The origin of the Miocene to Quaternary alkaline magmatism in the Pannonian basin, eastern-central Europe

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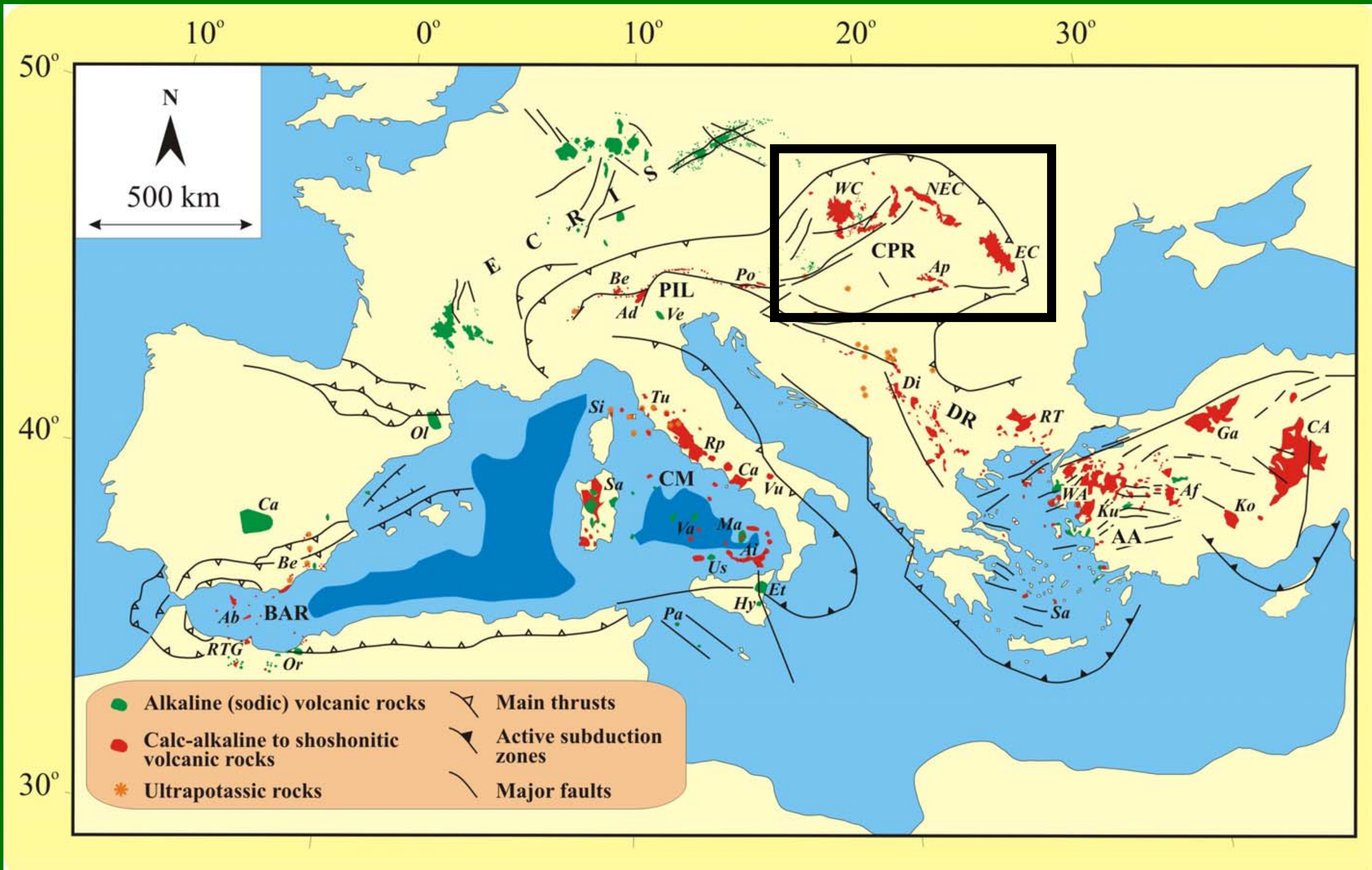
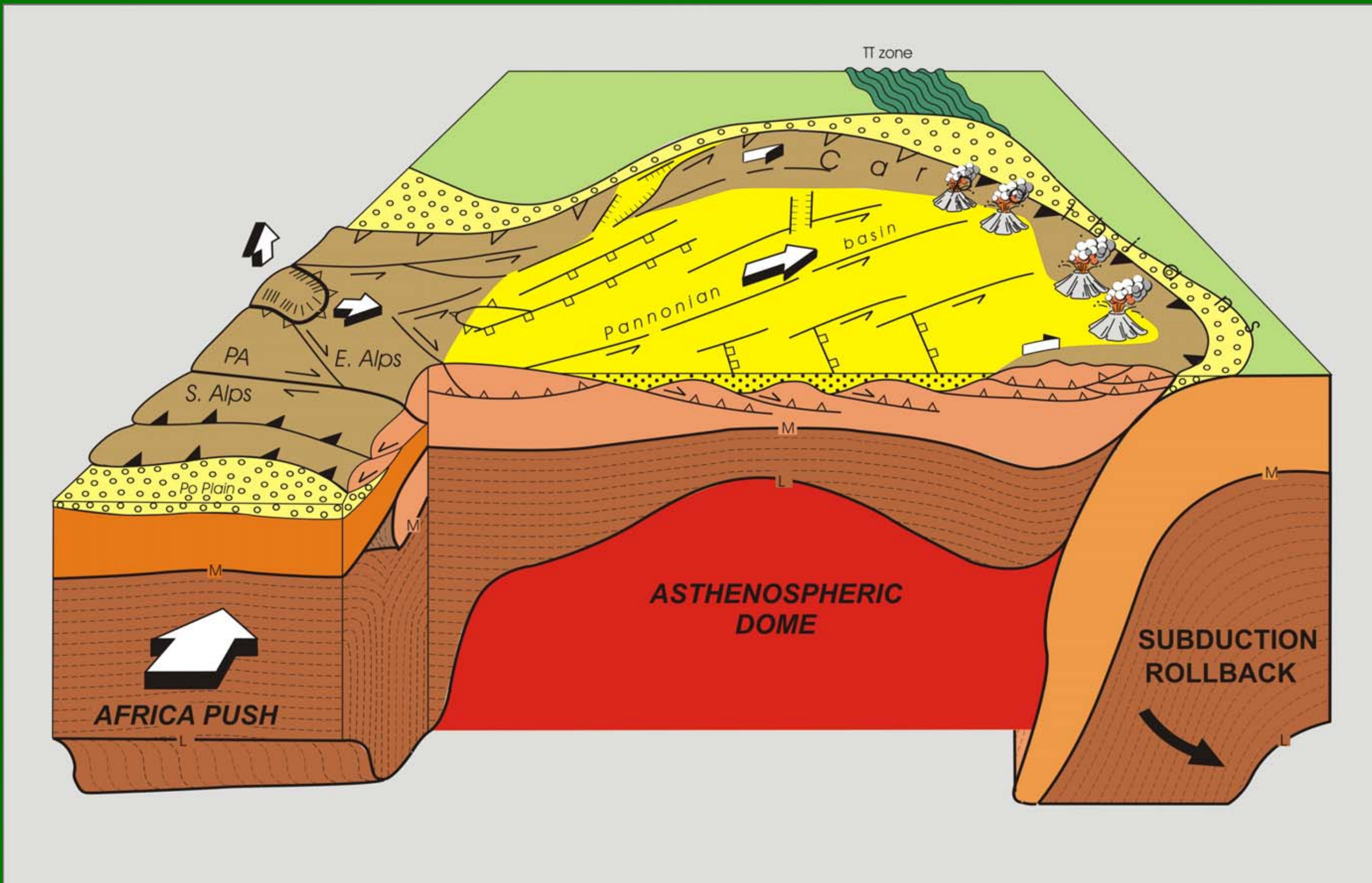
Neogene to Quaternary volcanic fields in Europe



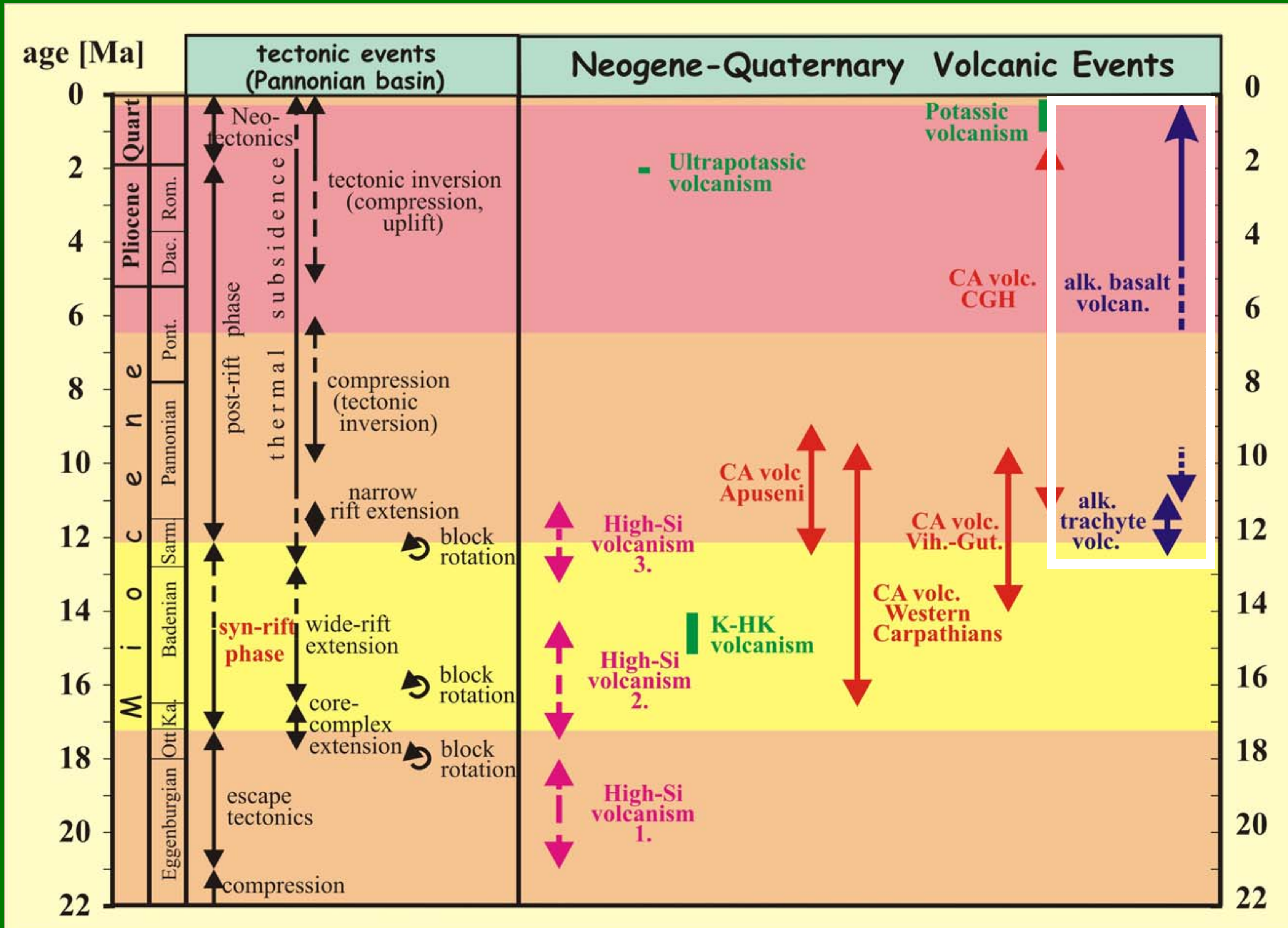
Harangi et al. 2006, GS London Memoir

General geodynamic view



Horváth et al. 2006, GS London Memoir

Temporal evolution of the Neogene to Quaternary volcanism

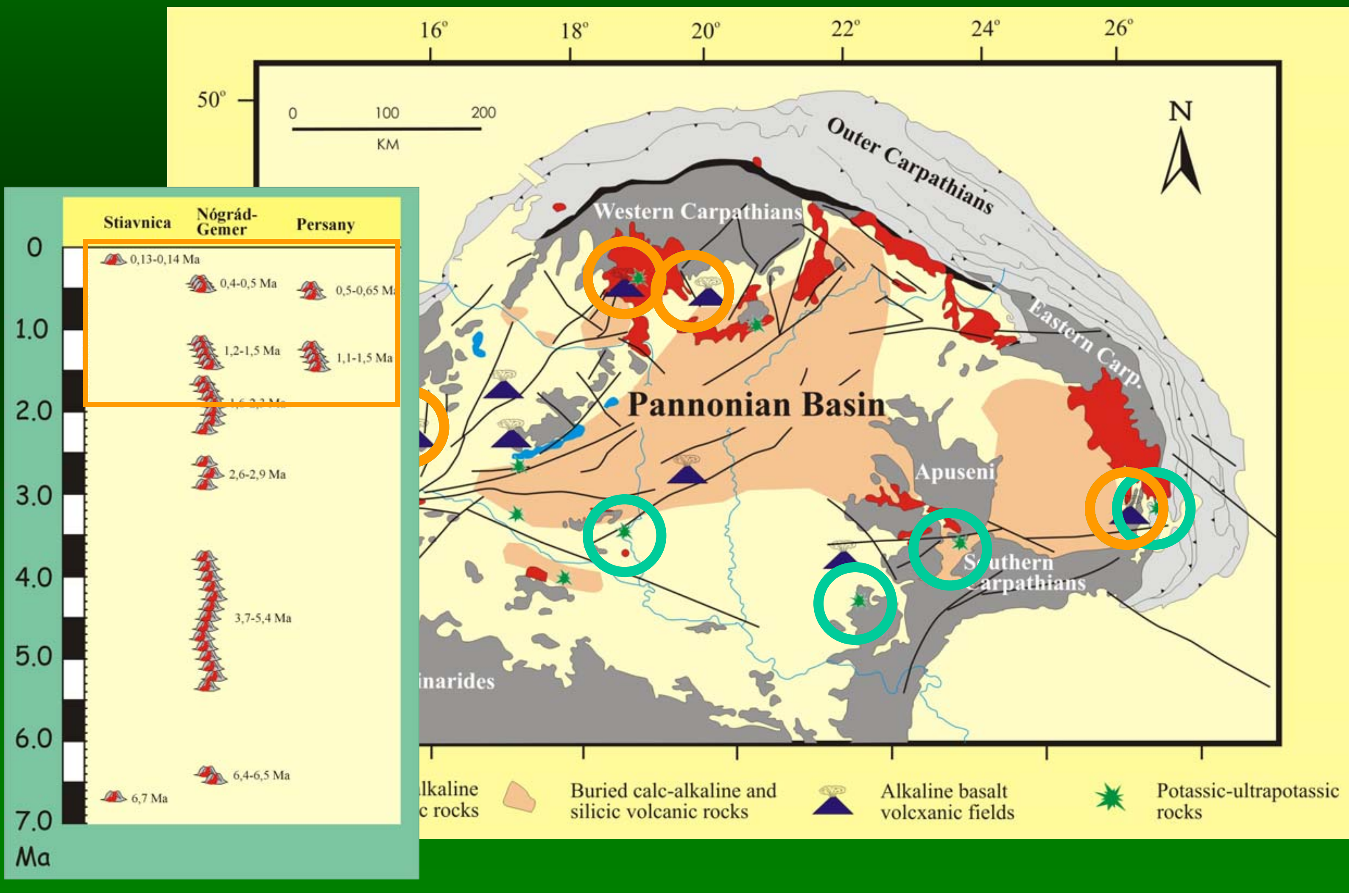


Harangi & Lenkey 2007, GSA Special Pap. 418

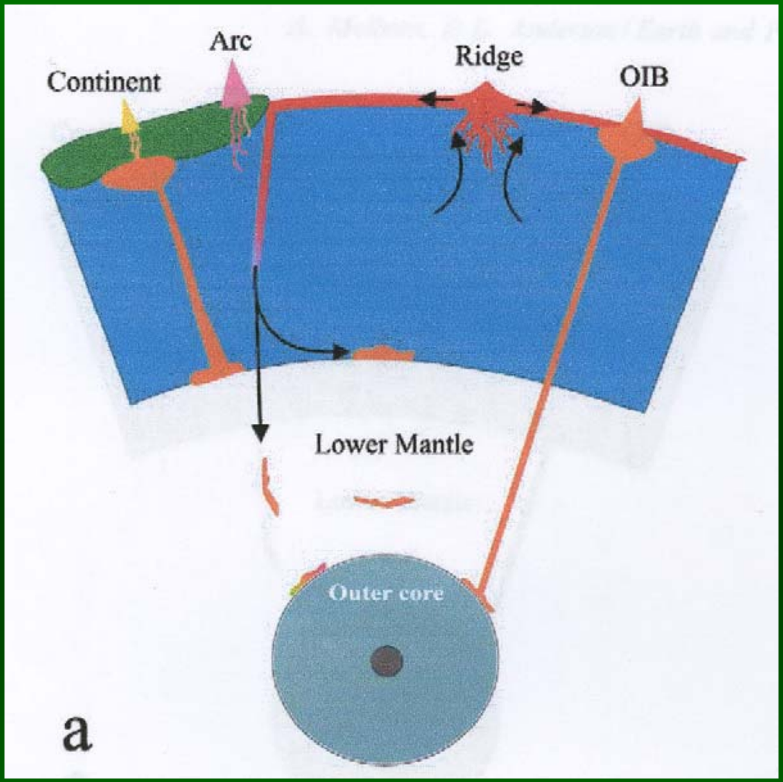
What is the origin of the alkaline mafic magmatism?

importance:

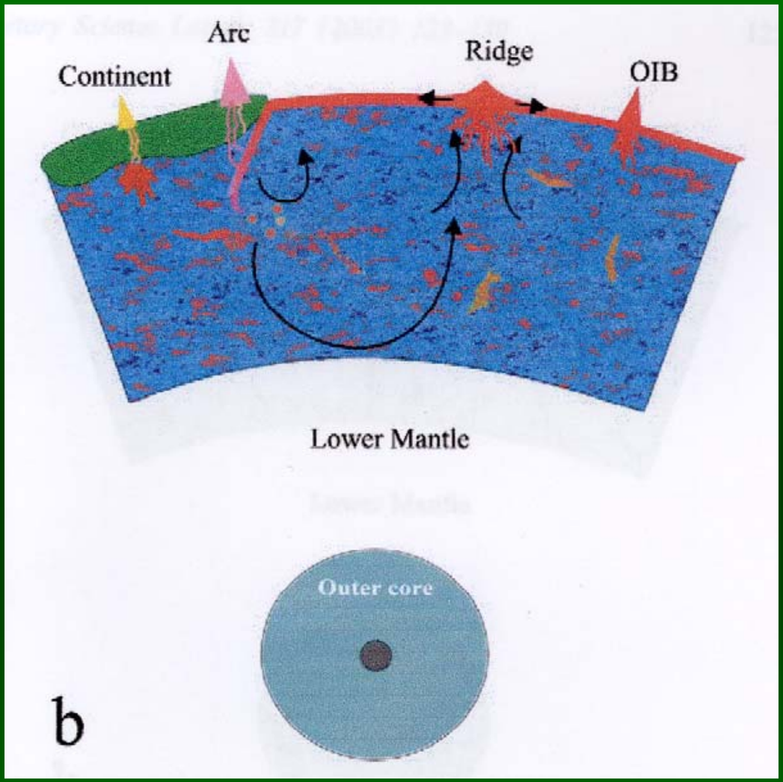
Quaternary volcanic eruptions in the CPR



Mantle models



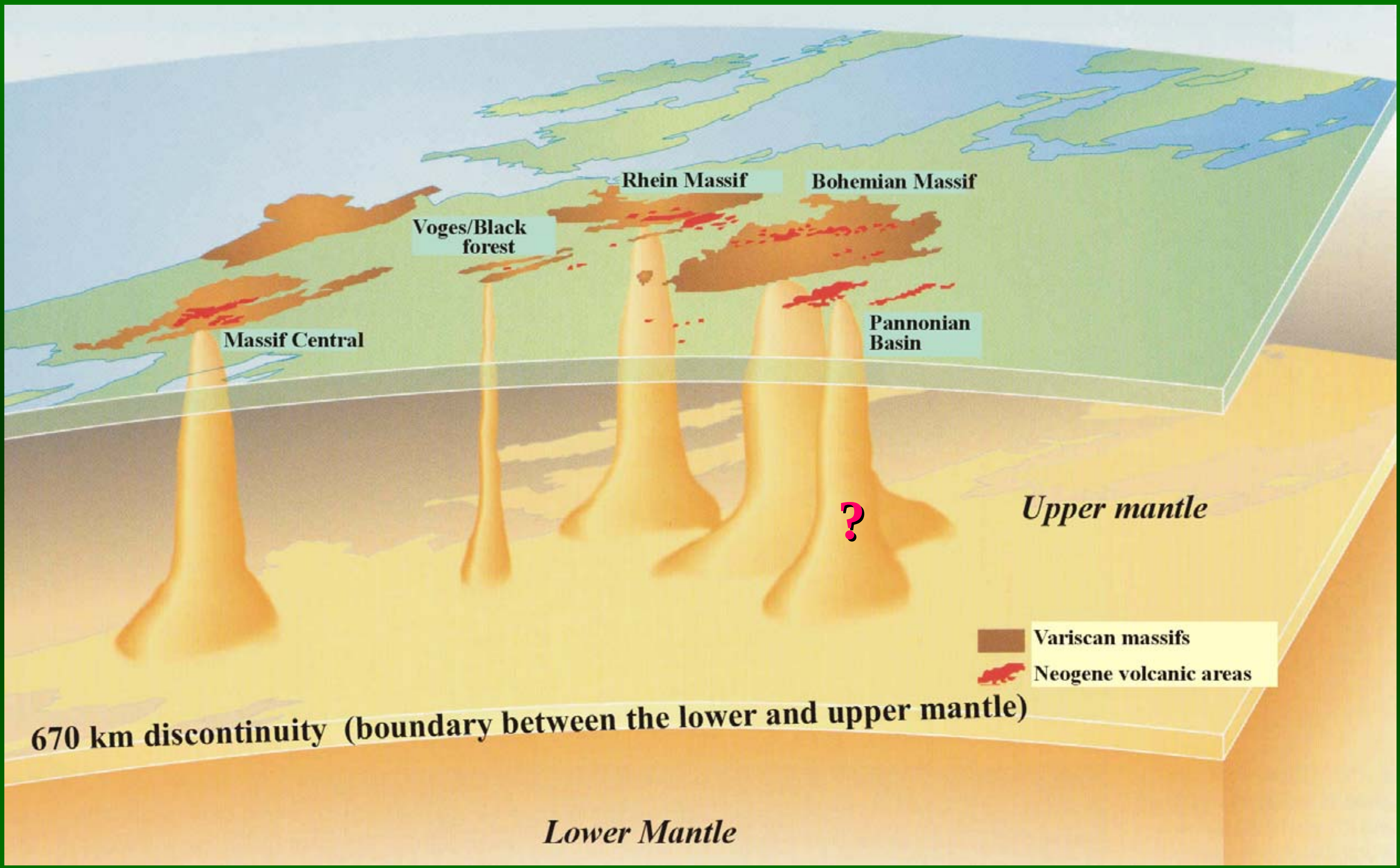
Layered mantle model with plumes



Heterogeneous mantle model without plumes

from Meibom & Anderson 2003 EPSL

Is there a mantle plume beneath the Pannonian Basin?

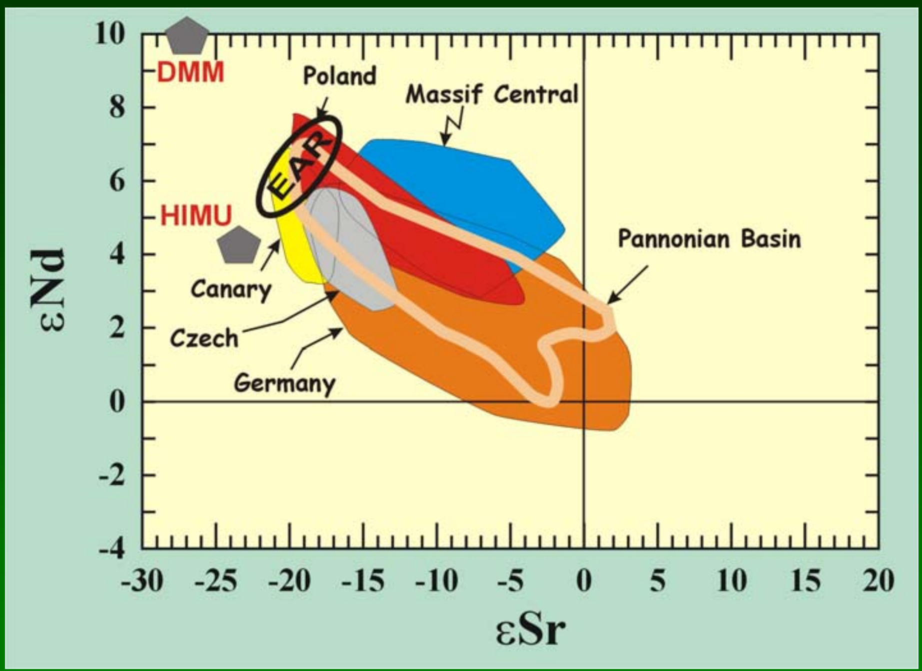


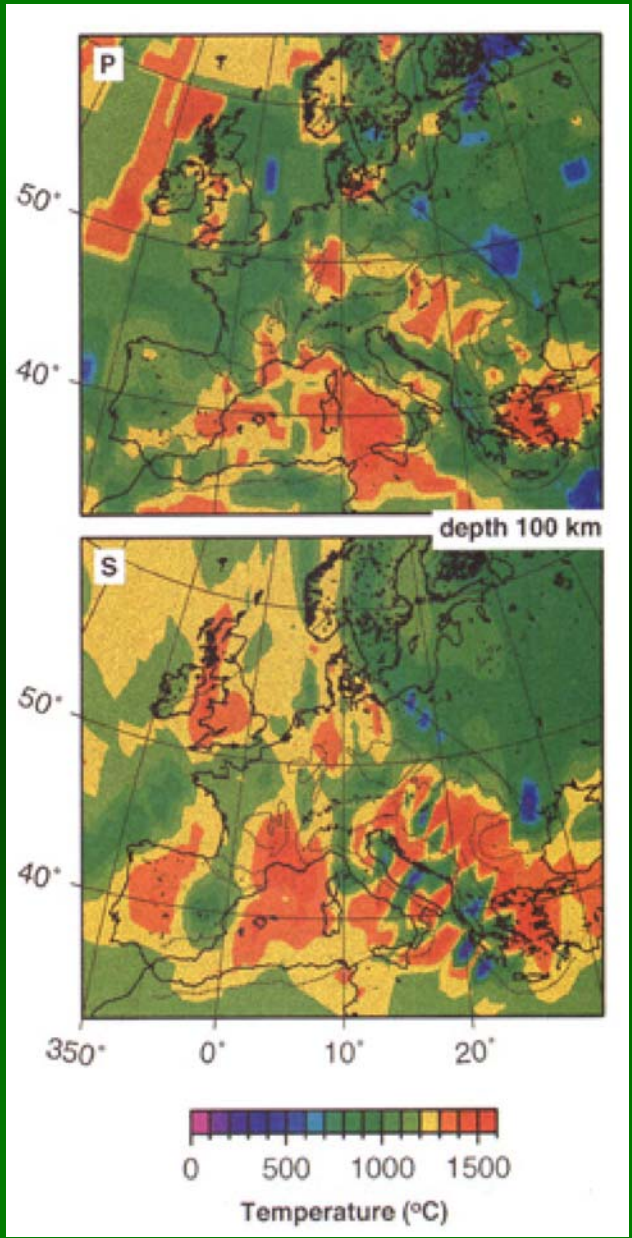
Granet et al. 1995, EPSL, 136

Wilson and Patterson, 2001 GSA SP, 352

Observations that could support the plume theory in the CPR:

- **High heat flow (>90 mW/m²)**
- **High mantle temperature (approx. 1500°C)**
- **Isotope composition of the basalts (EAR, i.e. HIMU/FOZO-like)**

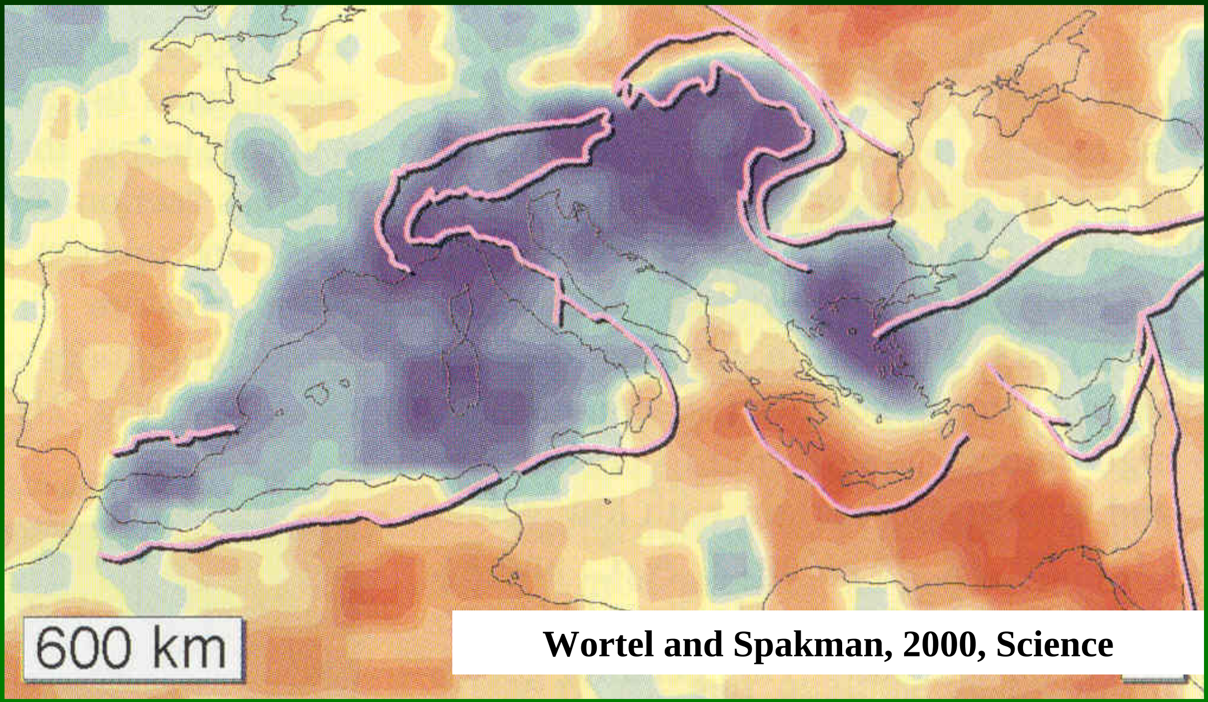




Goes et al. 2000, JGR, 105.

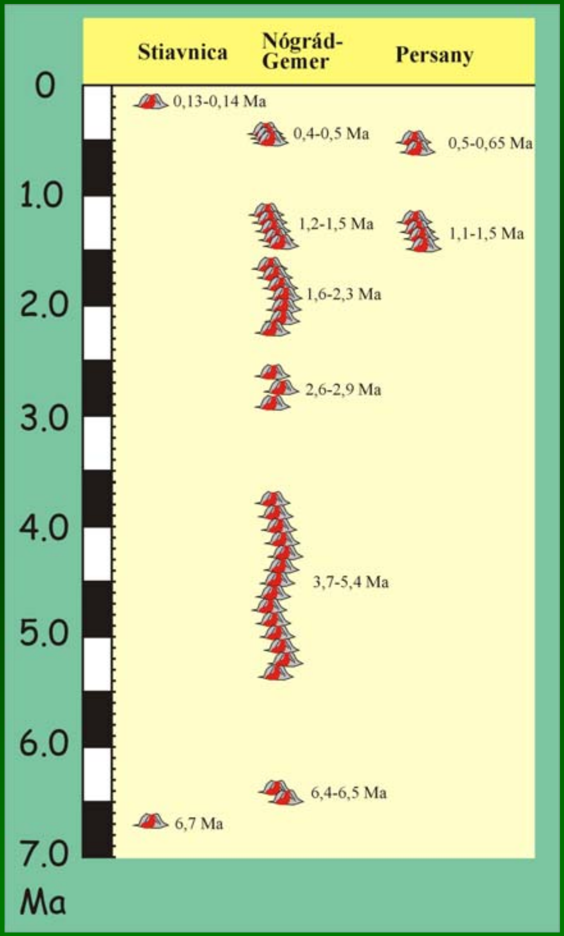
But…:

- no broad topographic updoming
- thick cold (?) material at the Transition Zone
- scattered volcanic fields
- episodic volcanic eruptions
- high heat flow can be explained by the shallow asthenosphere

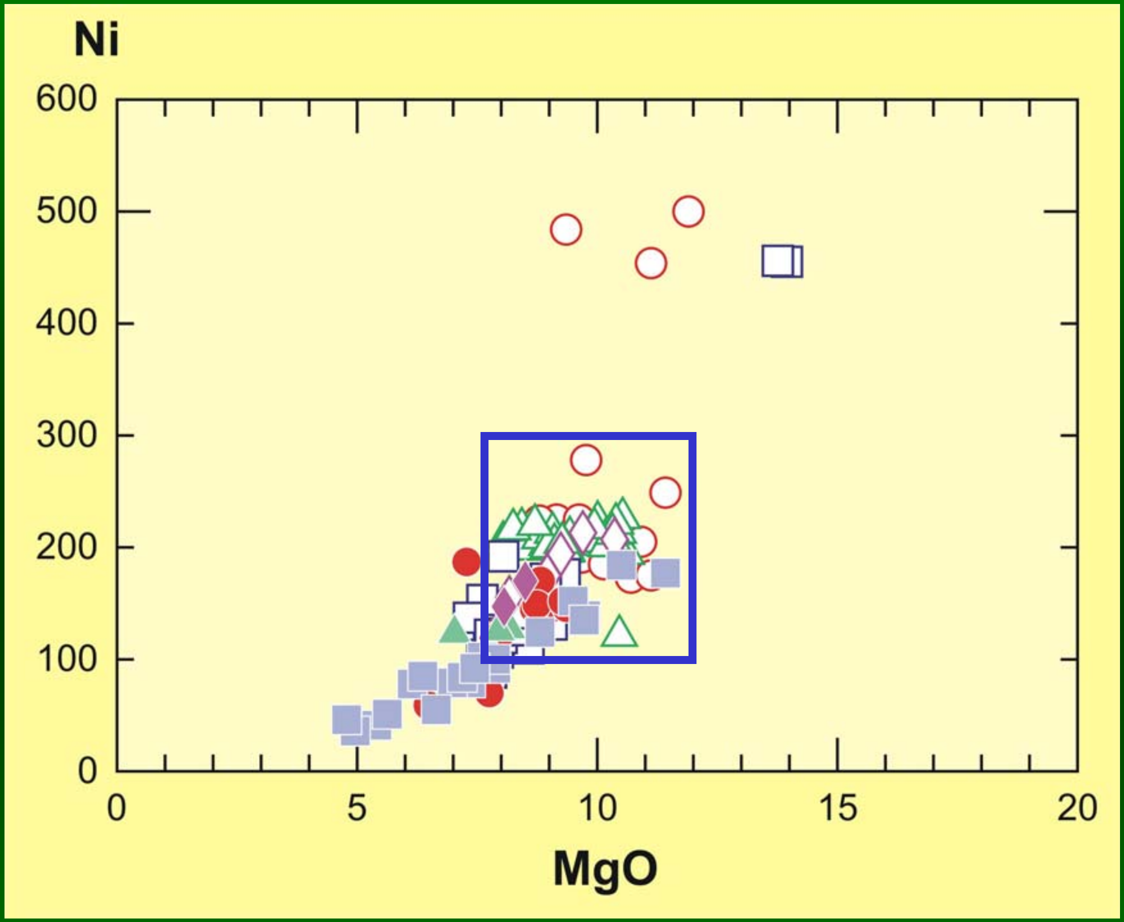


Wortel and Spakman, 2000, Science

- isotope composition: mantle heterogeneity?

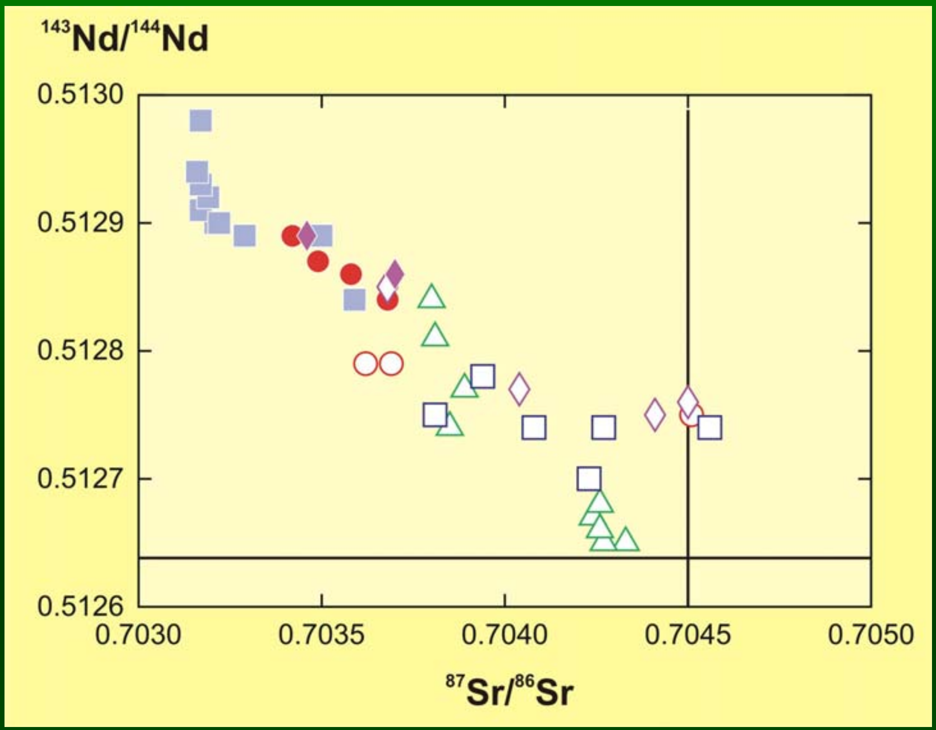


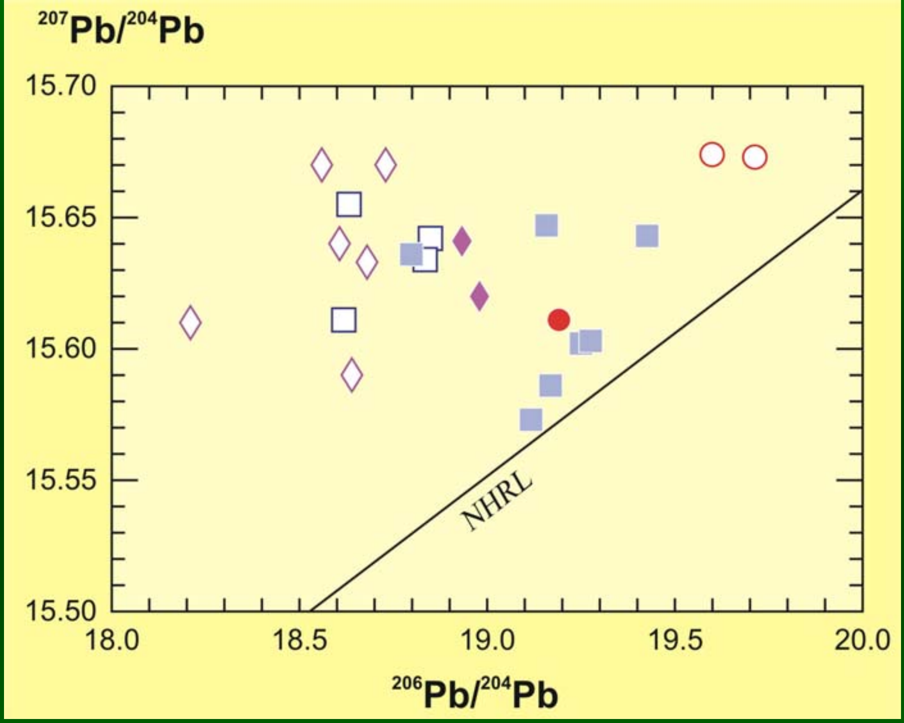
Characteristics of the mantle source regions



Most of the mafic rocks have fairly 'primitive' composition

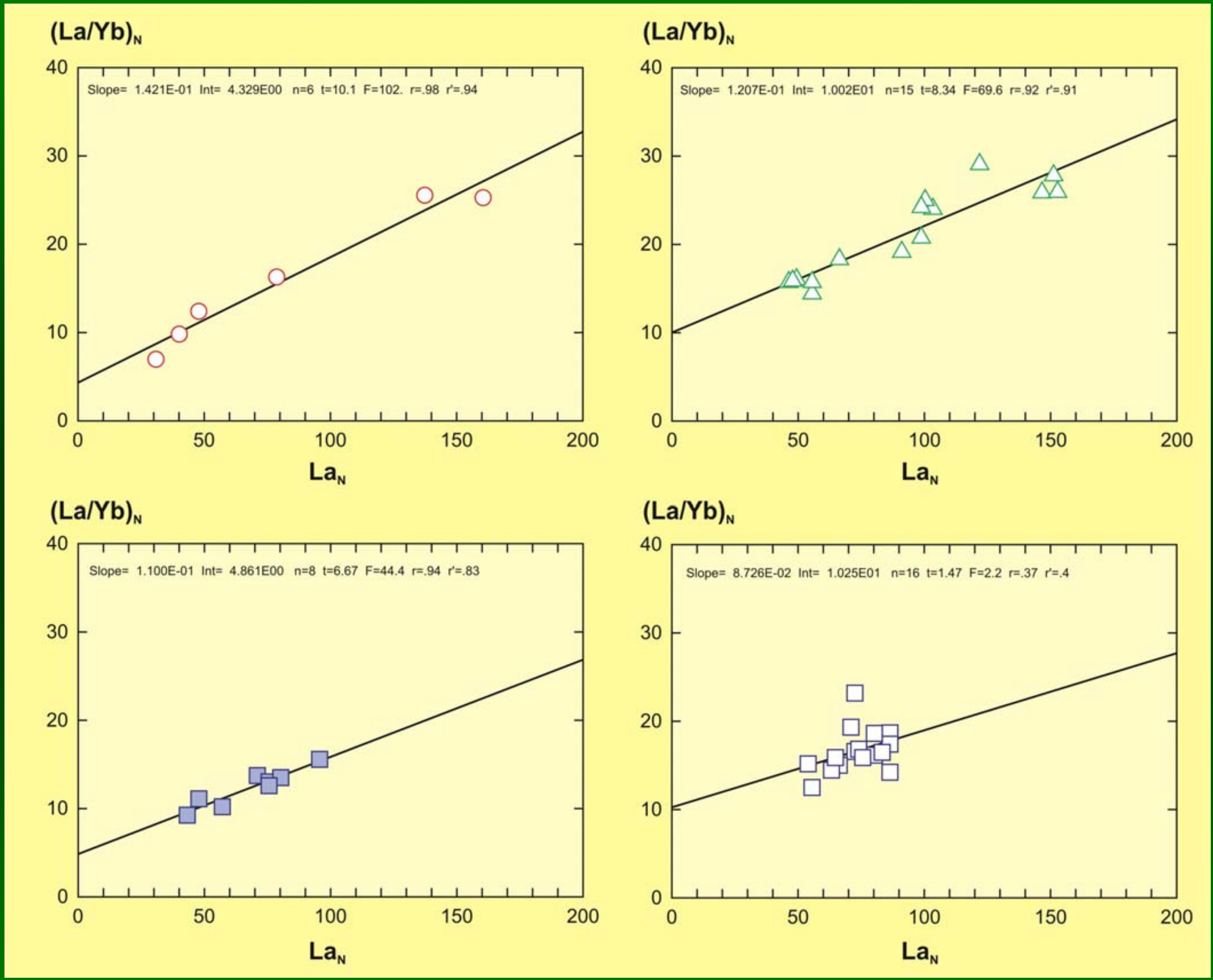
Characteristics of the mantle source regions





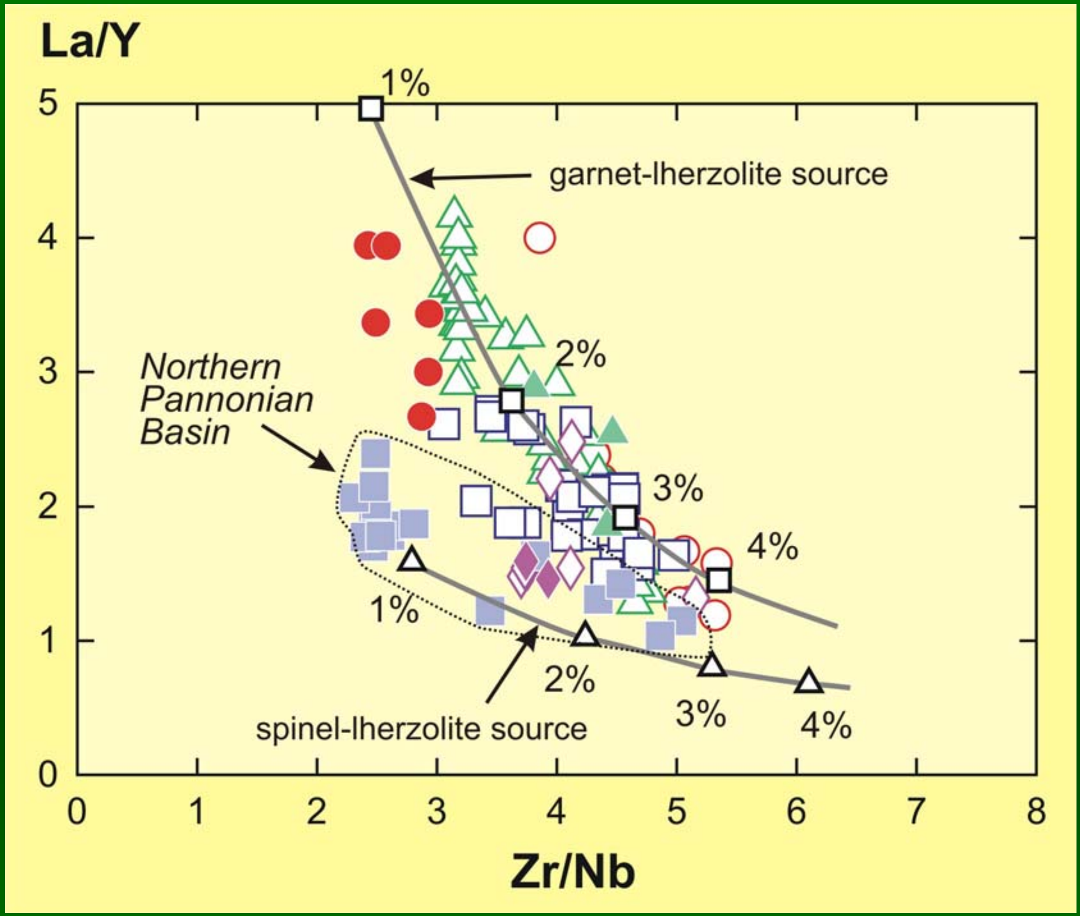
Large isotope variation!

Characteristics of the mantle source regions



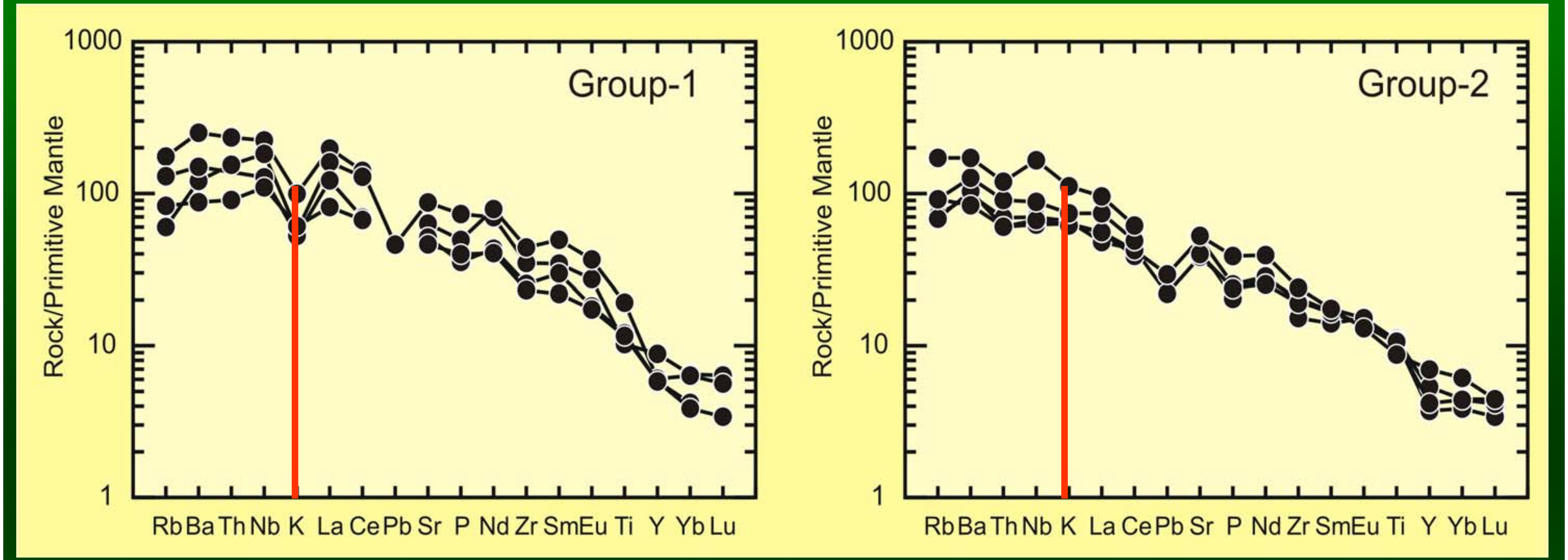
Inverse trace element modelling result: moderately enriched mantle source regions (incompatible trace elements: 1.5- to 4-times primitive mantle values)

Characteristics of the mantle source regions



Partial melting: mostly in the garnet and spinel-garnet stability field (>60 km), i.e. in the asthenosphere!

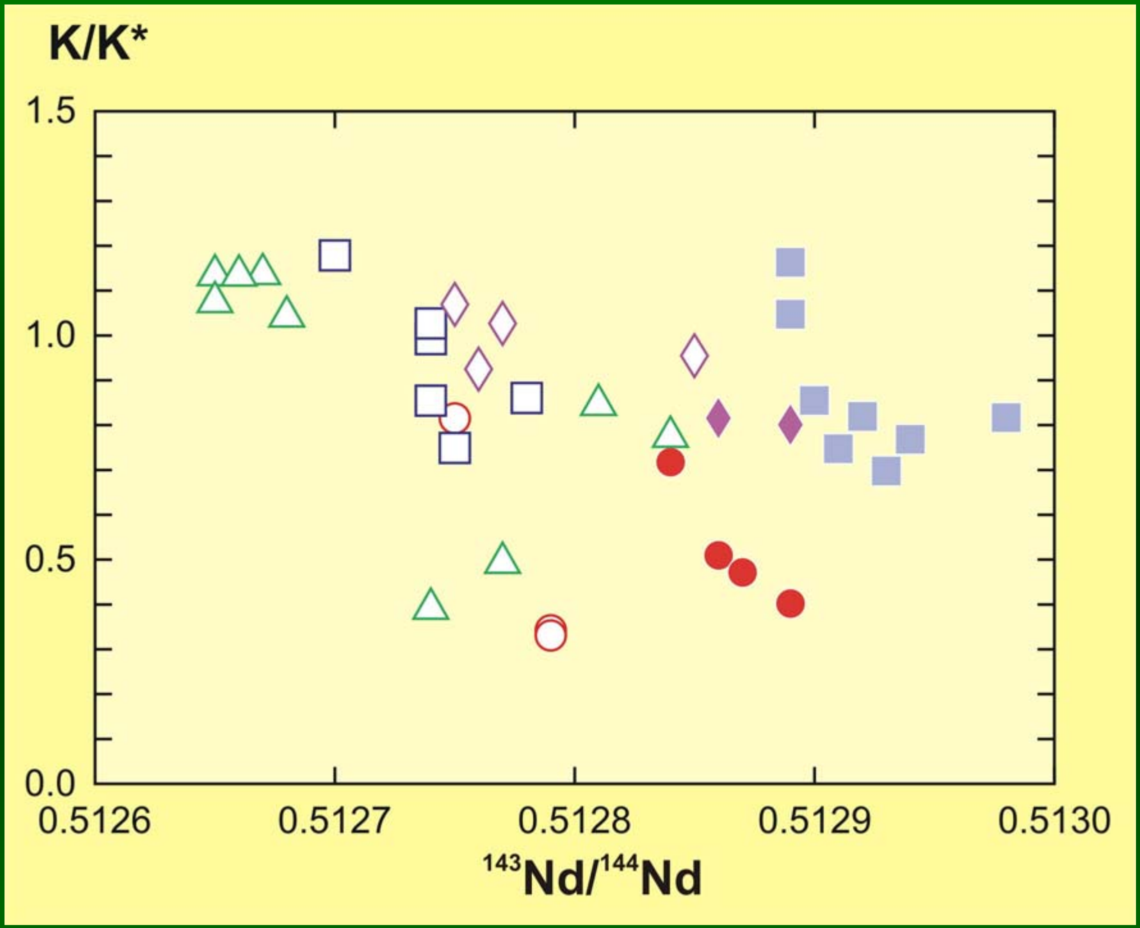
Characteristics of the mantle source regions



Origin of the negative K-anomaly?

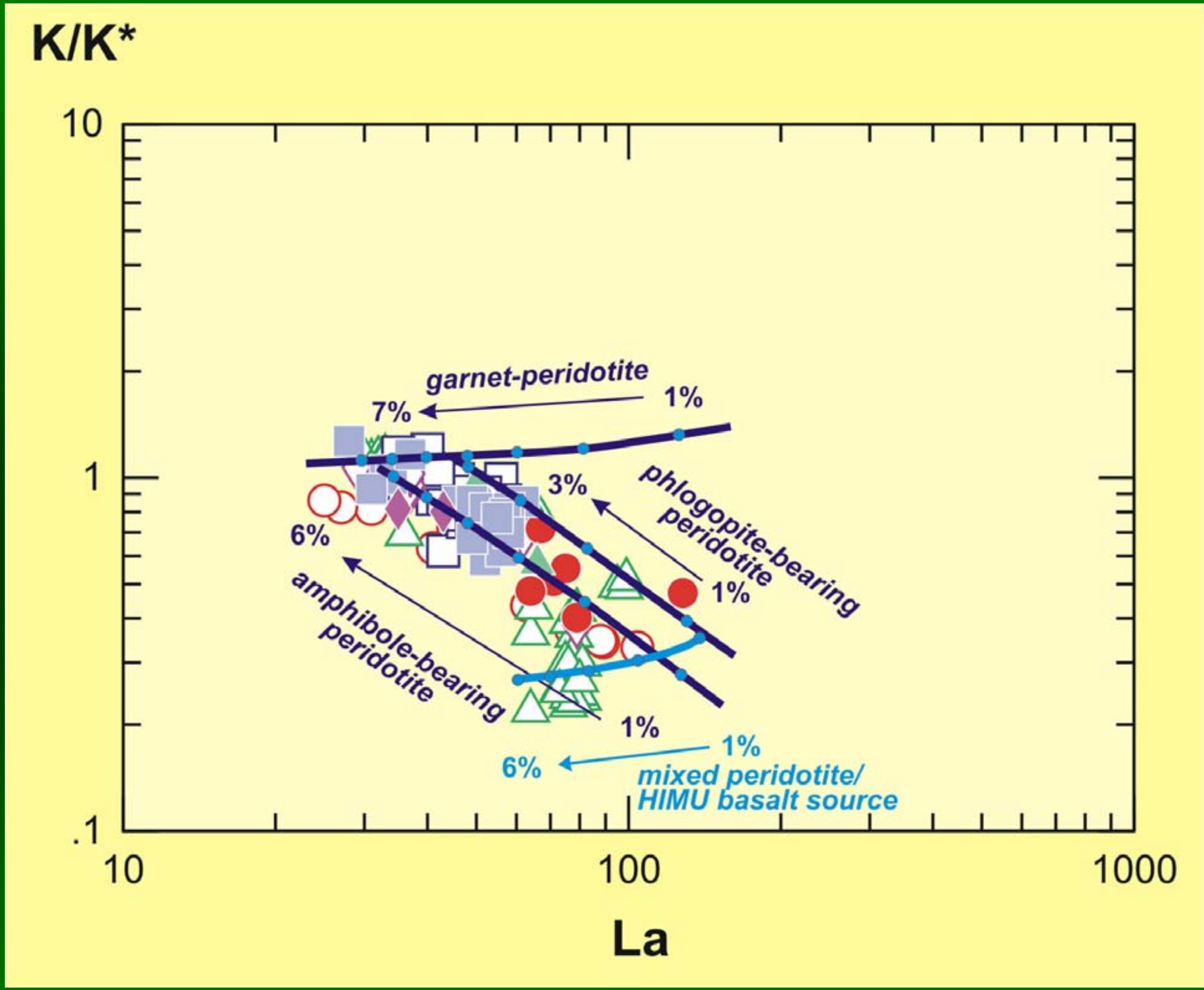
- **Source character (e.g. frozen HIMU-like veins or pockets in the depleted lherzolite)?**
- **Presence of residual K-bearing hydrous phase?**

Characteristics of the mantle source regions



No general relationship with the isotope variation, but negative correlation within volcanic fields!

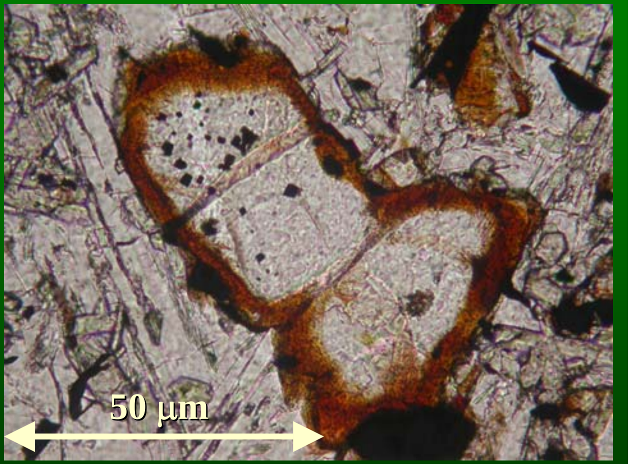
Characteristics of the mantle source regions

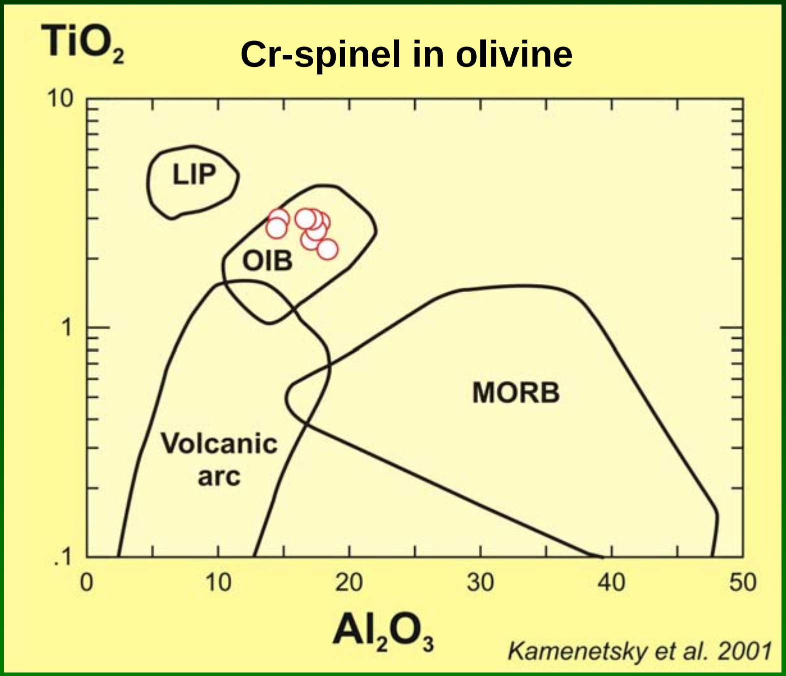


Presence of residual amphibole/phlogopite in the mantle sources!

Characteristics of the mantle source regions

Ság basalts: olivine phenocrysts (Fo≈87 mol%) with Cr-spinel (cr# ≈ 0.6) inclusions

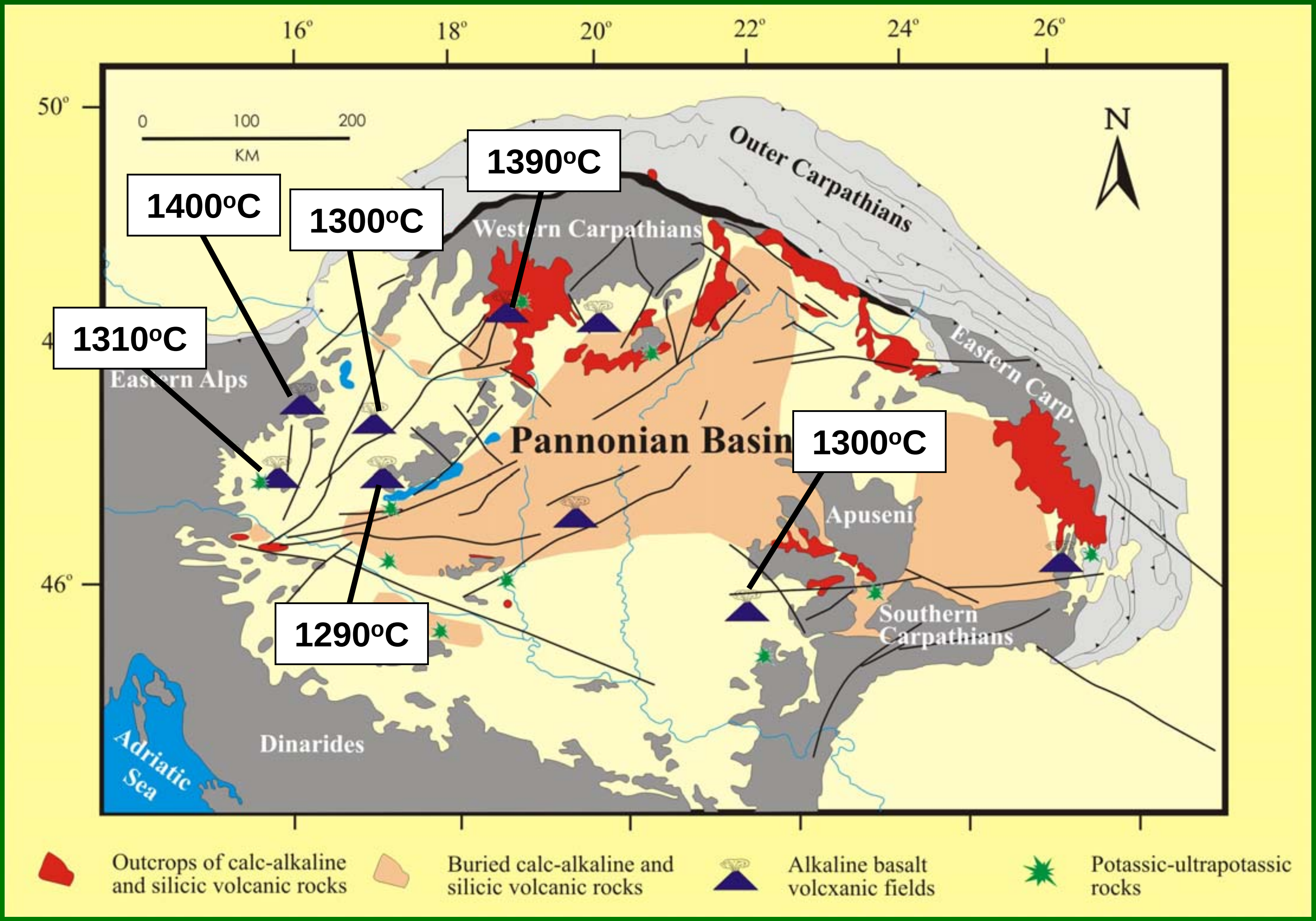




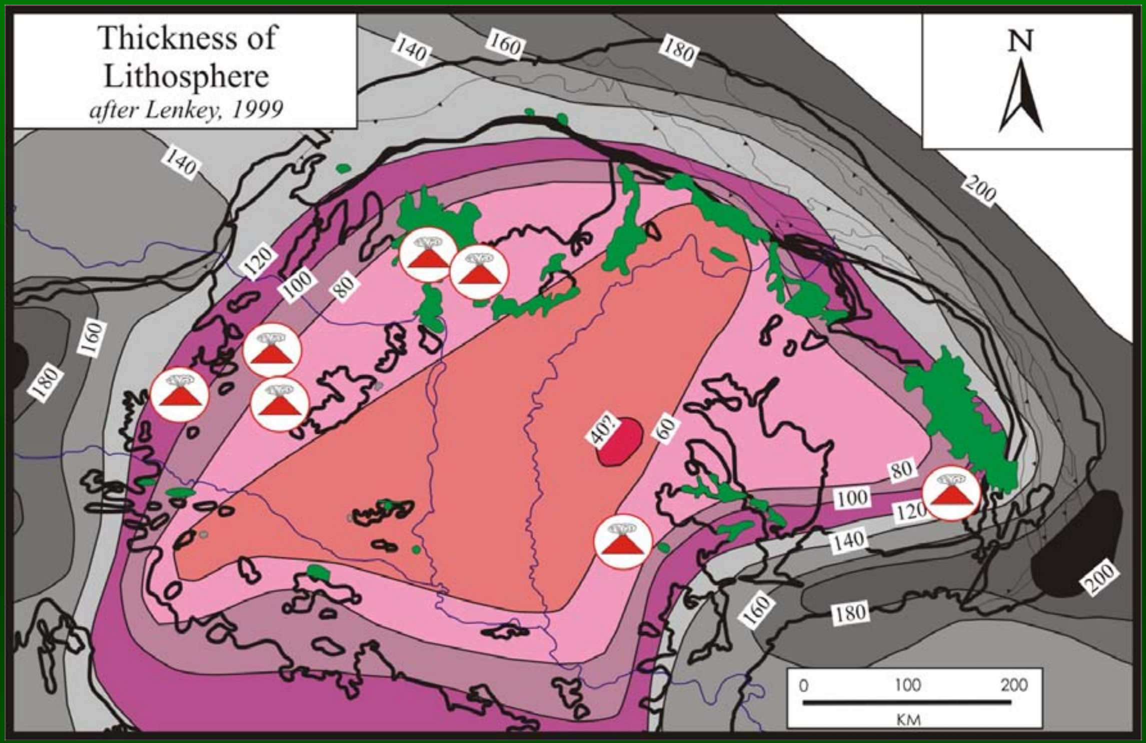
Enriched mantle source

Characteristics of the mantle source regions

Preliminary calculations for the mantle potential temperatures as inferred from olivine phenocrysts (Putirka, 2005 thermometry)



Reason of melt generation in the post-extensional stage - model #1



Suction by the Pannonian basin thin-spot

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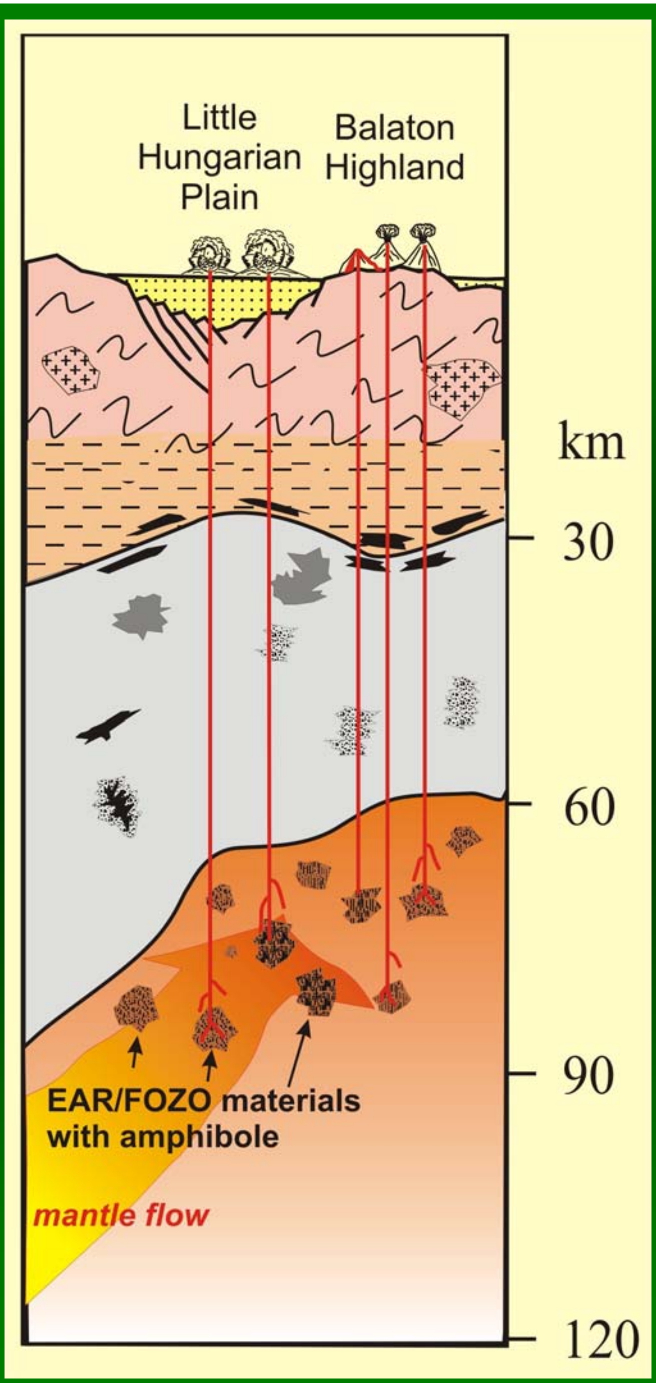
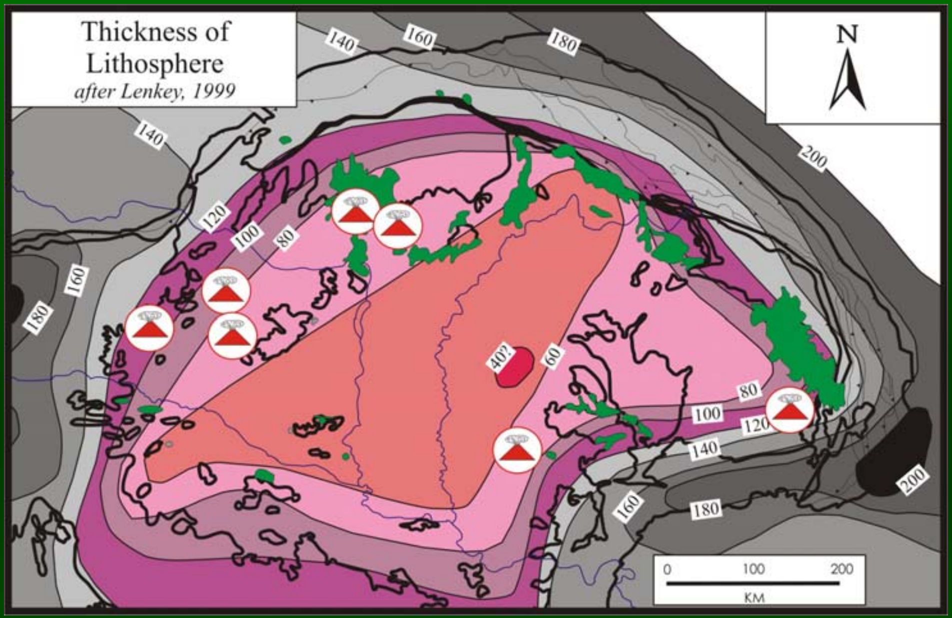
Mantle flow along LAB irregularities?



Reason of melt generation in the post-extensional stage - model #2



Splash plumes

Davies & Bunge (2006) Geology

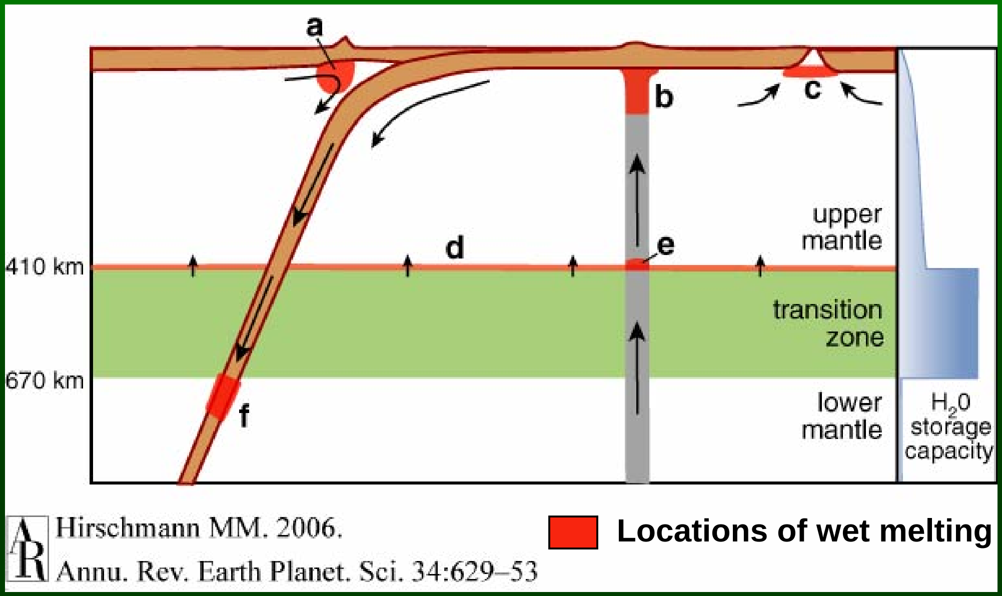
PLUME-like instabilities are dynamic upwellings representing upper mantle displaced by delaminating slabs of subducted oceanic lithosphere

after M. Wilson EMAW 2007 workshop presentation

Reason of melt generation in the post-extensional stage - model #3

European „plumes” are the products of fluid release from the top of the Transition Zone

So - they are “wetspots” NOT “hotspots”



The Transition Zone could be the “wettest” part of the Earth’s mantle!

Partial melting is triggered deep (point e) at 410 km depth
Small-degree melts migrate upwards
At “b” melt fractions from the melting column “pool” close to the base of the lithosphere and segregate

after M. Wilson EMAW 2007 workshop presentation

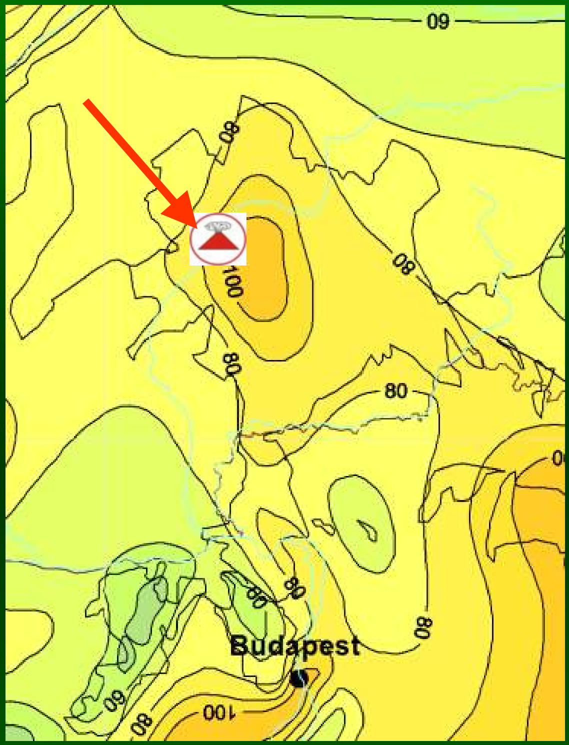
Summary

- No role of hot mantle plume
- No significant excess mantle temperature (T_p is about 1300-1400^{o}C)
- Melt generation due to mantle flow beneath steep LAB (thin spot suction)
- Magma generation in a strongly heterogeneous mantle at >60 km depth
- Enriched (OIB-like) mantle source
- Presence of volatile-bearing mineral (amphibole or phlogopite) in the source region
    - ‘wetspot’ instead of ‘hotspot’ as suggested by M. Wilson?
    - Scattered blocks of subducted slab material at shallow depth?
- Is the sublithospheric upper mantle wet? ➔ seismic tomography models

Probability of future eruption?

The youngest (≈130 ka) eruption of alkaline mafic magmas in the CPR (Putikov volcano)

Heat-flow data

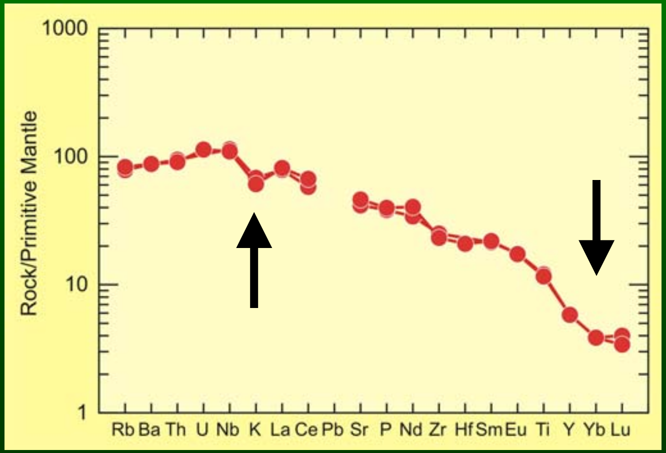


http://pangea.elte.hu/atlas.htm

- inferred T_p = 1340 °C (from olivine)

➔

Geochemistry



- Amphibole/phlogopite-bearing peridotite in the upper mantle
- Low degree partial melting approx. 80 km depth (asthenosphere)

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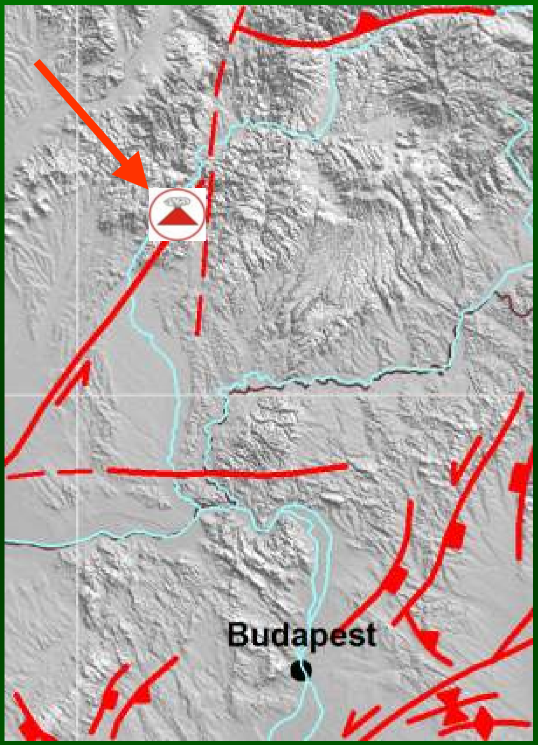
The upper mantle could be still capable to produce magma?

Neotectonics



http://pangea.elte.hu/atlas.htm

⇓

Reactivation of the still active transtensional fault could enhance the ascent of basaltic magma!

Thank you for the attention!

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