Petrogenesis and geodynamic relationships of the Neogene to Quaternary volcanism in the Carpathian-Pannonian region

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with contributions from T. Ntaflos, H. Downes, I. Seghedi, P.R.D. Mason, R. Lukács, Gy. Czuppon, T. Sági, B. Kiss, R. Klébesz, É. Jankovics, A.P. Vinkler, L. Lenkey,

K68587

Outline

- Data and tools
- The way of scientific thinking
- Origin of magmas
- Evolution of magmas
- Classification of the volcanic rocks in the CPR; temporal and spatial distribution
- Silicic volcanism
- Calc-alkaline volcanism
- Potassic-ultrapotassic volcanism
- Alkaline sodic volcanism
- Perspectives

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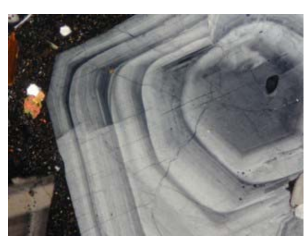
Data, tools…

observations, data…

Sample	description	locality	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO
N3	pumice clast	Mészhegy	74.06	0.21	13.76	1.92	0.04	0.33
TB-1	pumice	Túrbucka	71.81	0.17	13.11	1.62	0.03	0.44
N39	pumice clast	Szomolya	74.32	0.17	13.8	1.9	0.05	0.32
U10L	pumice clast	Kacs	74.54	0.14	14.41	2.5	0.03	0.24
D-1	pumice	Demjén, ba	69.3	0.19	12.85	1.47	0.03	0.41



A couple of important observations concerning the origin of volcanic rocks

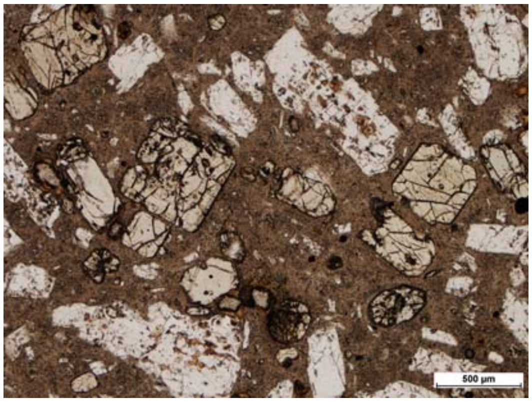
Field observations

⇨ Mechanism of volcanic eruptions, type of products

This is a pumiceous pyroclastic flow deposit (ignimbrite), formed by collapse of plinian eruption column – Tibolddaróc, Bükkalja volcanic field

A couple of important observations concerning the origin of volcanic rocks

Texture of the rocks



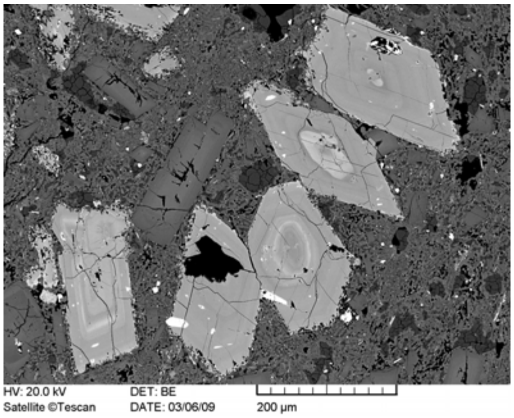
⇨ Procceses occurred in the magma chamber/magma reservoir prior to the eruption

This is a lithic clast from an 20 Ma old ignimbrite (Szomolya, Bükkalja volcanic field). Note the various shapes of the phenocrysts sitting in a Si-rich glassy matrix suggesting open-system magmatic processes

Data, tools…

A couple of important observations concerning the origin of volcanic rocks

Texture of single minerals



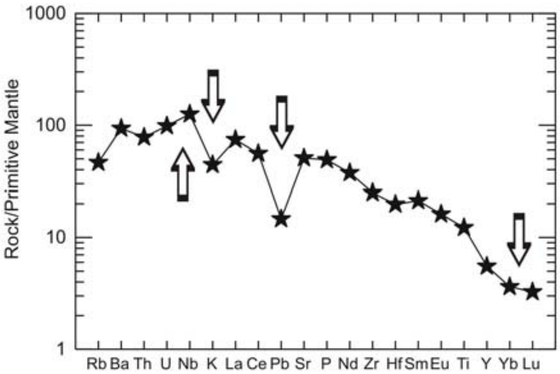
⇨ Conditions during the crystal growth; again, evolution of the magma chamber/magma reservoir prior to eruption

This picture shows amphibole phenocrysts with various zoning patterns. They could have formed at different stages and different time during the magma evolution and mixed together prior or during the eruption (Csomád dacite)

Data, tools…

A couple of important observations concerning the origin of volcanic rocks

Major and trace element composition



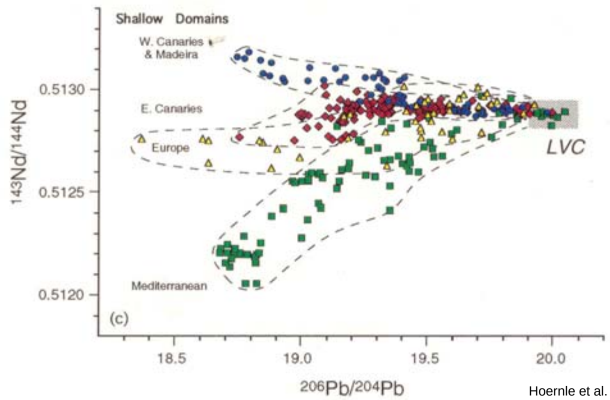
⇨ Shallow-level magmatic differentiation and/or condition of partial melting and nature of source rocks

This is the 'spider-diagram' of the youngest mafic rock of the CPR (Putikov basanite): Note the enrichment of Nb, but the relative depletion in Rb, K, Pb and the heavy REE – these could reflect the nature of the source region, the depth of melting and the low-degree partial melting process

Data, tools…

A couple of important observations concerning the origin of volcanic rocks

Radiogenic isotope ratios



Hoernle et al. 1995 Nature

⇨ nature of source rocks in the mantle and possible open-system magmatic processes

Radiogenic isotope composition of the Neogene alkaline mafic rocks in Europe appears to show a convergence in certain isotope planes suggesting a common mantle reservoir. It is variably called LVC, EAR or CMR

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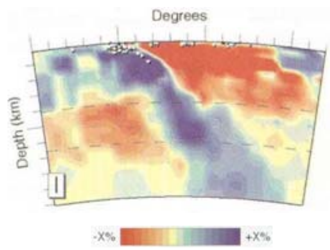
The way of scientific thinking

Example – 1: the case of seismic tomography models

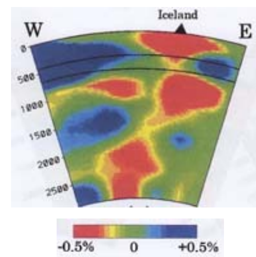
- Speculations
- Hypothesis
- Modell
- Paradigma
- Dogma

Seismic tomography model pictures are powerful tools to have an insight into the deep inaccessible interior of the Earth



Wortel & Spakman 2000, Science

Subduction



Nolet et al. 2007 Chemical Geology

Mantle plume

The way of scientific thinking

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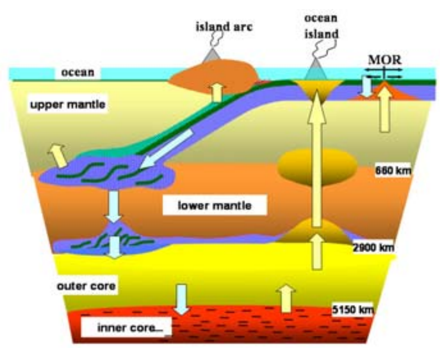

http://www.compres.stonybrook.edu:8080/COMPRESImageLibrary/

A general view about the geodynamics the deep Earth: Accumulation of residual slabs at the D"-layer and upwelling of hot mantle plumes…

Is it a fact or fiction?

The way of scientific thinking

Example – 1: the case of seismic tomography models

- Speculations
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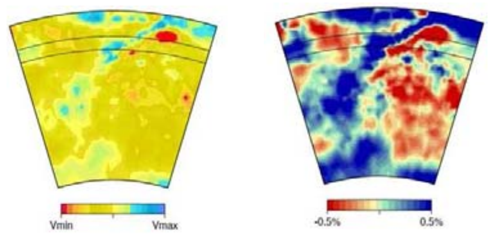
„Geochemical and geodynamic interpretations that involve large-scale mass transfer through the entire thickness of the mantle are often based on simplistic and indefensible interpretations of a few brightly colored images that may have been specially selected to make the strongest case possible in support of plumes."

„Global tomography is a powerful but imperfect tool."

Don Anderson
www.mantleplumes.org



Result of colour scale saturation:
A slab on command! Line of section traverses Japan
from Ricard et al., 2005

Don Anderson
www.mantleplumes.org

The way of scientific thinking

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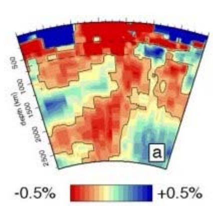
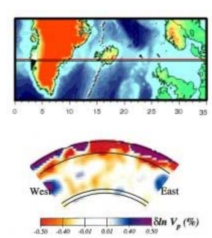




Result of colour scale saturation:
A mantle plume on command! The case of enigmatic
Iceland plume. Picture on left is from Bijwaard & Spakman (1999)

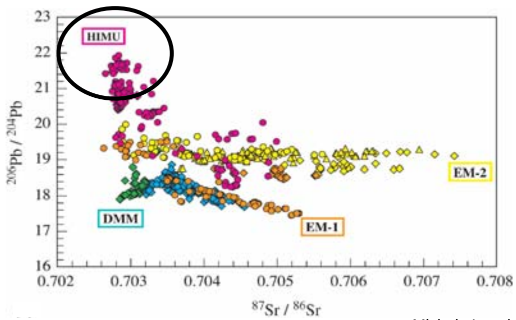
Gillian Foulger
www.mantleplumes.org

Comment:
seismic tomography is a model not a fact!
…but it is a powerful tool with a knowledge on the resolution and the method by which it was constructed

The way of scientific thinking

Example – 2: what do isotope ratios tell us about the deep mantle processes?

- Speculations
- Hypothesis
- Modell
- Paradigma
- Dogma



Michele Lustrino

Isotope characteristics of oceanic basalts can be described invoking hypothetical end-members, which might locate in the mantle *('Mantle Components')*

OIB with HIMU isotope signature is conventionally interpreted as a sign of mantle plume

The way of scientific thinking

Example – 2: what do isotope ratios tell us about the deep mantle processes?

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is further corroborated by Pb isotope ratios obtained on carefully leached clinopyroxenes (Rosenbaum et al. 1997). In Fig. 8a, b the mantle xenoliths indicate a mixing between depleted mantle with unradiogenic Pb compositions and a plume-type mantle (HIMU) with more radiogenic Pb. The latter component may relate to the upwelling of the asthenosphere during Tertiary times (Hoernle et al. 1995). However, some xenoliths have high ratios of $^{207}Pb/^{204}Pb$ at a given

(Fig. 8a, b) *the* asthenospheric component appears to lie parallel with the NHRL, indicating that it may be in itself a mixture between the depleted mantle (UMM) and HIMU mantle (with extremely high ratios of $^{206}Pb/^{204}Pb$). The HIMU signature (high $^{238}U/^{204}Pb$ mantle end-member) may be indicative of a plume-type, rather than a normal asthenospheric (MORB-type) component. As the influence of this signature is also discernible in the Tertiary alkali basalt of

Embey-Isztin et al. 2001; Acta Geologica Hungarica

Comment:

Mantle end-members are descriptive terms!

HIMU isotopic component does not equal with the existence of a plume!

The way of scientific thinking

Can speculations, hypotheses help us to understand natural processes?

- Speculations
- Hypothesis
- Modell
- Paradigma
- Dogma

Available online at www.sciencedirect.com
SCIENCE DIRECT
Earth-Science Reviews 65 (2004) 305–313
www.elsevier.com/locate/earscirev

Earth Reflections

From speculation to model: the challenge of launching new ideas in the earth sciences

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Geocom, P.O. Box 336, 6860 AH Oosterbeek, The Netherlands

It is shown that speculations, hypotheses and models do not differ fundamentally from each other, so that there is no reason for the scientific community to treat them in different ways. The commonly negative attitude towards speculations is not justified and hampers scientific progress. An example of a hypothesis on a process never observed is presented to indicate how small—if existing at all—the margins are between models, hypotheses and speculations. It is concluded that both hypotheses and speculations may trigger research that will deepen insight into complex earth-scientific relationships.

Comment:
Yes, they can promote new and further research!

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- ➢ Perspectives

Origin of magmas

Basic questions:

- Where are magmas generated?
- What is the source rock of basaltic magmas?
- What is the reason of melt generation?
- …

Origin of magmas

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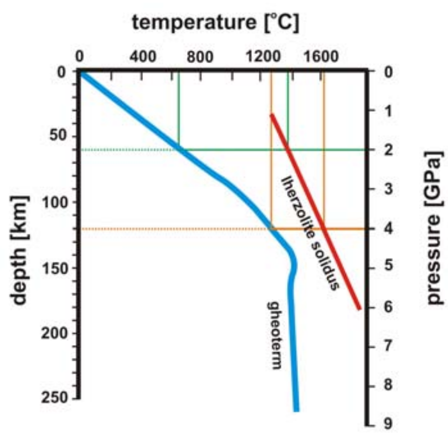


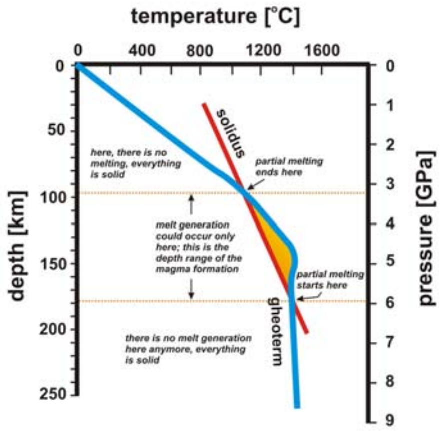
Geotherm: variation of temperature in the function of pressure (depth)

Solidus: variation of melting temperature in the function of pressure

Lherzolite: it is thought to be the dominant rock type of the upper mantle

Origin of magmas

- Where are magmas generated?
- What is the source rock of basaltic magmas?
- What is the reason of melt generation?



This simple explanation implies that magma could be generated only in the upper mantle, where the geotherm intersects the solidus of the ambient rock. T_p is about 1400°C, solidus is drawn for dry lherzolite

Origin of magmas

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- What is the source rock of basaltic magmas?
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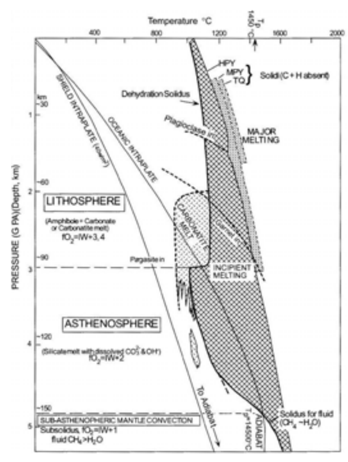

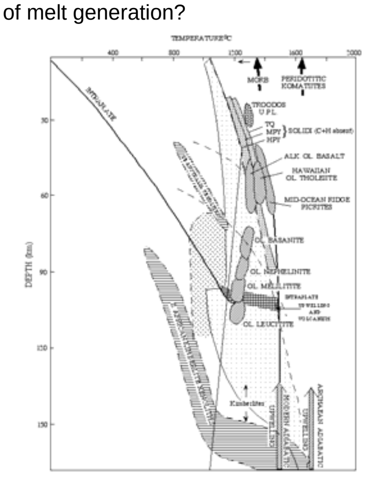

Green et al. 2001; European J. Miner.

Magma genesis in intraplate settings can be understood in terms of the lherzolite + (C-H-O) system. The proposed model is used to explain production of specific primary magmas in the P,T field between the regionally applicable conductive geotherm and adiabatic upwelling of mantle with potential temperature (Tp) ~1430°C

Origin of magmas

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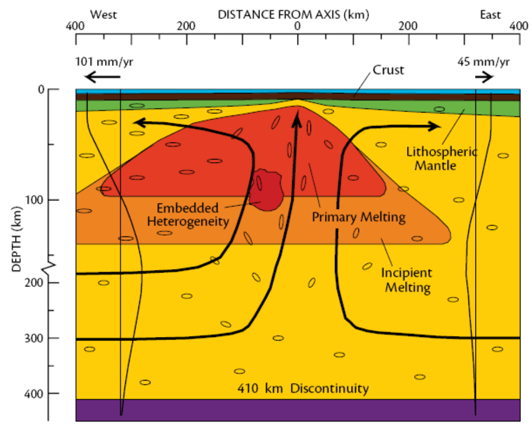
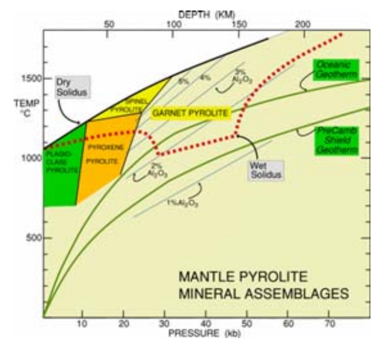


C.H. Langmuir & D.W. Forsyth (2006) Oceanography 20/1, 78-89

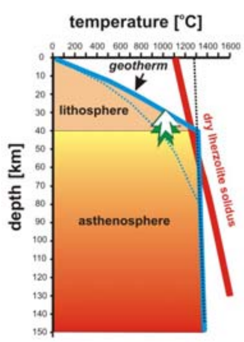


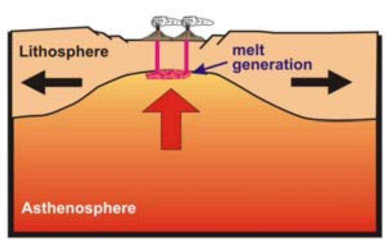
This is the result of MELTS experiment at the East Pacific Rise. This cartoon shows that melting beneath the ridge starts at the depth of about 150 km. This would require some volatile in the sublithospheric mantle!

Origin of magmas

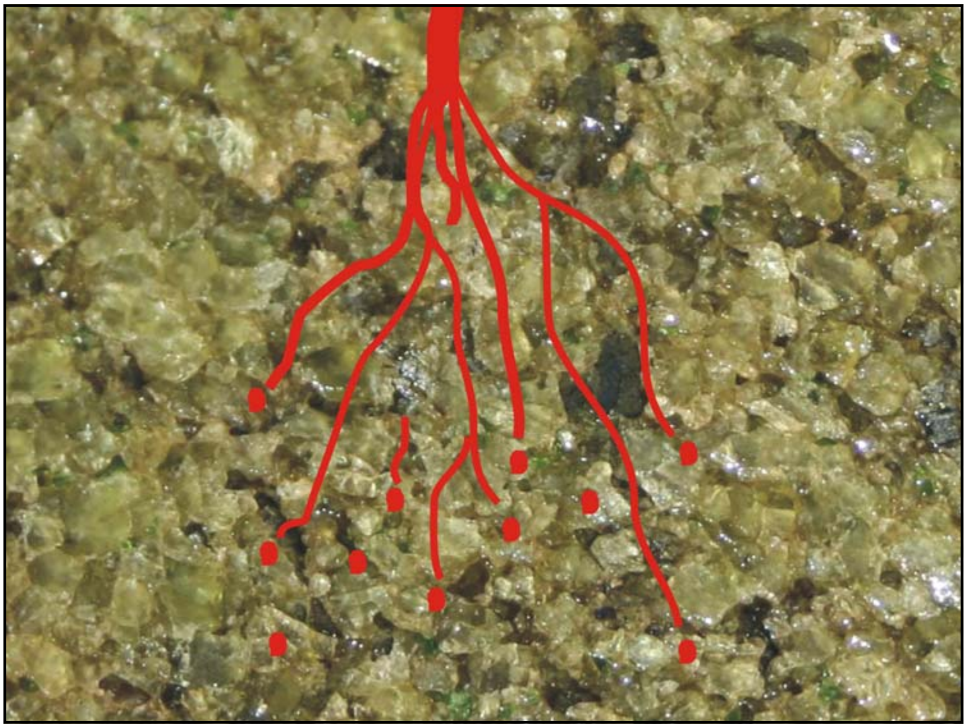
But, what is the principal reason of melt generation?
What kind of process could lead to melt the solid upper mantle material?

UPWARD MANTLE FLOW!



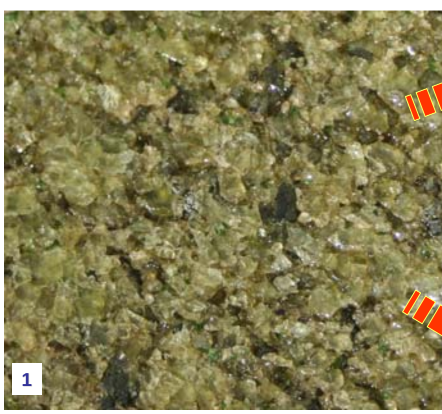


Decompression melting due to thinning of lithosphere and passive upwelling of asthenospheric material is the primary reason of magma generation in the mantle. The main location of the magma formation is beneath the oceanic ridges, but this decompression melting is the main cause of magma generation also beneath oceanic islands and intracontinental areas as well as at subduction zones!

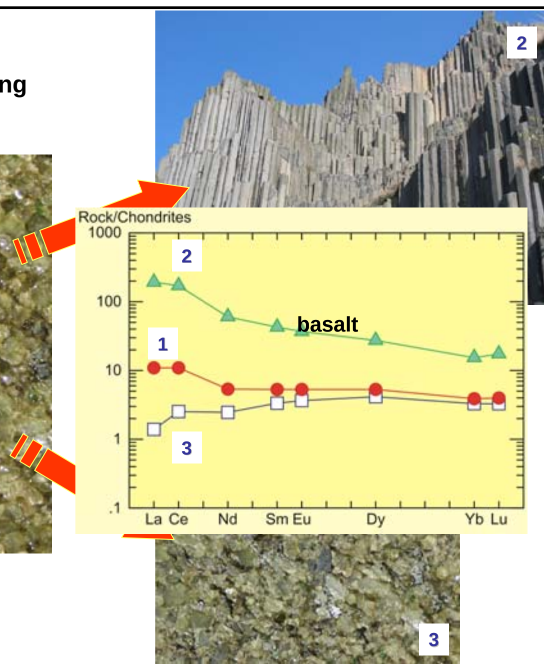


Origin of magmas

Consequence of partial melting



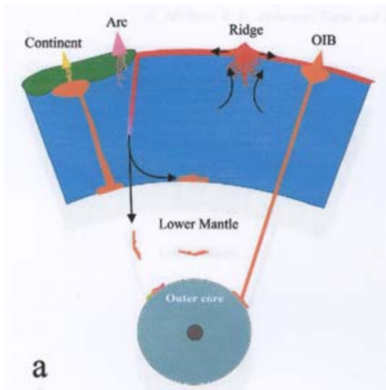
lherzolite



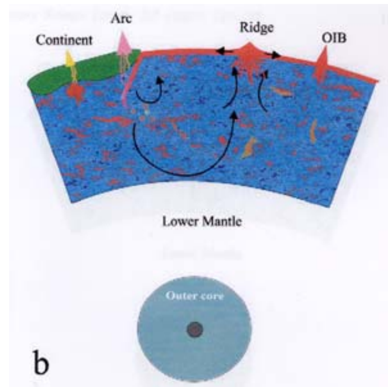
harzburgite

Origin of magmas

The source region



Layered mantle model with plumes

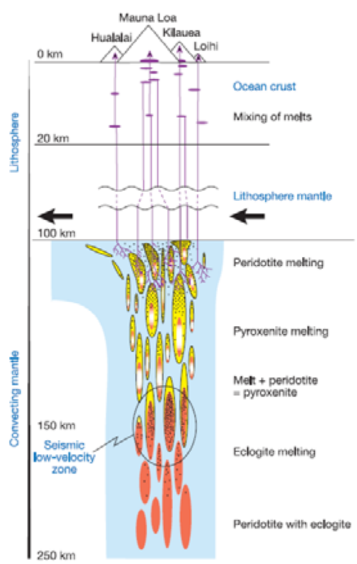


Heterogeneous mantle model without plumes

from Meibom & Anderson 2003 EPSL

Origin of magmas

The source region



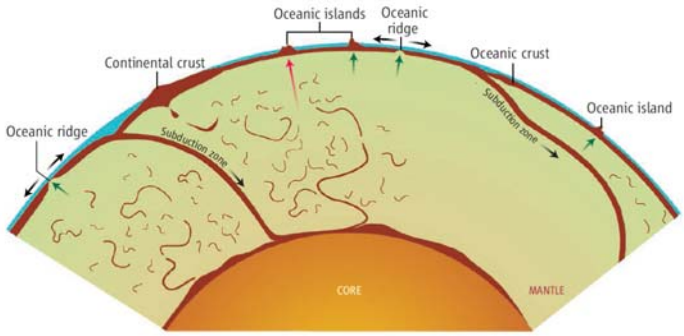
Sobolev et al. 2005 Nature

Model diagram of the Hawaiian mantle plume (Sobolev et al. 2005).

Primary and secondary rock types are colour coded as follows: red, eclogite representing recycled oceanic crust; blue, peridotite; yellow, reaction (secondary) pyroxenite produced by infiltration of eclogitederived melt into peridotite; white and red, eclogitic restite; black dots, melts; violet, magma pathways, conduits and small magma chambers. Recycled material is concentrated in the plume centre.

Mixing of melts probably takes place at shallow crustal levels in small magma bodies rather than in the mantle or in large stable magma chambers.

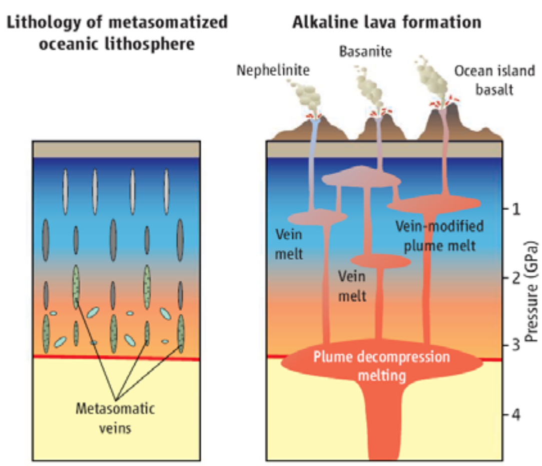
The source region



Herzberg 2007 Science

Oceanic crust (brown) is solidified liquid that forms by partial melting of mantle peridotite (green) at oceanic ridges; together with sediment, oceanic crust can be recycled back into the mantle at subduction zones (2, 3, 6). Continental crust (brown) forms at subduction zones and can be recycled when it thickens by delamination (5, 15). All crust (brown) is transformed to pyroxenite (brown) when recycled. Green arrow denotes melting peridotite. Red arrow denotes melting pyroxenite. Recycled crust may be distributed uniformly throughout the mantle, or it may be concentrated in certain hemispheres or depths (Herzberg, 2007).

The source region



Niu 2008 Science

*Metasomatic, amphibole-rich veins in the lower lithosphere (**left**; Pilet et al. 2008, Science). They crystallize in the lithosphere from small mass-fraction (low-degree) melts that ultimately originated in the LVZ.*

*However, metasomatic amphibole-rich veins in the lithosphere do not melt without thermal perturbation. Hot "plume" melts from the deep mantle may cause the veins to melt (**right**); mixing of the two melts in different proportions then results in the alkali-rich nature and compositional spectrum of ocean island lavas (Niu, 2008).*

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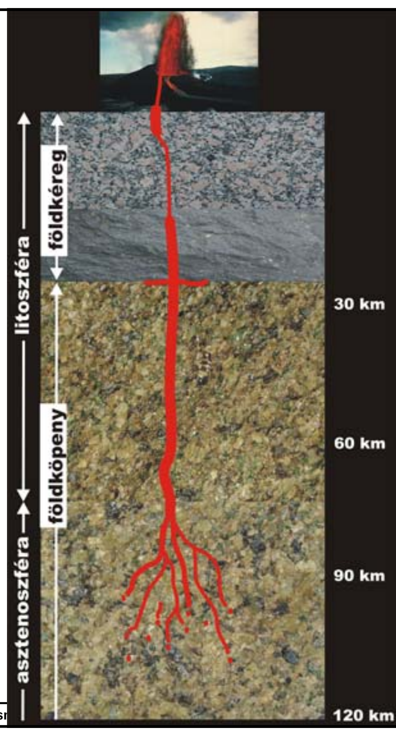
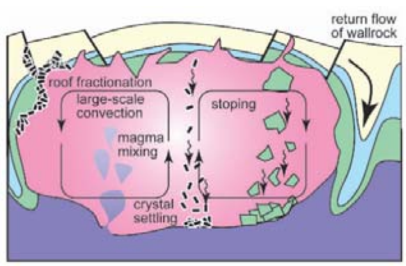
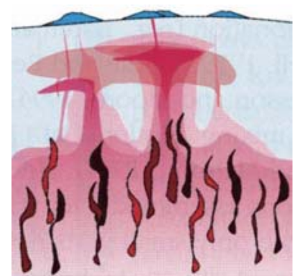
Evolution of magmas



How does a magma chamber look like?



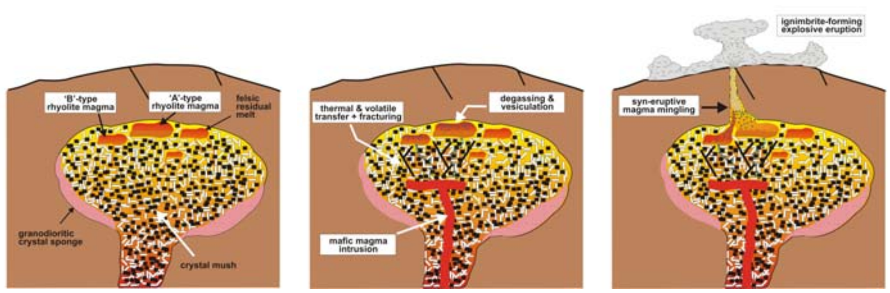
Traditional view: a big hole filled mostly by silicate liquid



A new view: a big magma reservoir filled mostly by crystal mush formed by repeated intrusion of magmas

Glazner et al., 2003, GSA Today & Lipman, 2007, Geosphere

How does a magma chamber look like?



Lukács et al. 2009, Central European Geology

This cartoon series shows the suggested evolution of the silicic magmas fed the 13.5 Ma Harsány ignimbrite eruption, Bükkalja Volcanic Field (Lukács et al., 2009). The Harsány ignimbrite contains two distinct rhyolitic pumice populations.

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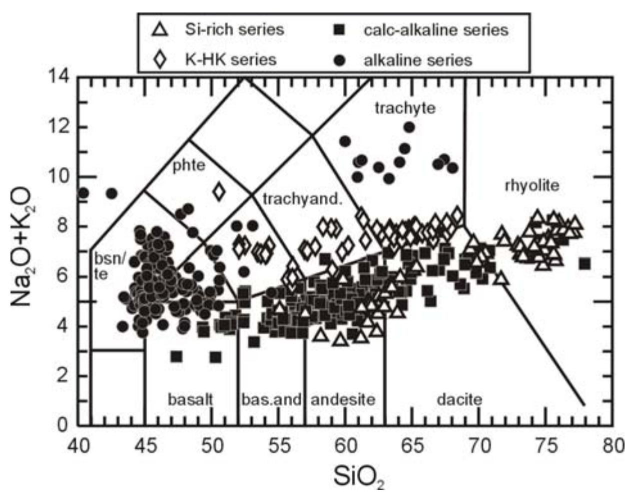
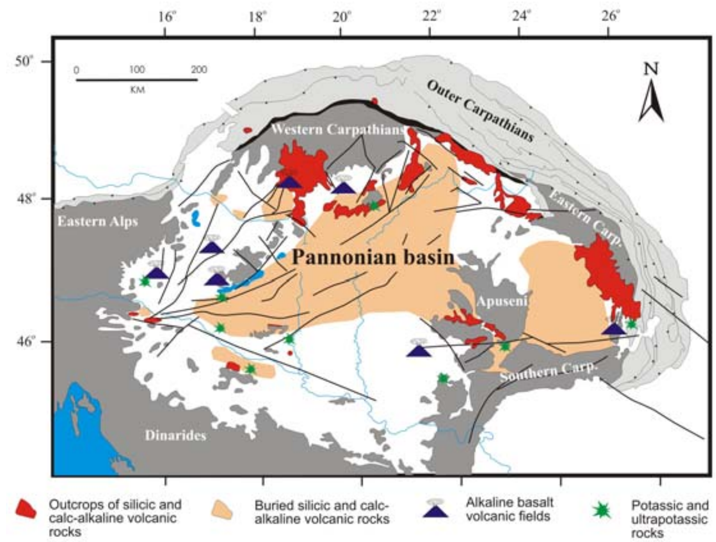
Classification of the volcanic rocks in the CPR; temporal and spatial distribution



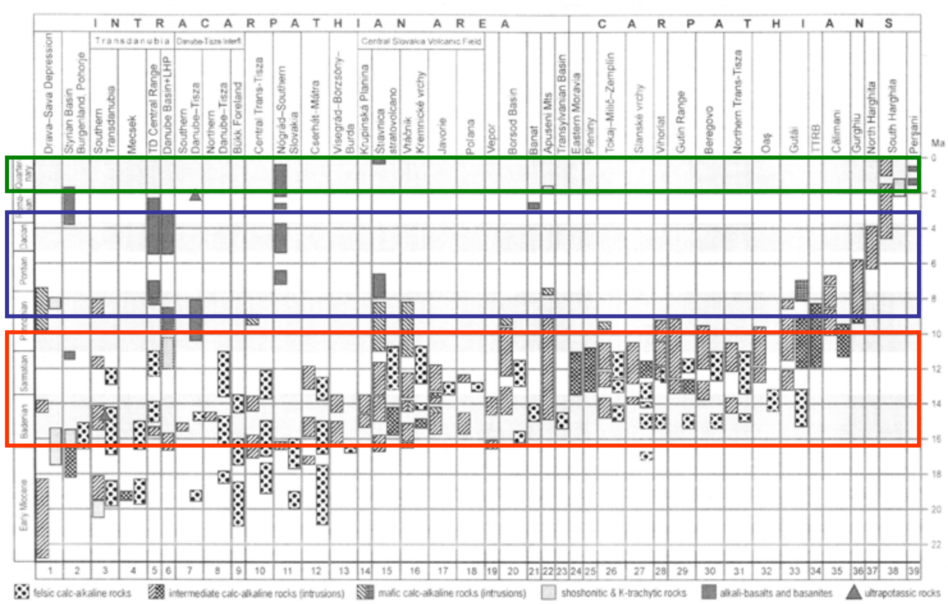
Four main compositional groups of volcanic rocks:

1. Si-rich volcanic rocks
2. Calc-alkaline volcanic rocks
3. Potassic-ultrapotassic volcanic rocks
4. Alkaline sodic volcanic rocks

Classification of the volcanic rocks in the CPR; temporal and spatial distribution



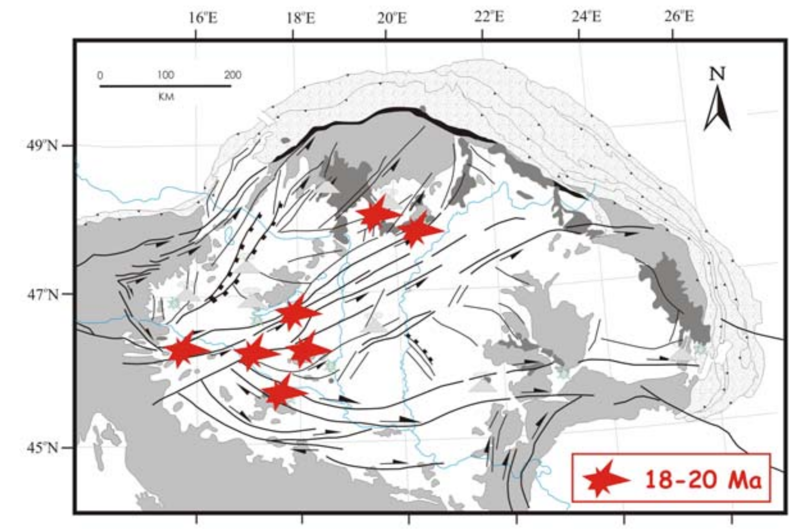
Classification of the volcanic rocks in the CPR; temporal and spatial distribution



Age of volcanic activities in certain areas of the CPR

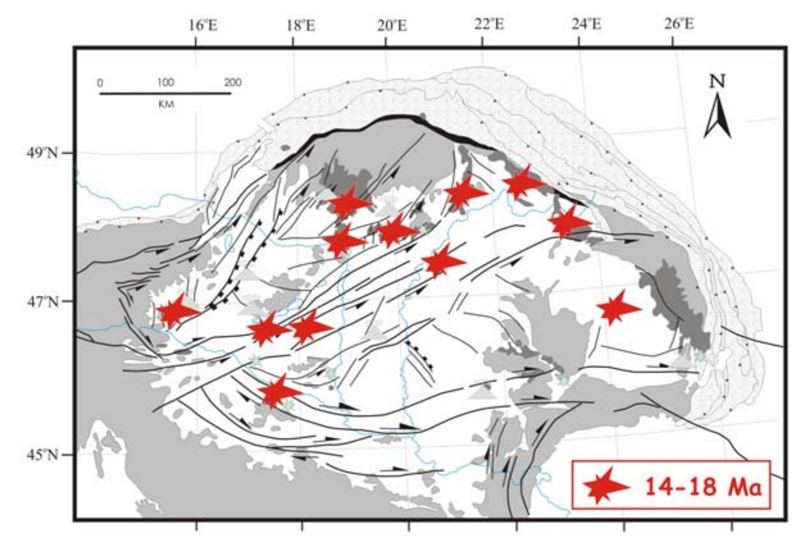
Pécskay et al. 2006, Geol. Carp.

Classification of the volcanic rocks in the CPR; temporal and spatial distribution



Temporal evolution of the volcanism in the CPR

Classification of the volcanic rocks in the CPR; temporal and spatial distribution



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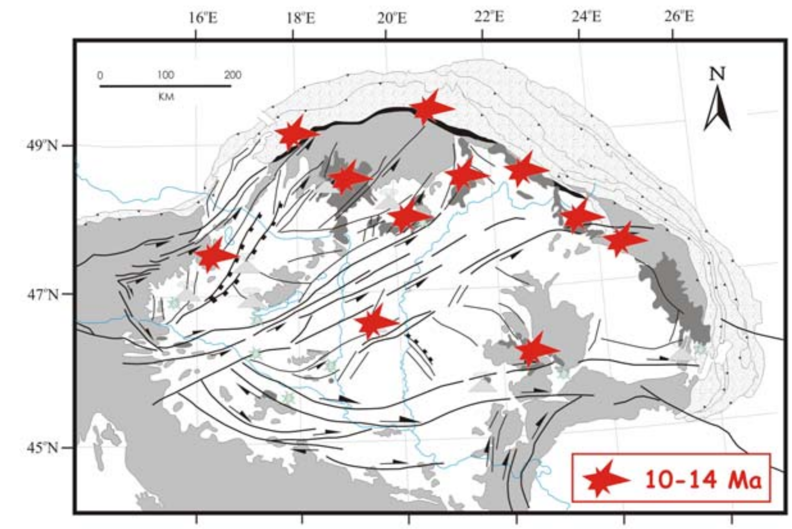

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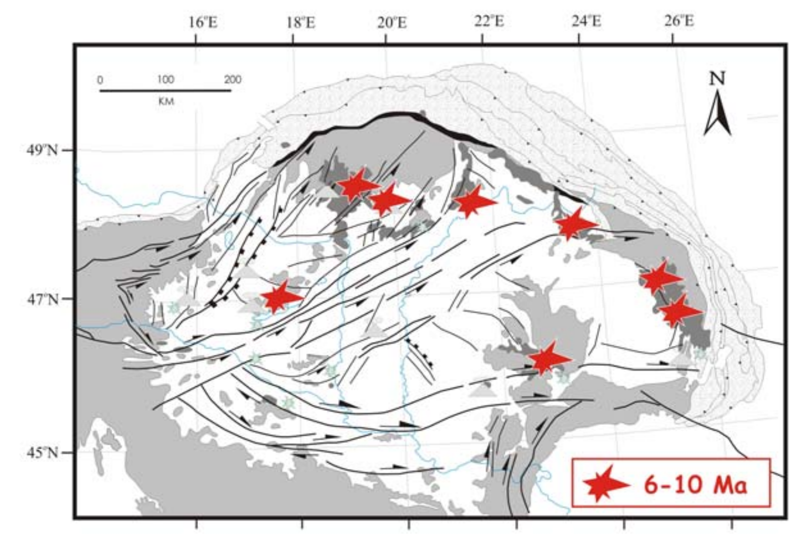

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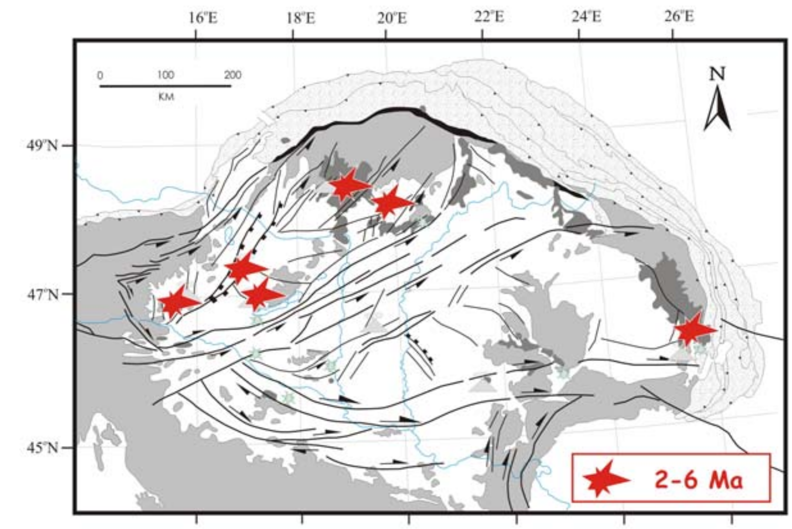

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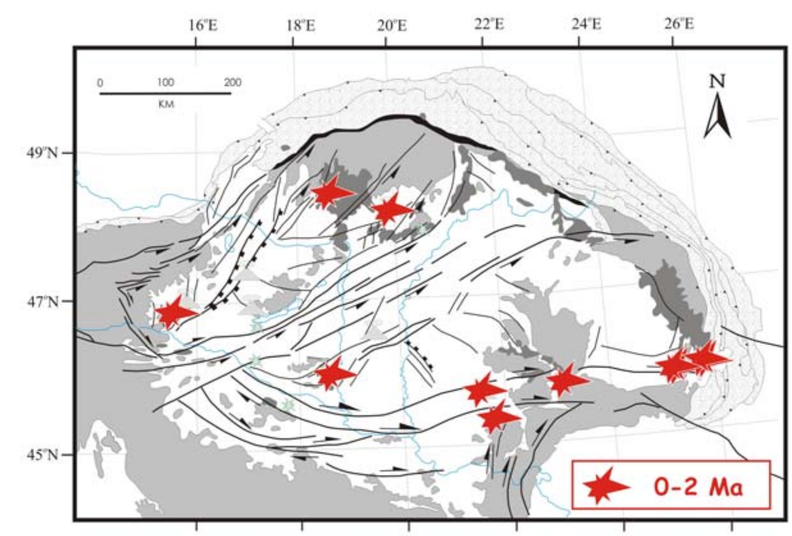

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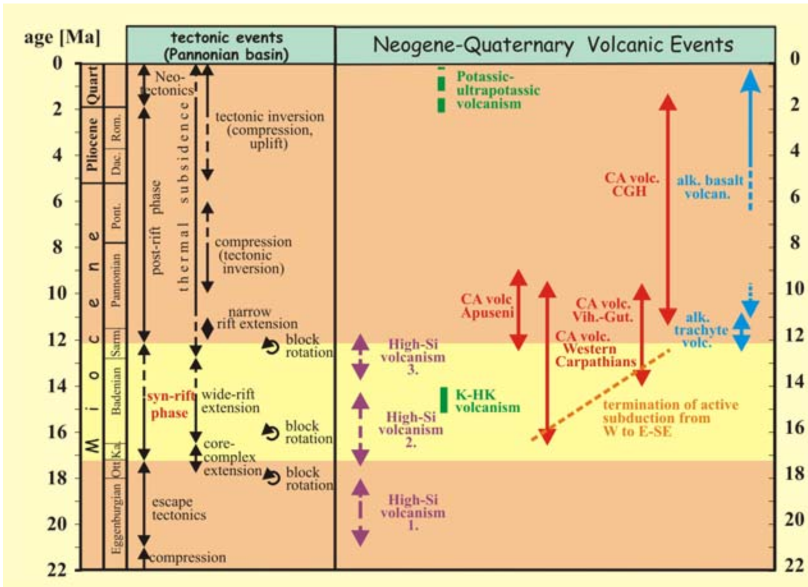

after Harangi, 2001, Acta Geologica Hungarica

Outline

- Data and tools
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- Calc-alkaline volcanism
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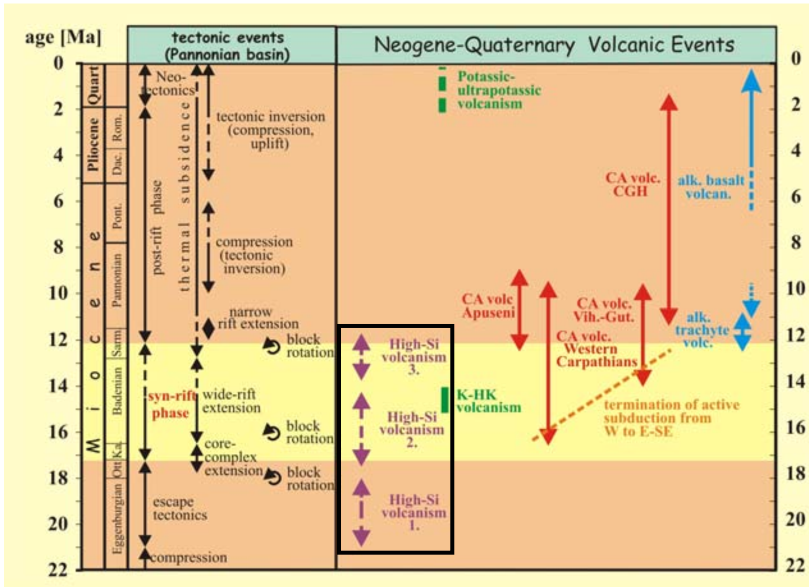
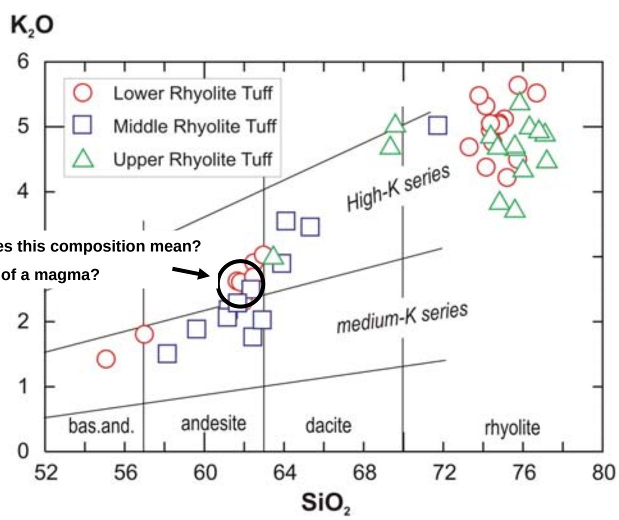
- Alkaline sodic volcanism
- Perspectives

Silicic volcanism



after Harangi, 2001, Acta Geologica Hungarica

Silicic volcanism



But, what does this composition mean?

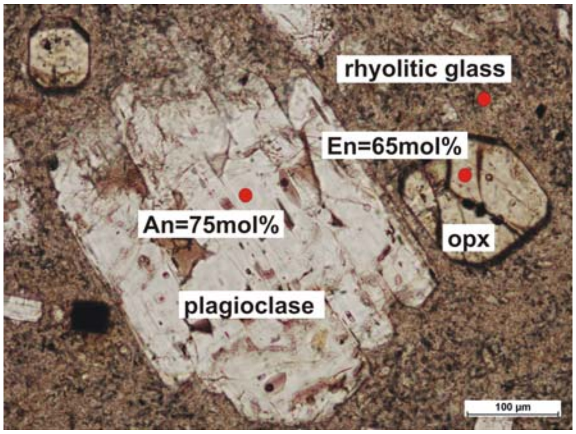
Composition of a magma?

Rhyodacite and rhyolite pumices; but there are basaltic andesite and andesite scoriae and lithic clasts.

Does it mean a bimodal (basalt-rhyolite) magmatism?

Silicic volcanism

Texture of an andesitic lithic clast

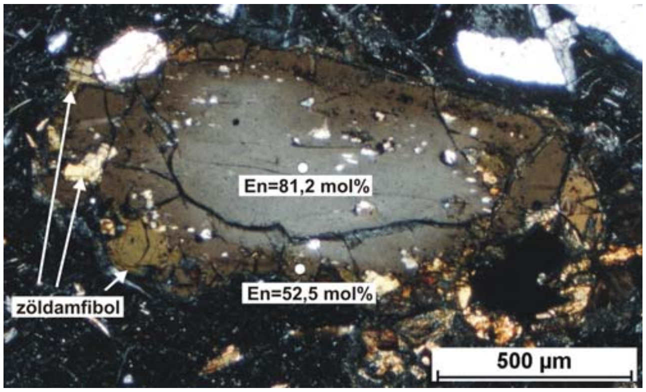


Lukács, 2009, PhD thesis

Mixture of various phenocrysts and silicic melt!

Silicic volcanism

Composition of orthopyroxenes in an andesitic lithic clast

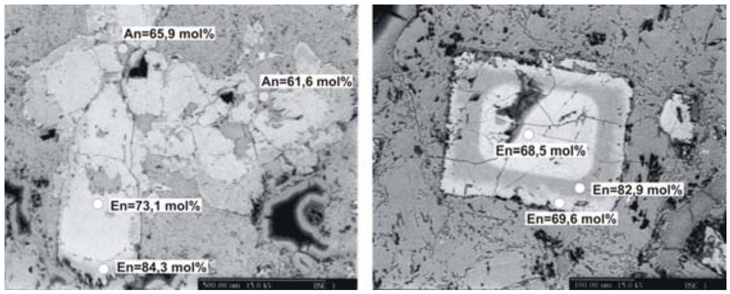


Lukács, 2009, PhD thesis

The high En-content of the orthopyroxene core indicates role of mafic magma!

Silicic volcanism

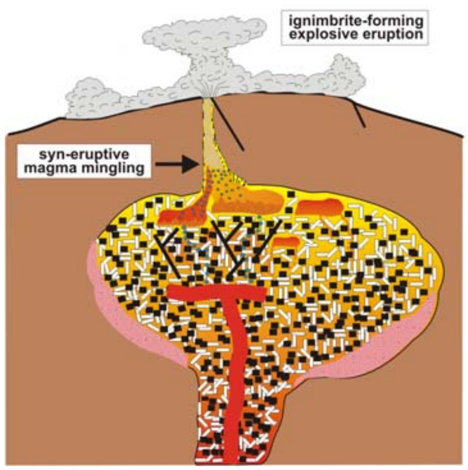
Composition of orthopyroxenes in an andesitic lithic clast



Lukács, 2009, PhD thesis

The high En-content at the orthopyroxene rim indicates role of mafic magma!

Silicic volcanism

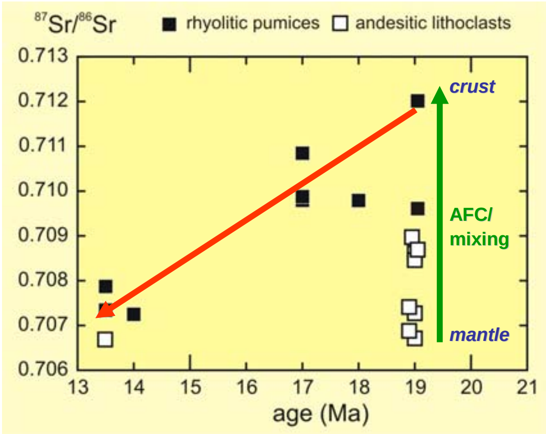


Lukács et al. 2009 Central European Geology

Complex evolution in a shallow magma reservoir, interaction between different crystal mushes and mixture with residual silicic melt

Silicic volcanism

Temporal changes of the isotopic composition

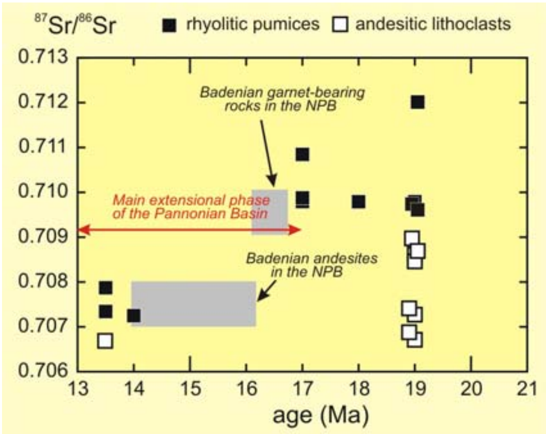


Harangi & Lenkey, GSA Spec. Publ, 2007

Is it a tectonic control? Sr isotope ratios tend to decrease contemporaneously with the thinning of lithosphere beneath the Pannonian Basin.
On the other hand we might see both mantle and crustal signature in the isotopic composition of the pumices and cognate lithic clasts

Silicic volcanism

Temporal changes of the isotopic composition



Harangi & Lenkey, GSA Spec. Publ, 2007

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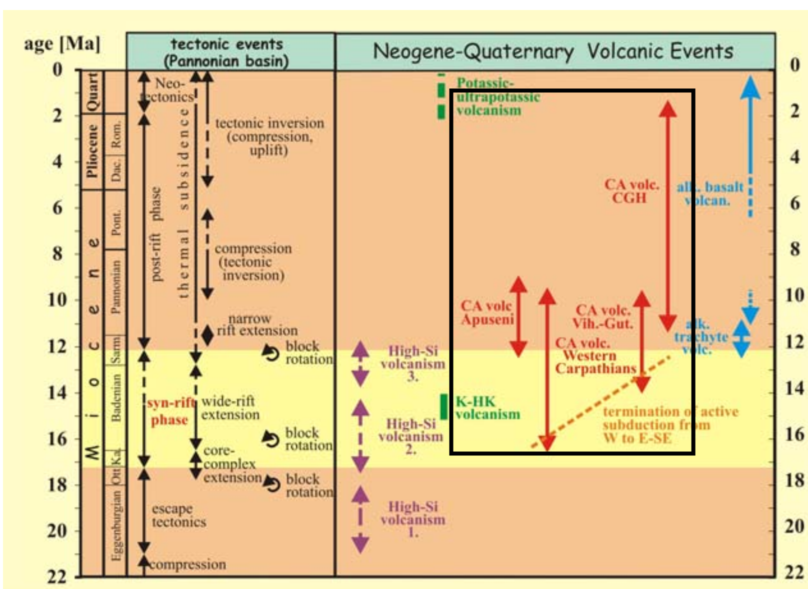
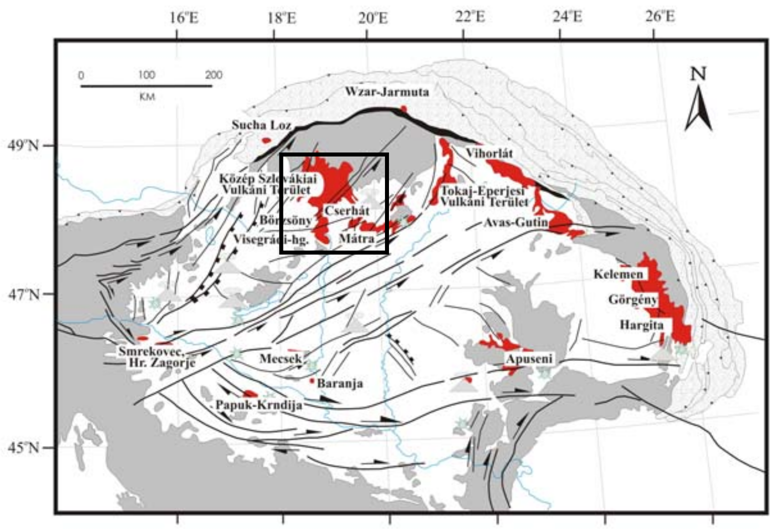
Calc-alkaline volcanism



after Harangi, 2001, Acta Geologica Hungarica

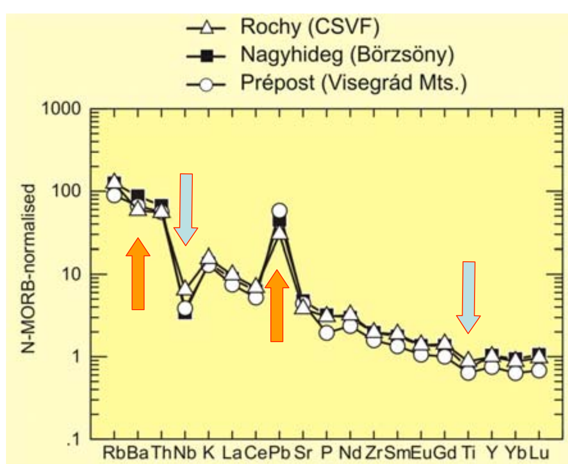
Calc-alkaline volcanism

The case of calc-alkaline volcanism in the western Carpathians…



Calc-alkaline volcanism

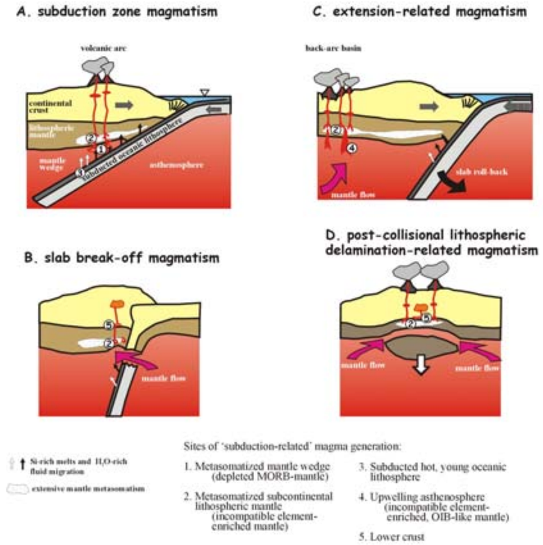
Trace element characteristics of the less evolved samples



It suggests a subduction-related component in the genesis of the magmas!
However, it does not necessarily imply an origin in an active subduction zone!

Calc-alkaline volcanism

Possible tectonic settings to produce magmas with ‘subduction” signature



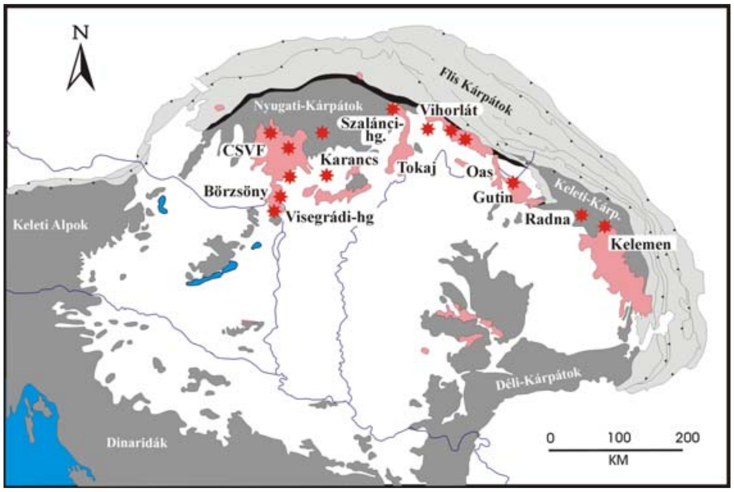
Harangi et al., 2006, Geol Soc. London Memoir

Calc-alkaline volcanism

The message of garnet

Sátoros, Karancs, Northern Pannonian Basin

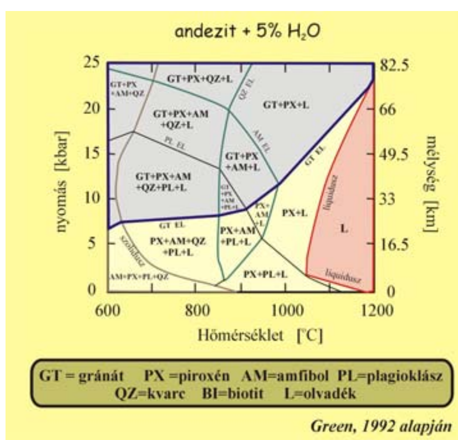
The message of garnet



Harangi, 2004, DSc thesis

Almandine garnets are quite frequent in the calc-alkaline volcanic rocks of the Northern part of the Pannonian basin, but not at the eastern part!

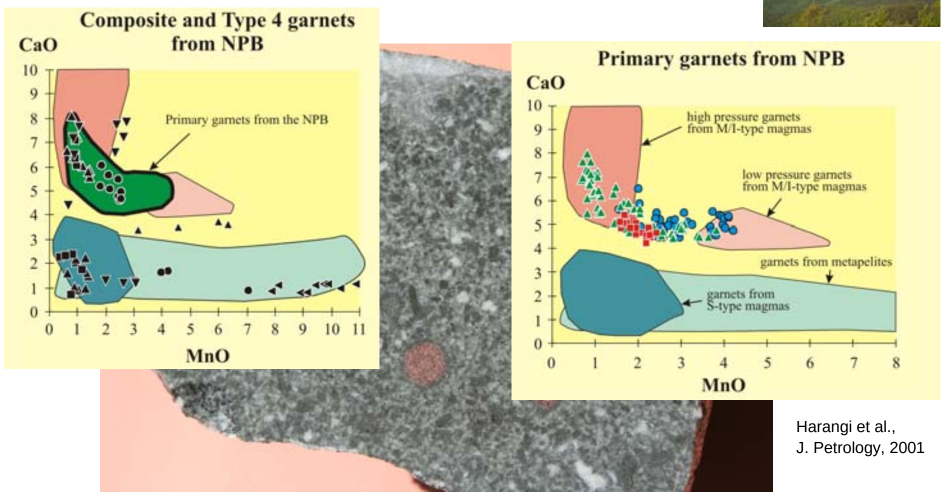
The message of garnet



Almandine garnet forms under special conditions; at high pressure (>7 kbar) and at high magma volatile content. At low pressure it is not stable anymore and decomposes into stable mineral assemblage. Thus, occurrence of almandine suggests high-pressure crystallization from a hydrous magma, followed by rapid magma ascent to the surface.

Calc-alkaline volcanism

The message of garnet

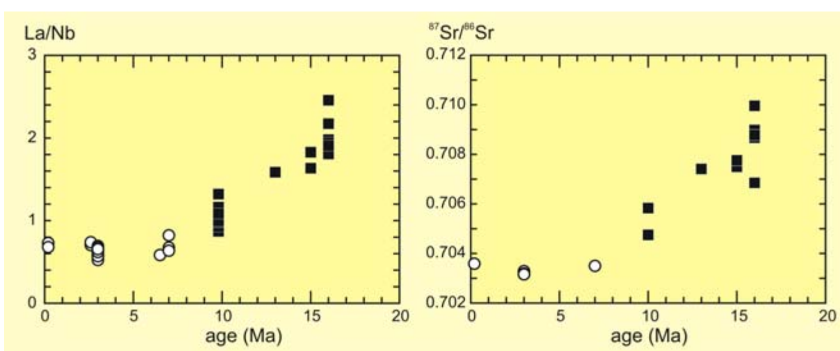


Harangi et al.,
J. Petrology, 2001

In addition to the primary M/I-type garnets, there are also xenocrystic garnet in these rocks. They could be derived from the metapelitic lower crust.

Calc-alkaline volcanism

Petrogenesis of the calc-alkaline volcanic rocks in the Northern Pannonian Basin

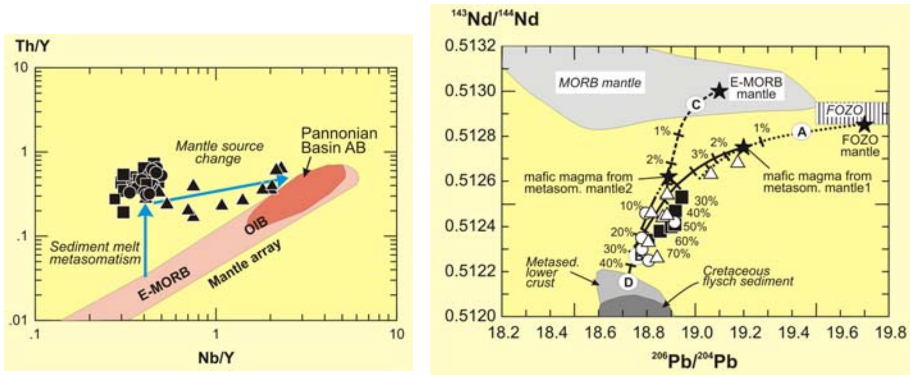


Harangi & Lenkey, GSA Spec. Publ, 2007

A gradual change both in trace element and isotopic composition cam be observed in the calc-alkaline rocks

Calc-alkaline volcanism

Petrogenesis of the calc-alkaline volcanic rocks in the Northern Pannonian Basin

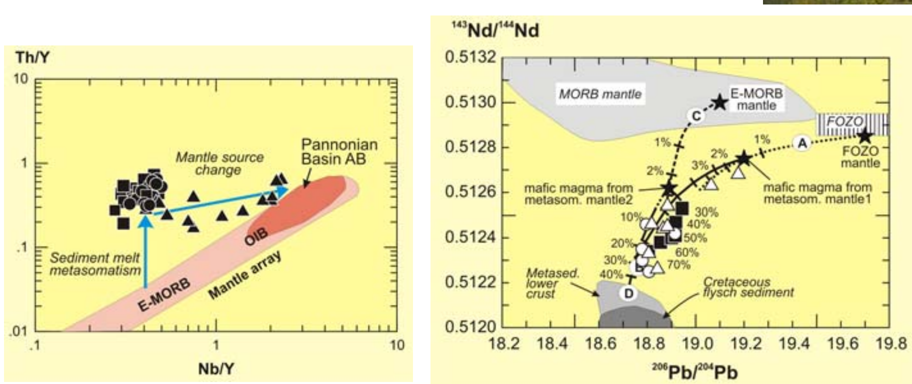


Harangi et al., J. Petrology, 2007

Isotopic data indicate a major role of crustal materials in the genesis of the magmas. Parental mafic magmas could have been generated from an E-MORB-type mantle source, previously metasomatized by fluids derived from subducted sediment. Initially, the mafic magmas ponded beneath the thick continental crust and initiated melting in the lower crust. Mixing of mafic magmas with silicic melts from metasedimentary lower crust resulted in relatively Al-rich hybrid dacitic magmas, from which almandine could crystallize at high pressure…

Calc-alkaline volcanism

Petrogenesis of the calc-alkaline volcanic rocks in the Northern Pannonian Basin



Harangi et al., J. Petrology, 2007

… Crustal involvement in the erupted magmas decreased with time as the continental crust thinned. A striking change of mantle source occurred at about 13 Ma. The basaltic magmas formed during the later stages of the calc-alkaline magmatism were derived from a more enriched mantle, akin to FOZO.

Calc-alkaline volcanism

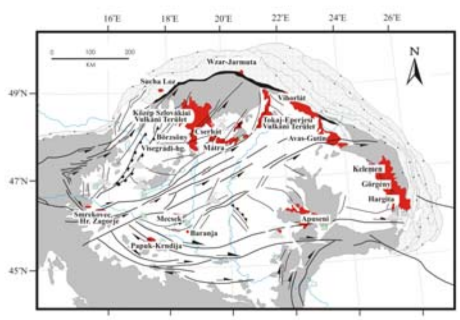
Summary

Silicic and calc-alkaline volcanism

(Central and Northern Pannonian Basin)

- **An example of long-lasting magmatism in which compositions changed continuously in response to changing geodynamic setting.**
- **Magma generation occurred during the period of peak extension by melting of metasomatized lithospheric mantle**
- **Early mafic magmas ponded beneath the relatively thick continental crust and initiated melting in the lower crust.**
- **As the continental crust thinned, the role of crustal contamination decreased**
- **Change of the magma source region, i.e. from an E-MORB-type mantle to a more enriched, OIB-type (≈FOZO) mantle**

Calc-alkaline volcanism



Calc-alkaline volcanism along the Eastern Carpathians…

This seems to be closely related to subduction process…

…but…

it appears that the active subduction terminated at about 11 Ma…

…and…

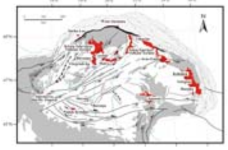
the calc-alkaline volcanism occurred roughly from 12 Ma to 2 Ma

…thus…

they are mostly post-collisional…

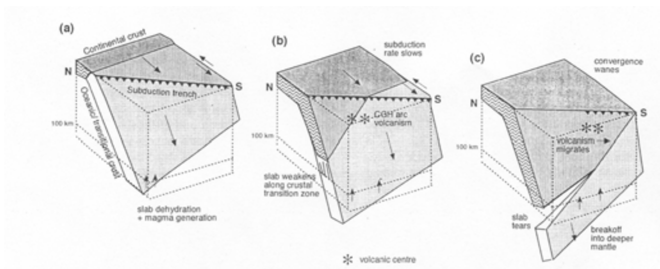
Calc-alkaline volcanism

Calc-alkaline volcanism along the Eastern Carpathians…



The reason of melt generation in such geodynamic condition is unclear…

slab detachment could be a possible mechanism?



Mason et al., Tectonophysics, 1998

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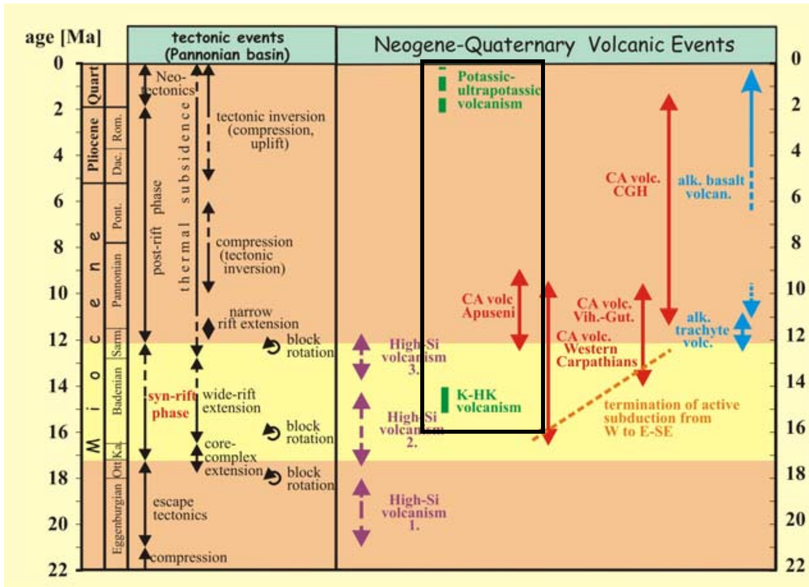
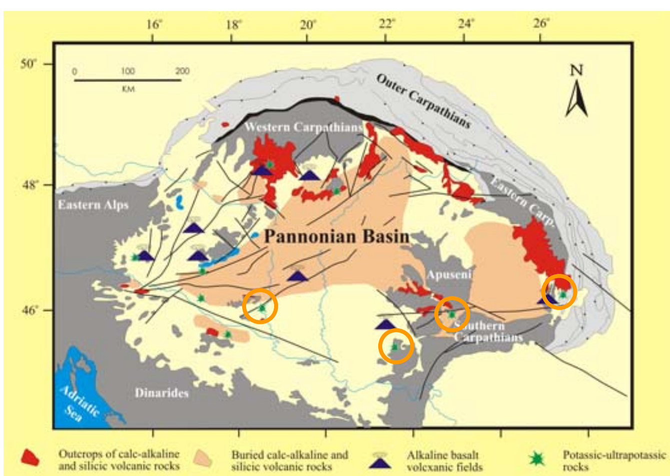
Potassic-ultrapotassic volcanism



after Harangi, 2001, Acta Geologica Hungarica

Potassic-ultrapotassic volcanism

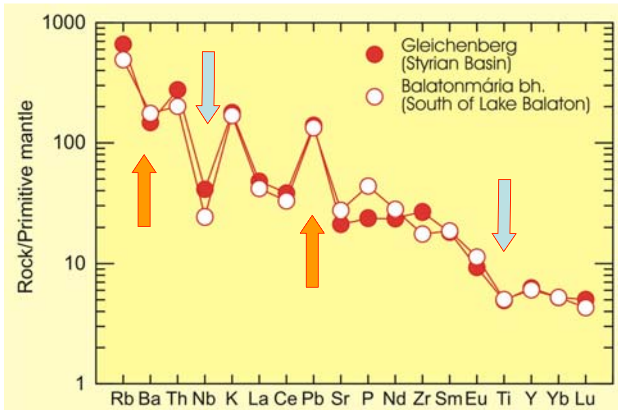
Occurrences

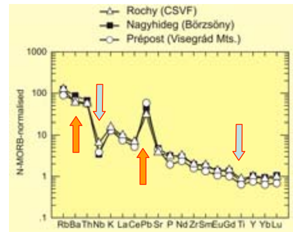


Note, that most of these rocks were formed <2 Ma and along the southern margin of the Pannonian Basin!

Potassic-ultrapotassic volcanism

Trace element characteristics



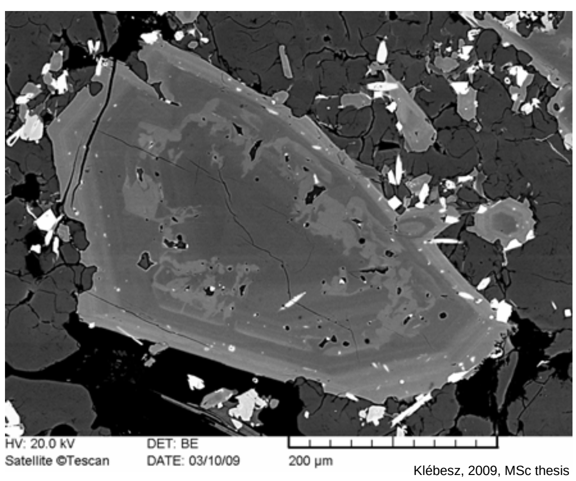


Harangi et al. 1995, Acta Vulc.

It looks like a subduction-related origin…
…but think again what was shown before: this trace element signature reflect the nature of the mantle source, NOT the tectonic setting!

Potassic-ultrapotassic volcanism

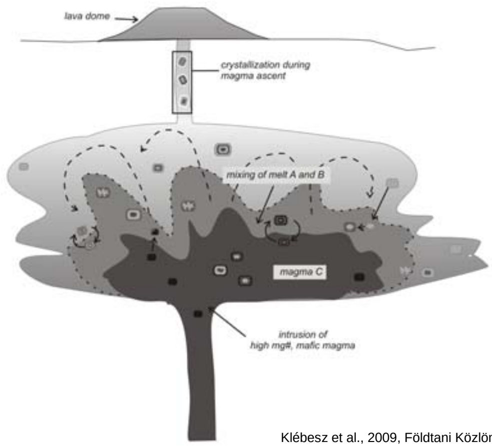
What do the mineral phases tell us about the genesis of the magmas?



Klébesz, 2009, MSc thesis

Texture of the clinopyroxene phenocrysts suggests open-system magmatic processes, i.e. periodically replenished crystallizing magma chamber.

What do the mineral phases tell us about the genesis of the magmas?



Klébesz et al., 2009, Földtani Közlöny

This the magma chamber model for the 14 Ma old Balatonmária latites

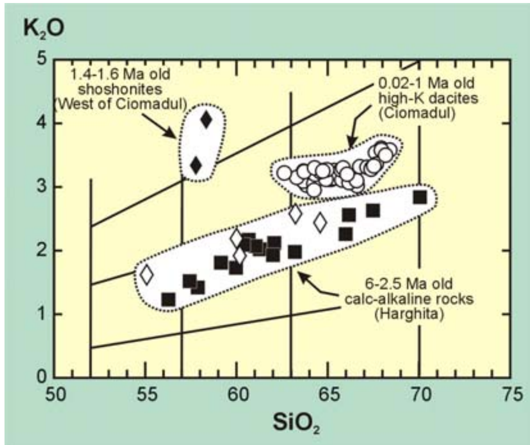
Significance of ultrapotassic magmatism

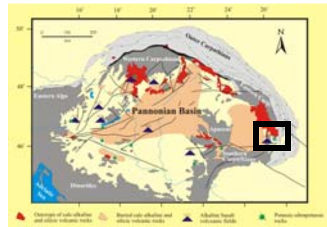
- Magmas from metasomatized mantle source region (remobilization of K-rich veins in the lowermost lithosphere)
- Metasomatism occurred in the past, either by freezing of small volume melts from the LVZ in the CLM or by reaction with subduction-related hydrous fluids
- These regions are capable to produce magmas due to their lower solidus
- Reason of remobilization
  - Hot mantle upwelling
  - Thinning of lithosphere

The 14 Ma old latites could have been formed due to the lithospheric extension, but what about the 2 Ma old Bár leucitite and the 1.3 Ma old Gataia lamproite?

Potassic-ultrapotassic volcanism

The youngest volcanic rocks in the CPR: high-K dacites from Ciomadul volcano

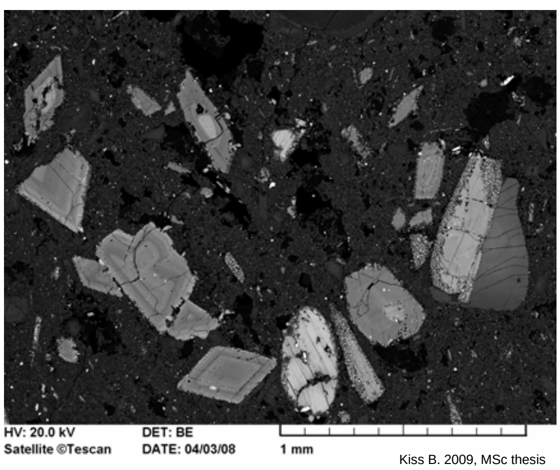




But, again we may ask what does this composition mean? Does this represent the composition of a certain magma?

Potassic-ultrapotassic volcanism

What do the mineral phases tell us about the genesis of the magmas?

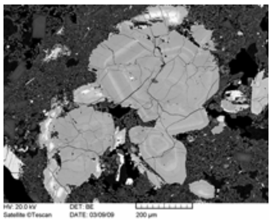


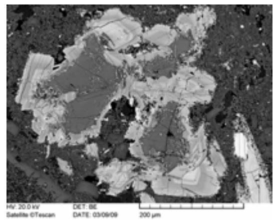
Kiss B. 2009, MSc thesis

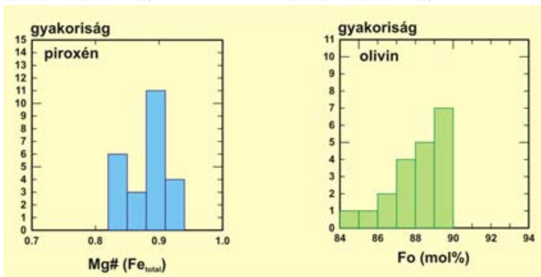
This rock is again a mixture of mineral phases formed at different stages and at different time during the magma evolution!

Potassic-ultrapotassic volcanism

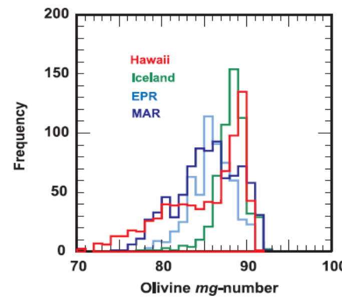
What do the mineral phases tell us about the genesis of the magmas?







Kiss B. 2009, MSc thesis



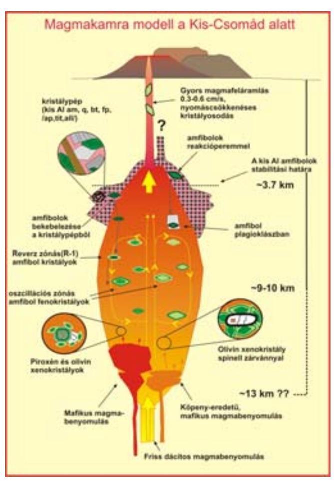
Herzberg et al. 2007 G^3

This is STRANGE! How could a high-Mg mineral, such as olivine and cpx survive in a dacitic magma?

…and why they are there?

Potassic-ultrapotassic volcanism

The youngest volcanic rocks in the CPR: high-K dacites from Ciomadul volcano

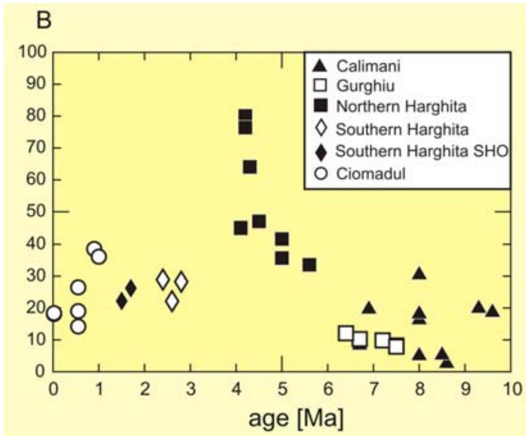


Kiss B. 2009, MSc thesis

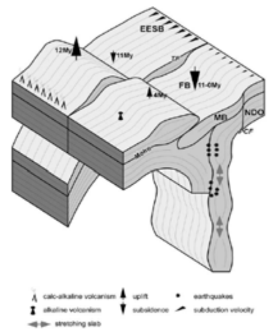
The integrated interpretation of the texture (zoning pattern) and composition of the mineral phases in the dacite suggests complex magma chamber processes as shown in this panel (Kiss, 2009)

Potassic-ultrapotassic volcanism

Geodynamical relationships



Harangi & Lenkey, GSA Spec. Publ, 2007

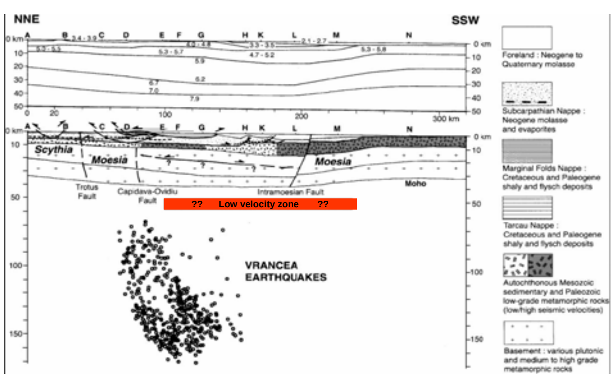


Cloething et al. 2004 EPSL

Role of Trotus line?

Potassic-ultrapotassic volcanism

Geodynamical relationships



Hauser et al., 2001, Tectonophysics

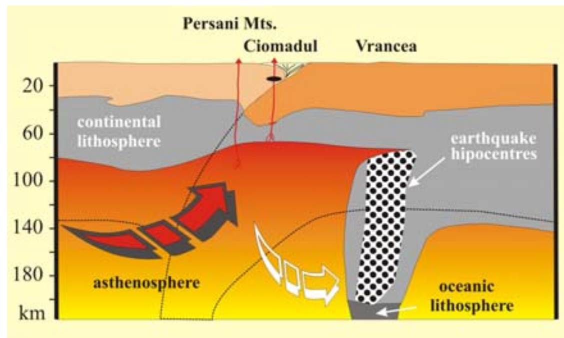
Potassic-ultrapotassic volcanism

Geodynamical relationships

Toroidal flow at the plate edge?

or

horizontal delamination of the lower lithosphere?



after Girbacea & Frisch, 1998, Geology

Potassic-ultrapotassic volcanism

Summary

Potassic-ultrapotassic volcanism

- **Middle Miocene HK volcanism: melt generation in the K-rich metasomatized lithsopheric mantle due to thinning of the lithosphere**
- **Complex evolution in deep-seated magma chambers: periodic refilling by HK melts**

Quaternary:

- **Sporadic eruption of K-rich magmas along a W-E lineament.**
- **Magma generation by melting of strongly metasomatized lithospheric mantle**
- **Involvement of mantle-derived mafic (ultrapotassic?) melt in the genesis of the youngest magmatism (Ciomadul)**
- **Mixing of mantle-derived and crustal-derived melts**
- **Complex magma chamber evolution in shallow magma reservoirs**
- **Mantle flow due to slab disturbance – still active melting at about 60 km depth?**

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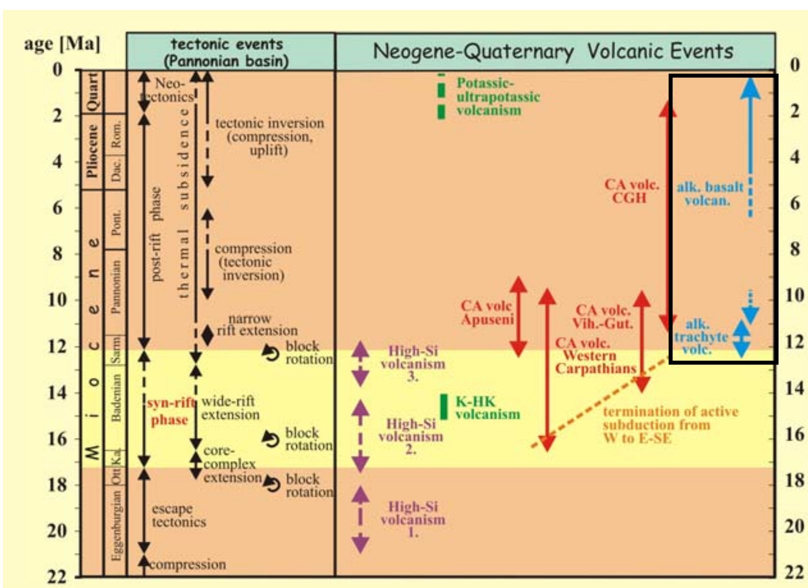
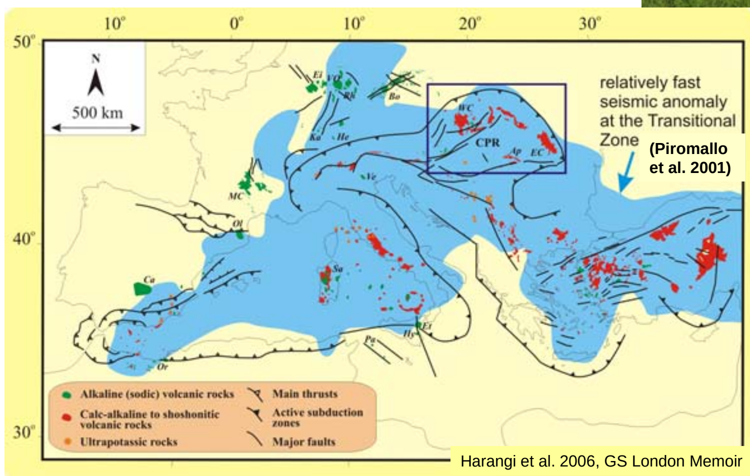
Alkaline sodic volcanism



after Harangi, 2001, Acta Geologica Hungarica

Alkaline sodic volcanism

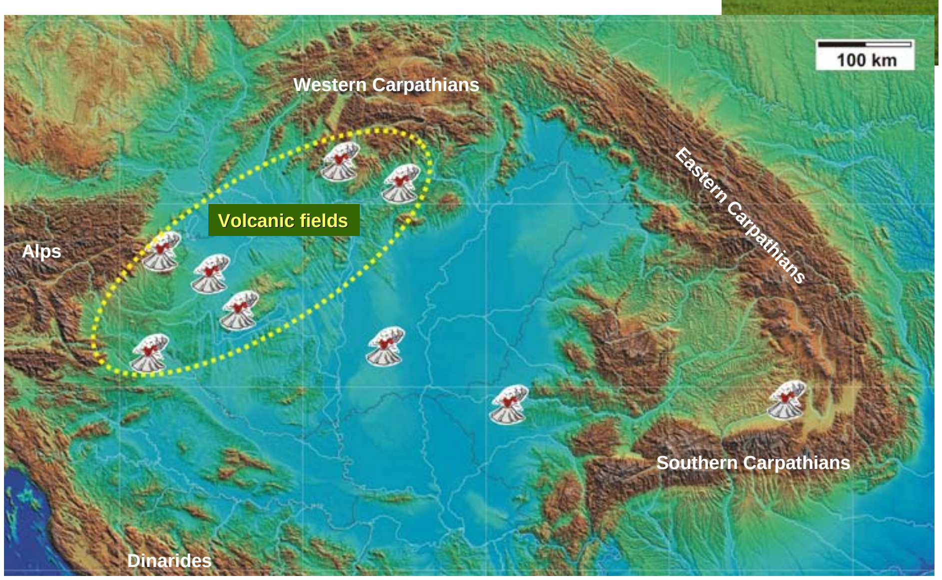
Neogene to Quaternary volcanic fields in Europe



Harangi et al. 2006, GS London Memoir

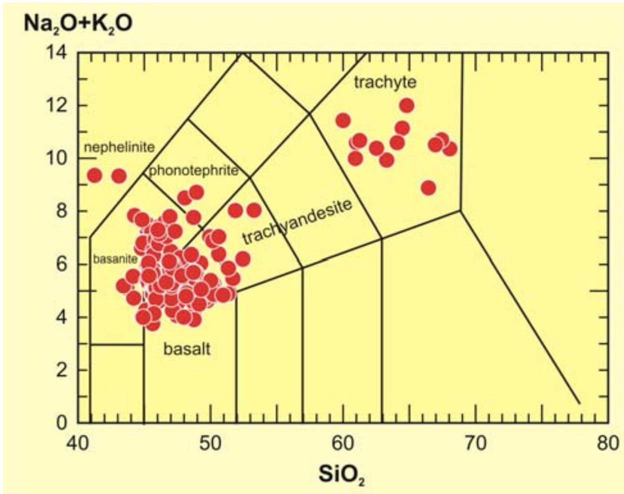
Alkaline sodic volcanism

Neogene to Quaternary volcanic fields in the CPR



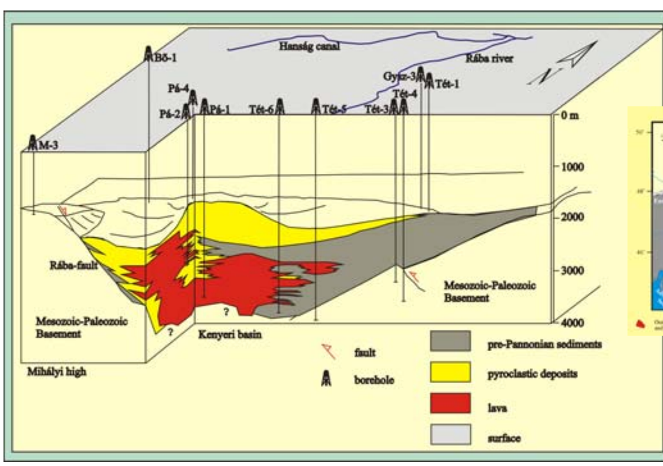
Alkaline sodic volcanism

Major element characters



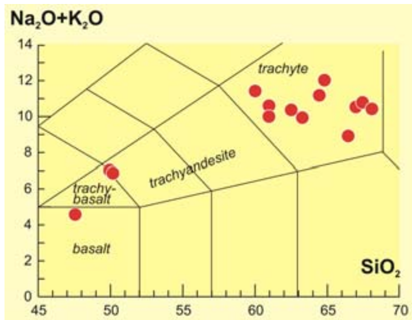
Not only mafic… beneath the Little Hungarian Plain a huge trachyandesite-trachyte volcano was revealed!

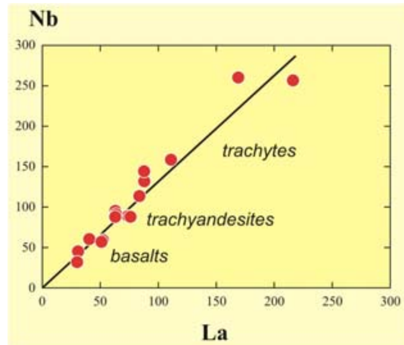
Alkaline sodic volcanism



This is the Pásztori volcano!

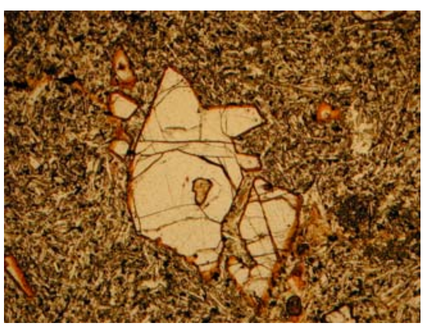
Petrogenesis of the Pásztori volcanic rocks



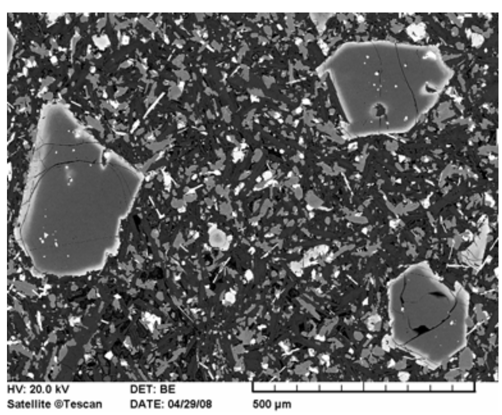


Incompatible trace elements suggest cogenetic link between the basalts and the more evolved rocks!

Petrography of the basalts



Mostly olivine-phyric mafic rocks



Many basalts contain olivine phenocrysts with spinel inclusions

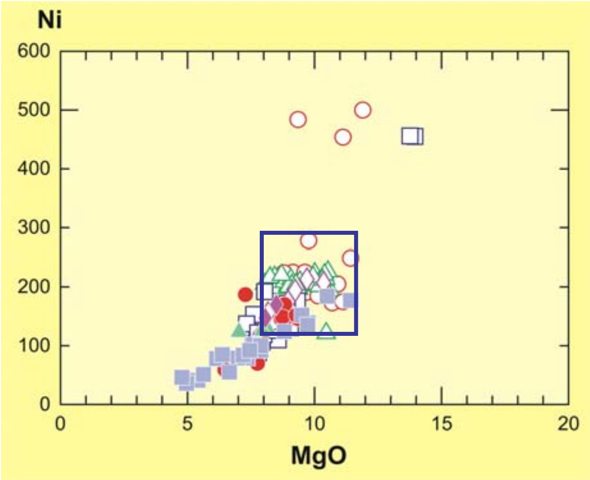
- **Petrology:**
  - **Mostly alkaline mafic rocks: nephelinites to trachybasalts**
  - **Sporadic basaltic trachyandesite differentiated rocks**
  - **Single alkaline trachyte volcano (buried)**
  - **Mostly olivine-phyric mafic rocks**
- **Age:**
  - **Sporadic eruptions at 11-12 Ma**
  - **Main phase: 2-5 Ma**
  - **Last eruptions: 100-500 ka**
- **Occurrences:**
  - **Basalt volcanic fields at the western and northern margins**
  - **Single basalt volcanoes and a small volcanic field at the southeastern margin**

Origin of the basalts

- Extension-related?
- Plume-related?
- Fluid-streaming from the Transitional Zone?

Alkaline sodic volcanism

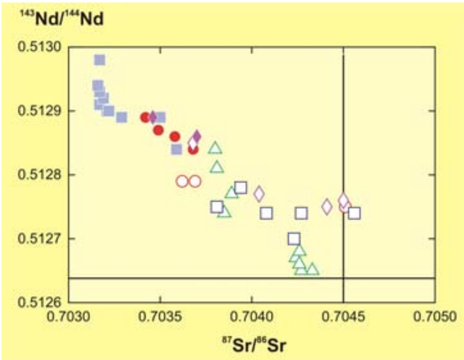
Characteristics of the mantle source regions

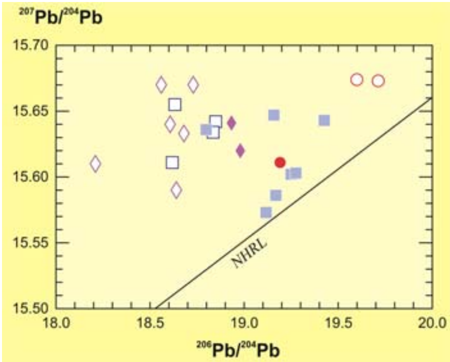


Most of the mafic rocks have fairly 'primitive' composition
with slight to moderate olivine-controlled fractionation

Alkaline sodic volcanism

Characteristics of the mantle source regions



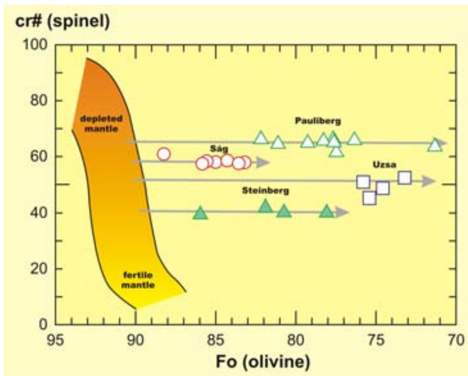


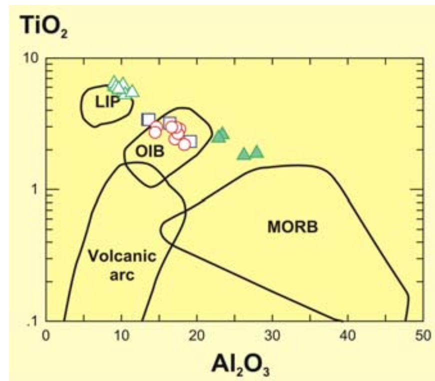
Large isotope variation!

Alkaline sodic volcanism

Characteristics of the mantle source regions

Spinel inclusions in olivine phenocrysts



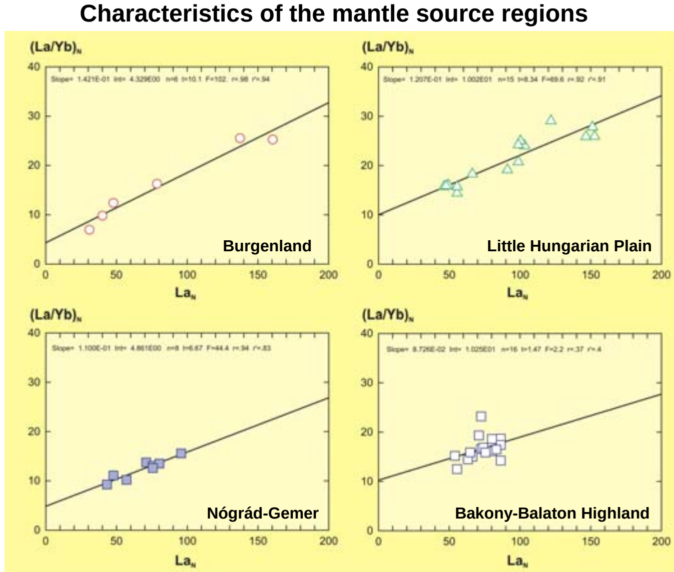


Sági, 2008, MSc thesis

Variably depleted, heterogeneous mantle sources!

Alkaline sodic volcanism

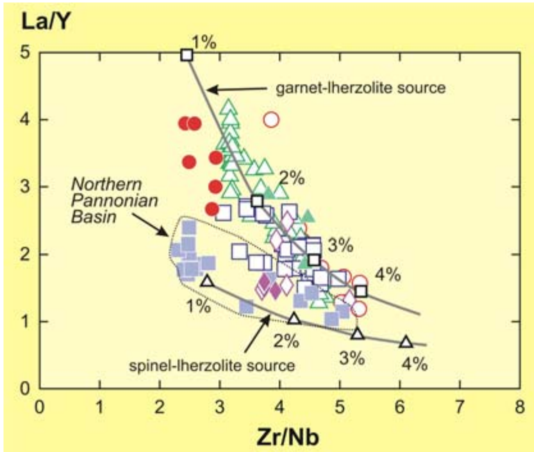
Characteristics of the mantle source regions



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

Alkaline sodic volcanism

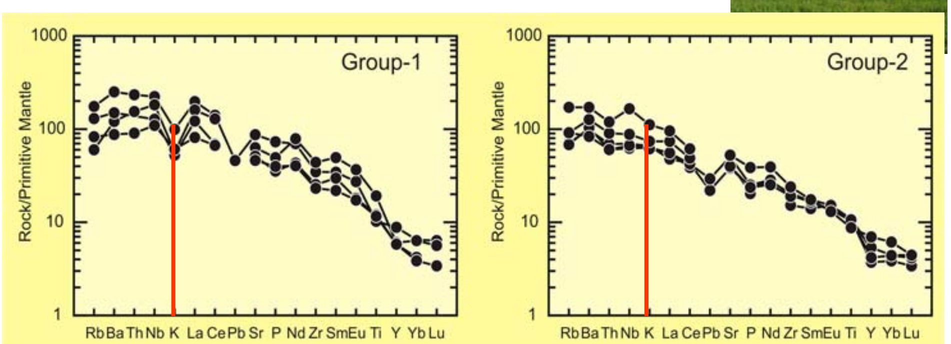
Characteristics of the mantle source regions



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

Alkaline sodic volcanism

Characteristics of the mantle source regions

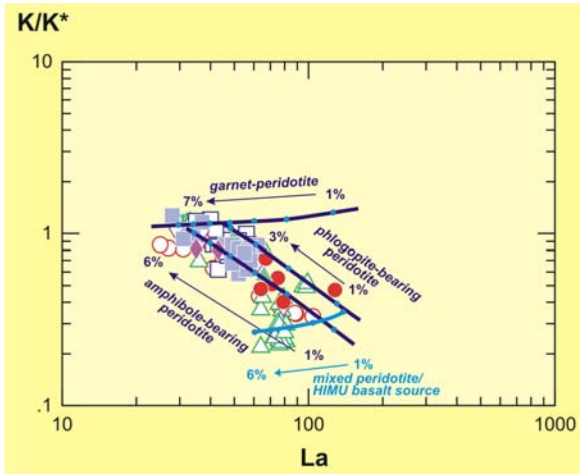


Origin of the negative K-anomaly?

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

Alkaline sodic volcanism

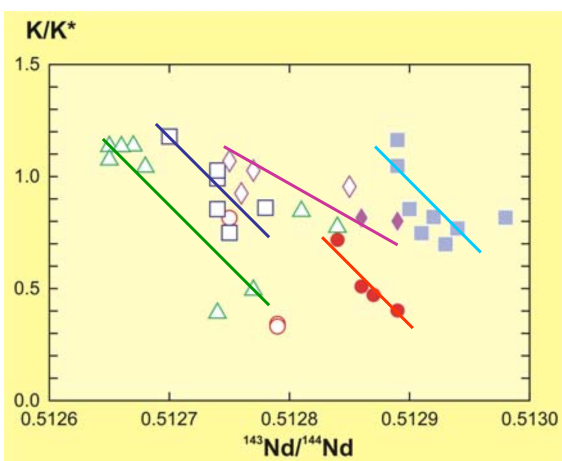
Characteristics of the mantle source regions



Presence of residual amphibole/phlogopite in the mantle sources!

Alkaline sodic volcanism

Characteristics of the mantle source regions

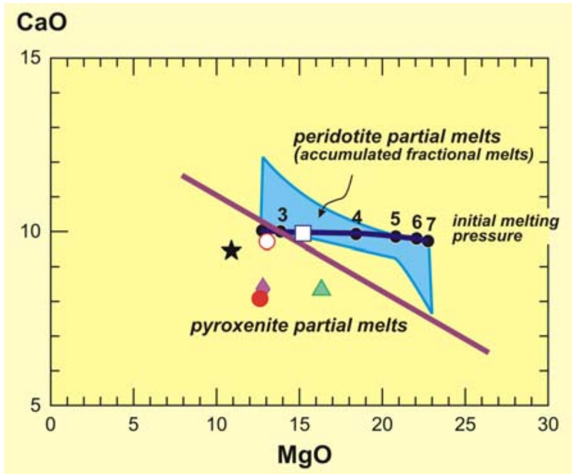


No general relationship with the isotope variation, but rough negative correlation within volcanic fields!

Alkaline sodic volcanism

Characteristics of the mantle source regions

Calculated primary magma compositions

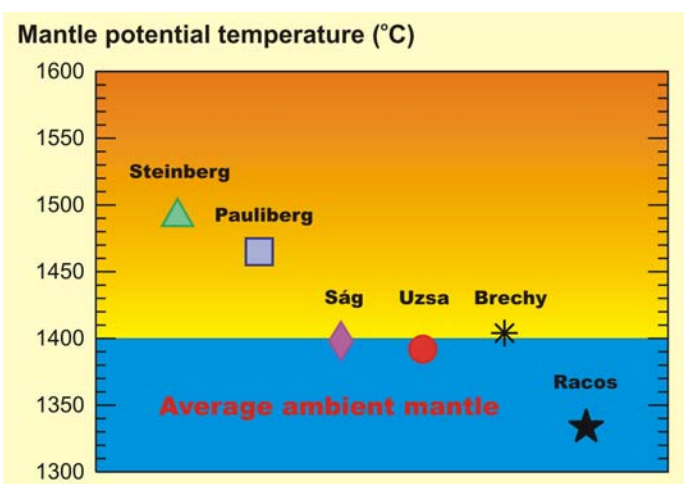


Contributions from pyroxenite melting?

Alkaline sodic volcanism

Characteristics of the mantle source regions

Calculated mantle potential temperature



modified from
Sági, 2008, MSc thesis

No significant excess temperature!

Summary

- **Mantle source characteristics:**
  - Heterogeneous (variously depleted + enriched domains)
  - Melting in the spinel-garnet and garnet stability field (>60 km depth)
  - Enriched mantle domains with phlogopite/amphibole
  - and/or melt generation involved different mantle domains in the source region?
  - Pyroxenite melting?
  - No significant excess temperature in the mantle!

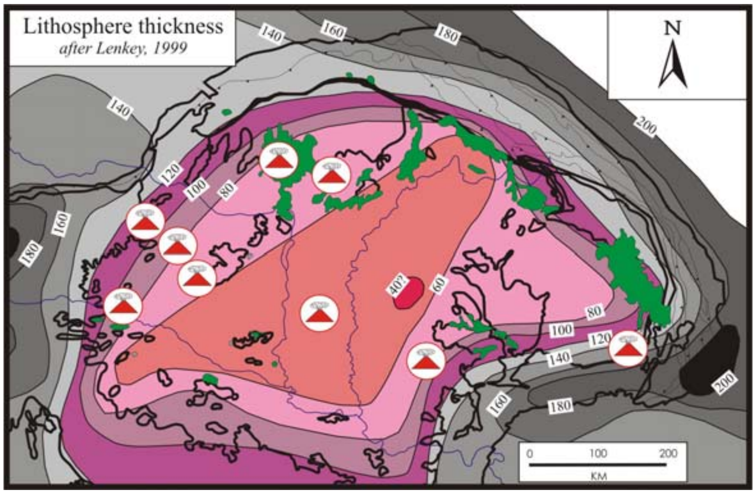
Reason of melt generation?

Reasons of melt generation

- **Extension-related?**
  - ☹ **Basaltic volcanism well postdates the peak-extension!**
- **Plume-related?**
  - ☹ **Fast velocitiy anomaly in the Transitional Zone!**
  - ☹ **No updoming!**
  - ☹ **No significant excess temperature!**
  - ☹ **Basaltic volcanism mostly at the marginal areas of the Pannonian Basin!**
- **Fluid-streaming from the Transitional Zone?**
  - ☹ **Basaltic volcanism mostly at the marginal areas of the Pannonian Basin!**

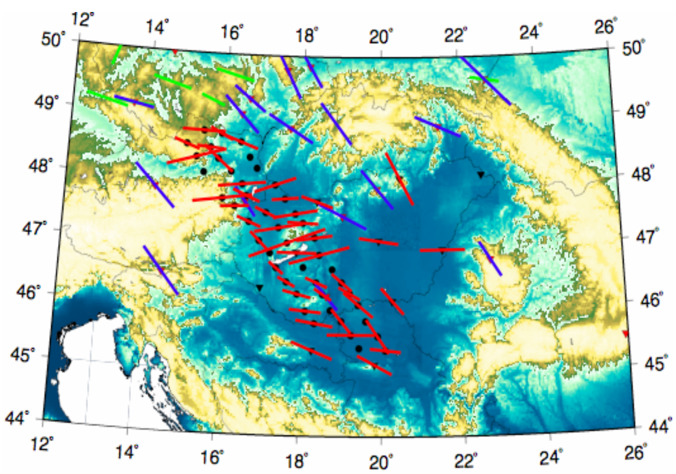
Alkaline sodic volcanism

Relationships with the deep structure



Alkaline sodic volcanism

SKS splitting results

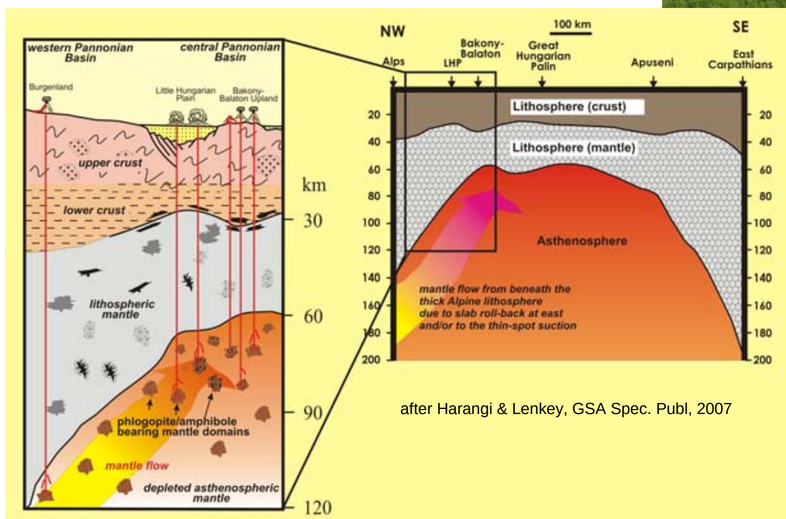


1 sec

Stuart et al. (2007)

Alkaline sodic volcanism

Reason of melt generation in the post-extensional stage – a possible model



after Harangi & Lenkey, GSA Spec. Publ, 2007

Outline

- Data and tools
- The way of scientific thinking
- Origin of magmas
- Evolution of magmas
- Classification of the volcanic rocks in the CPR; temporal and spatial distribution
- Silicic volcanism
- Calc-alkaline volcanism
- Potassic-ultrapotassic volcanism
- Alkaline sodic volcanism
- **Perspectives**

Perspectives

There are increasing data and models concerning the origin of the magmas fed the Neogene to Quaternary volcanism in the Carpathian-Pannonian Region!

but…

There are still a lot of unresolved questions related to the Neogene to Quaternary volcanism!

Further researches are necessary to constrain the generation and evolution of the magmas in this complex geodynamic setting

and…

also to evaluate the possible continuation of the volcanic eruptions in this region!

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