Geochemical and mineralogical features of the Beiras Group metasediments; are they relevant to regional metal endowment?

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RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS TO FOSTER CIRCULAR ECONOMY

ERA-MIN Joint Call 2019 (EU Horizon 2020 ERA-NET Co-fund Project ERA-MIN2, Grant agreement Nº 730238)

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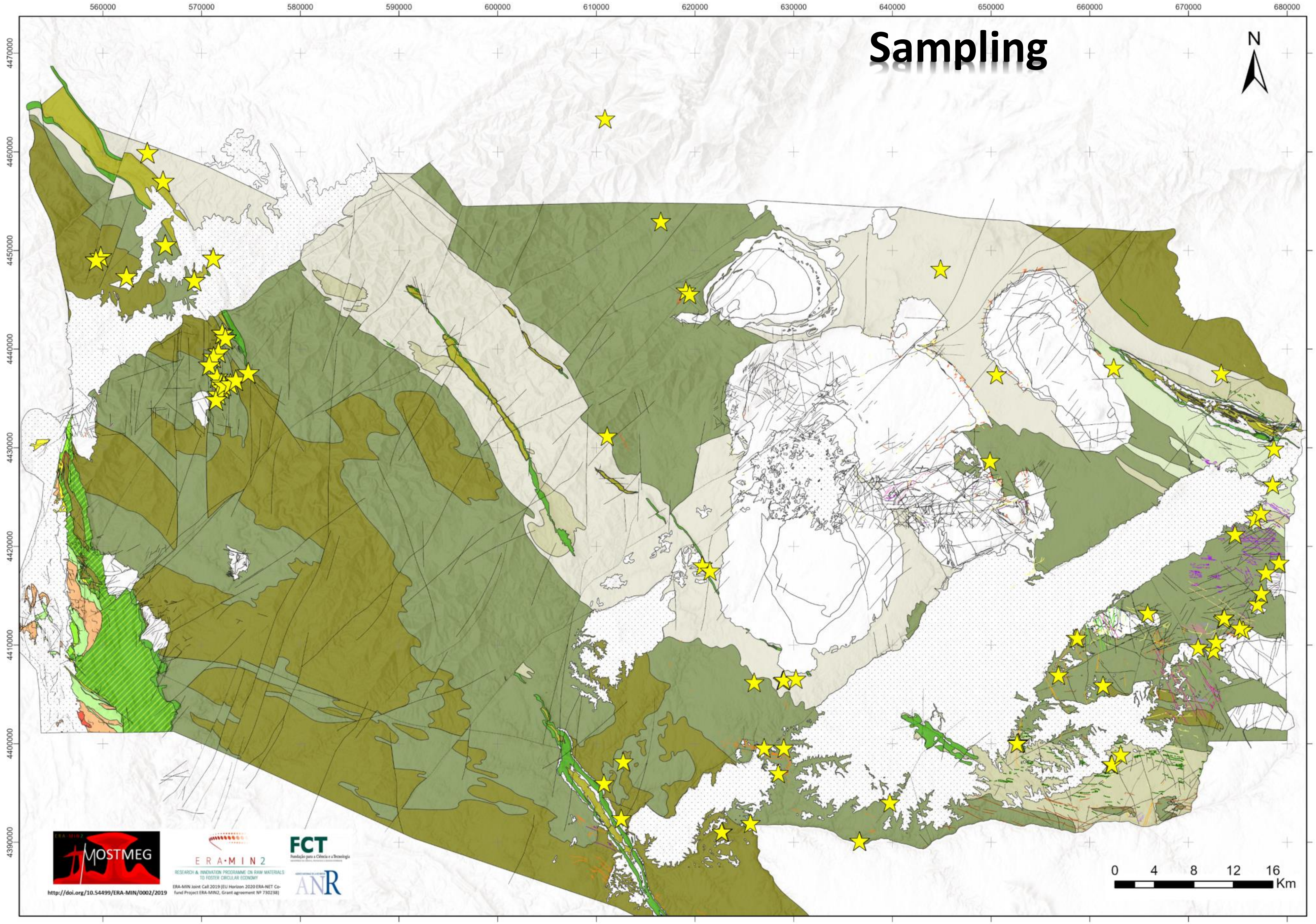
Sampling



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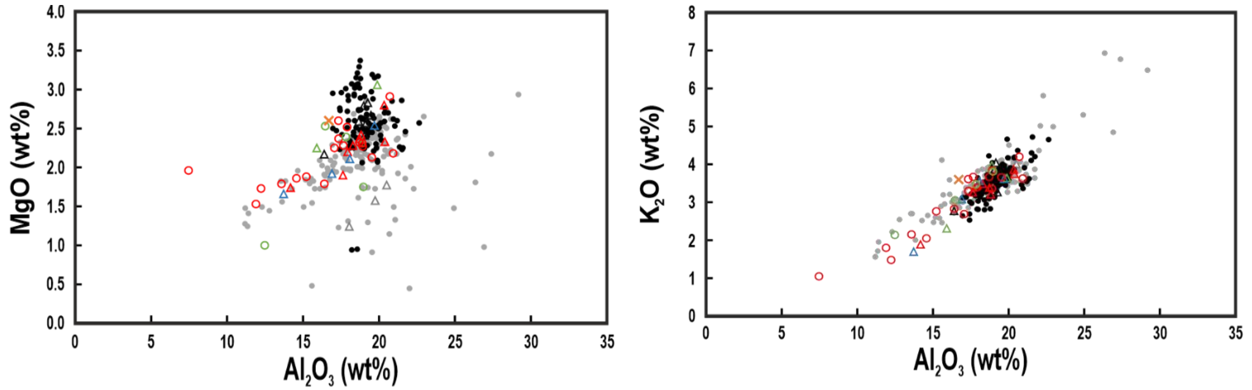
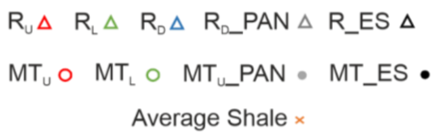
Beiras Group (major elements)

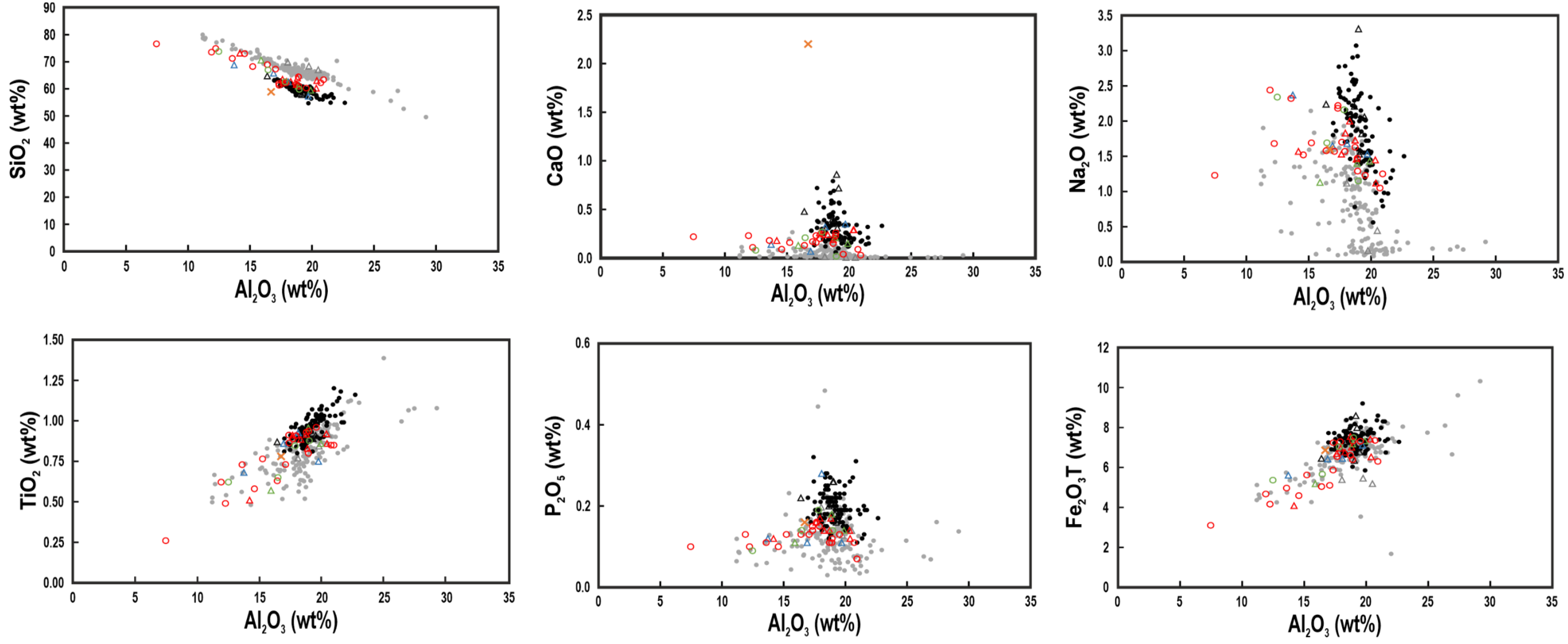
- Complemented with 169 samples collected in the Panasqueira area (Gonçalves et al., 2018);
- Compared with 140 samples described in Spain;



Major mineral assemblage of metapelites:

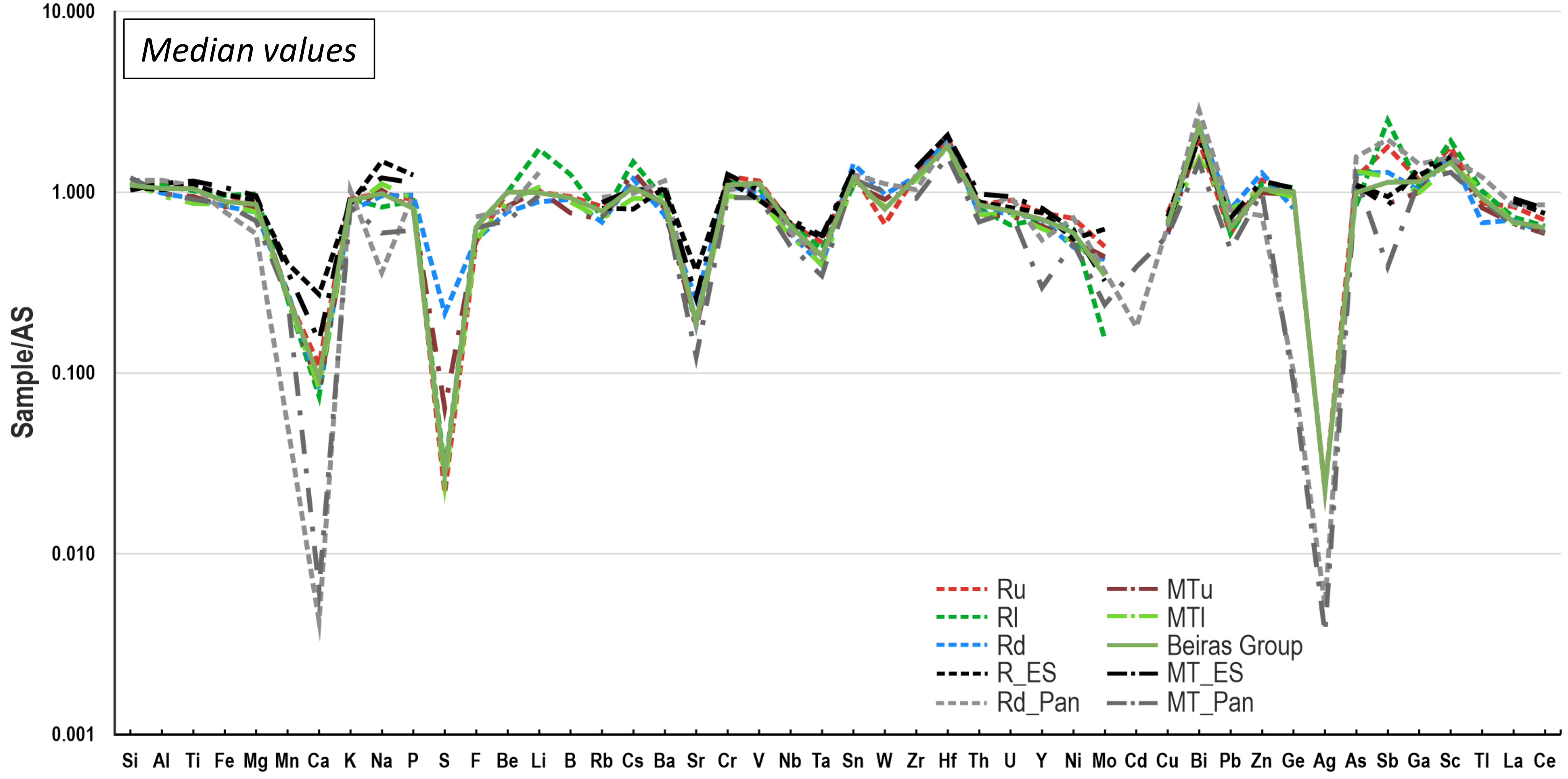
qz + mica (ms > bt) + chlorite





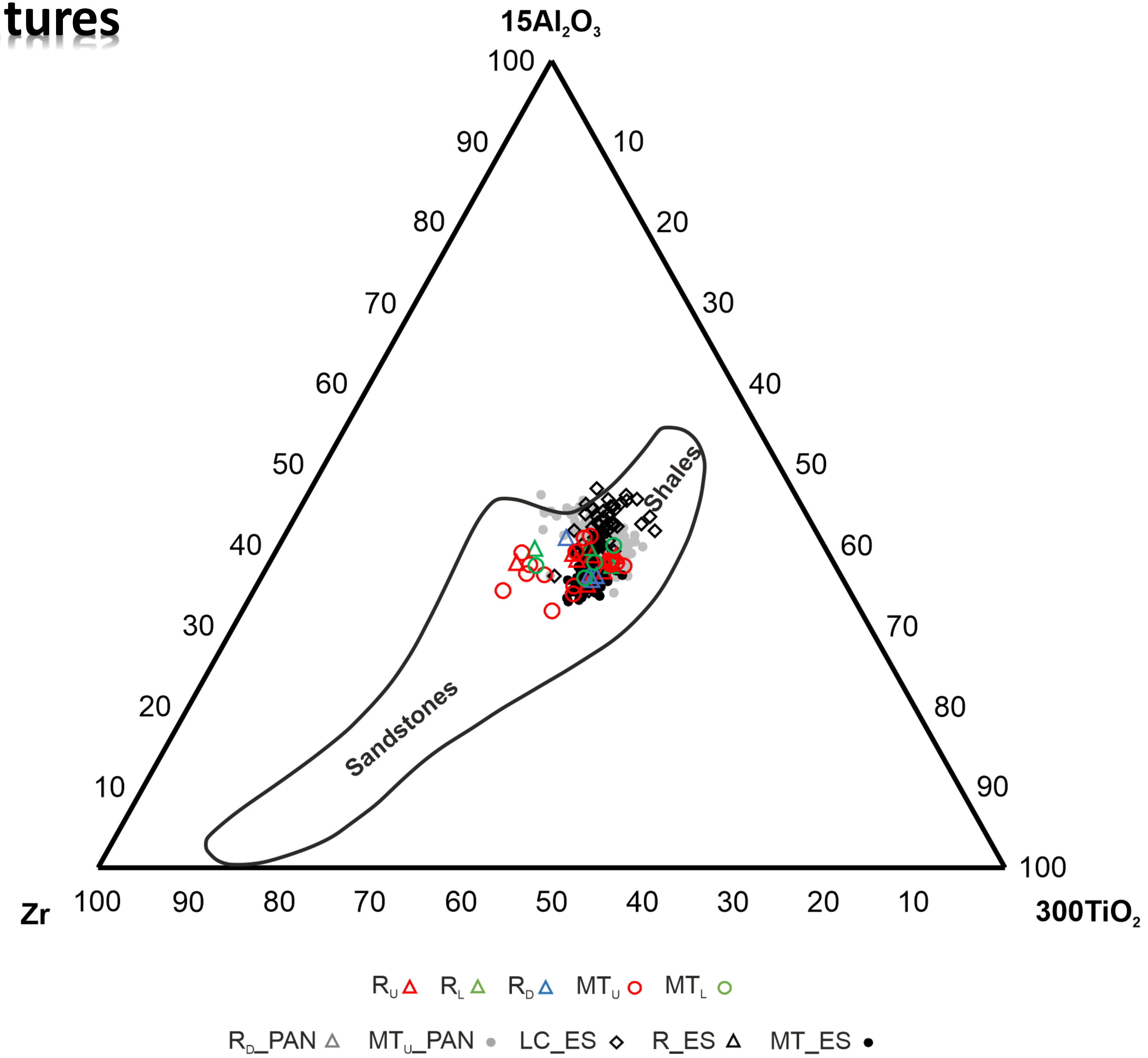
Beiras Group (minor and trace elements)

- Most significant: Ba, F, Zr, V, Rb, Cr, Zn, B, Li, Ce, Sr, Ni, Cu, Y, La, Ga, Sc, Pb, Nb and Th;
- Positive anomalies (up to ca. 3×AS): Li, Cs, Sn, Hf, Bi, As and Sc;
- Negative anomalies: Mg, Mn, Ca, S, F, Sr, Nb, Ta, W, Th, U, Y, Ni, Mo, Cd, Cu, Pb, Ge and Ag



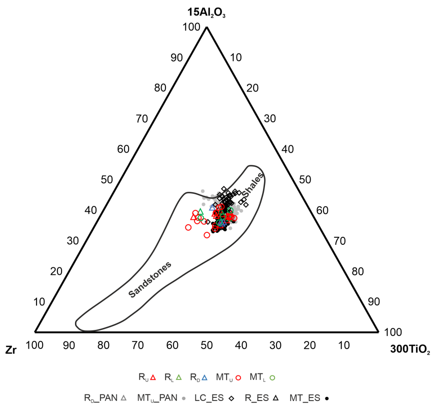
Beiras Group compositional features

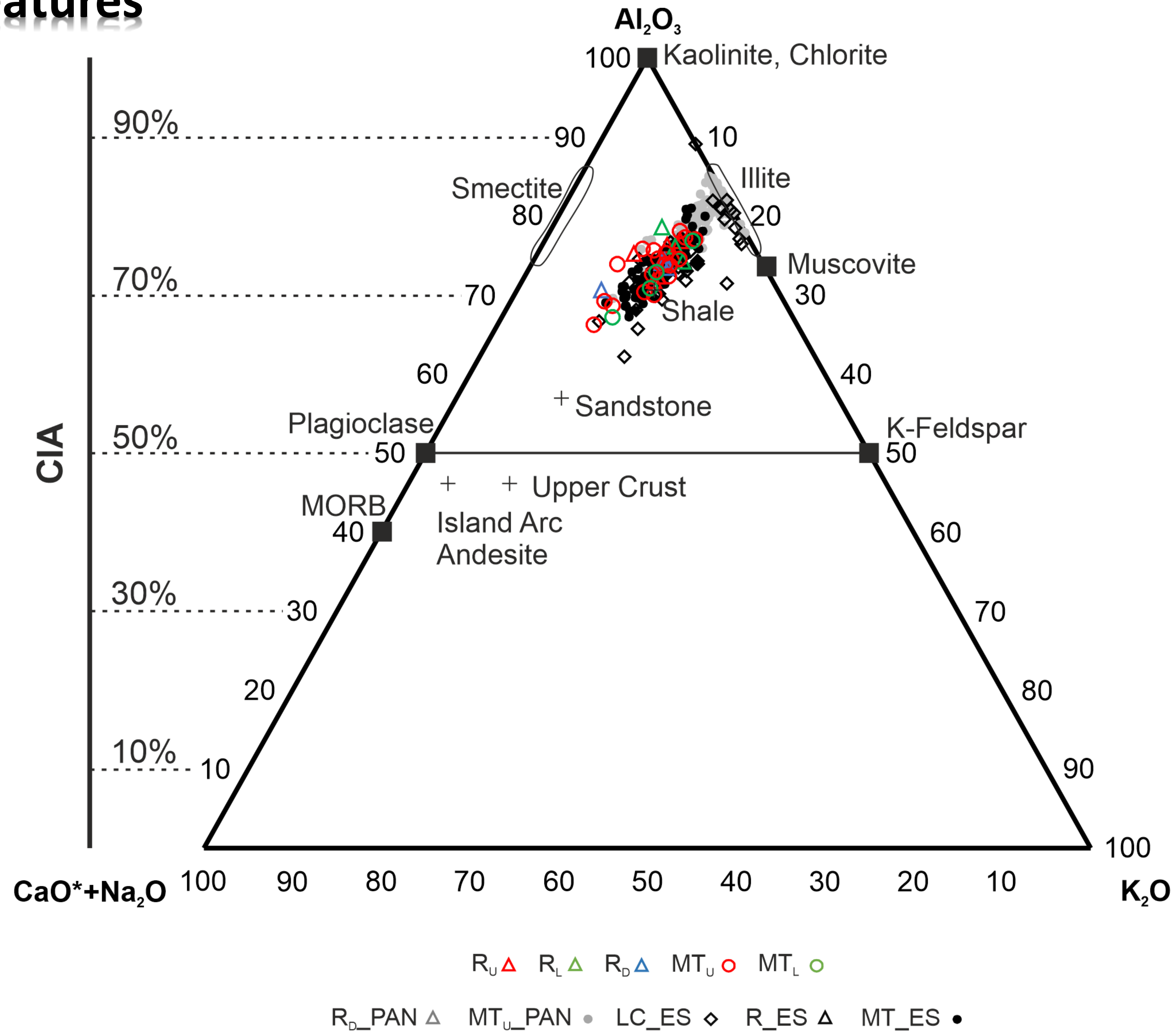
- **High compositional maturity**



Beiras Group compositional features

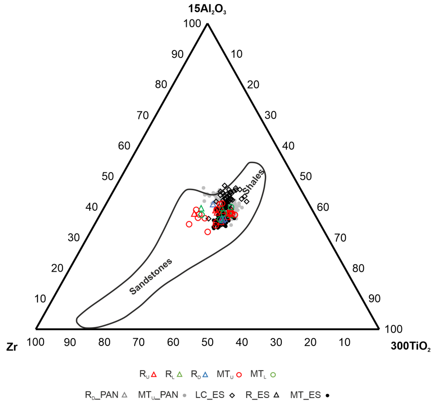
- High compositional maturity
- **Intensely chemical weathered sources (median CIA value 75)**

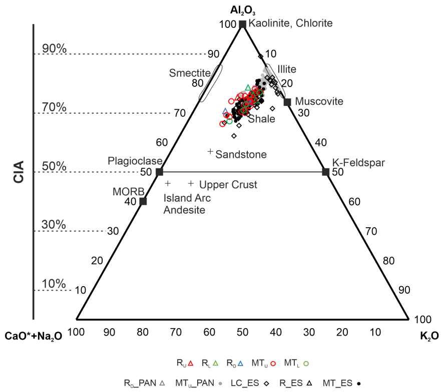


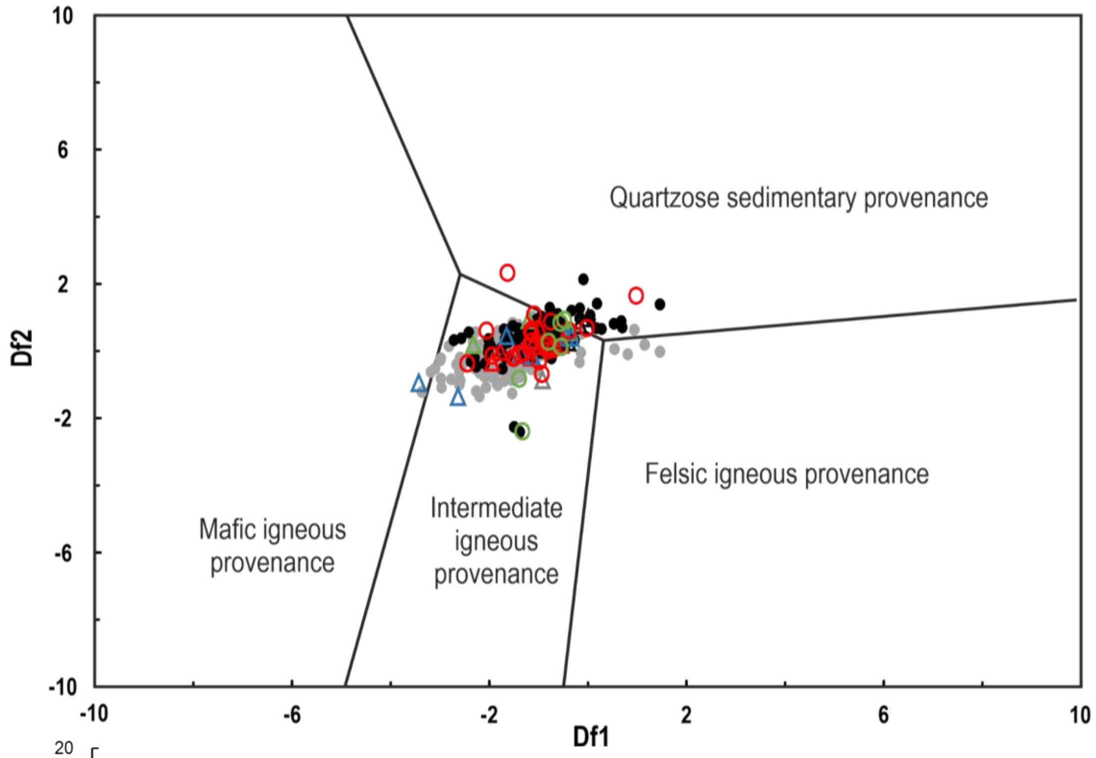


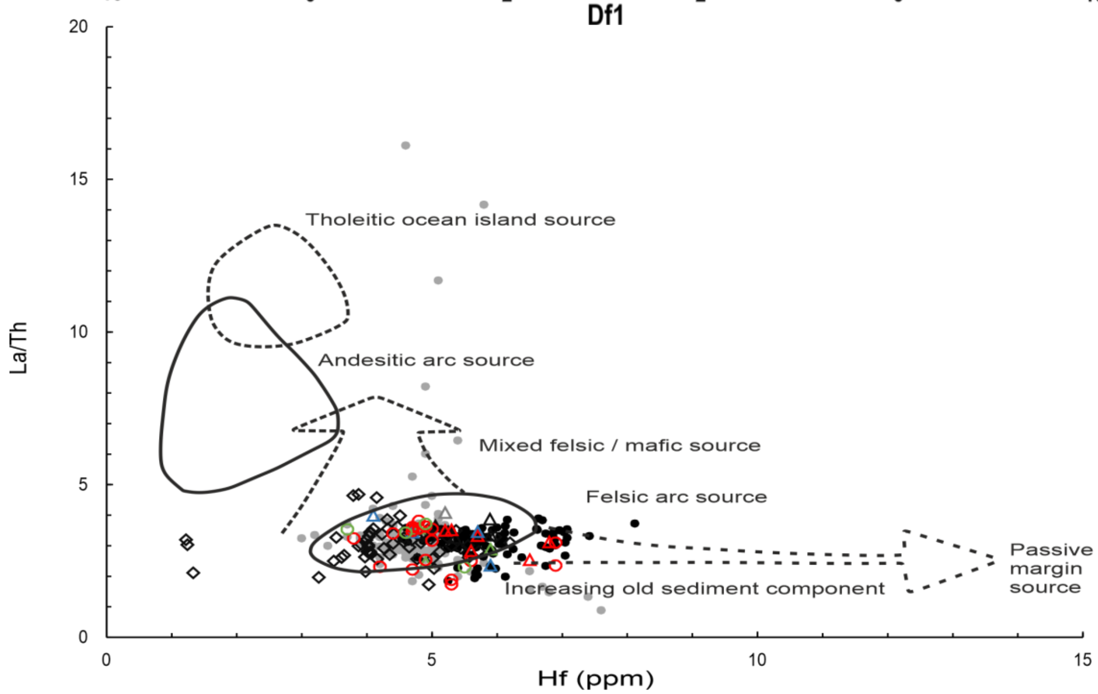
Beiras Group compositional features

- High compositional maturity
- Intensely chemical weathered sources (median CIA value 75)
- **Felsic to intermediate igneous sources**



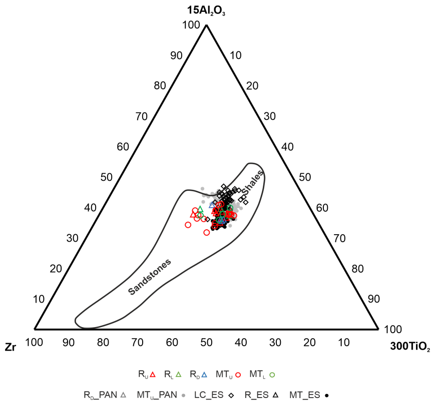


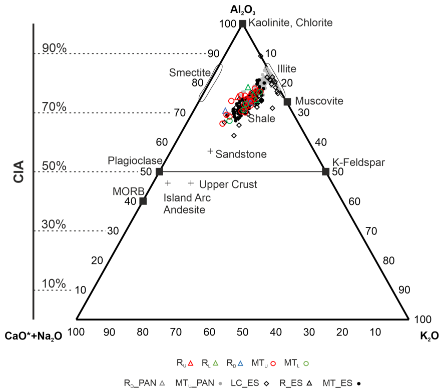


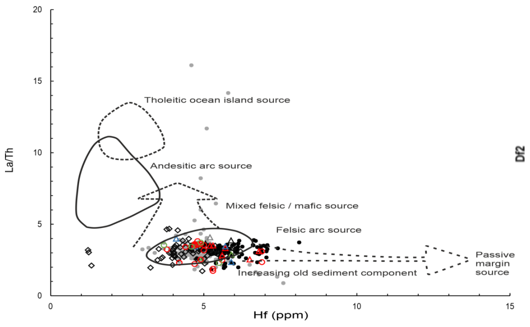


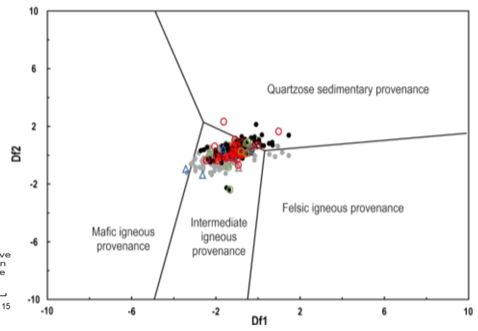
Beiras Group compositional features

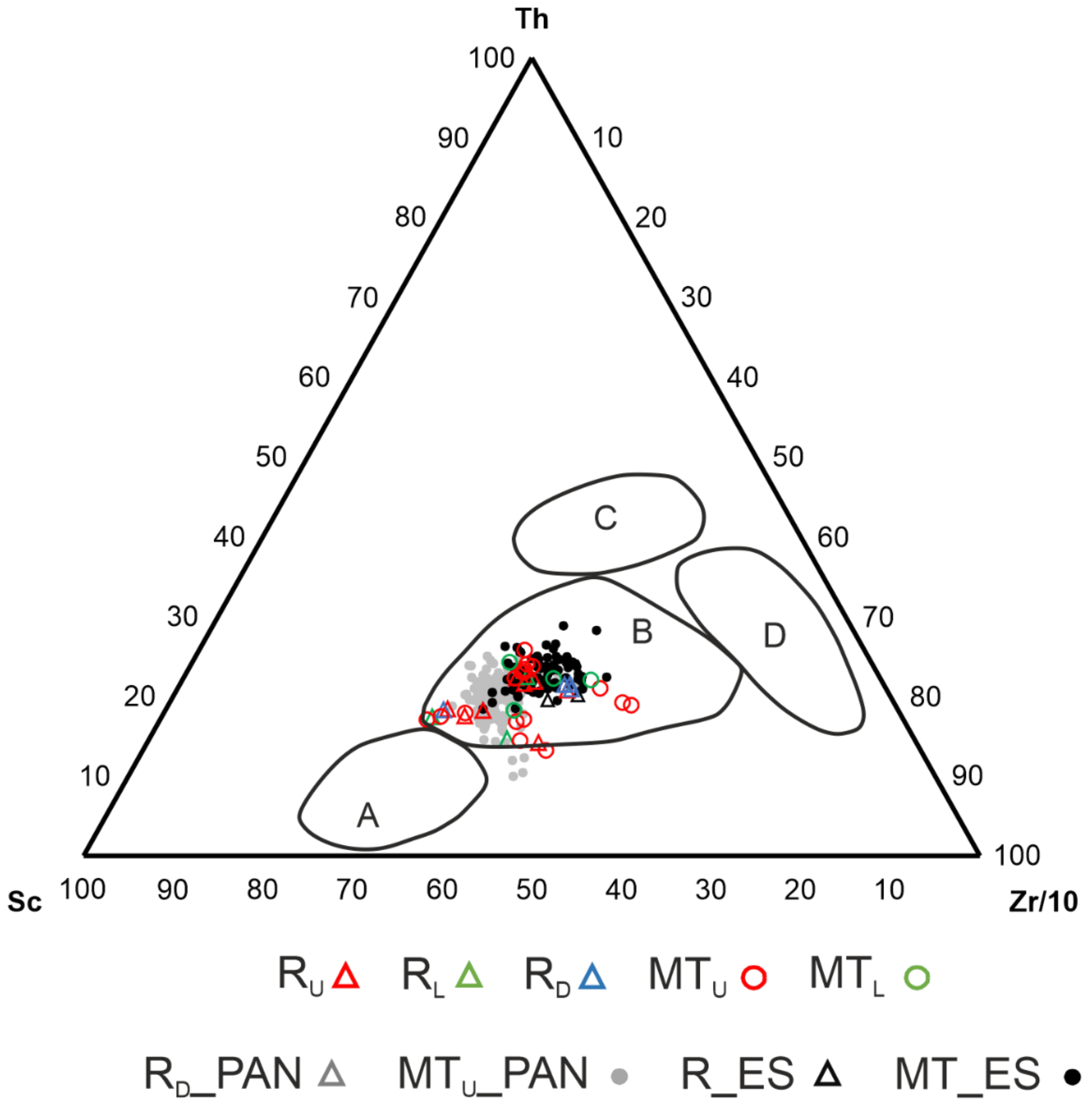
- High compositional maturity
- Intensely chemical weathered sources (median CIA value 75)
- Felsic to intermediate igneous sources
- **Typical composition of continental island arc sediments**





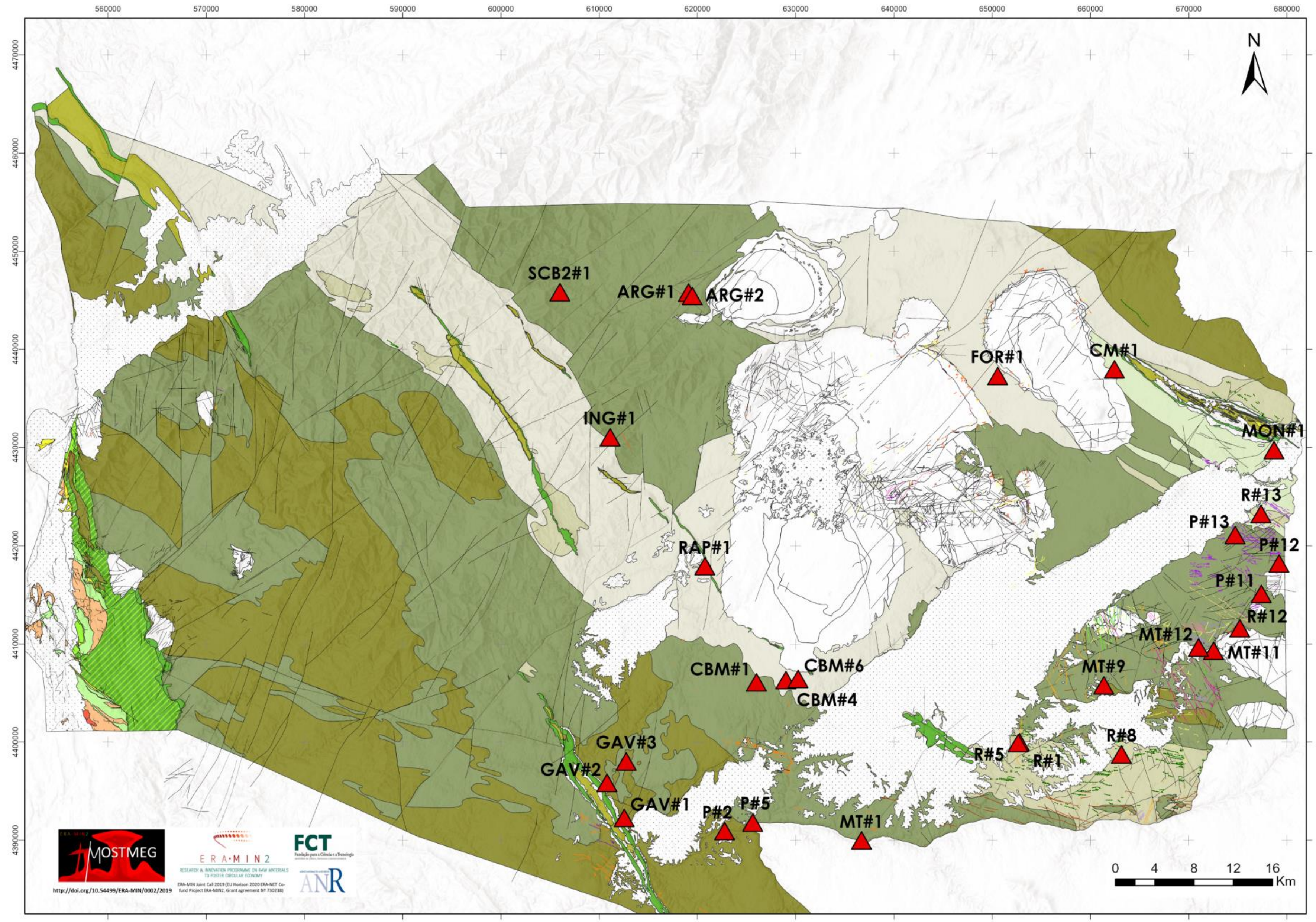






Beiras Group compositional features

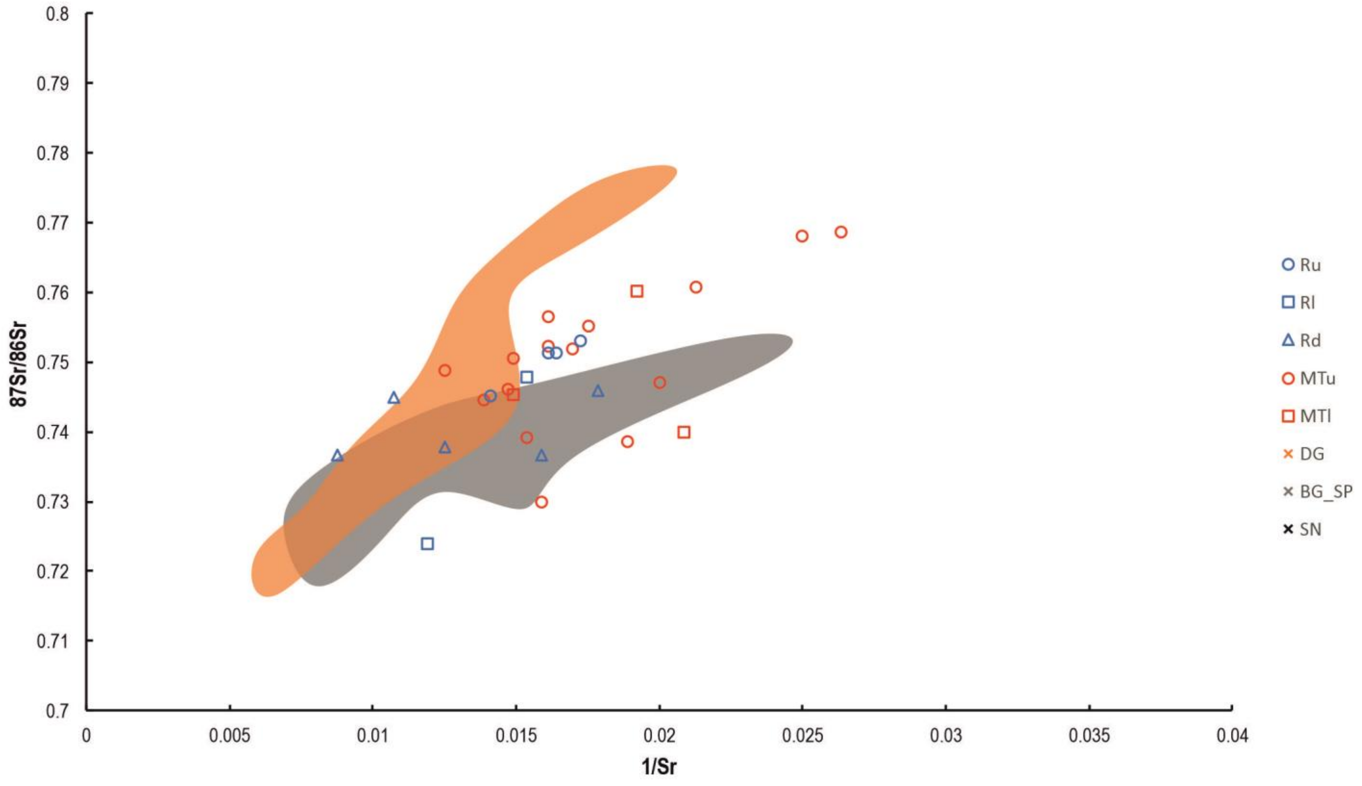
A subset of 30 samples was selected for multi-system (Pb-Sr-Nd) whole rock isotopic analysis



Beiras Group compositional features

Sr systematics

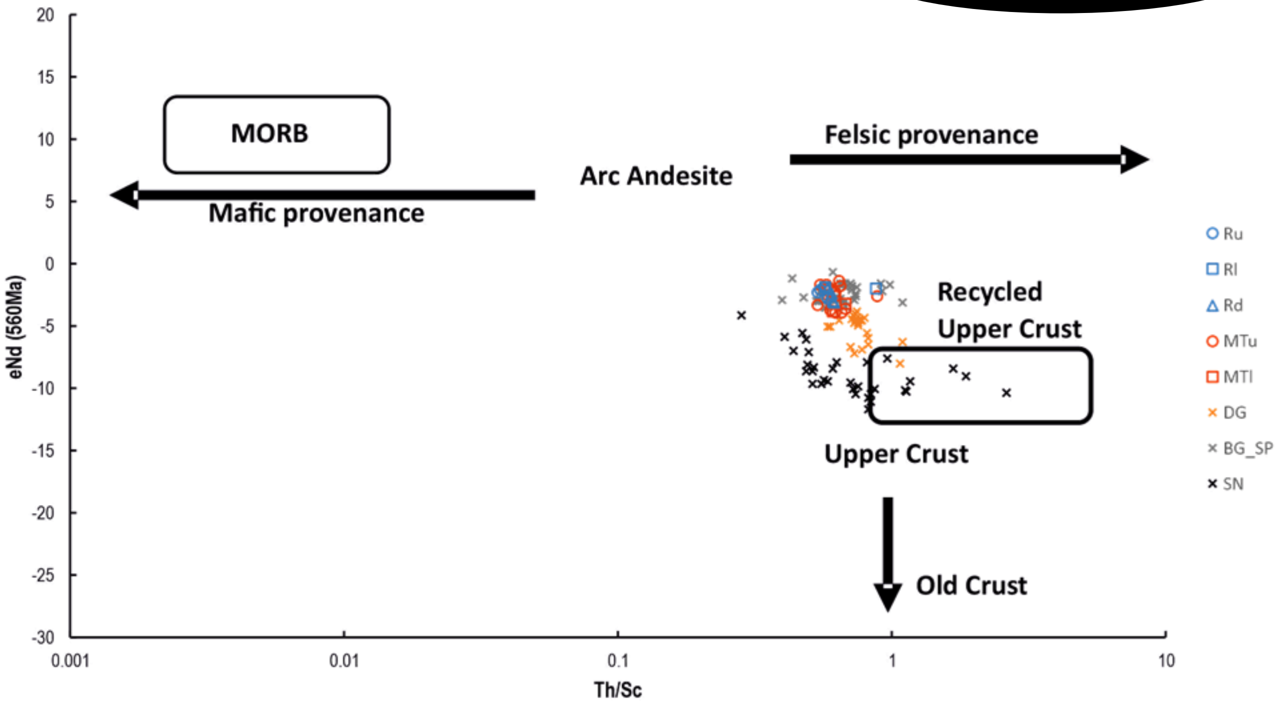
- **Variable Rb and Sr contents**, although similar order of magnitude.
- **Minor Rb/Sr variations**; medians range from:
  - 1.82 (lower member) to 2.07 (upper member) in the Malpica do Tejo *Fm*, and
  - 1.29 (distal and lower member) to 1.96 (upper member) in the Rosmaninhal *Fm*.
- **Median $^{87}Sr/^{86}Sr$ ratios** (0.745- 0.751 Malpica do Tejo *Fm;* 0.736-0.751 Rosmaninhal *Fm)* **comparable to sedimentary successions in Spain** (e.g., Villaseca et al., 2014).
- **Median $(^{87}Sr/^{86}Sr)_{560\ Ma}$ values: 0.703 Malpica do Tejo *Fm*; 0.706 to 0.711 Rosmaninhal *Fm*.**
- **Arguable provenance constraints** (Rb/Sr >> 1); post-depositional changes able to affect the concentration of relatively mobile elements.

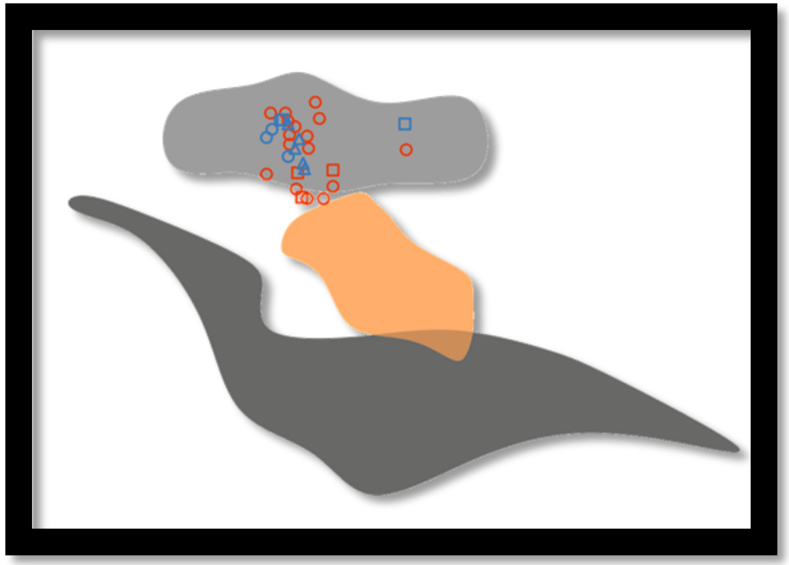


Beiras Group compositional features

Nd systematics

- **Similar range of Sm and Nd** for the different members of Malpica do Tejo and Rosmaninhal *Fms*: from ca. 4 to 9 ppm and 20 to 42 ppm, respectively.
- **Narrow variations of Sm/Nd** (0.20 – 0.22); median ca. 0.20.
- **Median values of εNd** range from:
  - -8.654 (lower member) to -7.440 (upper member) in Malpica do Tejo *Fm*;
  - -7.292 (lower member) to -7.582 (upper member) in the Rosmaninhal *Fm*, -7.943 for distal member.
- **Median $\varepsilon Nd_{560\ Ma}$:** -3.321 and -2.458 for lower and upper members of Malpica do Tejo *Fm; -* 1.977 and -2.277 for lower and upper members of Rosmaninhal Fm; -2.689 for distal member of the latter *Fm*. **Consistent with data reported in other studies** (Pereira et al., 2012; Villaseca et al. 2014)



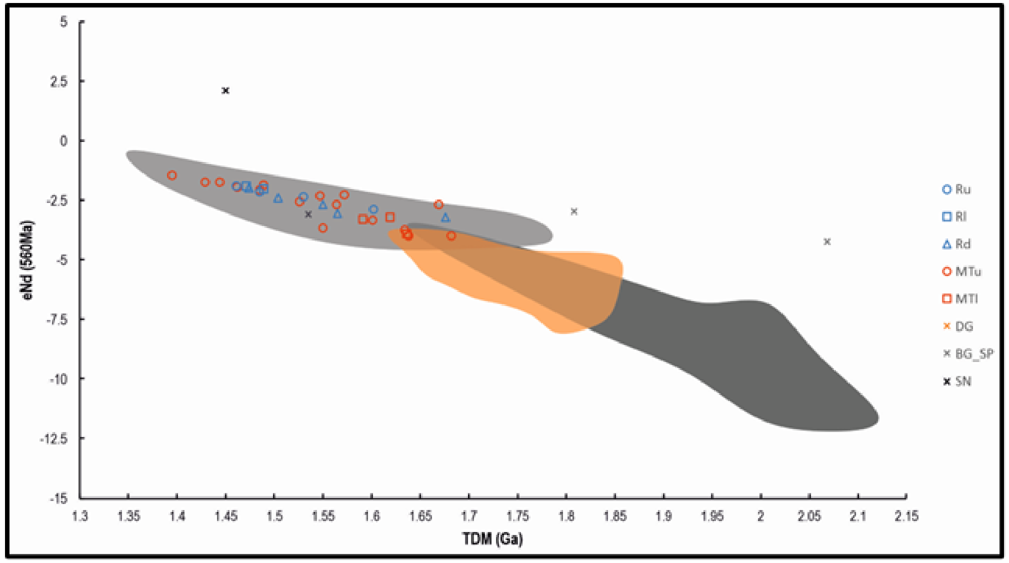


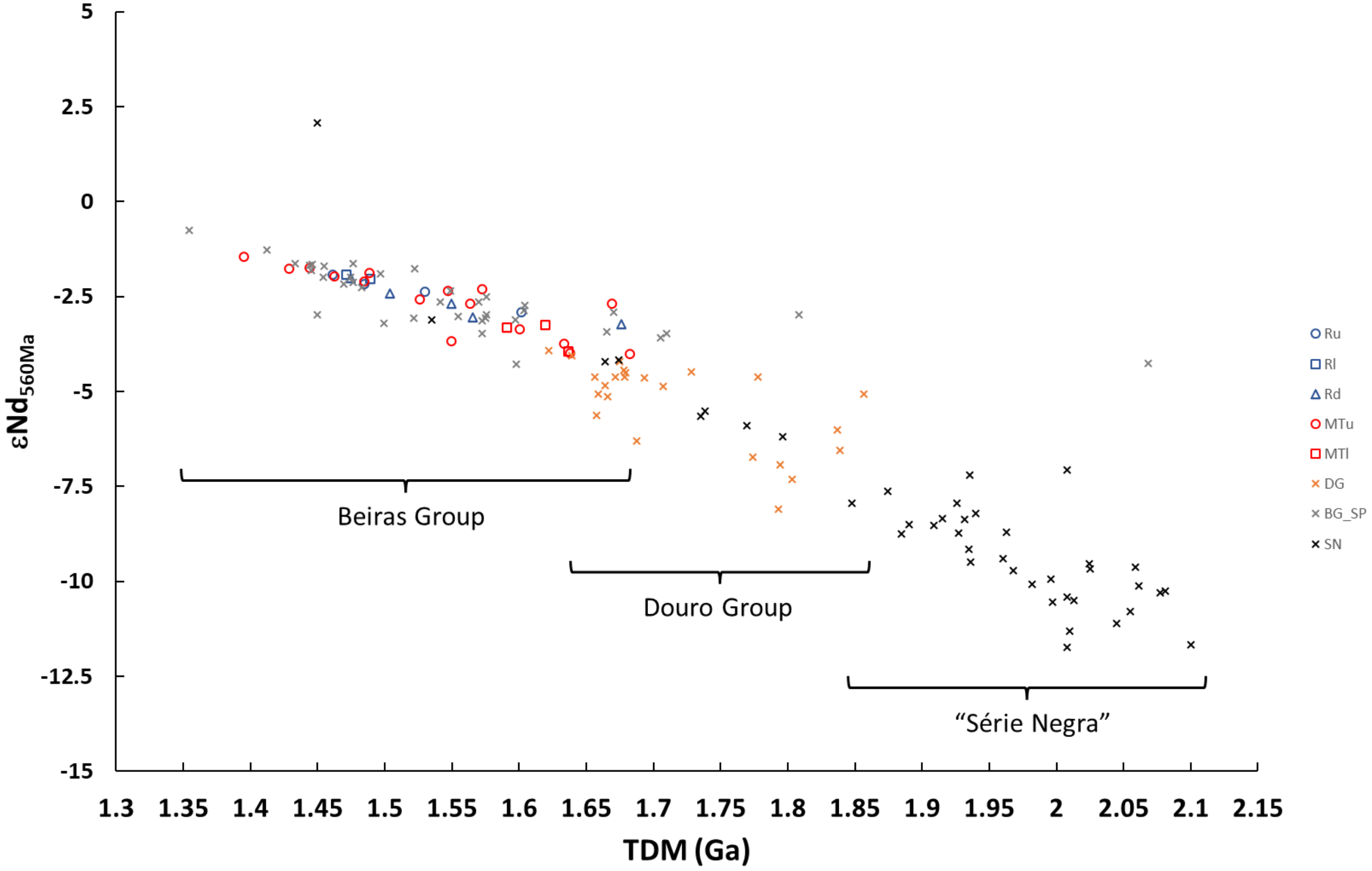
Beiras Group compositional features

Nd systematics

- **TDM model ages range from 1.40 to 1.68 Ga**. Median values are:
  - 1.62 and 1.55 Ga for lower and upper members of the Malpica do Tejo Fm;
  - 1.48, 1.51 and 1.55 Ga for the lower, upper, and distal members of the Rosmaninhal Fm.

- **Overlap the upper limit of the range reported for metapelites forming equivalent units in Spain** (1.20 to 1.56 Ga, mean of 1.38 Ga; Villaseca et al., 2014)





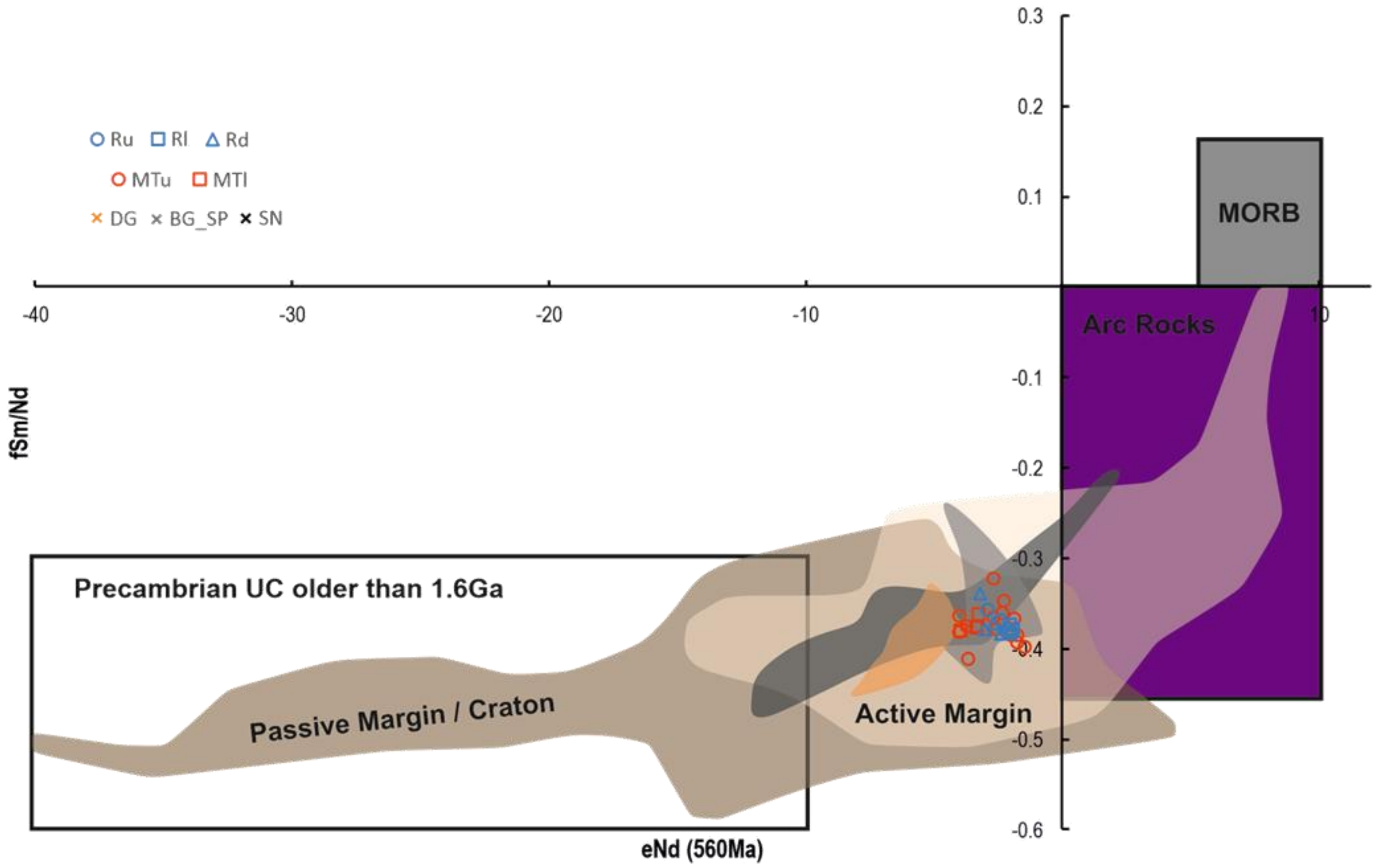
Beiras Group compositional features

Nd systematics

- Considering the bulk Sm-Nd isotopic data, Malpica do Tejo and Rosmaninhal *Fms* were **supplied by erosion of crustal rocks, including a noteworthy contribution of felsic (arc-derived) igneous sources**.

- These **igneous sources, younger than 1.2 Ga** if the wide range of TDM model ages is considered, may be related to juvenile magmas (e.g., Tassinari et al., 1996) and should document the **dismantling of a Cadomian arc** located to the south (present coordinates)

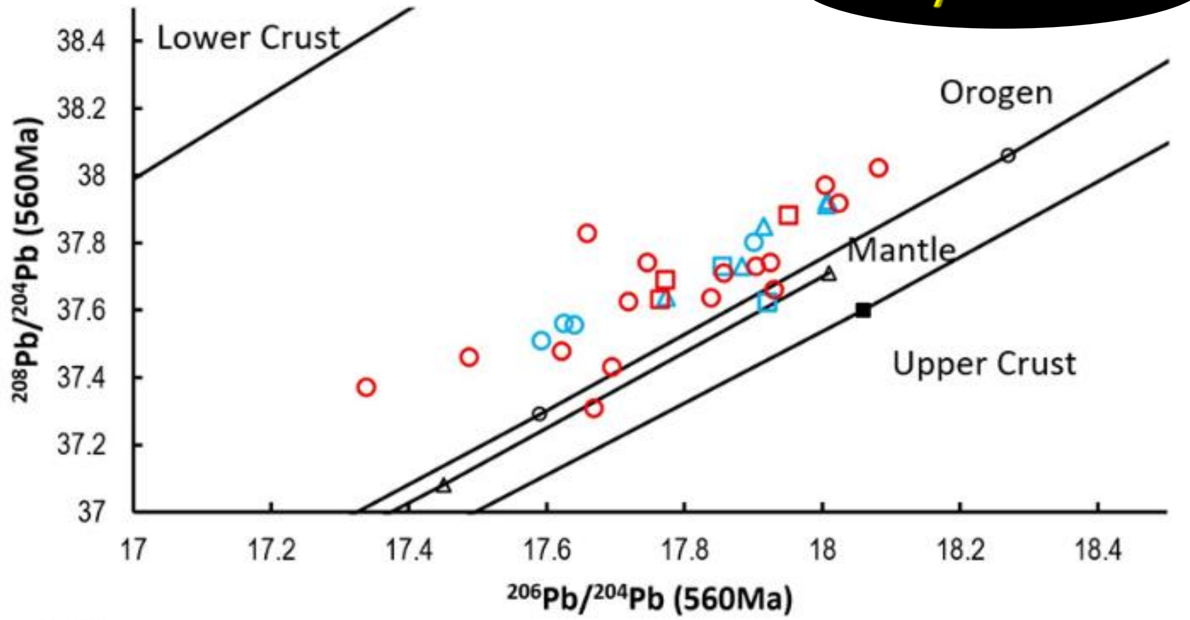
- The **contribution of felsic (arc-derived) igneous sources is relevant to the metal endowment** potentially provided by metasediments when subject to partial melting or intense hydrothermal leaching.

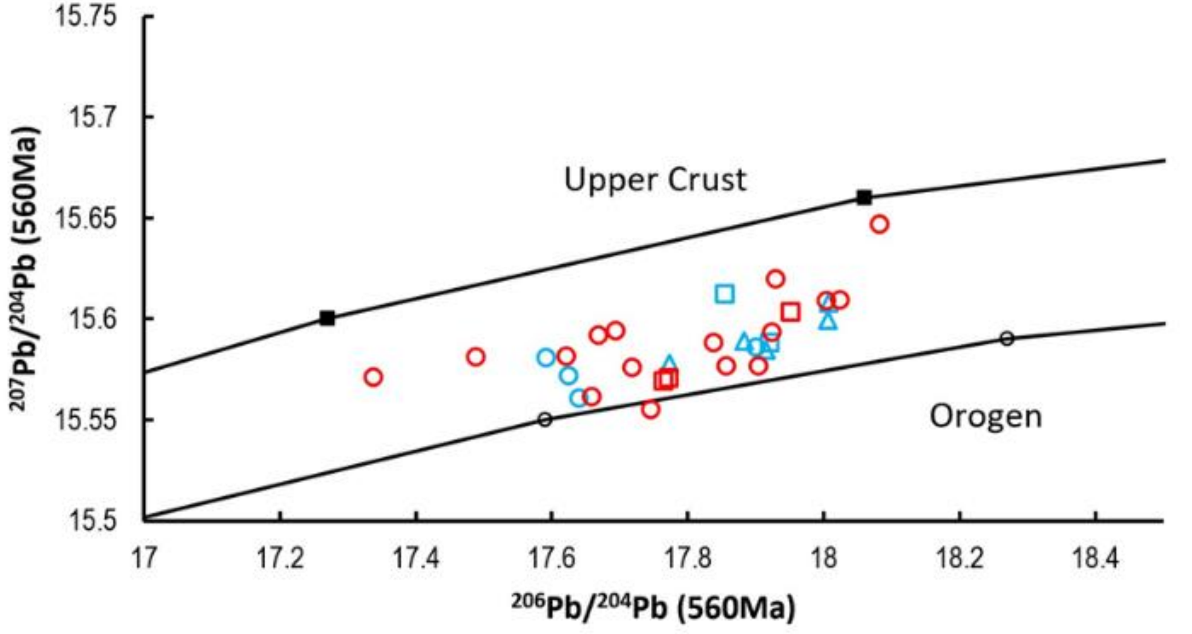


Beiras Group compositional features

Pb systematics

- **Similar U and Th contents** for all the members of Malpica do Tejo and Rosmaninhal *Fms* ⇒ median U/Th ratios:
  - 0.32 and 0.31 for lower and upper members of Malpica do Tejo *Fm*.
  - 0.30, 0.33 and 0.32 for the lower, upper and distal members of the Rosmaninhal Fm.
- **Pb contents more variable** with median values of:
  - 17.8 and 14.1 ppm for lower and upper members of Malpica do Tejo Fm.
  - 13.7, 14.2 and 20.2 ppm for lower, upper and distal members of the Rosmaninhal Fm
- **Isotopic Pb-Pb ratios show minor differences**.
- **Pb sources fall within the range of crustal, orogen protoliths**; signs of a mantle-derived component in some samples from the Malpica do Tejo Fm.
- **Pb isotopes consistent with info provided by Sm-Nd systematics**.





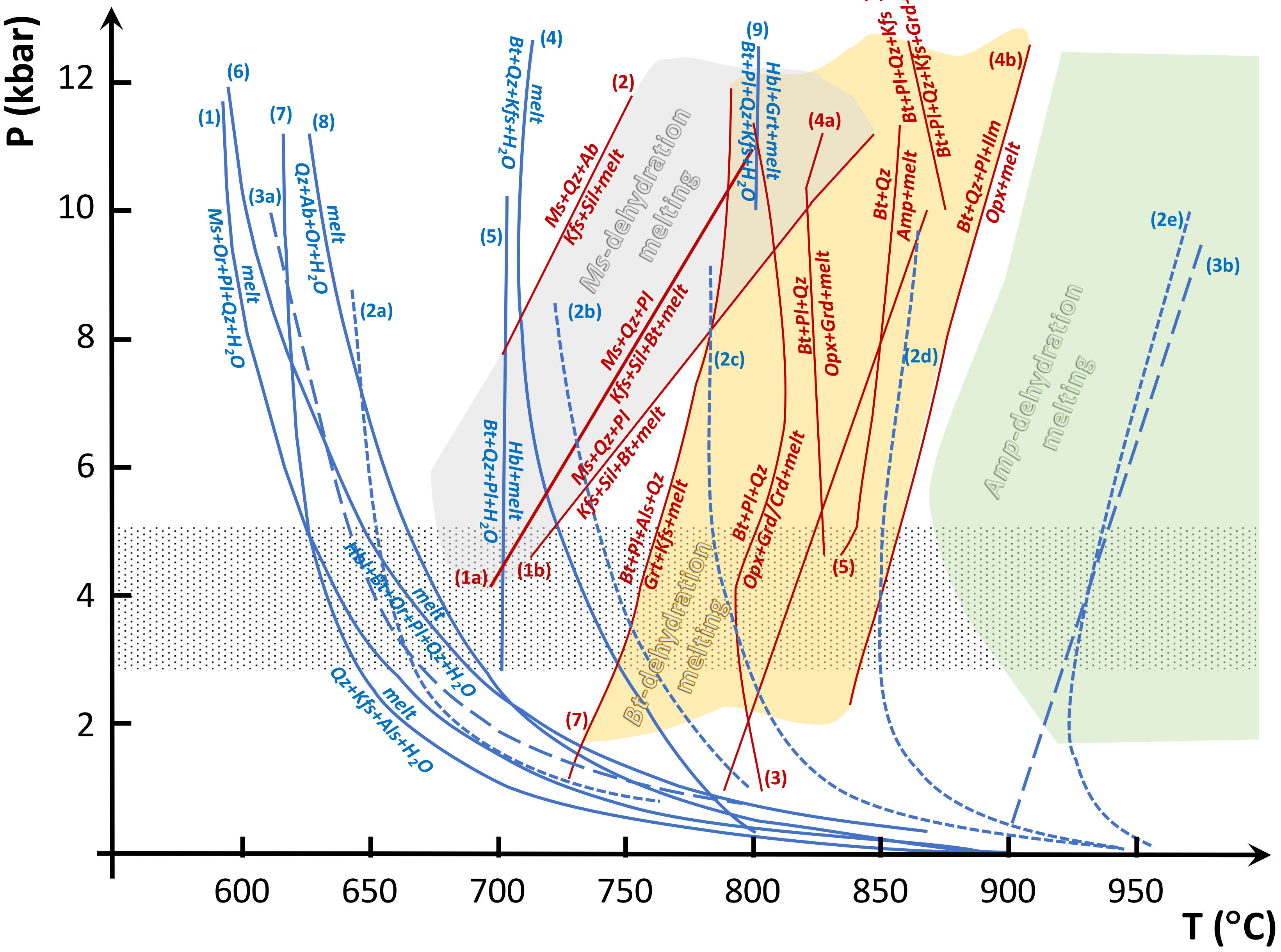
- Strongly weathered crustal rocks, including significant inputs from felsic (arc-derived) igneous sources

- Loss of Na, Ca and Sr; relative enrichment in K, Rb, Sn, W and elements with similar geochemical behaviour

- Sn and W preferentially incorporated in micas

- Potential to:
    - provide several chemical components when subjected to intense (and long-lasting) hydrothermal leaching;
    - generate Sn- and W-enriched melts if adequate conditions were achieved.

Freixedo do Torrão (Figueira de Castelo Rodrigo)



Experimental determined **water-present** melting reactions:

(1) H_2O-saturated *Ms*-granite solidus (Huang and Wyllie, 1973);

(2) H_2O-saturated solidus in Qz+Or+Ab+H_2O system (Johannes, 1985) with melt aH_2O = 1 (2a), aH_2O = 0.7 (2b), aH_2O = 0.5 (2c), aH_2O = 0.3 (2d) and aH_2O = 0.1 (2e);

(3) Melting reaction Qz+Pl+Kfs+H_2O with aH_2O = 1 (3a) and aH_2O = 0.1 (3b) (Stevens and Clemens, 1993);

(4) Melting reaction Bt+Qz+Kfs+H2O = melt (Peterson and Newton, 1989);

(5) H_2O-saturated melting of tonalite Bt+Pl+Qz+H_2O = Hbl+melt (Büsch et al., 1974);

(6) Tonalite H_2O-saturated solidus (Yoder and Tilley, 1962);

(7) H_2O-saturated melting reaction Qz+Kfs+Als+H_2O = melt (Johannes and Holtz, 1996);

(8) H_2O-saturated granite solidus (Qz+Ab+Or+H_2O=melt) (Ebadi and Johannes, 1991);

(9) Melting reaction (Bt+Pl+Qz+Kfs+H_2O=Hbl+Grt+melt) of gneiss with 4wt% H2O added (Gardien et al., 2000).

Experimental determined **dehydration** melting reactions:

(1) Ms-dehydration melting of *Ms-Bt*-schist (1a) and *Ms*-schist (1b) (Patiño Douce and Harris, 1998);

(2) Ms-dehydration melting (Pëto, 1976);

(3) Bt-dehydration melting of metagreywacke (Vielzeuf and Montel, 1994);

(4) Bt-dehydration melting of metagreywacke (4a) and gneiss (4b) (Patiño Douce and Beard, 1995, 1996);

(5) Bt-dehydration melting in MASH system (Vielzeuf and Clemens, 1992);

(6) Bt-dehydration of gneiss (Gradien et a., 2000)

(7) Bt-dehydration melting of metapelite (Le Breton and Thompson, 1988).

In comparison, note different slopes and solidus T. Water-present melting results in negative volume change whereas dehydration melting leads to positive volume change (⇒ fracturing and melt expulsion into the host).

Compositionally modified metasediments (Cabeço de Argemela)