ERA-MIN 2

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)

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

AGENCE NATIONALE DE LA RECHERCHE ANR

Mid-Term Review Webinar of ERA-MIN 2 Call 2019 projects
8th June 2022

Ciências ULisboa

U.PORTO FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO

UNIVERSIDADE DE ÉVORA ESCOLA DE CIÊNCIAS E TECNOLOGIA LABORATÓRIO HERCULES HERANÇA CULTURAL, ESTUDOS E SALVAGUARDA

LNEG Laboratório Nacional de Energia e Geologia, I. P.

UNIVERSIDADE D COIMBRA FACULDADE DE CIÊNCIAS E TECNOLOGIA

cnrs dépasser les frontières

GEOCIÊNCIAS USP

ERA·MIN2 MOSTMEG

https://mostmeg.rd.ciencias.ulisboa.pt/

Predictive models for strategic metal rich, granite-related ore systems based on mineral and geochemical fingerprints and footprints

Topaz and cassiterite rich quartz-lode (Panasqueira)

Project Summary

RESEARCH

- Critical processes of ore formation and preservation expressed as mappable attributes

MINERAL SYSTEM RESEARCH

MODELLING

- Spatial and temporal distribution of geological features that record critical processes

2D-3D-4D MODELLING

TARGETING

- Conceptual and empirical evaluation of mineral potential and selection of areas for exploration

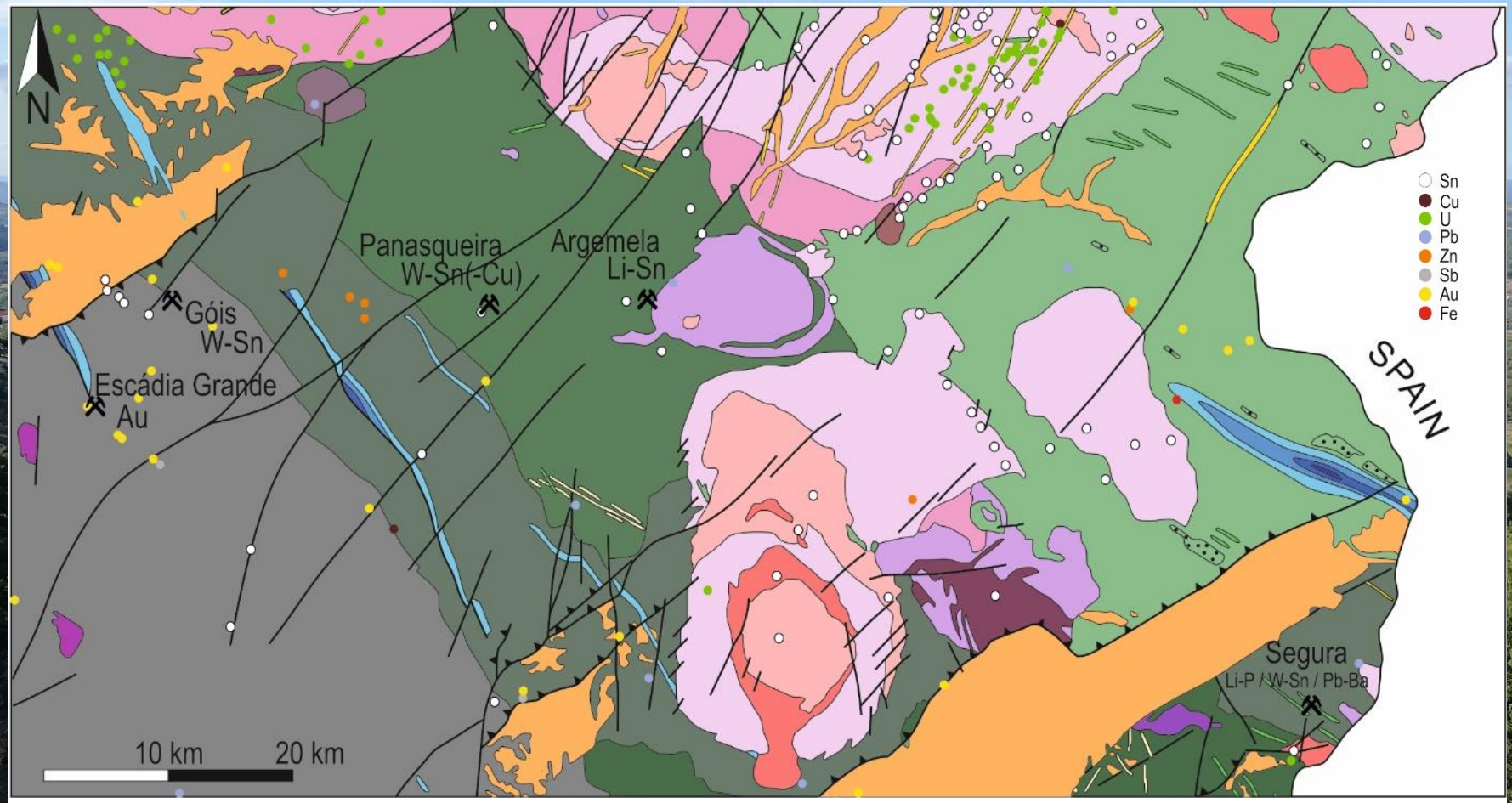
PROSPECTIVITY MAPPING

MAIN GOAL

The MOSTMEG project intends to develop and validate predictive models for strategic metal rich, granite-related ore systems. To this end, some concepts and exploration strategies are being refined, combining mineral and geochemical criteria that can be used as pathfinders or vectors to mineralization centres.

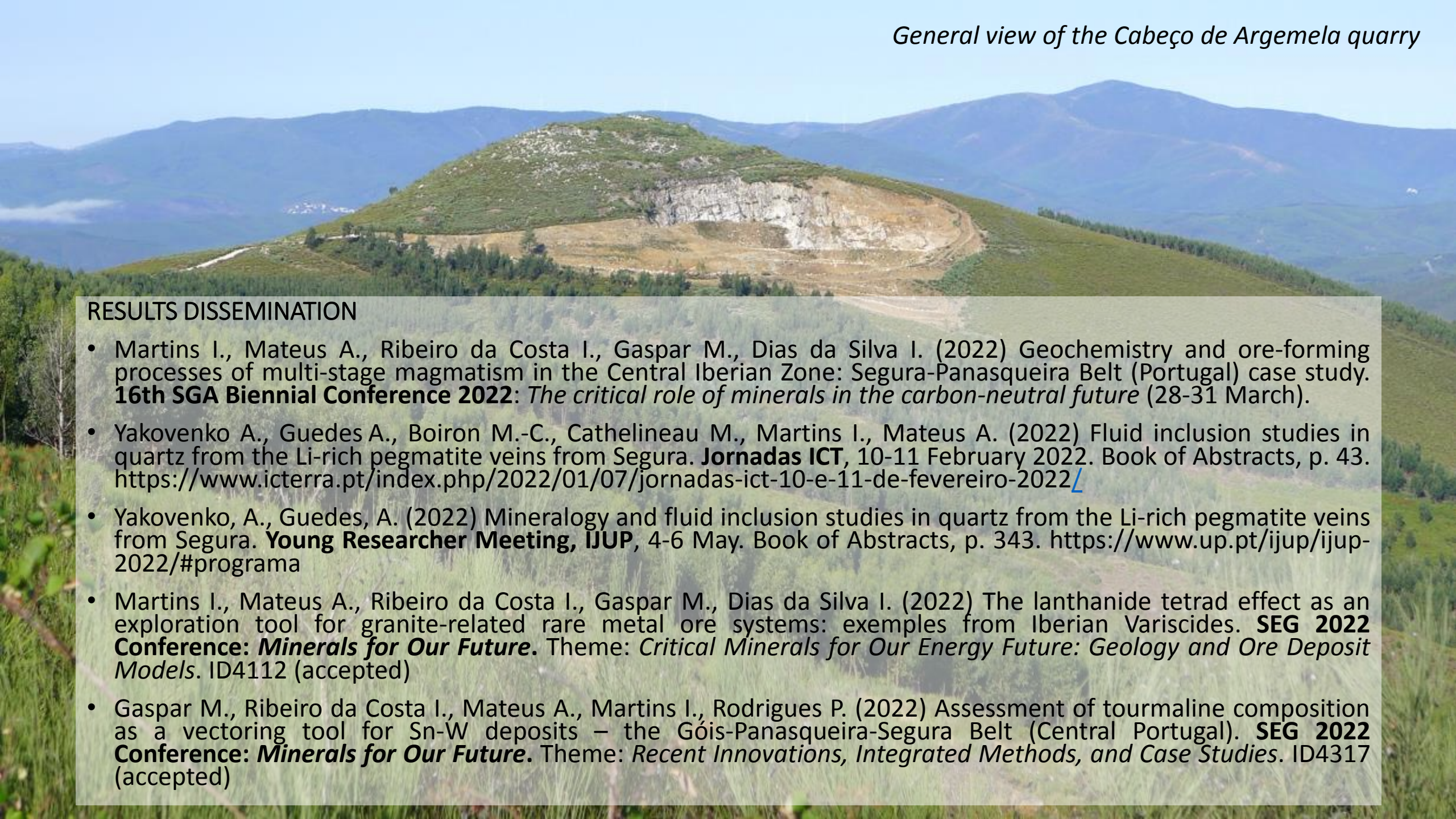
Several case studies are being examined in MOSTMEG, typifying brownfields of different types of granite-related ore systems and promising greenfields for their occurrence.

These case studies, distributed across the **Segura-Argemela-Panasqueira-Góis (SAPG) belt**, illustrate common scenarios in the Iberian Variscides.



Simplified after the official, 1:500.000 Geological Map (LNEG). Mineralization occurrences as in SIORMINP (LNEG)

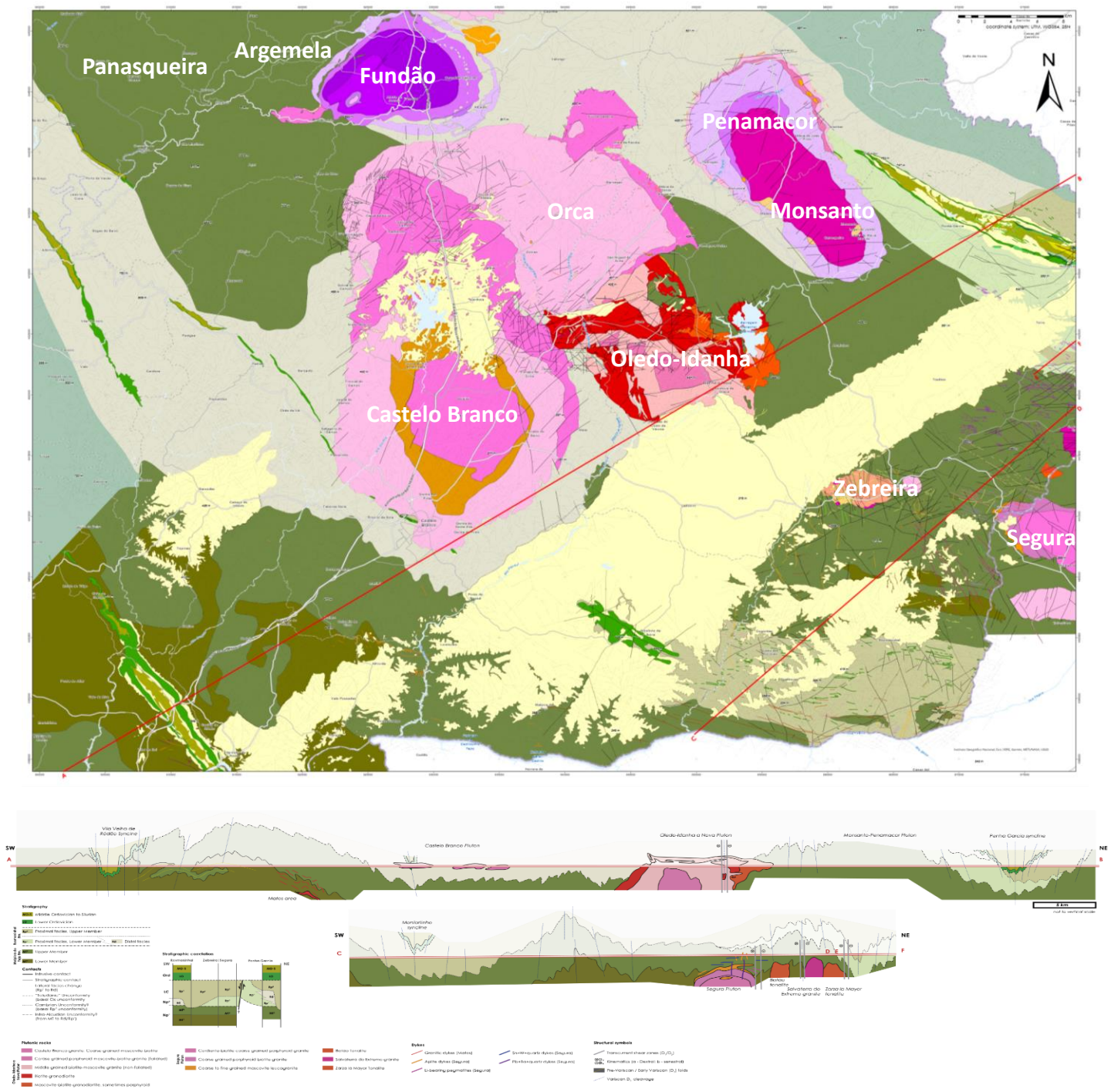
General view of the SAPG belt from Monsanto to the WNW



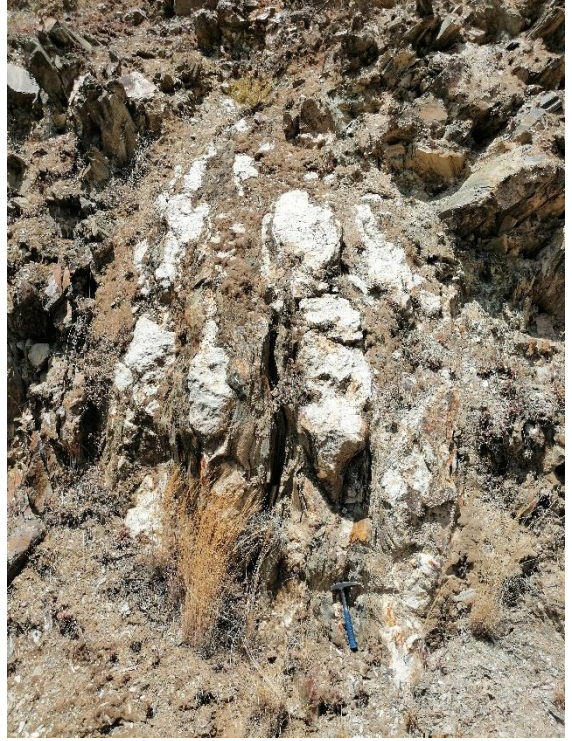
General view of the Cabeço de Argemela quarry

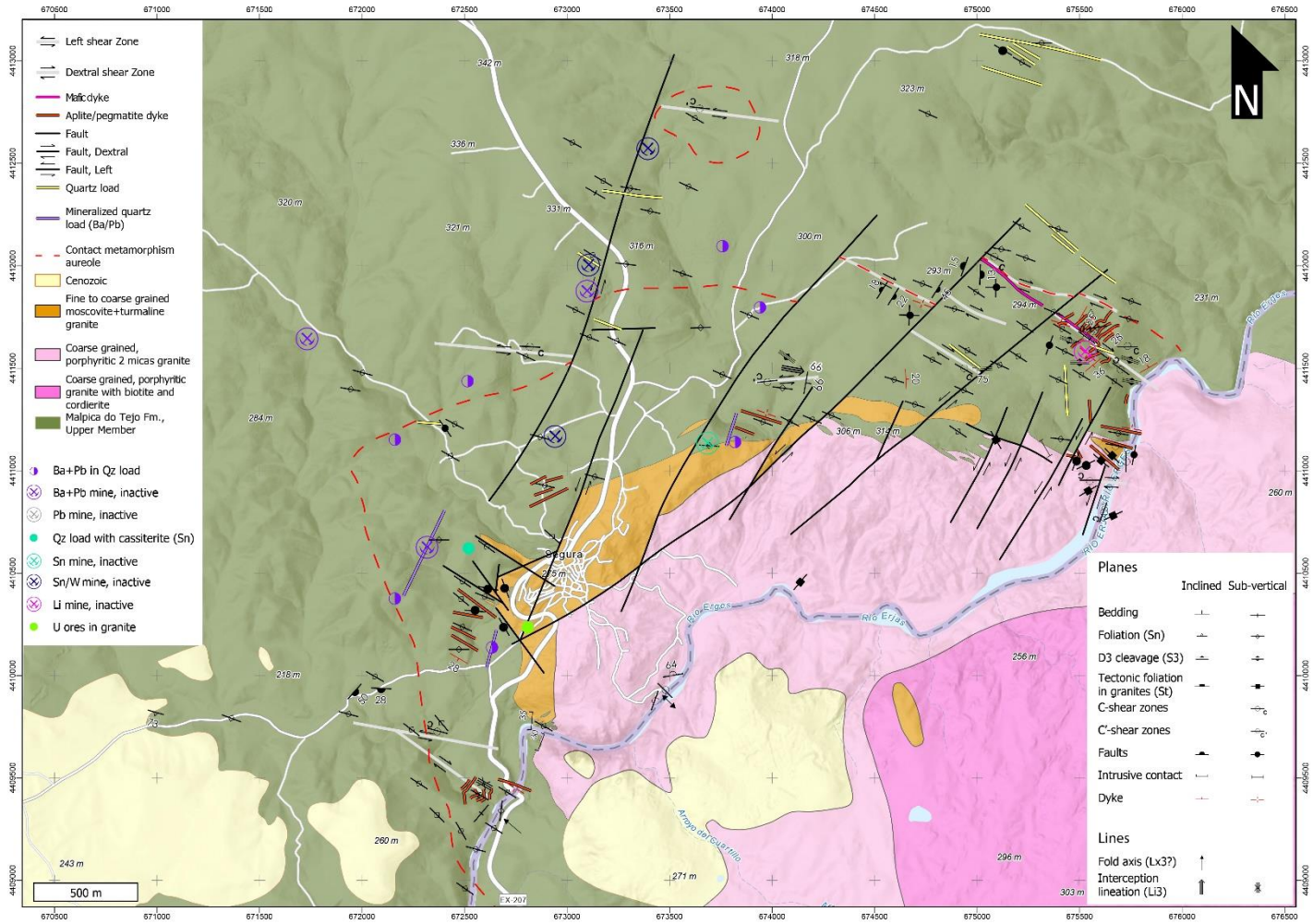
RESULTS DISSEMINATION

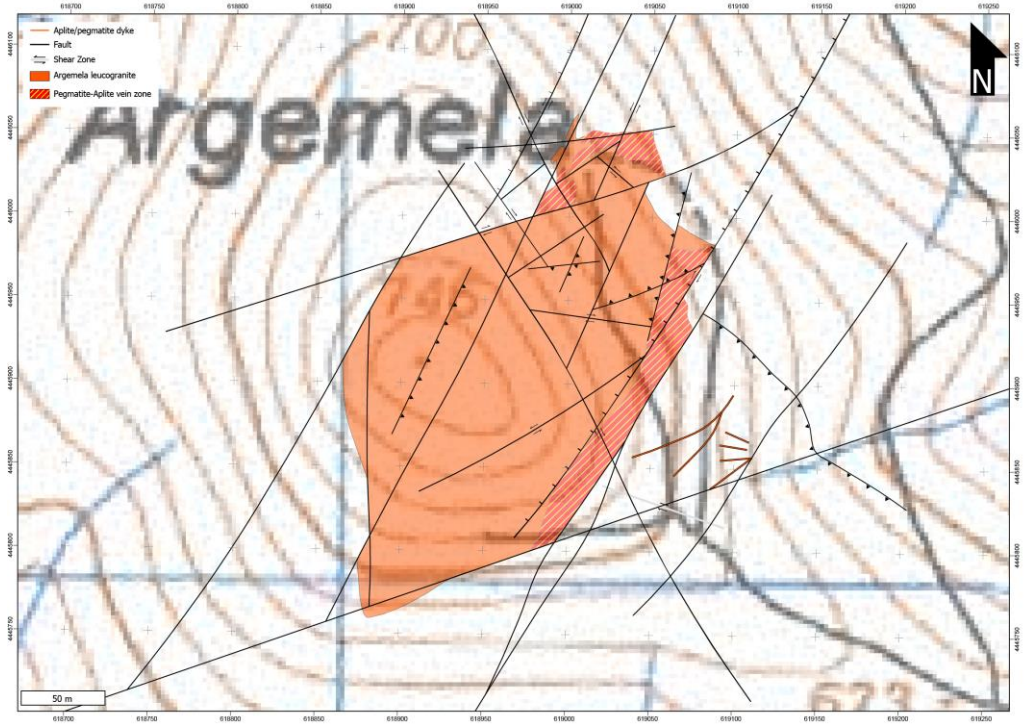
- Martins I., Mateus A., Ribeiro da Costa I., Gaspar M., Dias da Silva I. (2022) Geochemistry and ore-forming processes of multi-stage magmatism in the Central Iberian Zone: Segura-Panasqueira Belt (Portugal) case study. **16th SGA Biennial Conference 2022**: *The critical role of minerals in the carbon-neutral future* (28-31 March).
- Yakovenko A., Guedes A., Boiron M.-C., Cathelineau M., Martins I., Mateus A. (2022) Fluid inclusion studies in quartz from the Li-rich pegmatite veins from Segura. **Jornadas ICT**, 10-11 February 2022. Book of Abstracts, p. 43. https://www.icterra.pt/index.php/2022/01/07/jornadas-ict-10-e-11-de-fevereiro-2022/
- Yakovenko, A., Guedes, A. (2022) Mineralogy and fluid inclusion studies in quartz from the Li-rich pegmatite veins from Segura. **Young Researcher Meeting, IJUP**, 4-6 May. Book of Abstracts, p. 343. https://www.up.pt/ijup/ijup-2022/#programa
- Martins I., Mateus A., Ribeiro da Costa I., Gaspar M., Dias da Silva I. (2022) The lanthanide tetrad effect as an exploration tool for granite-related rare metal ore systems: exemples from Iberian Variscides. **SEG 2022 Conference: *Minerals for Our Future*.** Theme: *Critical Minerals for Our Energy Future: Geology and Ore Deposit Models*. ID4112 (accepted)
- Gaspar M., Ribeiro da Costa I., Mateus A., Martins I., Rodrigues P. (2022) Assessment of tourmaline composition as a vectoring tool for Sn-W deposits – the Góis-Panasqueira-Segura Belt (Central Portugal). **SEG 2022 Conference: *Minerals for Our Future*.** Theme: *Recent Innovations, Integrated Methods, and Case Studies*. ID4317 (accepted)


Panasqueira
Argemela
Fundão
Penamacor
Orca
Monsanto
Oledo-Idanha
Castelo Branco
Zebreira
Segura
N
SW
NE
A
B
C
D
E
F
Vila Velha de Ródão Syncline
Castelo Branco Pluton
Oledo-Idanha a Nova Pluton
Monsanto-Penamacor Pluton
Penha Garcia syncline
Malcata area
Monfortinho syncline
Segura Pluton
Salvaterra do Extremo granite
Zarza la Mayor Tonalite
Stratigraphy
Contacts
Stratigraphic correlation
Plutonic rocks
Dykes
Structural symbols







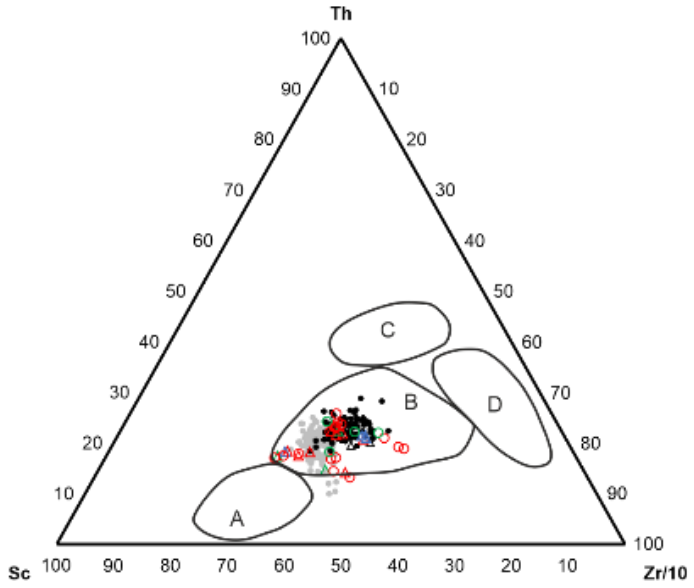
Work in progress

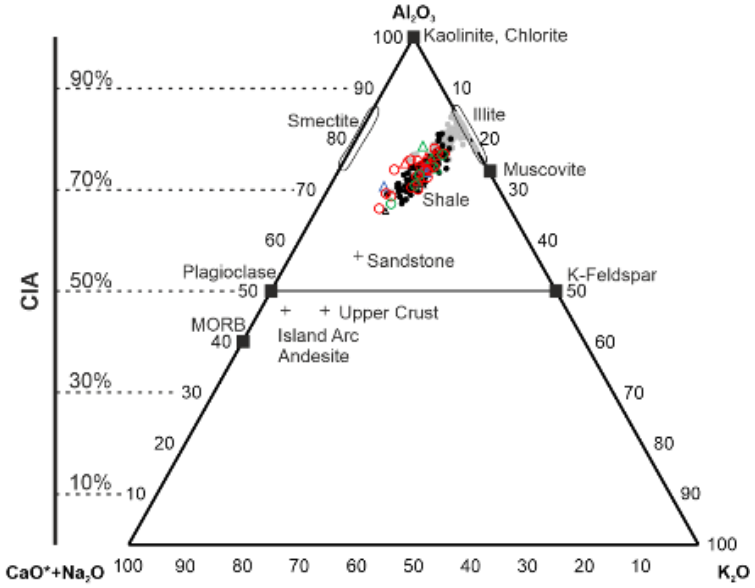

Lentiscais area

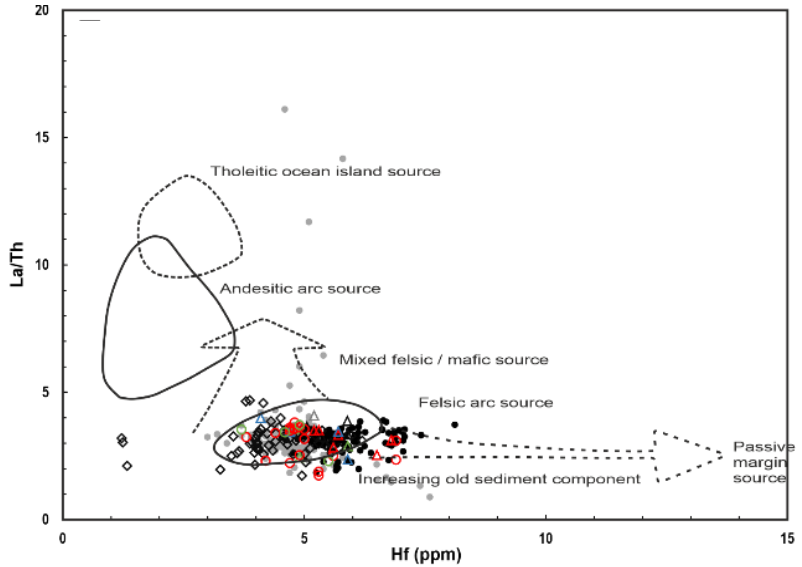

Segura (old mining works)


Segura area


Panasqueira (active mine)

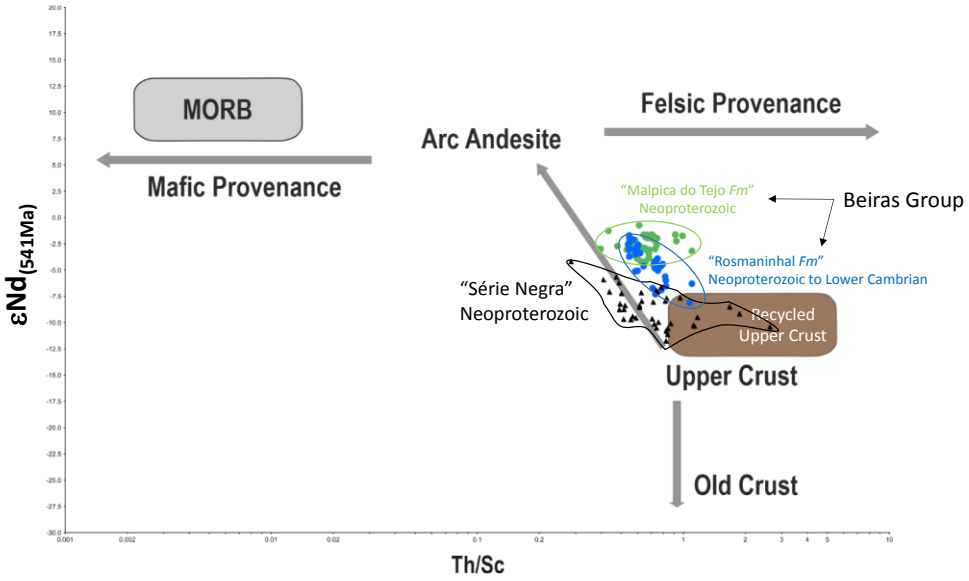


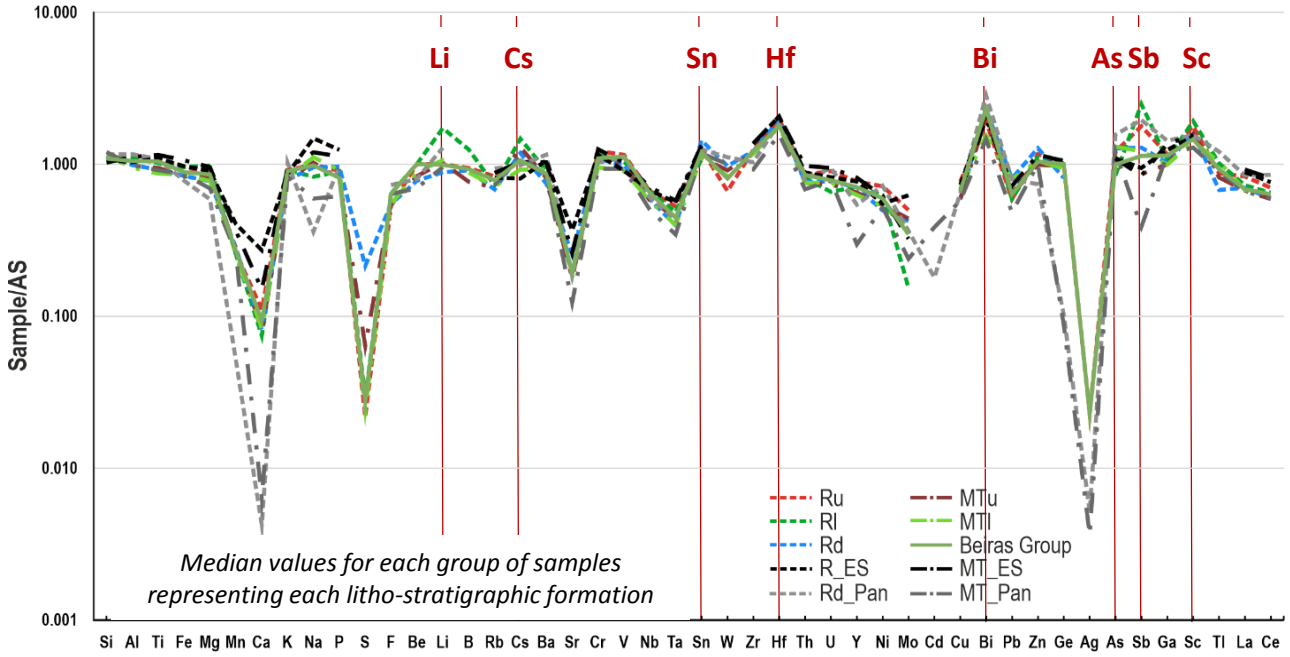


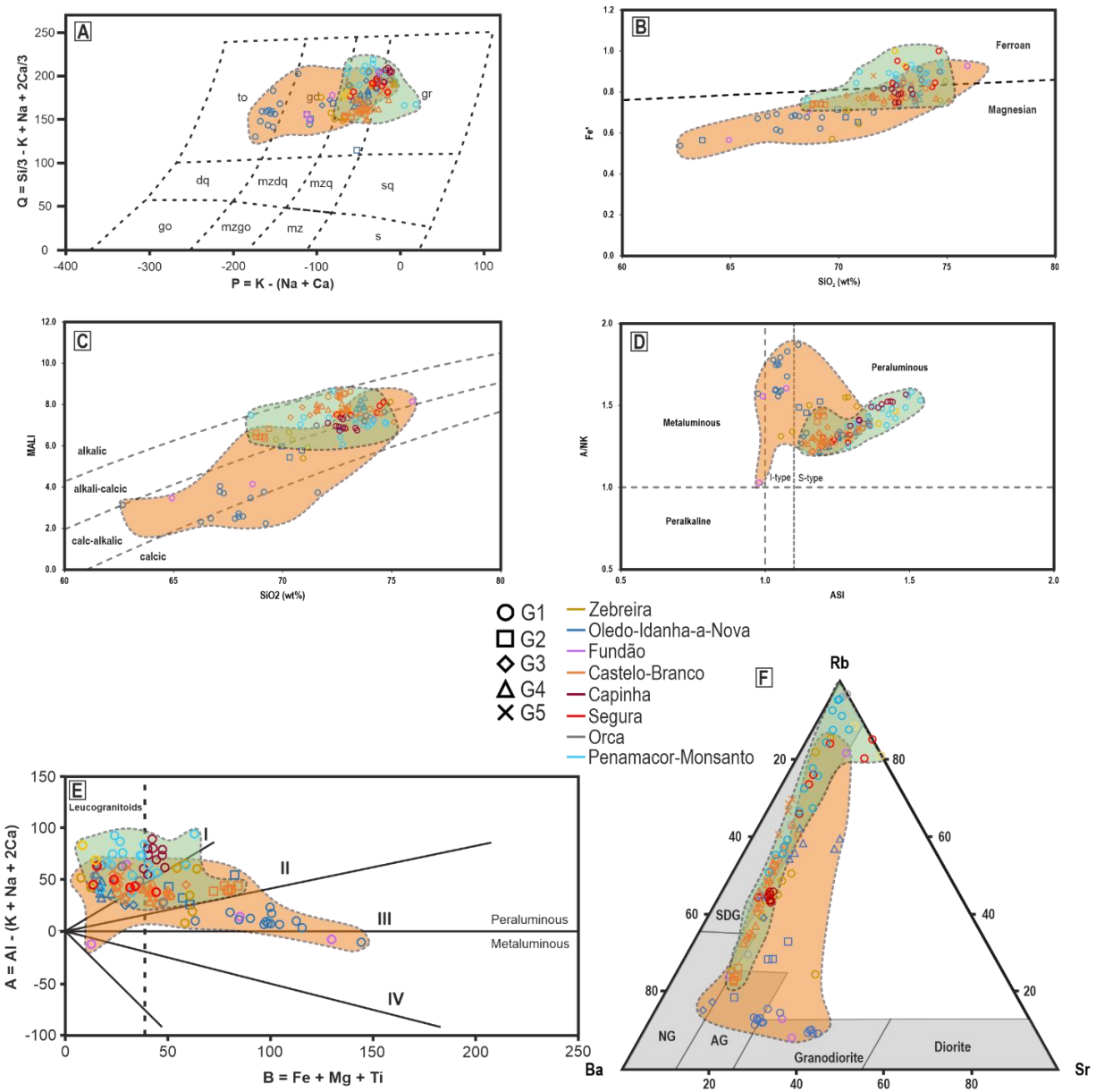


R_U R_L R_D MT_U MT_L

R_D_PAN MT_U_PAN R_ES MT_ES

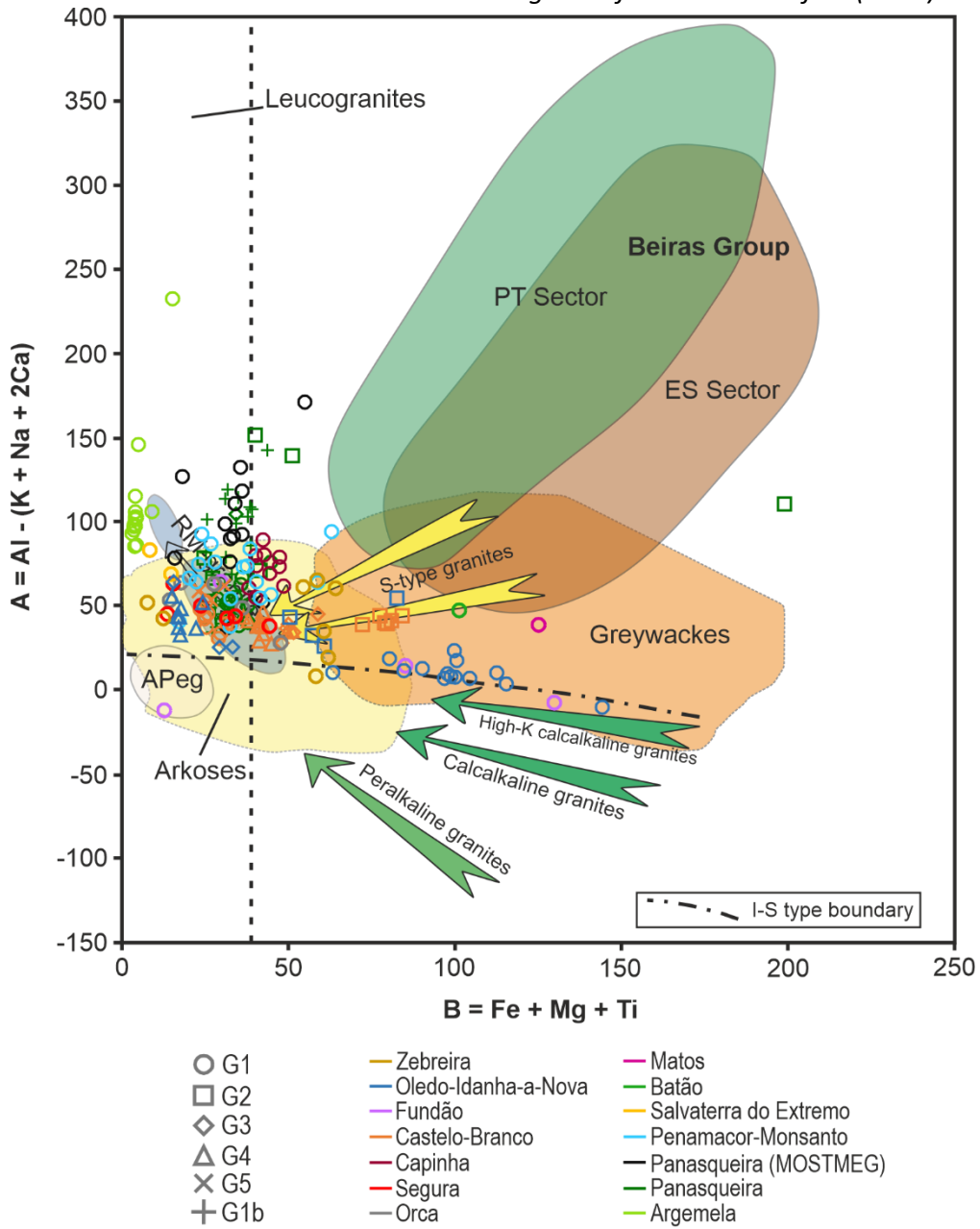




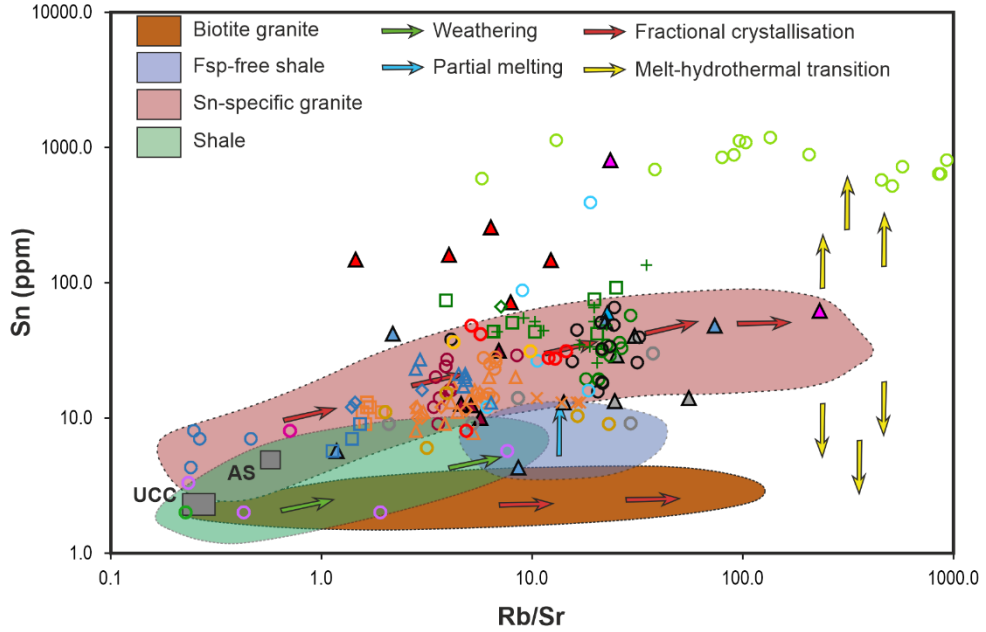


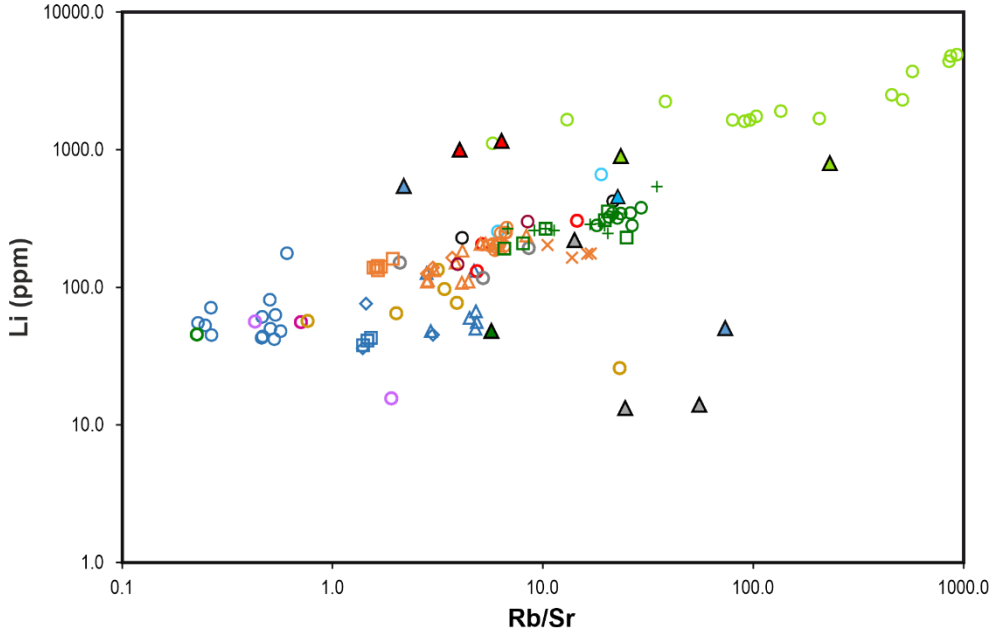
*Diagrams from: **(A, E)** Debon & Lefort (1983, 1988); **(B, C)** Frost & Frost (2008); **(D)** Shand (1943), Frost et al. (2001); **(F)** El Bouseily & El Sokkary (1975)*

B-A diagram of Debon and Lefort (1988)

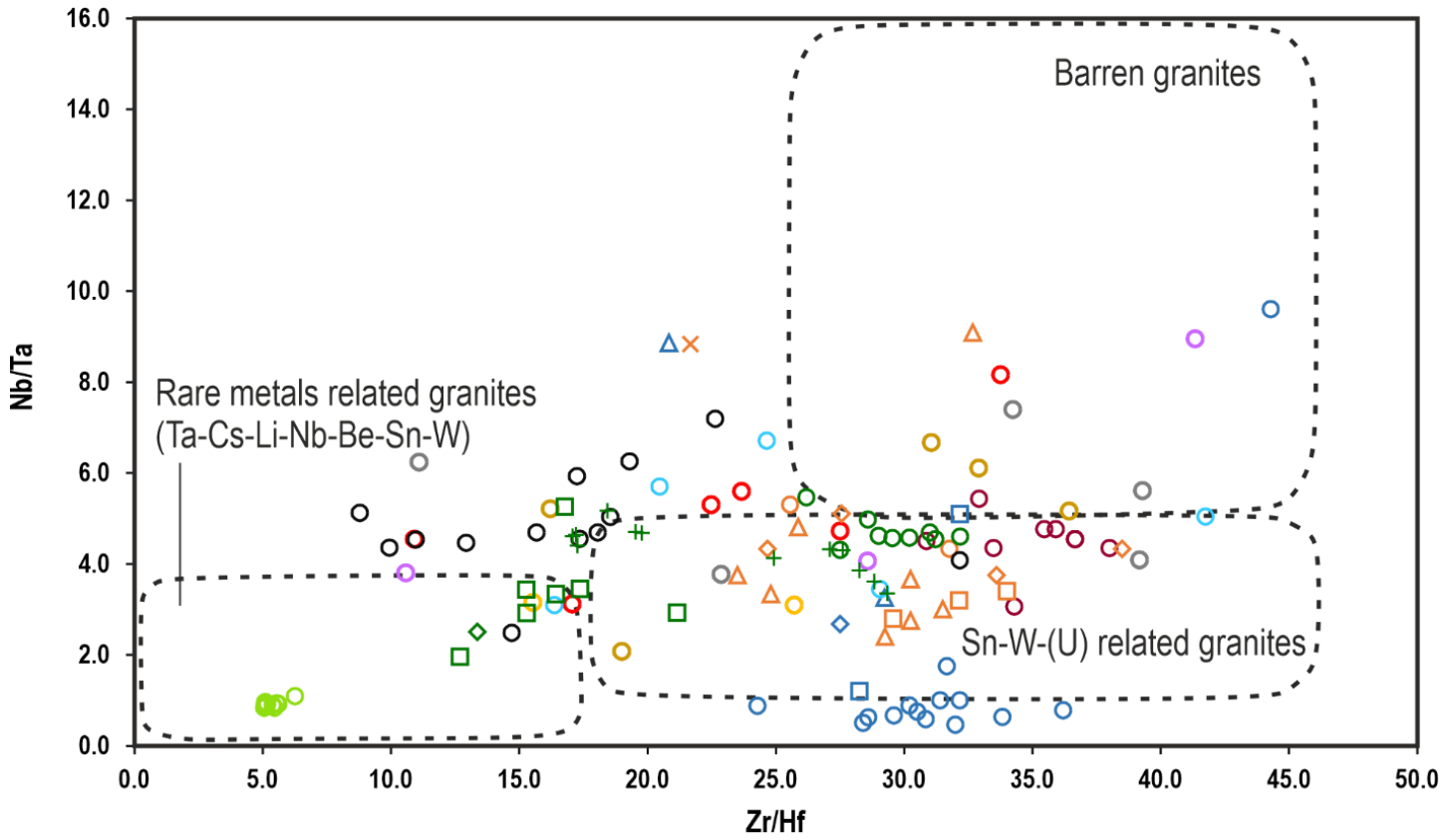


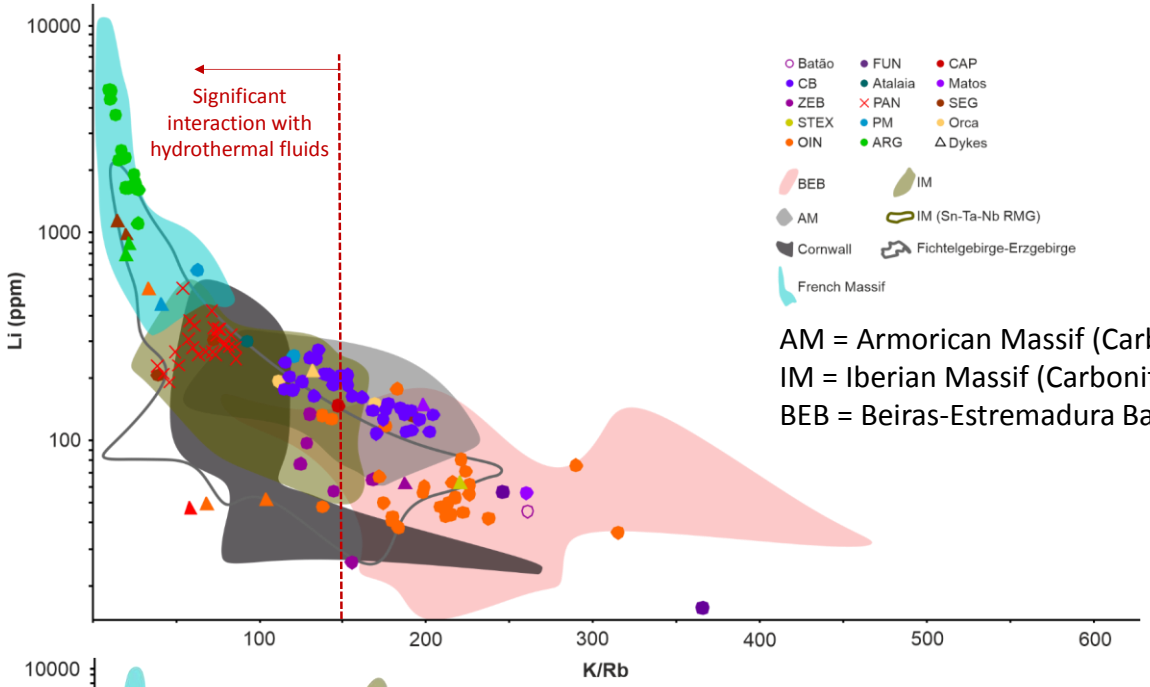
(adapted from Romer & Pichavant, 2020)



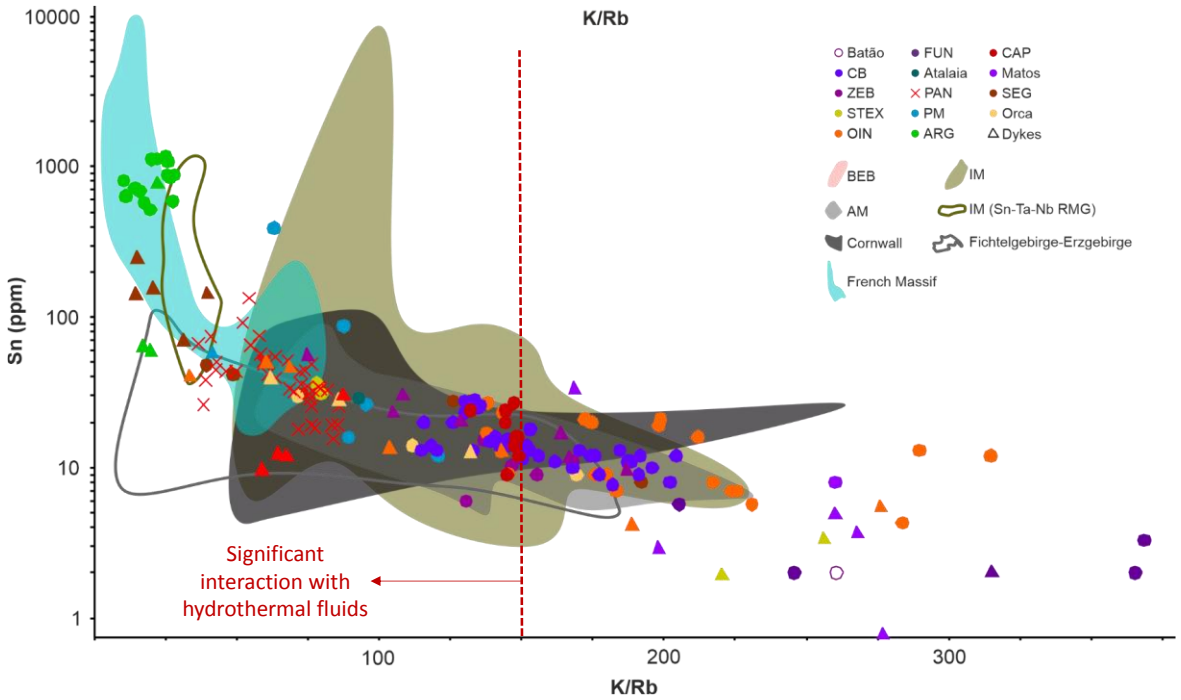


(adapted from Ballouard et al., 2016)





AM = Armorican Massif (Carboniferous)
IM = Iberian Massif (Carboniferous)
BEB = Beiras-Estremadura Batholith (Lower Ordovician)

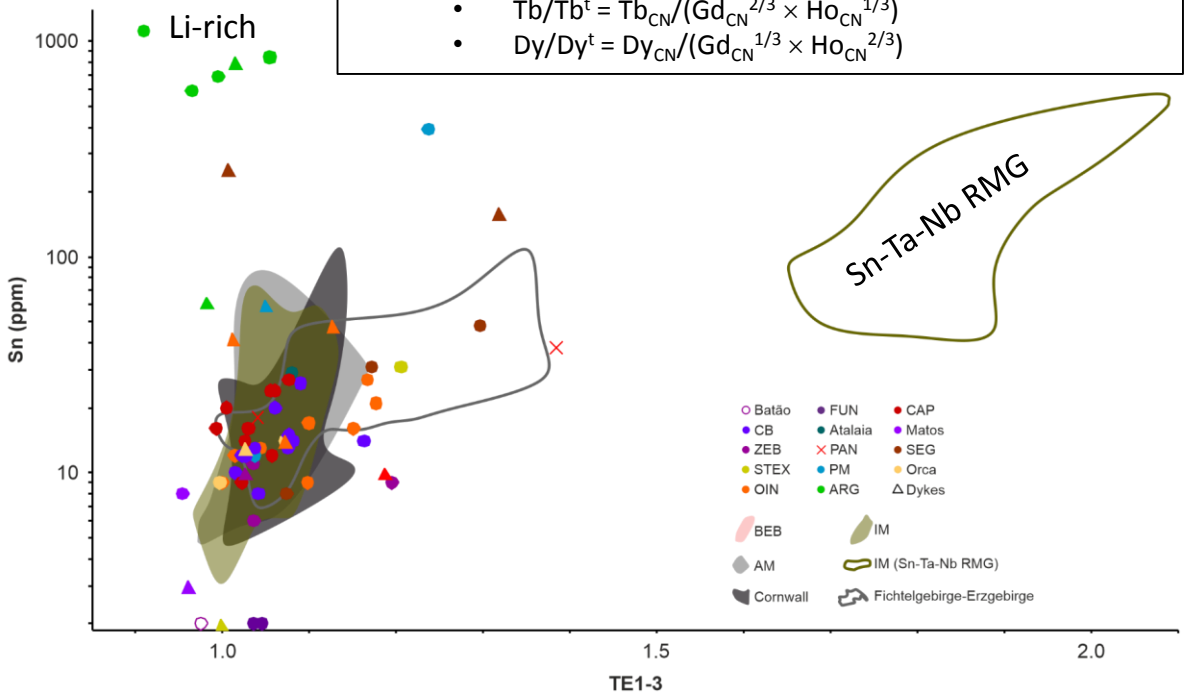


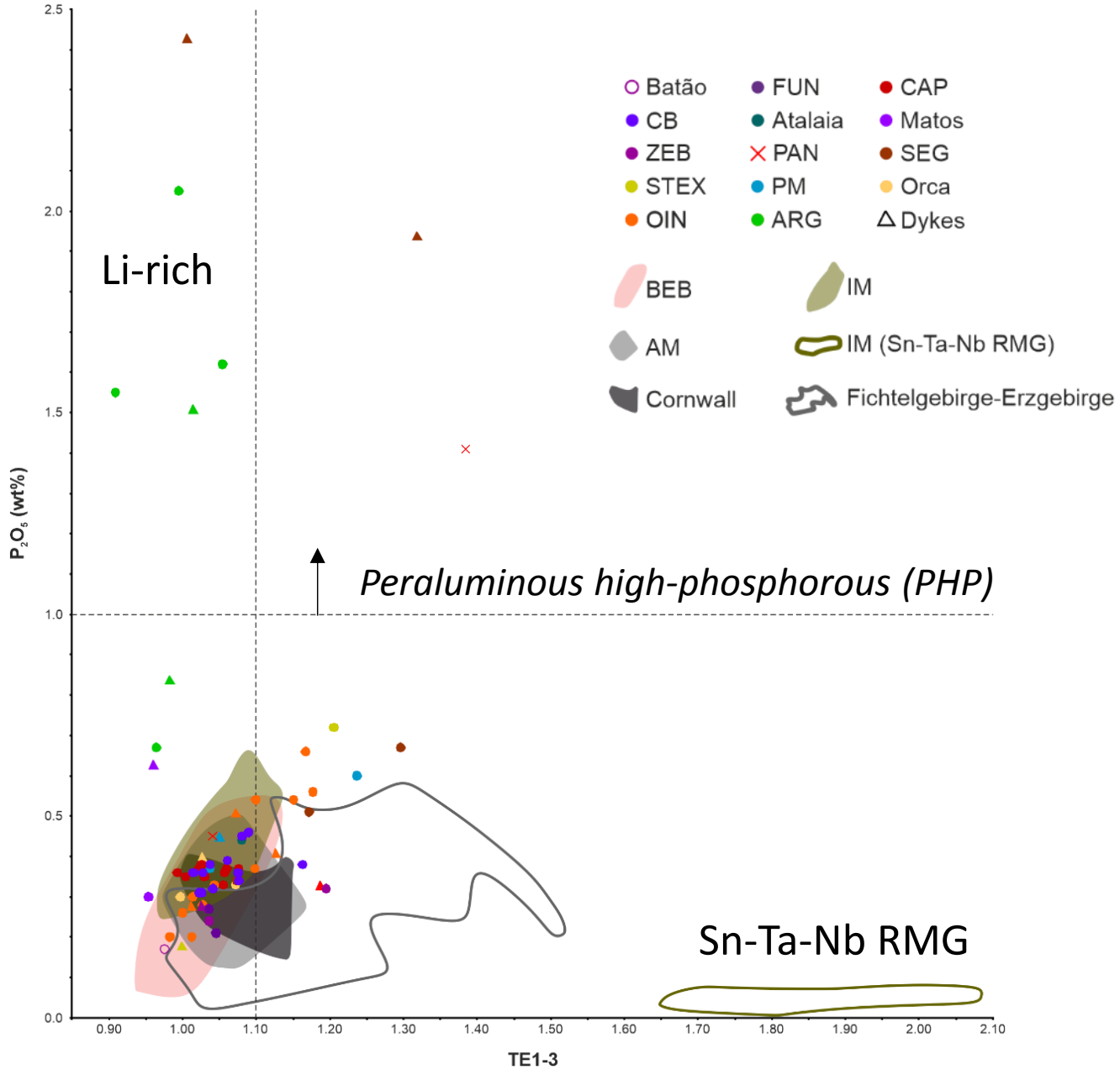
Similar conclusions when Sr/Eu or Eu/Eu* or Y/Ho or Zr/Hf or Nb/Ta are used instead of K/Rb

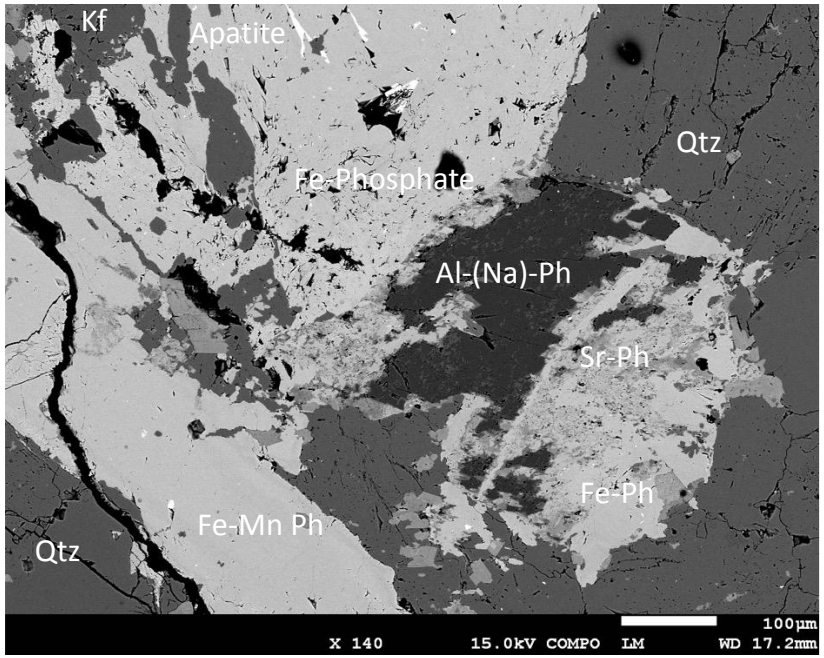
The tetrad effect as possible vector for different types of granite-related mineralization.

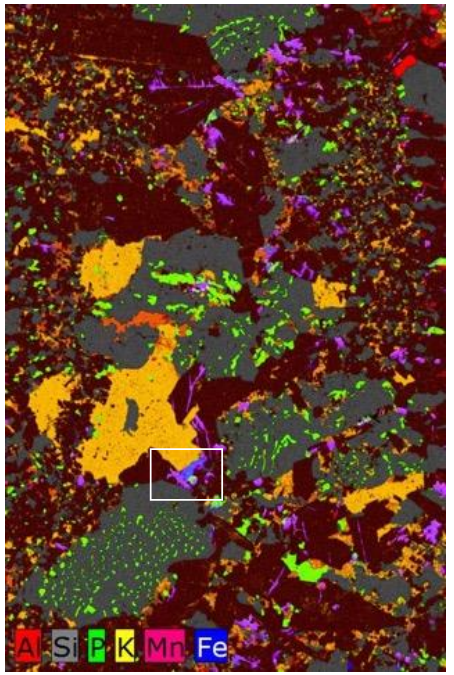
$TE_{1-3} = (t_1 \times t_3)^{0.5}$ where

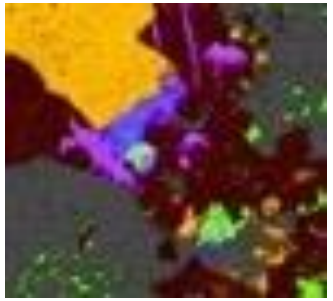
- $t_1 = (Ce/Ce^t \times Pr/Pr^t)^{0.5}$ and $t_3 = (Tb/Tb^t \times Dy/Dy^t)^{0.5}$
- $Ce/Ce^t = Ce_{CN}/(La_{CN}^{2/3} \times Nd_{CN}^{2/3})$
- $Pr/Pr^t = Pr_{CN}/(La_{CN}^{1/3} \times Nd_{CN}^{2/3})$
- $Tb/Tb^t = Tb_{CN}/(Gd_{CN}^{2/3} \times Ho_{CN}^{1/3})$
- $Dy/Dy^t = Dy_{CN}/(Gd_{CN}^{1/3} \times Ho_{CN}^{2/3})$

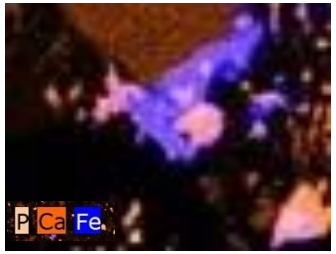



Li-rich
Batão
FUN
CAP
CB
Atalaia
Matos
ZEB
PAN
SEG
STEX
PM
Orca
OIN
ARG
Dykes
BEB
IM
AM
IM (Sn-Ta-Nb RMG)
Cornwall
Fichtelgebirge-Erzgebirge
Peraluminous high-phosphorous (PHP)
Sn-Ta-Nb RMG
P2O5 (wt%)
TE1-3
2.5
2.0
1.5
1.0
0.5
0.0
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.00
2.10


Kf
Apatite
Qtz
Fe-Phosphate
Al-(Na)-Ph
Sr-Ph
Fe-Ph
Fe-Mn Ph
Qtz
X 140
15.0kV COMPO
LM
100µm
WD 17.2mm

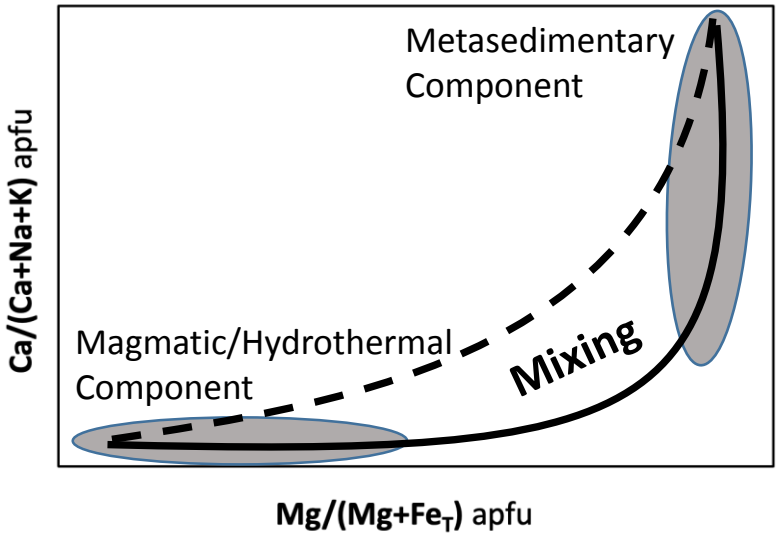

Al
Si
P
K
Mn
Fe

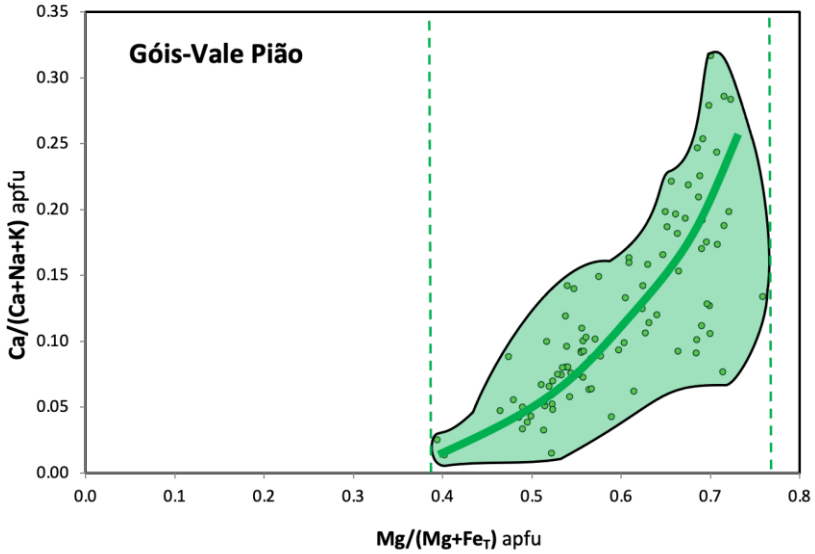


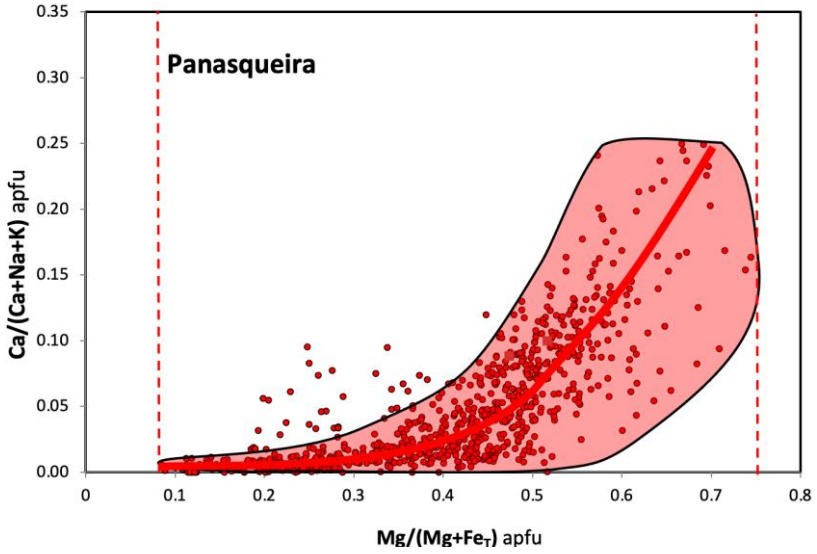

P
Ca
Fe

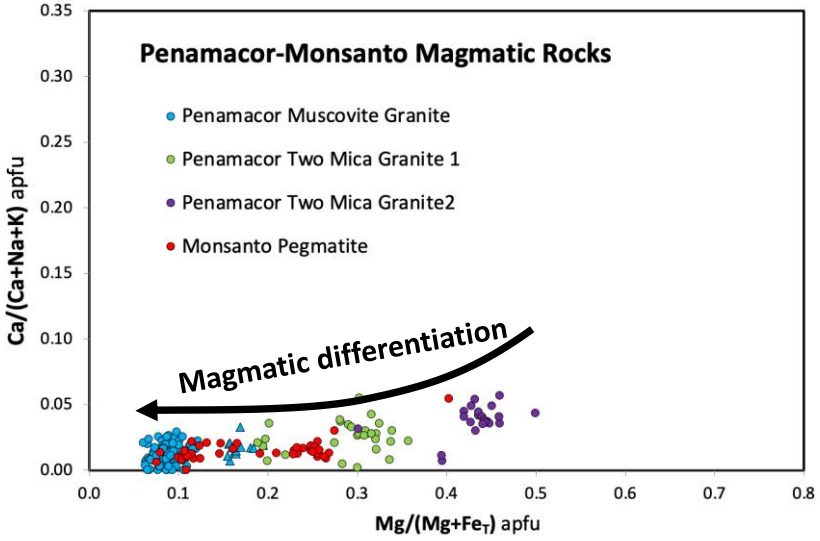
Phosphates

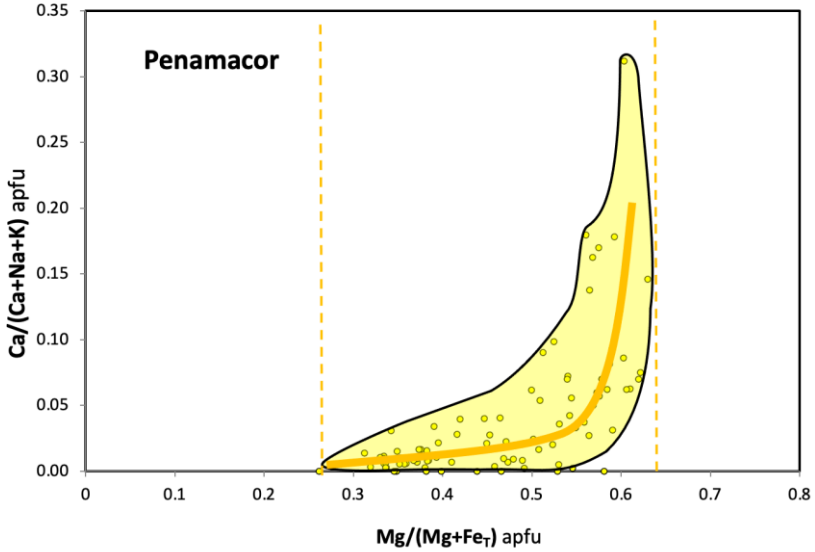
Assessment of Tourmaline Composition as a Vectoring Tool for Sn-W Deposits

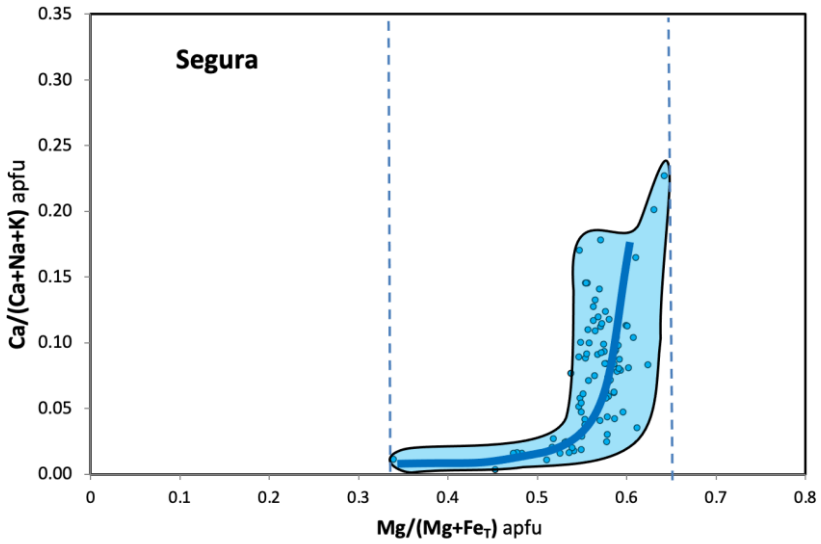








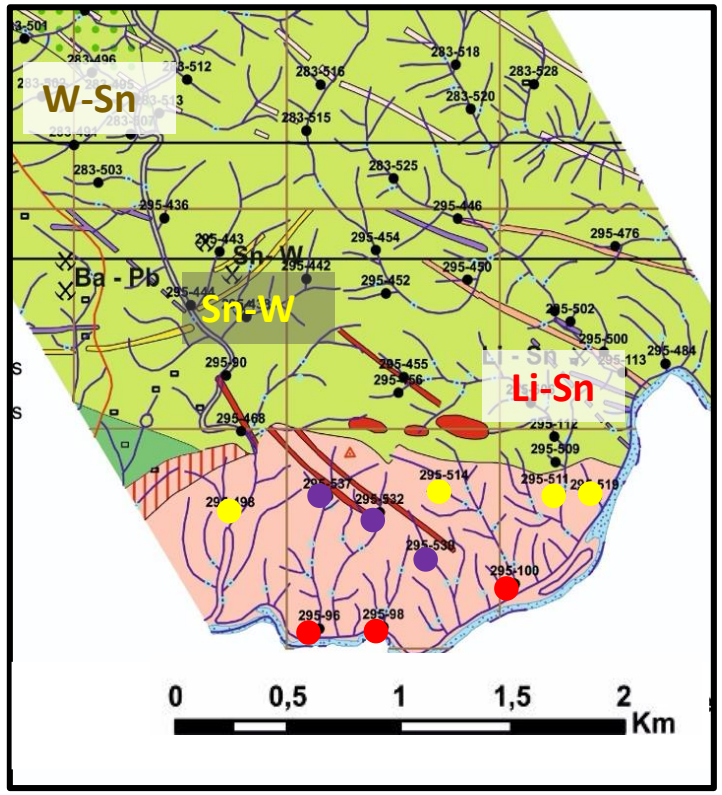




Exploration Tools

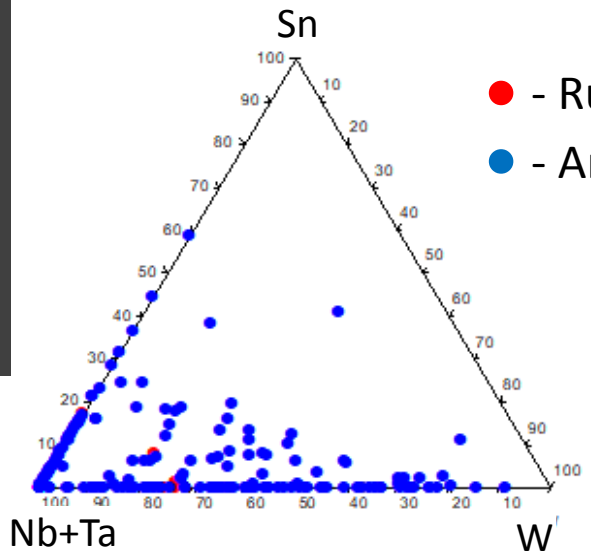
Alluvial TiO_2 Polimorphs

Trace Element Fingerprints



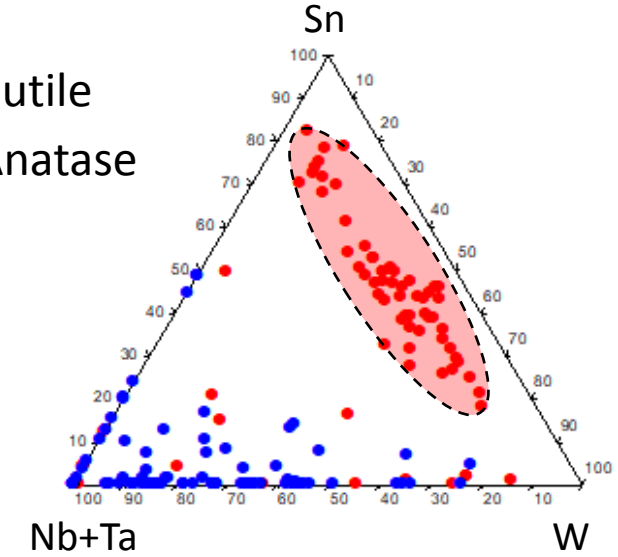
Mineralization

Sn ± W

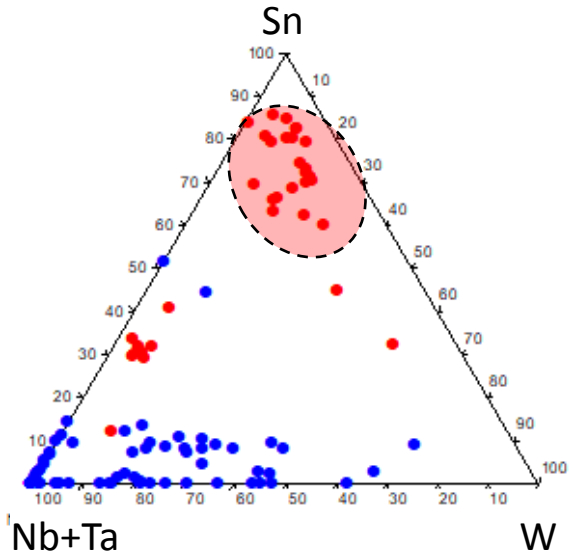


- Rutile
- Anatase

W ± Sn

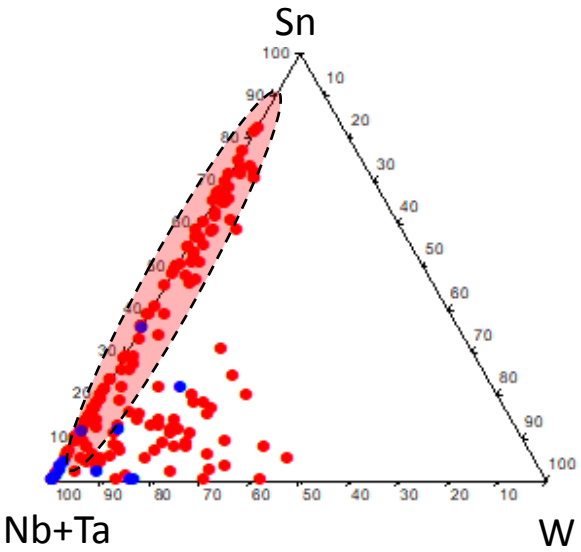


Li ± Sn

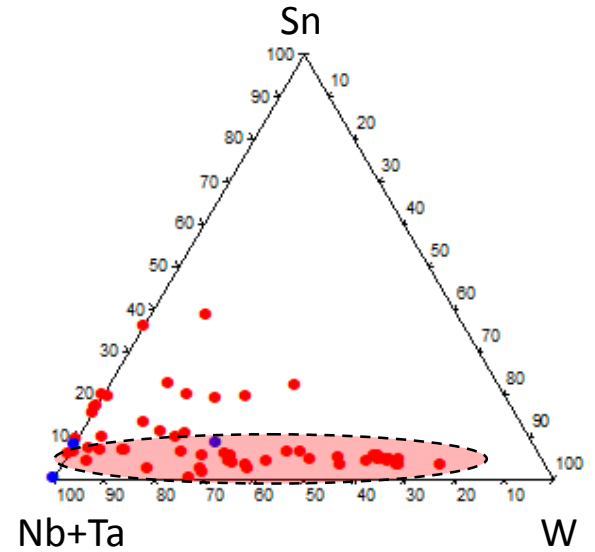


Granites

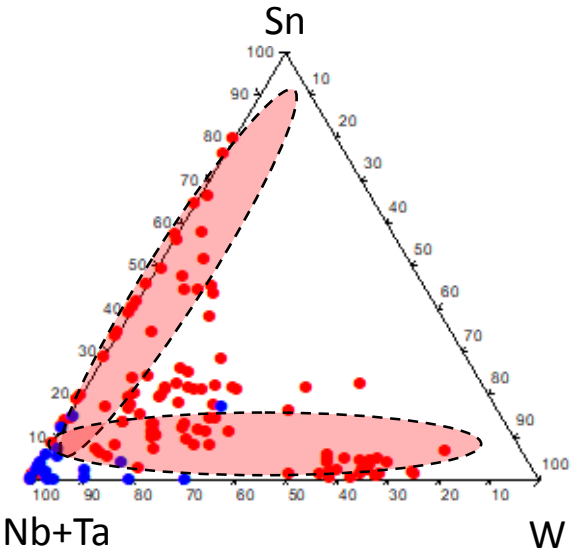
Internal Zone



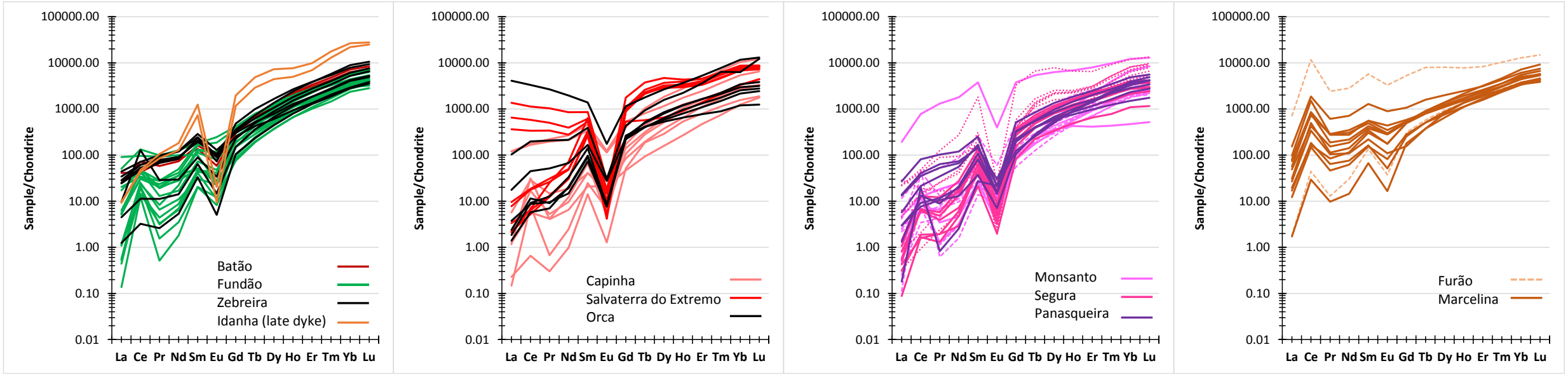
Border Zone



Aplitic-rich Zone



REE contents in Zircon

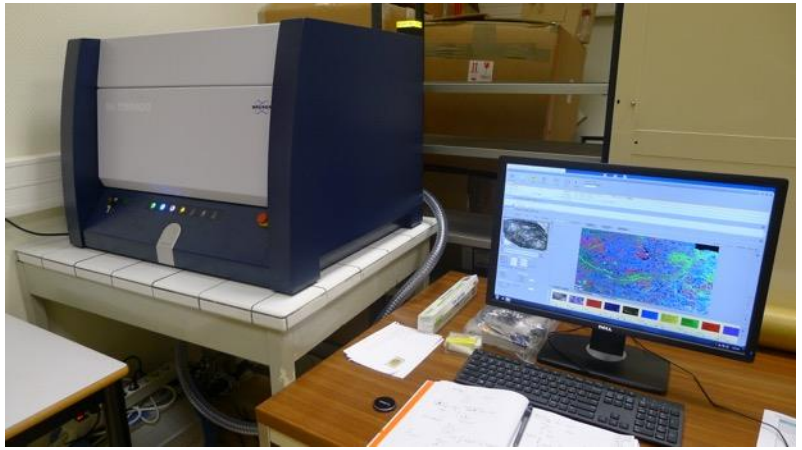


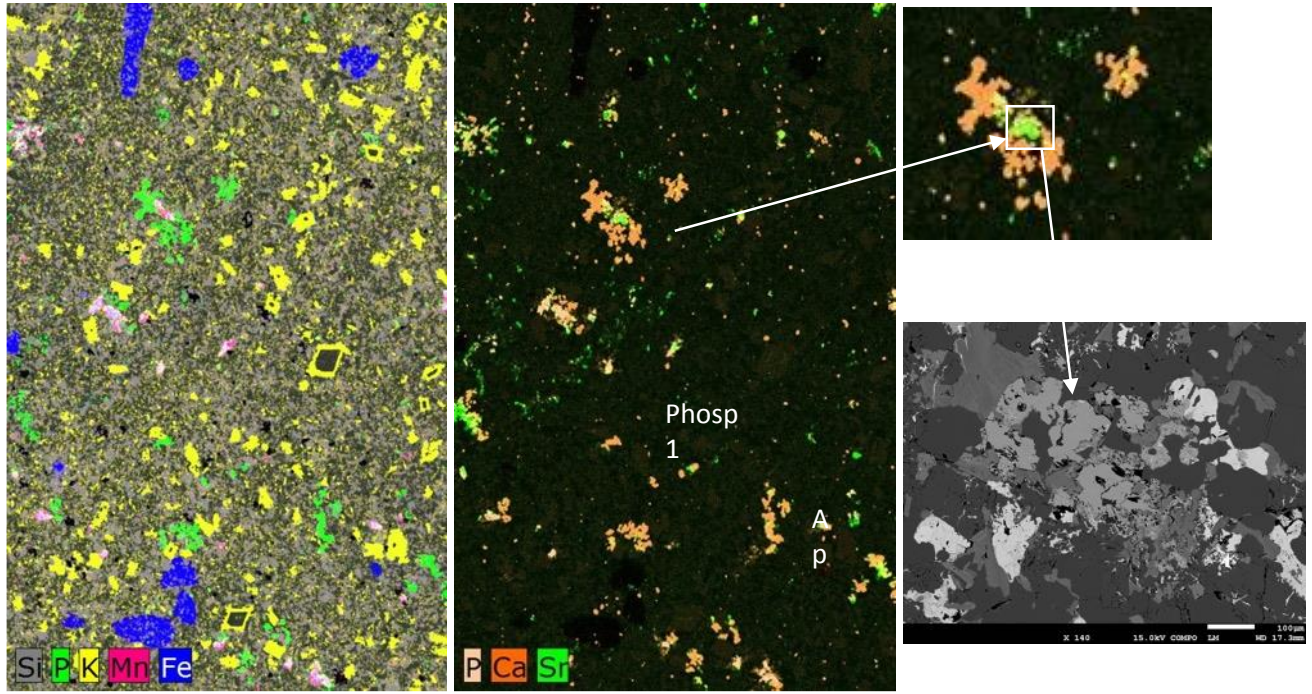
- LREE-HREE fractionation + positive Ce anomaly + negative Eu anomaly in non-altered zircons from granite rocks;
- LREE enrichment, but keeping the typical Ce and Eu anomalies, in non-altered zircons from late porphyry rocks;
- LREE enrichment along with evident fading or elimination of Ce (and Eu) anomaly in zircon grains variably affected by HT hydrothermal processes.

Preliminary conclusions with implications in mineral exploration

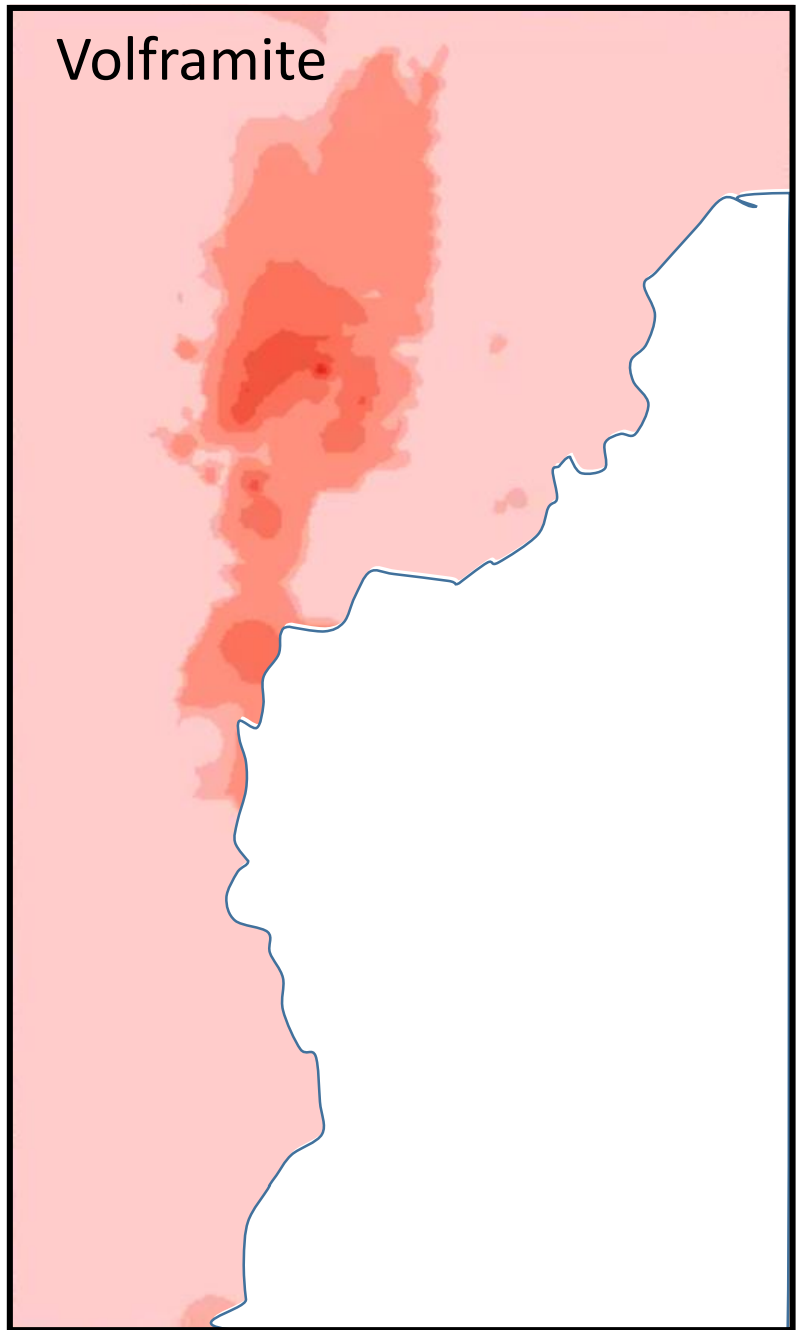
In **<u>methodological</u>** terms:

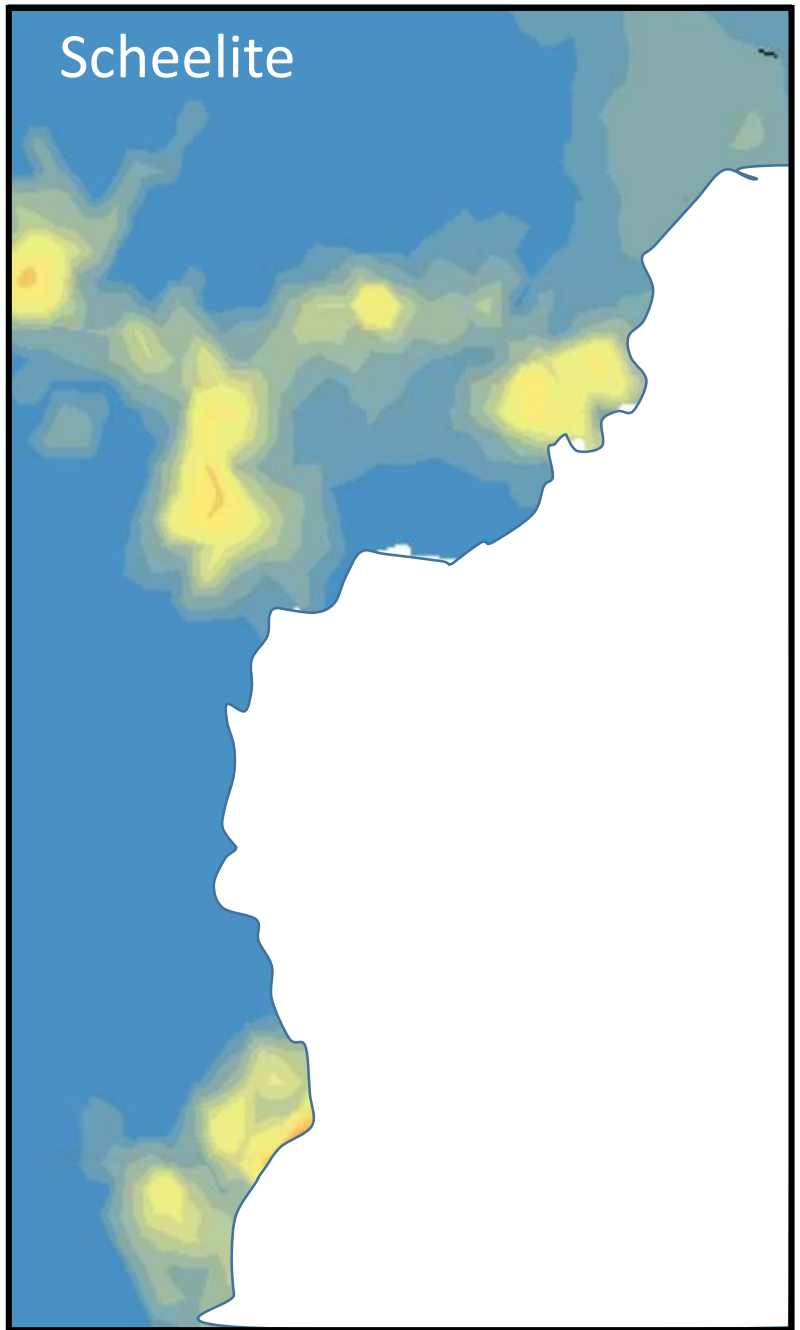
- The absolute need of conduct multi-scale structural analysis and of confine in time the multiple ore-forming events;
- The importance of have representative and accurate multi-element whole-rock analyses for country rocks (not only in domains adjoining mineralization);
- The usefulness of micro-XRF to unravel textural arrangements and compositional patterns, even in rock samples looking “homogeneous”; and
- The relevance of collect and analyse alluvial heavy minerals.

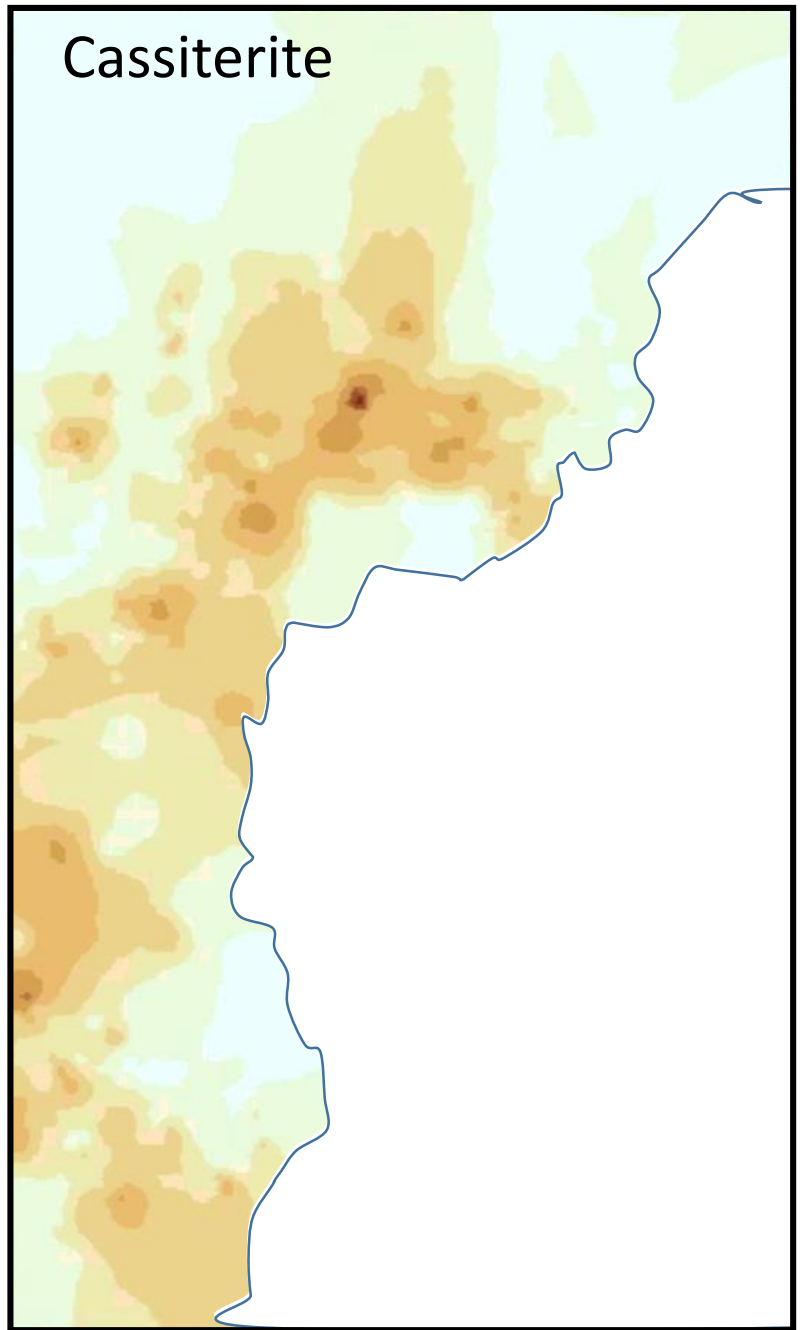




Maps of anomalies based on alluvial sediments data







Preliminary conclusions with implications in mineral exploration

Constraints to fertility of granite melts further involved in the ore-forming processes imposed by:

- Chemical composition of (metasedimentary) protoliths, *determining variable enrichments in metals of interest;*
- Degree of partial melting and possibility of have multiple extractions under different T conditions;
- Temperature of partial melting, *higher (≈800 ℃) in Sn-related granites than in W-related granites (≈750 ℃)*; and
- Water saturation along with the availability and relative abundance of P and F (±B), *that could regulate the development of particular Li-bearing mineral assemblages.*

Thank you so much for your attention!

On behalf of the MOSTMEG partnership

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