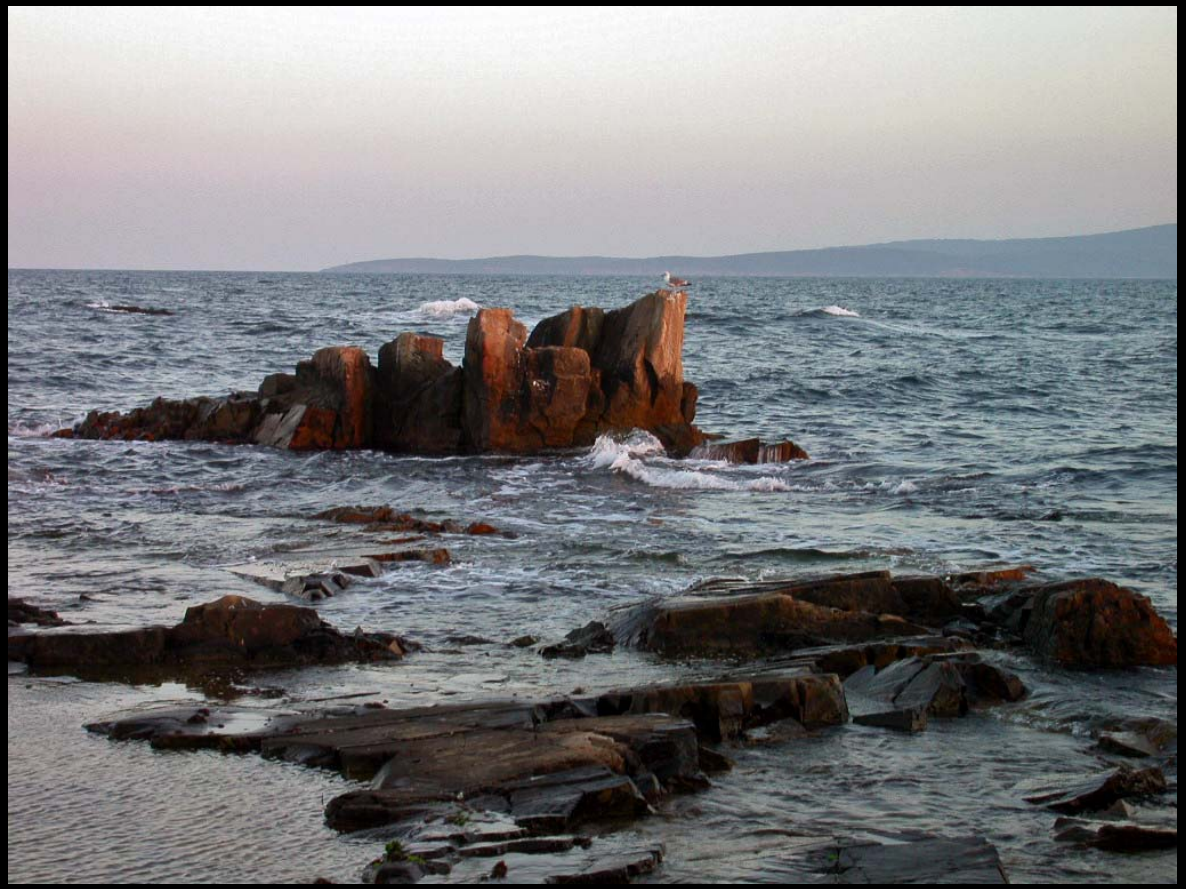
Geochemistry and geochronology of Eastern Srednogorie zone, Bulgaria



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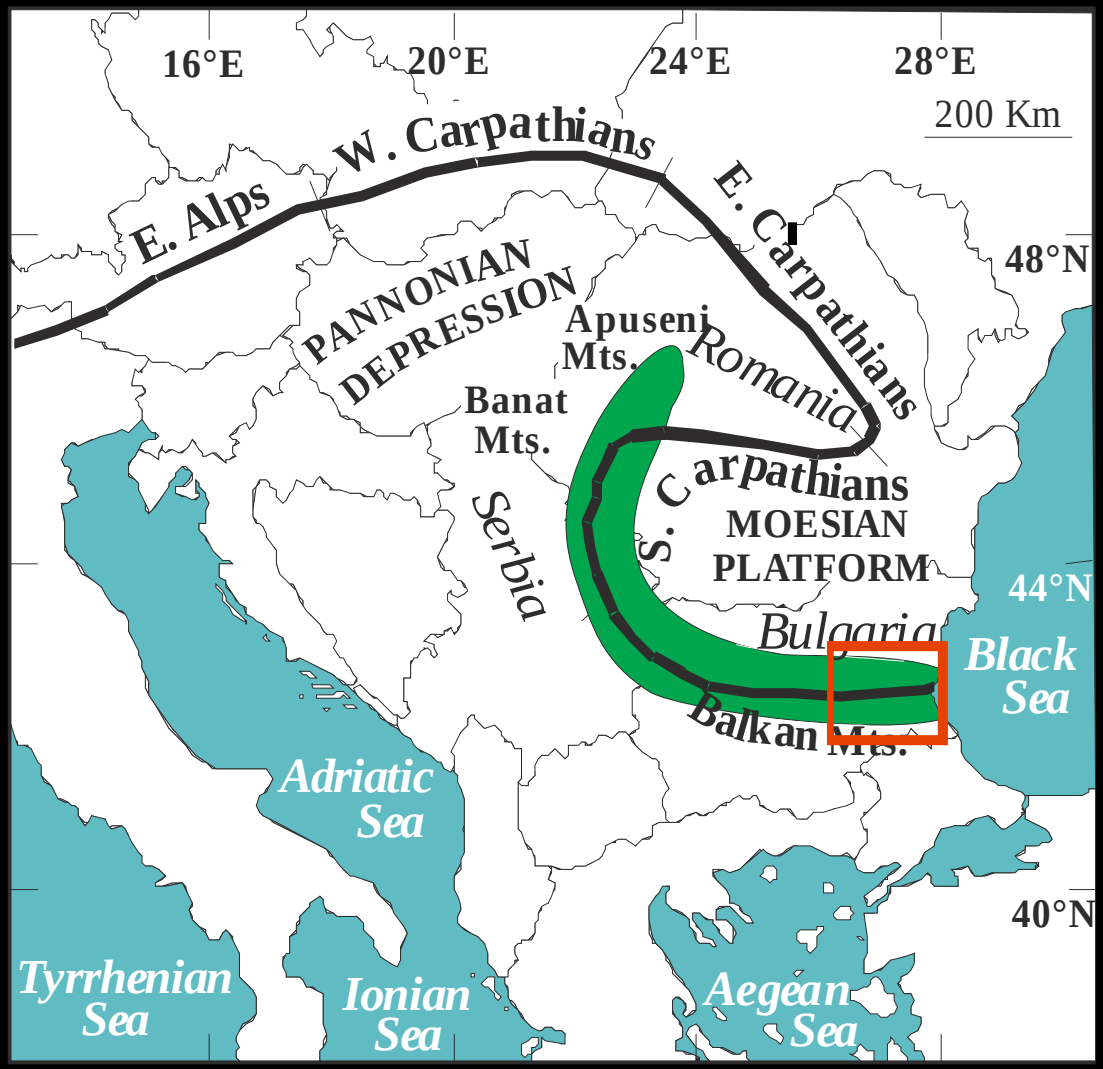
ABTS belt in SE Europe

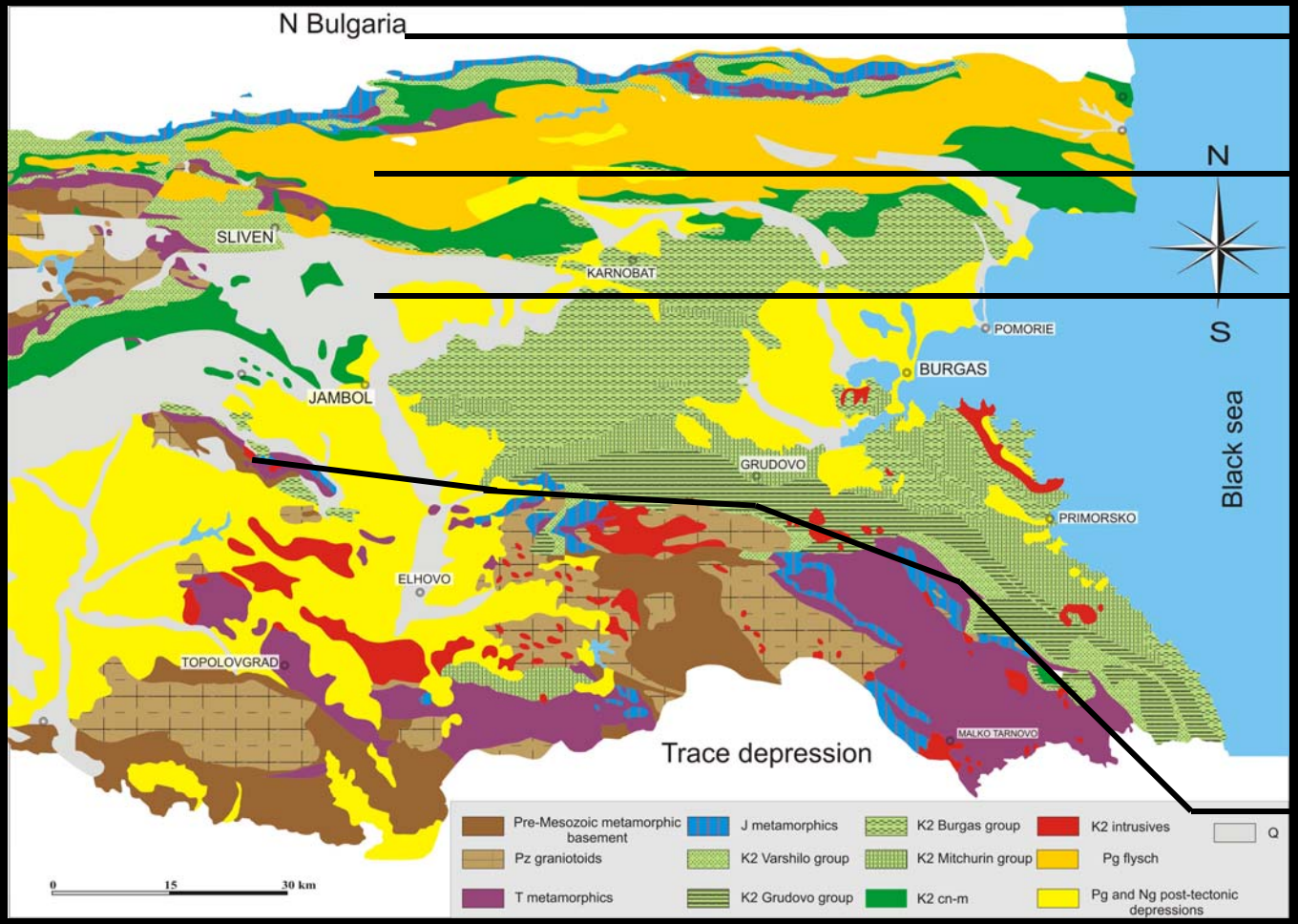
K_2 igneous activity

Numerous ore deposits

Controversial tectonics



Magmatism in Eastern Srednogorie



LKVR

NBVR

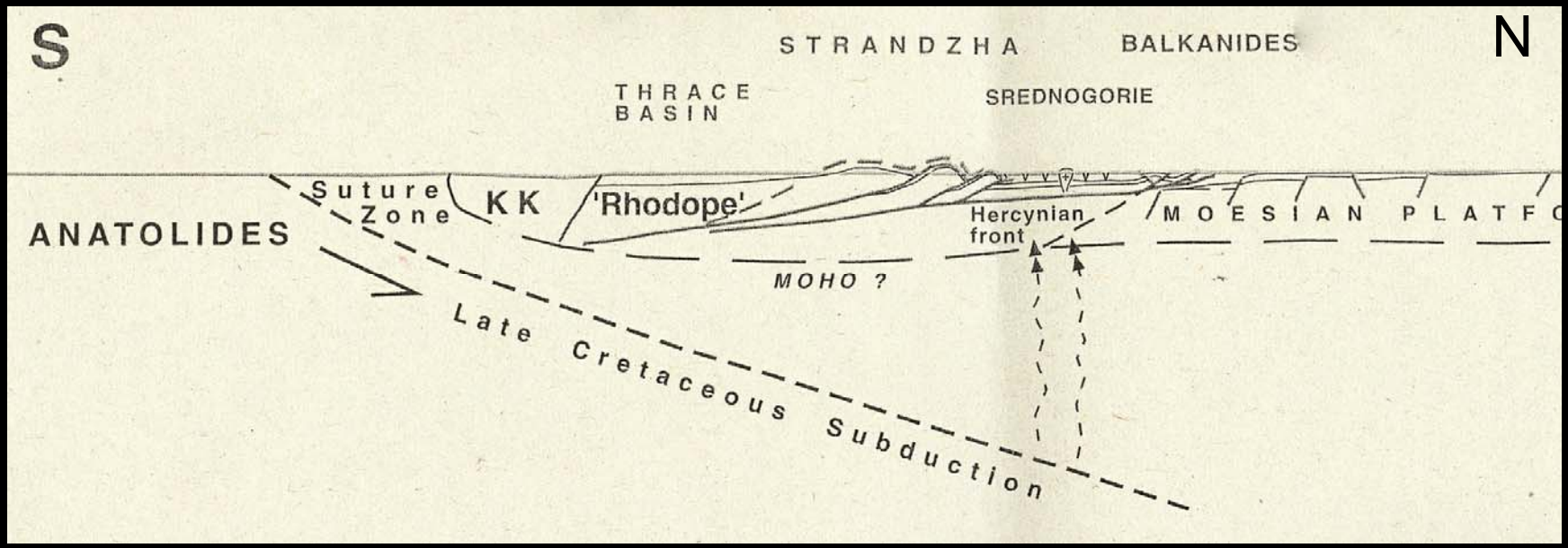
YBVIR

SVIR

Specifics of Eastern Srednogorie zone

- **Thinnest crust in the Balkan Peninsula (27-30km)**
- **Most voluminous magmatism in ABTS (ca. 60% of Srednogorie magmatism)**
- **Great variety of magmatic rocks**
- **Basic magmatism prevails**
- **Specific style of mineralization**
- **Lack of major economic deposits**

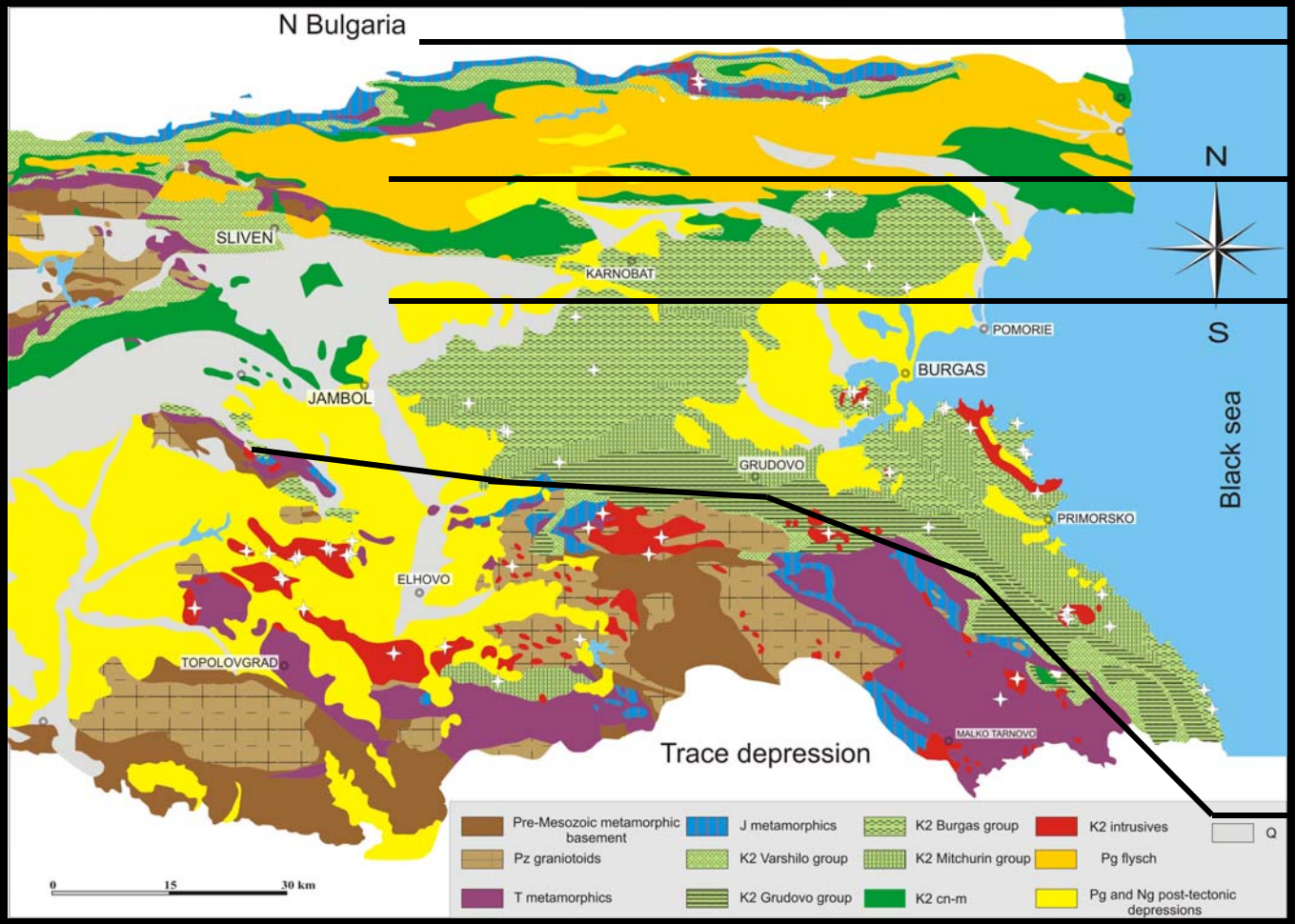
- K2 subduction of the Tethys ocean (Vardar branch) beneath the Moesian platform



Aims

- to characterize the magmatic products in terms of their major and trace elements content
- to put constraints on the potential sources involved in the genesis of the magmatic rocks
- to quantitatively model the contributions of the different sources
- to obtain precise ages of the Cretaceous igneous rocks, as well as the basement granites
- to trace the temporal and compositional evolution of the magmatism
- to start discussion

Sampling strategy:



LKVR (6)

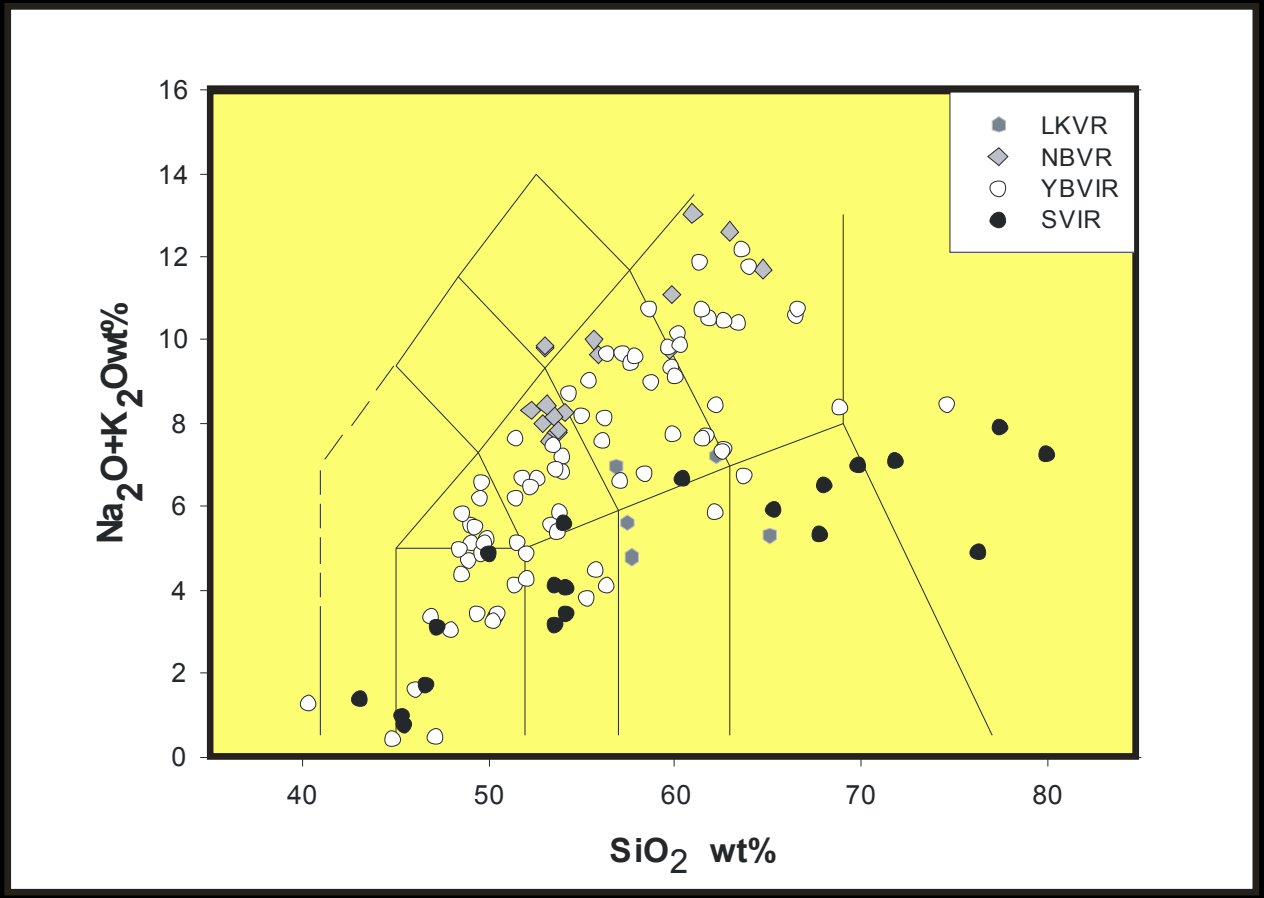
NBVR (17)

YBVIR (78)

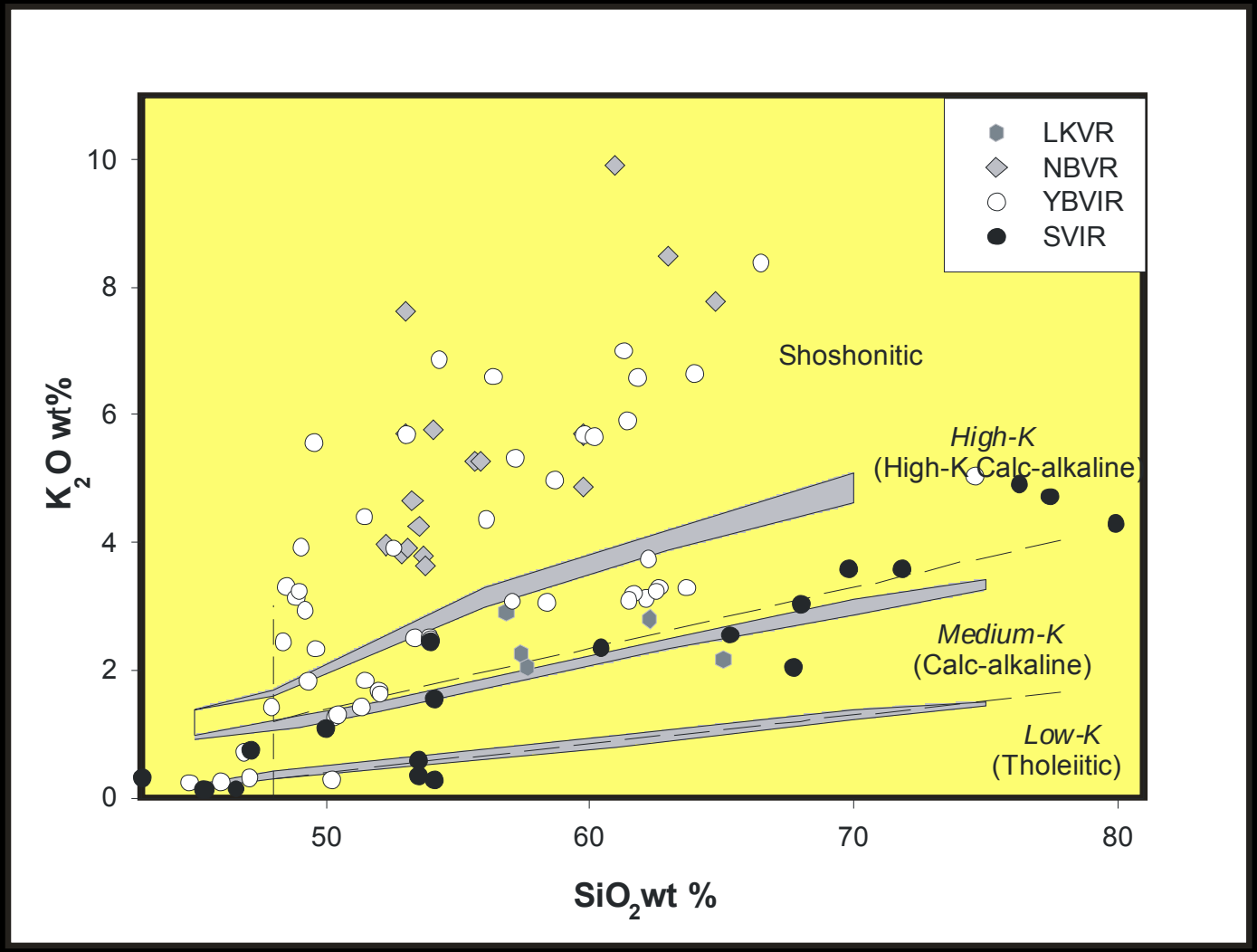
SVIR (20)

Whole-rock geochemistry

- Great diversity
- intrusive more common in SVIR
- Mafic rocks predominate
- High-Si rocks more common in SVIR
- total alkalinity higher in YBVIR and NBVR

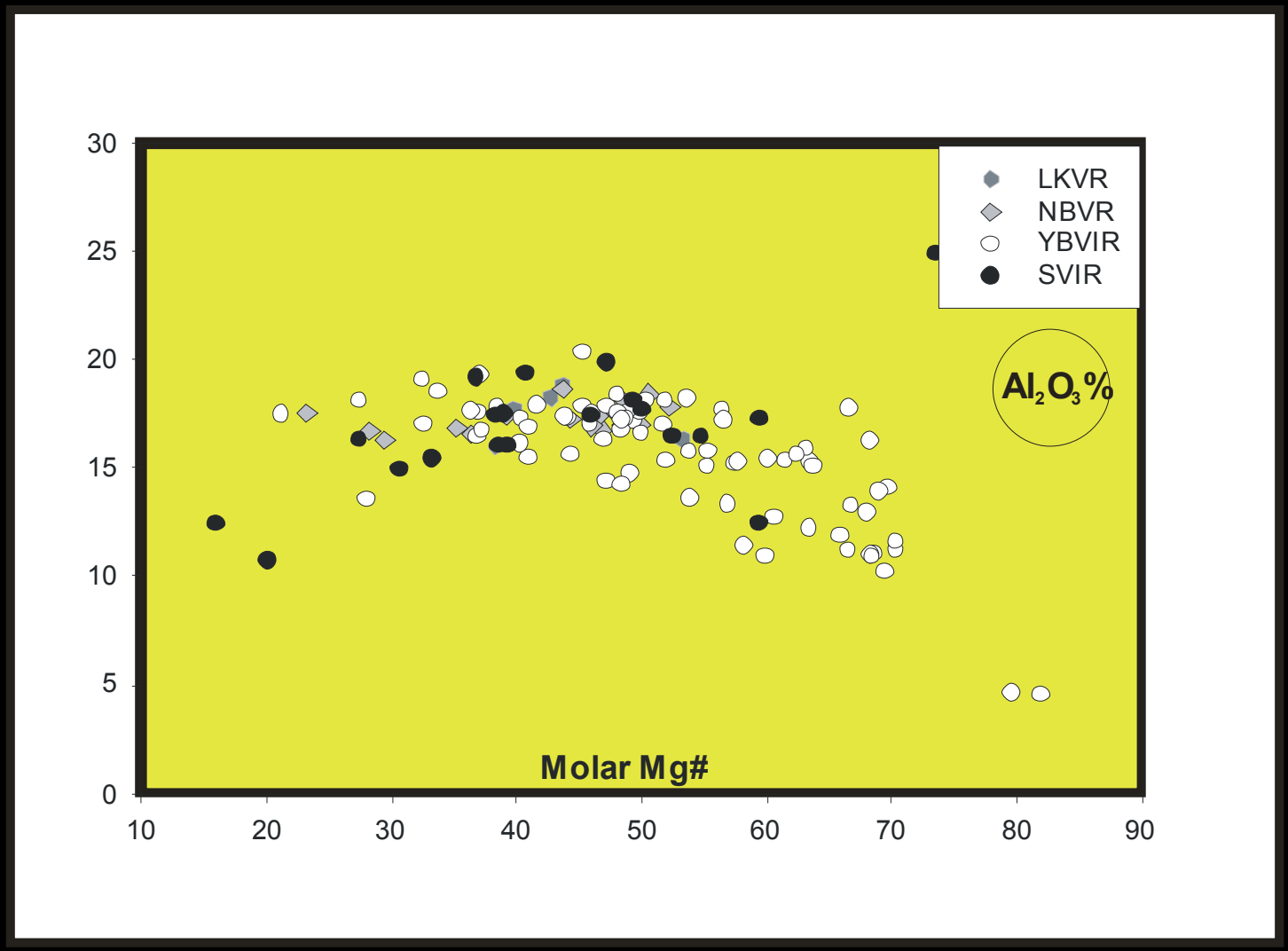


Whole-rock geochemistry



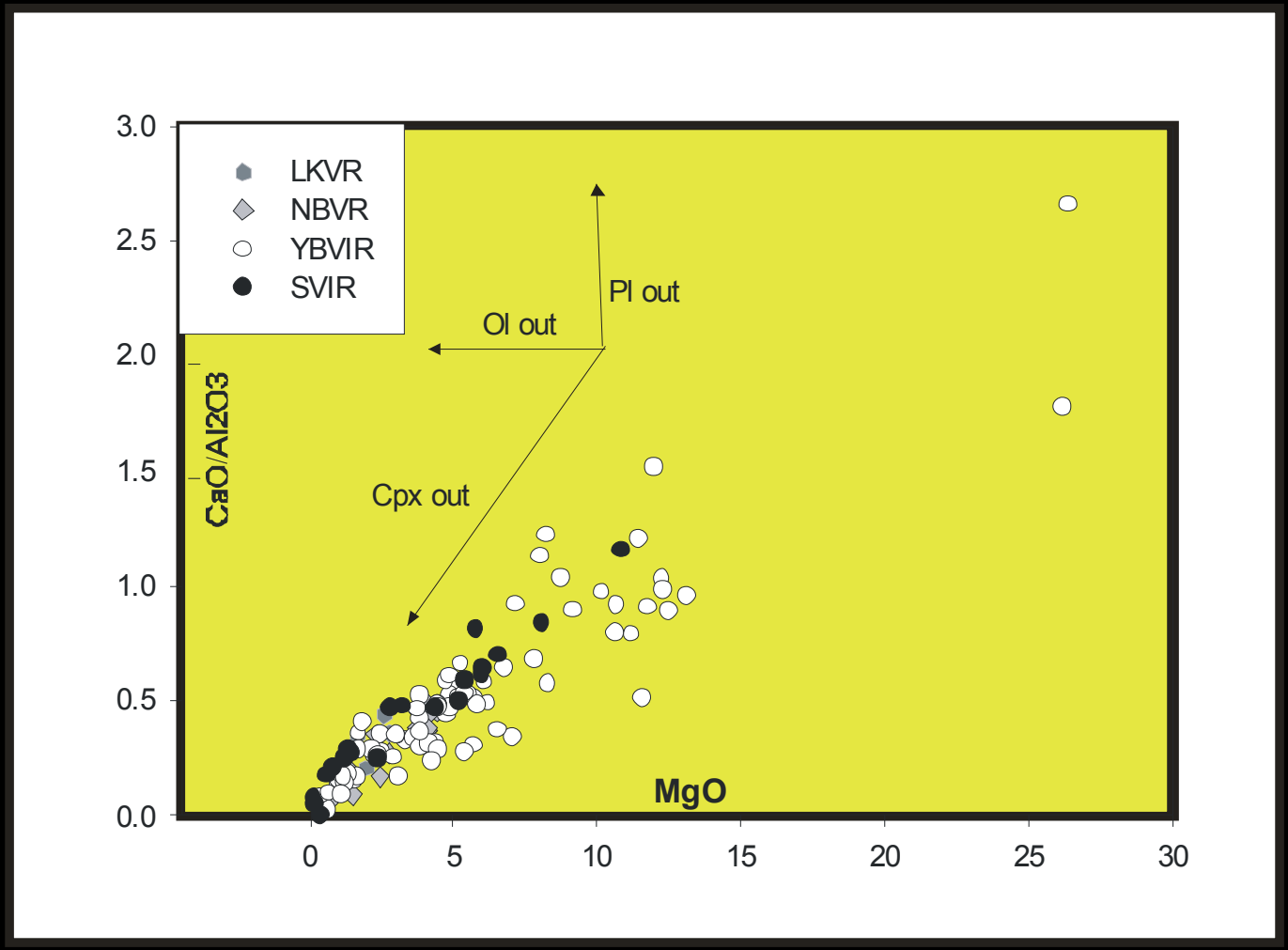
- SVIR and LKVR:calc-alkaline trend
- YBVIR and NBVR high-K, shoshonitic and ultra-High K

Whole-rock geochemistry



- Cpx fractionation controls differentiation.
- Ol, and later Pl, Bt, Fe-Ti oxides play subordinate role

Whole-rock geochemistry



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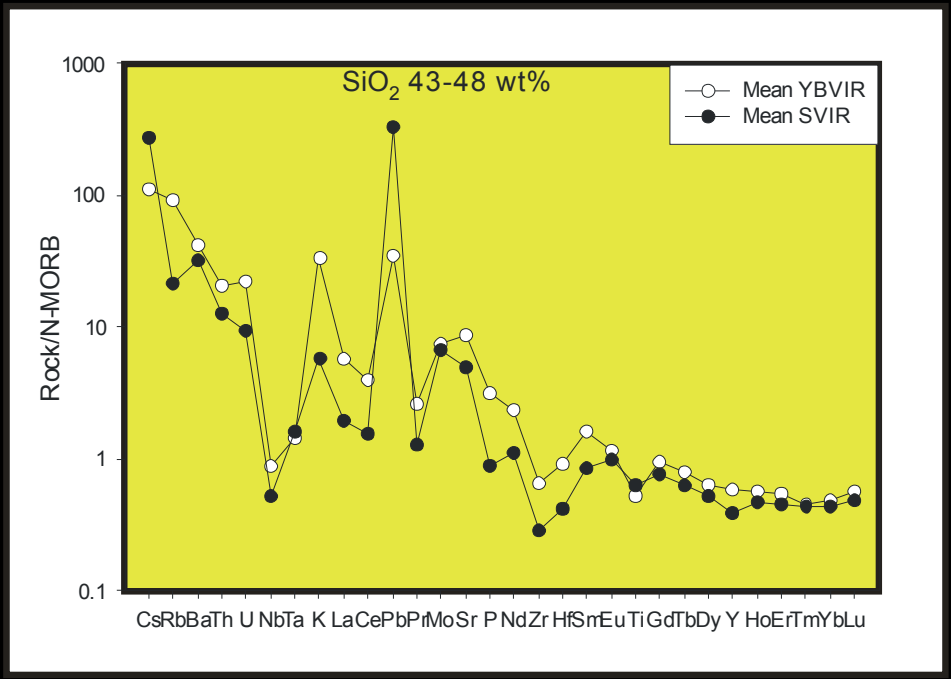
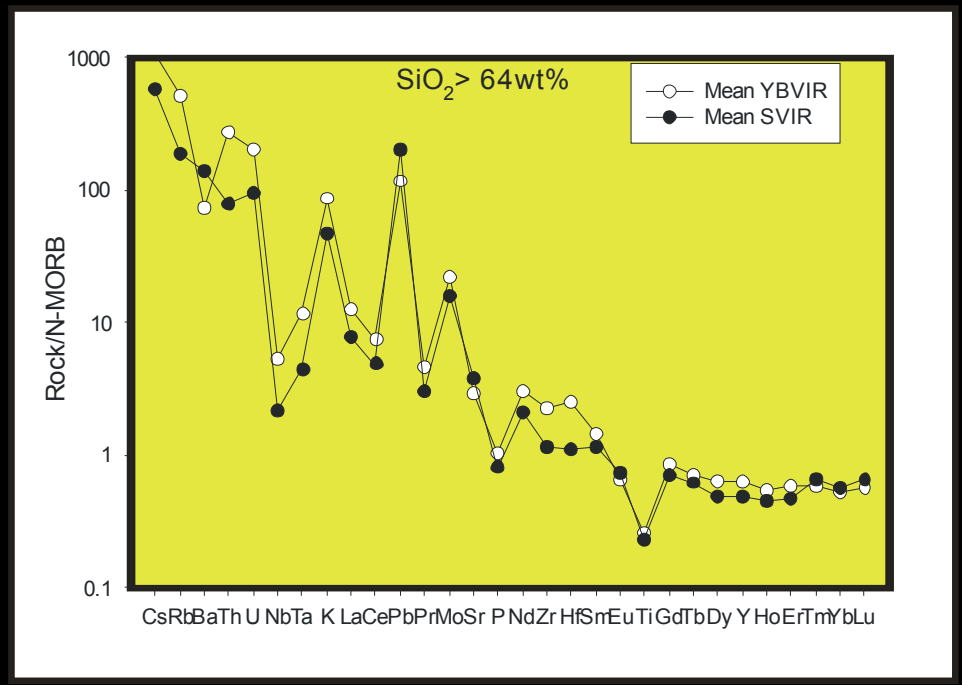
Whole-rock geochemistry

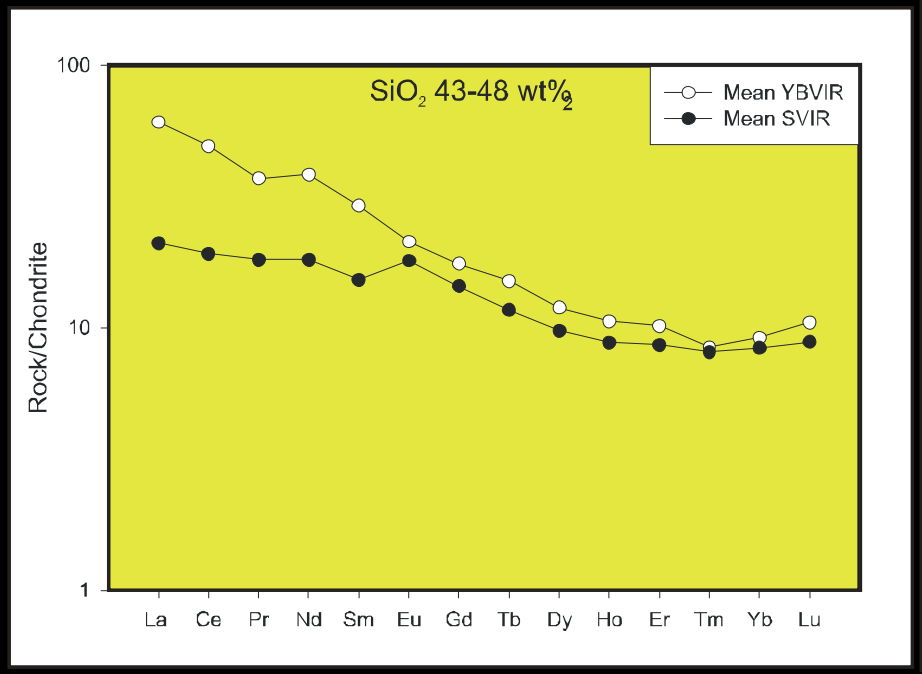


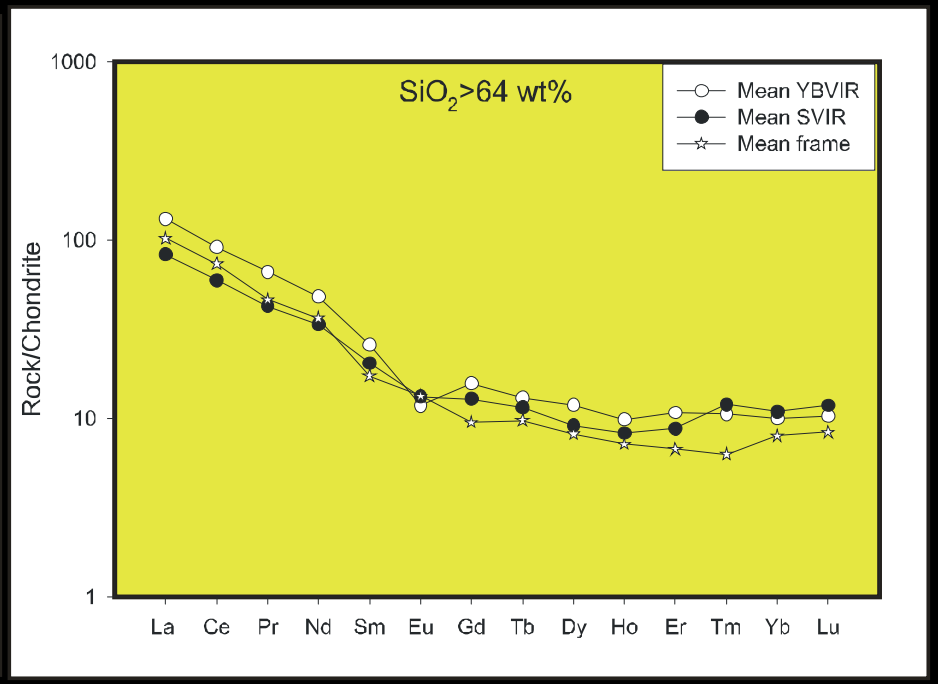


- Rocks from all SiO2 groups show similar Patterns. Strong subduction signature
- Enriched in LILE and LREE relative to HFSE and HREE

- Pronounces Nb-Ta trough Zr, Hf and Ti negative anomalies
- Strong Pb, K and Sr positive spikes
- Absolute abundances higher in YBVIR and NBVR

Whole-rock geochemistry

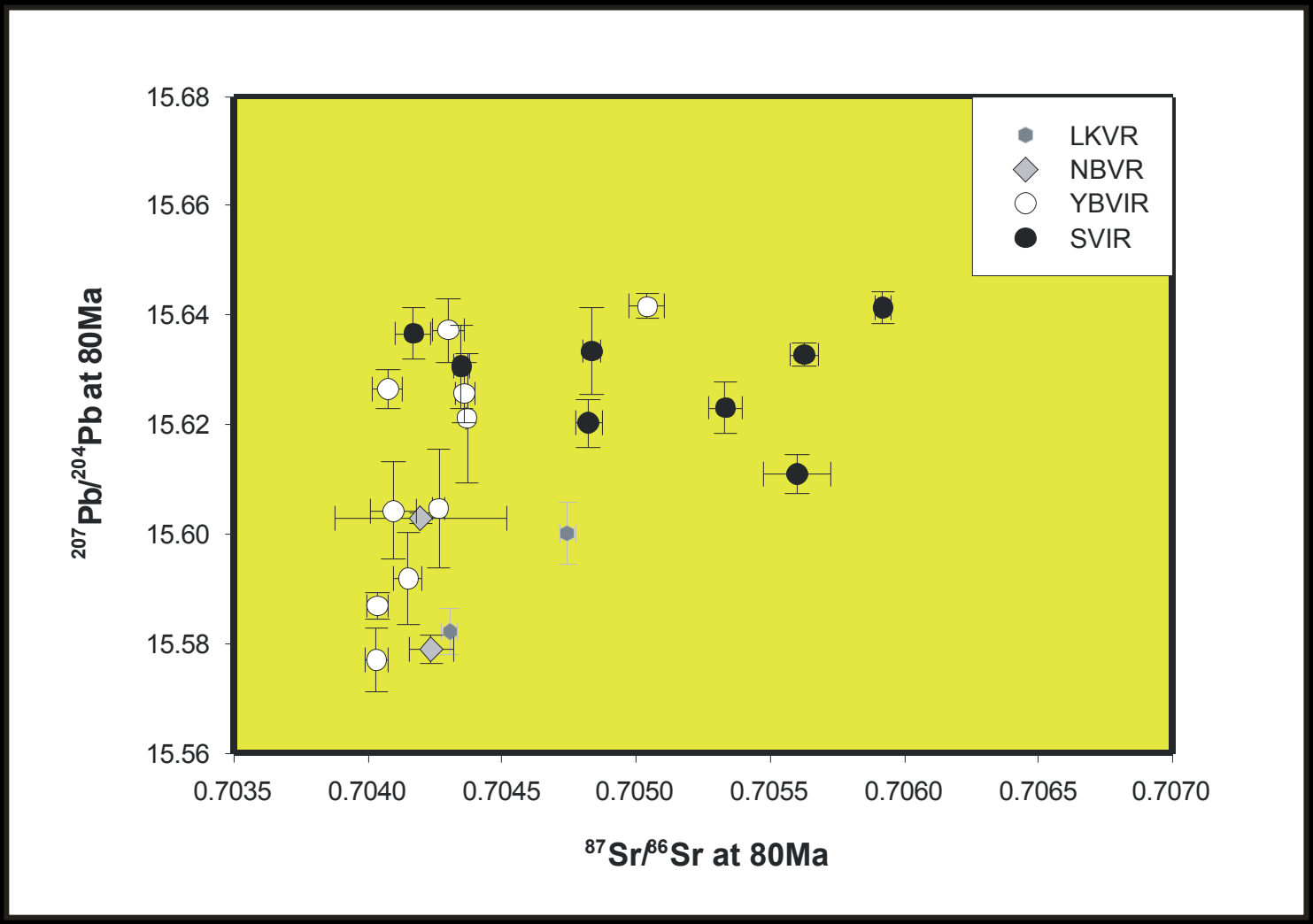




- Similar patterns
- LREE to HREE enrichment
- Flat HREE patterns

- Absolute abundances and LREE to HREE enrichment higher in YBVIR and NBVIR
- Lack of Eu anomaly

Whole-rock isotopes



- Sr isotopes higher in SVIR

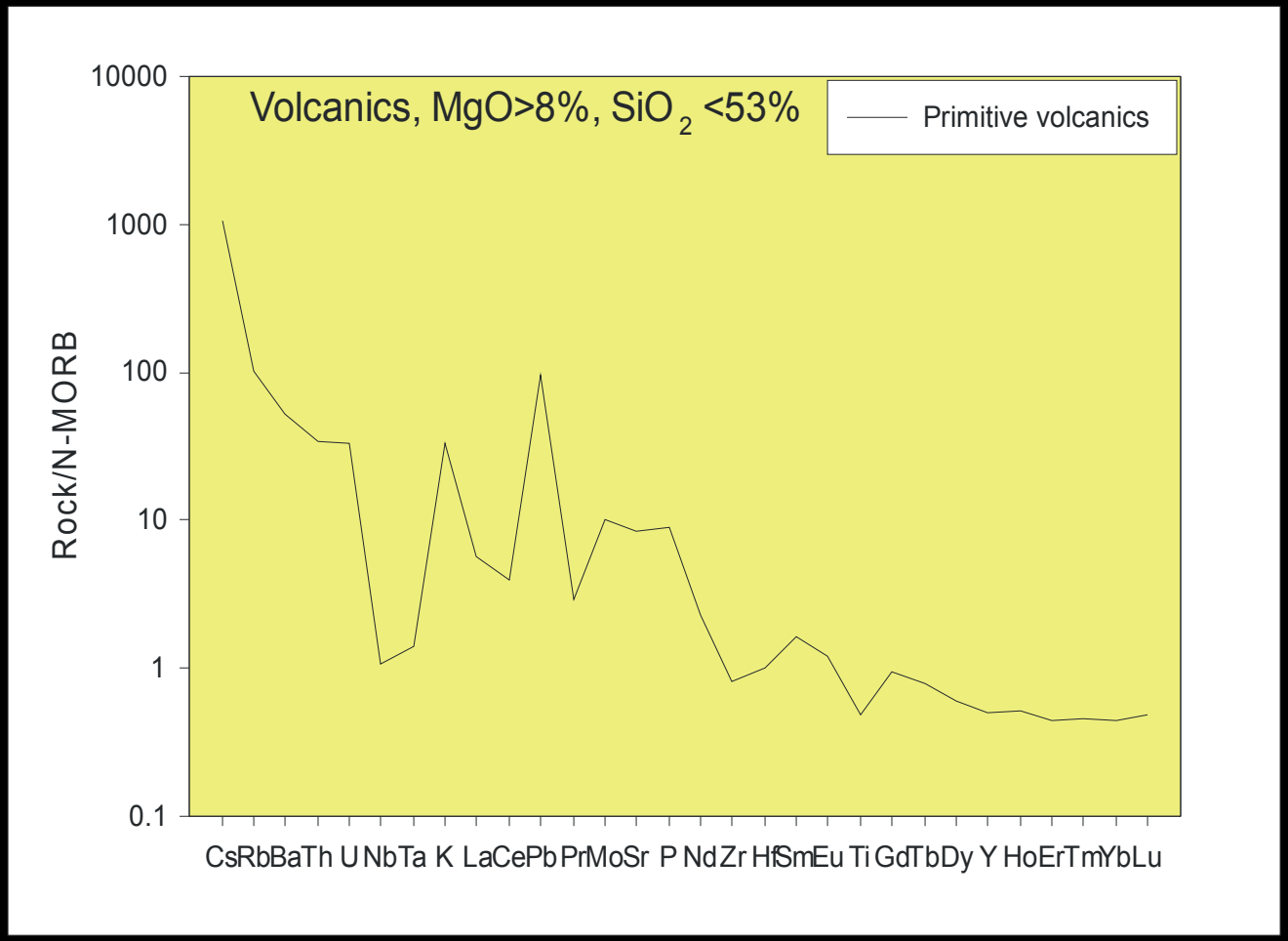
YBVIR rocks more primitive signature

Primitive rocks: rare case in arc environment

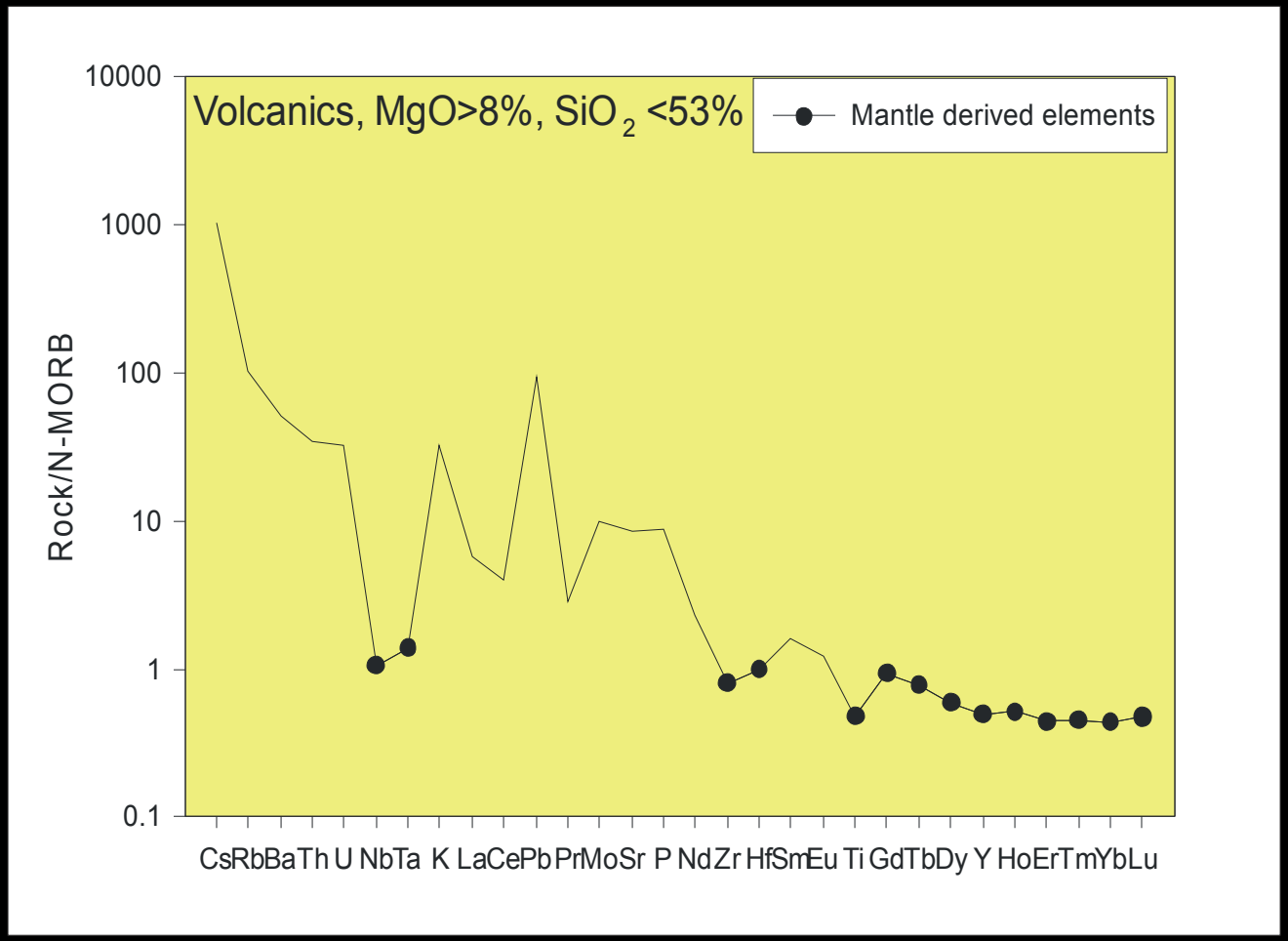
- Volcanic
- MgO > 8 wt%
- SiO2< 53%
- Least radiogenic Sr and Pb isotopes

- Insignificant degree of differentiation and crustal assimilation
- Unique information about processes deep in the earth

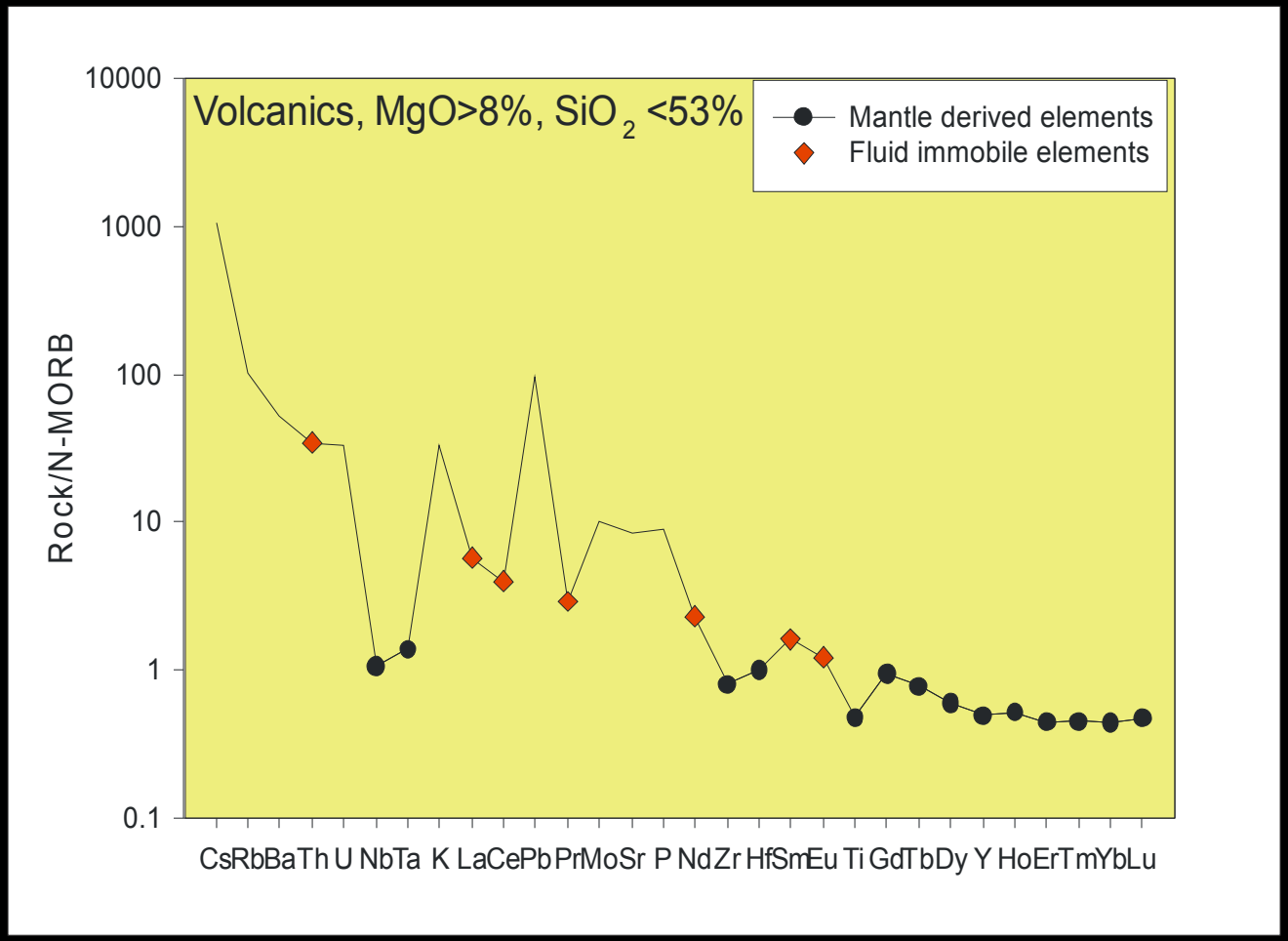
Subduction zone elemental budget



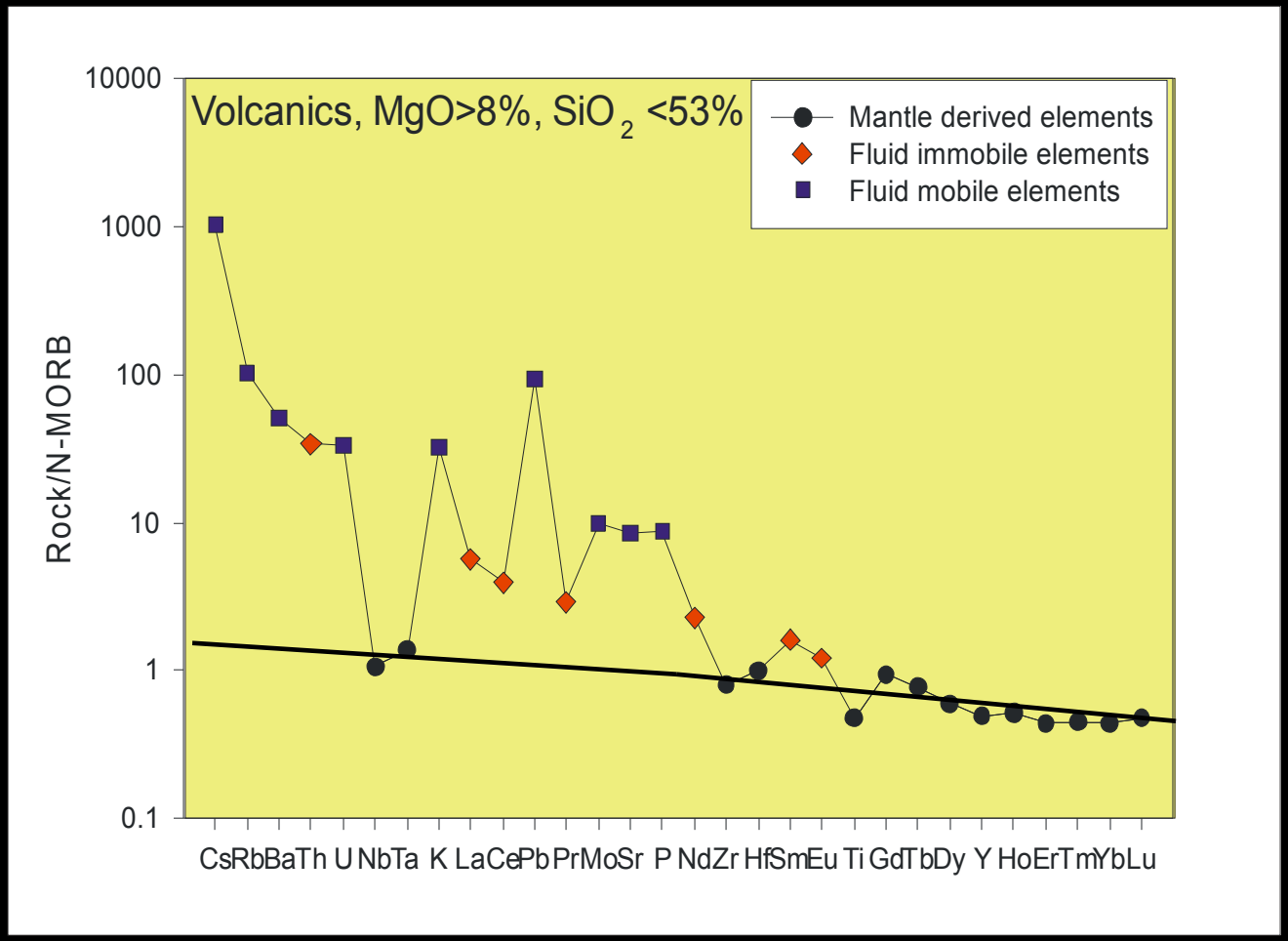
Subduction zone elemental budget



Subduction zone elemental budget

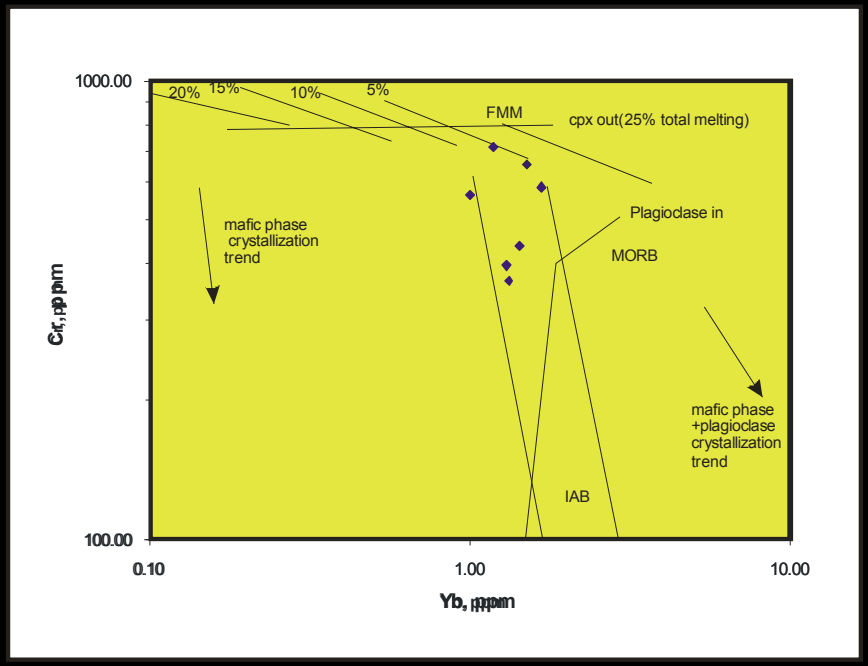


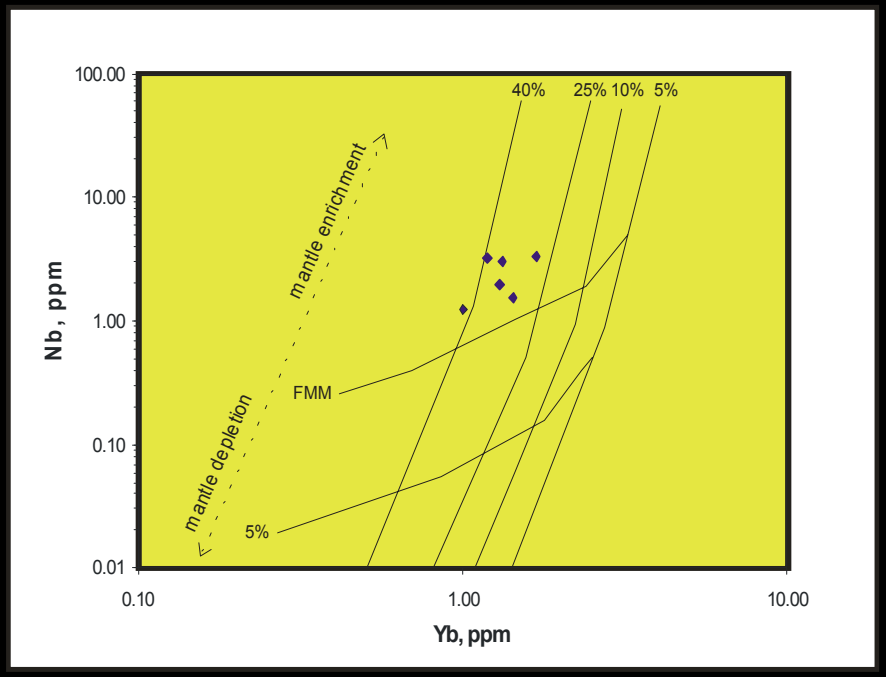
Subduction zone elemental budget



- Inferred unmodified source composition - slight degree of enrichment

Source characteristics. Degree of melting

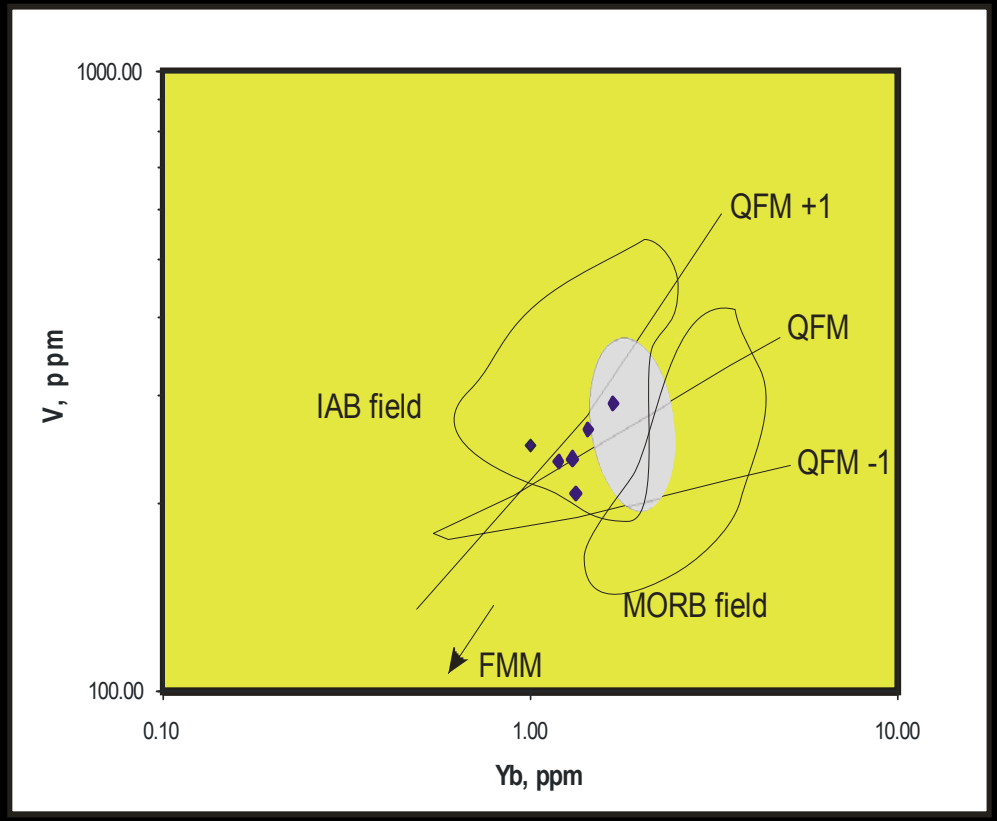


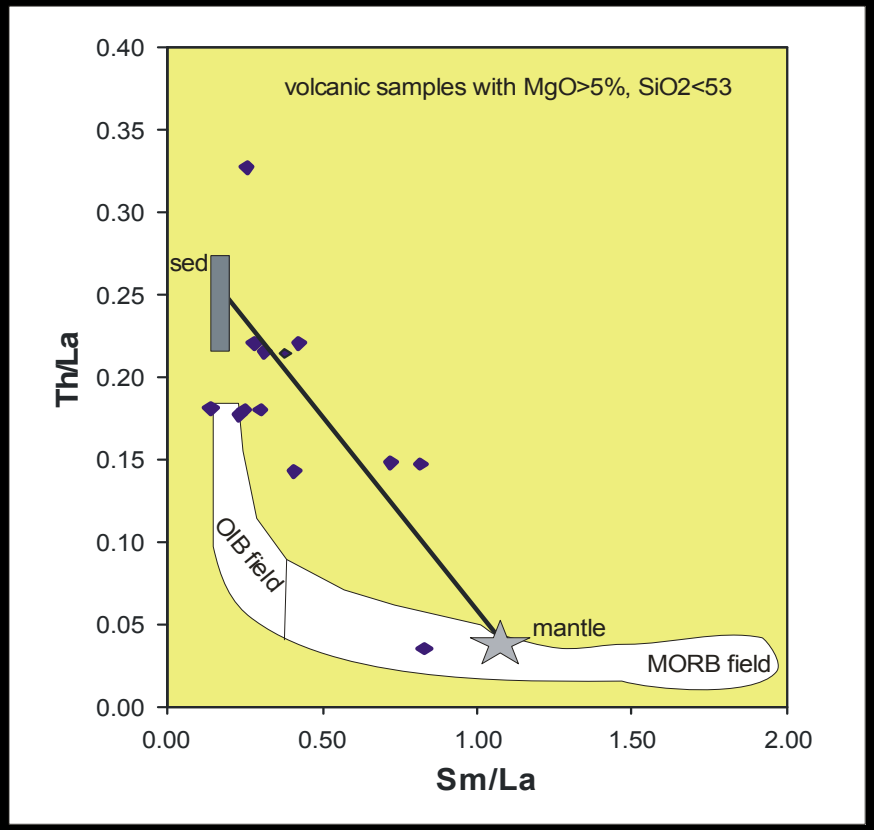


- Normal to slightly enriched source.

25-40 % degrees of mantle melting

Source characteristics. Additional components

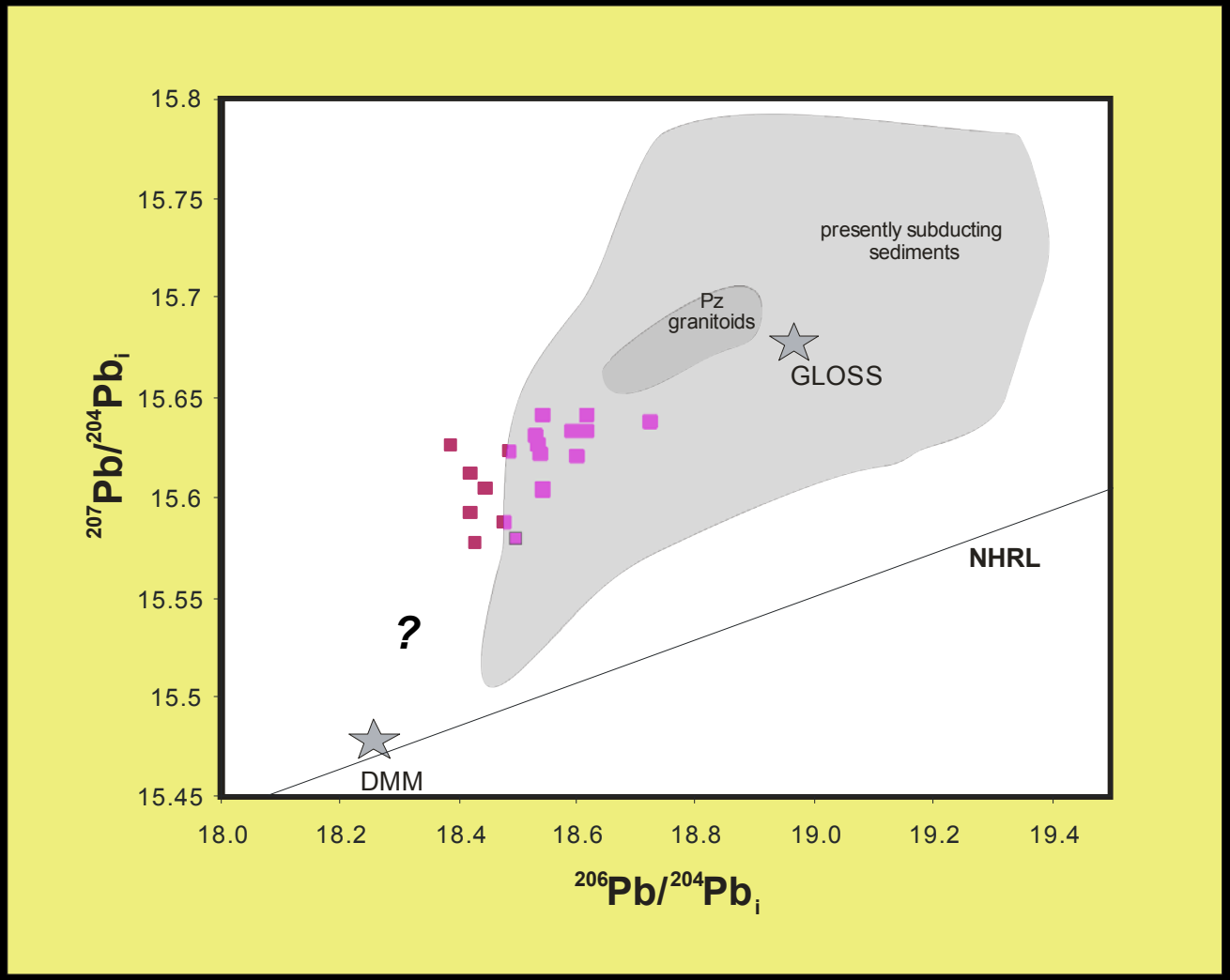




- Enriched source.
- Oxygen fugacities QFM +1

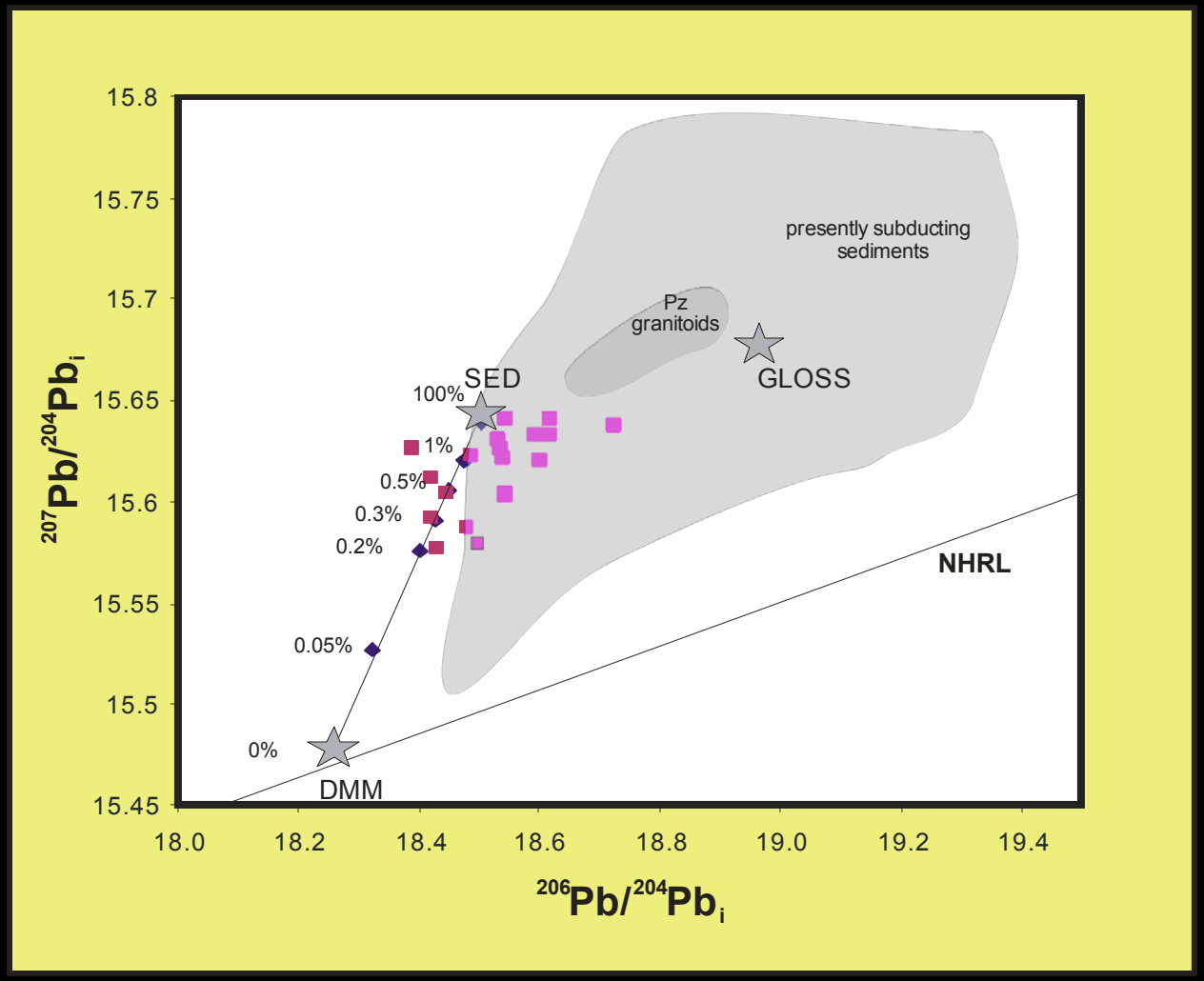
- High Th/LREE require sediment addition or slab melts.
- Intersection of the line with MORB filed confirms undepleted nature of the source

Stage I. Subduction modification



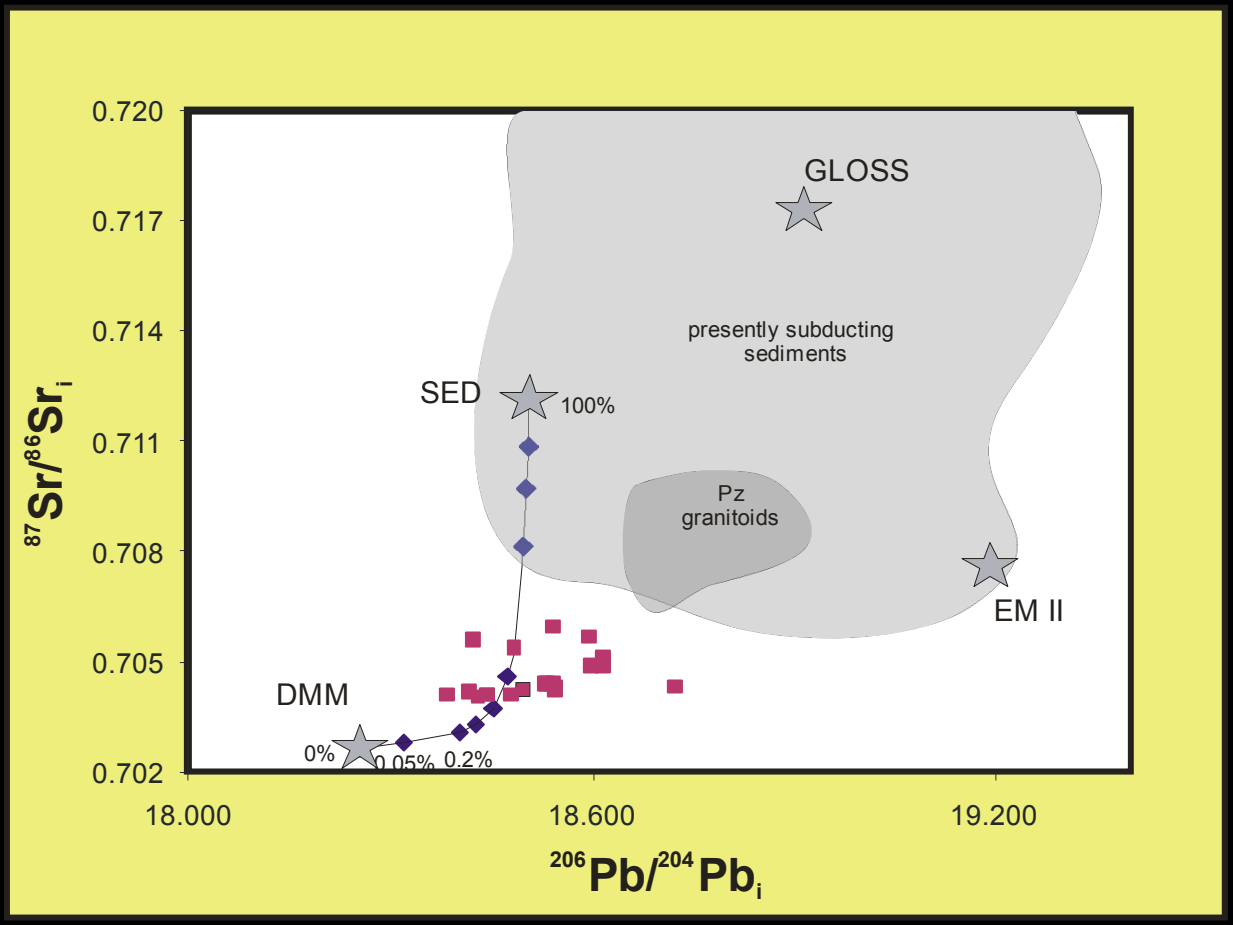
- Apparent modification of the DMM source

Stage I. Subduction modification



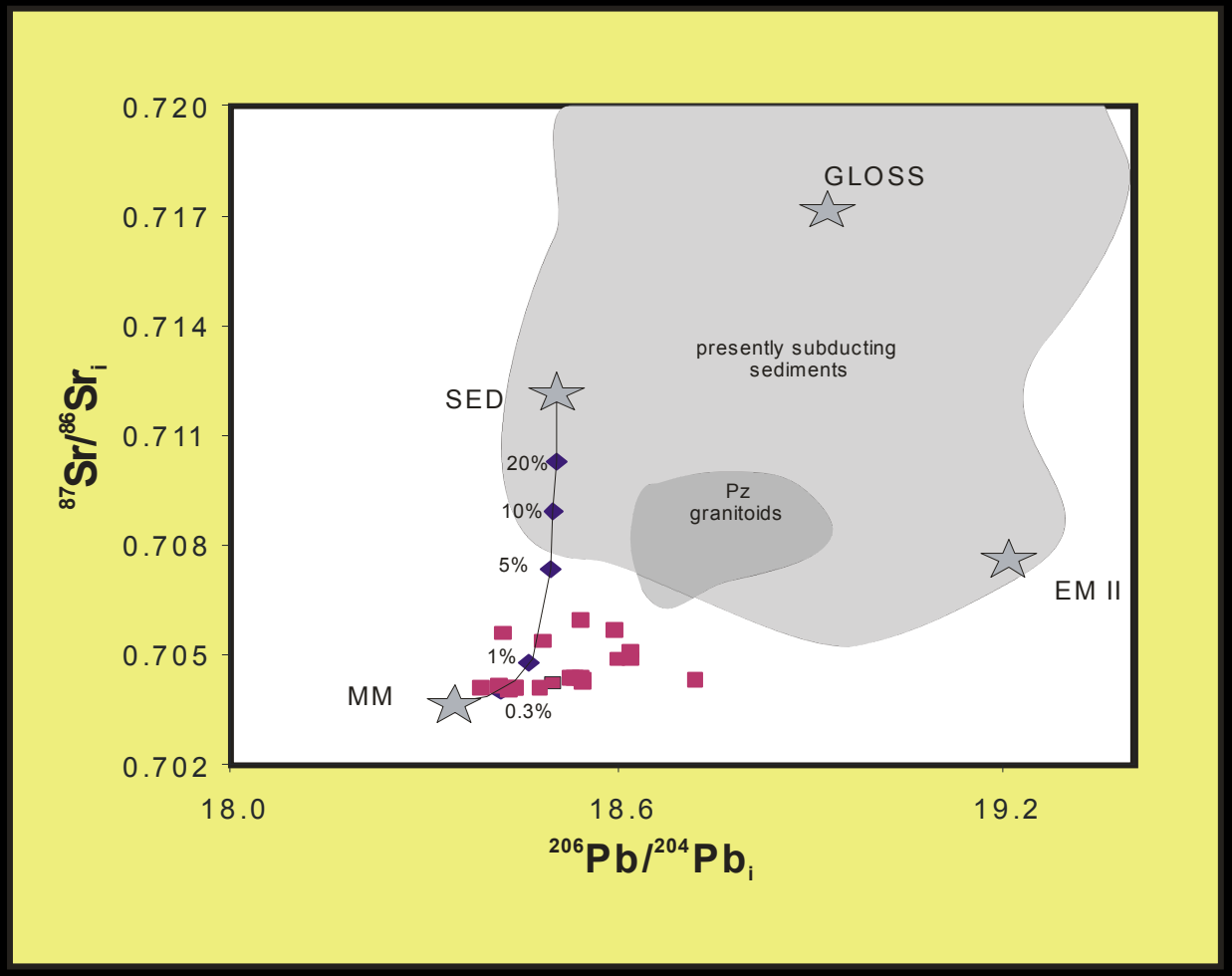
- Few sediments appropriate, Terrigenous-biogenic sediment from the Southrhern Pacific explains Pb ratios of primitive rocks

Stage I. Subduction modification



- Additional component needed to explain Sr ratios

Stage I. Subduction modification



Modification of the mantle wedge from:

- 0.09wt% AOC fluid

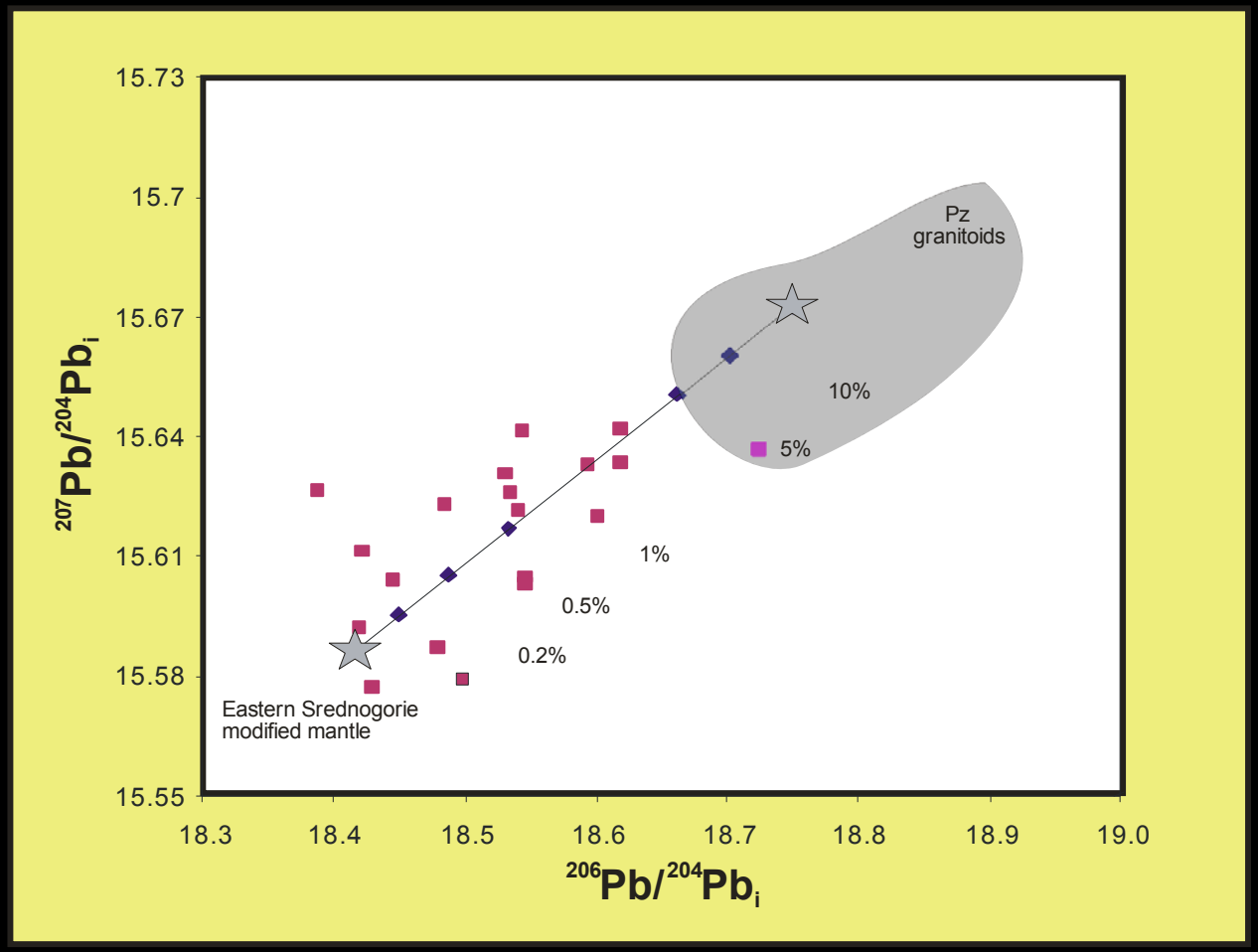
and

- 0.01wt% sediment fluid

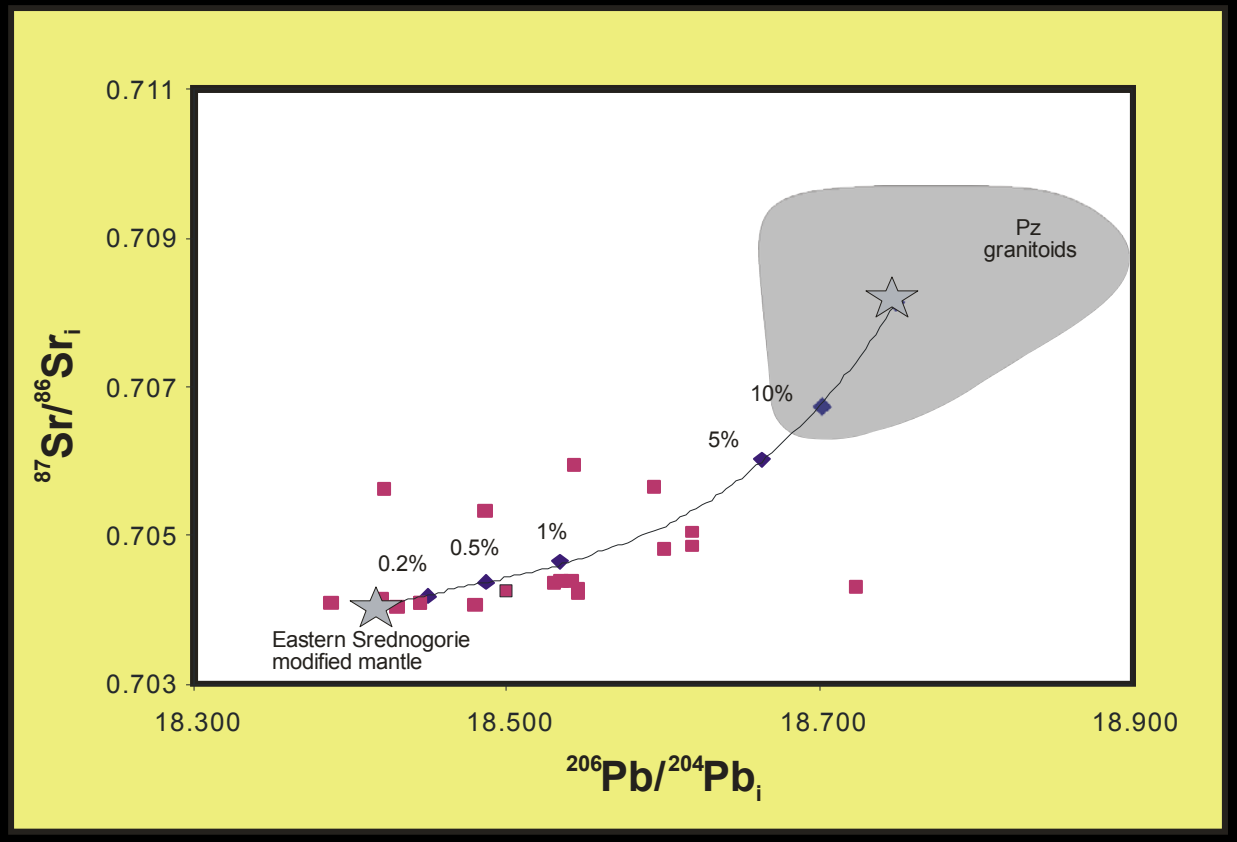
produce modified mantle

- 0.3wt% bulk sediment addition

Stage II. Assimilation of basement rocks

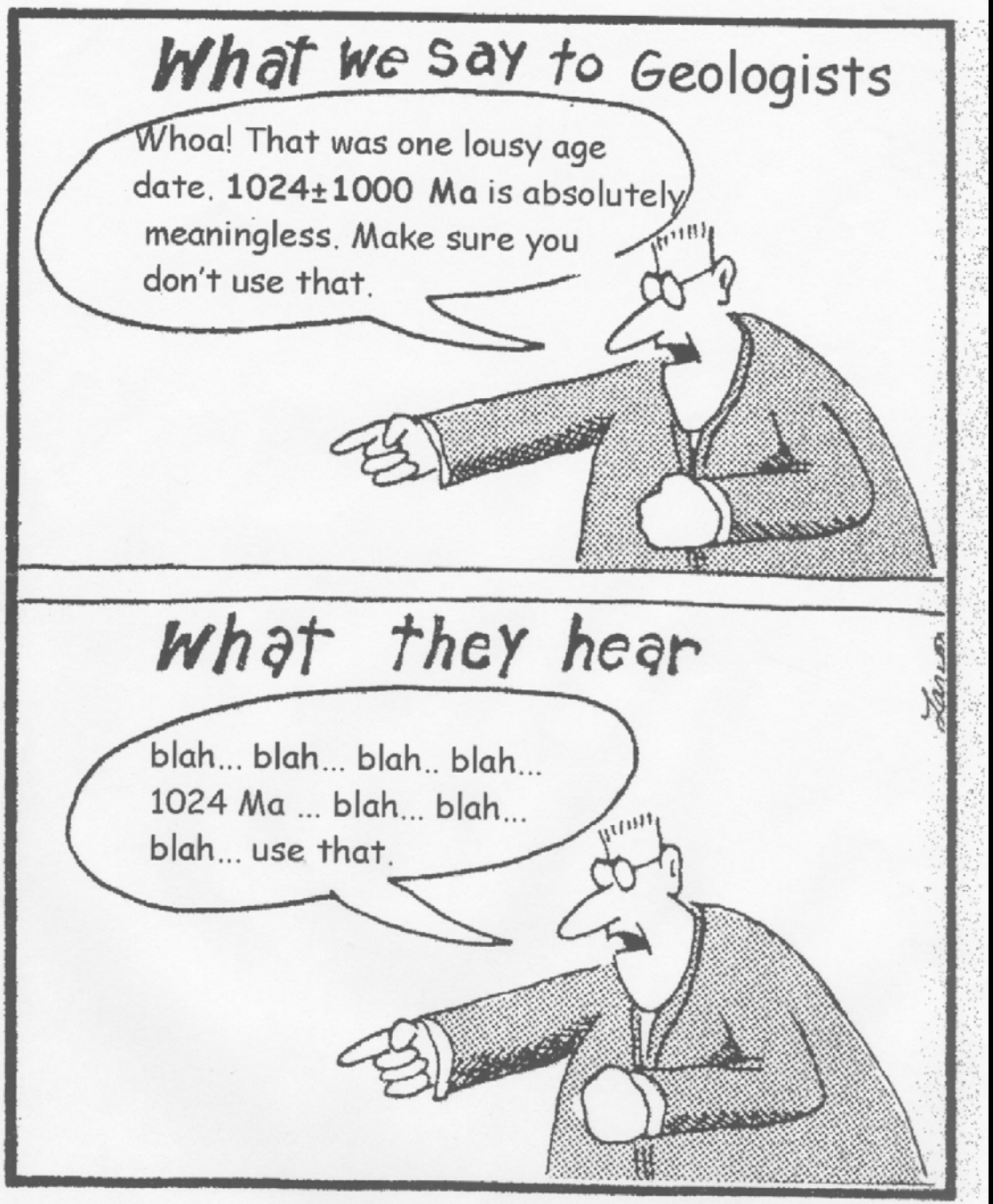


Stage II. Assimilation of basement rocks



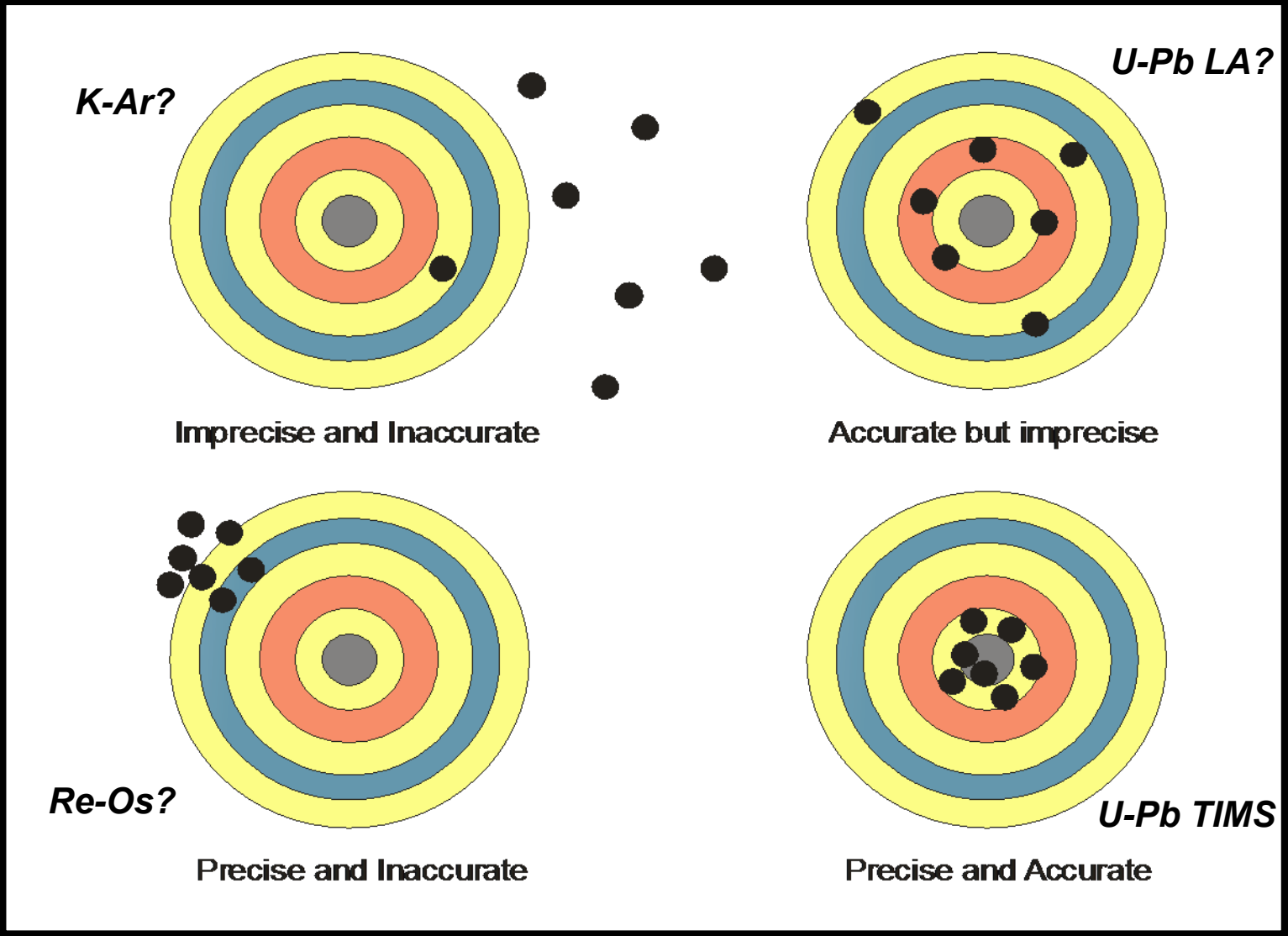
- Further assimilation of 0 to 5% crustal rocks (Permian granites) explain Pb and Sr isotope ratios

U-Pb zircon dating



after M Villeneuve, with apologies to Larson

Accuracy and Precision



Zircon dating- TIMS

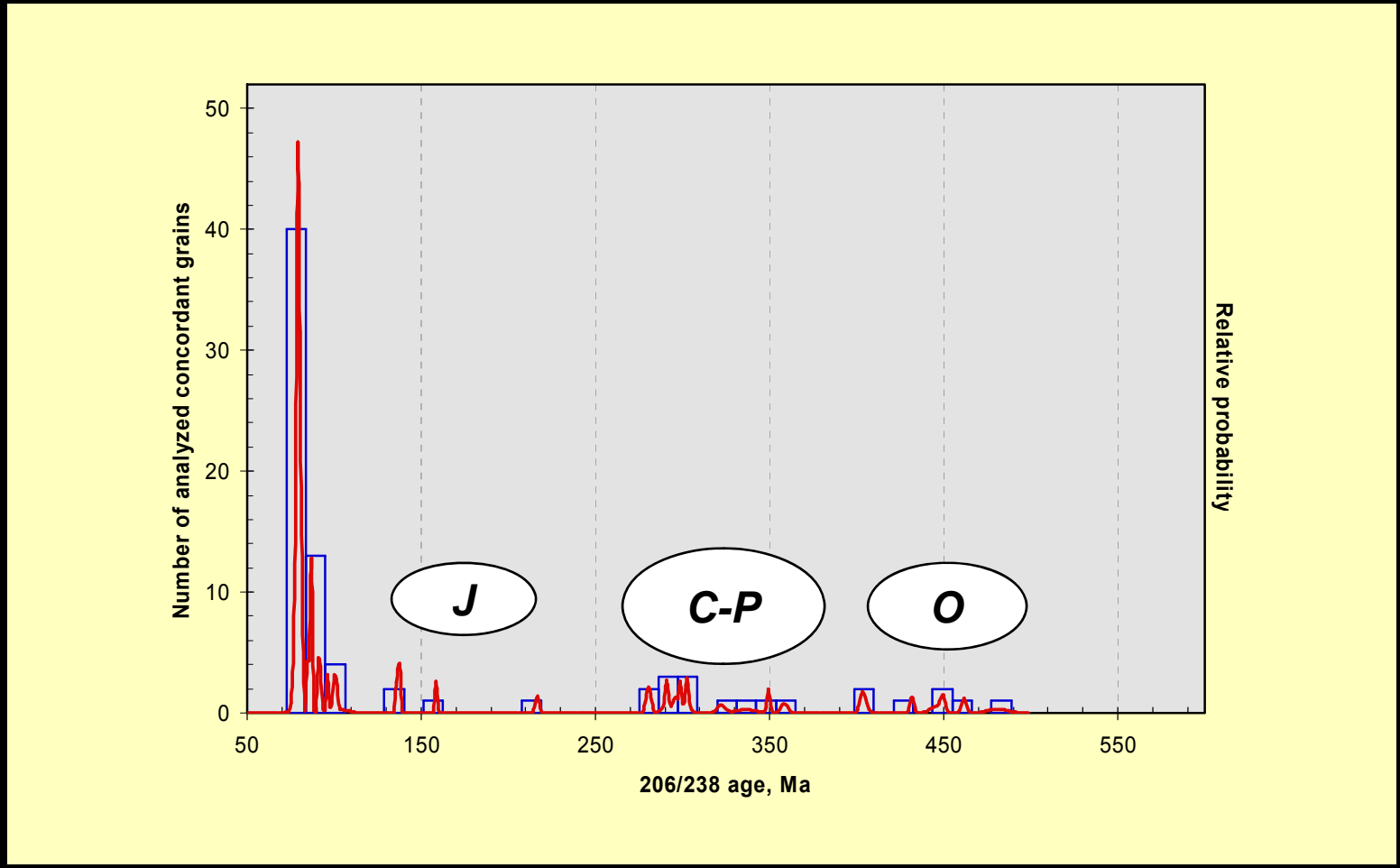
- accurate
- high precision
- time consuming and expensive
- problems with inheritance

LA-ICPMS dating

- little amount of pre-treatment
- fast (c.a. 2 min for a single shot)
- preserves at least part of the sample (unlike conventional)
- avoids/detects inheritance
- lower precision, lower accuracy

!!!!!!! Ideally use both methods !!!!!!!!

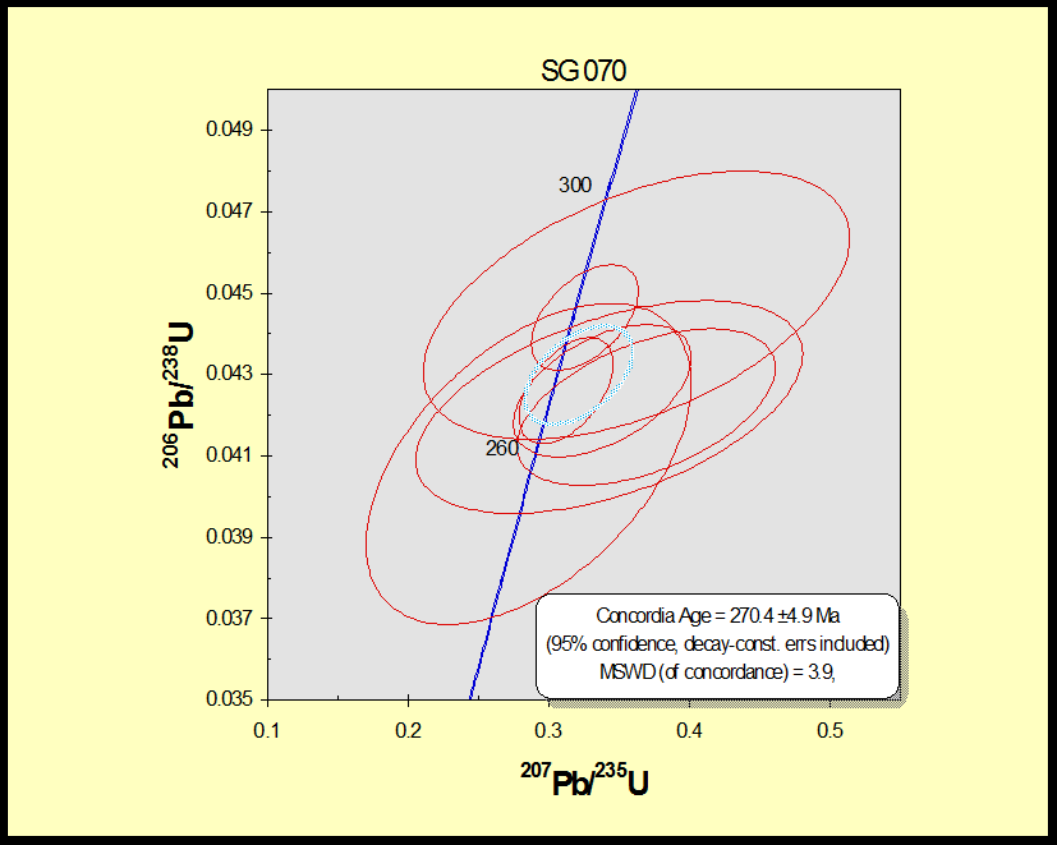
Cumulative plot of concordant zircons from K2 rocks: TIMS

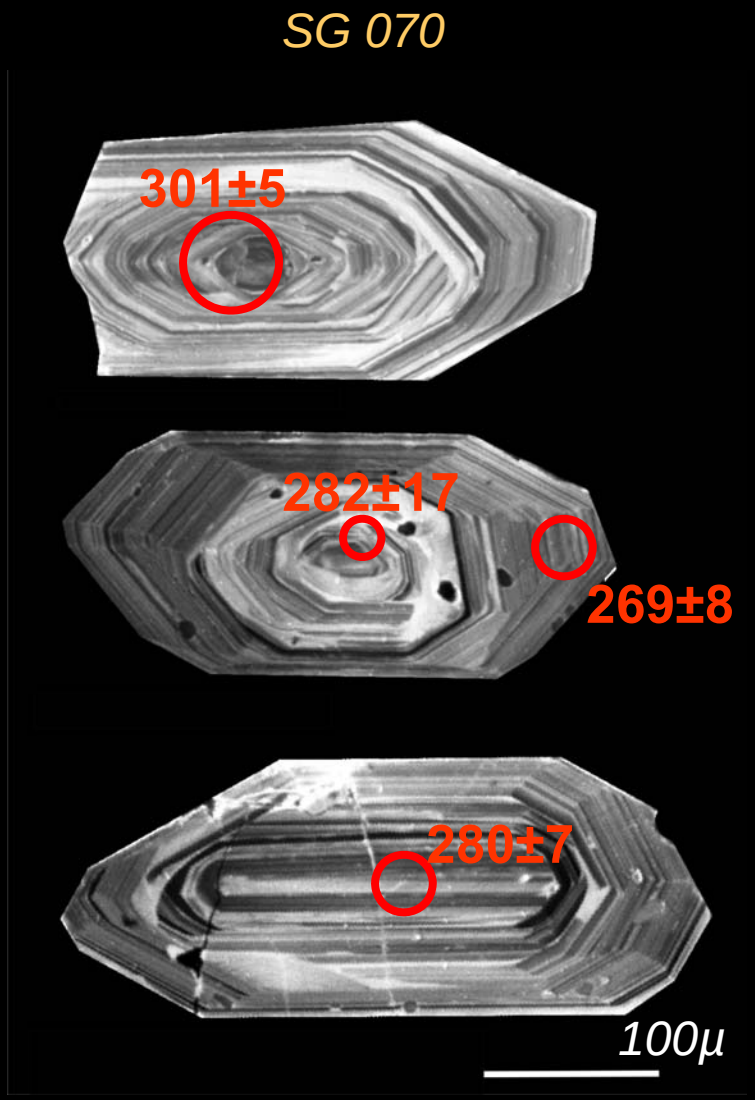


- Information about basement rocks
- inheritance patterns for different samples/zones

Zircon dating- LA ICPMS

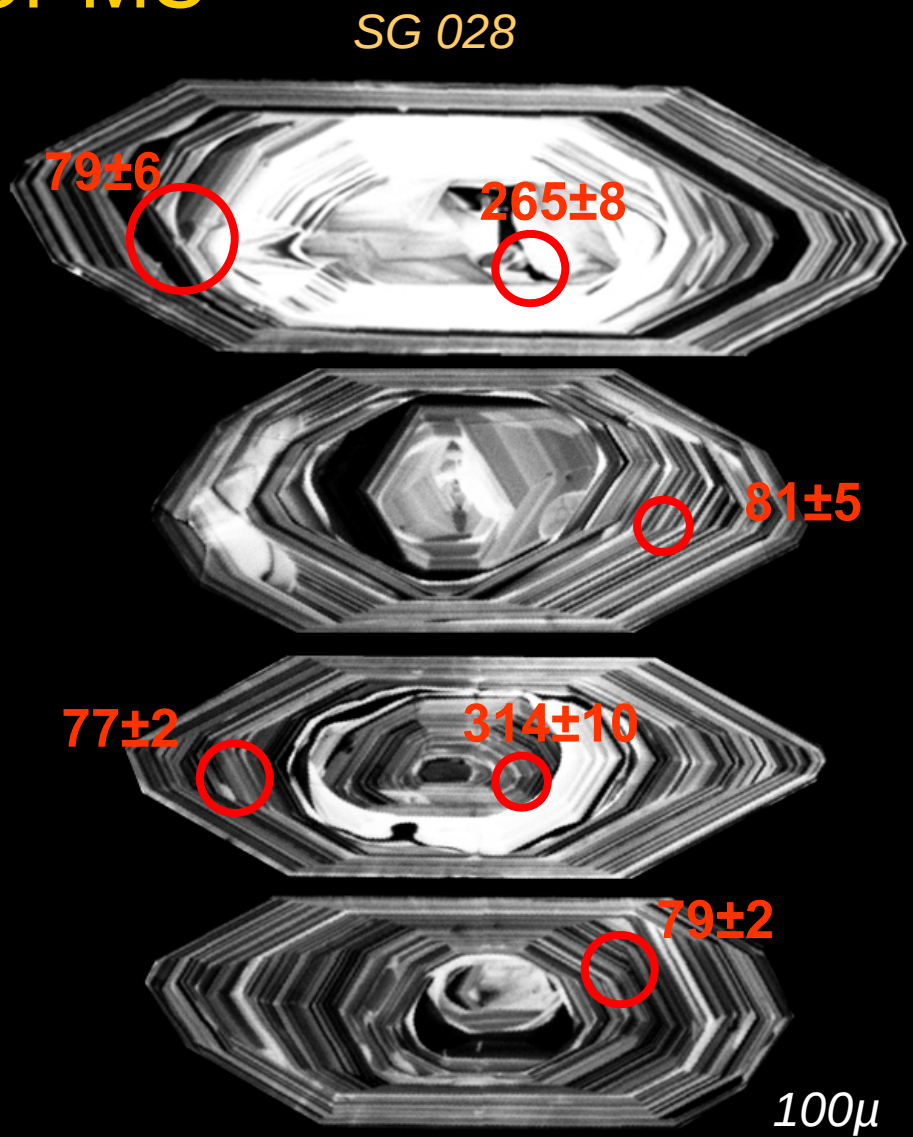
- SEM-CL imaging
- Dating basement granites





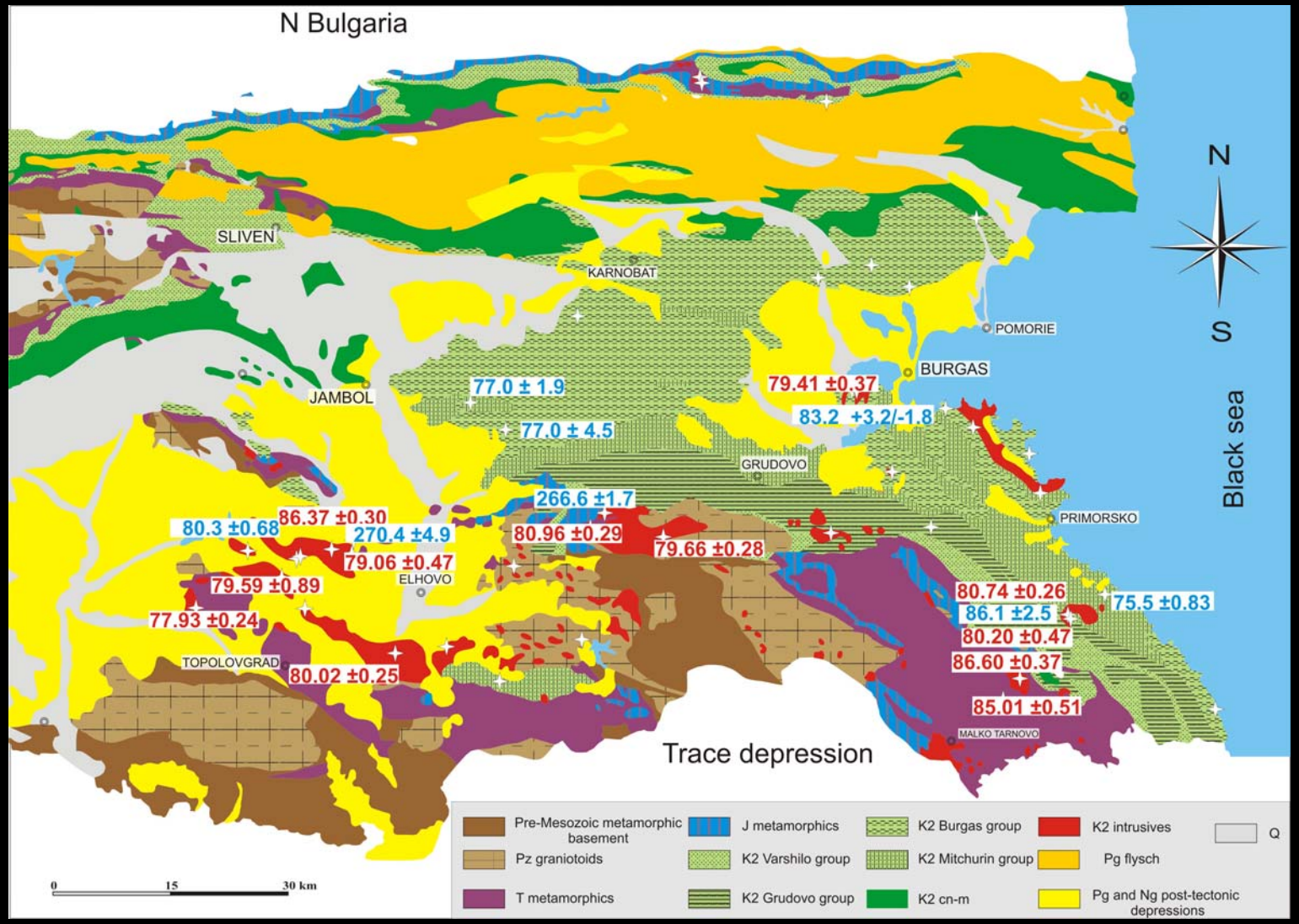
Zircon dating- LA ICPMS

- Dating younger rocks
- Inheritance



Zircon dating - results

- Permian (270Ma) basement granites
- K2 activity
- Coniacian-Santonian event (86Ma)
- Majority Campanian (81-78 Ma)
- No lateral age zonation is observed



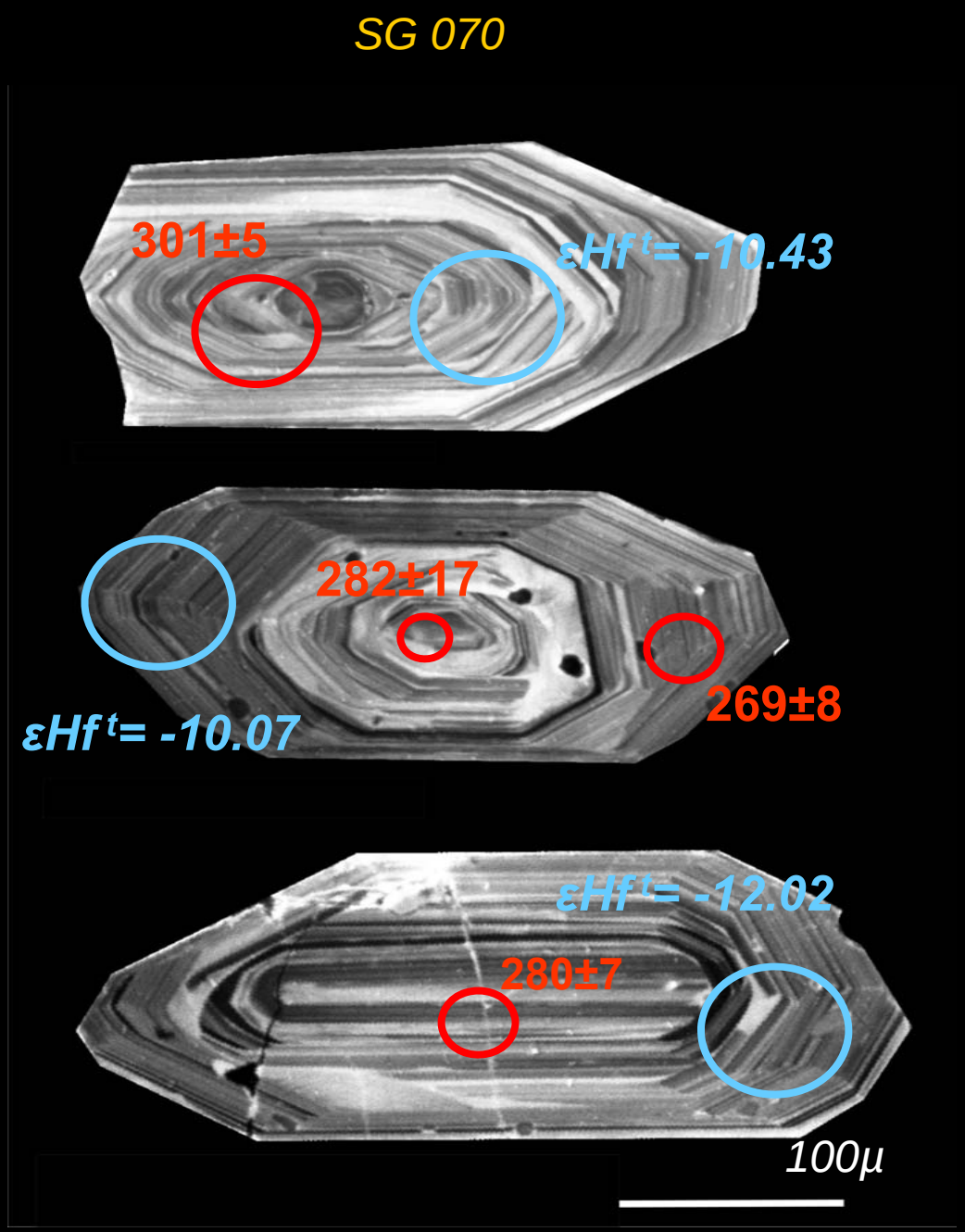
Hf isotopes in zircon

- similar information as whole rock Nd and Sr isotopes

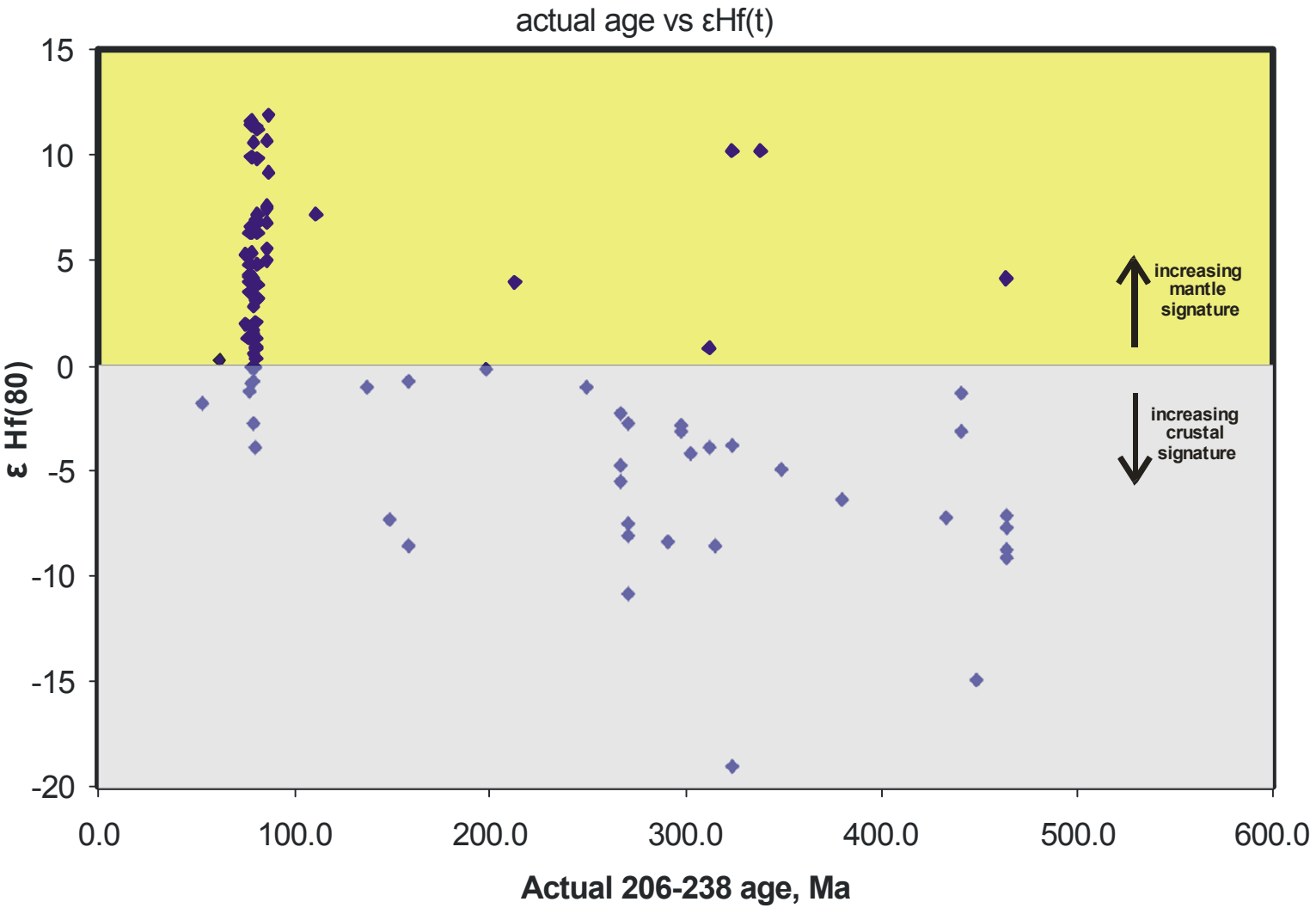
- More sensitive than Nd (Lu/Hf of DM has increased approx. double the rate of Sm/Nd)

- benefits from host resistance = no influence from metamorphism or hydrothermal activity

Hf isotopes in zircon

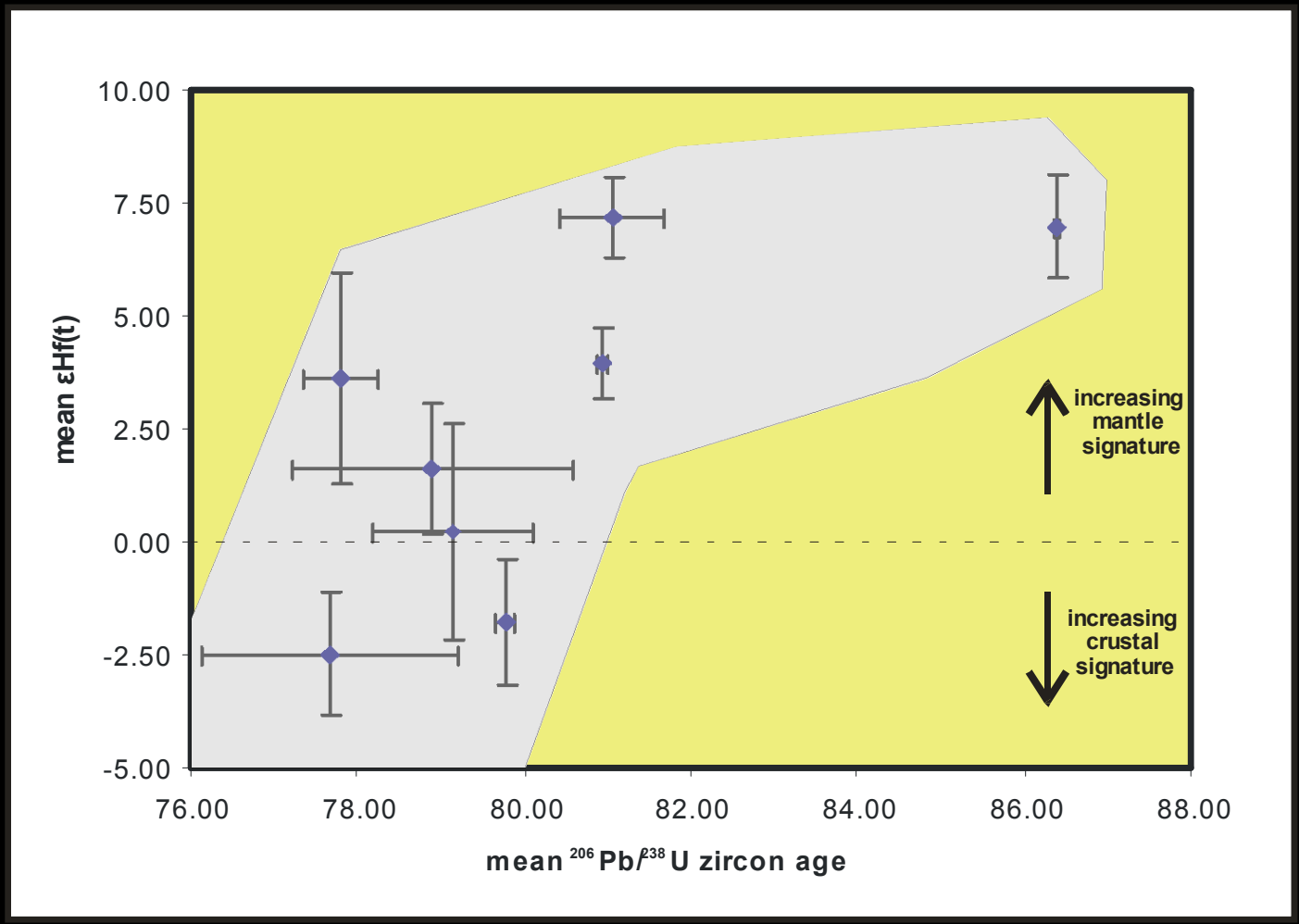


Hf isotopes in zircon - results



- Assimilated material with crustal characteristics
- Mantle-dominated source for K_2 zircons

Hf isotopes in zircon - results



- increasing crustal input for younger zircons?
- Central Srednogorie data shows opposite trend!!!
- agreement with whole-rock Sr isotopes

Conclusions

- Eastern Srednogorie is a zone with abundant and diverse magmatism Mafic to intermediate rocks with high alkalinity prevail

- Primitive rocks with clear subduction signature

- The mantle wedge prior to subduction had the characteristics of normal to slightly enriched DMM

- Melting took place in spinel lherzolite facies at high oxigen fugacities.
- Degrees of melting are rather high (20-40)

- Small amounts of sediments and AOC + sediment derived fluids are necessary to explain trace element and isotope data of primitive rocks

- Further assimilation of 0 to 5% crustal rocks (Permian granites) explain trace and isotope data of primitive rocks

- Cpx was the main fractionating phase. Ol, Pl, Fe-ti oxides and Bt played less significant role

Conclusions

- Magmatism commenced at 86Ma. The peak of the magmatic activity was from 82 to 78 Ma
- Basement granitoids are Permian in age
- Magmas in the volcanic zones in the middle went through different basement
- Age of mantle depletion for basement rocks is from 1300 to 900 Ma
- Mantle signature of Cretaceous magmatism decreases with time

Future directions

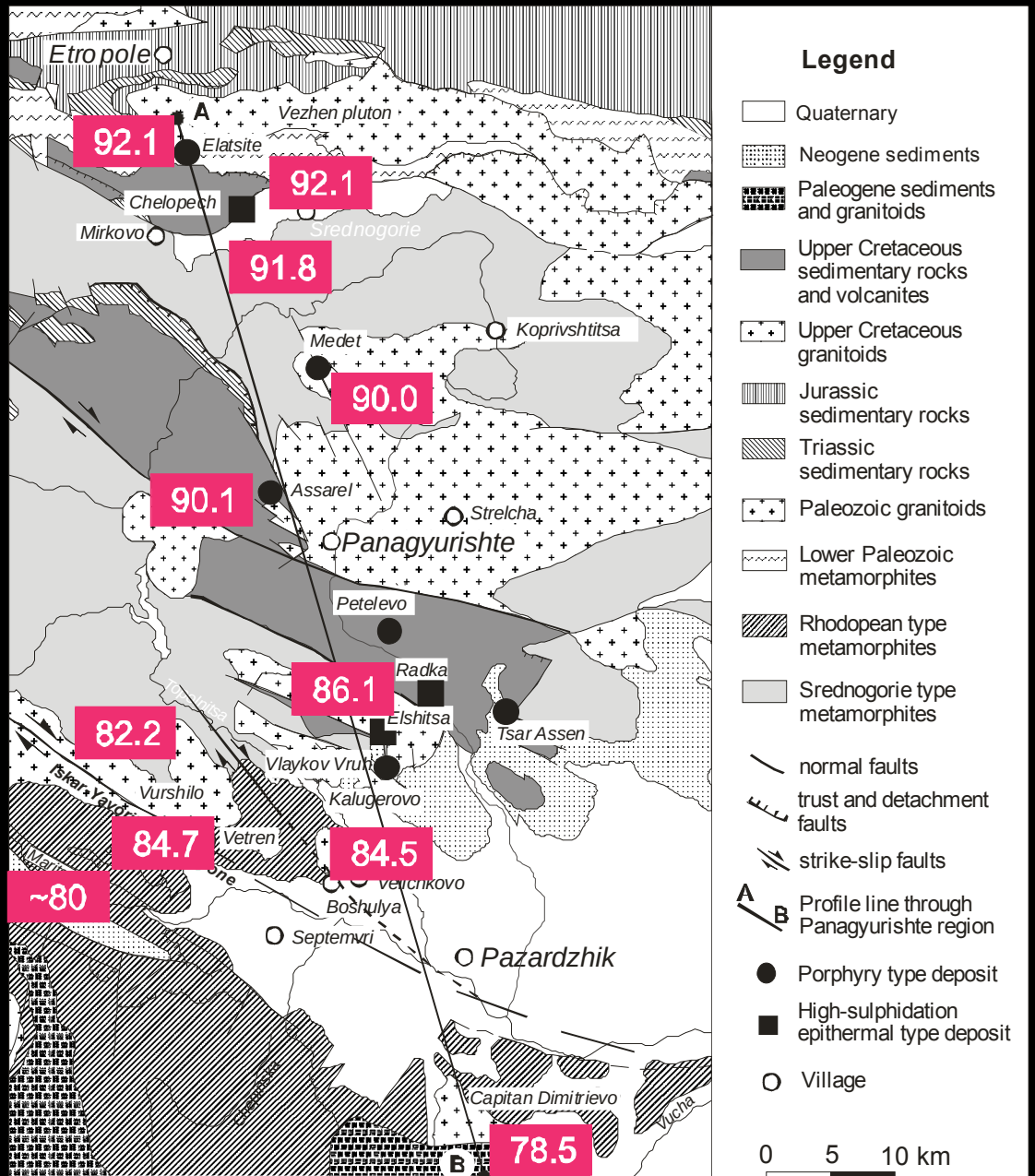
- Examine across- and along-arc chemical zonation
- Comparison with Central Srednogorie zone
- Incorporate Hf isotopes and more trace element data in the mantle-melting model
- Melt-inclusions in Ol and Cpx from primitive volcanics

Where is the answer???

- What is the physical link with Central Srednogorie zone??
- What is the relation with the opening of the Black sea basin???
- Where are the missing ophiolites????
- What does the decreasing mantle signature with age means? How to form that?
- Are the high degrees of melting realistic?
- Is there residual amphibole/phlogopite in the source?

Thanks for the attention

Published data-ages



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