# Zircon trace element indicators for porphyry-style deposit fertility of New Zealand plutons

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# Zircon trace element indicators for porphyry-style deposit fertility

- Developed and applied internationally over >20 years
- For example:

  Cu-Au, Chuquicamata-El Abra, Chile (Ballard et al., 2002)

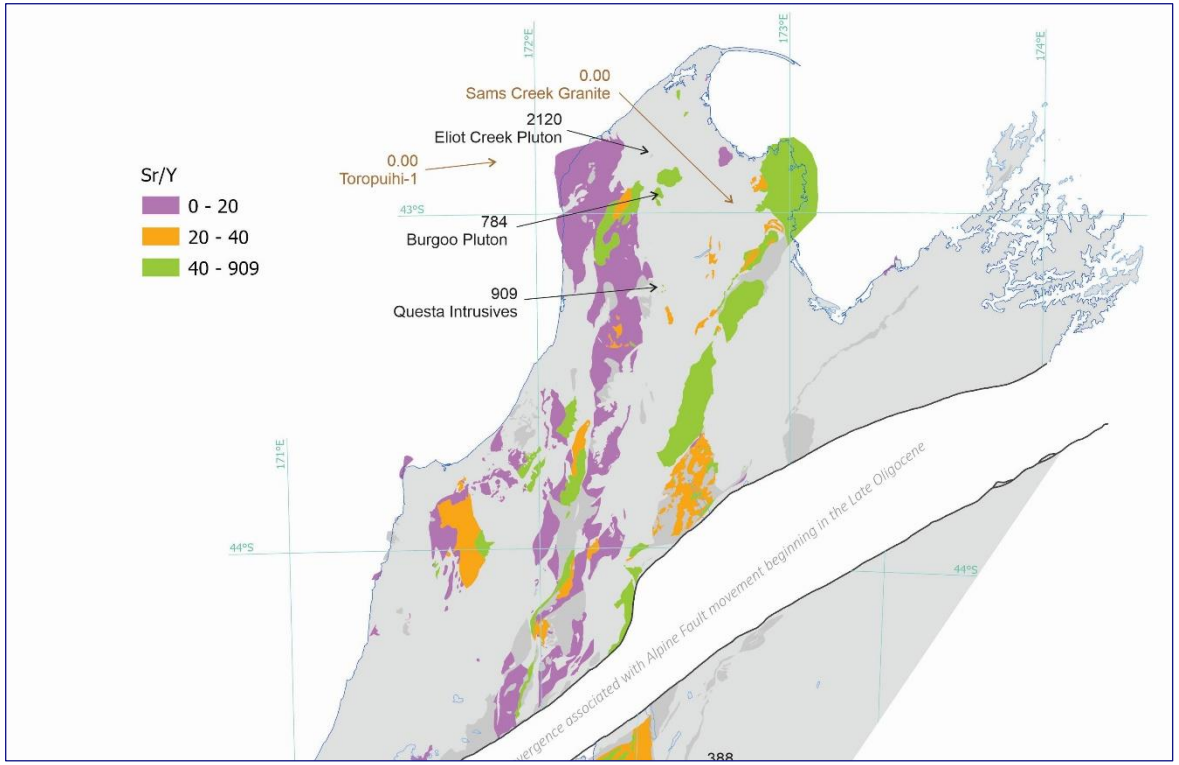
  Cu(-Mo), Yulong, Tibet (Liang et al., 2006)

  Cu-Mo, Oyu Tolgoi, Mongolia (Loader et al., 2017)

  Cu-Au and Cu-Mo, global compilation (Loucks et al., 2014)
- Data acquired for zircon from Paleozoic–Mesozoic New Zealand plutons over the past c. 15 years

# Zircon trace element indicators: What, where, why, how?

- **What:** $ZrSiO_4$
- **Where:** Widespread
- **Why:**
  - Easily (relatively) separated from over minerals
  - Resistant
  - Widespread
  - Trace elements reflect magma



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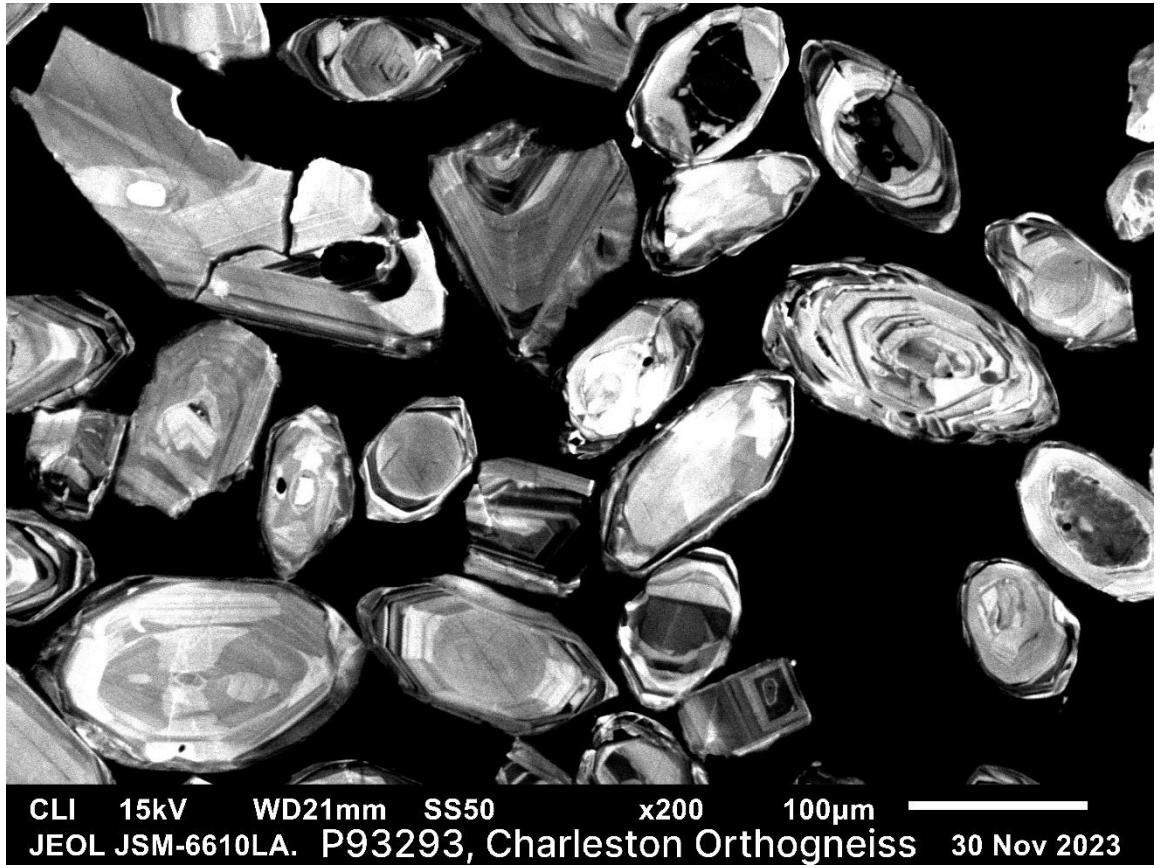
# Zircon trace element indicators: What, where, why, how?

## How:

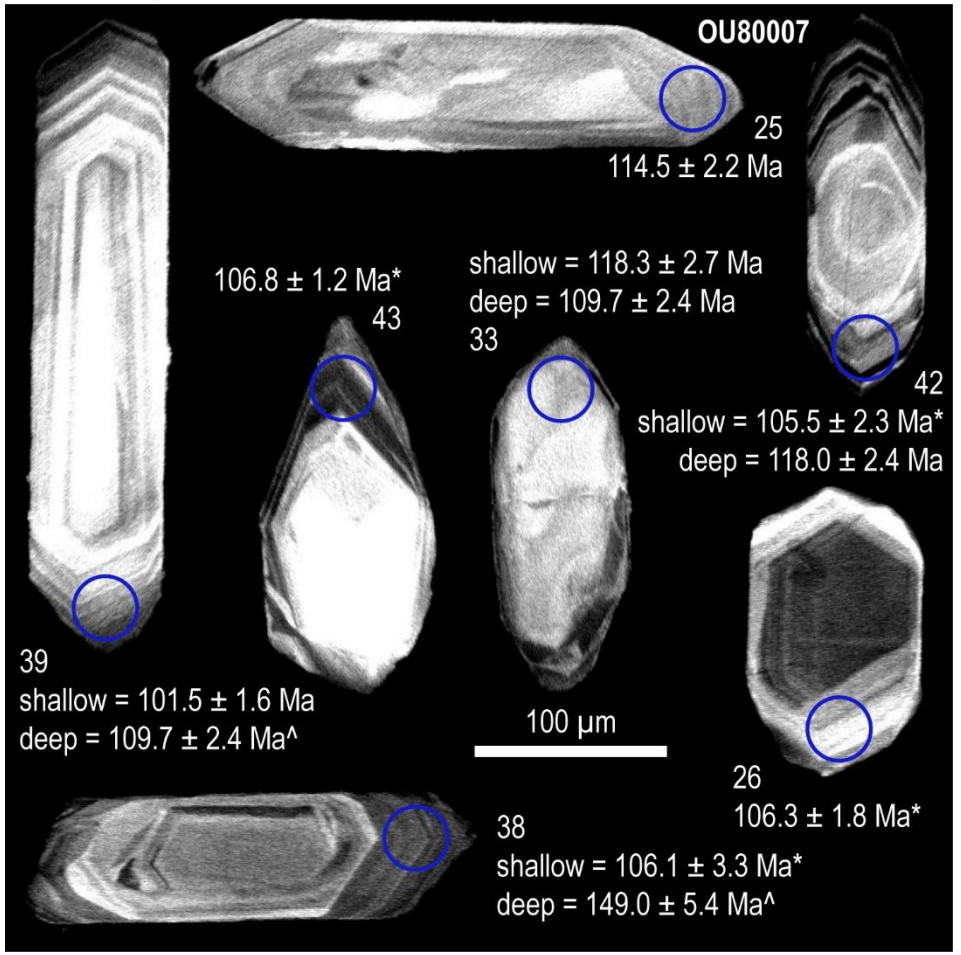
- $Zr^{4+} \leftrightarrow Y^{3+}$, $REE^{3+} + P^{5+}$
- $Zr^{4+} \leftrightarrow U^{4+}$, $Th^{4+}$, $Ti^{4+}$
- $^{238}U \rightarrow {}^{206}Pb$
- $^{235}U \rightarrow {}^{207}Pb$
- **Controls:** redox, magma chemistry, mineral crystallisation, magma source



# Zircon trace element indicators: What, where, why, how?

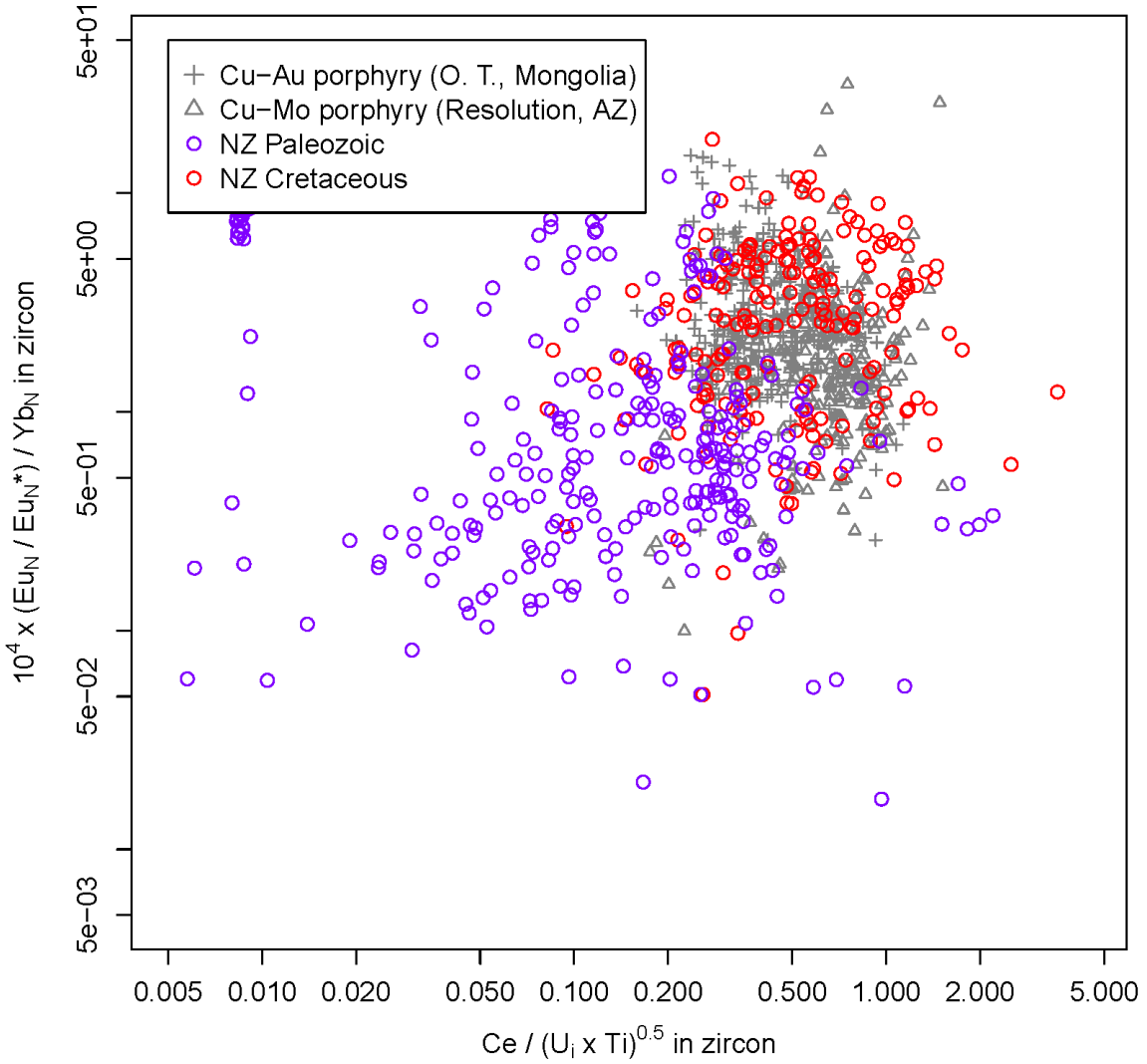
**How:**

- Ce and U in zircon dependent on magma redox state
- Ti in zircon dependent on magma temperature
- Eu and Yb in zircon dependent on:
  - plagioclase and hornblende crystallisation
  - in turn, depends on magma $H_2O$ content
  - (and/or magma source/depth)



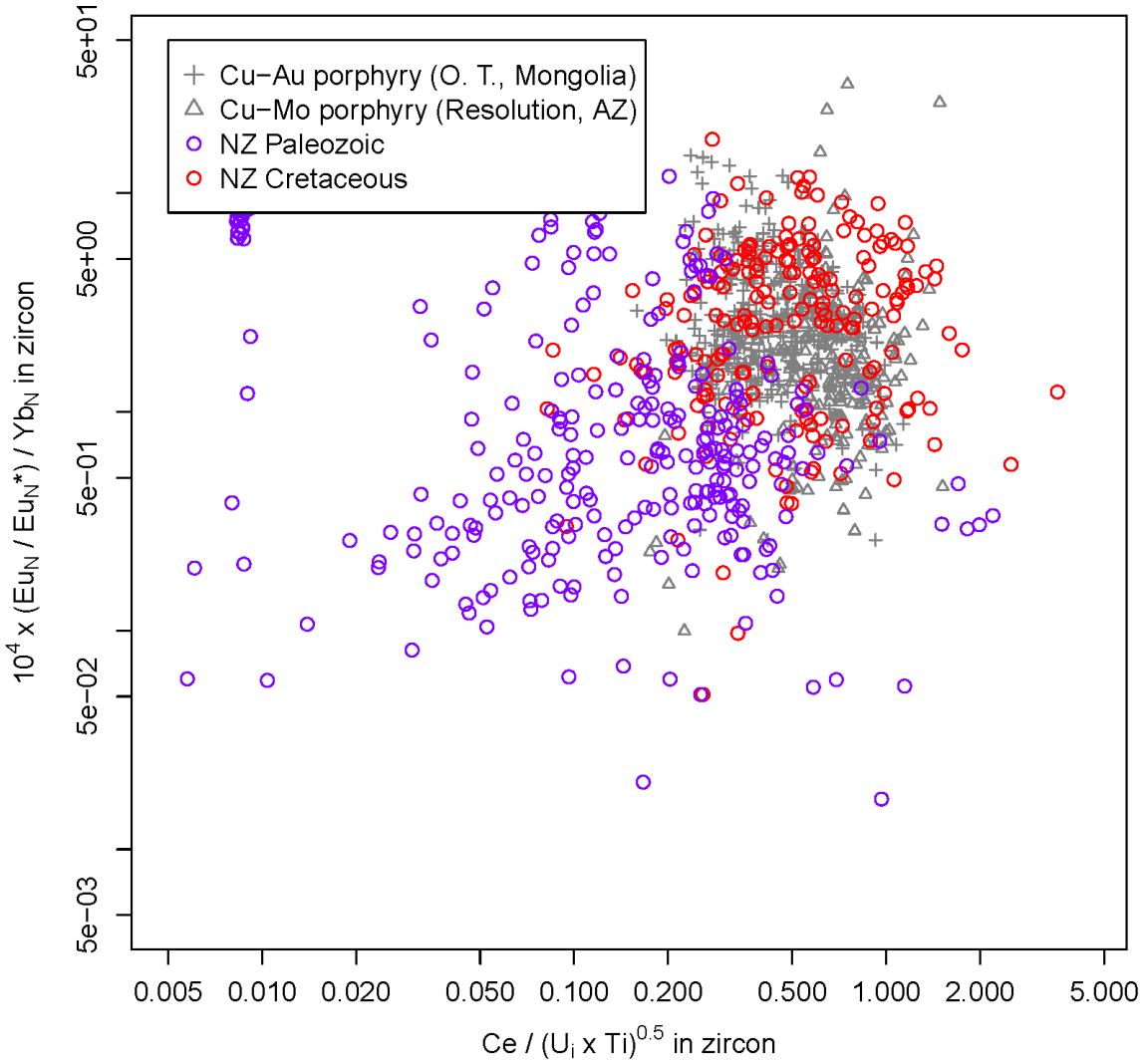
# Zircon trace element indicators

- Loucks et al. (2024). Economic Geology 119: 511–523.
- Ce / $(U_i \times Ti)^{0.5}$ in zircon
  - magma oxidation state
  - S carrying capacity
  - QFM buffer (approx. −4 to +4)
- $(Eu_N/Eu_N^*)$ / $Yb_N$ in zircon
  - magma hydration state
  - chloride complexed metals
  - empirical



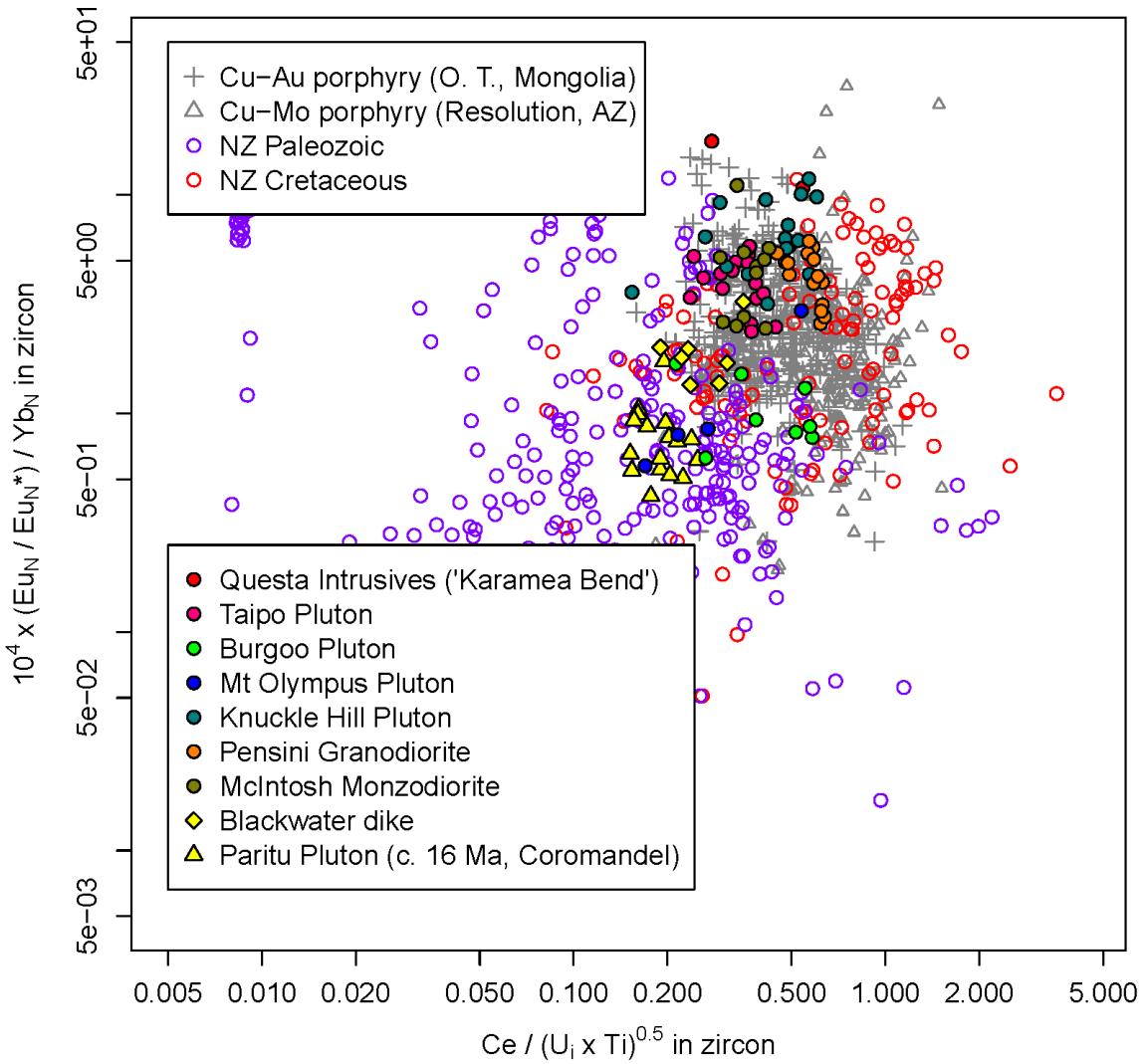
# New Zealand pluton zircon

- NZ Mesozoic pluton zircon overlap international porphyry Cu-Au/Mo deposit zircon
- NZ Mesozoic magmas more hydrous and more oxidised than NZ Paleozoic magmas
- NZ Mesozoic plutons more prospective for porphyry-style mineralisation



# New Zealand pluton zircon

- Highest NZ ($Eu_N/Eu_N^*$) / $Yb_N$ and Ce / $(U_i \times Ti)^{0.5}$
  - often plutons with high whole-rock Sr/Y (e.g. Knuckle Hill, Sr/Y = 367)
  - exceptions (e.g. Burgoo, Sr/Y = 784; Taipo, Sr/Y = 84)
- Interesting:
  - 118.5 ± 1.3 Myr Blackwater dike, Reefton (Dickie et al., 2019)
  - c. 16 Myr Paritu Pluton, Coromandel (Turnbull et al., 2023)



# Thank you

Earth Sciences New Zealand

**Matt Sagar**

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# References


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