Are the REE, U, and Th contents of zircon sensitive to magmatic-hydrothermal processes concurrent of mineralisation?

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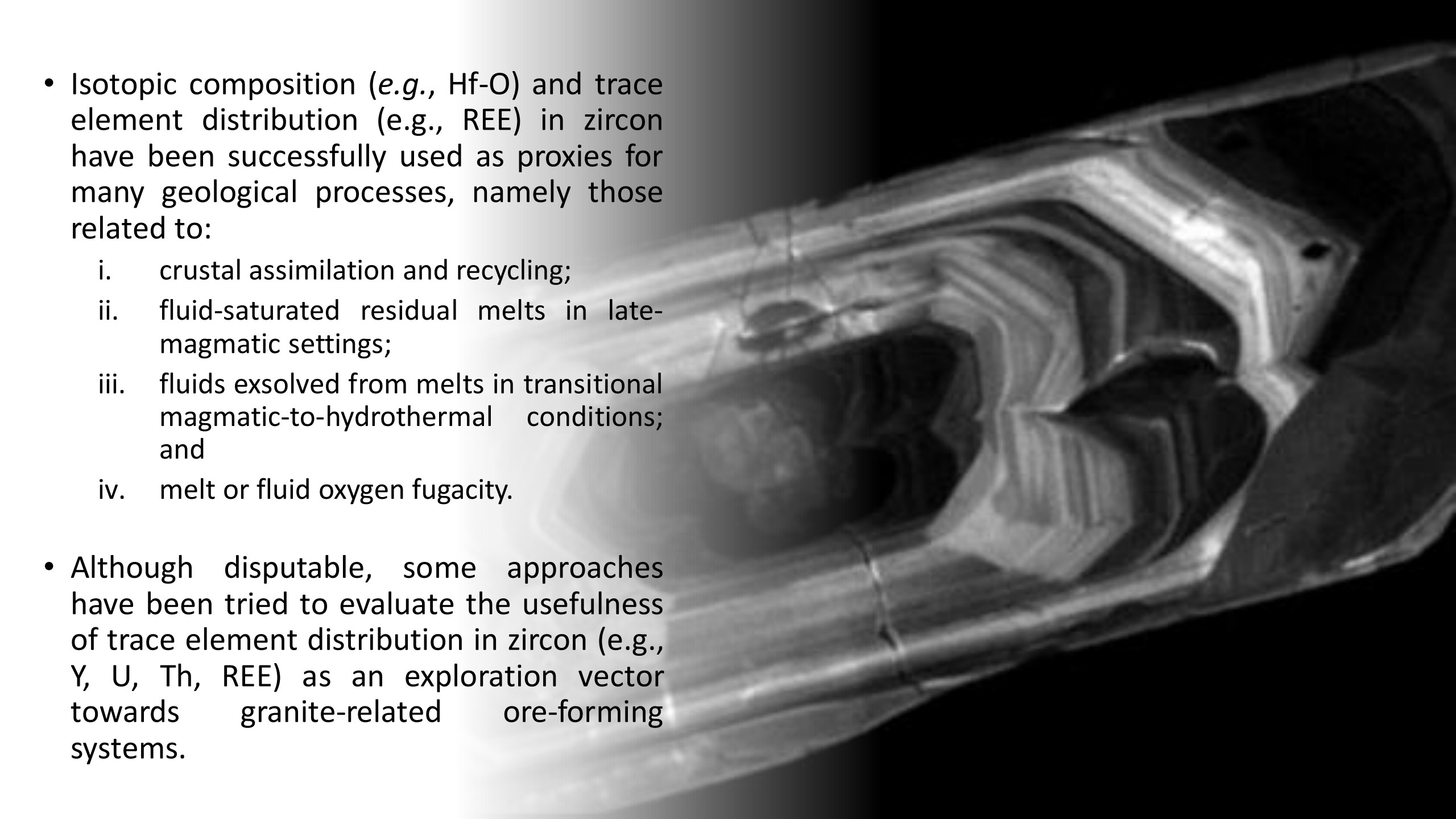
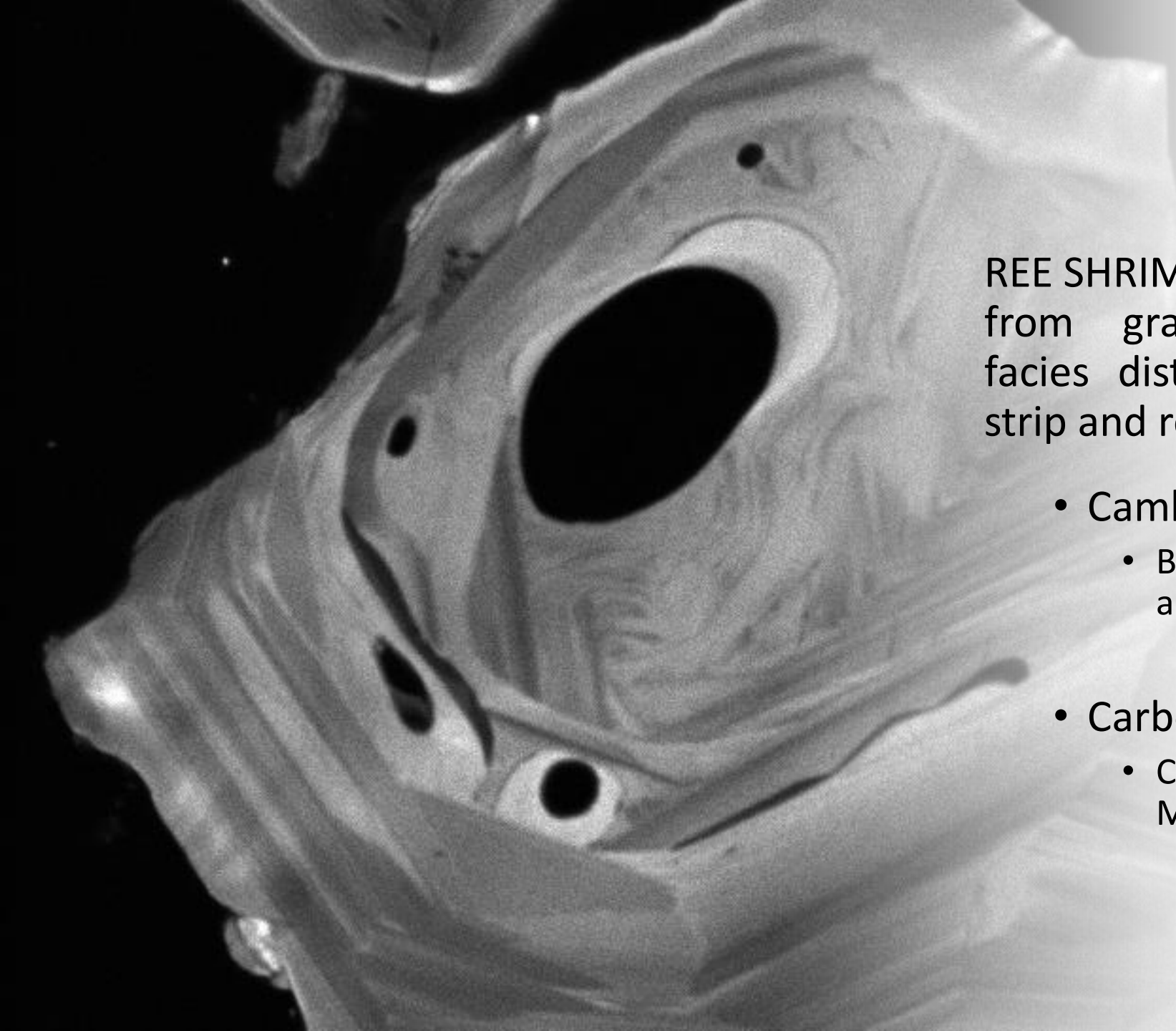
- Isotopic composition (*e.g.*, Hf-O) and trace element distribution (e.g., REE) in zircon have been successfully used as proxies for many geological processes, namely those related to:
    i. crustal assimilation and recycling;
    ii. fluid-saturated residual melts in late-magmatic settings;
    iii. fluids exsolved from melts in transitional magmatic-to-hydrothermal conditions; and
    iv. melt or fluid oxygen fugacity.

- Although disputable, some approaches have been tried to evaluate the usefulness of trace element distribution in zircon (e.g., Y, U, Th, REE) as an exploration vector towards granite-related ore-forming systems.



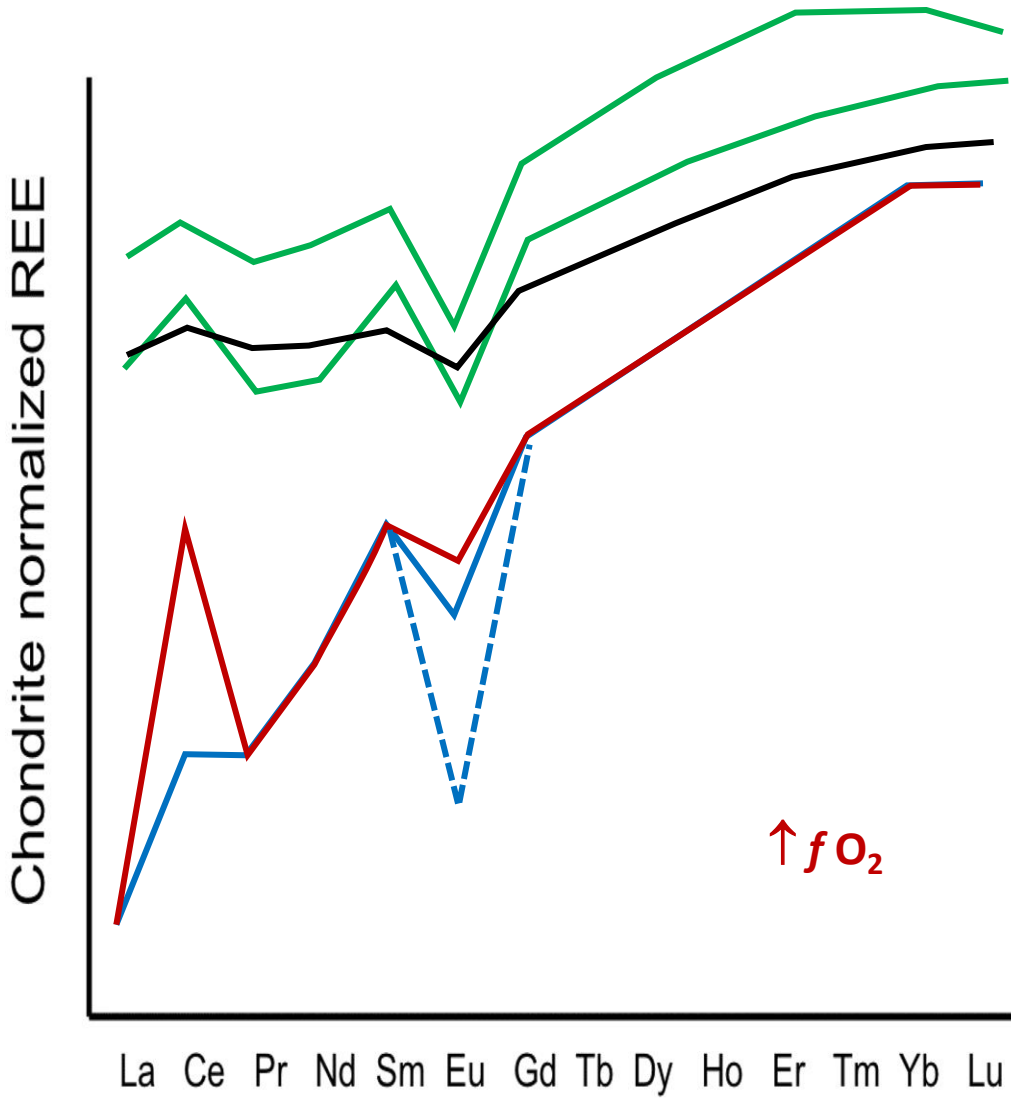


REE SHRIMP analysis in zircon populations from granitoid and aplite-pegmatite facies distributed across the G.-P.-A.-S. strip and representing:

- Cambrian-Lower Ordovician suites
  - Batão, Oledo/Idanha-a-Nova, Zebreira and Fundão
- Carboniferous-Lower Permian suites
  - Capinha, Salvaterra do Extremo, Orca, Monsanto, Segura and Panasqueira

$Ce/Ce^* = (Ce)_{cn}/[(La)_{cn} \times (Pr)_{cn}]^{0.5}$

$Eu/Eu^* = (Eu)_{cn}/[(Sm)_{cn} \times (Gd)_{cn}]^{0.5}$



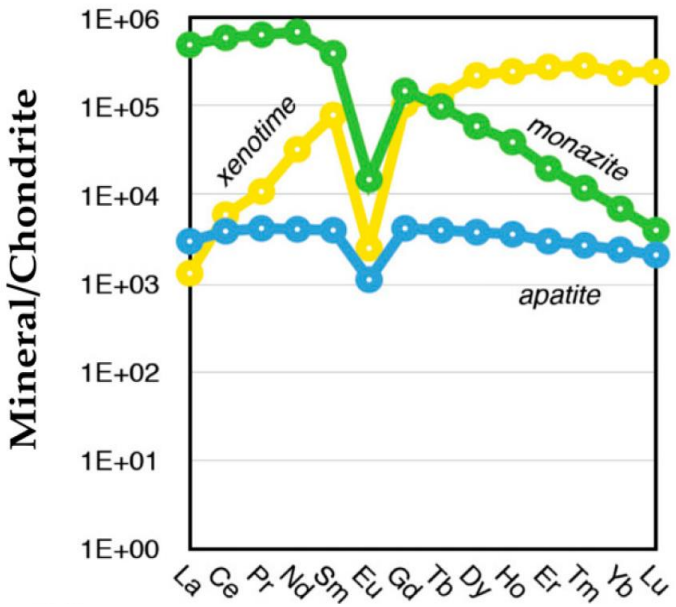
Zircon: $ZrSiO_4$

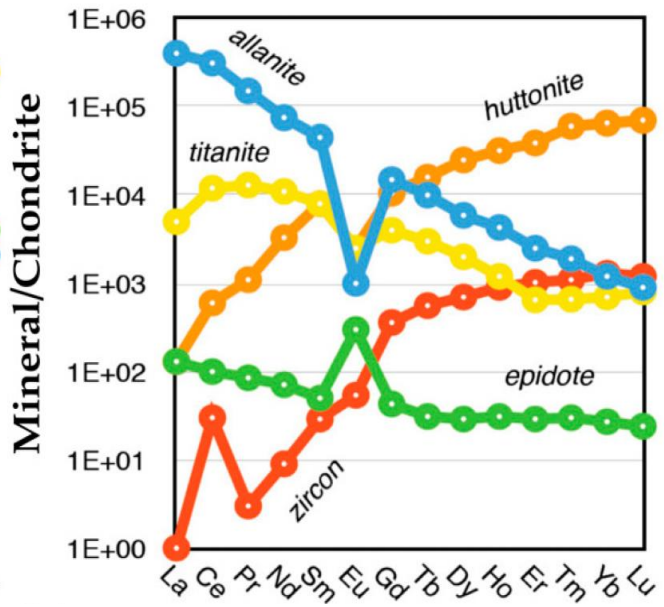
$(Zr_{1-y}, REE_y)(SiO_4)_{1-x}(OH)_{4x-y}$

$REE^{3+} + P^{5+} = Zr^{4+} + Si^{4+}$

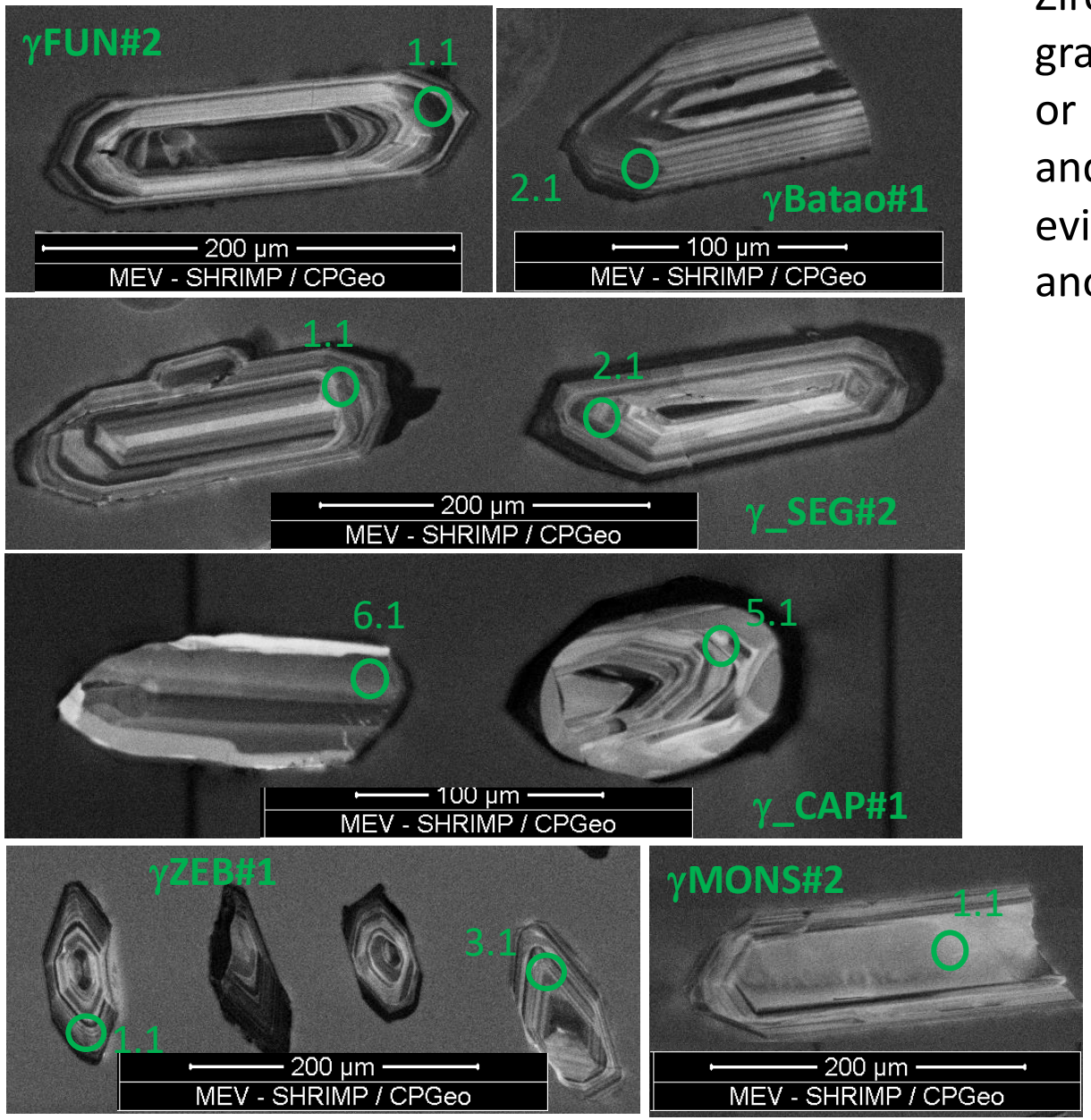
alkali-bearing fluids

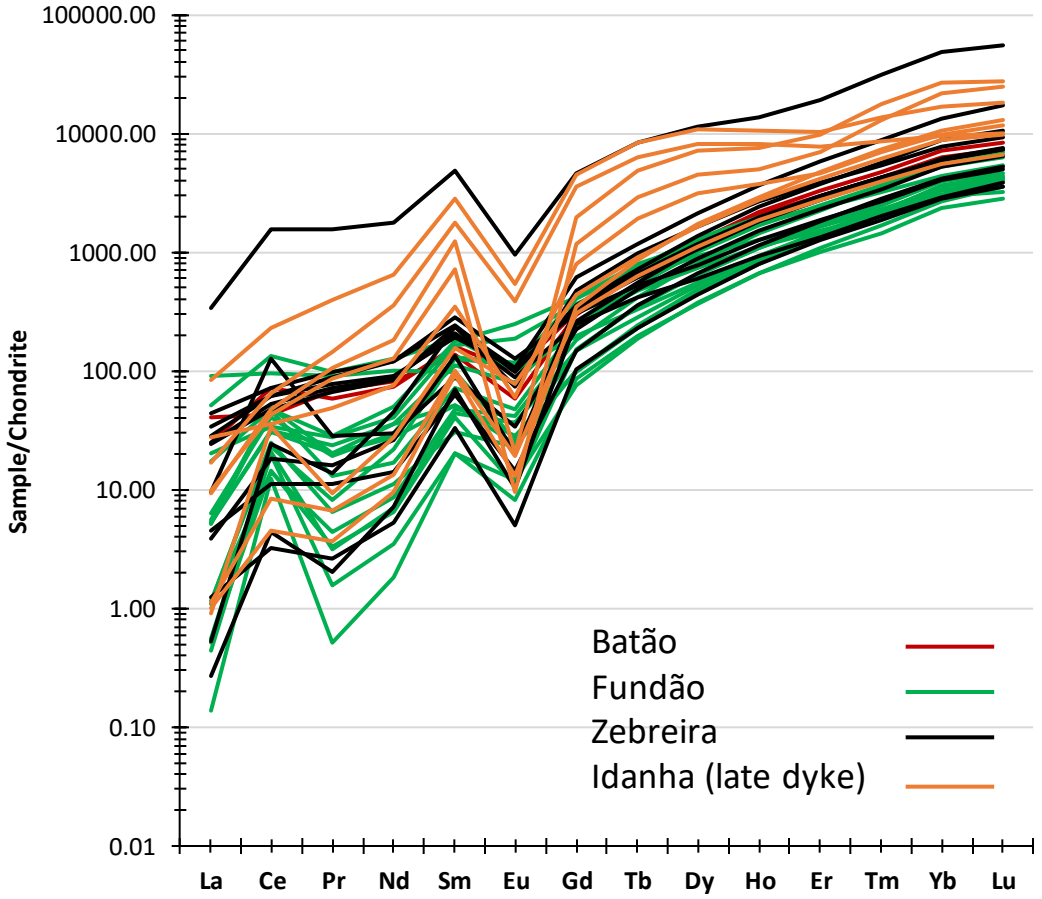
$Ce^{3+} \rightarrow Ce^{4+}$ (0.97Å) $\Leftrightarrow$ Zr^{4+} (0.84Å)



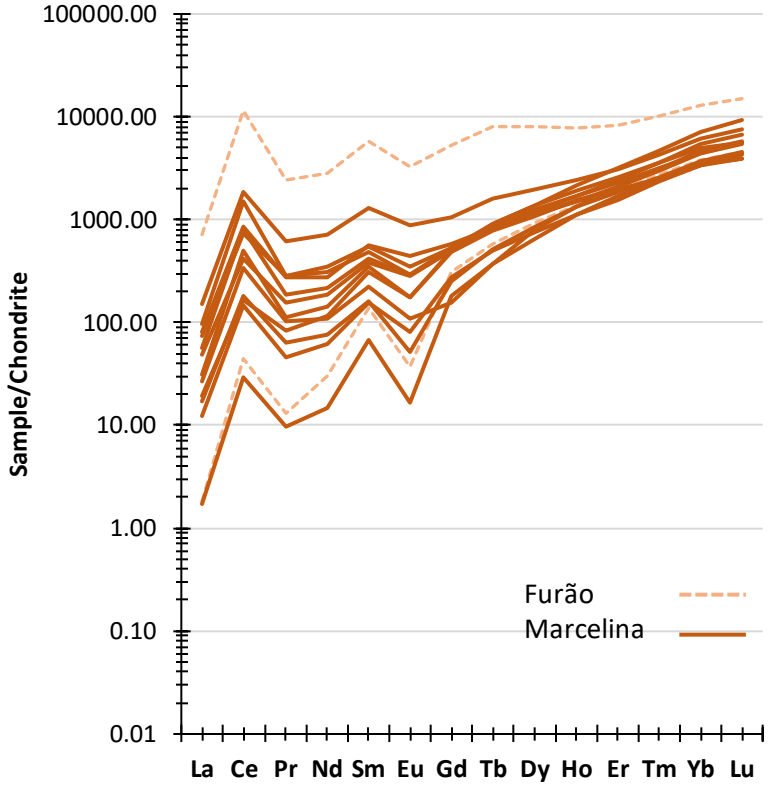


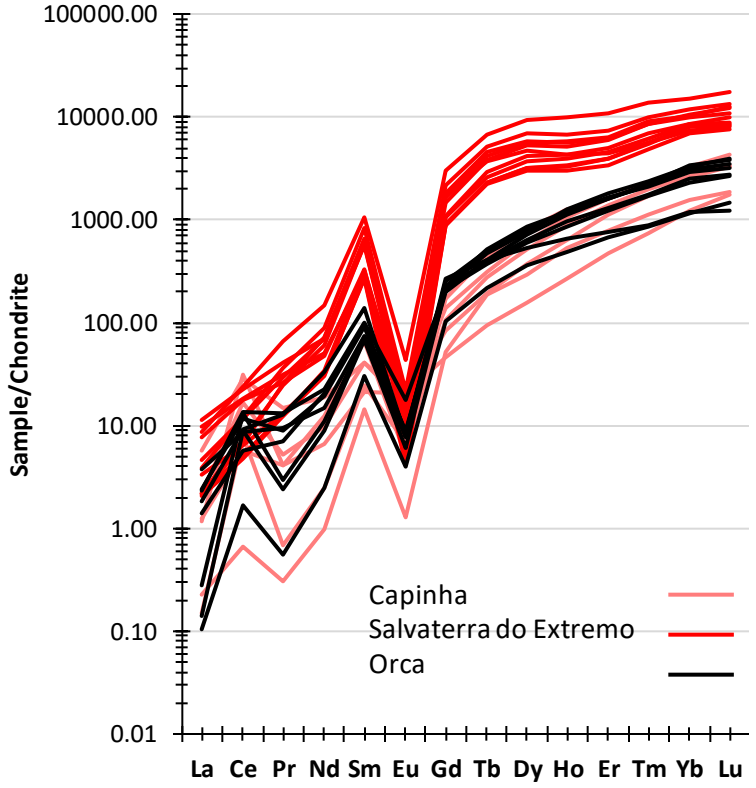
Zircons showing oscillatory growth or zoned sectors in granitoid rocks free from effects due to late metasomatic or hydrothermal processes, have similar REE contents and CN-normalised patterns, irrespective of their age: evident LREE-HREE fractionation, with Ce (+) and Eu (-↑) anomalies.

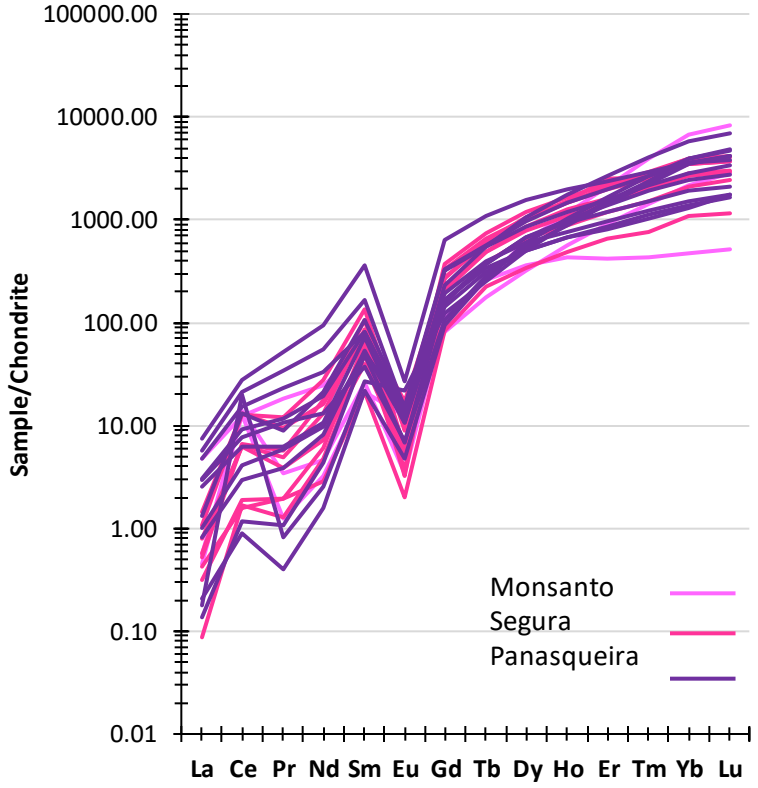




In the same rocks, some texturally similar zircons present CN-normalised REE patterns typified by more pronounced positive Ce anomalies, possibly denoting consecutive stages of zircon crystallisation under conditions of higher fO_2.

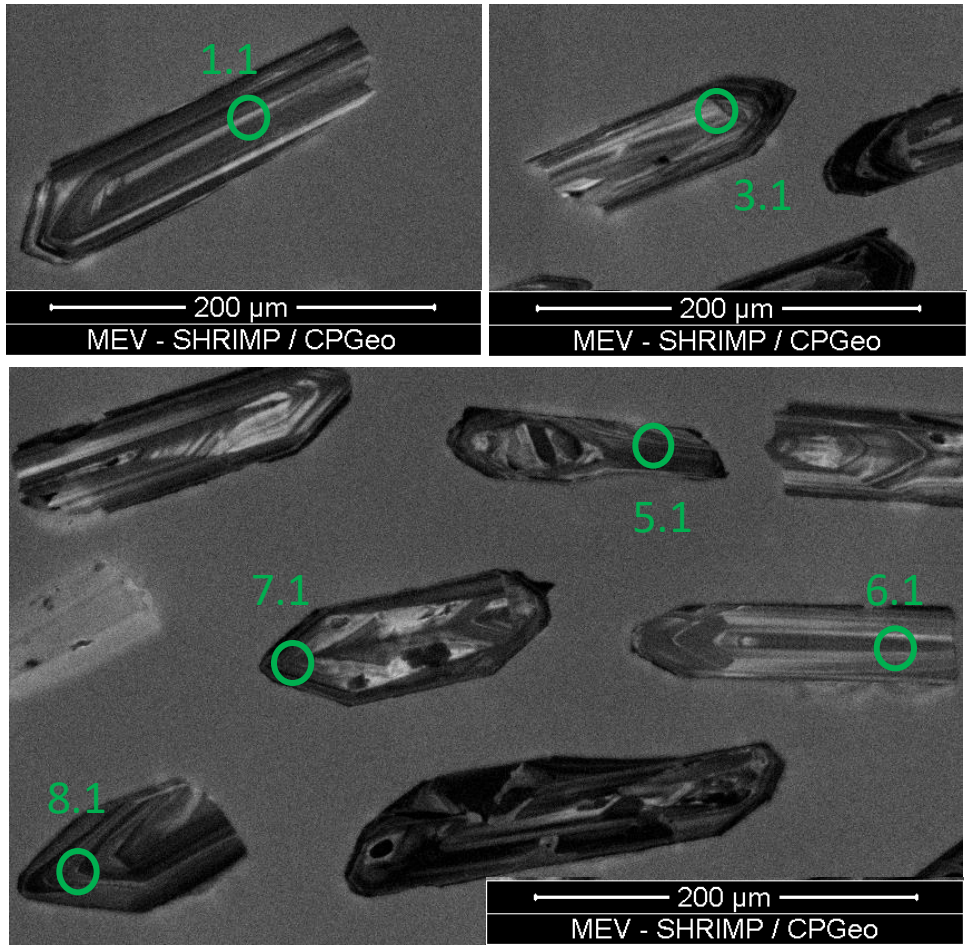




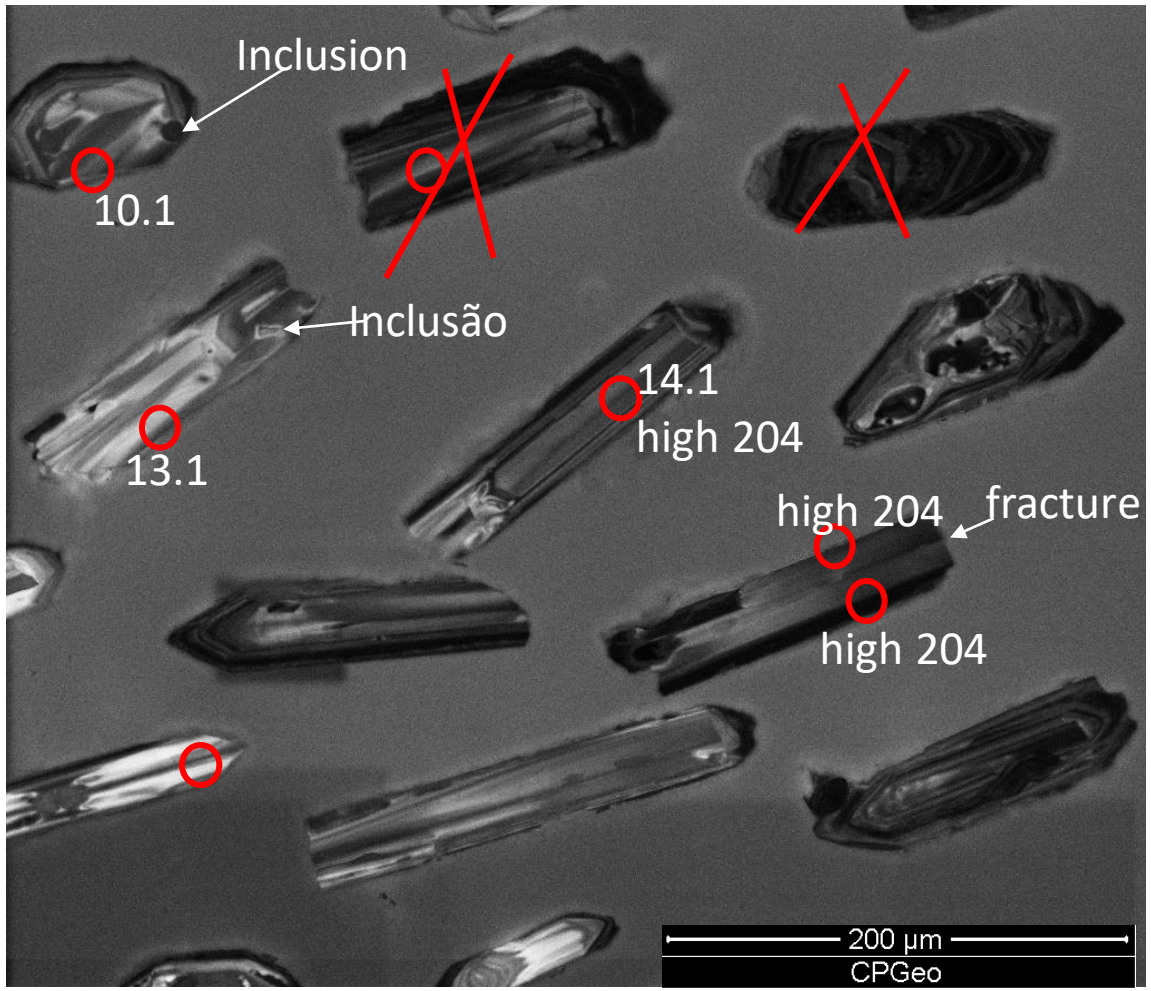


Identical explanation justifies the contrasting Ce and Eu anomalies obtained for many zircon grains in porphyry dykes and laccoliths (Furão and Marcelina), although requiring higher LREE saturation, as indicated by the LREE enrichment trend.

γMarcelina#1

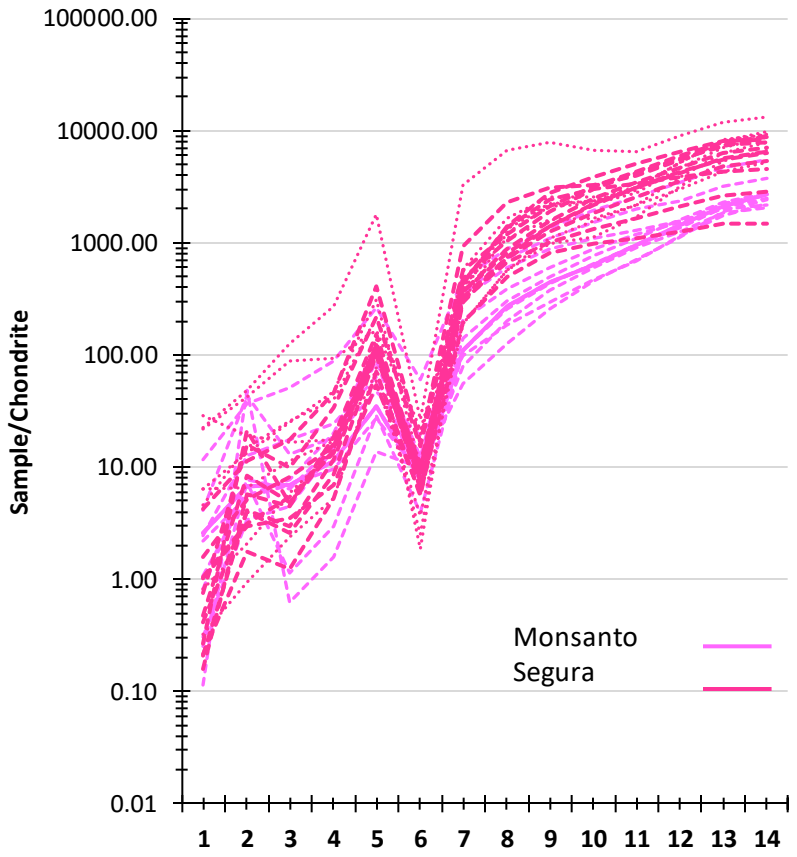


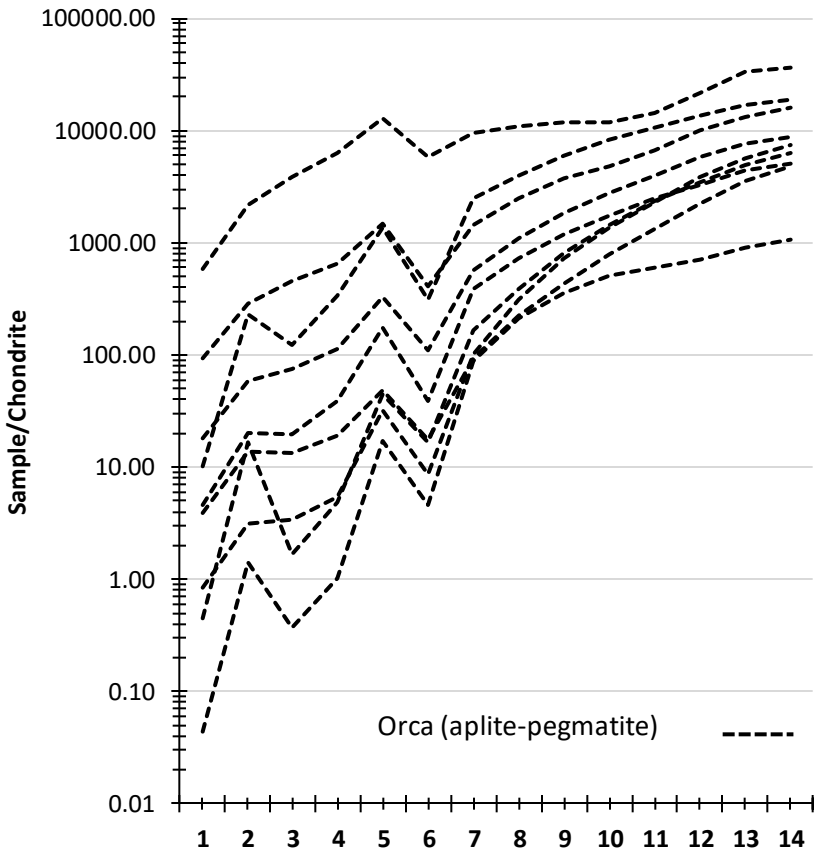
γf Furão#1



Zircons from aplite/pegmatite bodies rarely preserve oscillatory zoning, possibly due to significant interaction with melts saturated in aqueous fluids. Blurry oscillatory zoning is common.

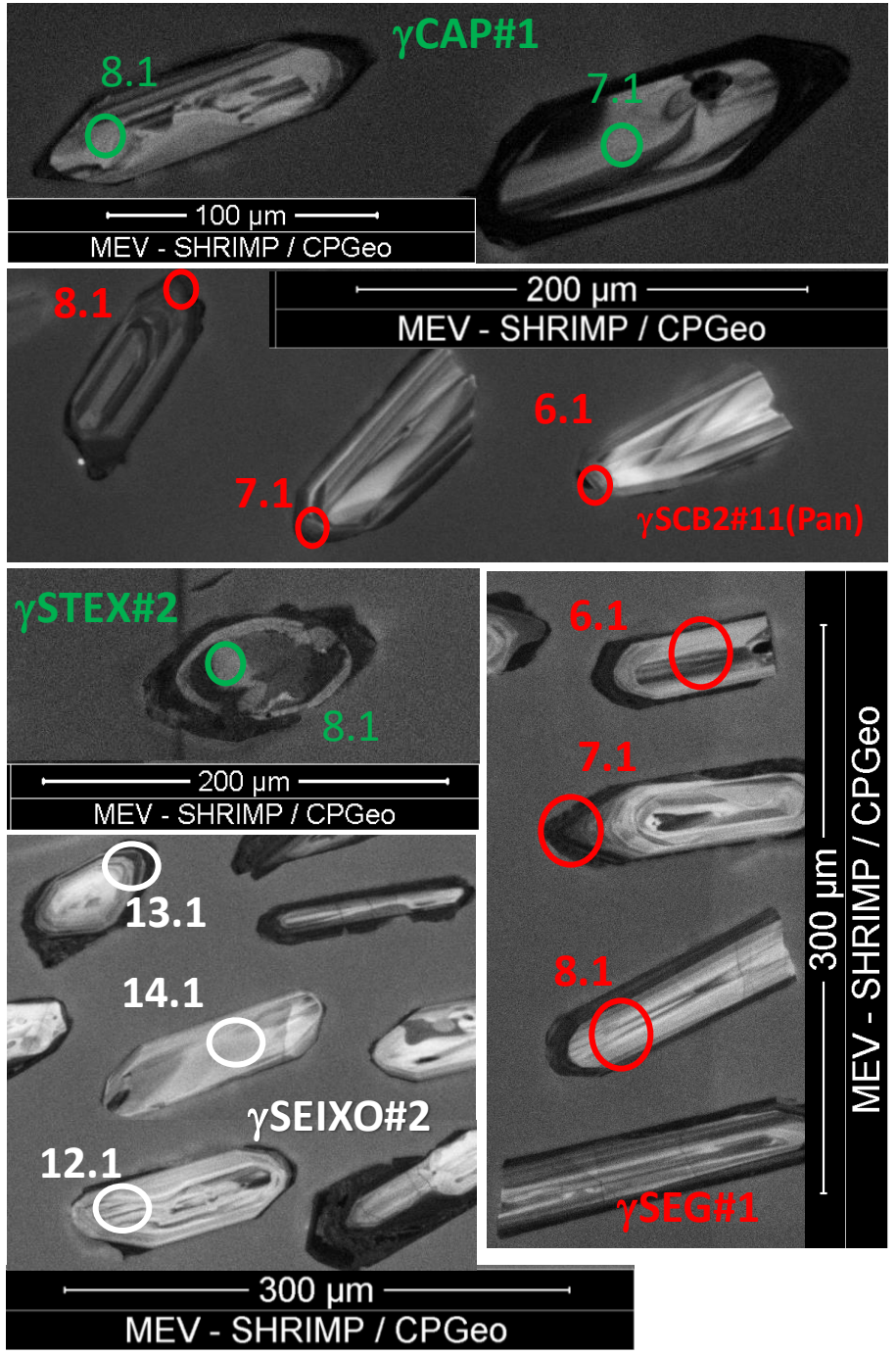
The CN-normalised REE patterns are identical to those of zircons in contiguous granitic facies.



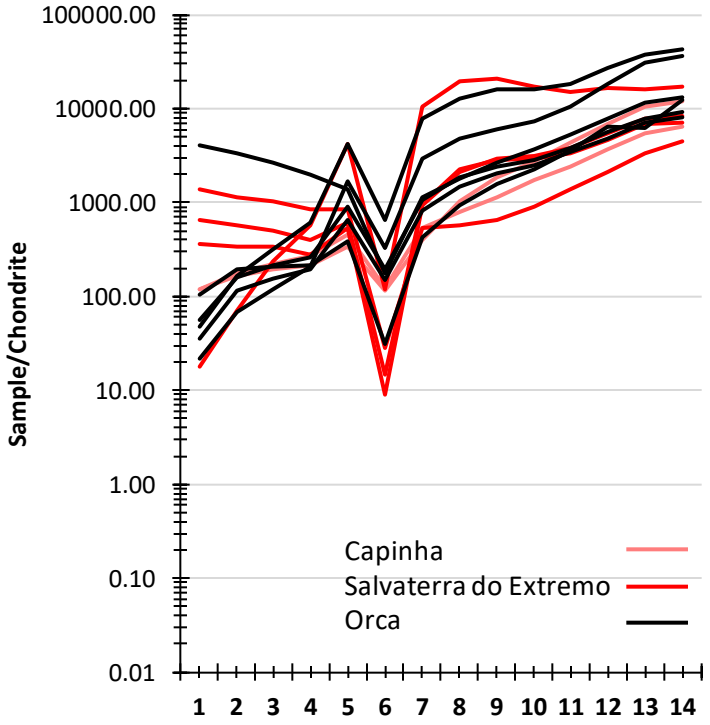


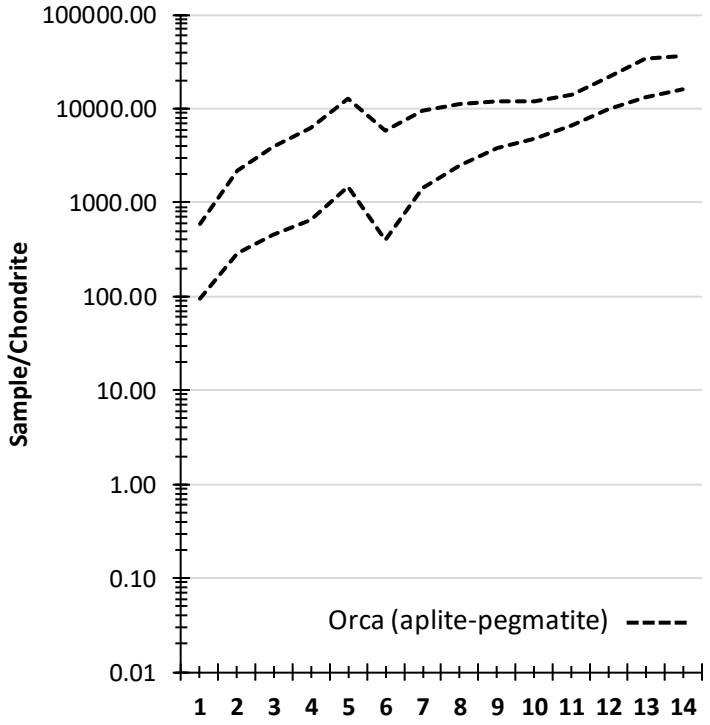
Larger differences occur when zircons come from aplite/pegmatite bodies or granitic samples subjected to strong compositional changes, generally related to signs of mineralization.

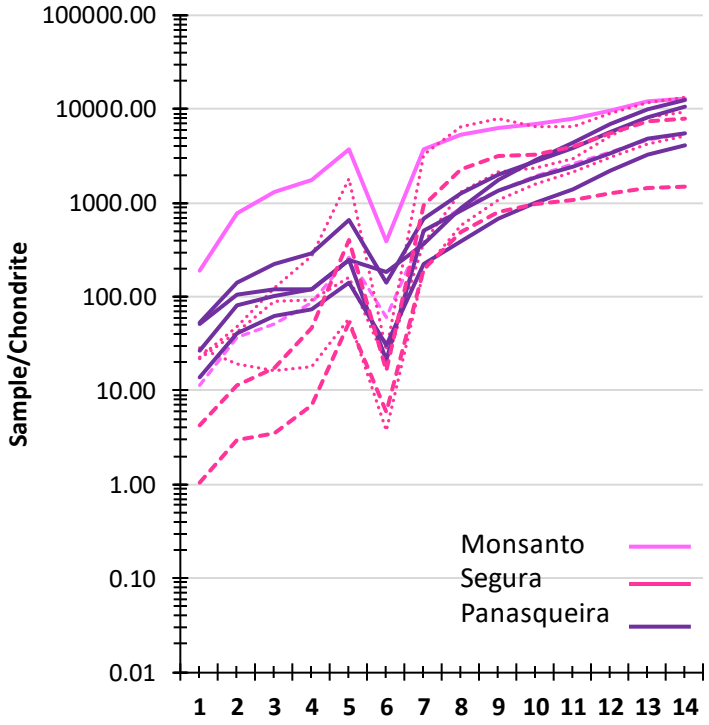
In these cases, zircon grains have complex internal textures in which the secondary domains cut through the primary growth zones…



… showing, in addition, trends towards LREE enrichment along with the fading or elimination of (+) Ce anomalies.



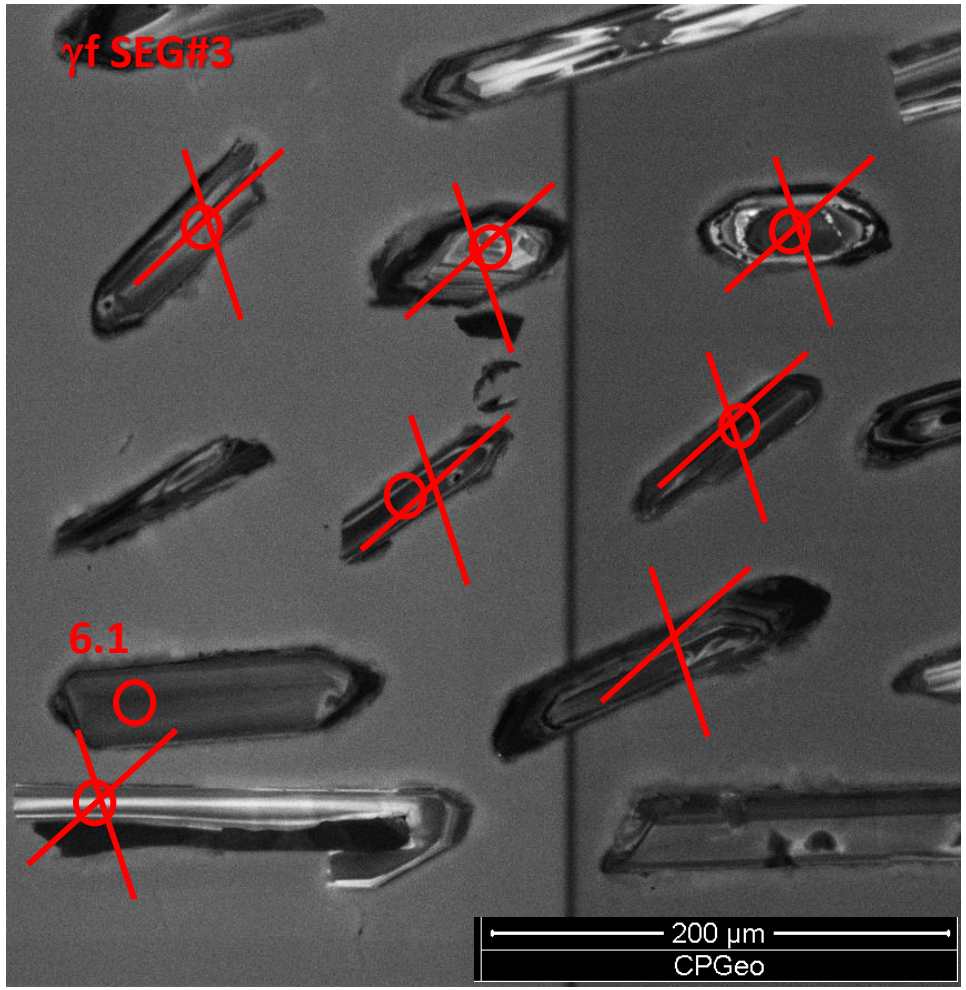


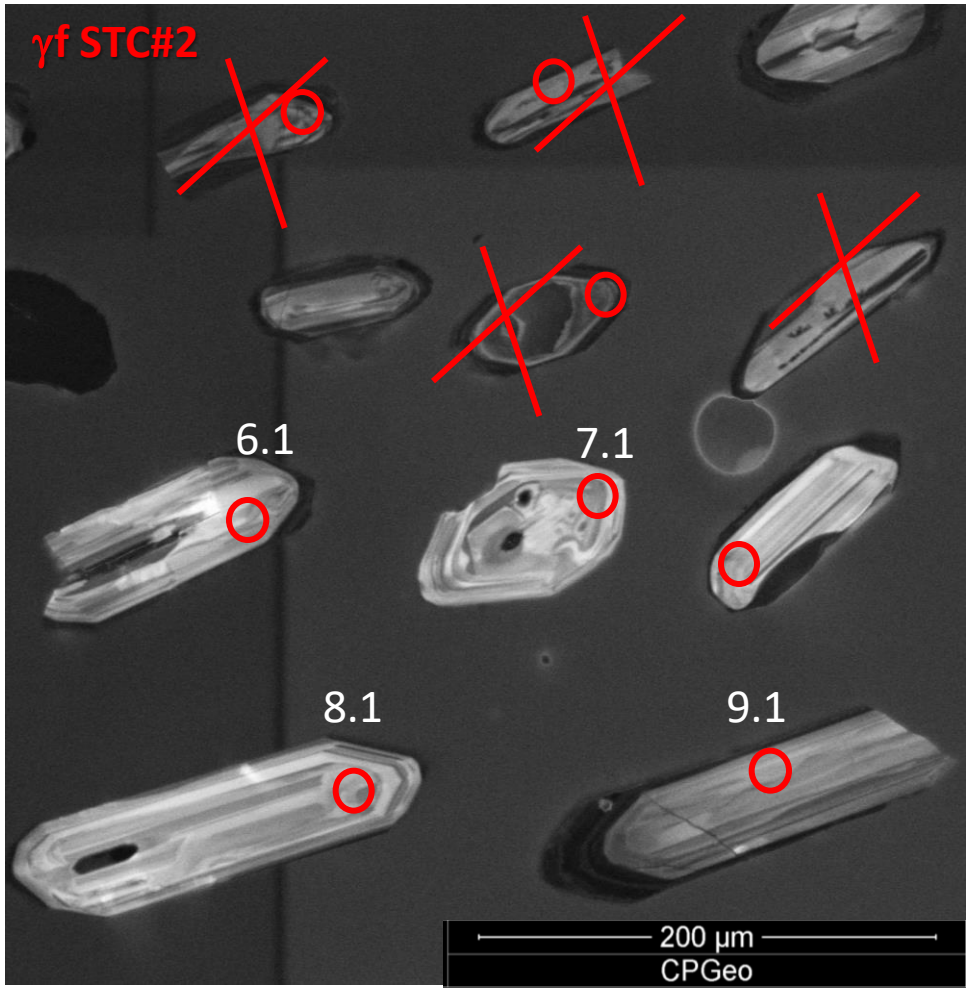


Despite the care put into the analytical work, part of this LREE enrichment might be due to incidental sampling of submicrometric inclusions of, e.g., monazite or apatite.

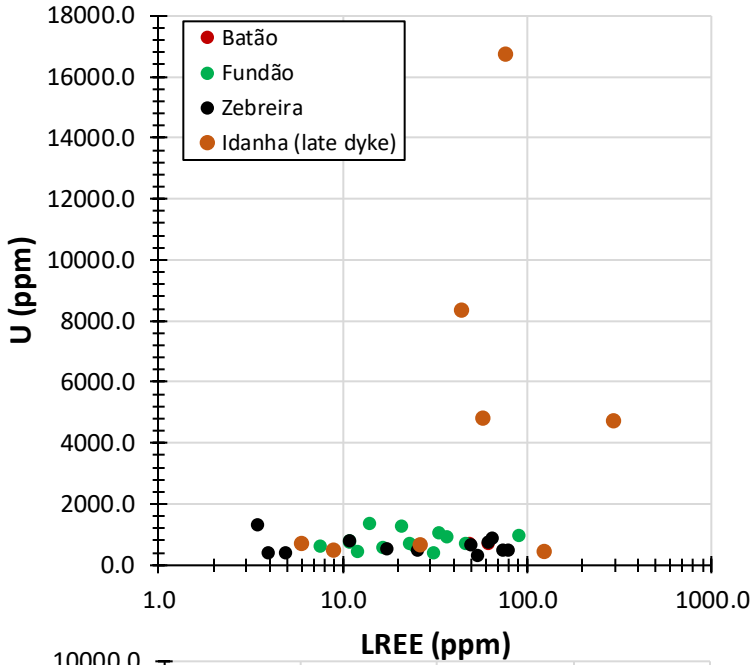
The textural and compositional modifications of these zircon grains are, however, irrefutable.

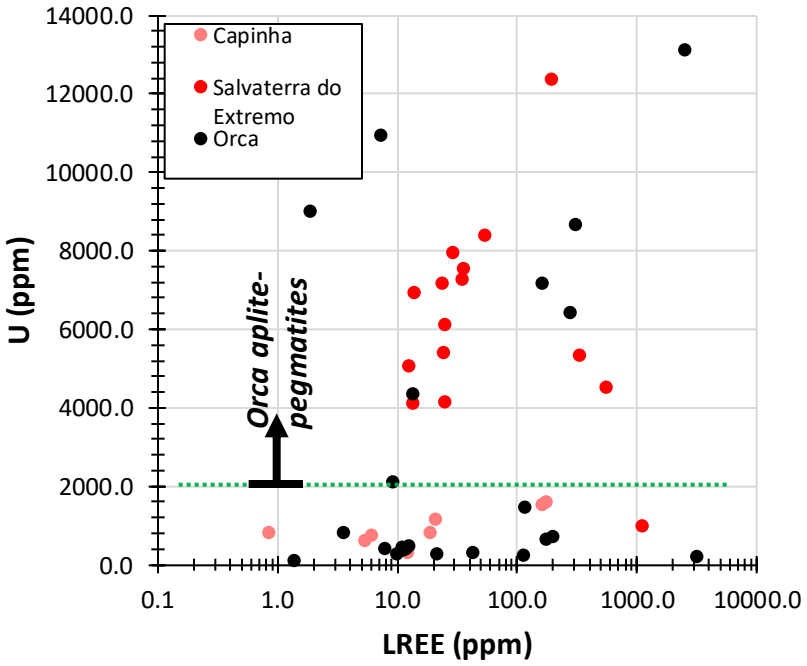
HIGH ^{204}Pb

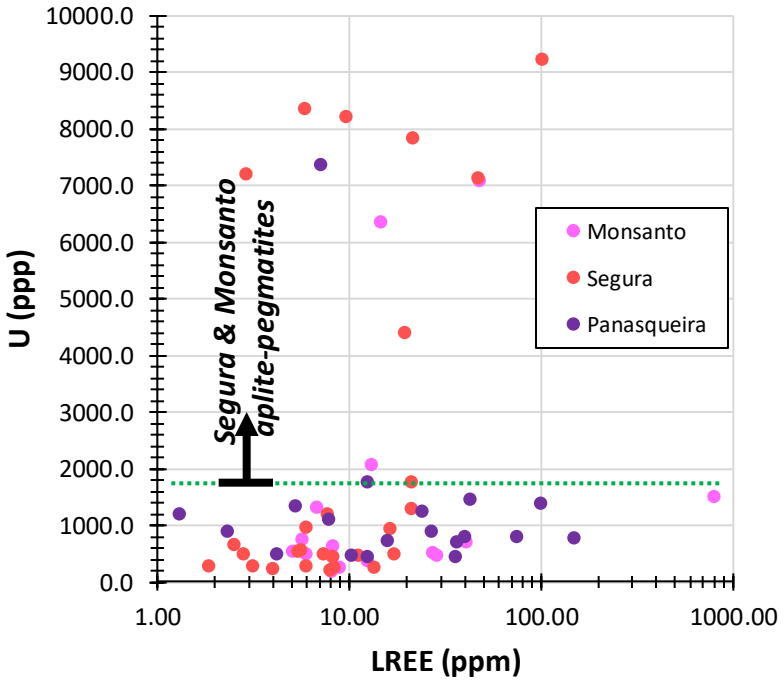


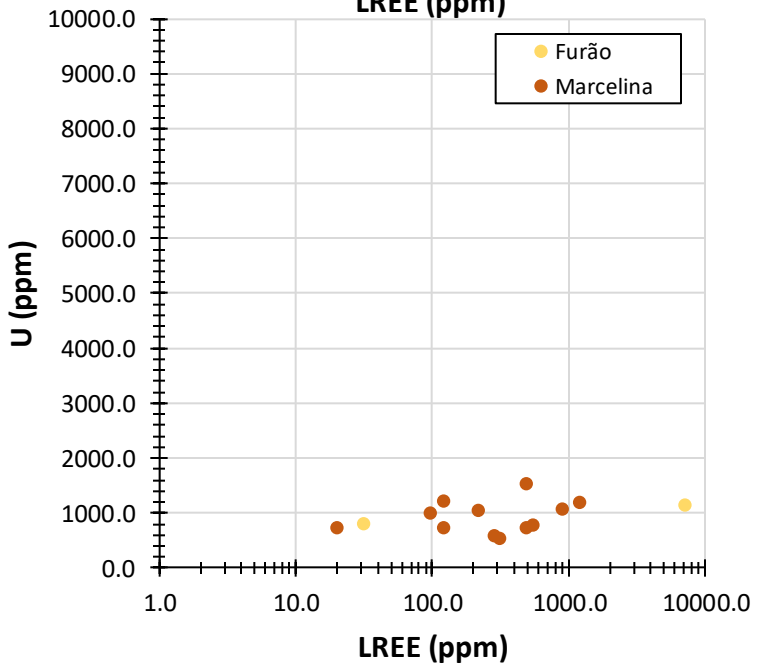


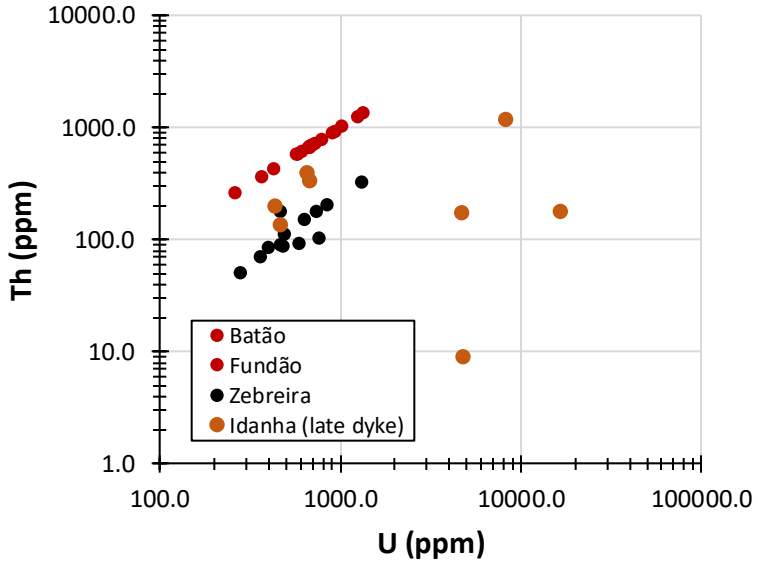
Additional evidence for late compositional transformations recorded by zircon grains in highly differentiated rocks or in facies affected by mineralizing fluids is provided by the high U and ^{204}Pb contents, varying between 500 and 10000 ppm, and often above 1 wt%, respectively.





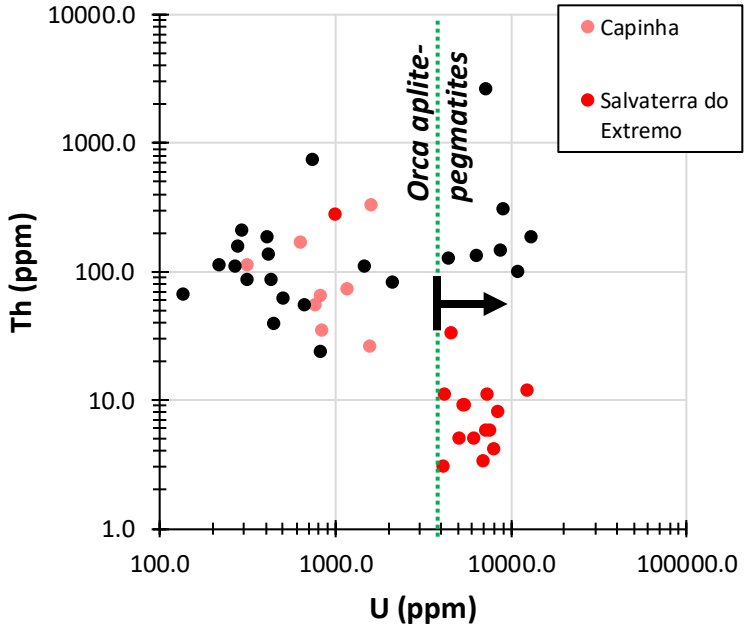


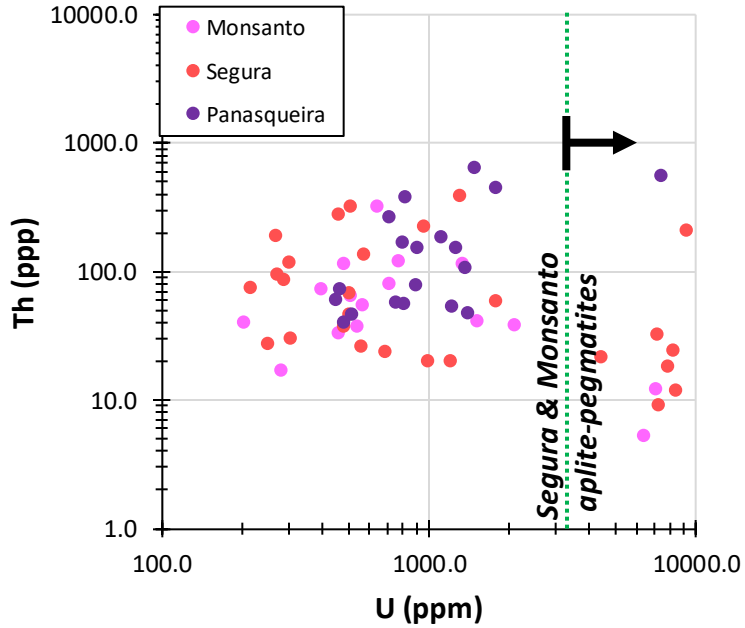


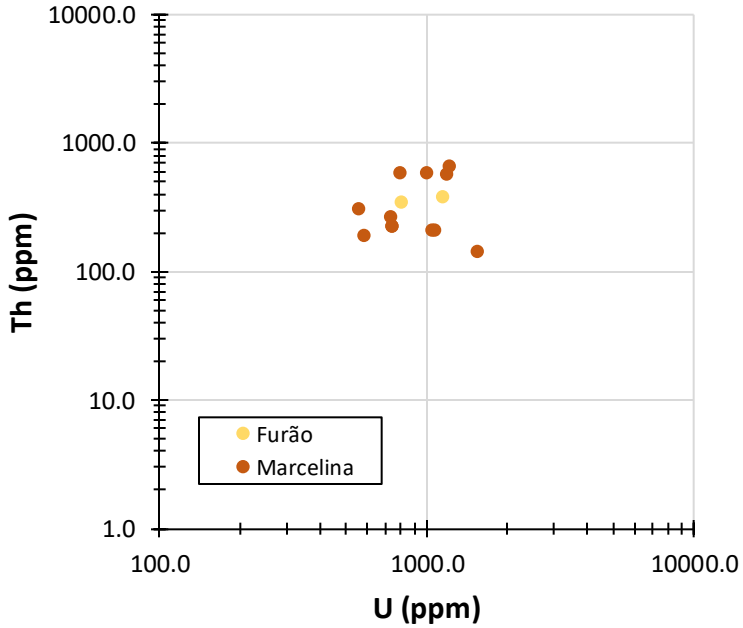


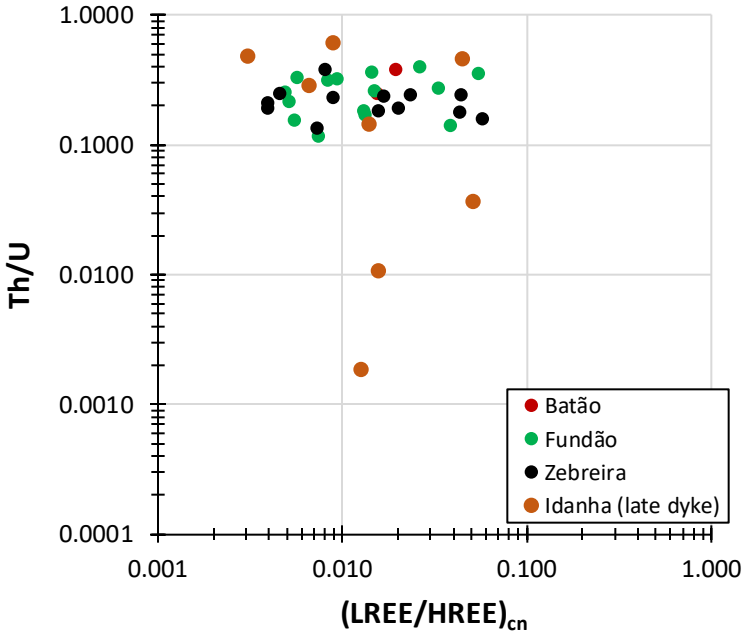
What is the geological meaning of U-enrichment, not always followed by Th?

Zircons from rocks affected by long-term interaction with chemically reactive fluids, possibly exsolved from melts under magmatic-hydrothermal transition conditions





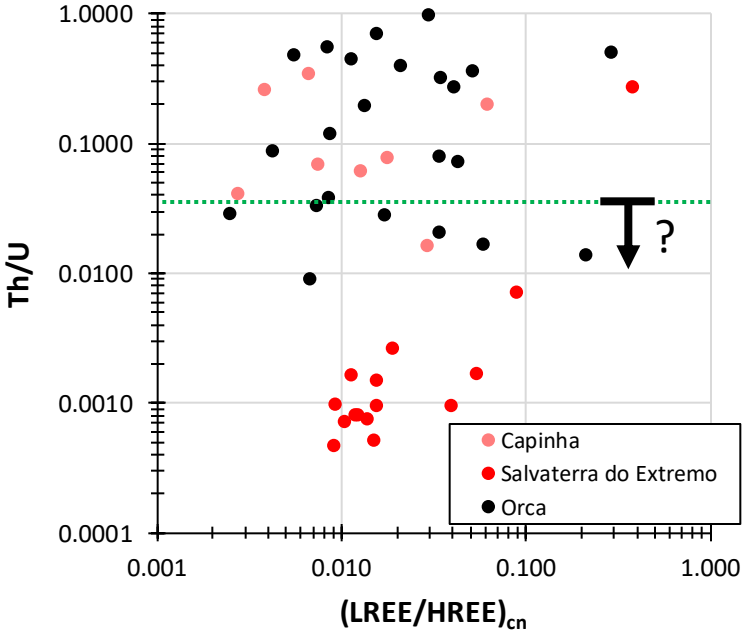


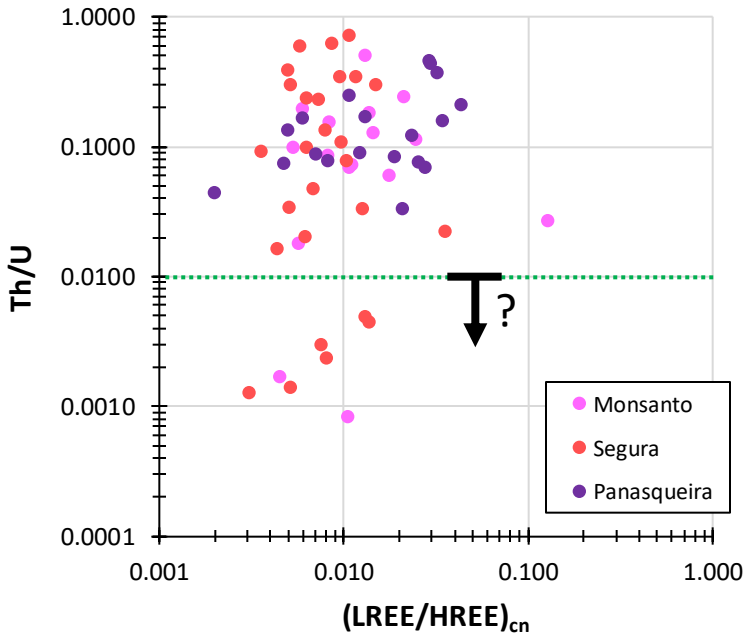


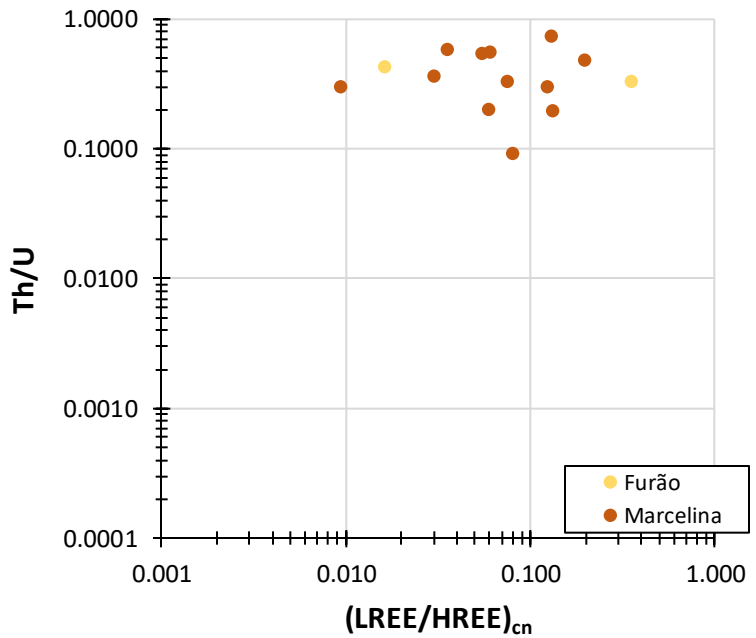
Replacement of Zr by tetravalent cations (Th, U, Hf) is favoured in evolved γs.

Heterogeneous REE incorporation might be related to fluid-mediated dissolution-precipitation reactions under P-T conditions compatible with aplite-pegmatite development (or even late modifying events).

Micro-domains significantly enriched in U (>3000 ppm) and Th (>100 ppm) experience increased levels of radiation damage ⇒ structure damage (metamictisation) ⇒ enhanced susceptibility to late compositional changes.







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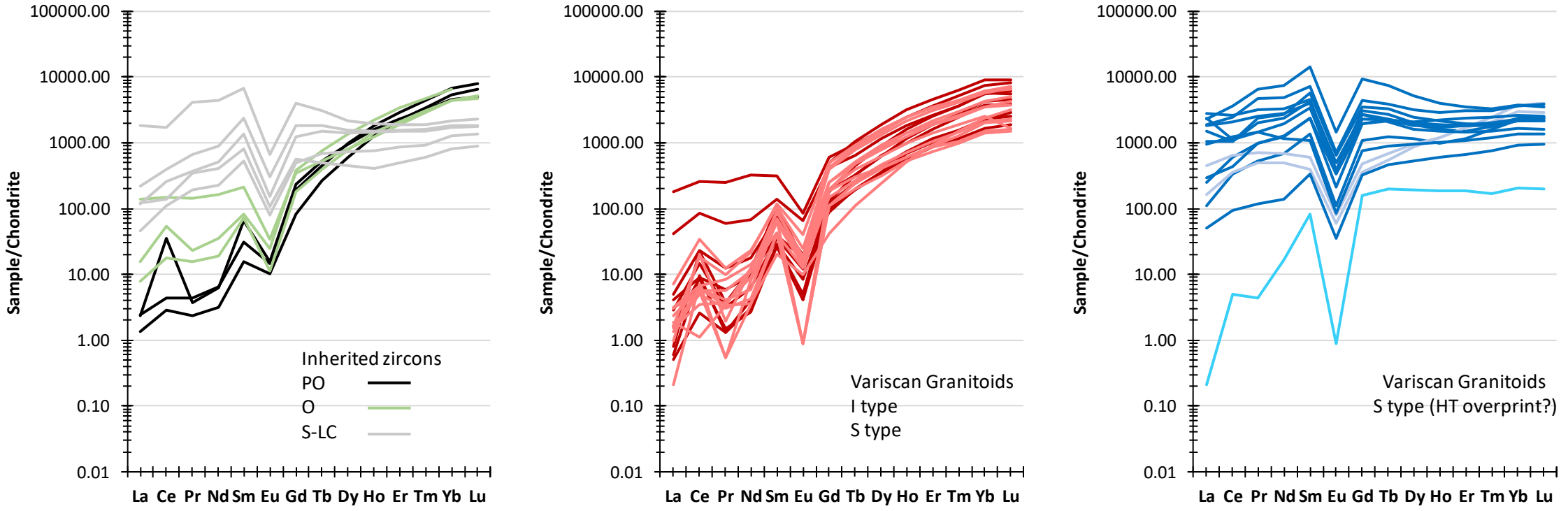

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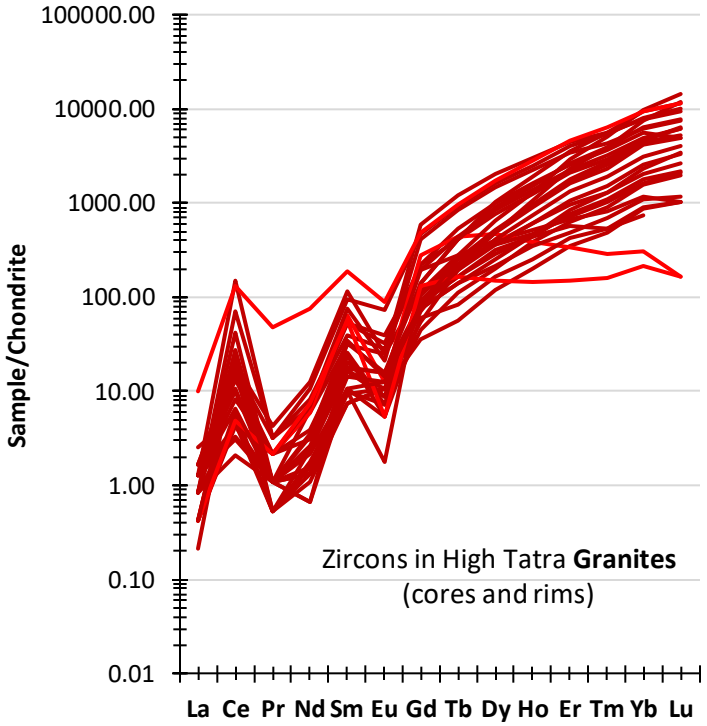

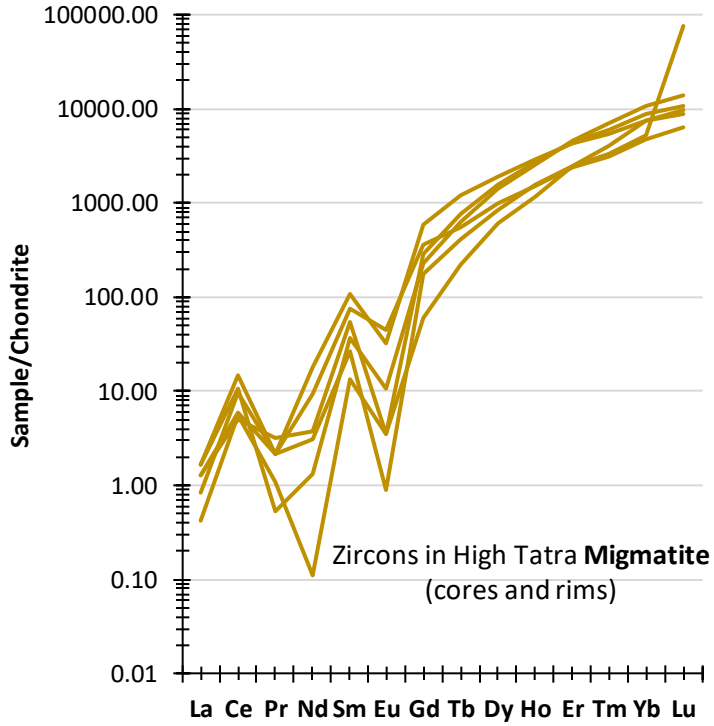

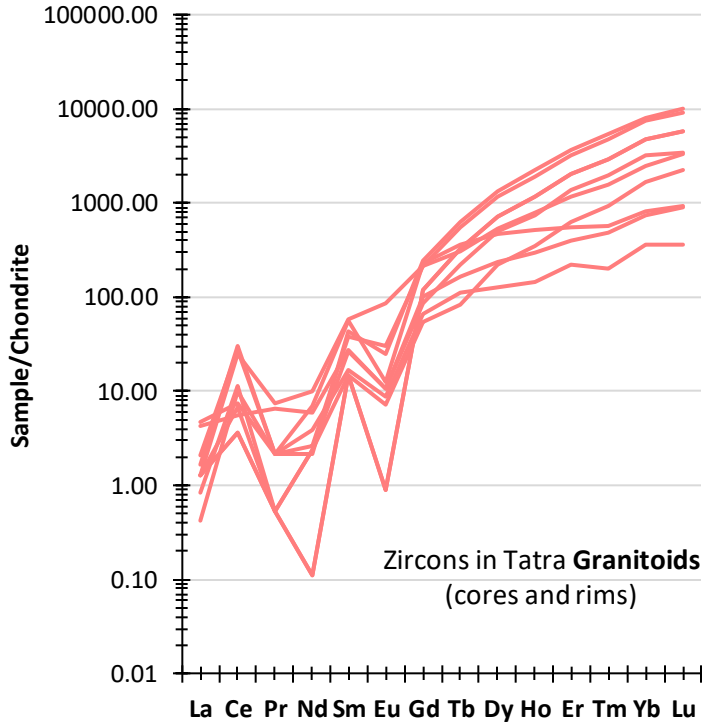

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