Petrology and Geochronology of Iran Tepe volcano, Eastern Rhodopes, Bulgaria: Age relationship with the Ada Tepe gold deposit. (preliminary data)

Peter Kibarov, Peter Marchev, Maria Ovtcharova, Raya Raycheva, Robert Moritz

Goals and tasks of the investigation

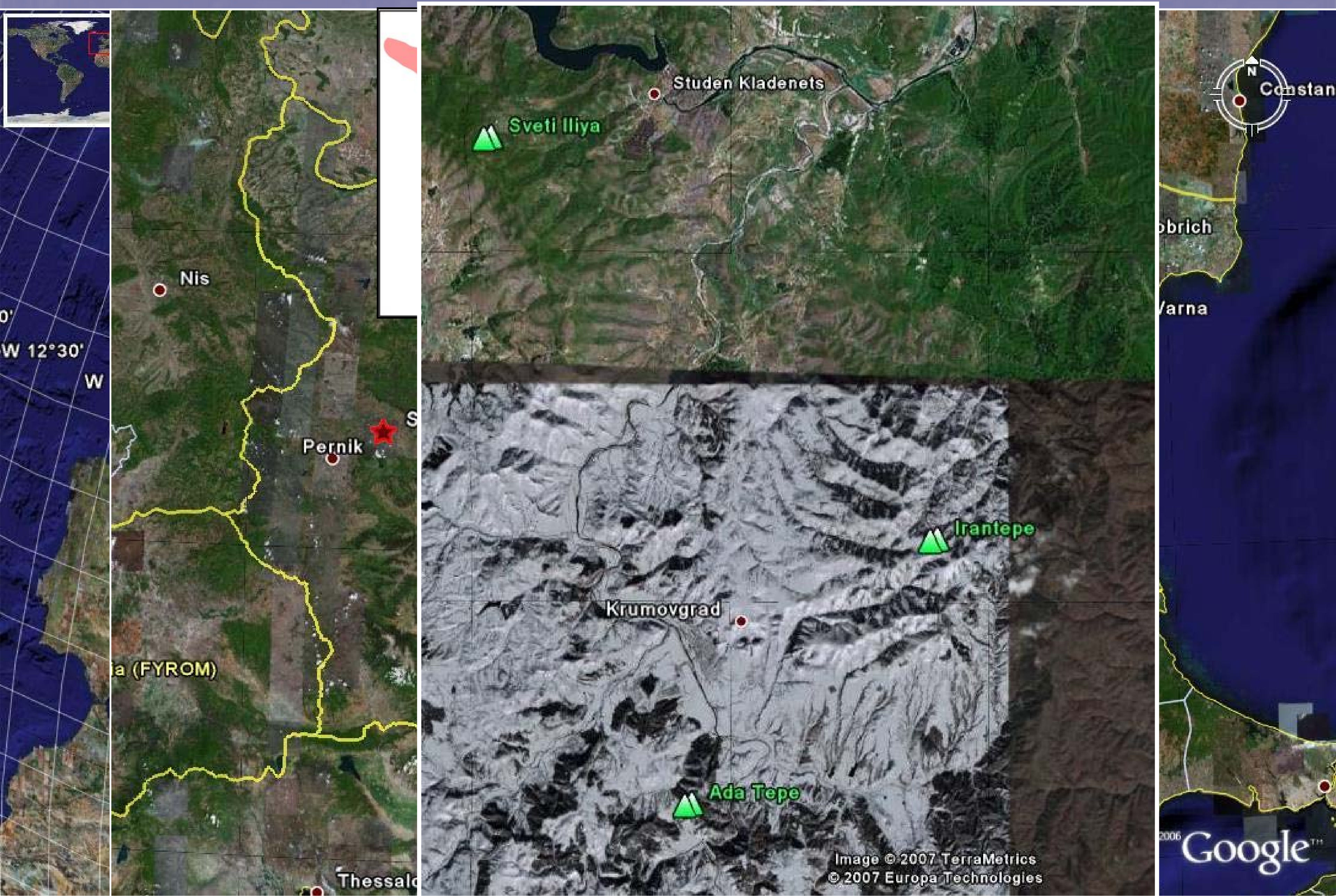
Goal:

Detail characteristics of Iran tepe volcano and its lavas.
Age relationship between Iran tepe volcano and Ada tepe gold deposit.

Talk outlines:

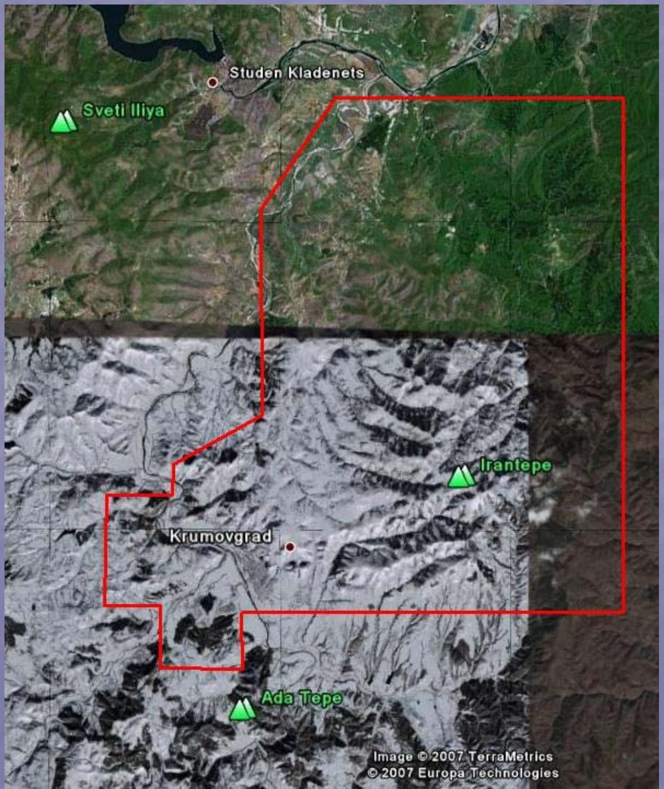
- lithology and volcano stratigraphy
- classification of the rocks
- petrographic, geochemical and mineralogical characteristics of the volcanic rocks
- petrogenesis of Iran tepe lavas
- U-Pb geochronology of the volcanic activity
- age relationship with the Ada tepe gold deposit

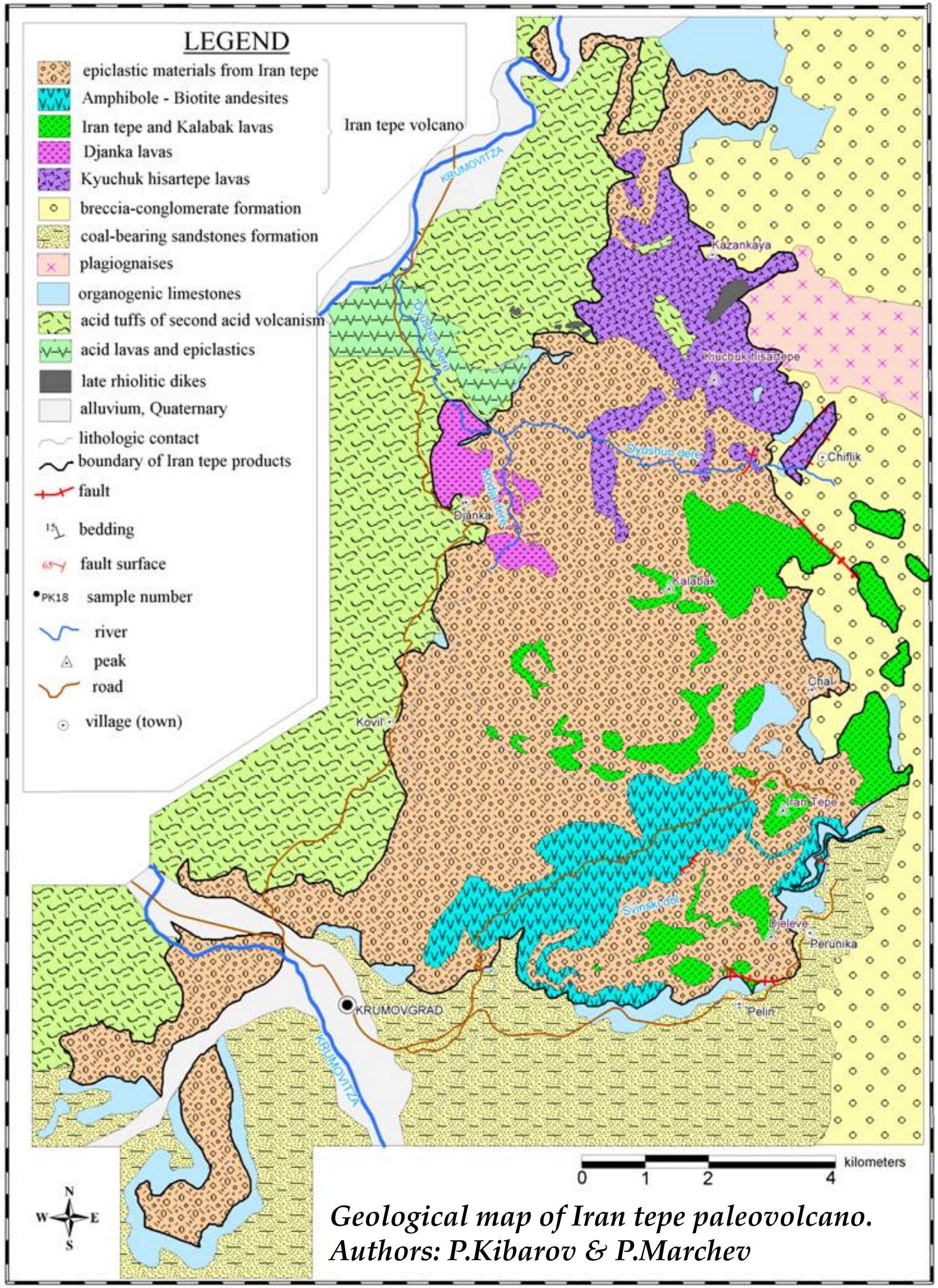
Position of investigated area



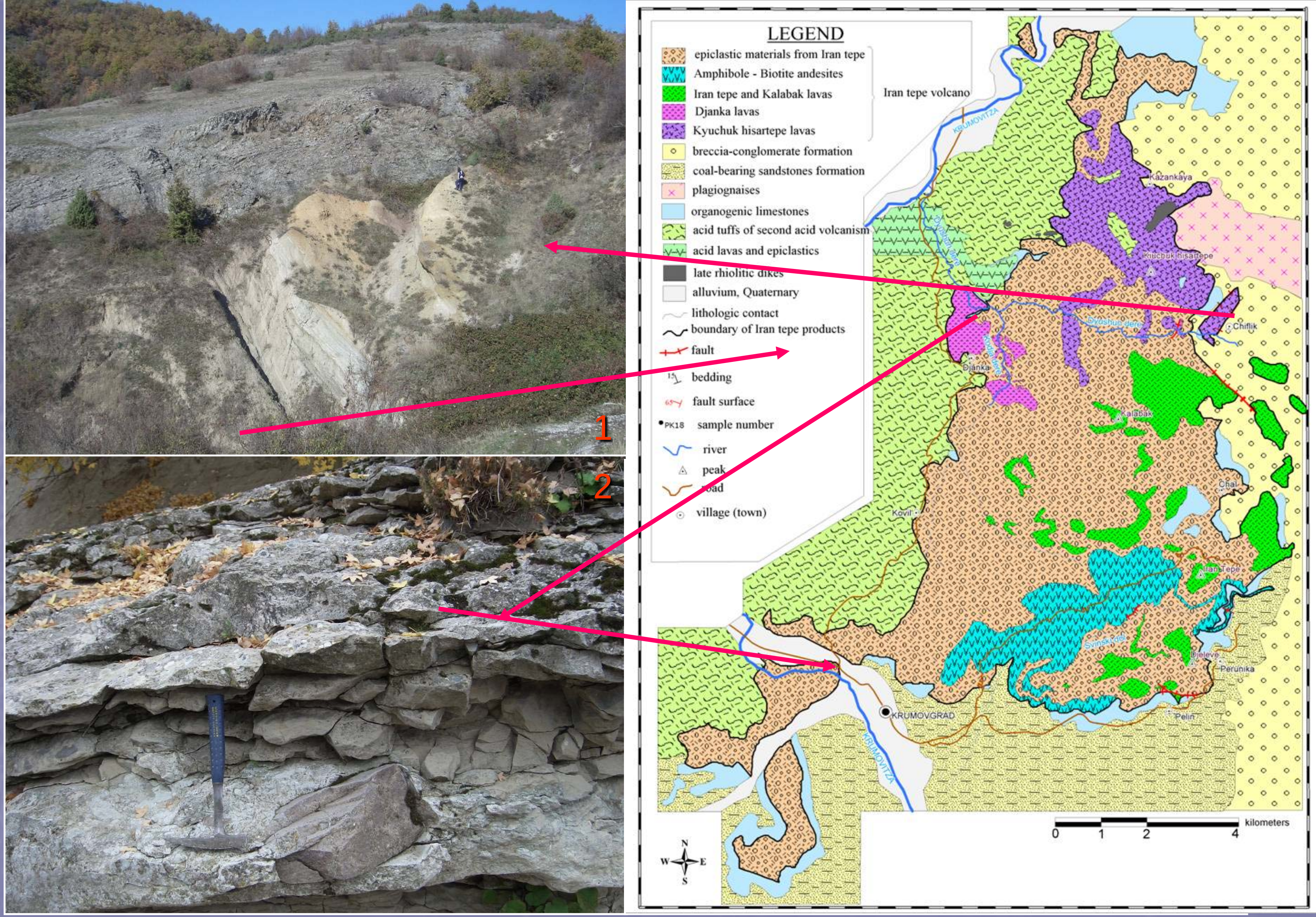
Volcano stratigraphy

- **Basement - Pg sandstones, breccia-conglomerates, organogenic limestones and metamorphic basement.**
- **Cover - acid tuffs and lavas, produced by first acid volcanism; alluvium.**
- **Iran tepe volcano - massive lavas, lavabreccias and epiclastics.**





Geological map of Iran tepe paleovolcano. Authors: P.Kibarov & P.Marchev

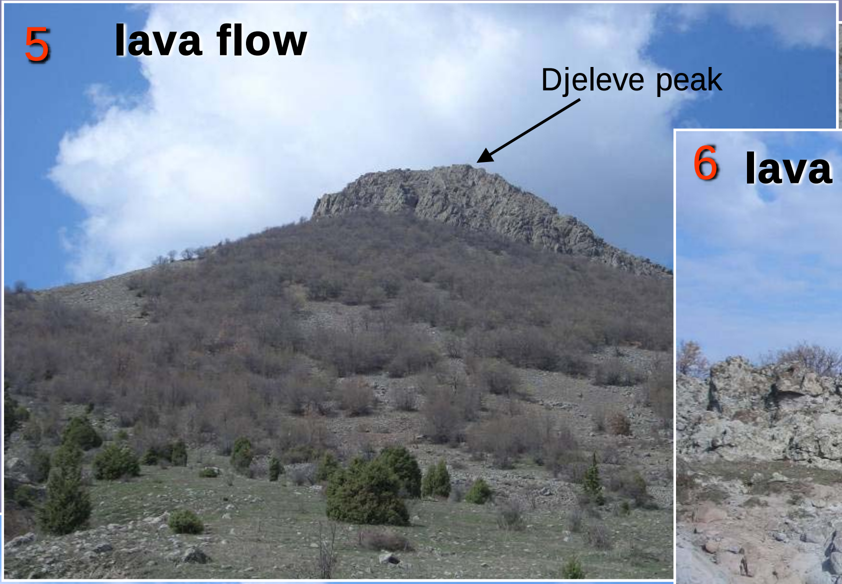


Interrelation of Iran tepe lavas with basement and cover units

1. Boundary lavas - conglomerates
2. Lava clasts in organogenic limestone
3. Acid tuffs covered Iran tepe lavas
4. Fault surface between lavas and epiclastics

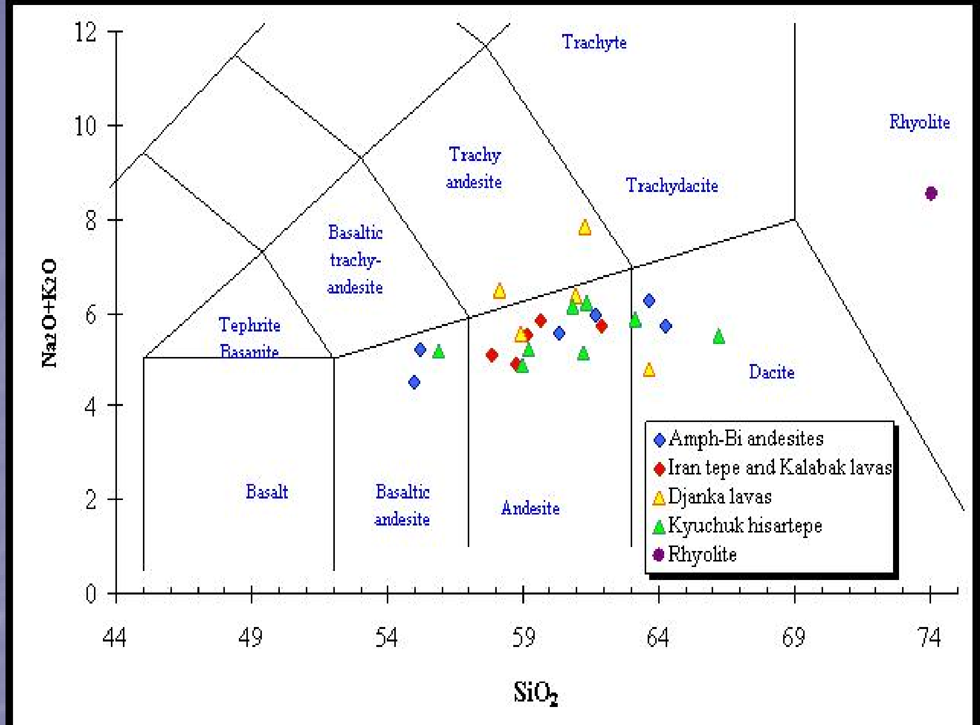
Petrology

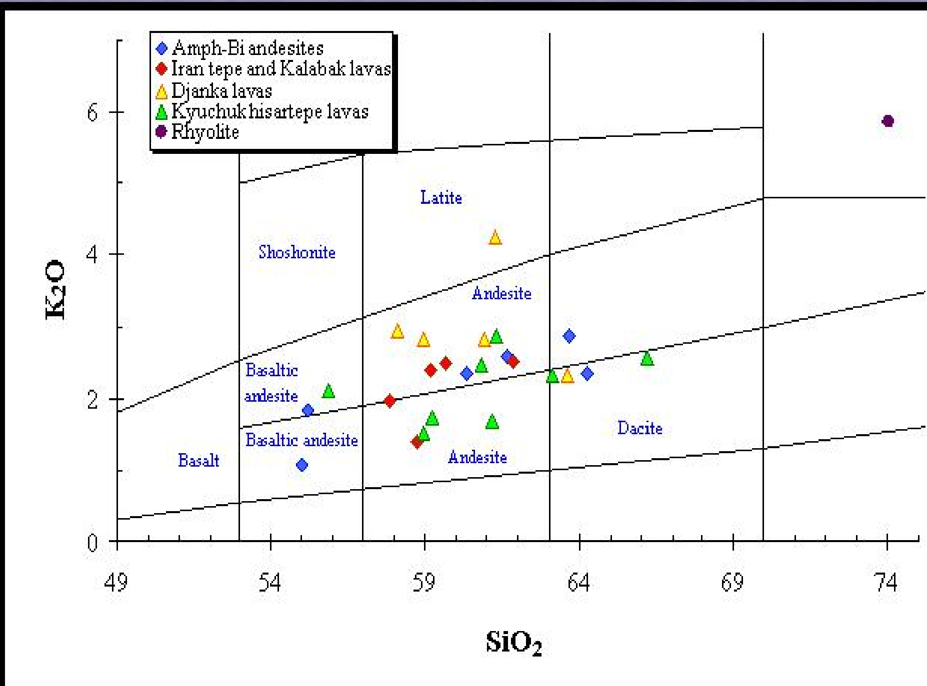
Iran tepe products

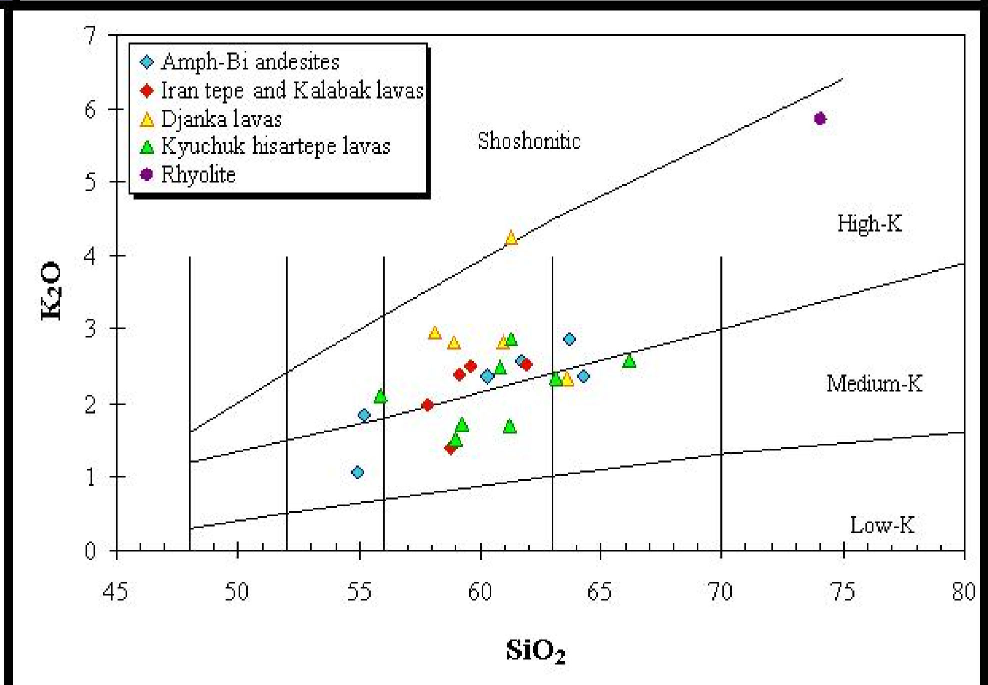


Petrology

- Lavas range - from basaltic andesites (54,9% SiO_2) to dacites (66,2% SiO_2) with prevailing andesites.
- Medium- to high-K calc alkaline series (exception is a shoshonitic dyke).
- Late rhyolitic dykes.

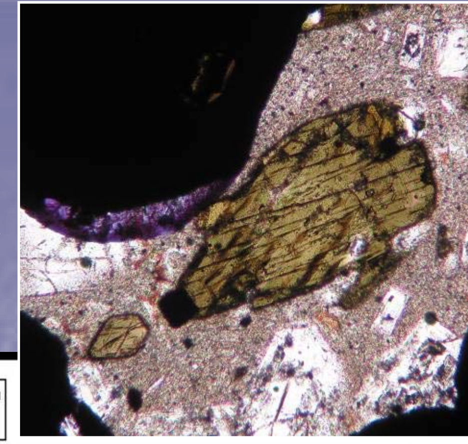






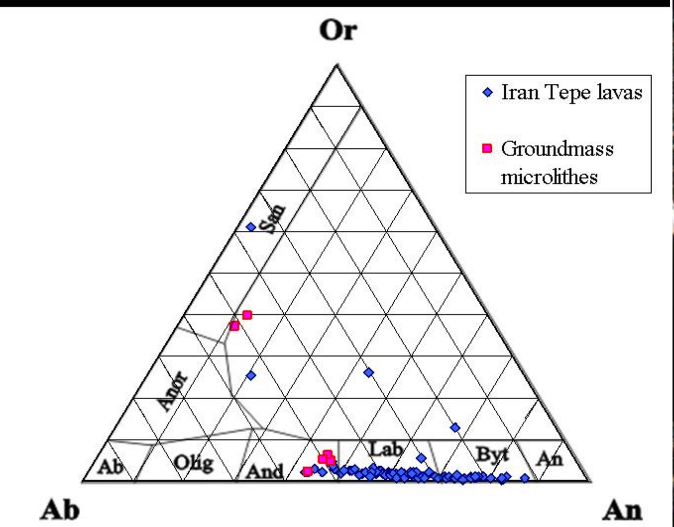
Mineralogy

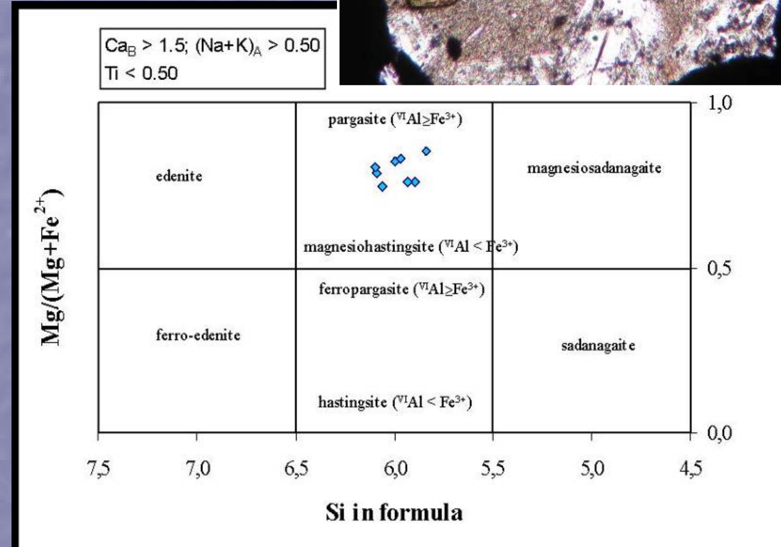
Pl, Amph, OPx, CPx, Bi phenocrysts.
Frequently vesiculated, with vesicles filled by quartz, chalcedony, opal.

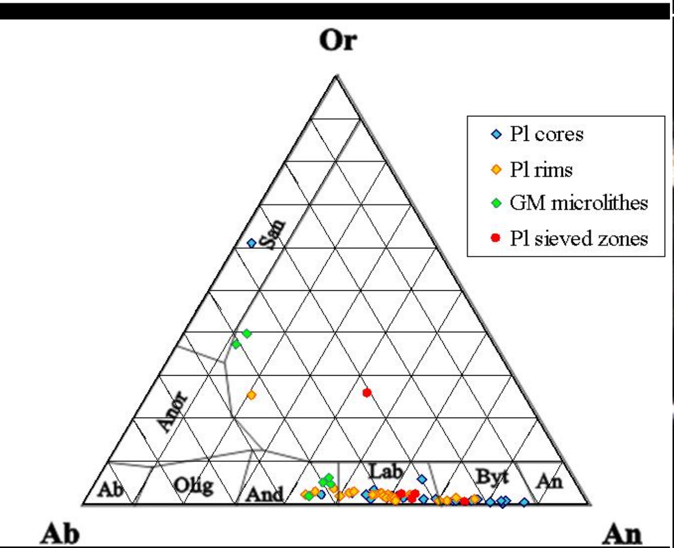


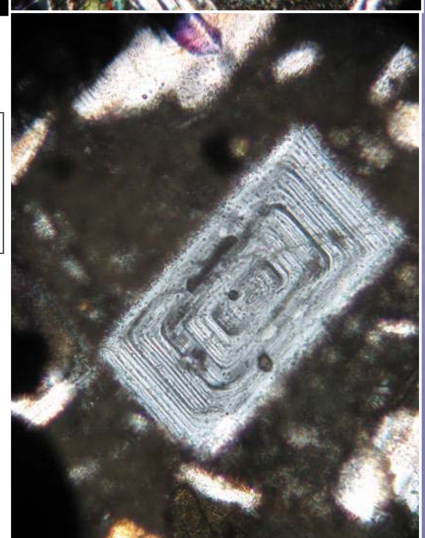
Pl phenocrysts - (An_{51} - An_{83}); normally and rarely reversely zoned.
Microlites – andesine and sanidine.

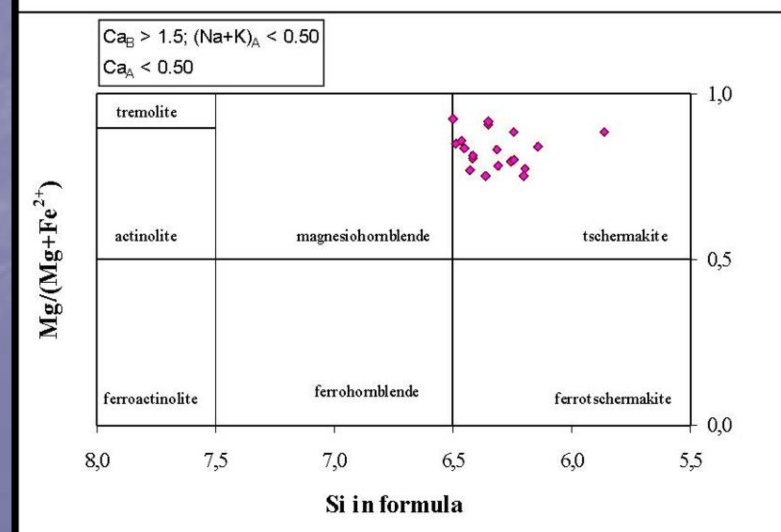
Amph- Magnesiohastingsite and Tchermakite (Leake et al.,1997) Mg# 62-70.





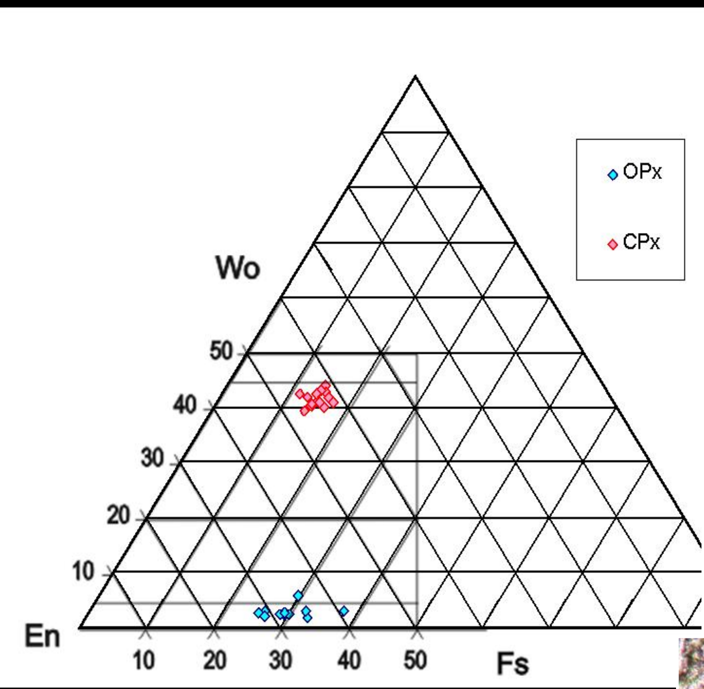


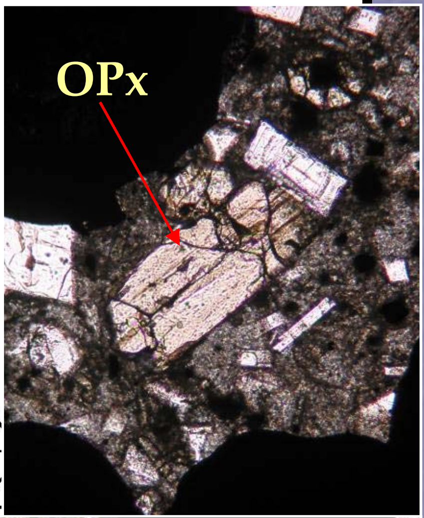


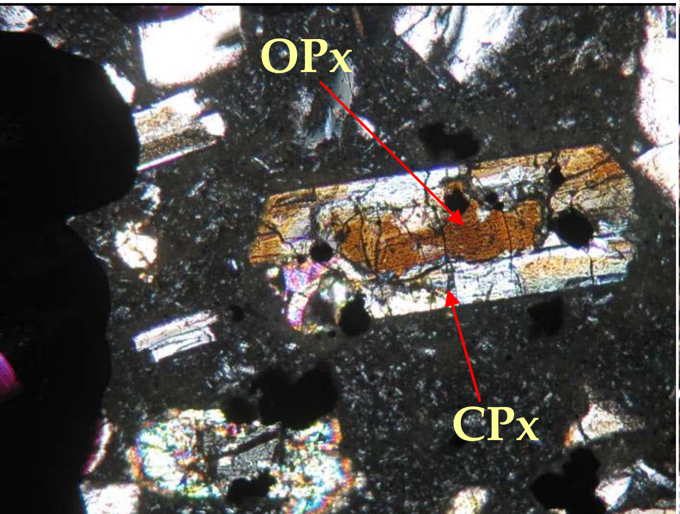


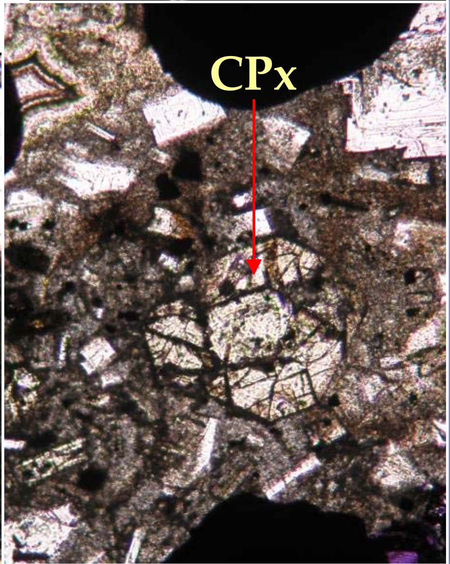
Mineralogy

Px - phenocrysts: **CPx** - Augite ($En_{42-46}Fs_{12-18}Wo_{39-44}$), **OPx** - Enstatite ($En_{59-72}Fs_{26-37}Wo_{2-6}$), rare Pigeonite in groundmass (Morimoto et al., 1989).

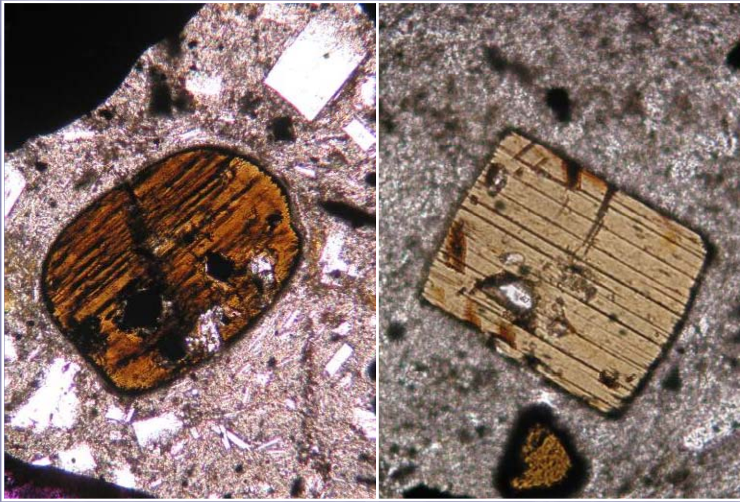








Bi - phenocrysts in Amph-Bi andesites and single crystals in most lavas; Mg# 59,6 - 70



Accessory minerals - **Mag, Ap, Zir** and in few samples **Py**.

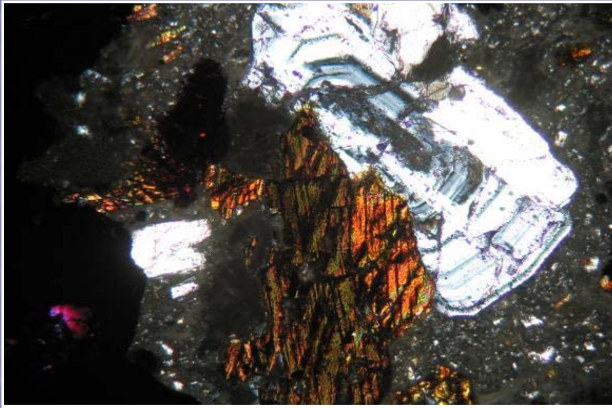
P-T conditions

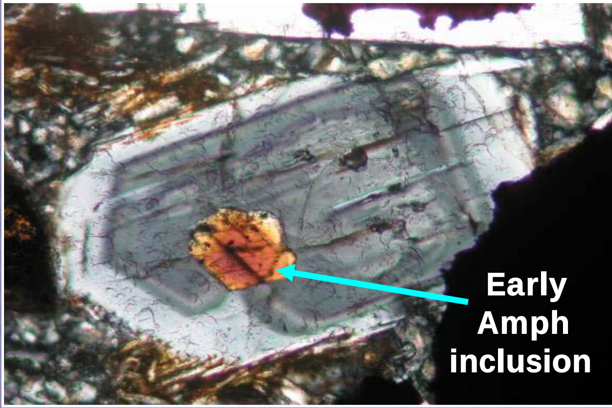
T = 920º - 1080ºC

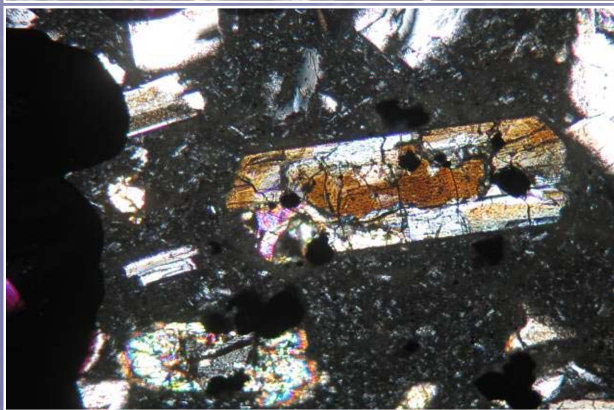
P = 3.5 - 9 kbar

Crystallization temperatures are calculated using Amph-Pl and CPx-OPx geothermometers. Obtained temperatures range between 920º-1080ºC, with higher values yielded from the two-pyroxene geothermometer, respectively 920º-980ºC from Amph-Pl geothermometer and 980º-1080ºC from two-piroxene geothermometer.

Pressure is calculated using four different geobarometers, on the bases of Al content in amphibole. The obtained results vary between 3.5 - 9 kbar.







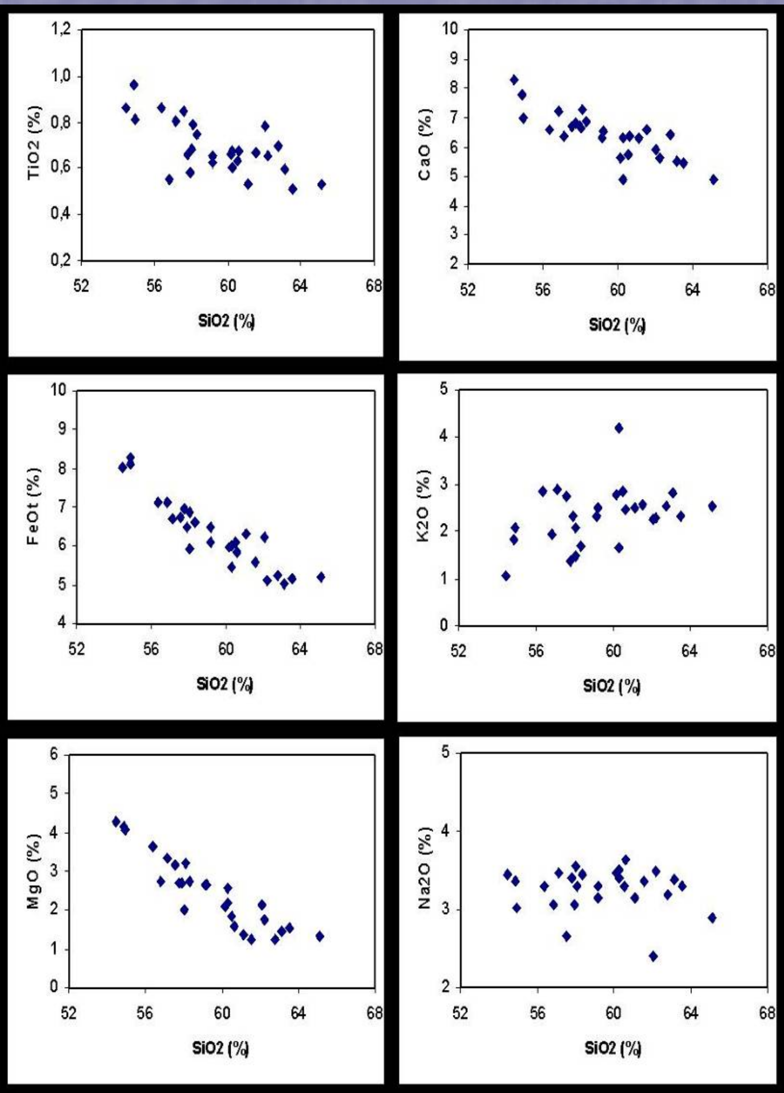
Volatile content

Indirect evidences such as high content and early crystallization of Amph and Bi, along with vesicles filled by chalcedony, opal and quartz suggest a comparatively high content of water in the magma.

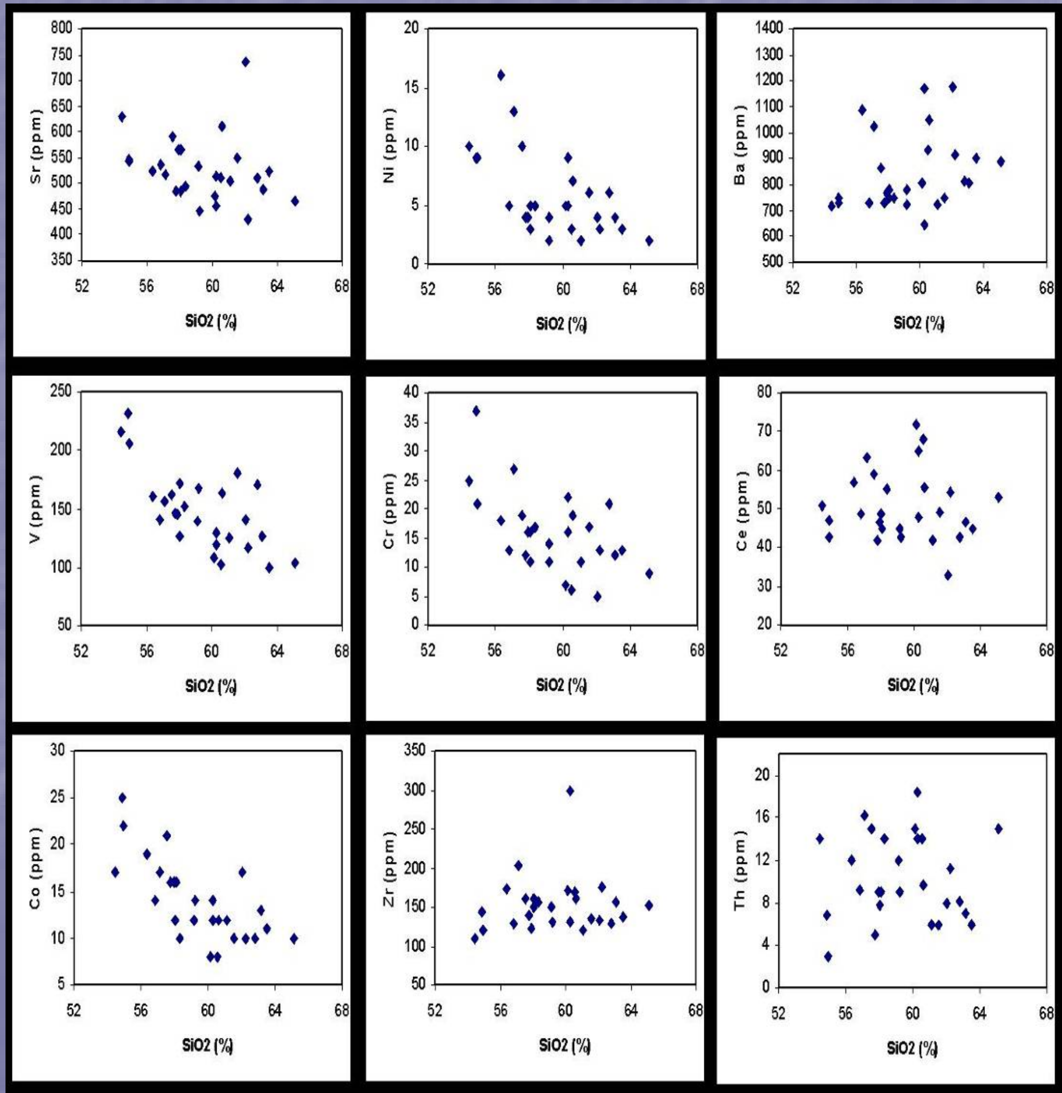
Geochemistry

SiO_2 = 54,9 - 66,2 w.%
K_2O = 1,1 - 4,3 w.%
Na_2O = 2,4 - 3,6 w.%

SiO_2 - major elements



SiO_2 - trace elements

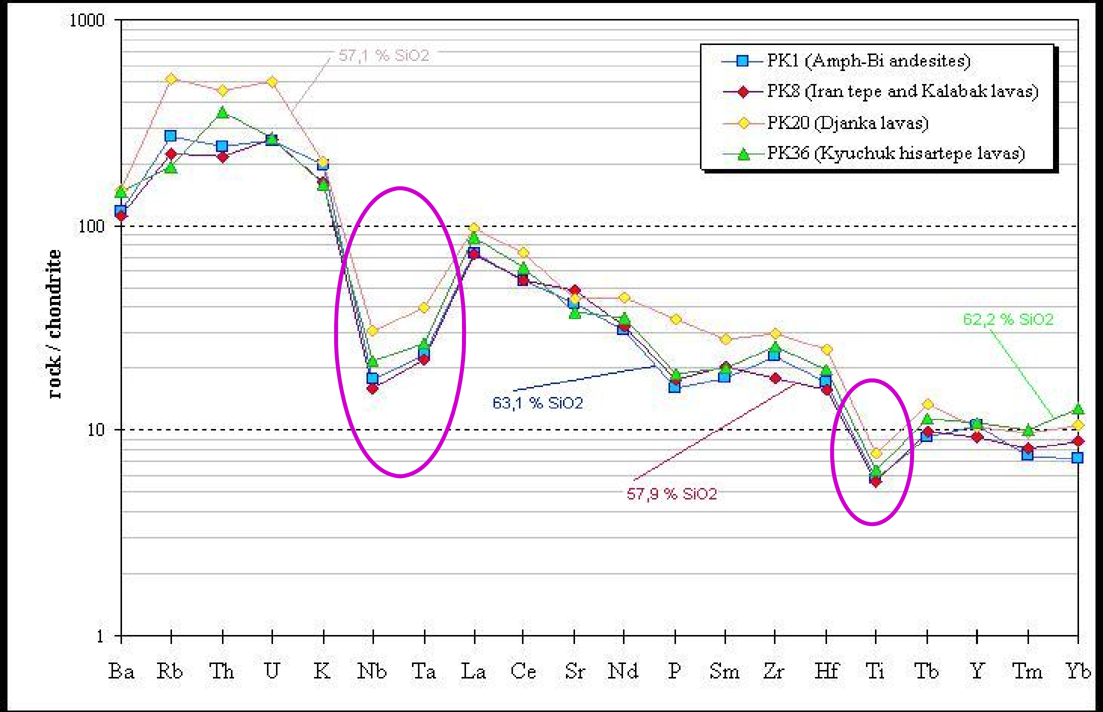


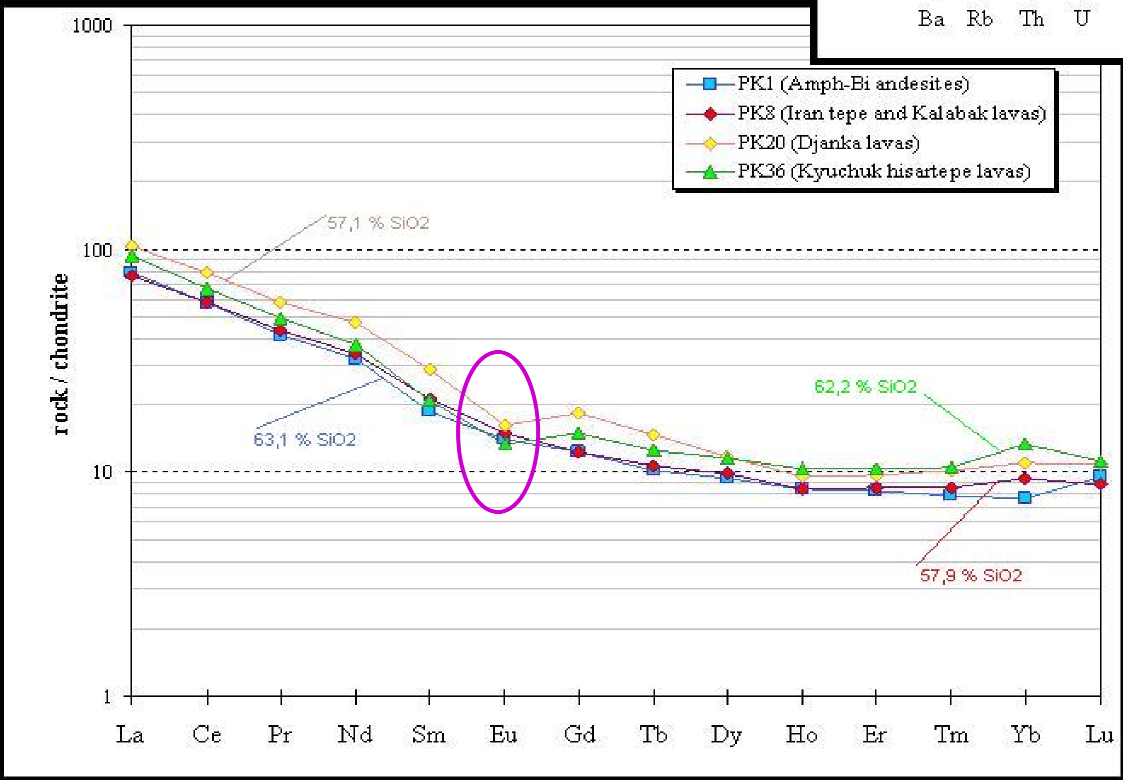
Geochemistry

Typical patterns for lavas in convergent margins.

Enrichment in highly incompatible trace elements, especially for Ca-alkaline and shoshonitic lavas.

Nb-Ta and Ti minimum - typical subductional characteristics.





Samples PK 1, PK 8, PK 20 and PK 36 are most representative for the different lavas in Iran tepe.

General content of REE in Iran tepe lavas is relatively low (64-155 ppm)

No tendency for change REE content from andesitic basalts to dacites.

Fractionated LREE and flat HREE.

Slightly pronounced Eu anomaly.

Only in Djanka lavas Eu/Eu* is 0.55 - 0.68, in other is 0.80 - 0.95.

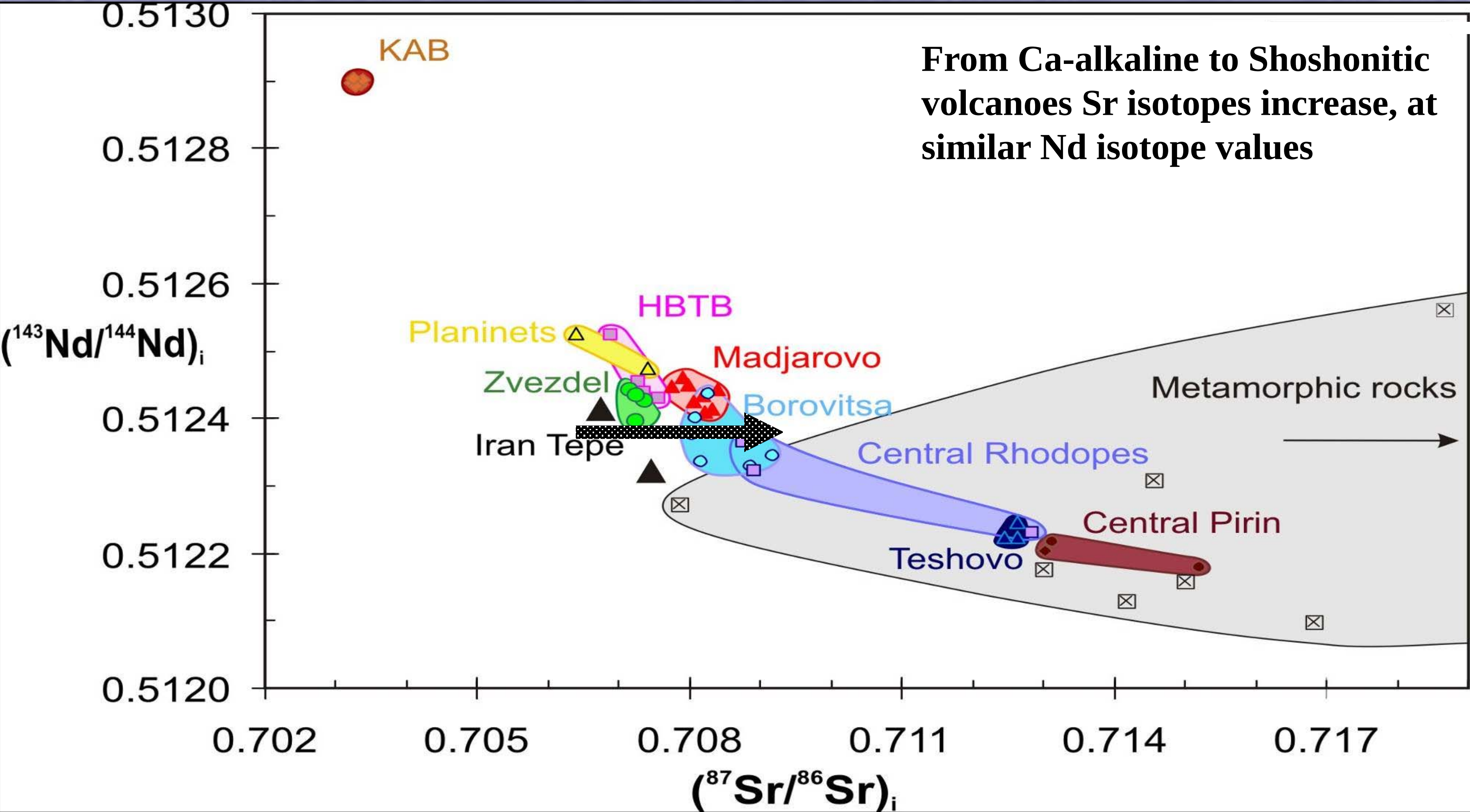
Sr-Nd isotopes

At this moment we have Sr and Nd isotopes just for two samples - IT2 and IT4.

$^{87}Sr/^{86}Sr$ isotopes range between 0.70680 - 0.70750.

$^{143}Nd/^{144}Nd$ isotopes range between 0.512443 - 0.512548.

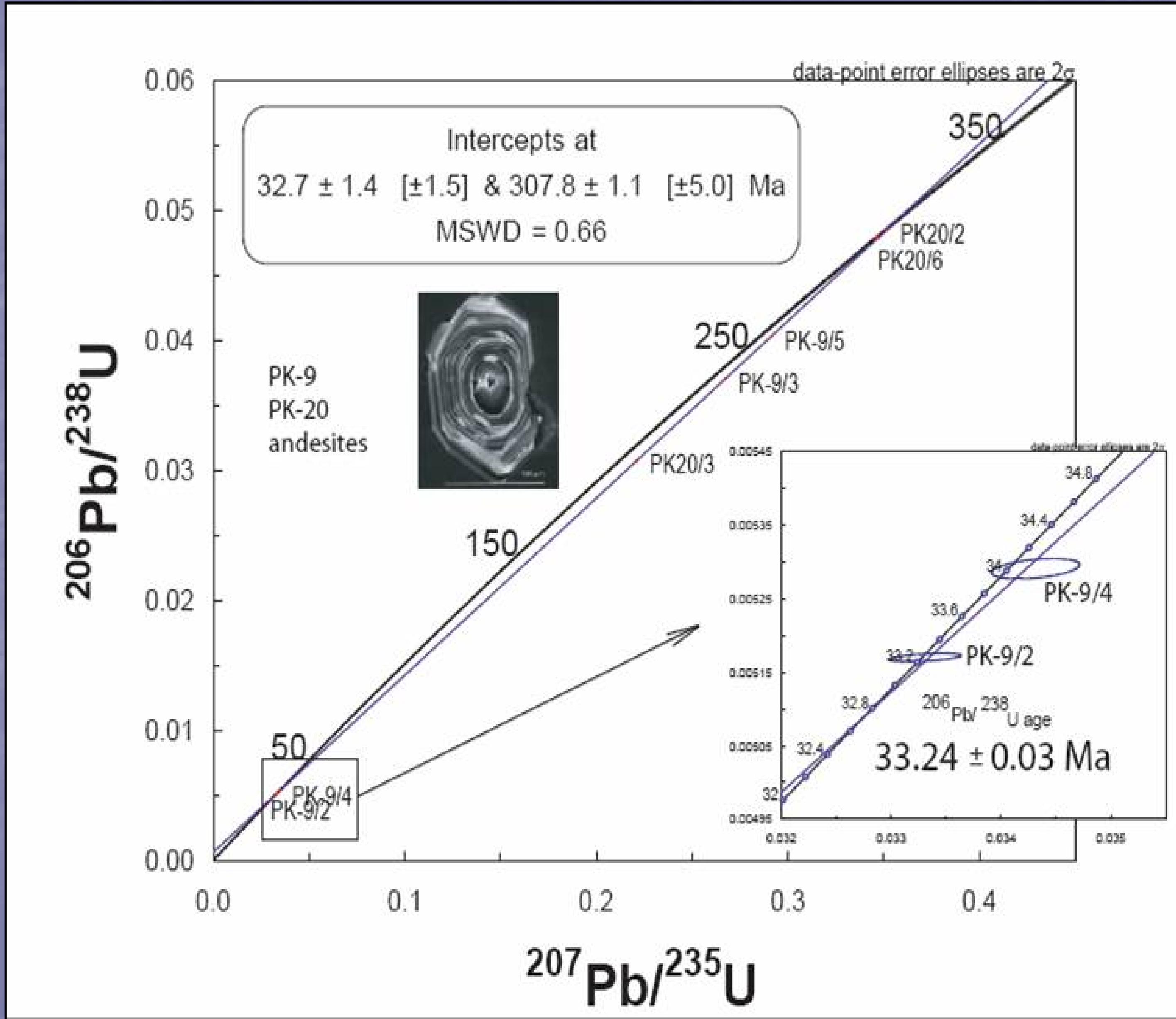
$^{87}Sr/^{86}Sr$ isotope values decrease, while $^{143}Nd/^{144}Nd$ increase with increasing SiO_2.



U-Pb geochronology

Iran tepe volcanic activity began at 33.24 Ma.
This is the first reliable U-Pb zircon age for the Iran tepe volcano.

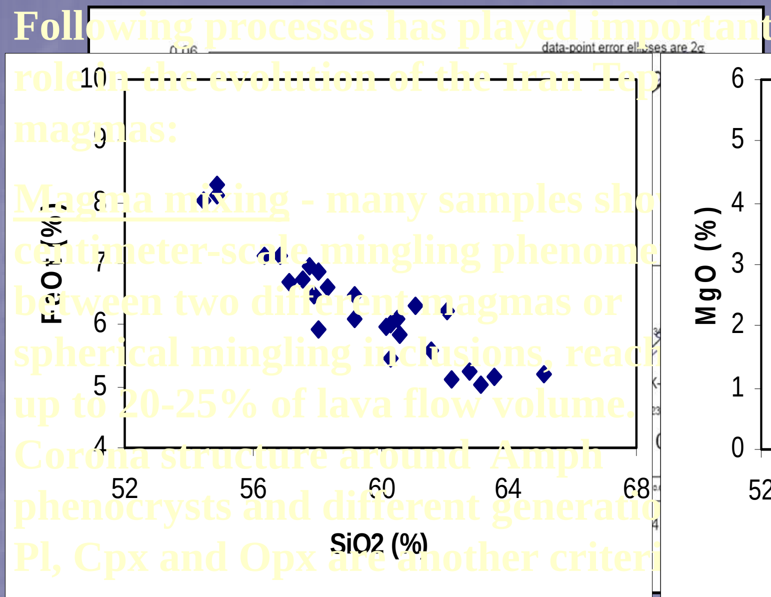
On the bases of its stratigraphic position and previous K-Ar data Iran tepe has been considered as one of the oldest volcanic structures in the region with Priabonian age (35-39Ma).
New U-Pb zircon dating from a stratigraphically low lava flow demonstrated that the volcanic activity began at *c*. 33.2 Ma.
The lower intercept of the discordia zircons from two lava flows yield a similar age of 32.7 ± 1.4 and an upper intercept of 307.8 ± 1.1 Ma;
the latter may be interpreted as the age of inherited zircon from the Variscan basement.

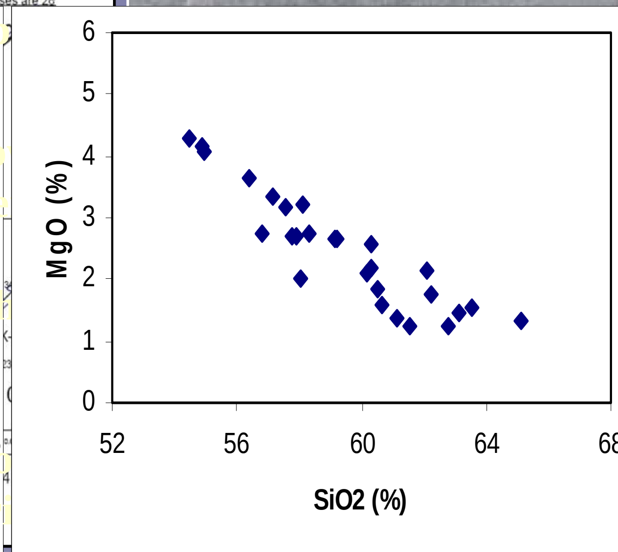


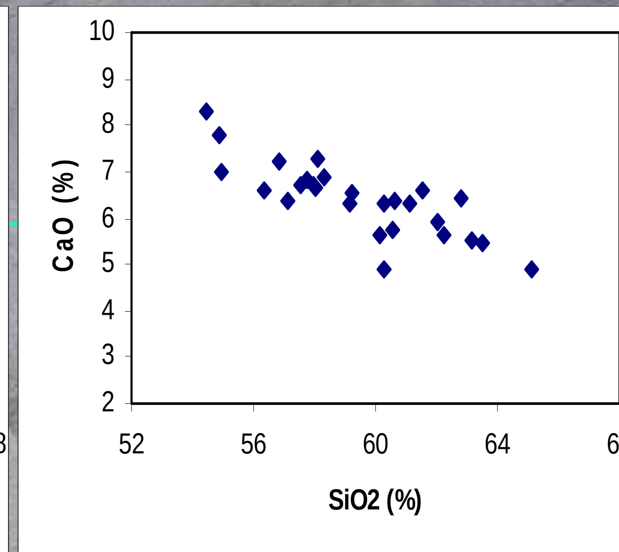
Evolutionary processes in Iran tepe lavas

Following processes has played important role in the evolution of the Iran Tepe magmas:

Magma mixing - many samples sho centimeter-scale mingling phenome between two different magmas or spherical mingling inclusions, reach up to 20-25% of lava flow volume. Corona structure around Amph phenocrysts and different generatio Pl, Cpx and Opx are another criteri

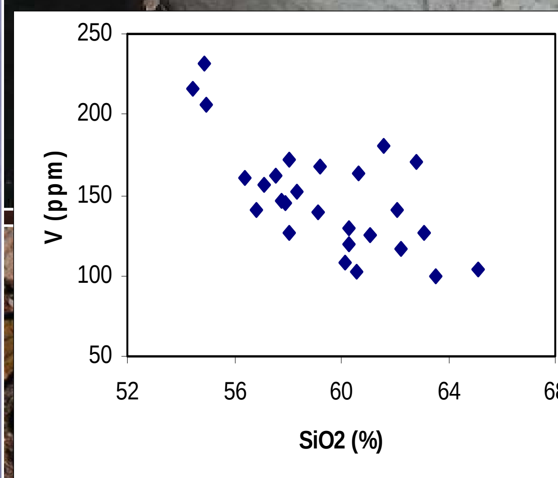


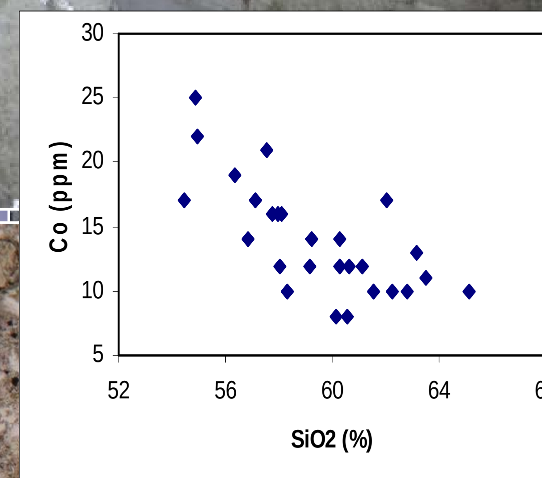


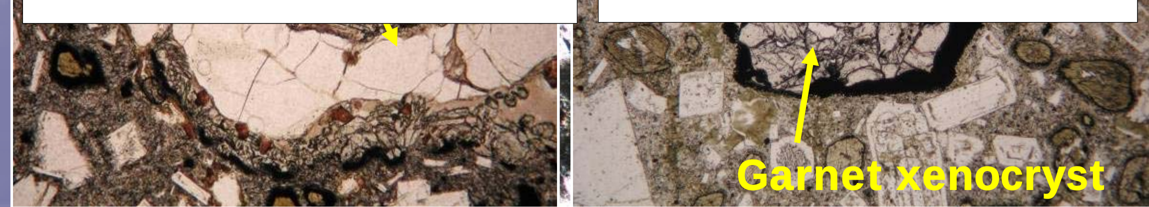


Crustal contamination – petrographic observation of small metamorphic xenoliths or xenocrysts of metamorphic quartz, garnet and plagioclase.
Sr and Nd composition between mantle and crustal basement composition and inhereted zircons from the metamorphic basement with Variscan age.

Fractional crystallization – evident from some of the compatible element behavior, but it operates simultaneously with the processes of magma mixing and crustal contamination and is weakly expressed.







Possible relationship between Iran Tepe volcano and Ada Tepe gold deposit

Iran Tepe paleovolcano is situated only 3-4 km north of the sedimentary-hosted, low-sulphidation, detachment-fault controlled Ada Tepe gold deposit. Age relationship between volcanic activity and ore deposition is of critical importance for understanding the genesis of the ore mineralization. The age of Ada Tepe deposit was recently determinate by $^{40}Ar/^{39}Ar$ geochronology at 35 Ma.

The new precise U-Pb zircon ages for the beginning of the volcanic activity at Iran tepe (33.2 Ma) clearly show that the ore formation in Ada Tepe is at least 1.7-2.5 Ma older than the igneous activity in Iran Tepe, and thus eliminating Iran Tepe as a source for the hydrothermal activity.

Conclusions

- **Iran tepe volcano is built up of alternating lava flows and thick epiclastic deposits**
- **Lavas vary in compositions from basaltic andesites to dacites . They belong to medium- to high-K calc alkaline series with rare shoshonitic varieties**
- **The pre-eruptive temperatures of crystallization is 920º-1080ºC at pressure 3.5-9 kbar**
- **Complexity of the magmatic composition can be explained by different evolutionary processes, including magma mixing, crustal contamination and fractional crystallization**
- **U-Pb zircon ages constrain the beginning of Iran tepe volcanism at 33.24 Ma. The age of the inherited zircons (307.8 ± 1.1 Ma) implies a Variscan age of the metamorphic basement**
- **The new U-Pb zircon age exclude Iran tepe volcano activity as a potential source of fluids and metals for the Ada tepe gold deposit**

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