Zircon Geochemistry of the Hogem batholith, Quesnel terrane, British Columbia

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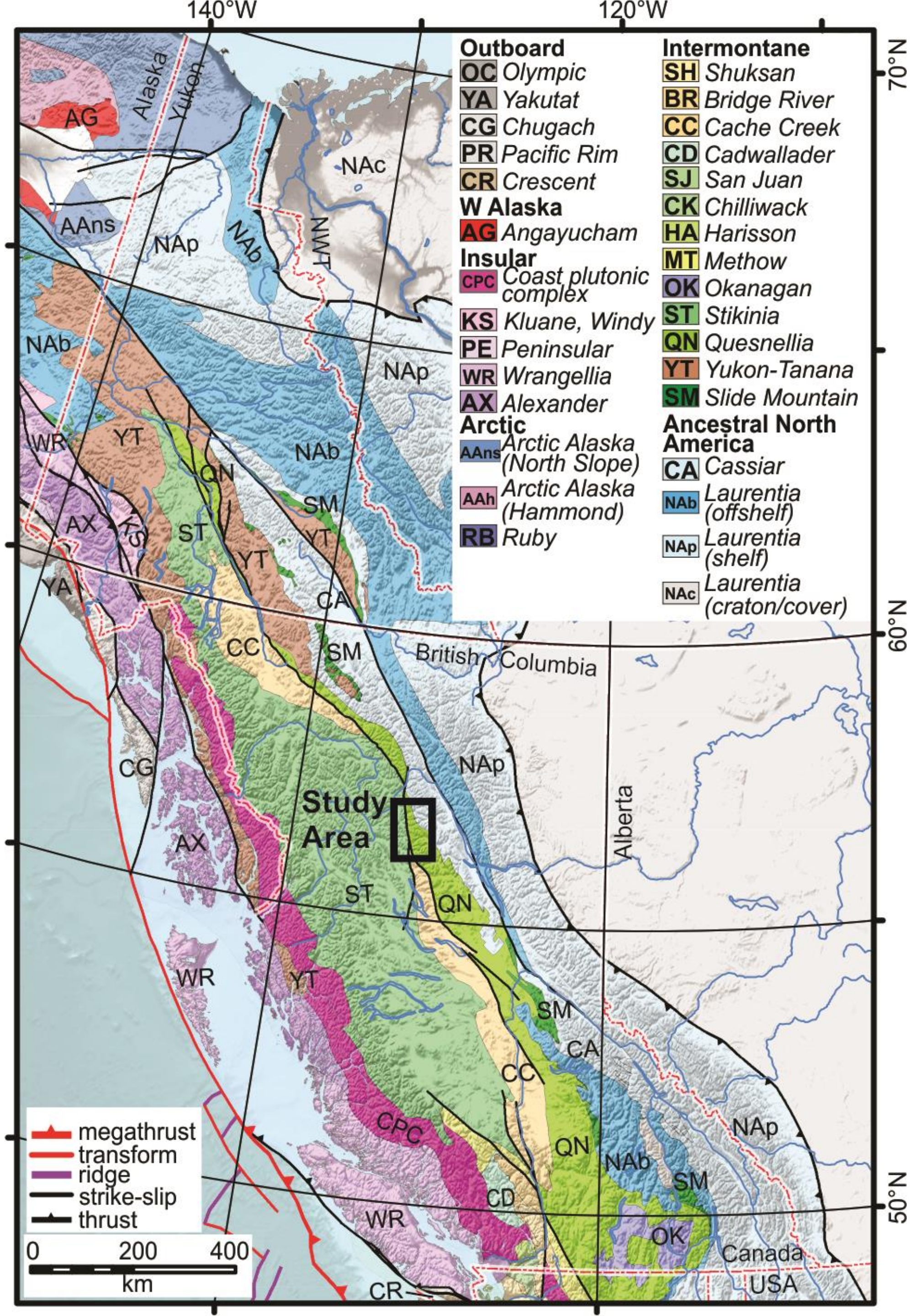
Geological Background

Quesnel Terrane

- Accreted terrane with **oceanic arc** affinity
- Variable Paleozoic **basement**
- Mesozoic plutons
  - Important hosts to **porphyry** mineralization
  - **Hogem** batholith
    - Lorraine, Kwanika Cu-Au deposits

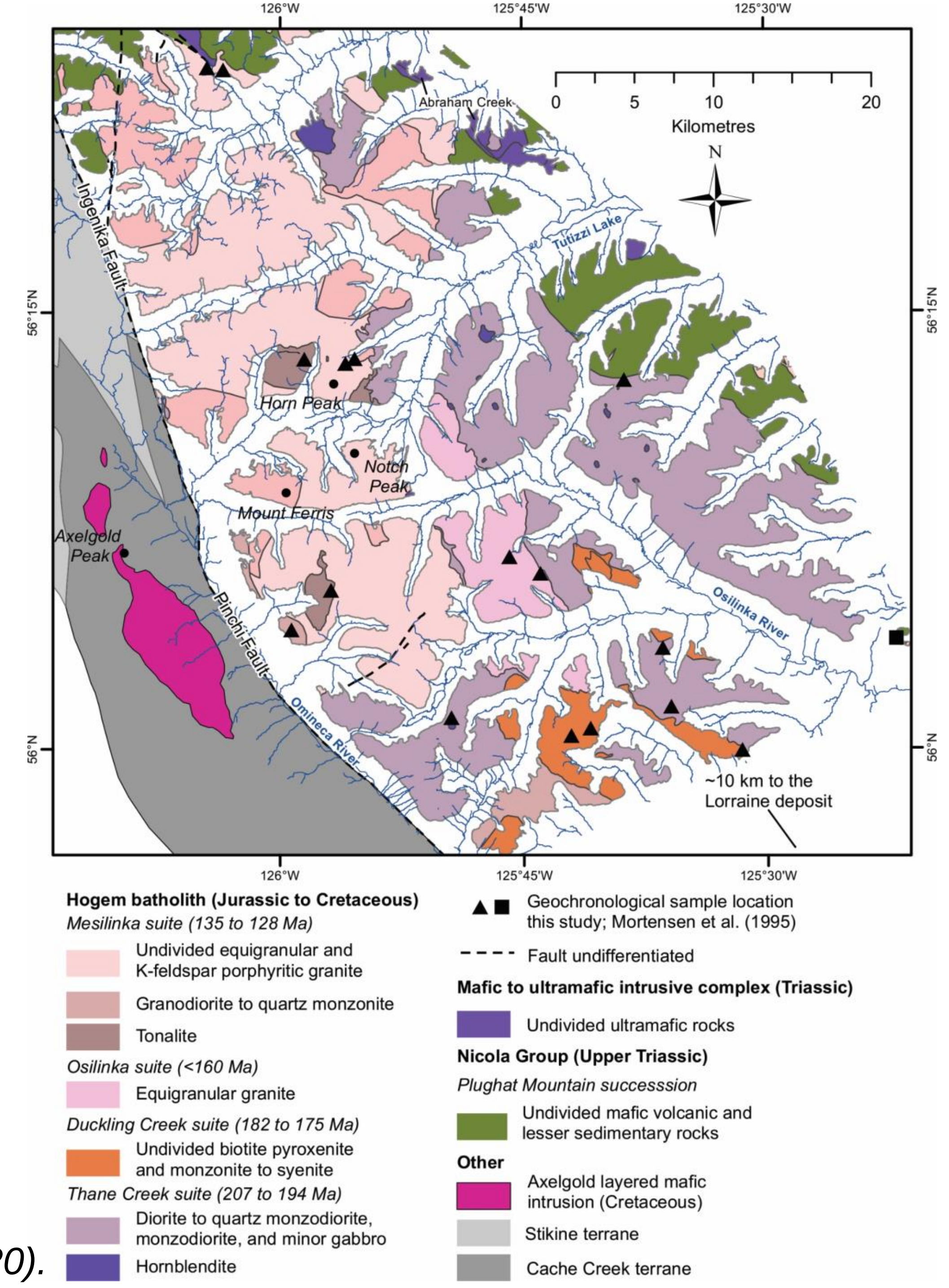


Modified after Colpron (2020).

Hogem Geology

Hogem Geology

- Emplaced into **Triassic Nicola Group** volcanic and sedimentary strata
- Basement **Paleozoic Lay Range** assemblage to the east
- Pinchi-Ingenika dextral strike-slip fault
  - **Cache Creek** and **Stikine** **terranes** to the west



Modified after Ootes et al. (2020).

Hogem Geology

Hogem batholith (Jurassic to Cretaceous)

Mesilinka suite (135 to 128 Ma)

- Undivided equigranular and K-feldspar porphyritic granite
- Granodiorite to quartz monzonite
- Tonalite

Osilinka suite (<160 Ma)

- Equigranular granite

Duckling Creek suite (182 to 175 Ma)

- Undivided biotite pyroxenite and monzonite to syenite

Thane Creek suite (207 to 194 Ma)

- Diorite to quartz monzodiorite, monzodiorite, and minor gabbro
- Hornblendite

▲ ■ Geochronological sample location this study; Mortensen et al. (1995)

- - - Fault undifferentiated

Mafic to ultramafic intrusive complex (Triassic)

- Undivided ultramafic rocks

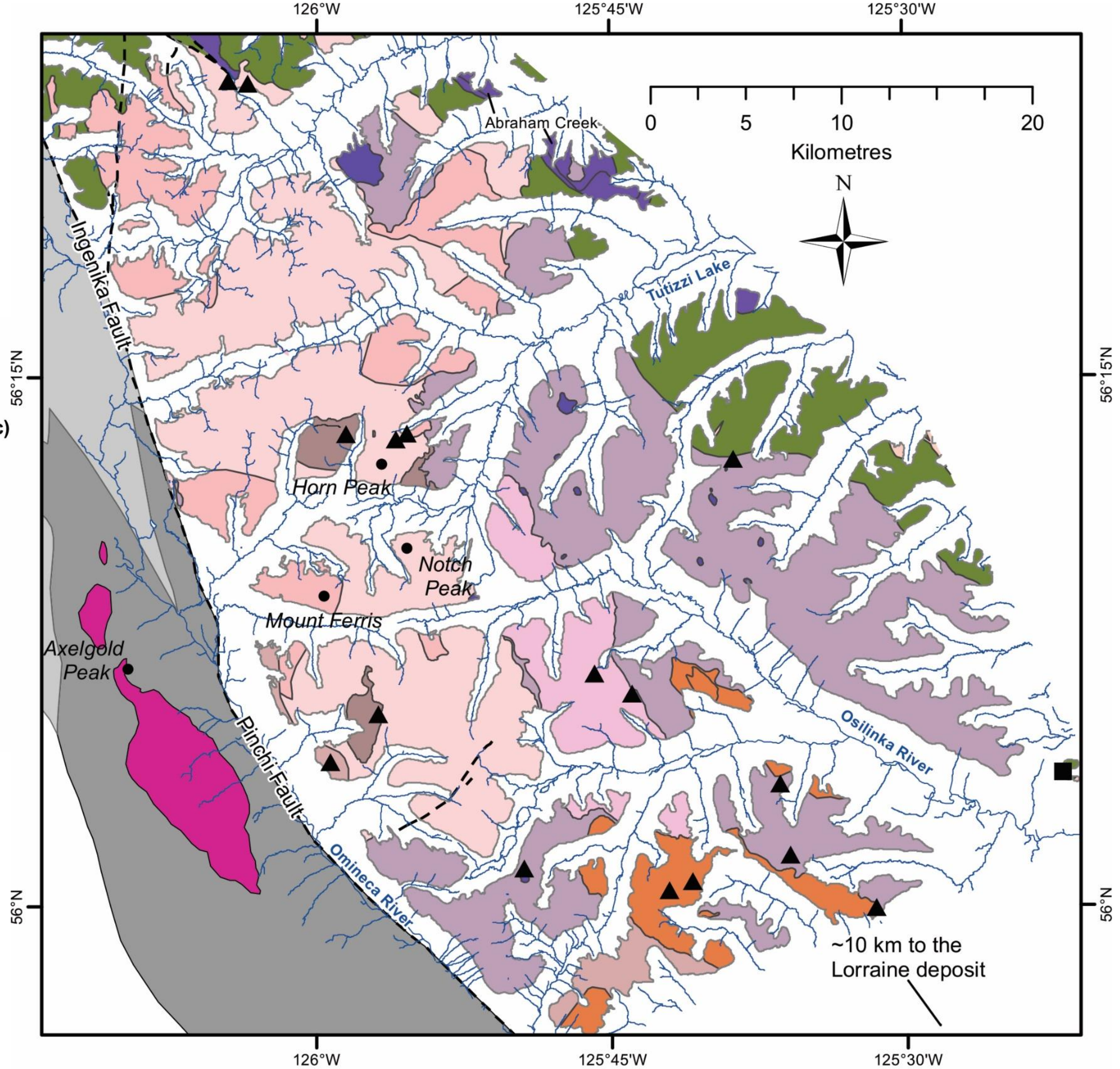
Nicola Group (Upper Triassic)

Plughat Mountain successsion

- Undivided mafic volcanic and lesser sedimentary rocks

Other

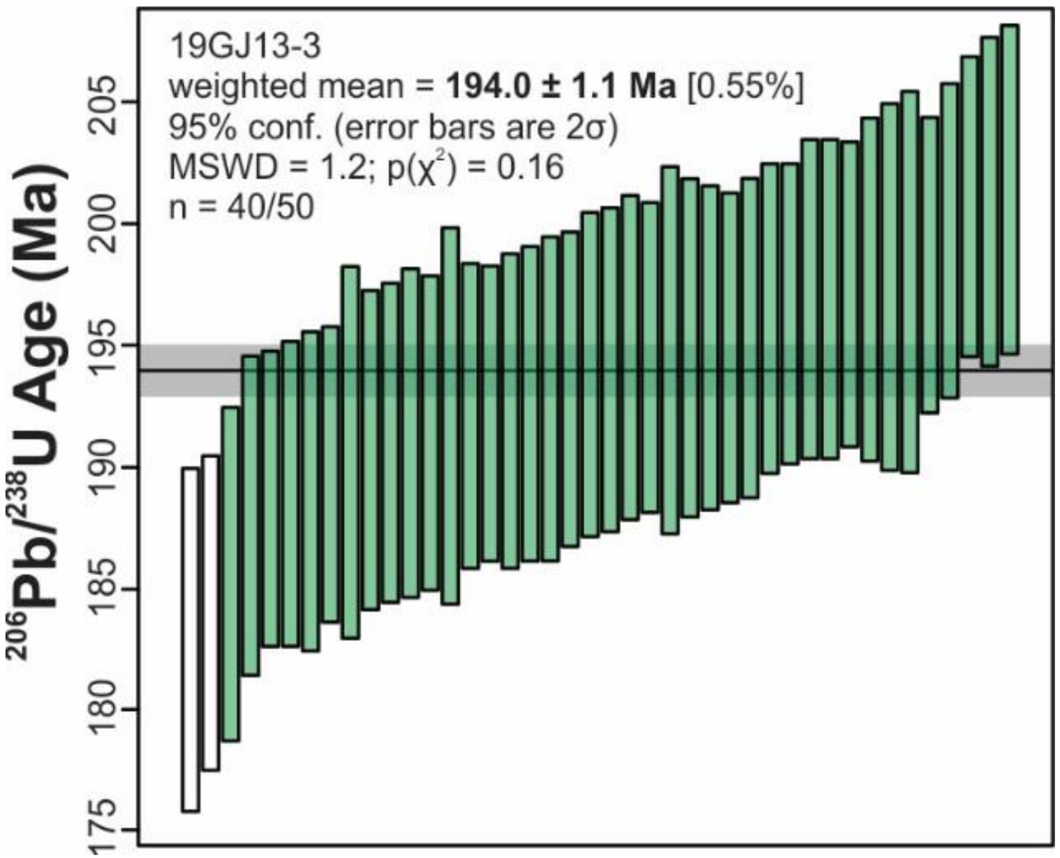
- Axelgold layered mafic intrusion (Cretaceous)
- Stikine terrane
- Cache Creek terrane

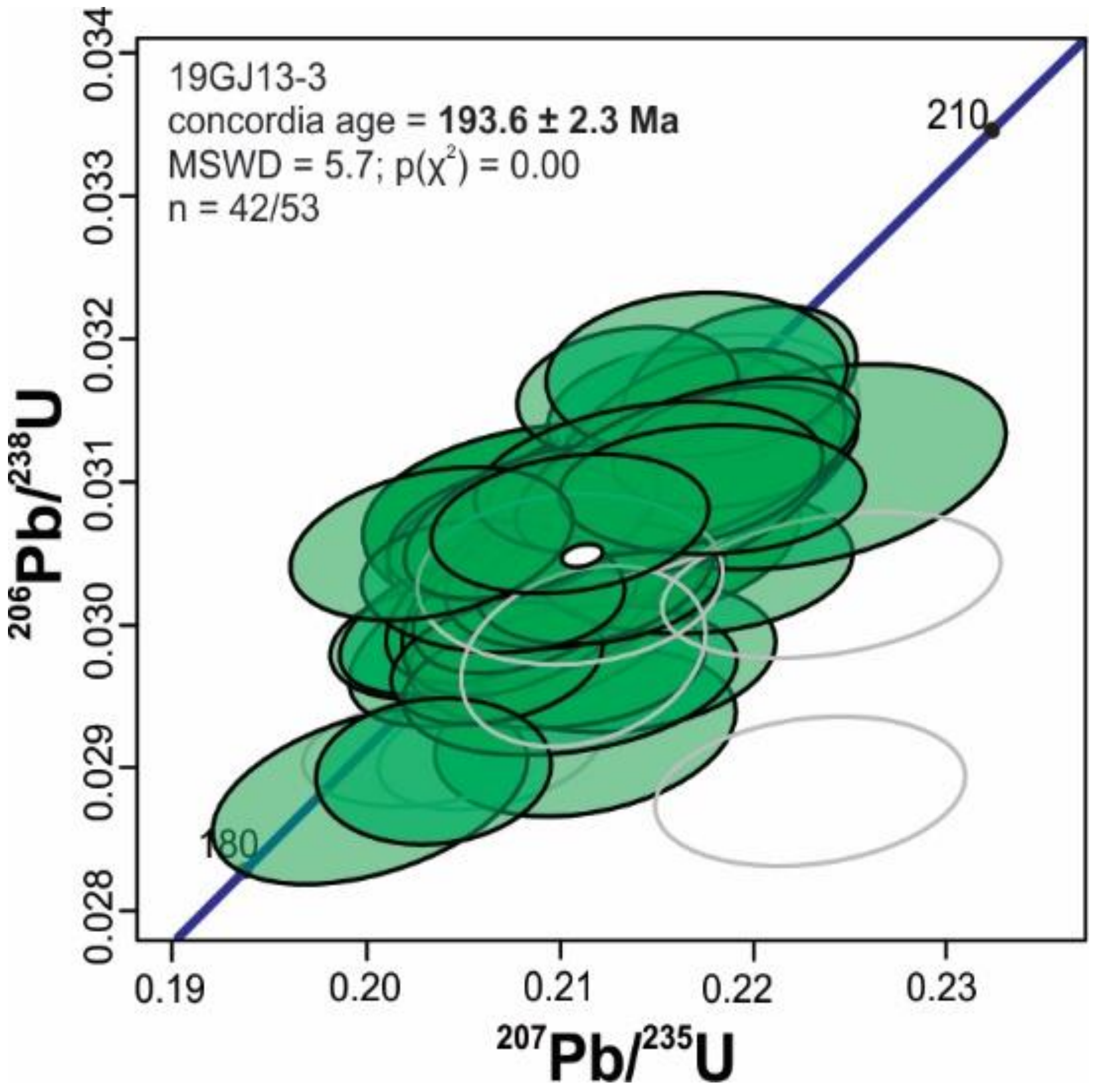


Modified after Ootes et al. (2020).

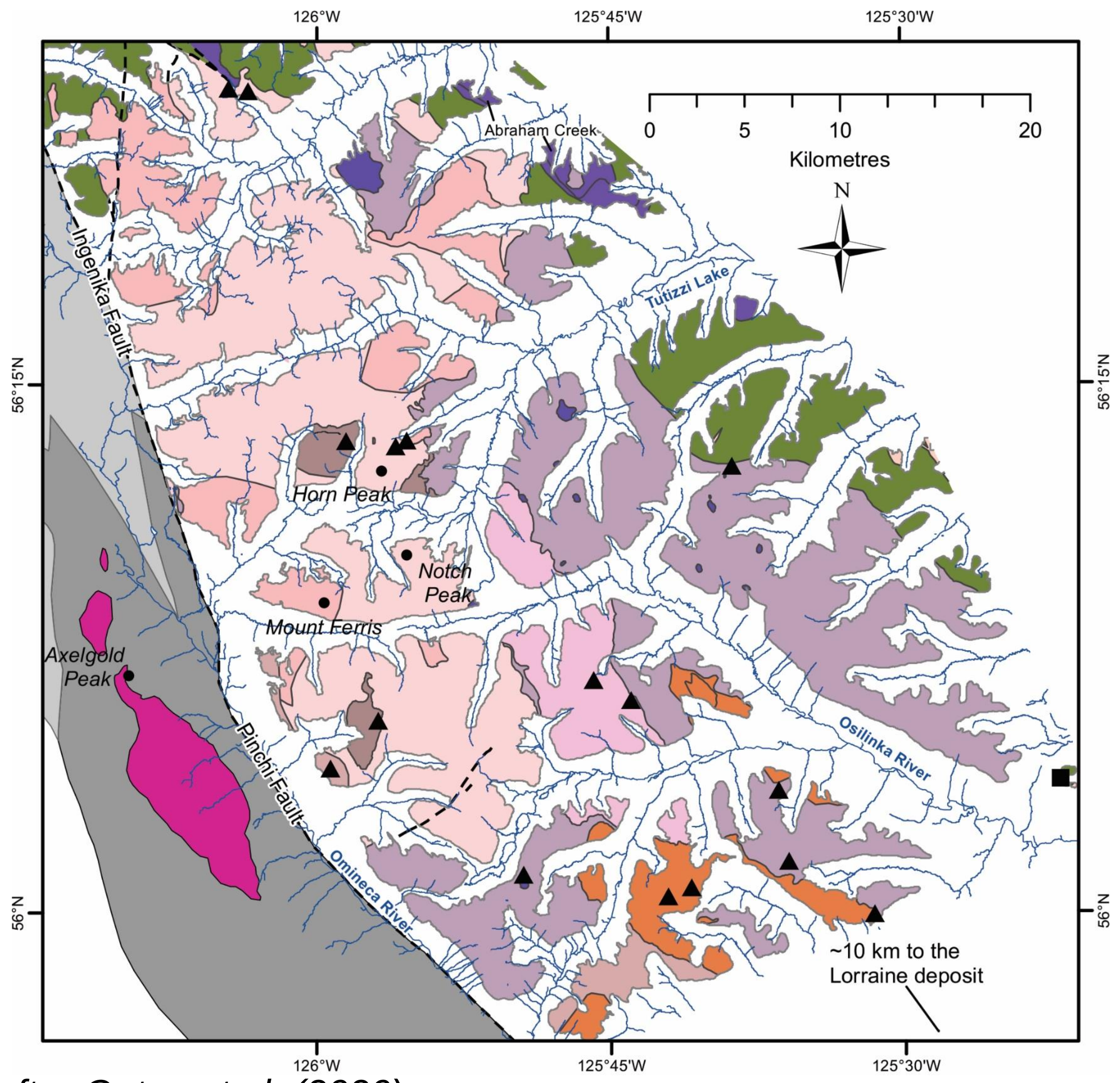
Hogem Geology & Zircon U-Pb Results

- U-Pb age data collected using LA-ICP-MS





Hogem Geology & Zircon U-Pb Results



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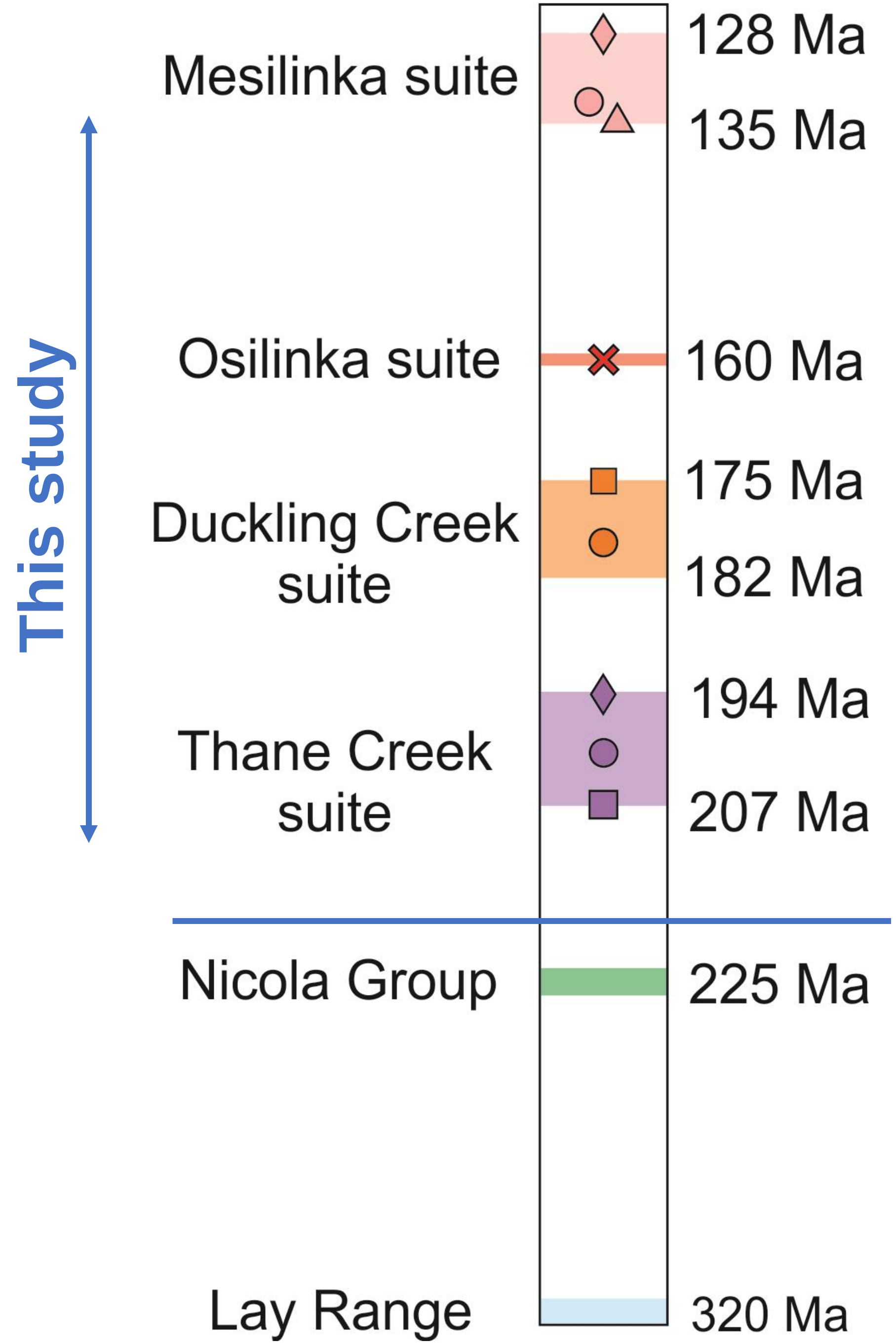
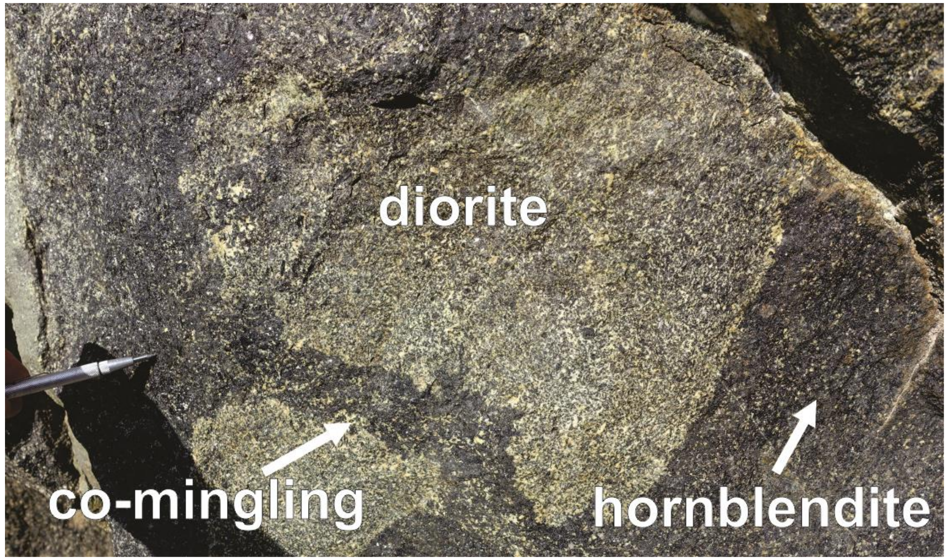
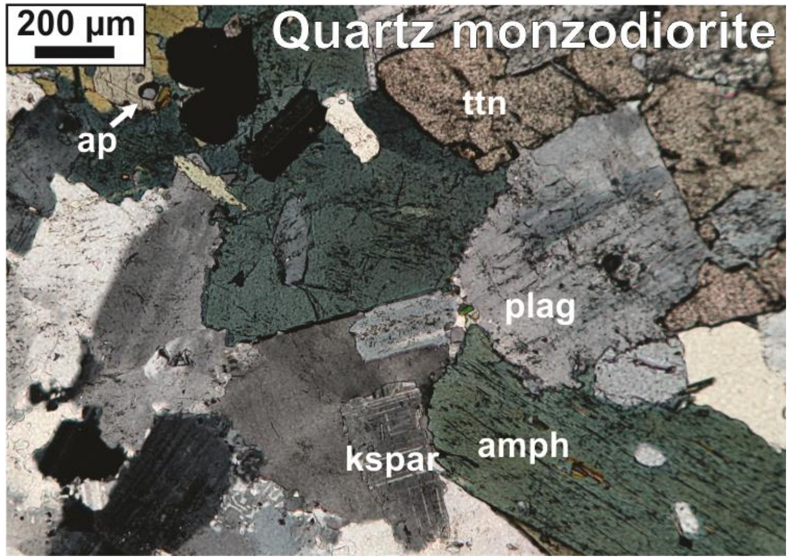
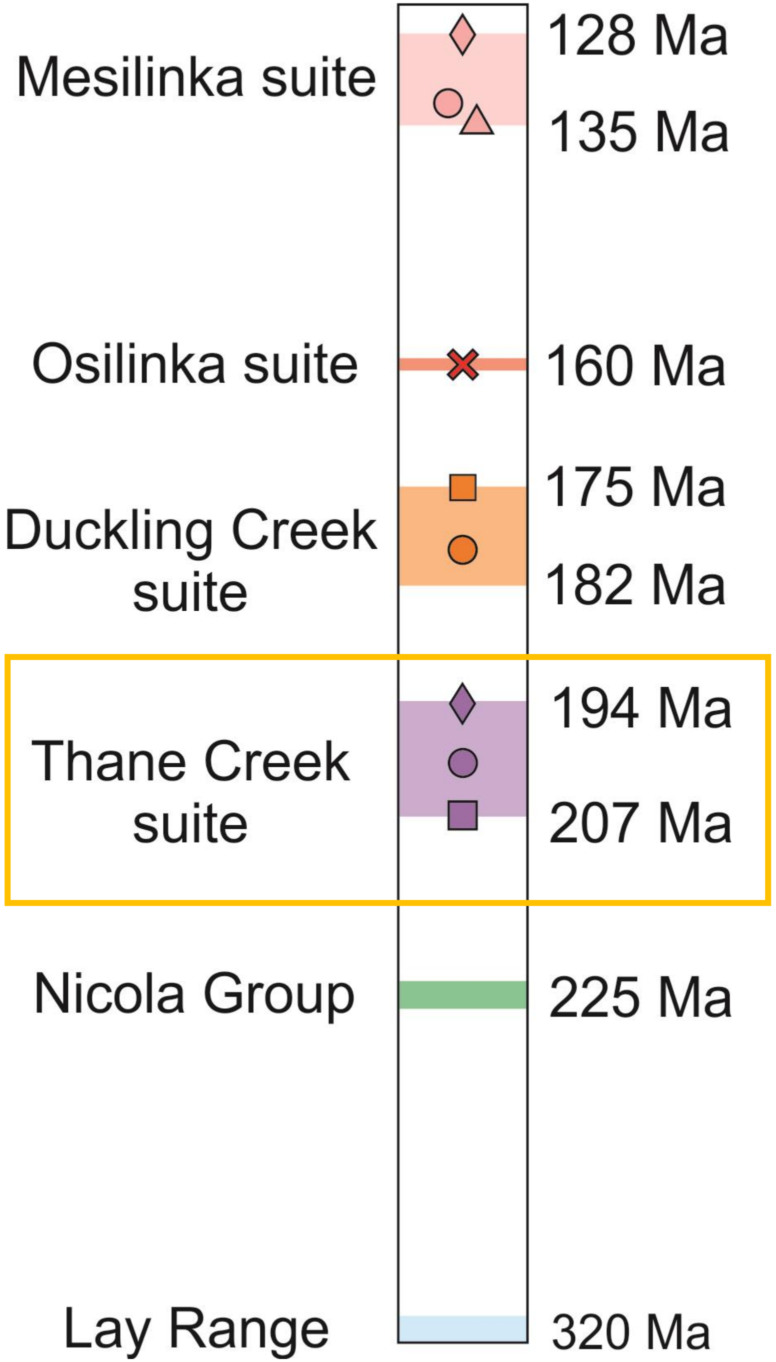


Hogem Geology & Zircon U-Pb Results

1. Thane Creek suite:
   - ca. 207 to 194 Ma
   - Metaluminous and calc-alkalic
   - Mainly diorites to granodiorites, minor pegmatitic hornblendite and gabbro

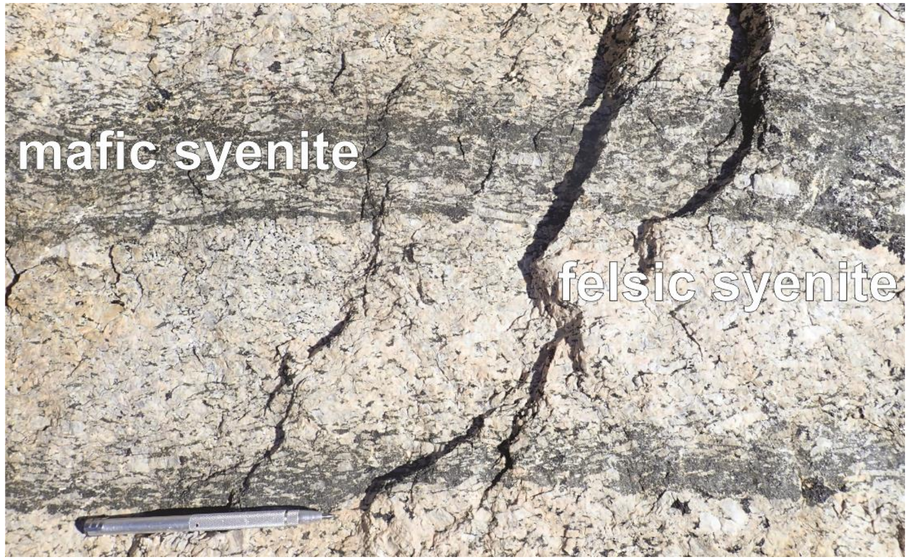


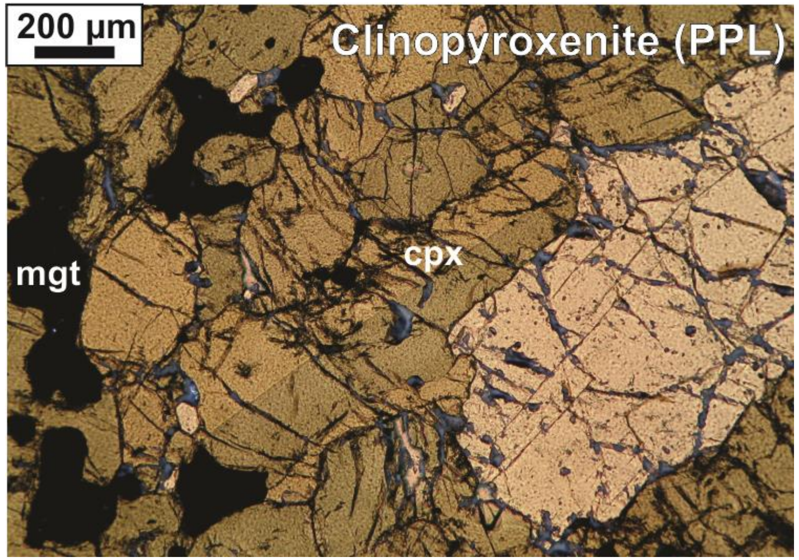


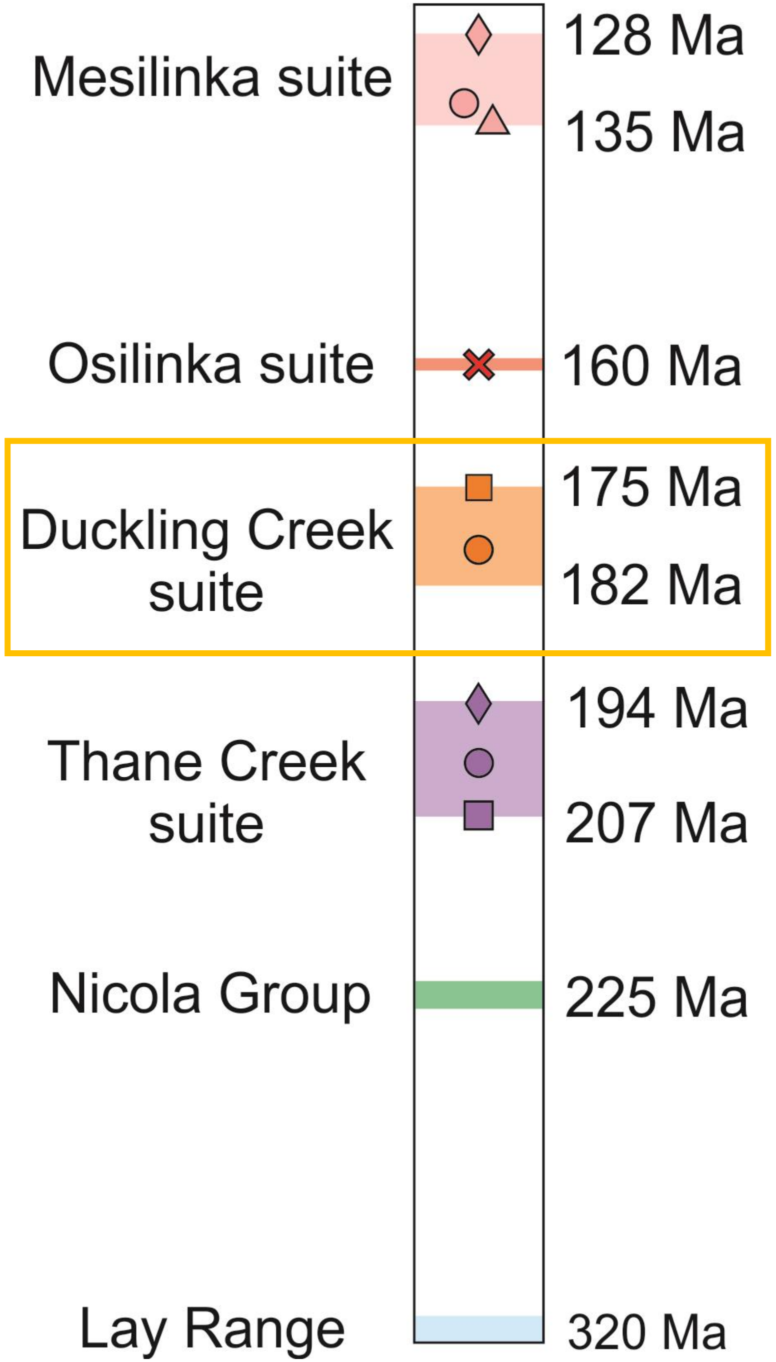


Hogem Geology & Zircon U-Pb Results

2. Duckling Creek suite:
- ca. 182 to 175 Ma
- Metaluminous and alkalic
- Mainly syenites to monzonites that intruded older biotite clinopyroxenite

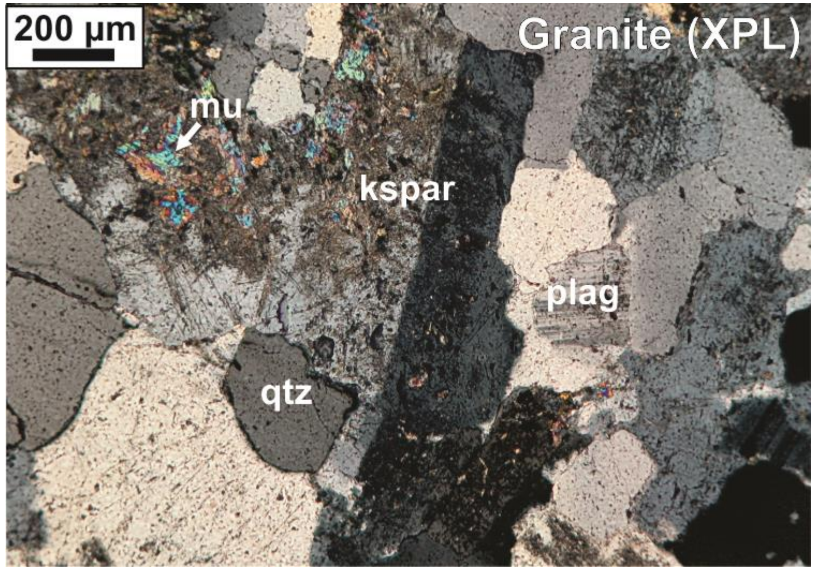


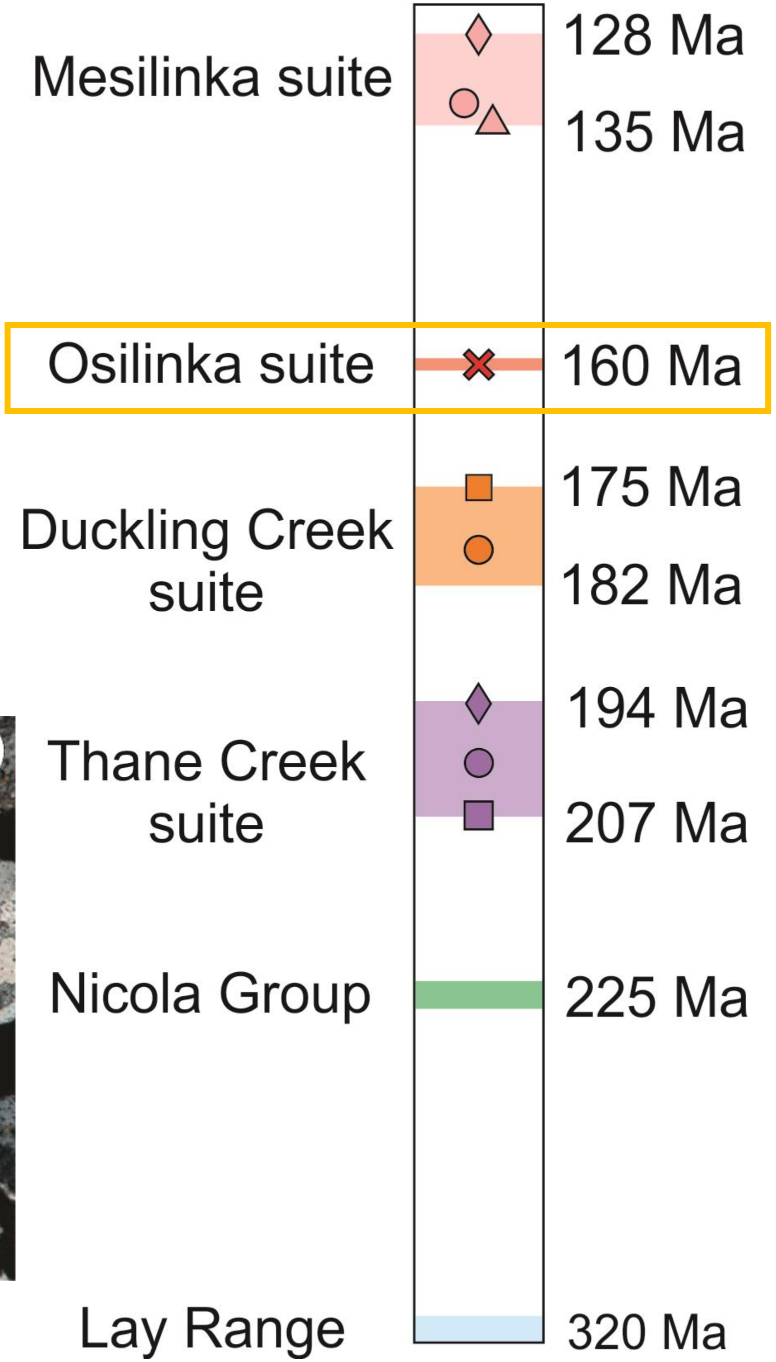




Hogem Geology & Zircon U-Pb Results

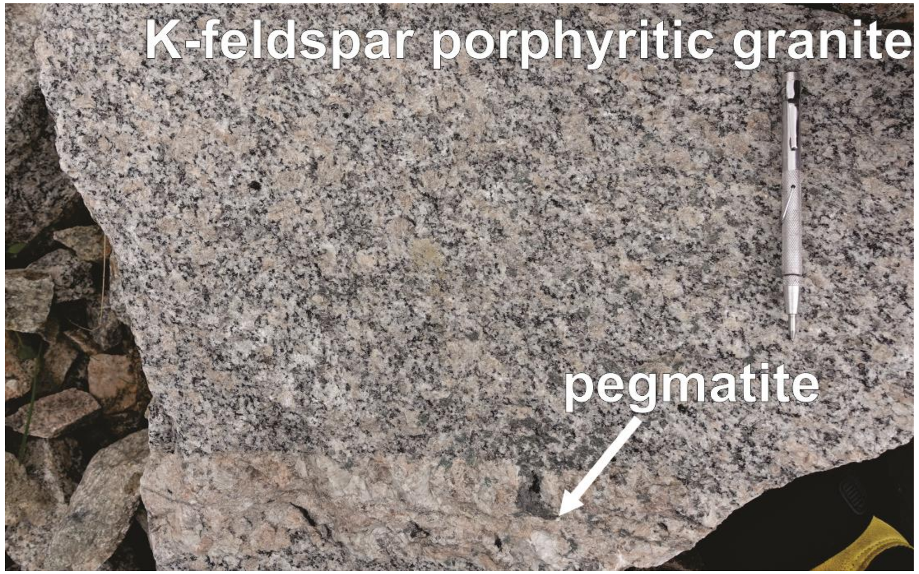
3. Osilinka suite:
- ca. 160 Ma (youngest inherited zircon)
- Weakly peraluminous and calc-alkalic
- Leucocratic granites cut by younger feldspar porphyry sheets

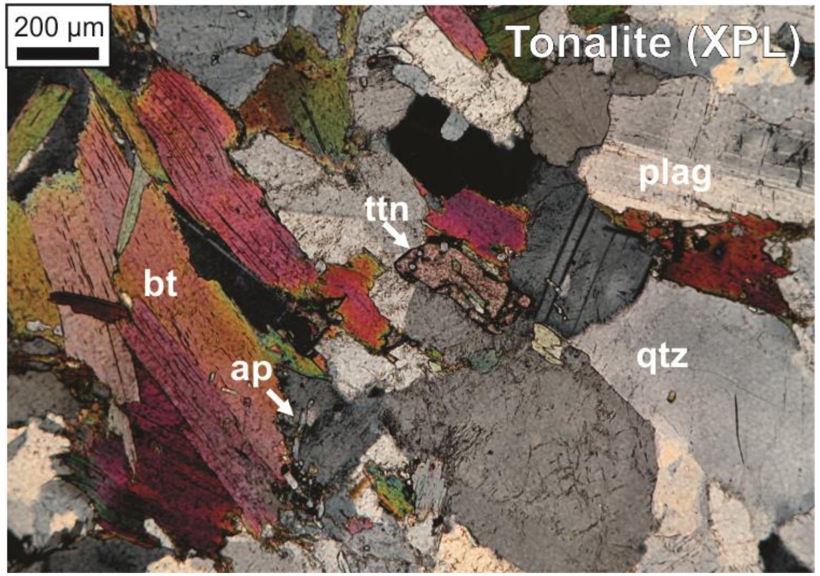


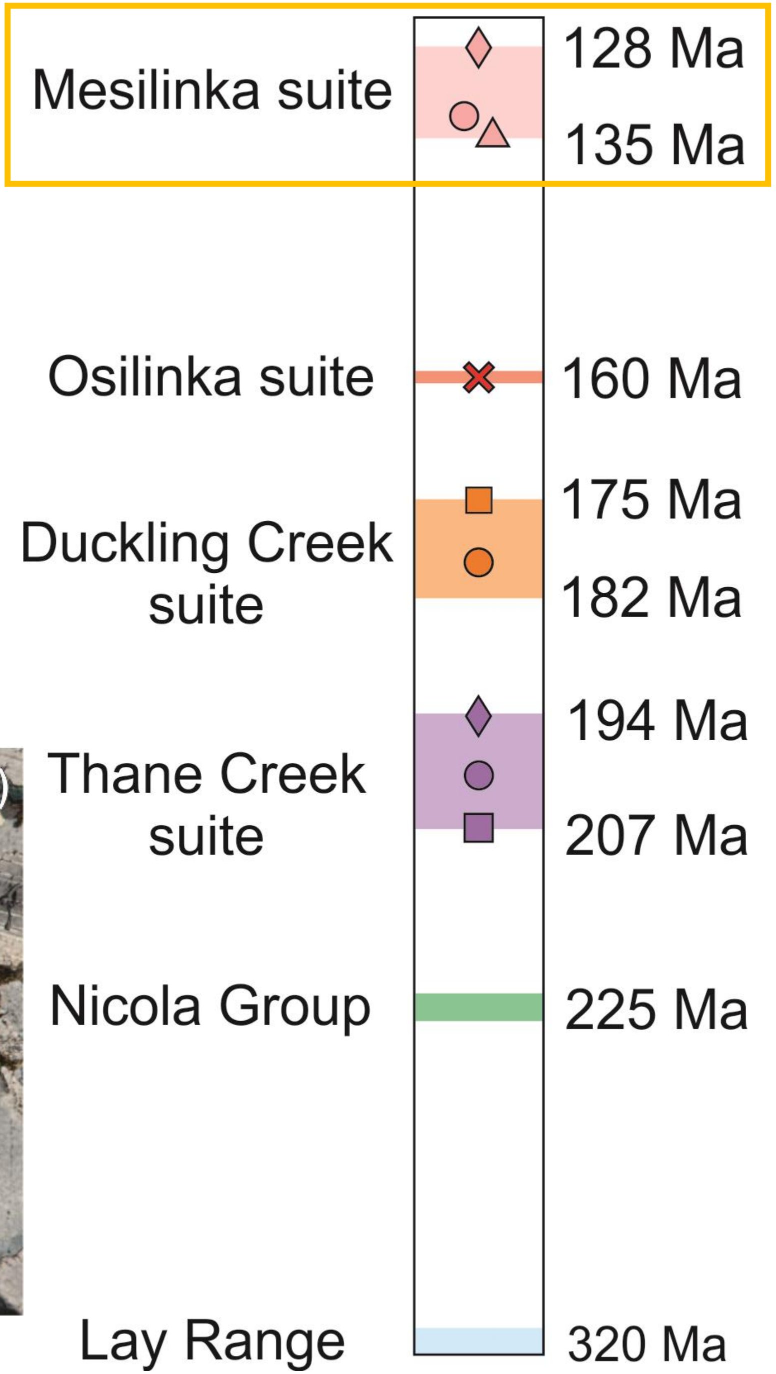


Hogem Geology & Zircon U-Pb Results

4. Mesilinka suite:
- ca. 135 to 128 Ma
- Metaluminous to peraluminous and calcic tonalite
- Weakly peraluminous and calcic to calc-alkalic equigranular and K-feldspar porphyritic granites

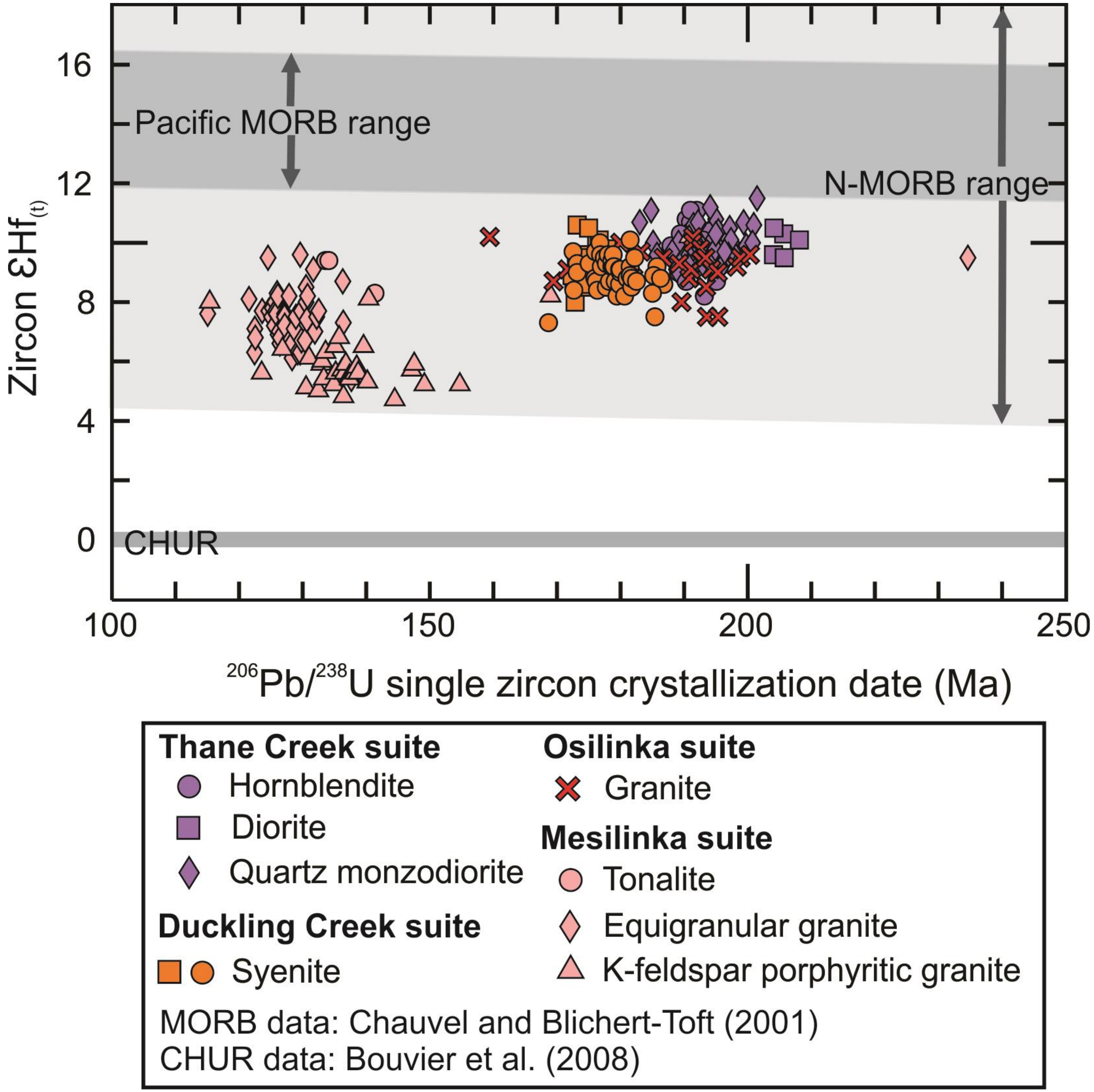






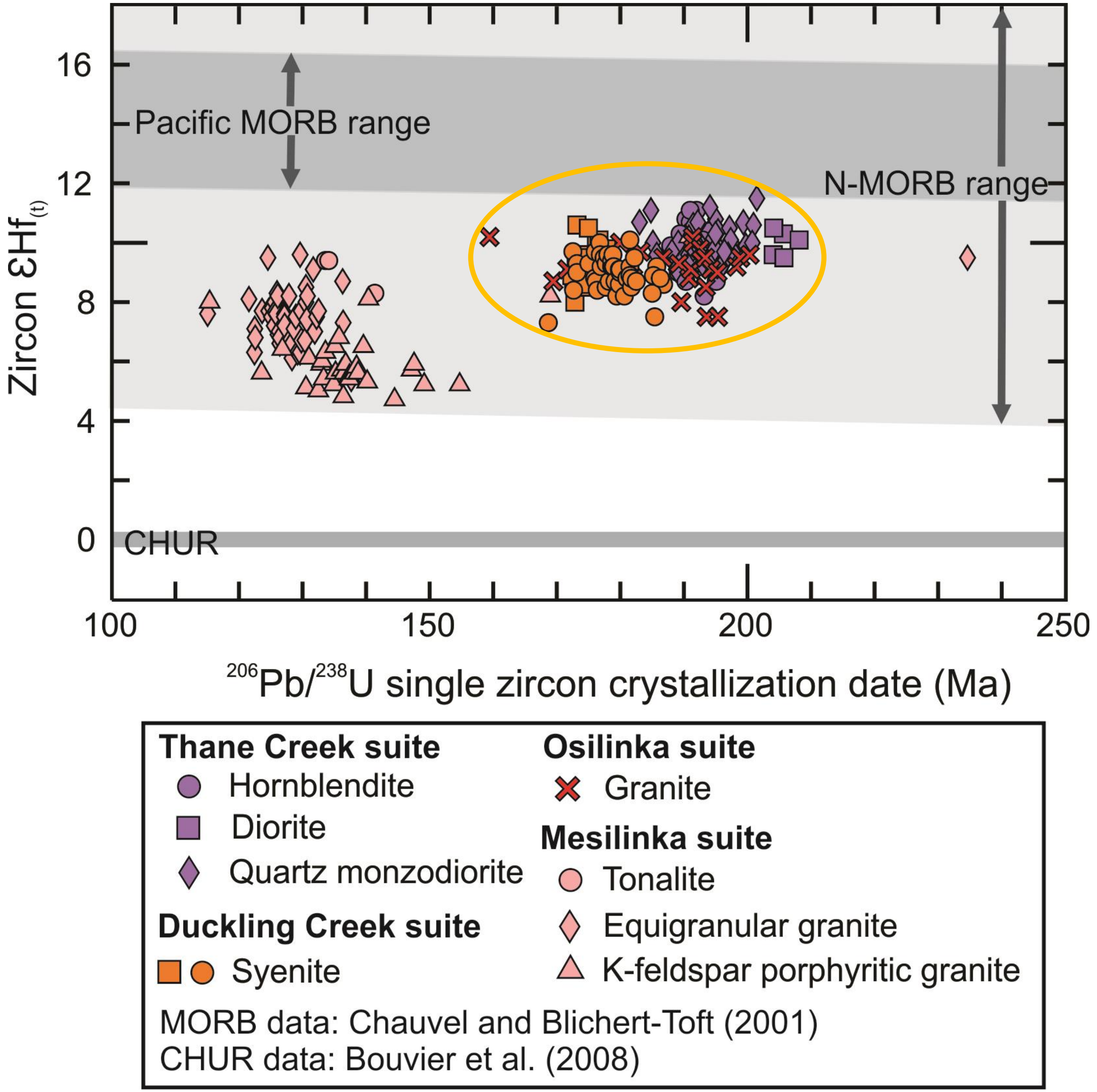
Zircon Lu-Hf isotopes

- Calculated as εHf(t): relative to CHUR at time of zircon crystallization
- Results are relatively **juvenile**
  - Occur within range of global N-MORB values
  - Less radiogenic than Pacific MORB range



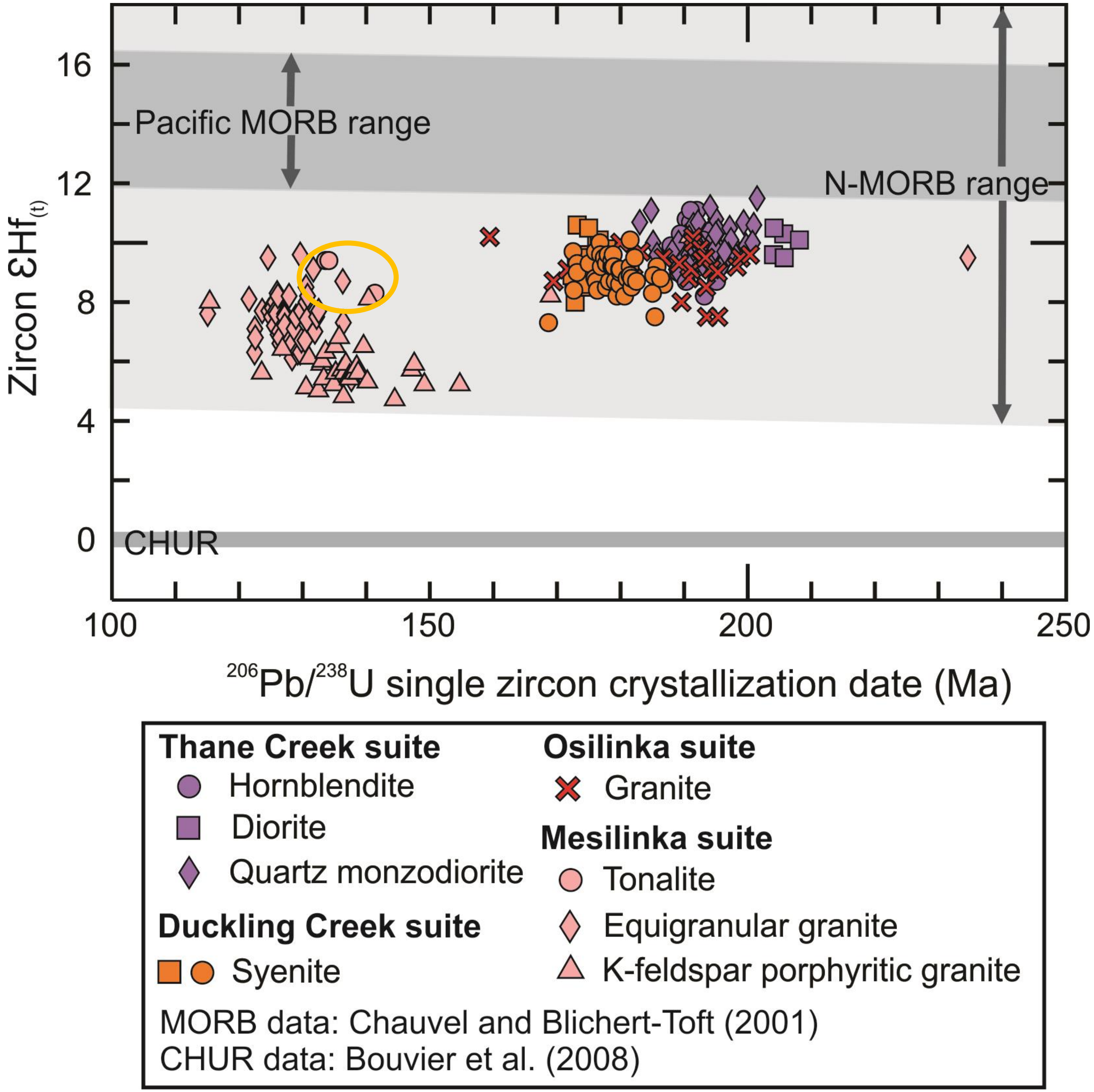
Zircon Lu-Hf isotopes

- **Thane Creek** suite: most juvenile
  - Mean εHf(t): +10.0 (n=94)
- **Duckling Creek** suite
  - Mean εHf(t): +9.1 (n=74)
- **Osilinka** suite
  - Mean εHf(t): +9.2 (n=24)



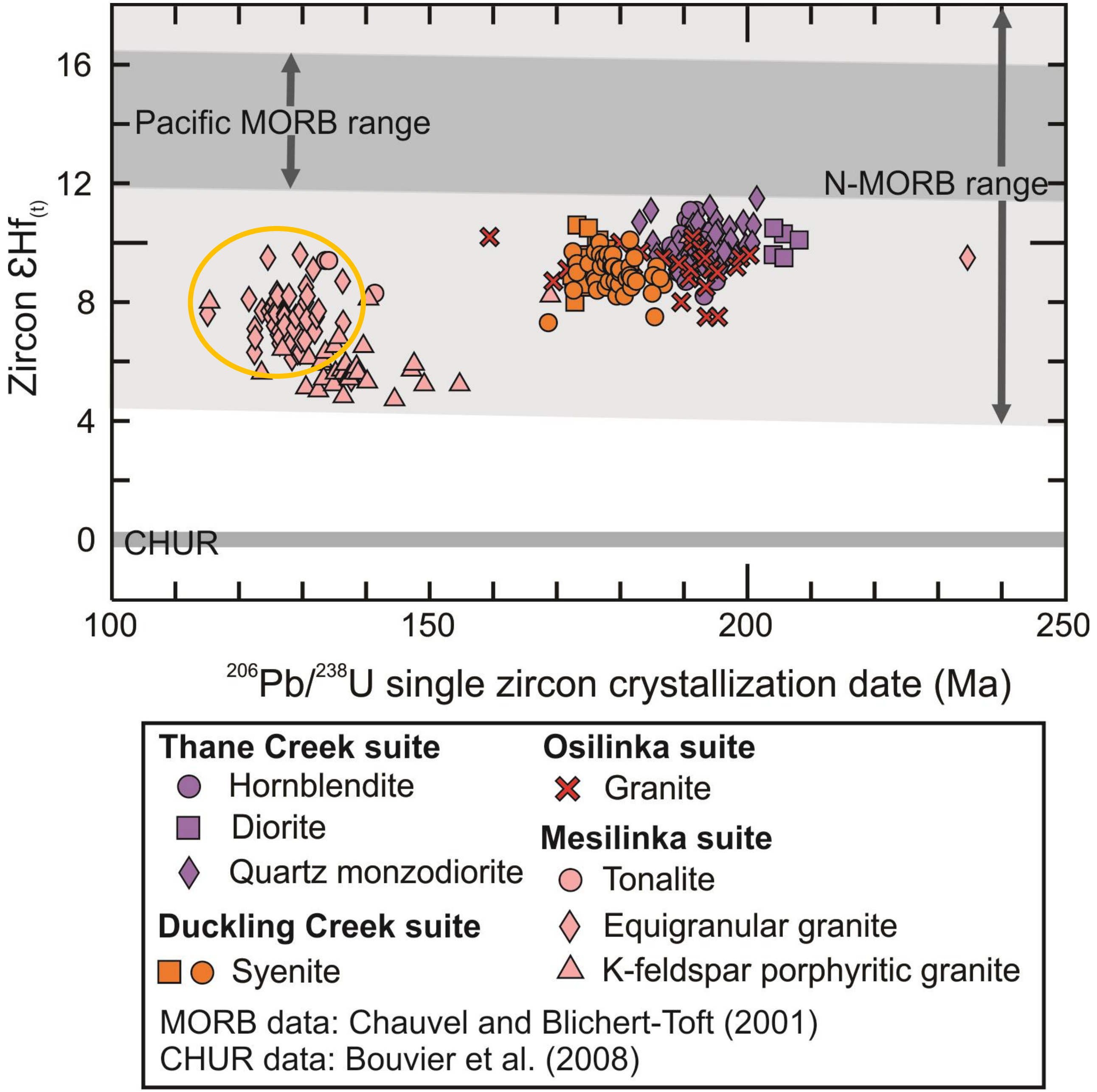
Zircon Lu-Hf isotopes

- **Mesilinka** suite: variable
- Tonalite: more juvenile
  - Mean εHf(t): +8.8 (n=9)



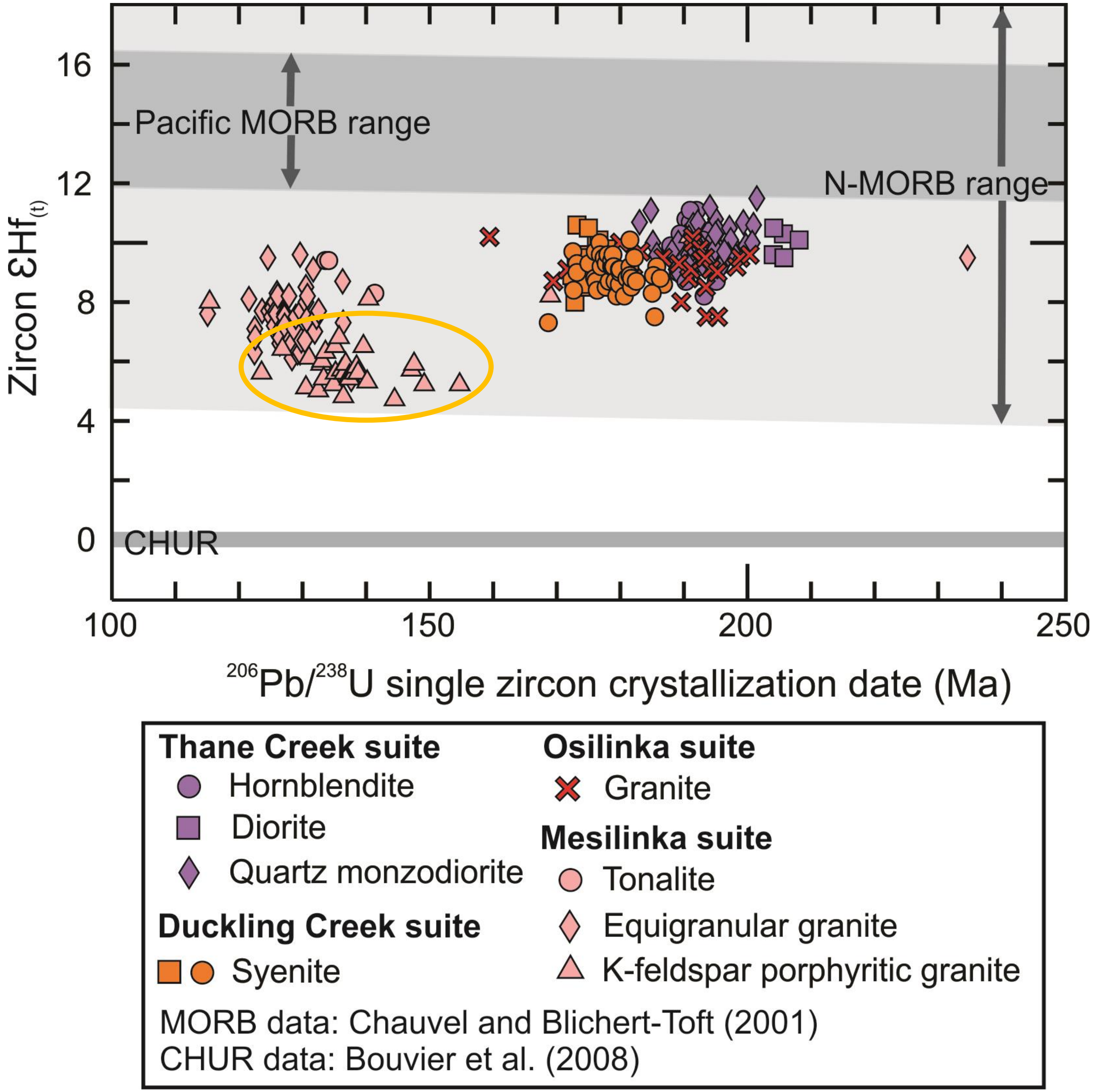
Zircon Lu-Hf isotopes

- Mesilinka suite: variable
- Tonalite: more juvenile
  - Mean εHf(t): +8.8 (n=9)
- Equigranular granite: intermediate
  - Mean εHf(t): +7.5 (n=48)



Zircon Lu-Hf isotopes

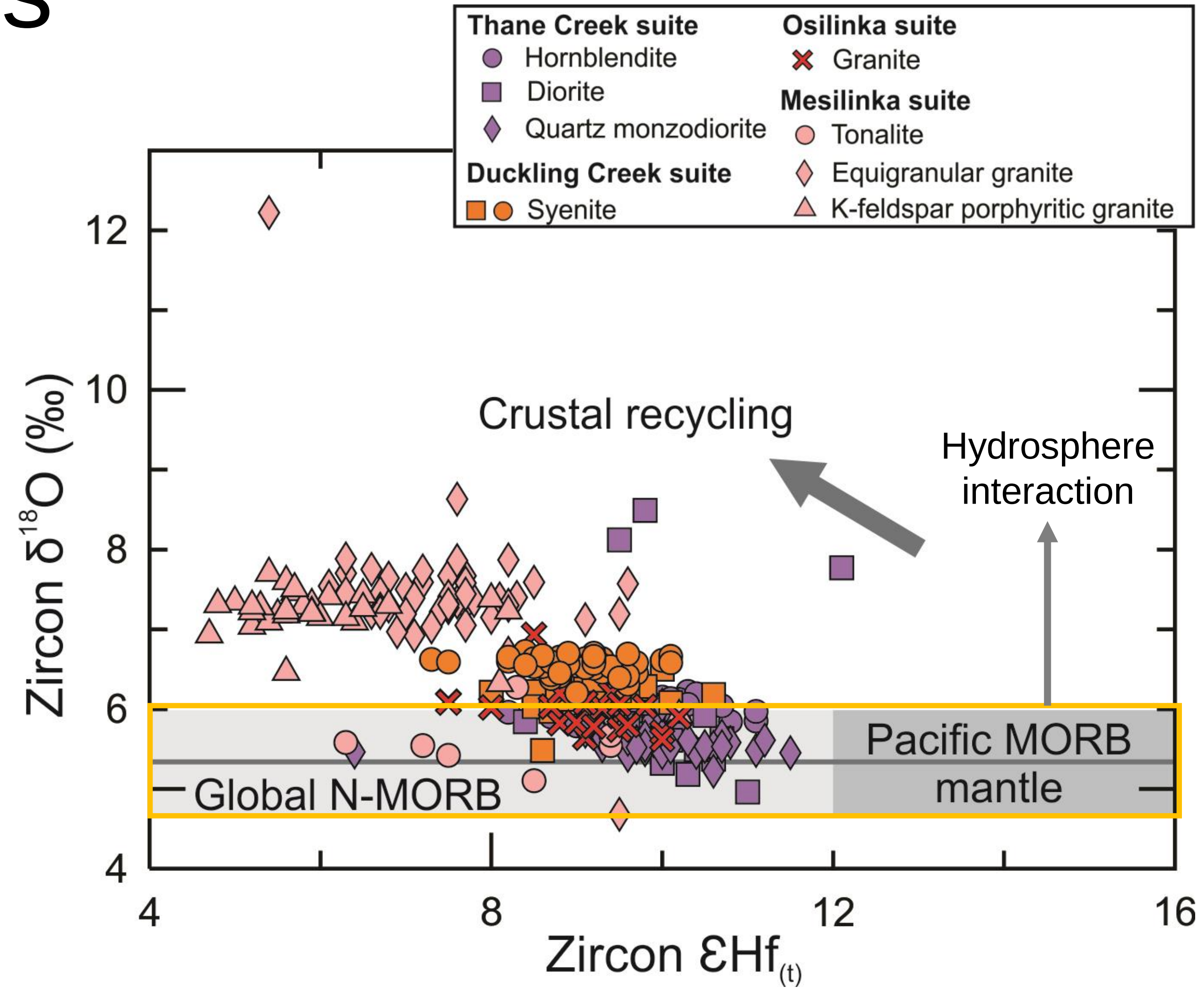
- Mesilinka suite: variable
- Tonalite: more juvenile
  - Mean εHf(t): +8.8 (n=9)
- Equigranular granite: intermediate
  - Mean εHf(t): +7.5 (n=48)
- K-feldspar porphyritic granite:
  - Least radiogenic
  - Mean εHf(t): +6.0 (n=33)



Zircon oxygen isotopes

- May be used to assess **crustal recycling**

- Mantle does not significantly fractionate oxygen ($\delta^{18}O$ = +5.3±0.6‰, Valley et al., 1998)
  - Zircon $\delta^{18}O$ >5.3‰: interaction with low temperature **hydrosphere**



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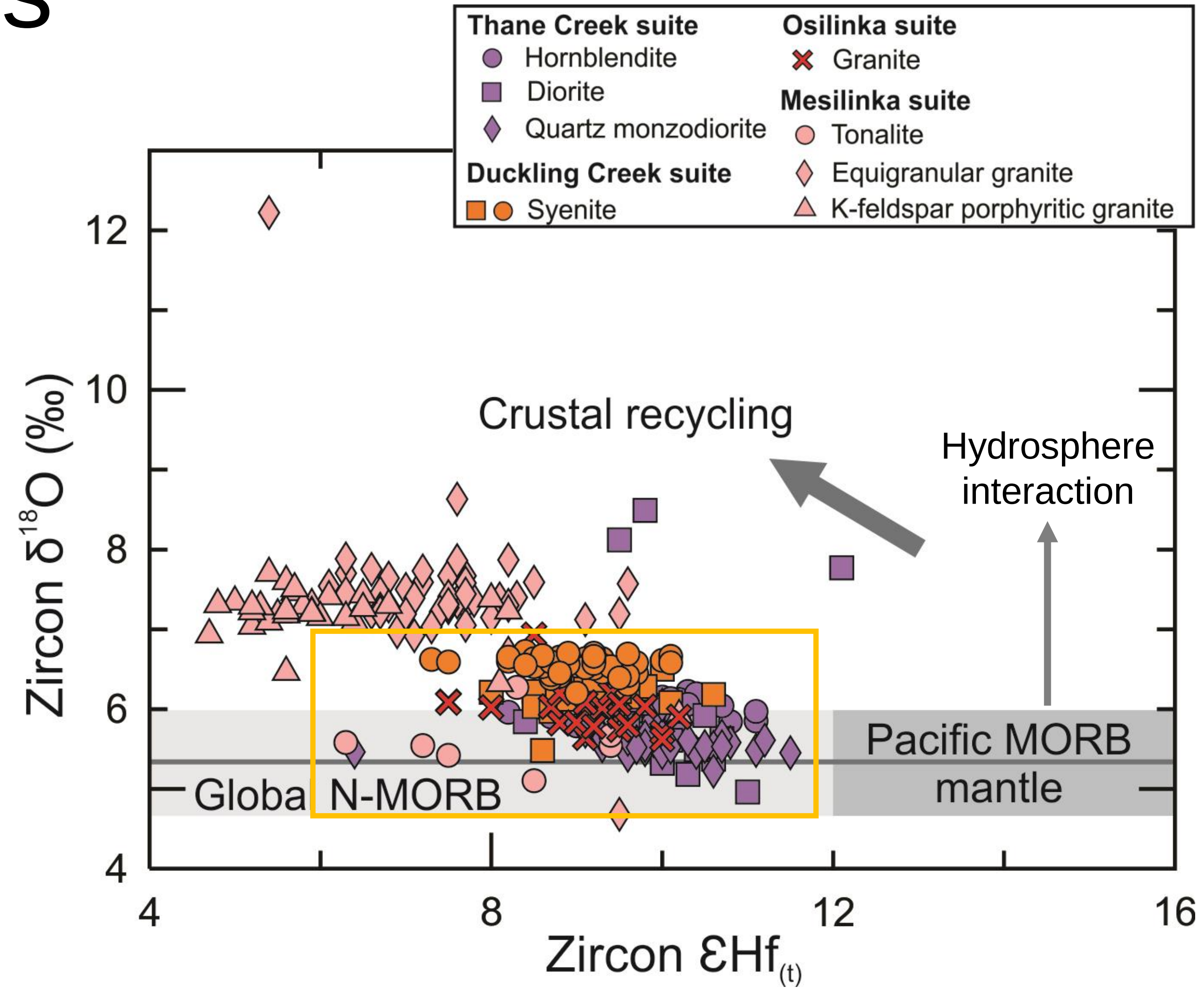
- Thane Creek, Duckling Creek, and Osilinka suites and most Mesilinka tonalite mostly mantle-like



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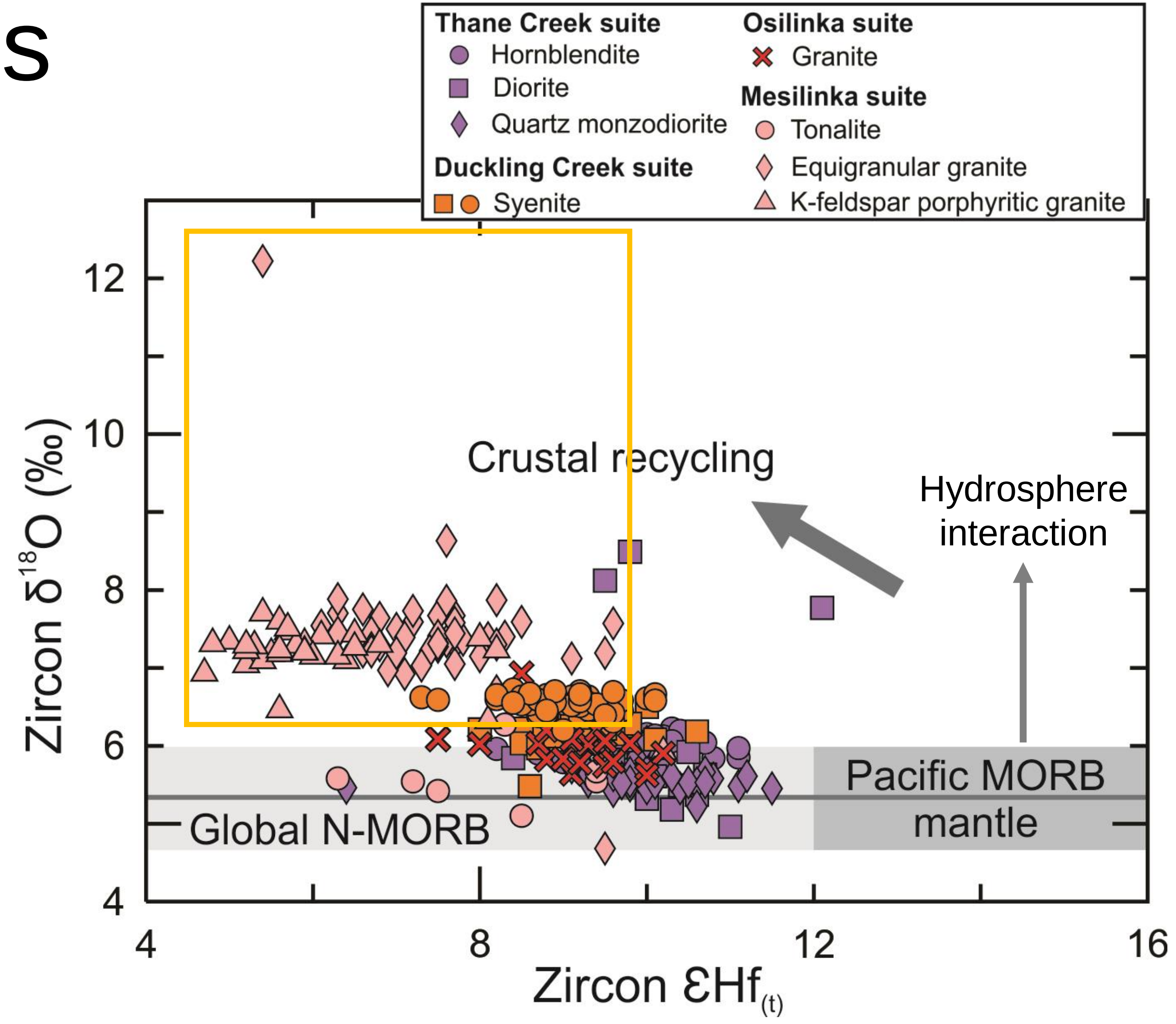
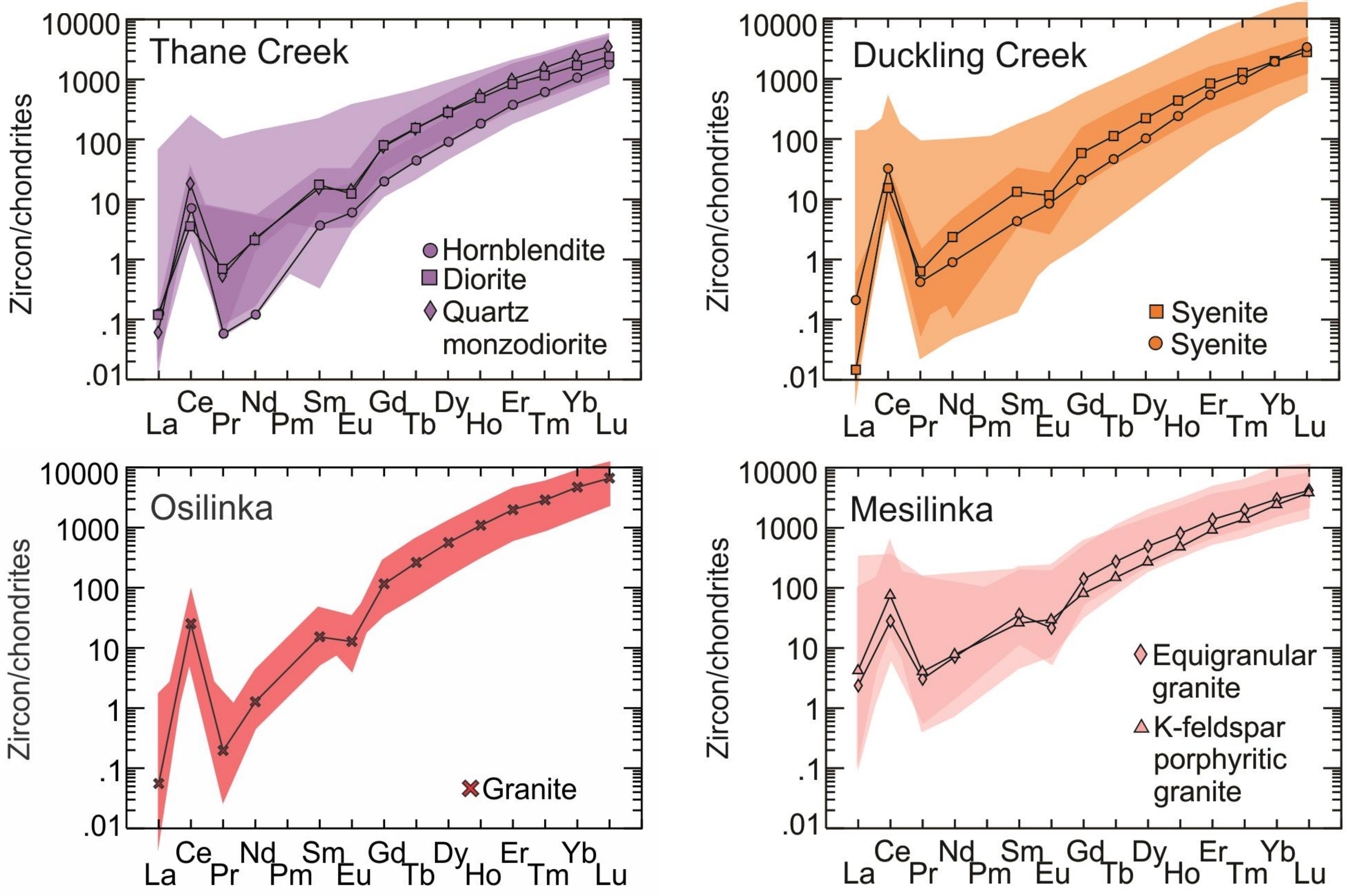
  - Zircon $\delta^{18}O$ >5.3‰: interaction with low temperature **hydrosphere**
- Thane Creek, Duckling Creek, and Osilinka suites and most Mesilinka tonalite mostly mantle-like
- Mesilinka granites: hydrosphere interaction



Zircon Trace Element Results



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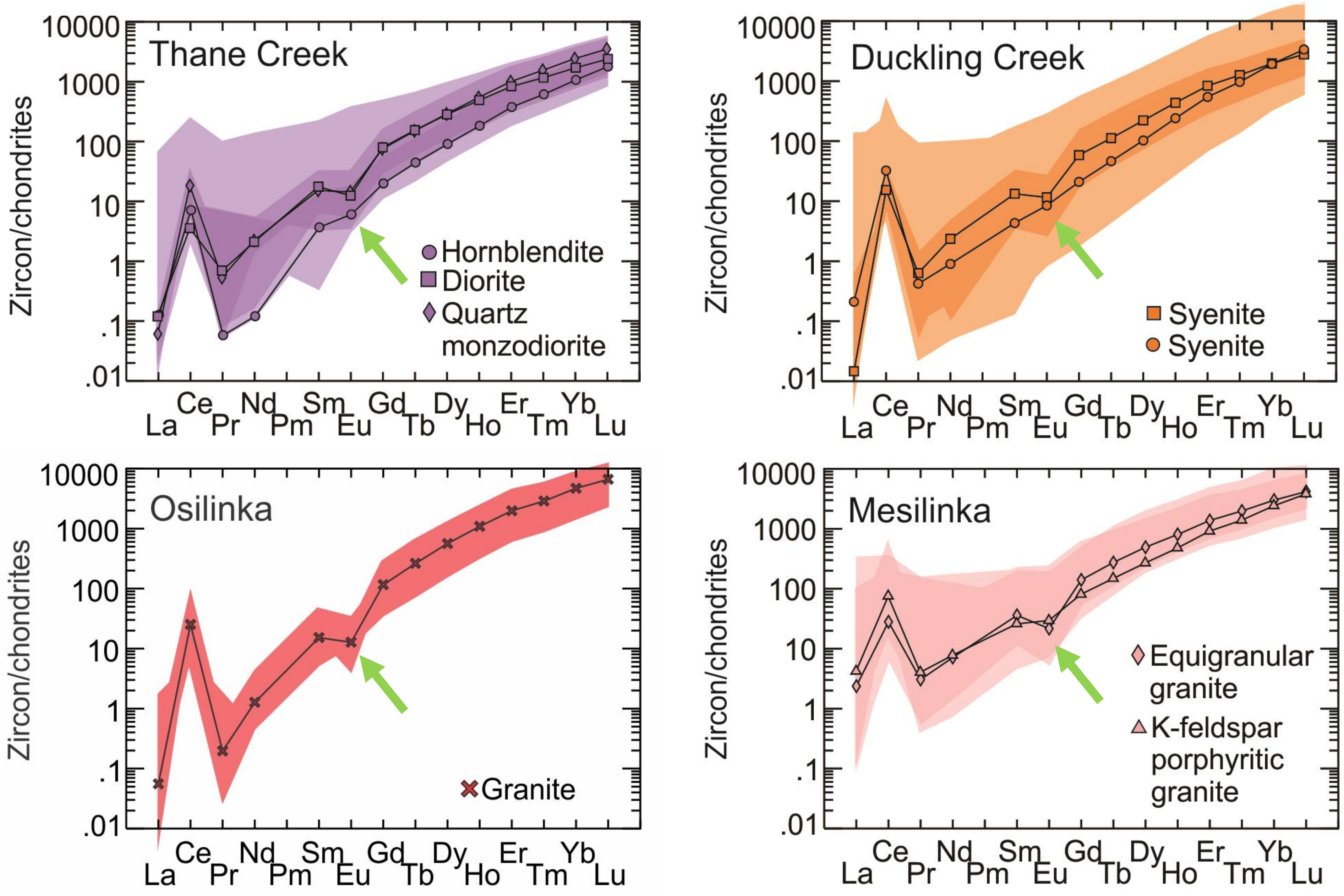
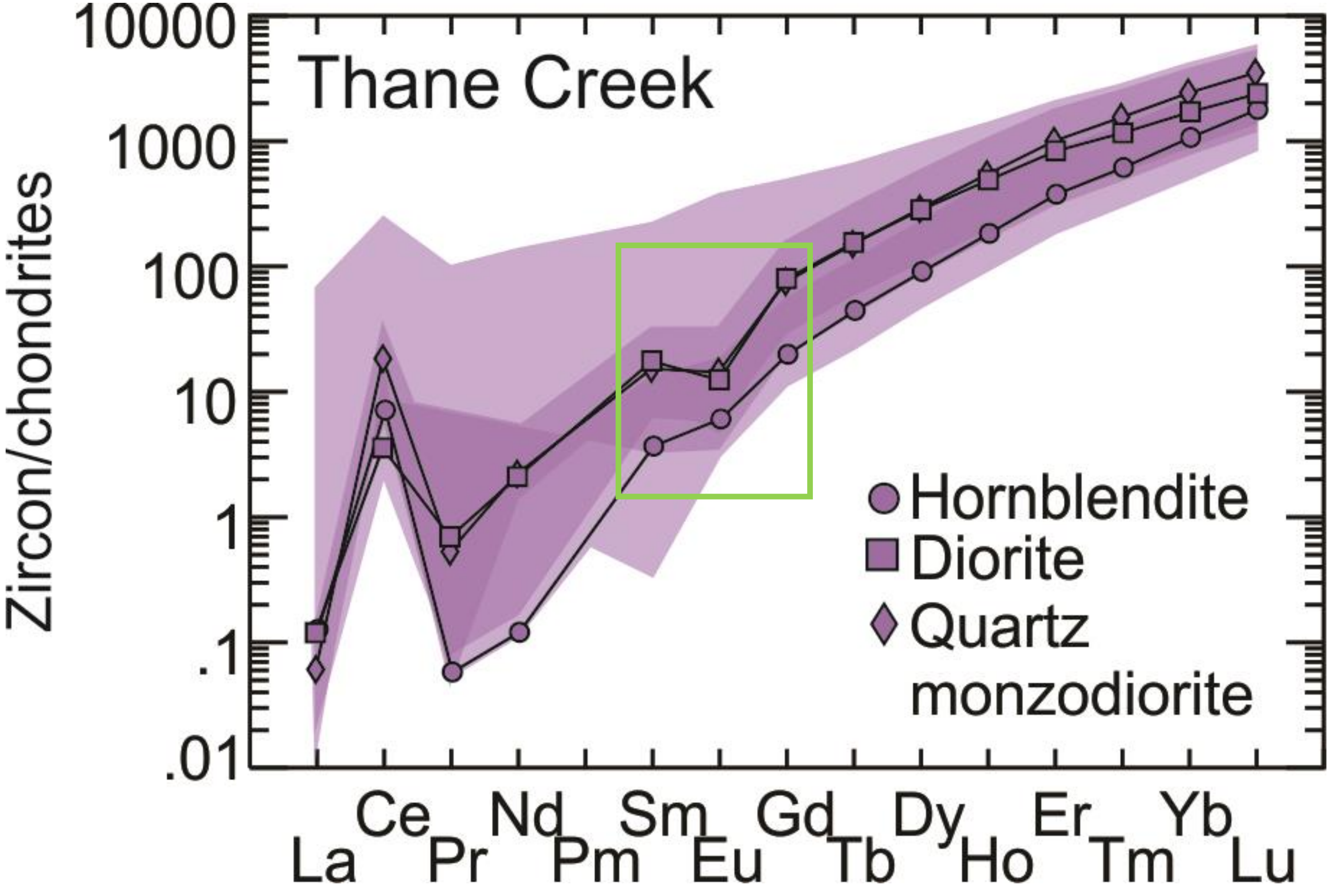


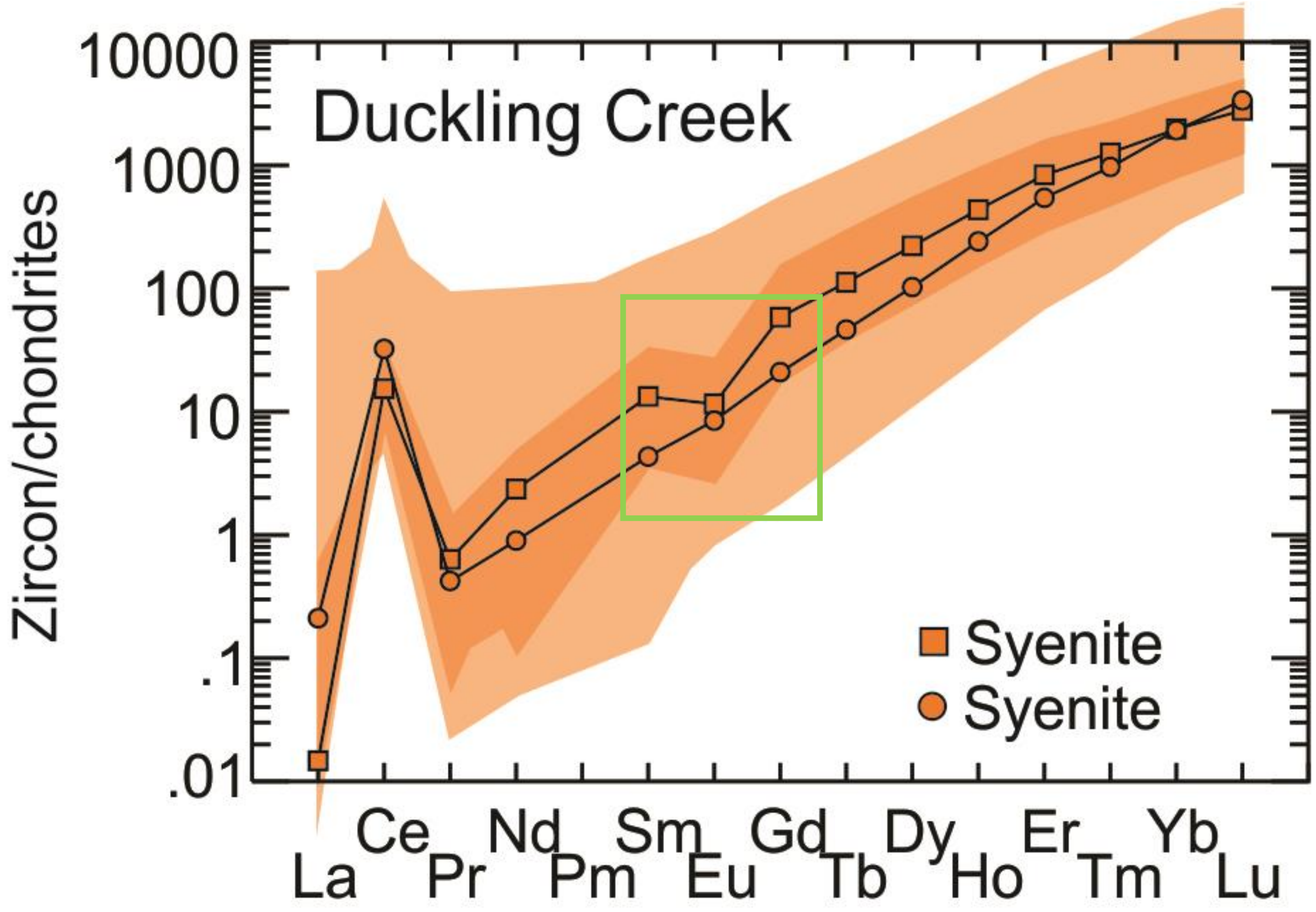
Zircon Eu/Eu$_N$* Anomalies



- Hornblendite: avg. 0.73
- Diorite: avg. 0.34
- Quartz monzodiorite: 0.43

- Feldspar accumulation

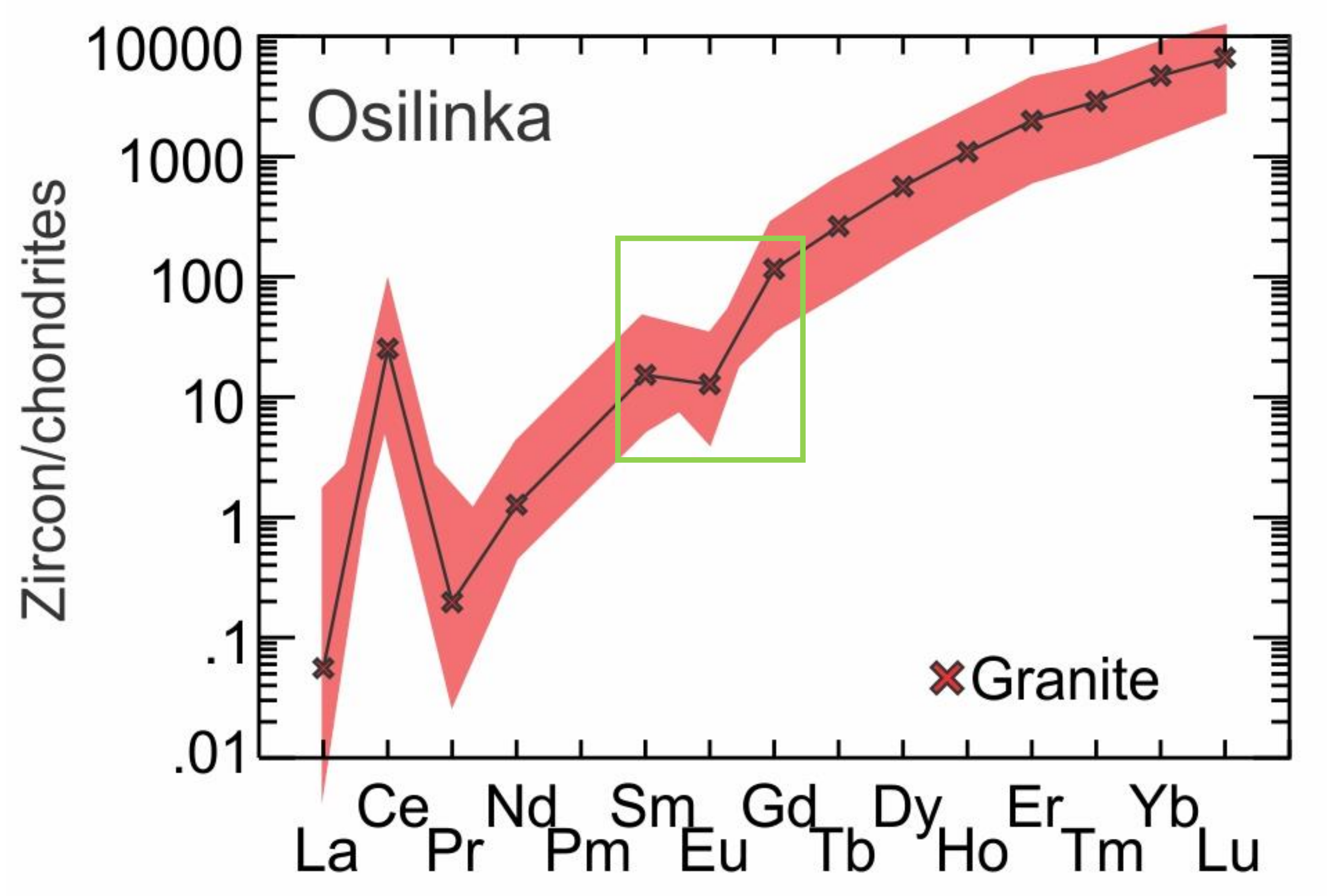
Zircon Eu/Eu$_N$ * Anomalies



- Syenite (179 Ma): avg. 1.0
- Syenite (175 Ma): avg. 0.39

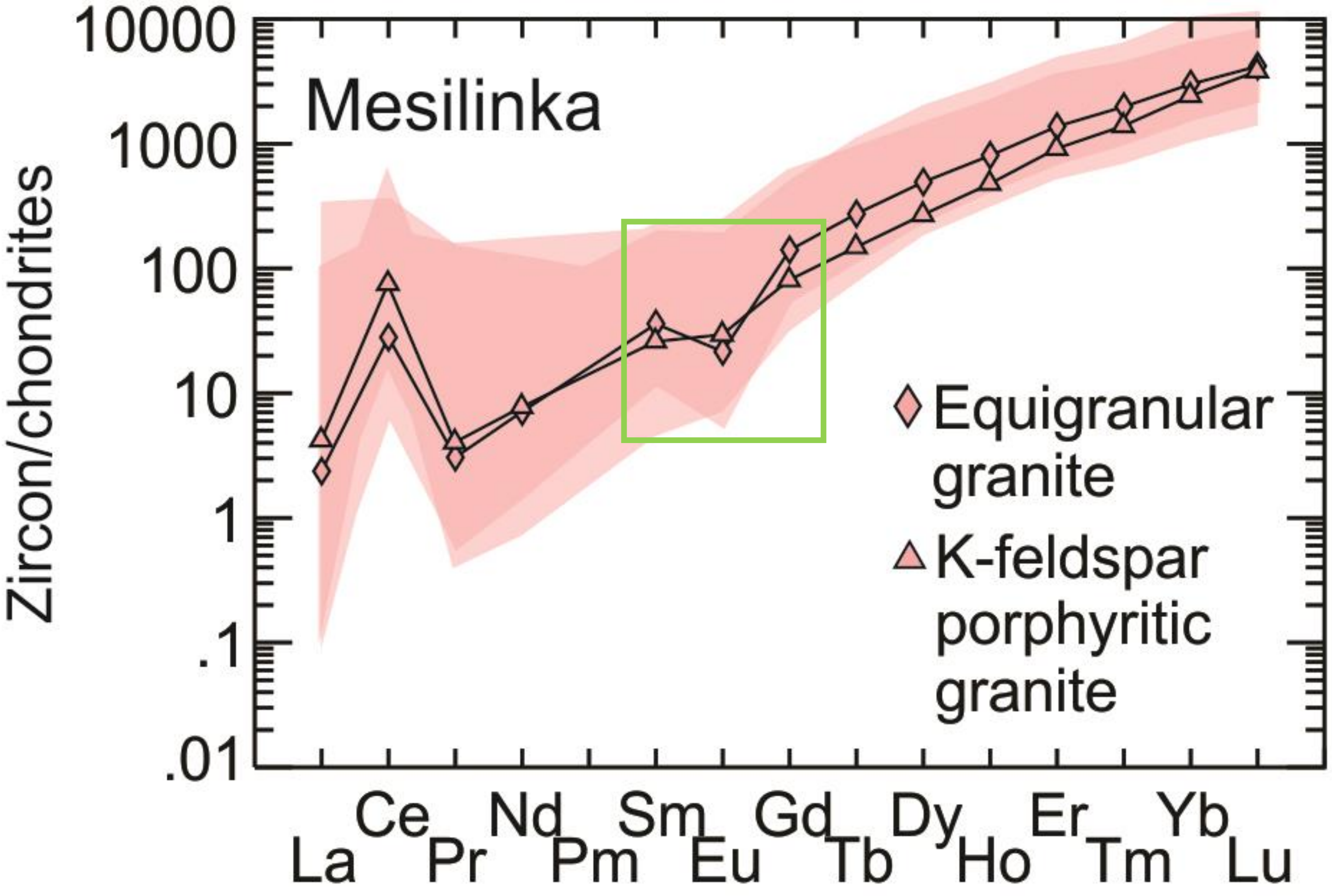
- Decreasing oxidation state or water content in magma?

Zircon Eu/Eu_N* Anomalies



- Granite: avg. 0.42
- Inherited zircons, relatively constrained REE profile
- Similar to Thane Creek diorites and Duckling Creek syenites

Zircon Eu/Eu_N^* Anomalies



- Porphyritic granite (134 Ma):
  avg. 0.60
- Equigranular granite (128 Ma):
  avg. 0.31
- Decreasing oxidation state/water content?

Zircon Ti thermometry

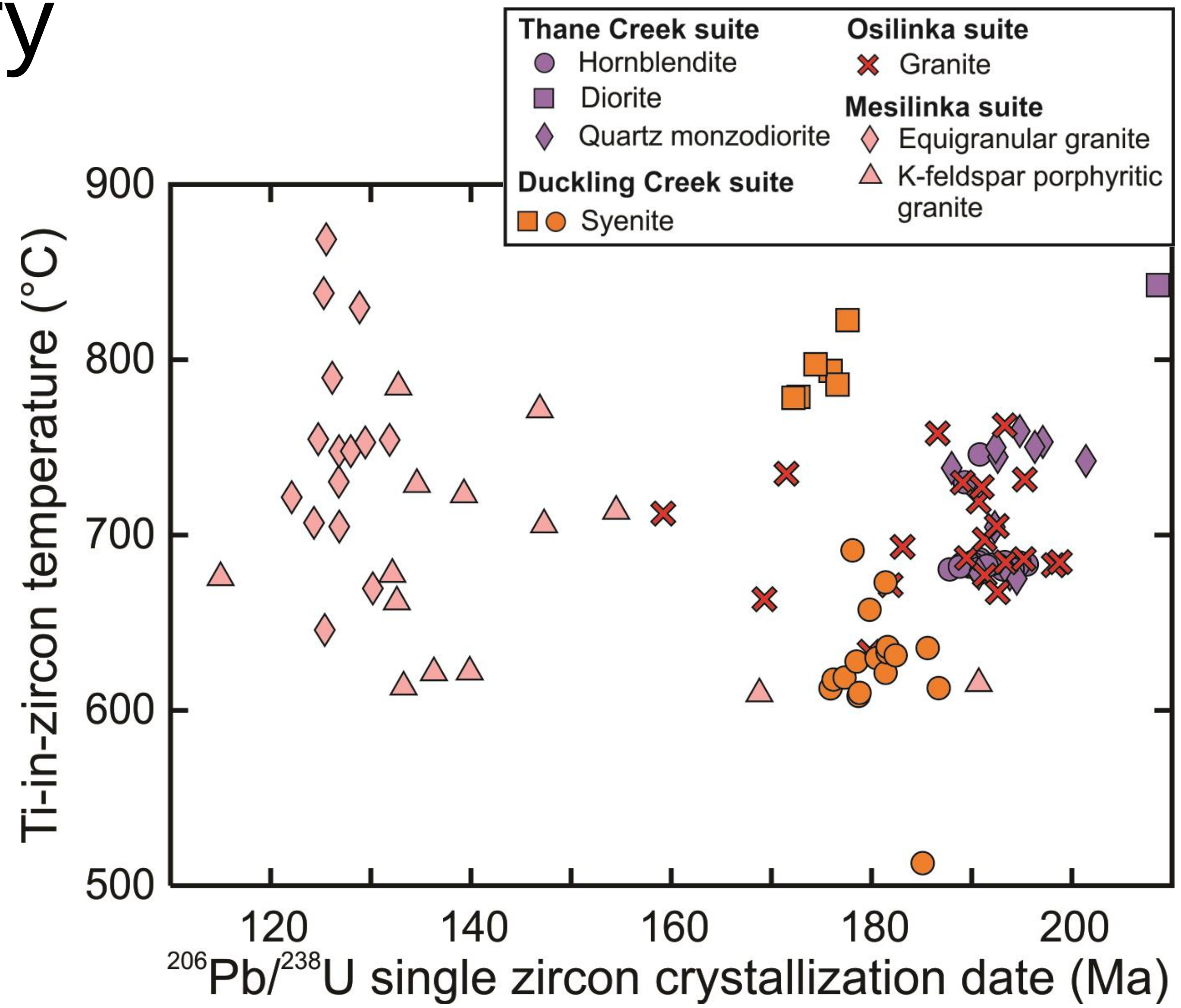
- Modified calculation of Ferry & Watson (2007)

- Base assumption of αSi=1.0 and

  αTi =0.7

  - Presence of titanite, Fe-Ti oxides

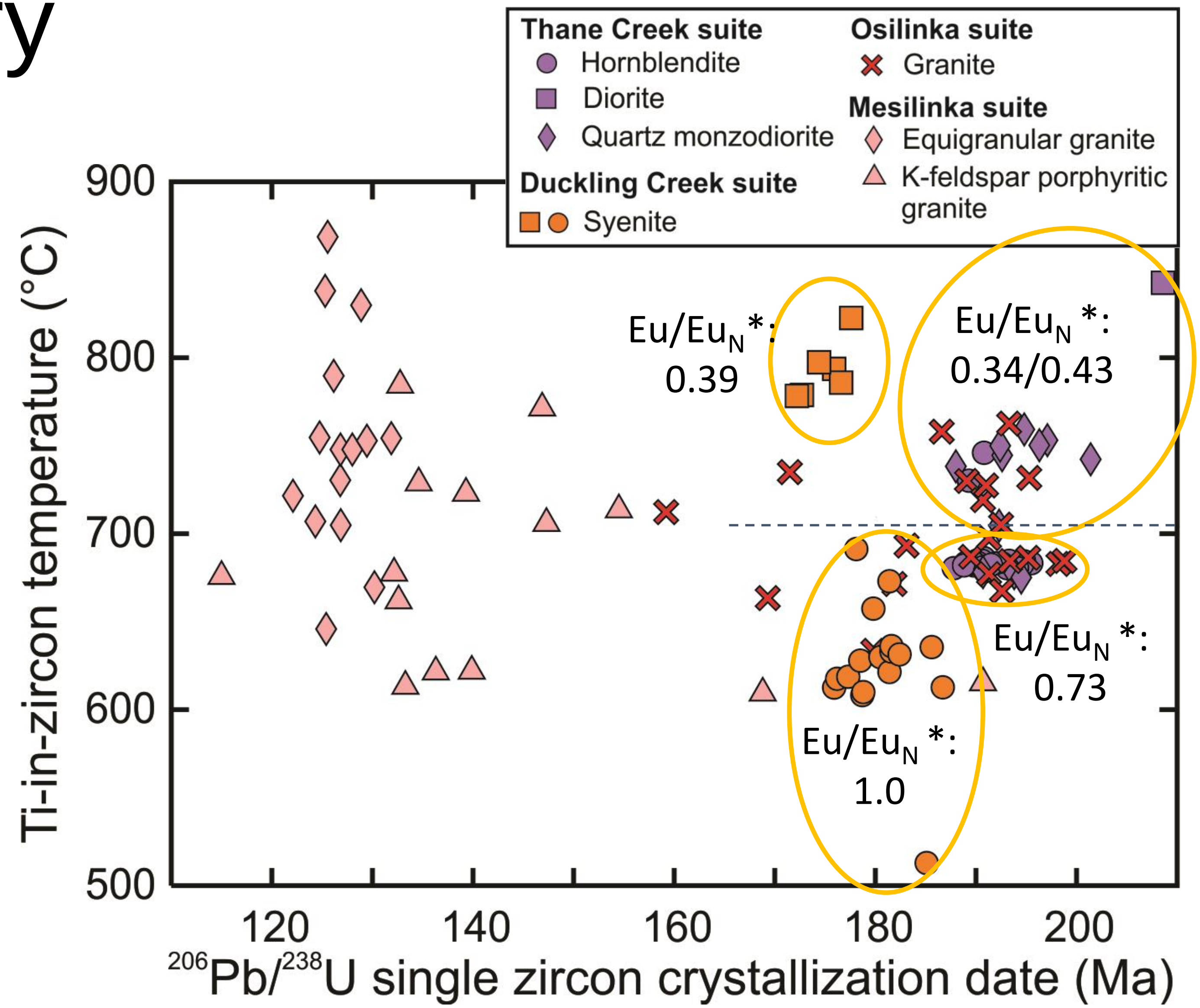
- Relative temperature variation between suites



Zircon Ti thermometry

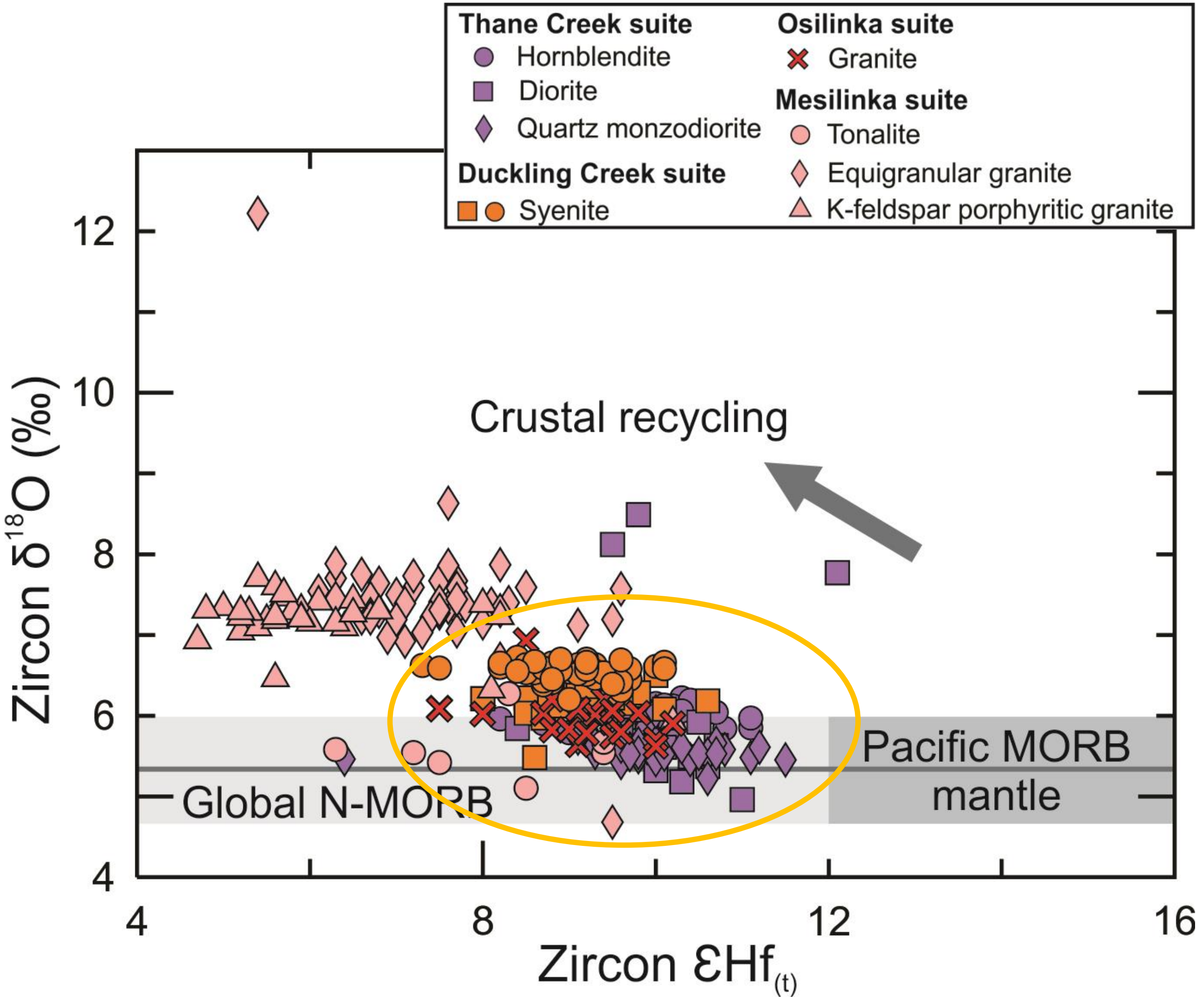
- Thane Creek suite:
  - Lower T hornblendite: avg. 690°C
    - High Eu/Eu*
  - Higher T diorite and quartz monzodiorite: avg. 850 and 720°C
    - Low Eu/Eu*

- Duckling Creek suite:
  - Low T syenite: avg. 625°C
    - High Eu/Eu*
  - High T syenite: avg. 780°C
    - Low Eu/Eu*



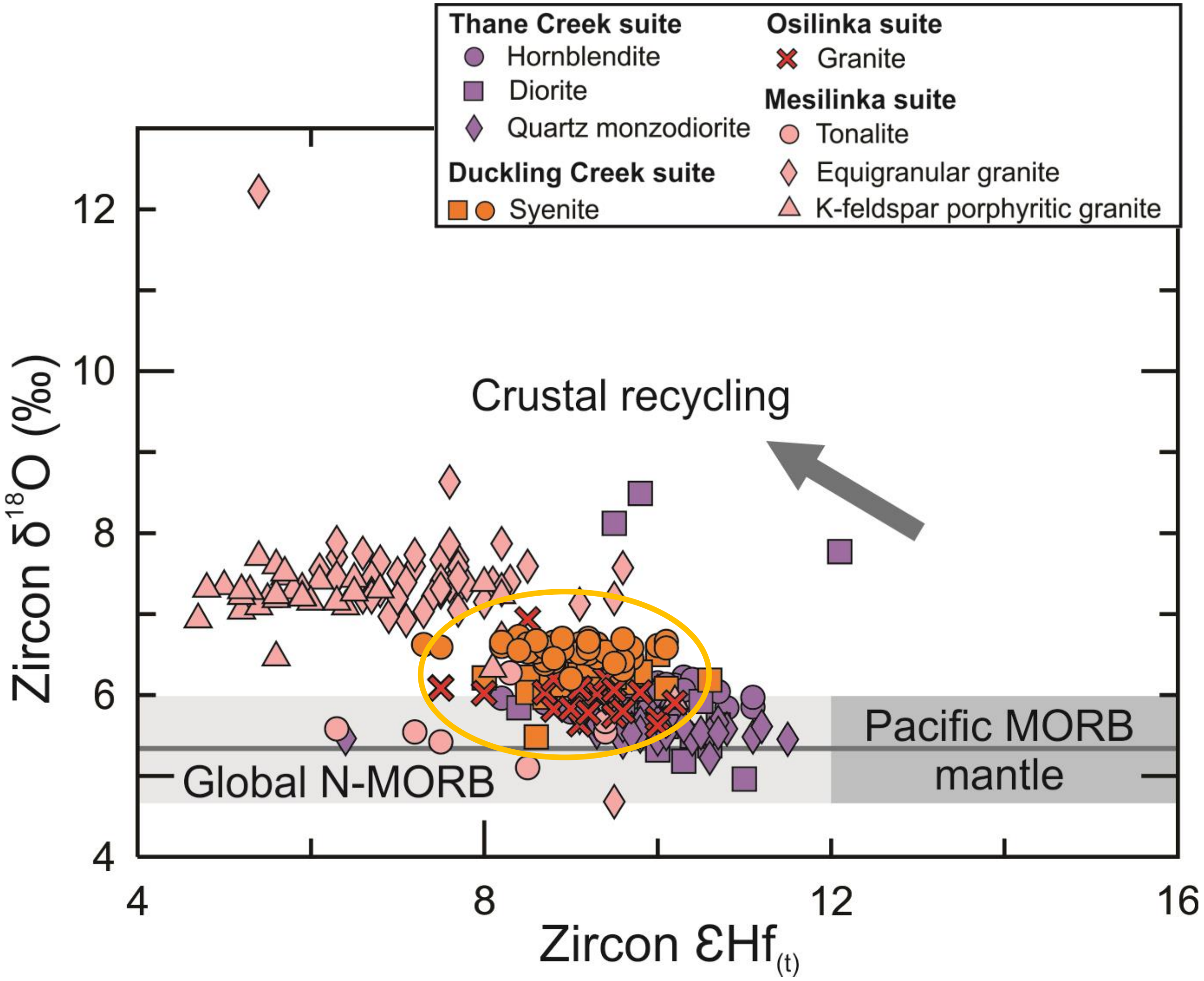
Tectonic Implications

- Pre-170 Ma: Thane Creek and Duckling Creek suites
- Most juvenile εHf(t) results and mantle-like zircon $\delta^{18}O$ values
- Variation in Ti-in-zircon temperatures: magma inputs through time
- Eu/Eu_N^* correlates with temperature: higher oxidation state/water content of magma?
  - More favourable for porphyry formation
- Transition from an **island arc** setting into syn-collisional



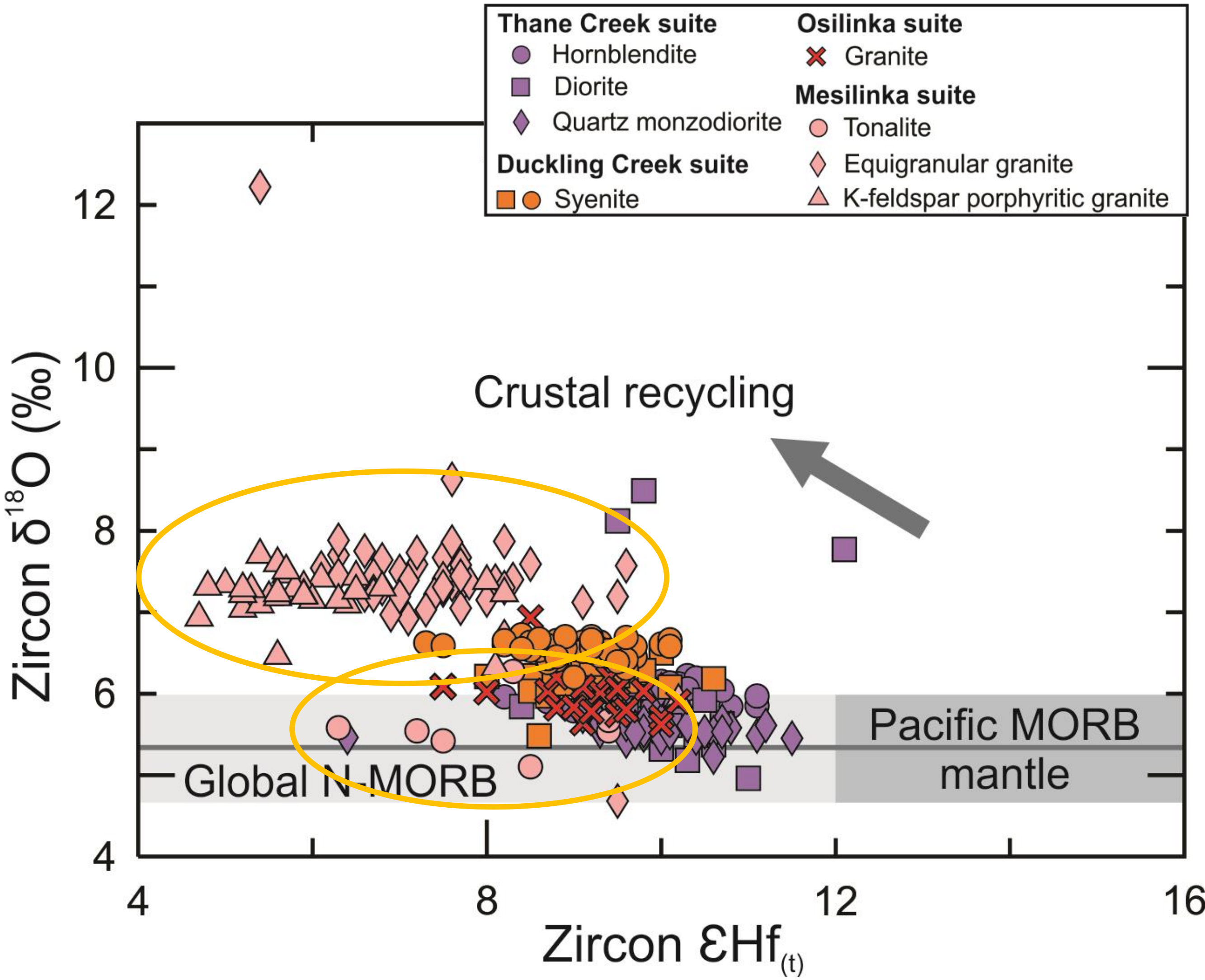
Tectonic Implications

- Post-170 Ma: Osilinka suite
- Inherited zircons
- Predominantly overlap Thane Creek and Duckling Creek results
- Syn-to-post accretion in north-central Quesnel terrane
  - Re-melting of Thane Creek and Duckling Creek suite, or similar rocks
  - Magmatism ceased



Tectonic Implications

- Post-140 Ma: Mesilinka suite
- Tonalite mantle-like $\delta^{18}O$ and relatively juvenile εHf(t) signatures
- Strong low temperature **hydrosphere** $\delta^{18}O$ signature and less radiogenic Hf in granites
- Wide variation in Ti-in-zircon temperatures and more negative Eu/Eu_N^*
- **Mix** of sources:
  - Evidence of **crustal recycling**: post-accretionary crustal thickening
  - **Juvenile** magmatism



Conclusions

- Zircons from the composite Hogem batholith record changing tectonic environments in the four intrusive suites

- This study provides an opportunity to study the background magmatic conditions of a porphyry forming environment

- Varying tectonic setting through time likely had an impact on magma fertility in Hogem batholith

Thank you

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