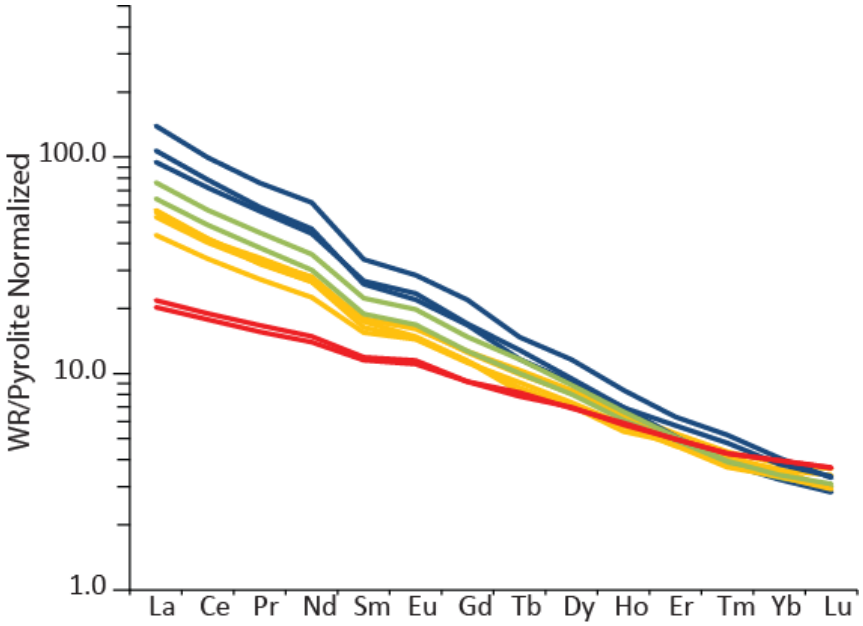
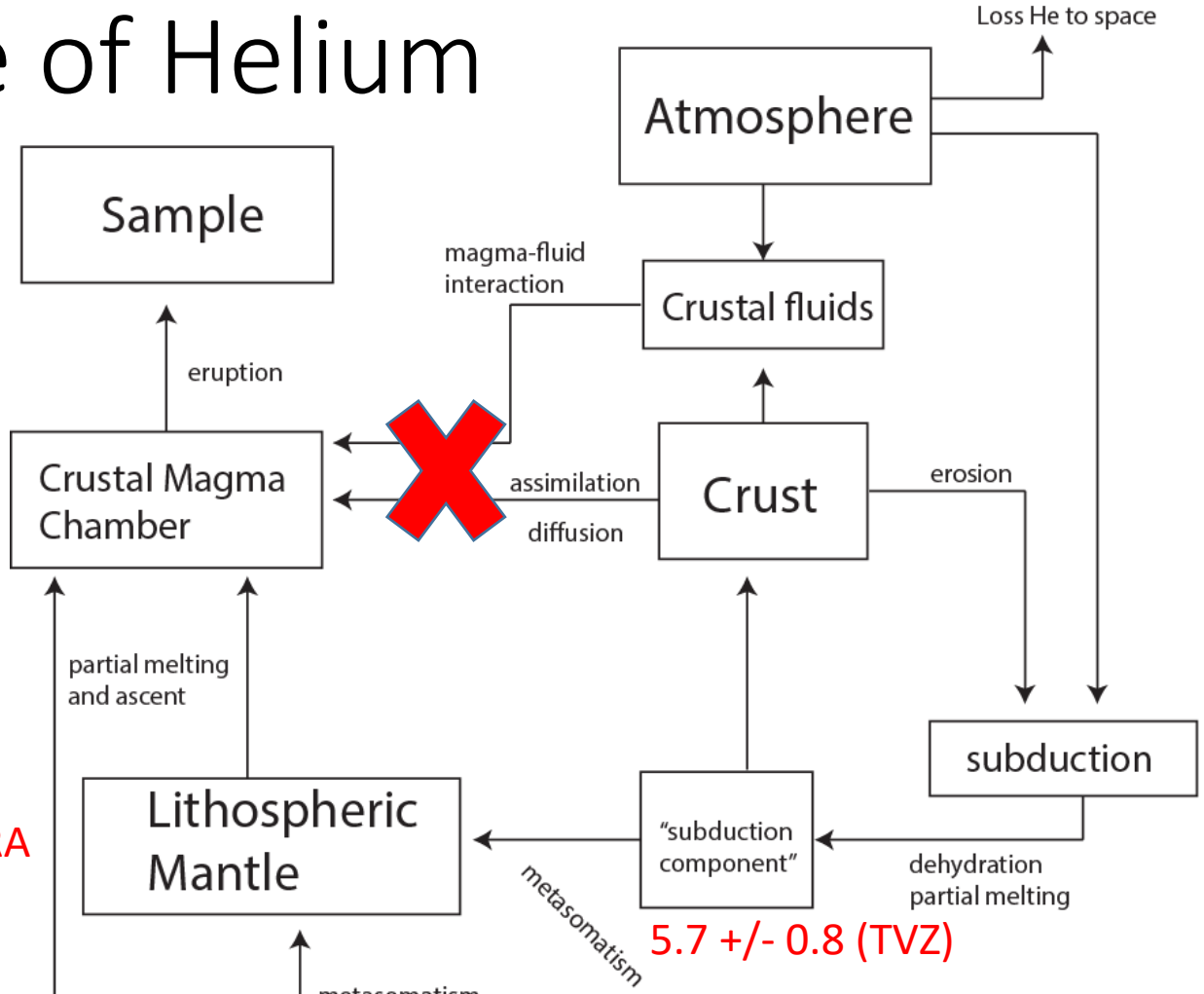






Modified from Patterson et al (1993)

Fate of Helium



~5-7 RA

5.7 +/- 0.8 (TVZ)

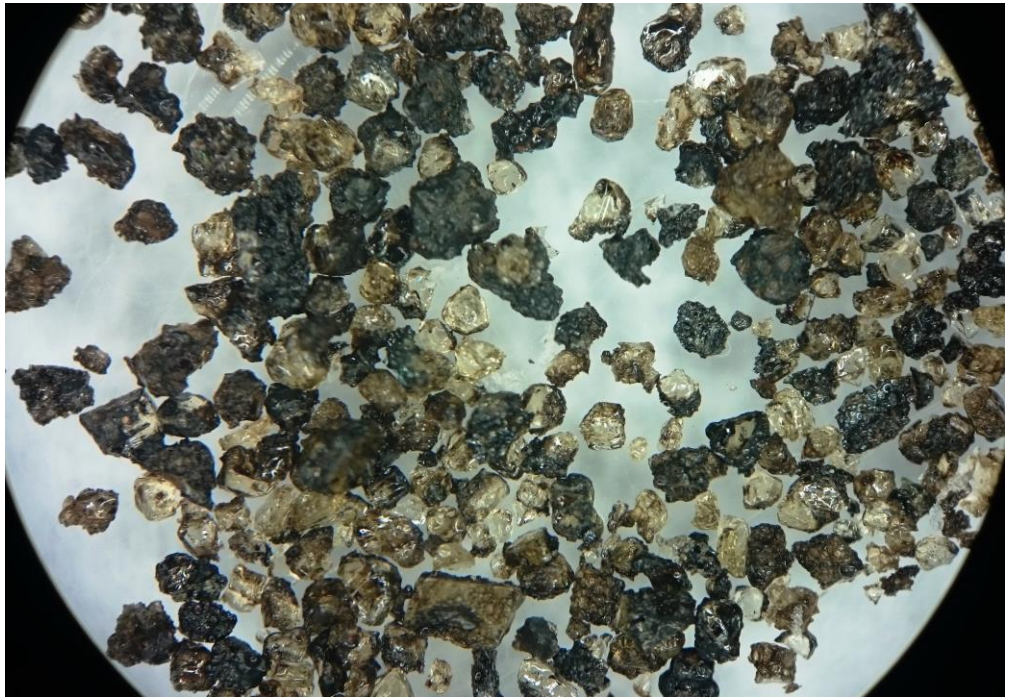
7-10 (MORB)

>10 "primitive mantle"

$R_A = (^3He/^4He)/air$

primordial

U, Th decay (alpha decay)



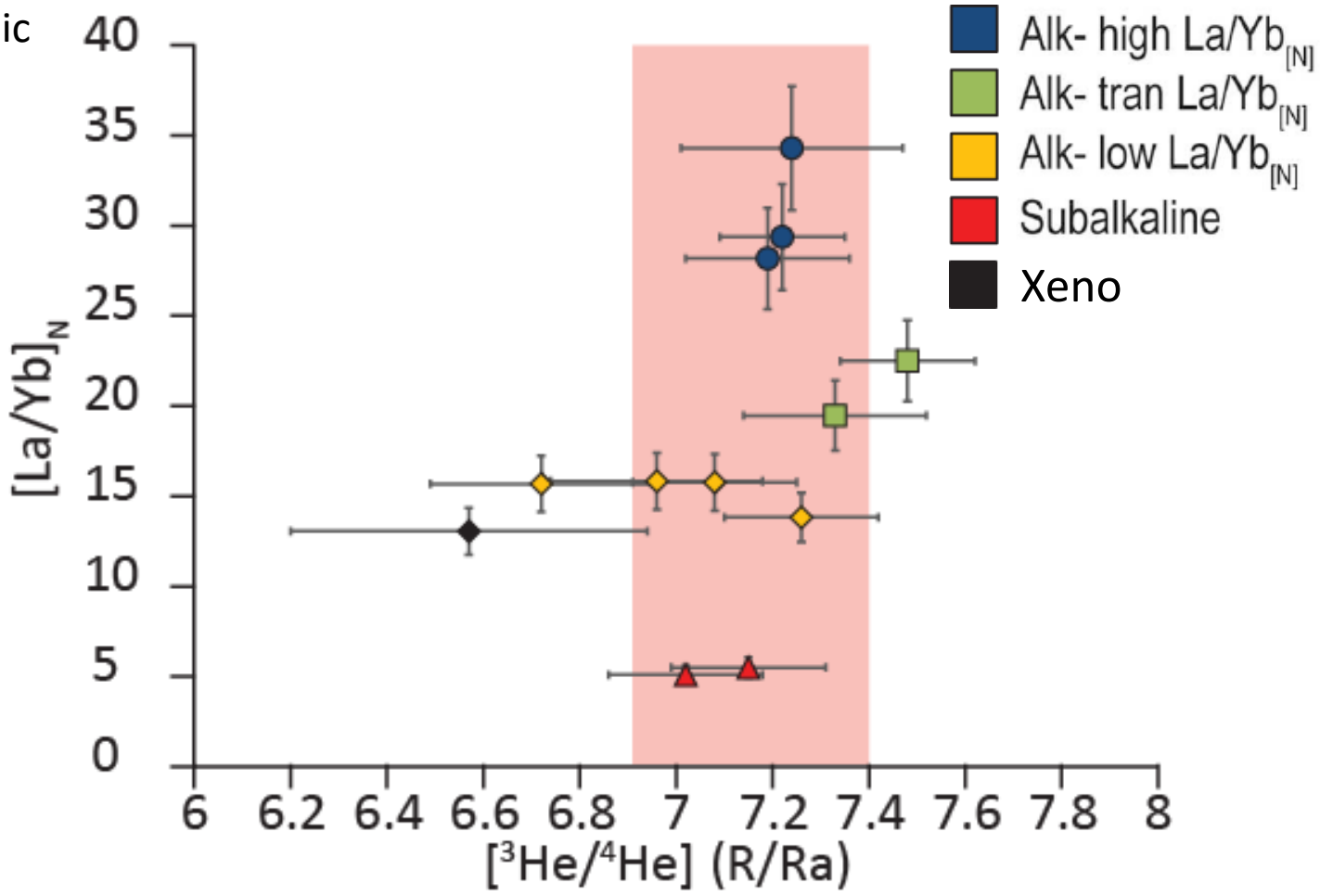
Sample preparation

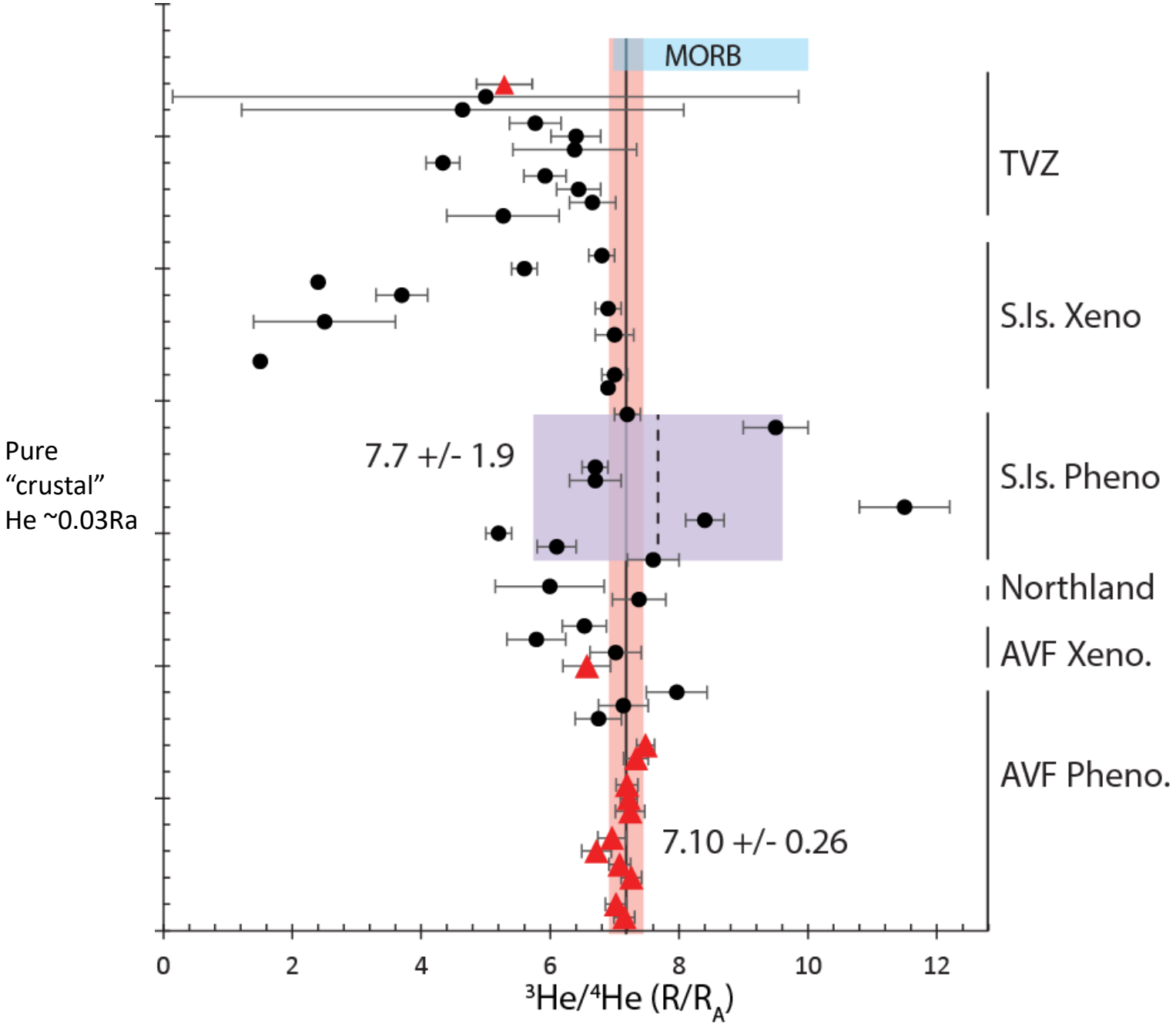
- Olivine treated with HBF_4 (fluoroboric acid) to dissolve exterior glass/groundmass.

- Removes U-, Th-rich glass (α particle producers).
- Etches the outer surface of grains.
  - Removes outer surface of grains embedded with α particles).
- Makes grains more brittle.
  - May result in loss of volatiles from fluid inclusions.

Correlating melt trace elements

- Lack of isotopic correlation to REE enrichment.
- No high $^{3}He/^{4}He$ component.
- No “shallow” crustal component.
- No “subduction” component

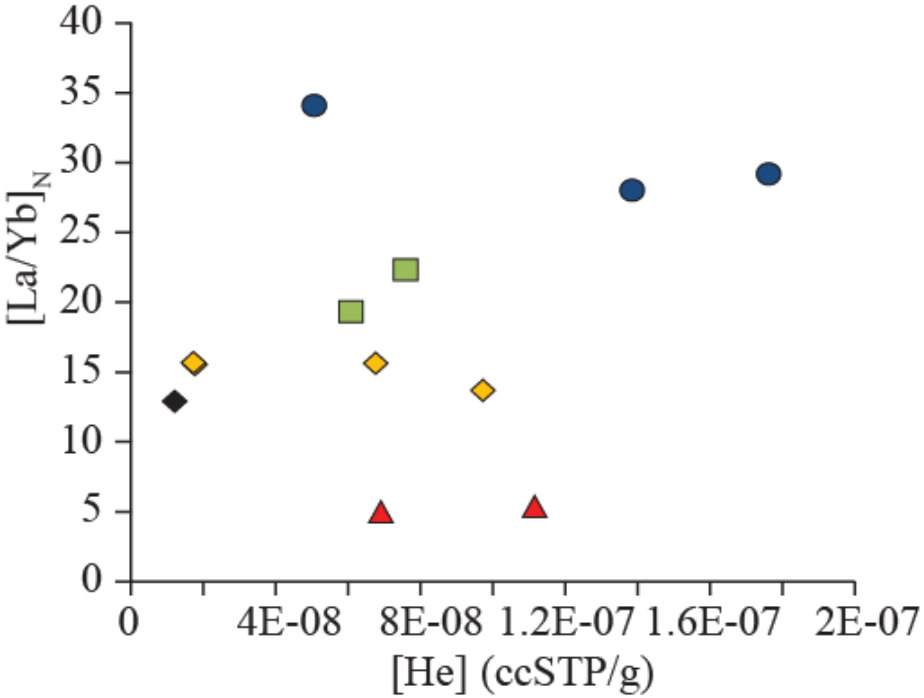


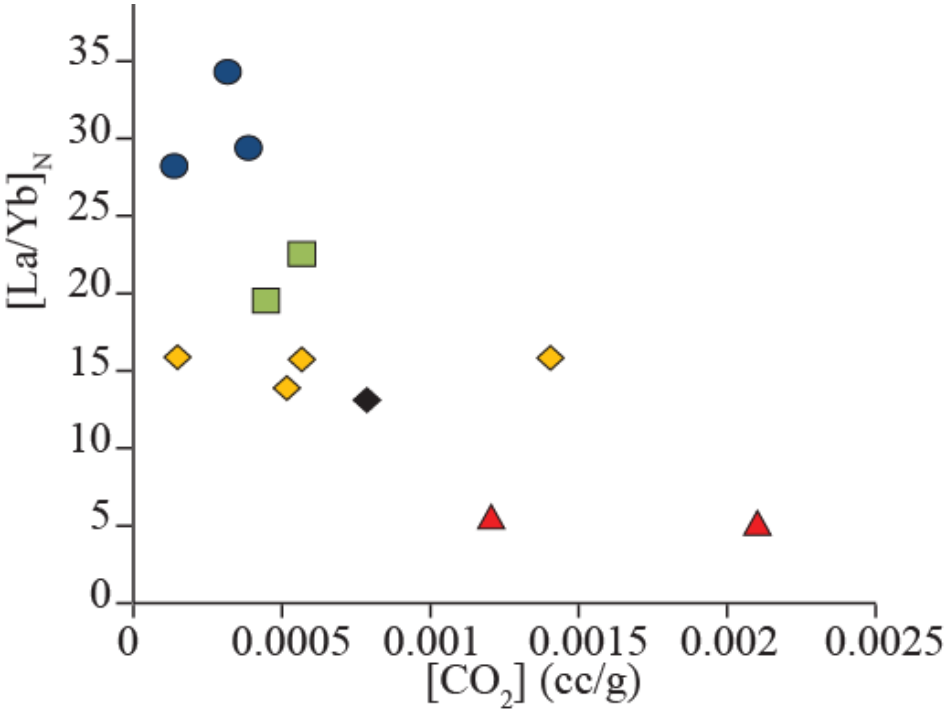


Literature data from Hoke et al (2000) Patterson et al (1993)

Volatile abundances

- [He]: no systematic variation, wide range.
- $[CO_2]$: decreases with increasing $[La/Yb]_N$ (as well as other trace elements!).
- Remember, this doesn't necessarily represent gas in the magma.
  - [High/Low] may reflect trapping efficiency or nature of trapped material.





So what does it mean….(CO_2)?

- magma composition (alkaline versus subalkaline) cannot explain the variation.
  - All else being equal, CO_2 will be higher in alkaline magma.
- Partial melting generally doesn't work.
  - Would get the opposite trend from observed.
  - Except… if CO_2 is lost early (saturated) from low degree partial melts.
- CO2 variation may relate to cooling and ascent rate.
  - Faster ascent of alkali magmas = less

So what does it mean...($^{3}He/^{4}He$)?

- Decoupling of trace elements from He isotopes:
  - Small heterogeneities must dominate the He budget; or
  - Long-term diffusion of He has homogenized the mantle

- Significance of “7”:
  - Low values observed throughout the “Zealandia-Antarctic” mantle domain.
    - Stretches beyond region of 90Ma Gondwana break-up, but no single obvious mechanism.

  - Unlikely to be associated with the lithospheric mantle or subduction.