LAMPROPHYRES FROM OSPA OPHIOLITE OF THE EAST SAYAN (RUSSIA)

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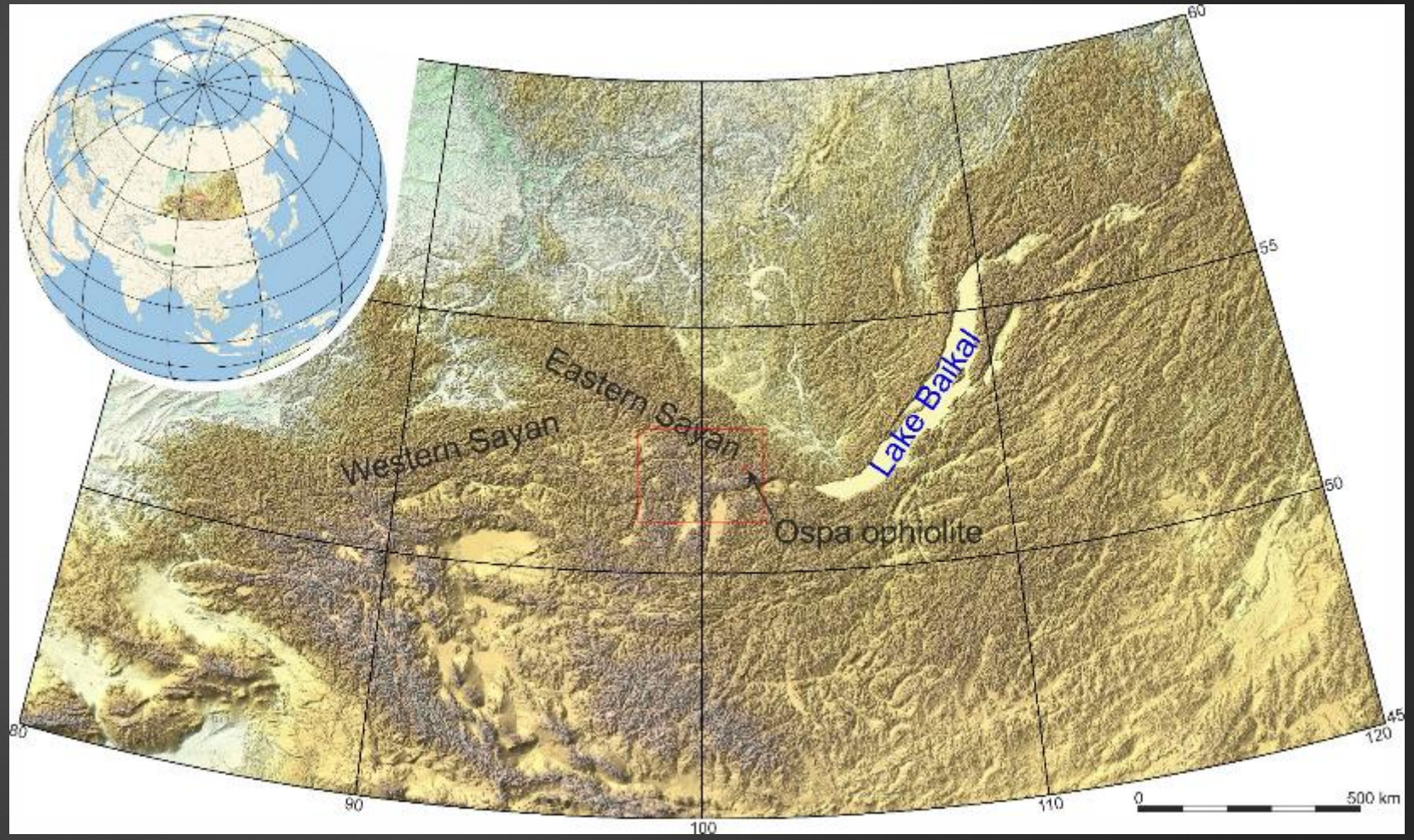
EGU2020: Sharing Geoscience Online, 4-8 May 2020
Session GD4.3

The geographical position

Eastern Sayan mountains are located to the West of Lake Baikal.

Eastern Sayan ophiolites are a part of the Central-Asian Fold Belt.



The geographical position of the Eastern Sayan mountains

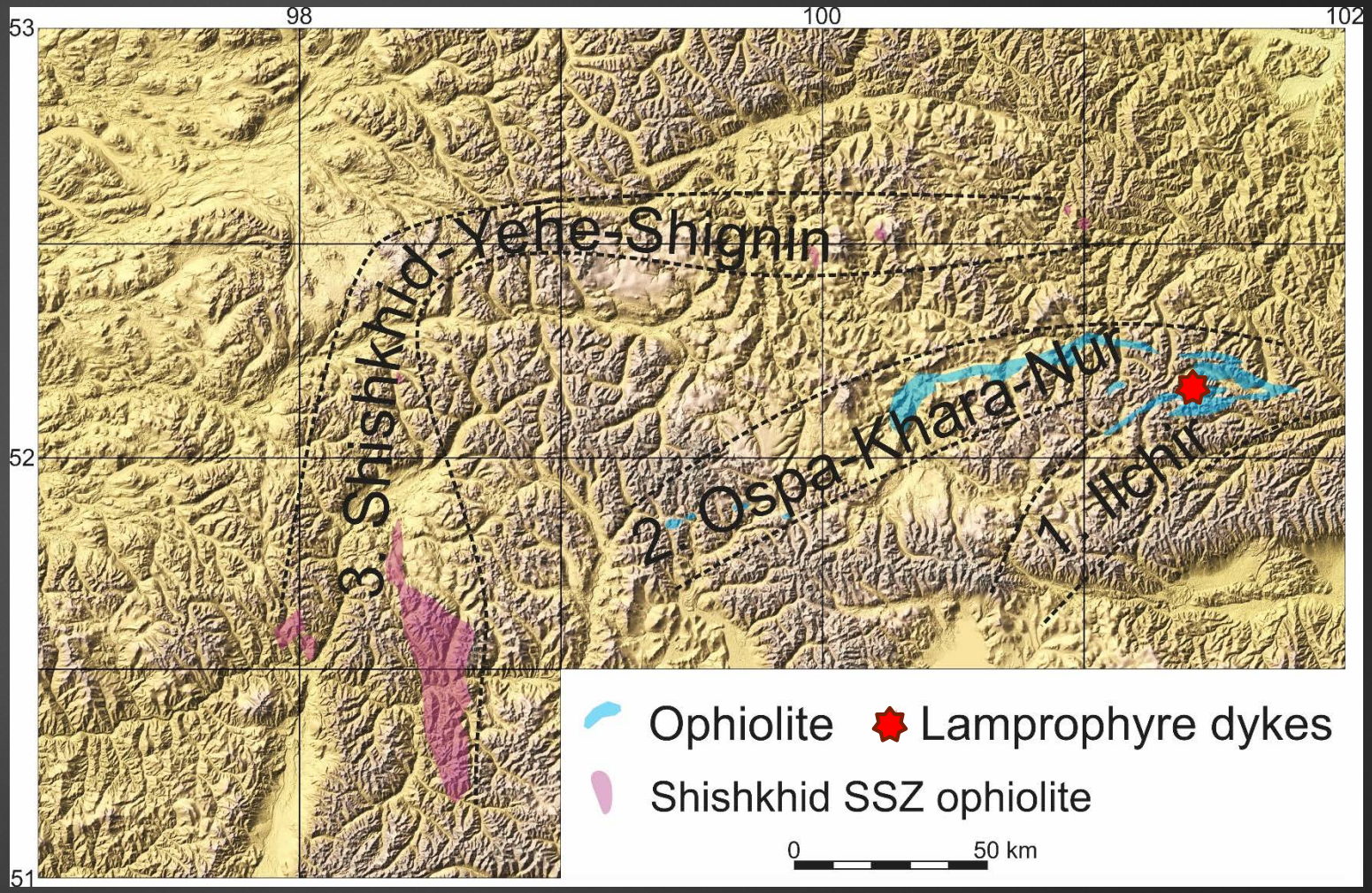
The geological position

In the Eastern Sayan mountains (E. Siberia), ophiolite complexes form <u>three extended branches</u>:

1 - **Ilchir** (MOR ophiolites)

2 - **Ospa-Khara-Nur** (suprasubduction zone (SSZ) and volcanic arc (VA) ophiolites)

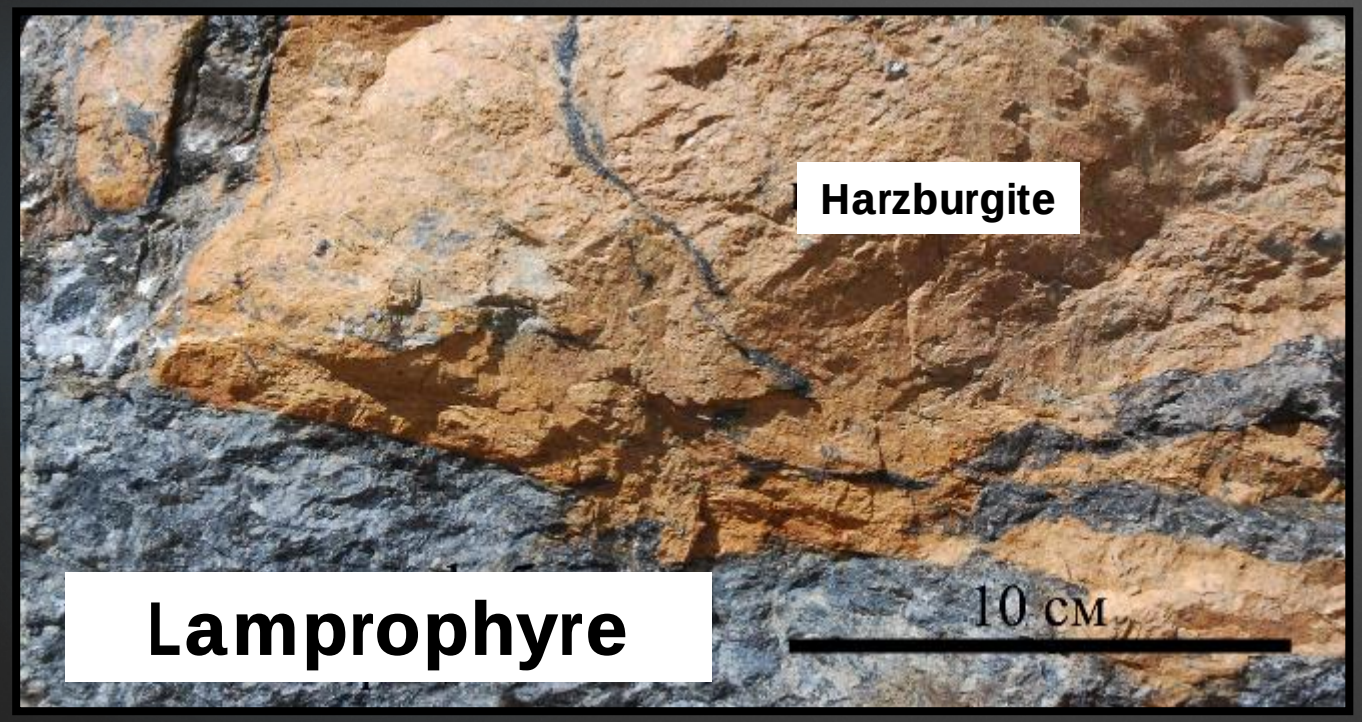
3 - **Shishkhid-Yehe-Shignin** (back-arc ophiolites).



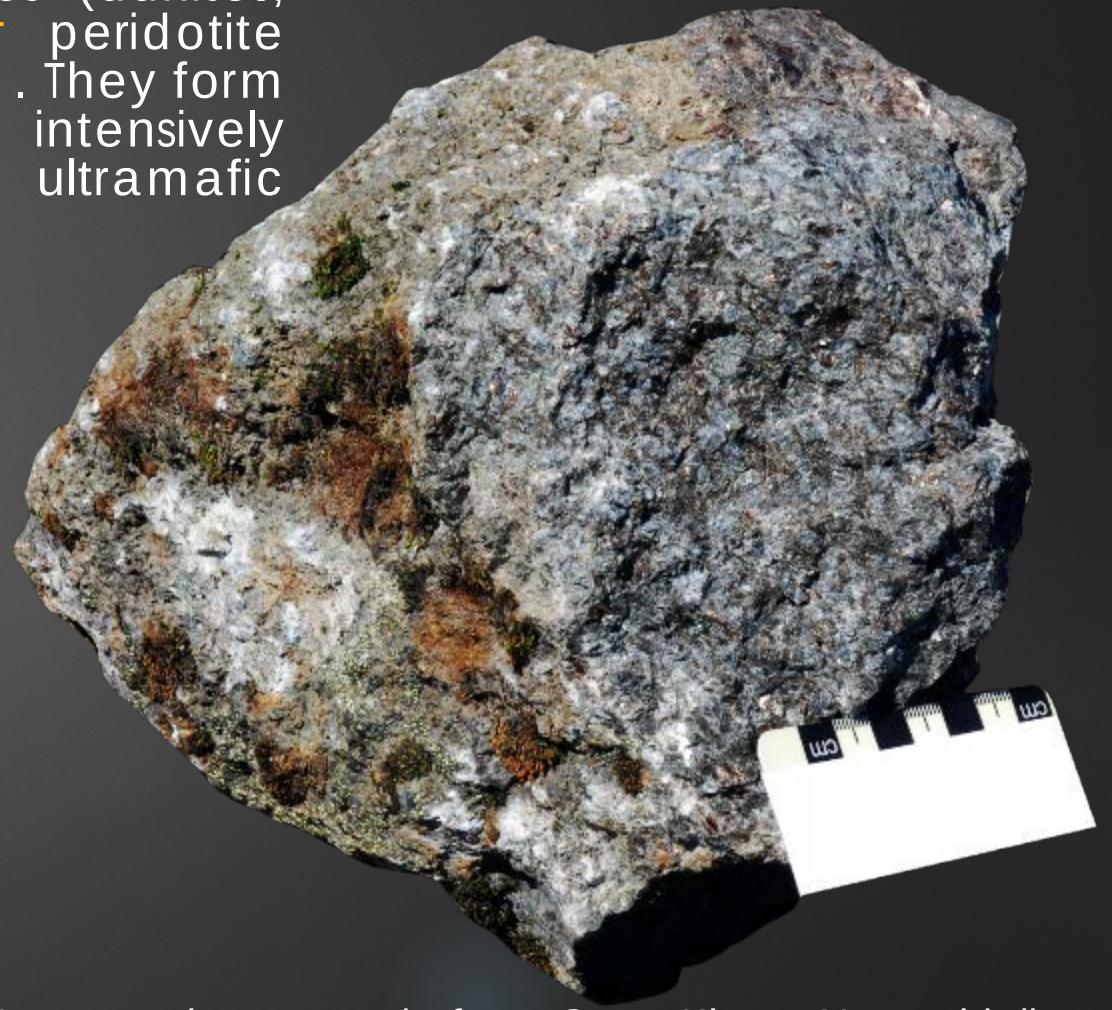
Relief map of the south-eastern part of the Eastern Sayan with schematic ophiolite branches position

The history of discovery of the unique rocks

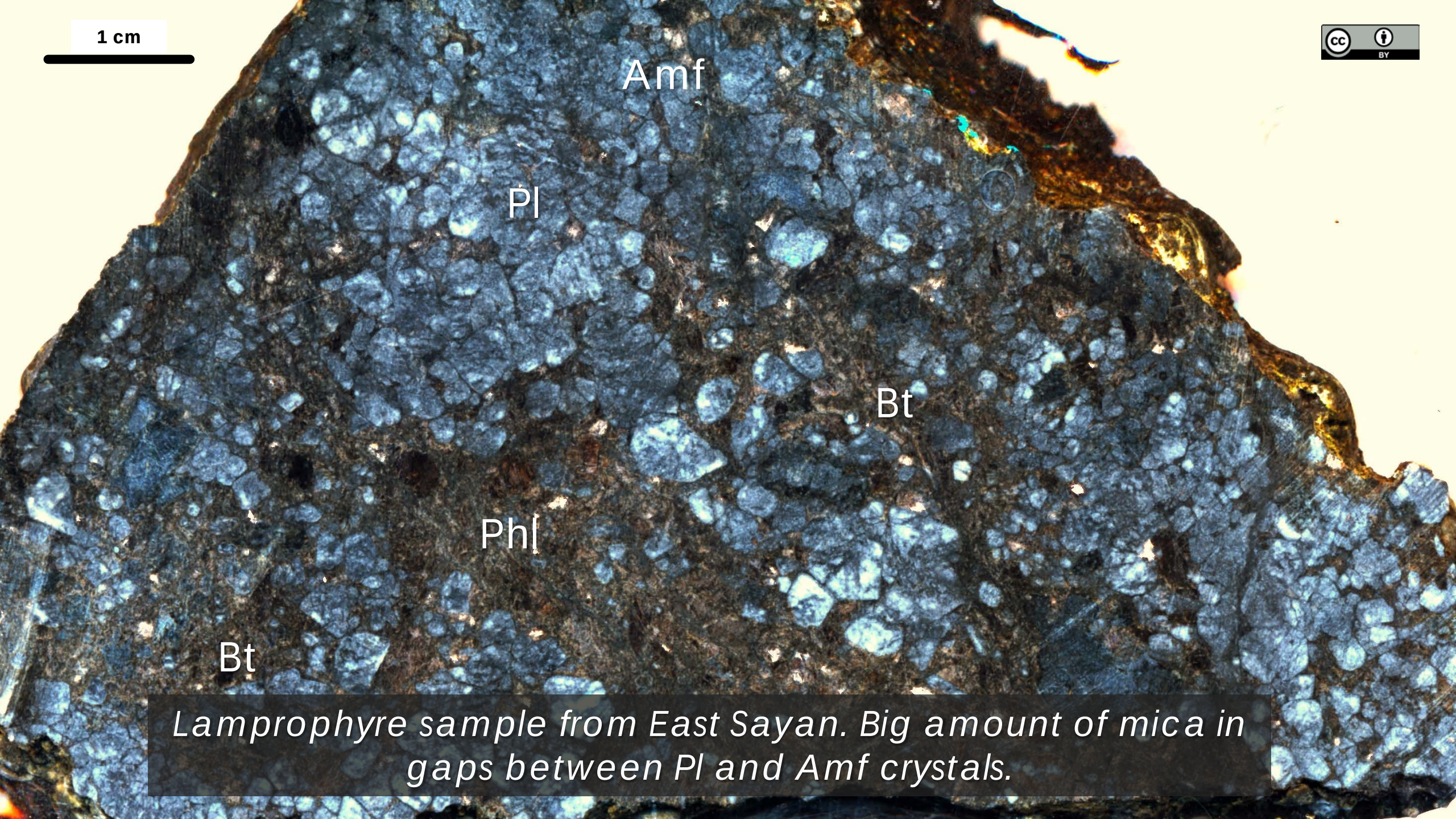
Lamprophyre (L) dykes or mica peridotites (Shestopalov, 1938) were found in brecciation zone of ophiolites (dunites, harzburgites, serpentinites) of the Ospa-Khara-Nur peridotite complex (a part of Ospa-Khara-Nur ophiolite branch) . They form bodies to 1 m thick, and vein-like fragments in intensively deformed and altered (serpentinized, tremolitized) ultramafic rocks.



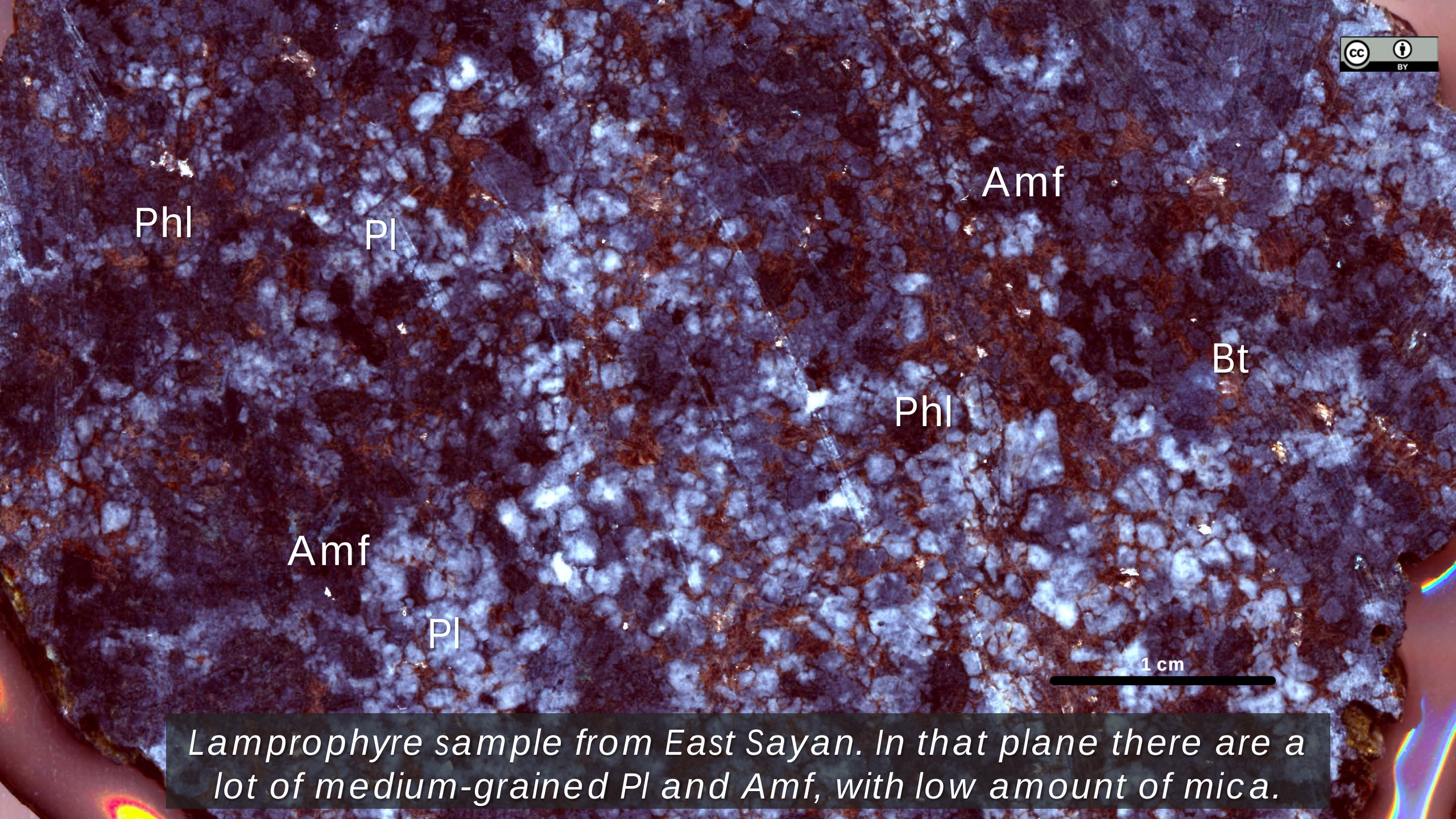
Contact between lamprophyre and harzburgite



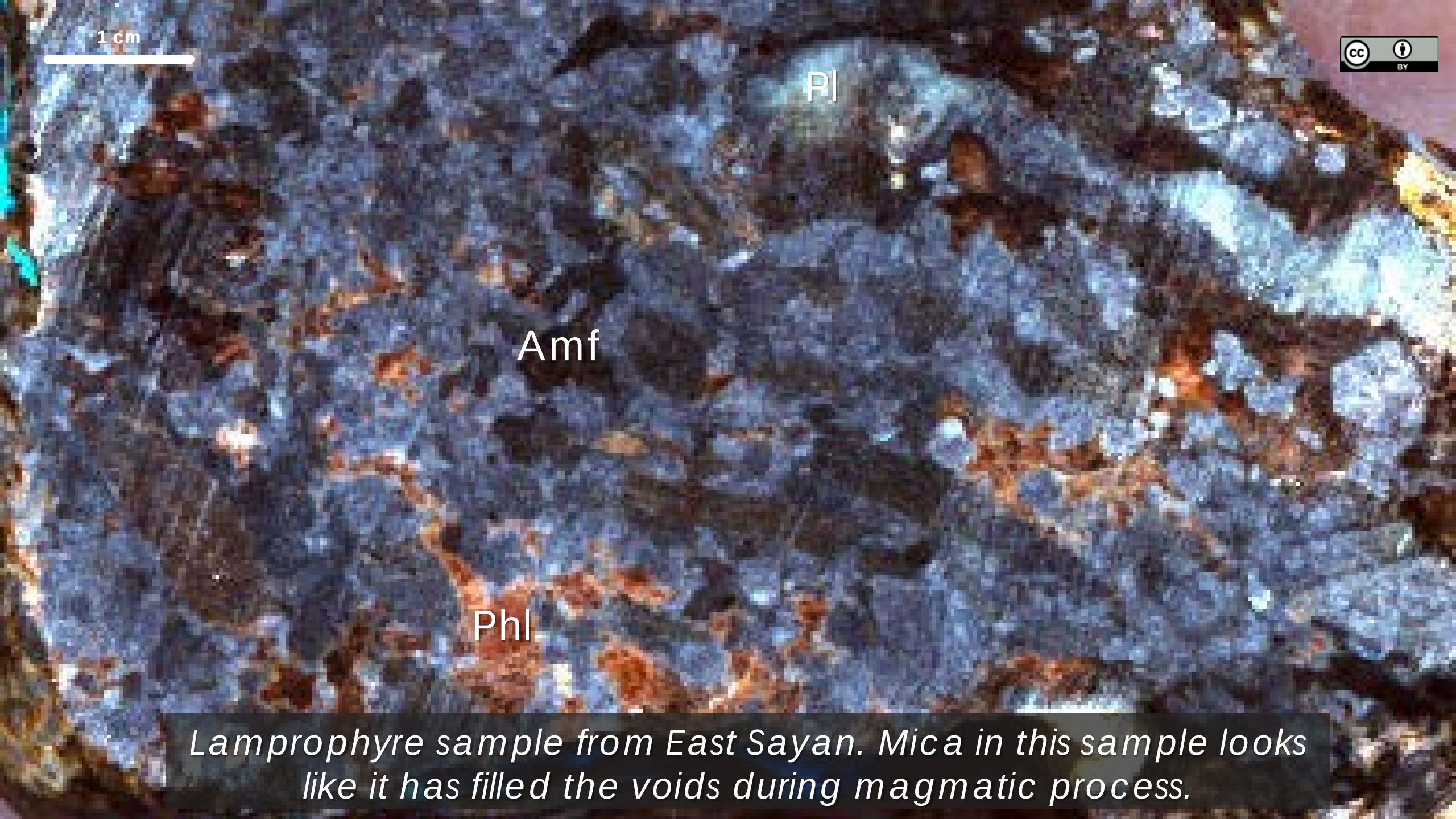
Lamprophyre sample from Ospa-Khara-Nur ophiolites



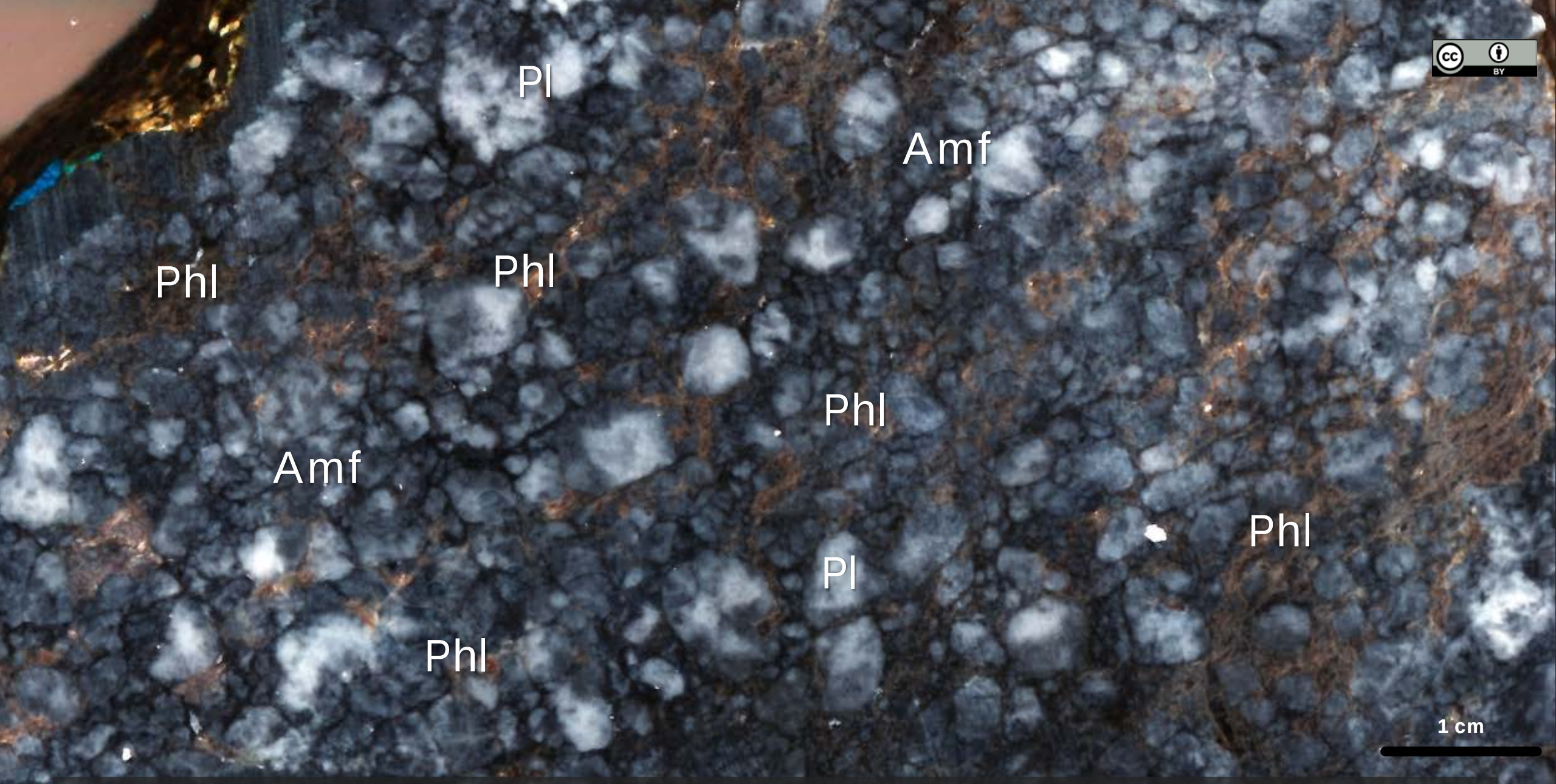
Lamprophyre sample from East Sayan. Big amount of mica in gaps between Pl and Amf crystals.



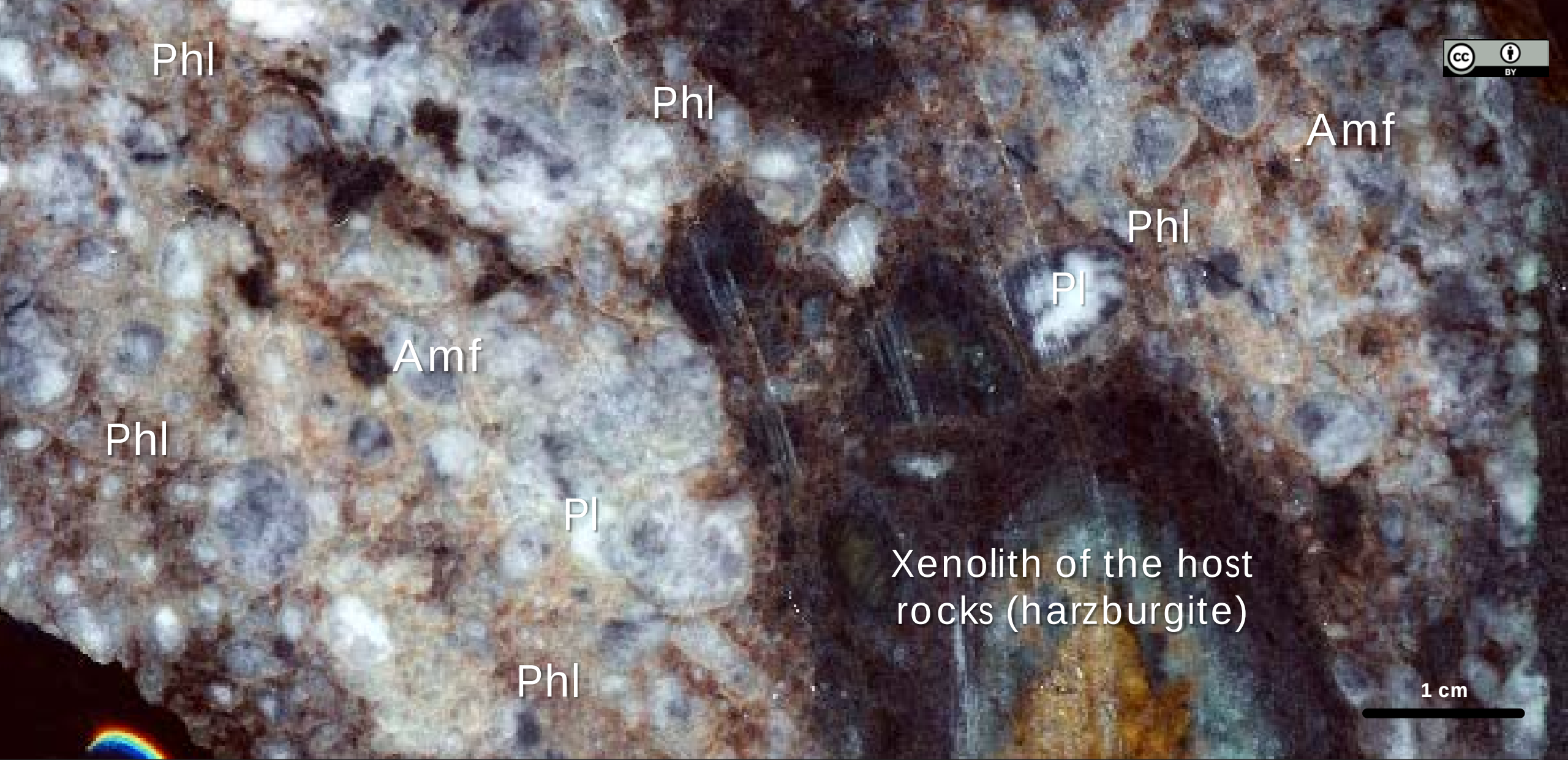
Lamprophyre sample from East Sayan. In that plane there are a lot of medium-grained Pl and Amf, with low amount of mica.



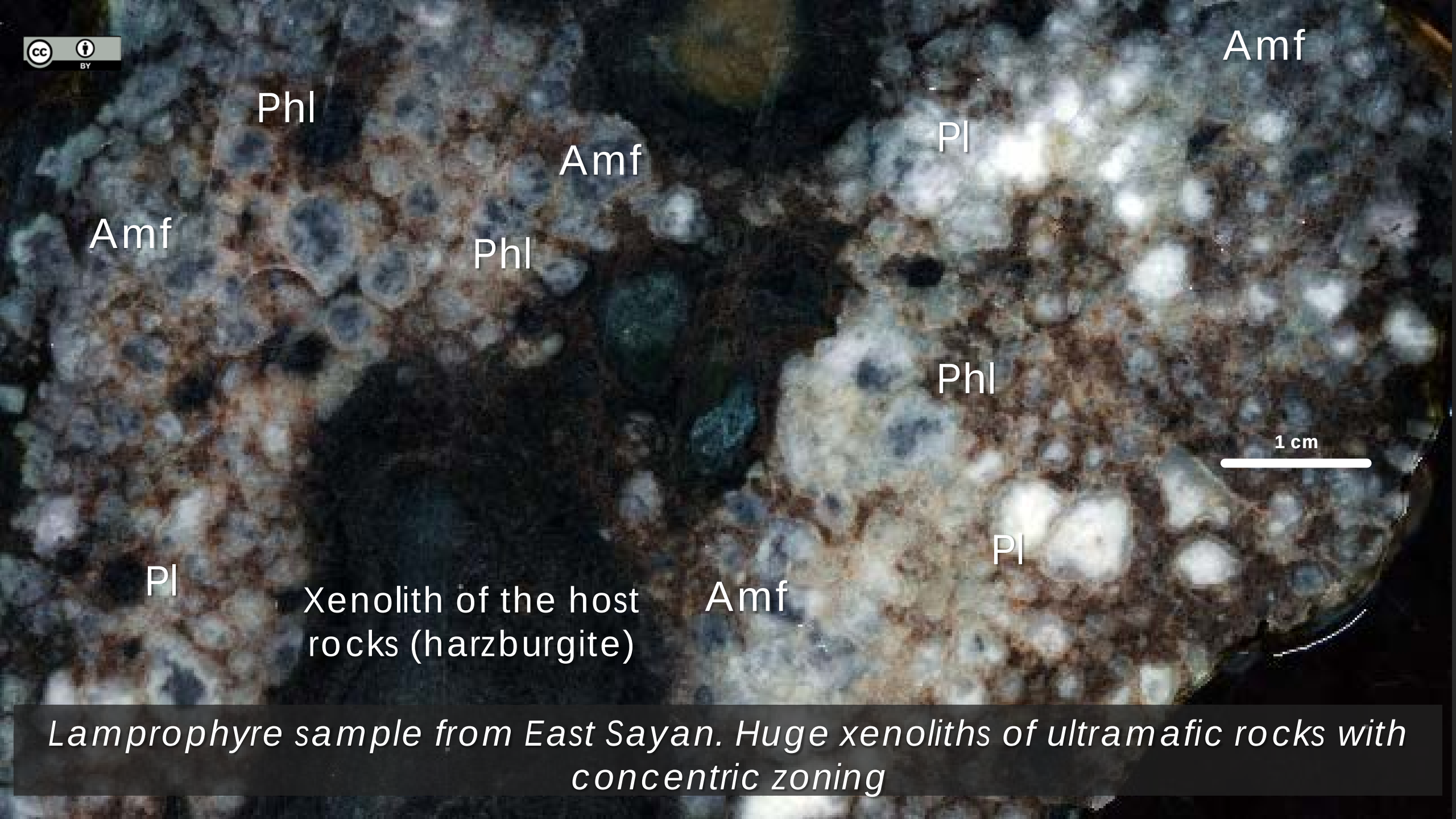
Lamprophyre sample from East Sayan. Mica in this sample looks like it has filled the voids during magmatic process.



Lamprophyre sample from East Sayan. Fine-grained and coarse-grained Pl



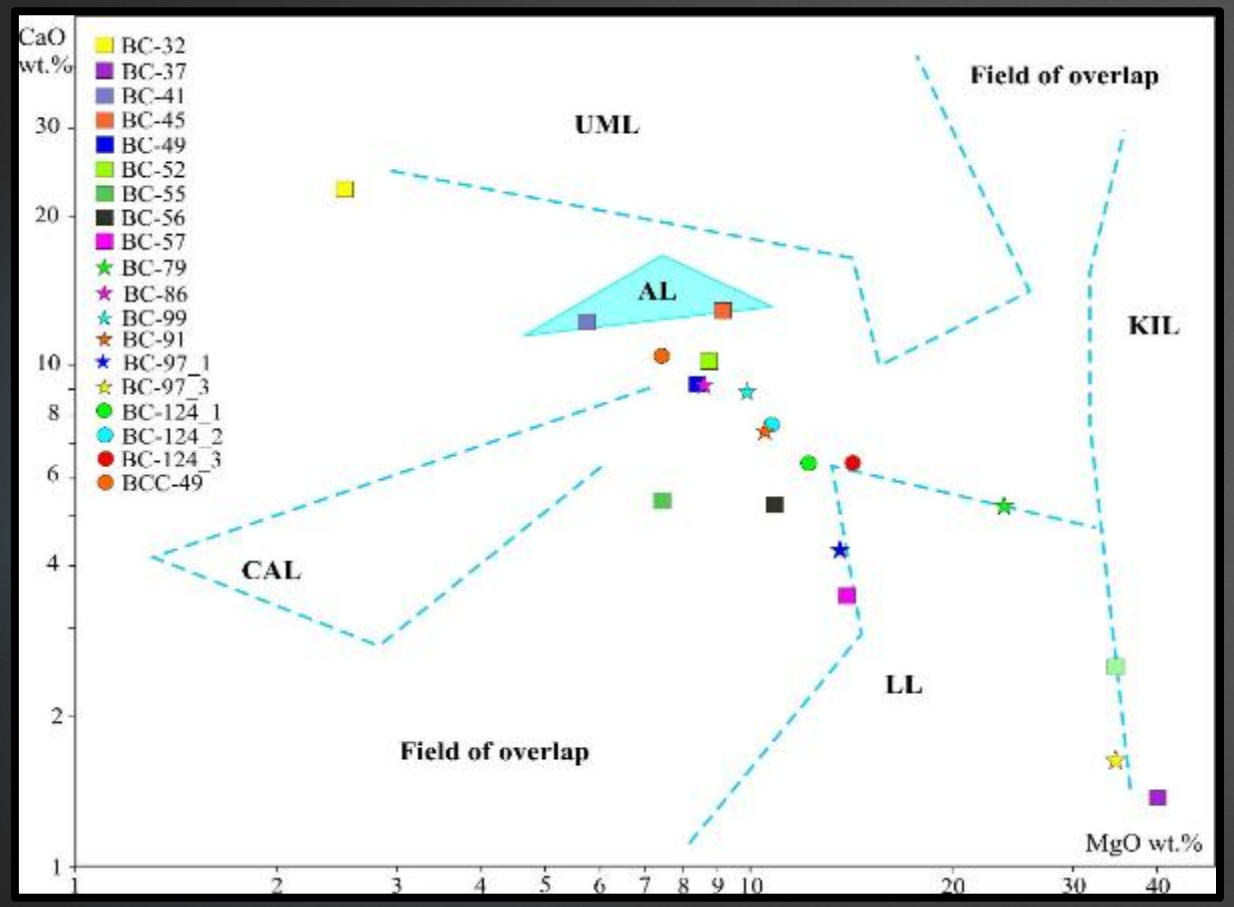
Lamprophyre sample from East Sayan. Huge xenoliths of serpentinized harzburgite with concentric zoning



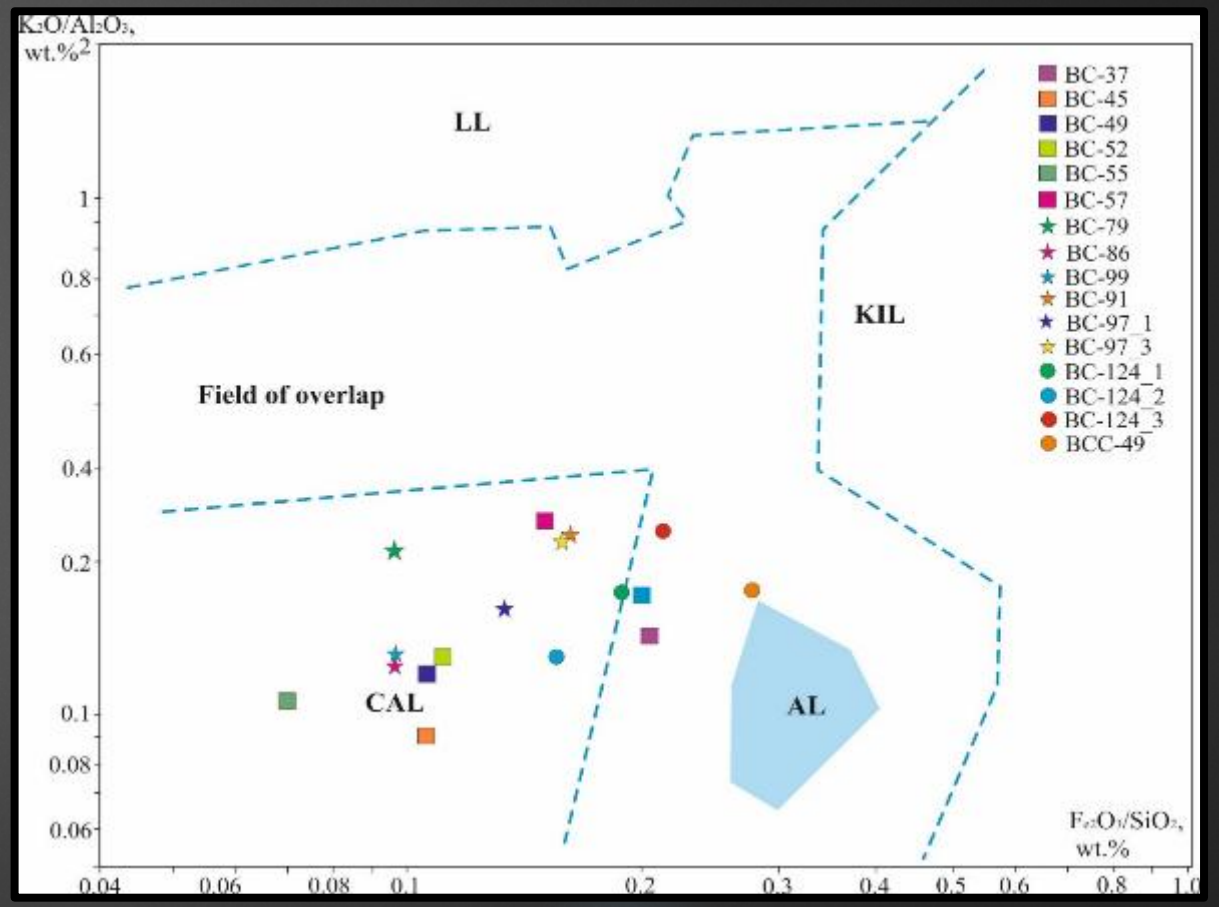
Lamprophyre sample from East Sayan. Huge xenoliths of ultramafic rocks with concentric zoning

Classification

Dark gray massive porphyric L correspond to the range between ultramafic (UML), alkaline (AL), Ca alkaline lamprophyre (CAL), and lamproite lamprophyres (LL) according to Rock's classification (1991) and shows compositional range in MgO-CaO, - Al_2O_3, - Na2O, - P_2O_5 diagrams.



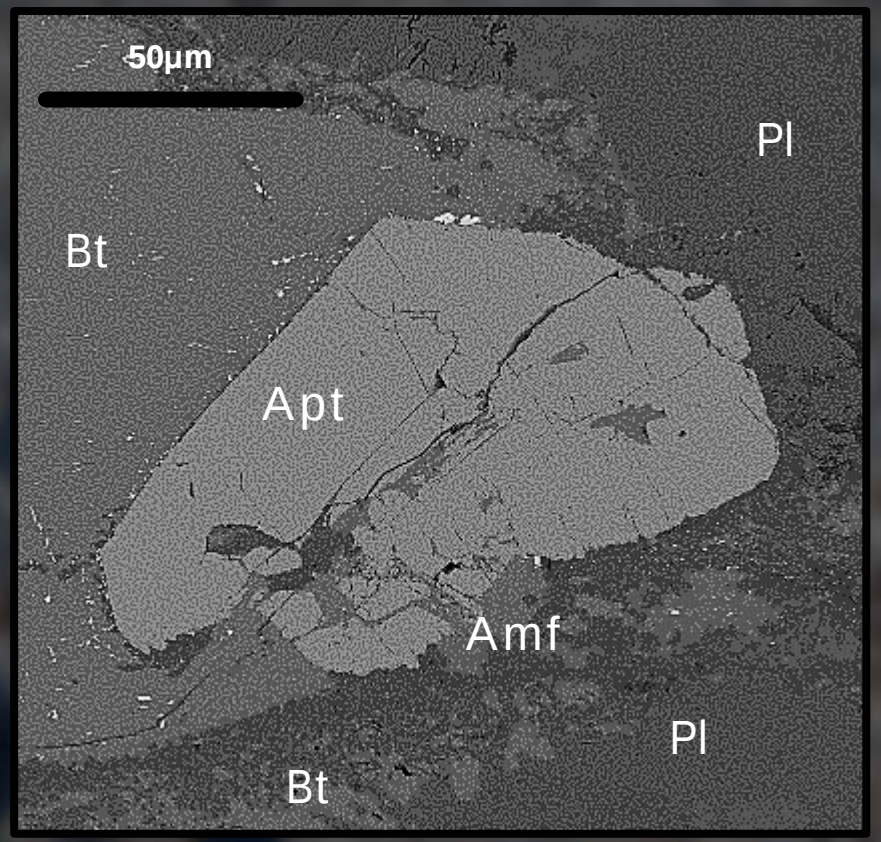
CaO/MgO wt.% diagram according to Rock, 1991

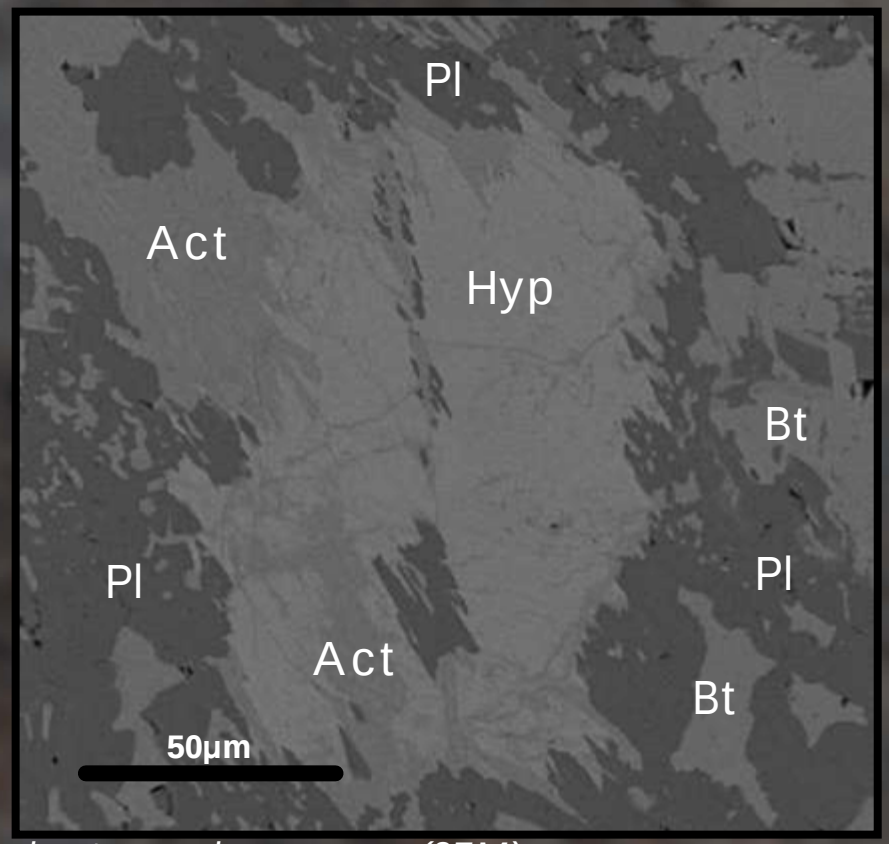


$(K_2O/Al_2O_3)/(Fe_2O_3/SiO_2)$ wt.% diagram according to Rock, 1991

Mineral composition

Lamprophyre rocks consist of feldspar, phlogopite, orto- and clinopyroxene, amphibole, with relics of olivine (Fo=45-50, rarely 22-30) and large (up to 1 cm) porphyric phlogopite. In more acid L of CAL type with prevailing hypersthene and fieldspars are associated by amphiboles metasomatic type (ferro-eckermannite, actinolite, tremolite) and rarely metamorphic glaucophane.

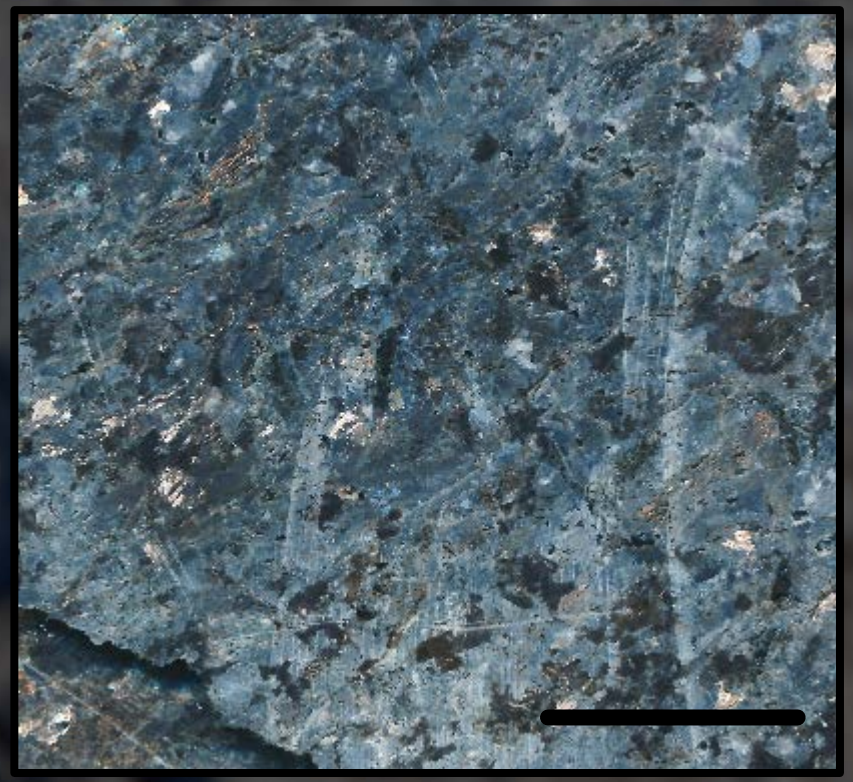




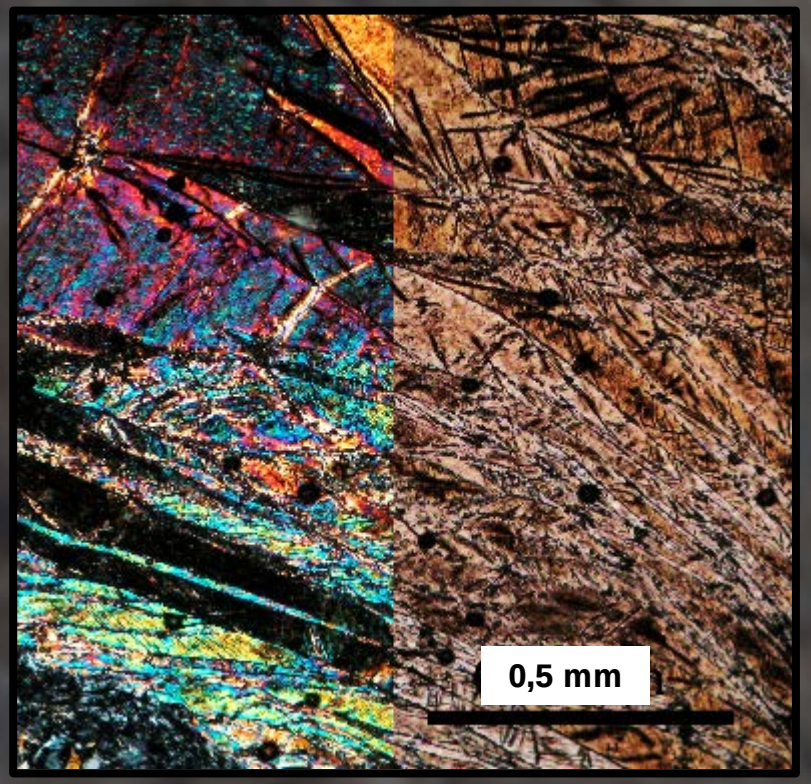
Results of researches with scanning electron microscope (SEM)

Mineral composition

Micas grains from phlogopite to biotite (0.2-1.7% and 2.1-2.8% TiO2) are surrounded by sericite. Feldspar vary albite to anorthite, and rare grains of orthoclase and Ba-feldspar. Fluorine-apatite (Cl to 0.3%), ilmenite, rutile are common in L but zircon, monazite and Ce-La-epidote are rare. Mineral thermometry range from 1300˚C to 950˚C for LL then 850°C - 560˚C and low metamorphic stage.



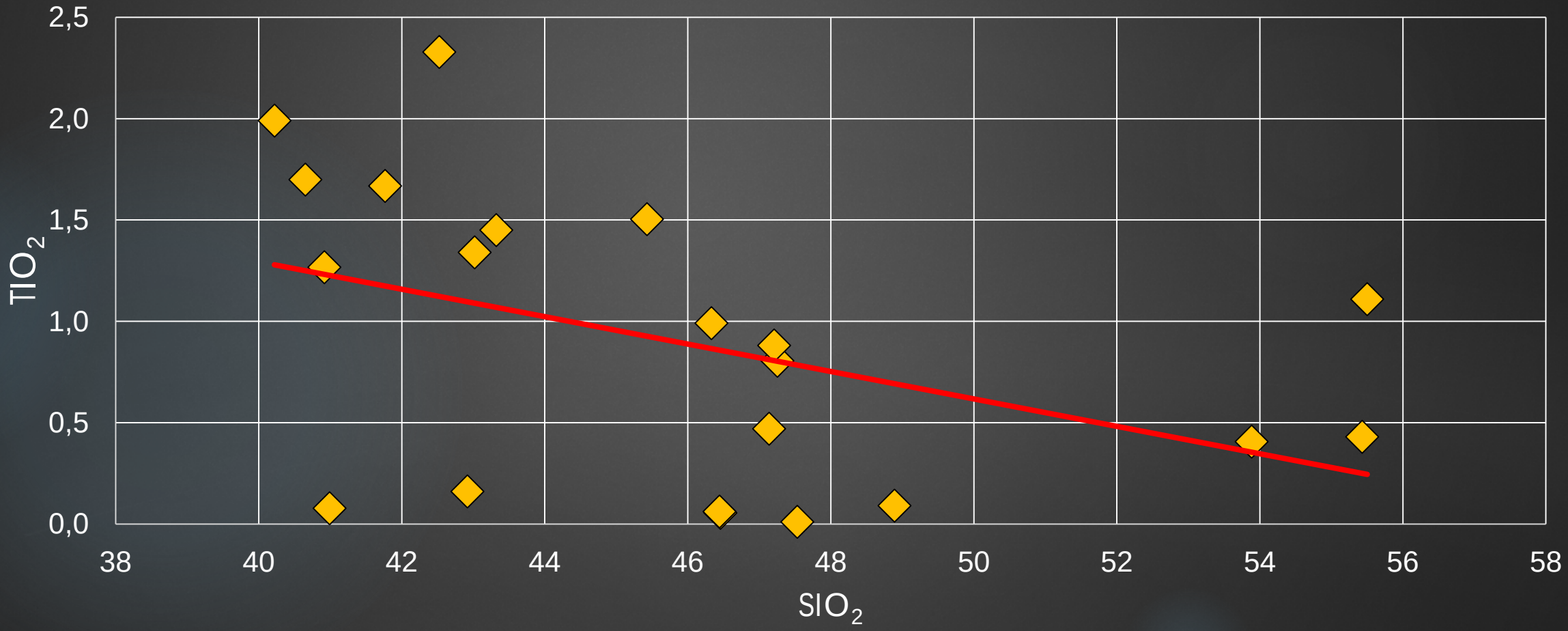
Sample scan picture fragment with large amount of mica



Mica under the magnification of the microscope

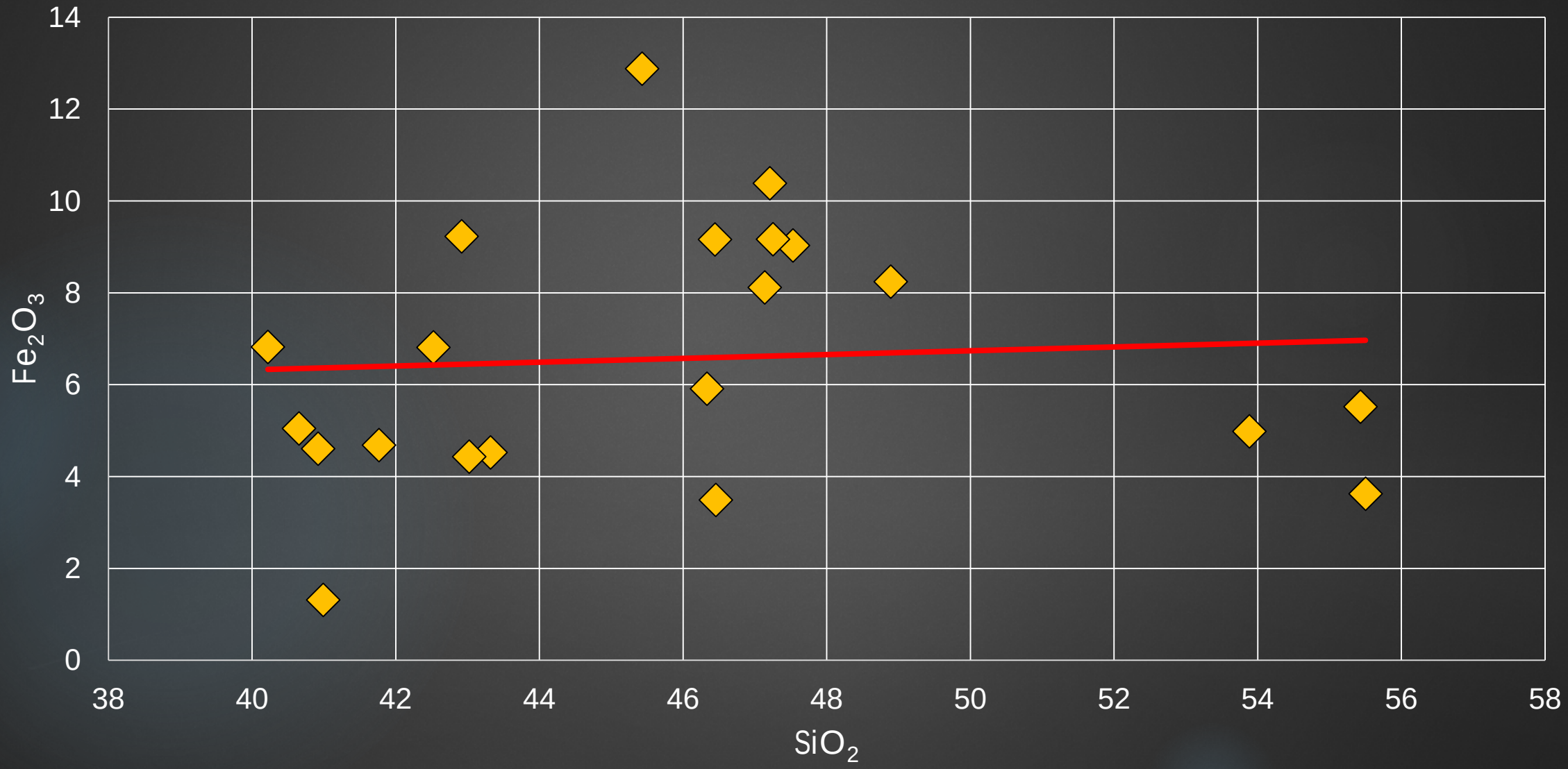
Harker diagrams – TiO_2/SiO_2

Variation Harker diagrams were built for lamprophyre samples, in order to understand the evolution of melt composition.



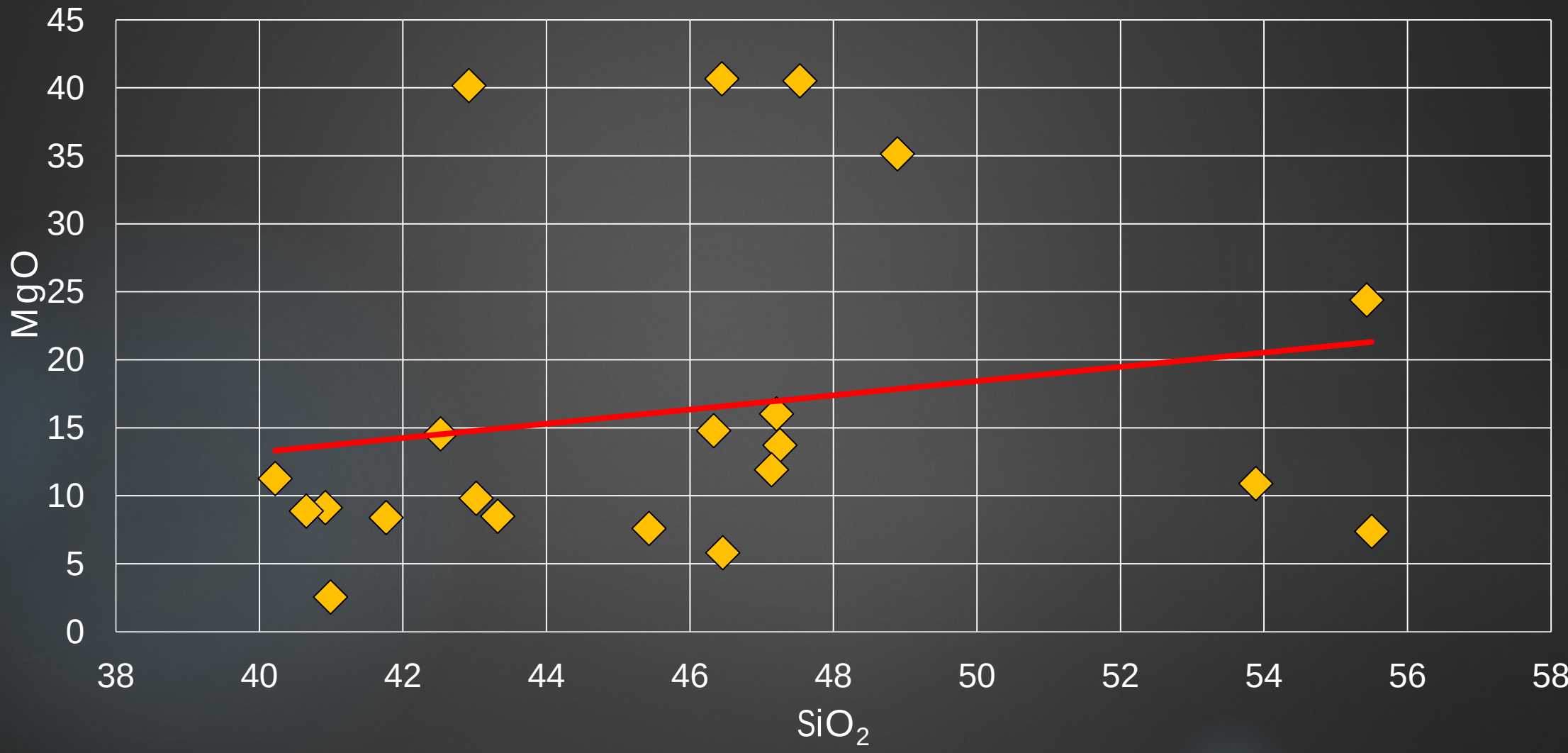
Harker diagram based on lamprophyres samples – TiO_2/SiO_2 ratios. The red line indicates a trend

Harker diagrams – Fe_2O_3/SiO_2



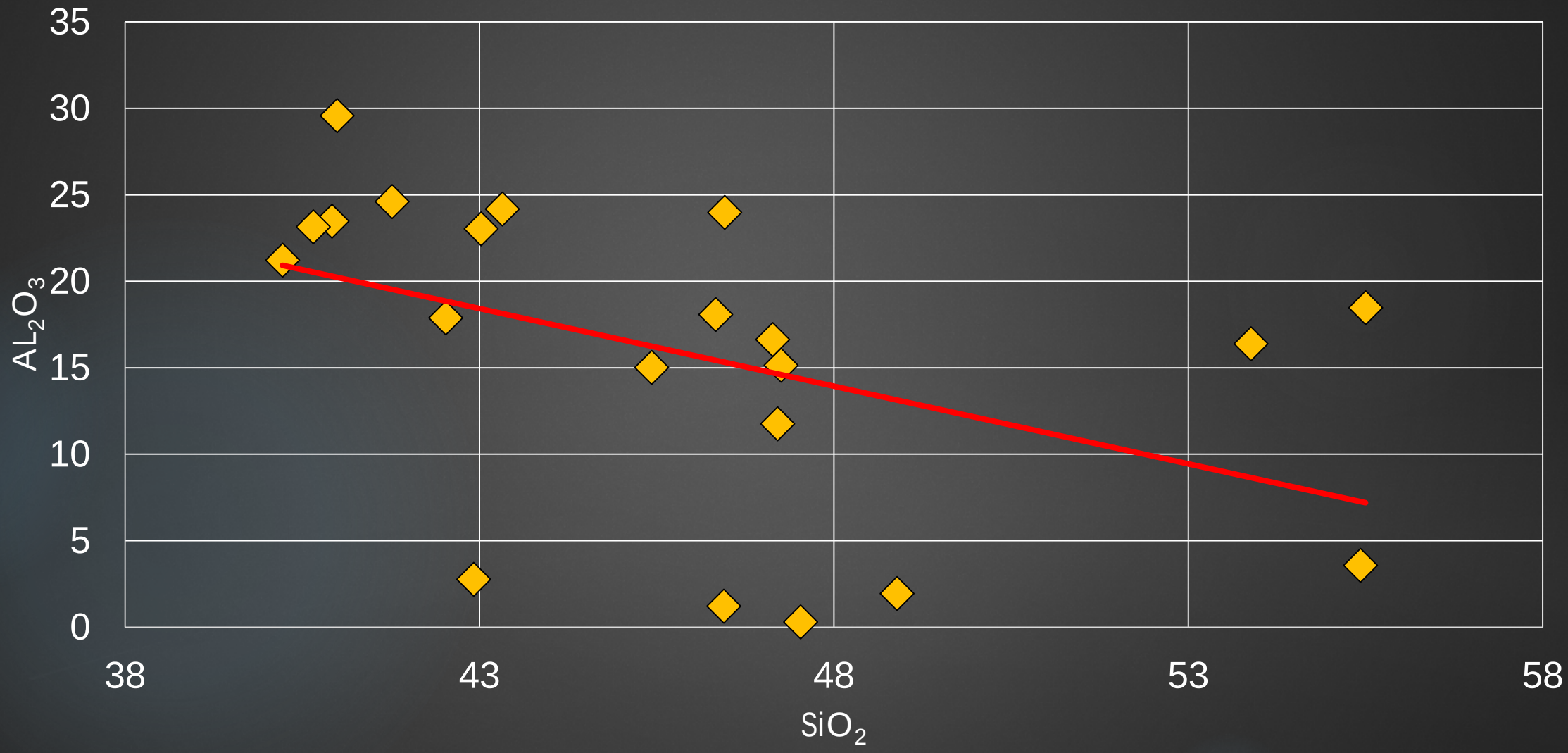
Harker diagram based on lamprophyres samples – Fe_2O_3/SiO_2 ratios. The red line indicates a trend

Harker diagrams – MgO/SiO_2



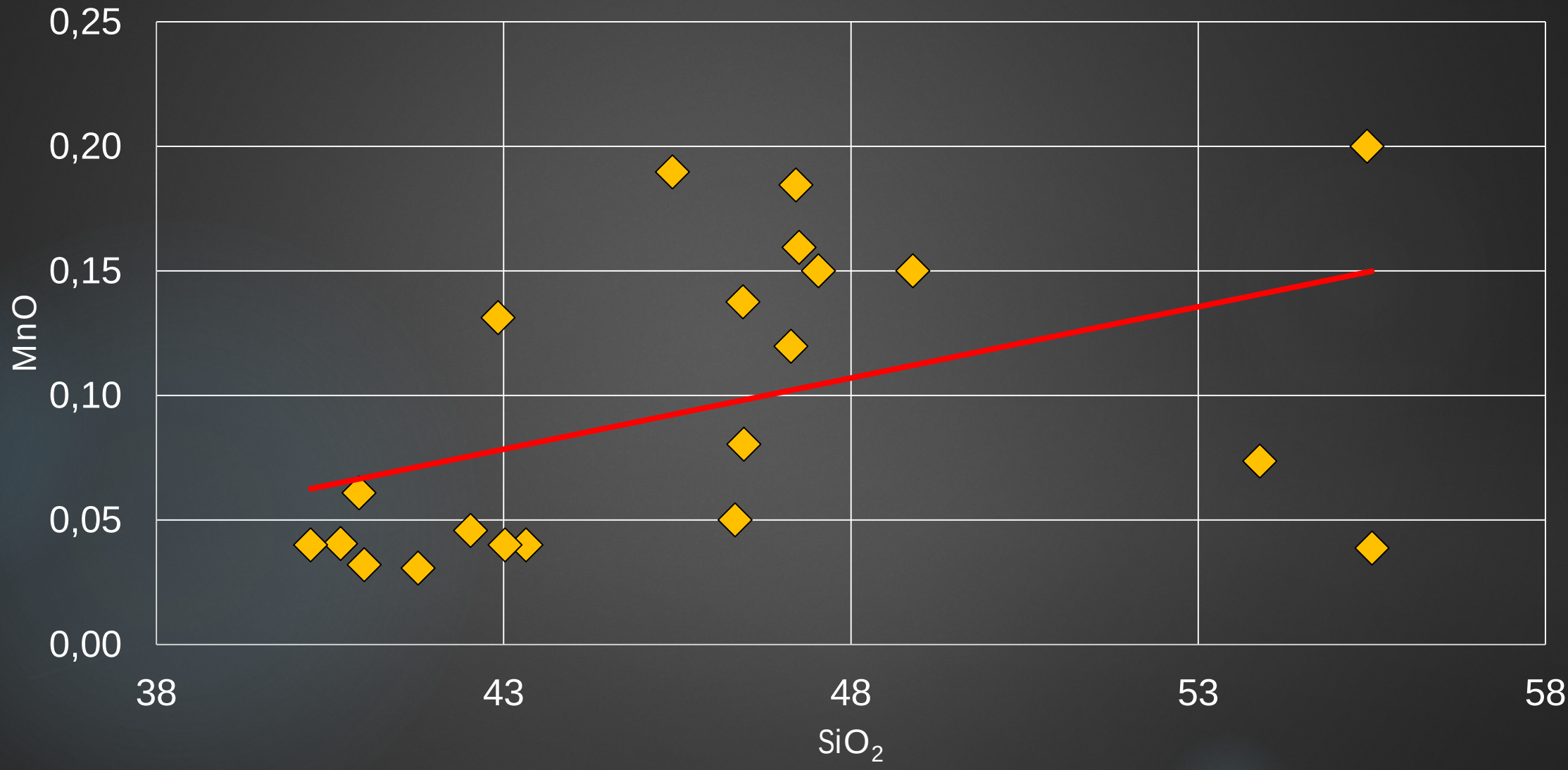
Harker diagram based on lamprophyres samples – MgO/SiO_2 *ratios. T*he red line indicates a trend

Harker diagrams – Al_2O_3 /SiO_2



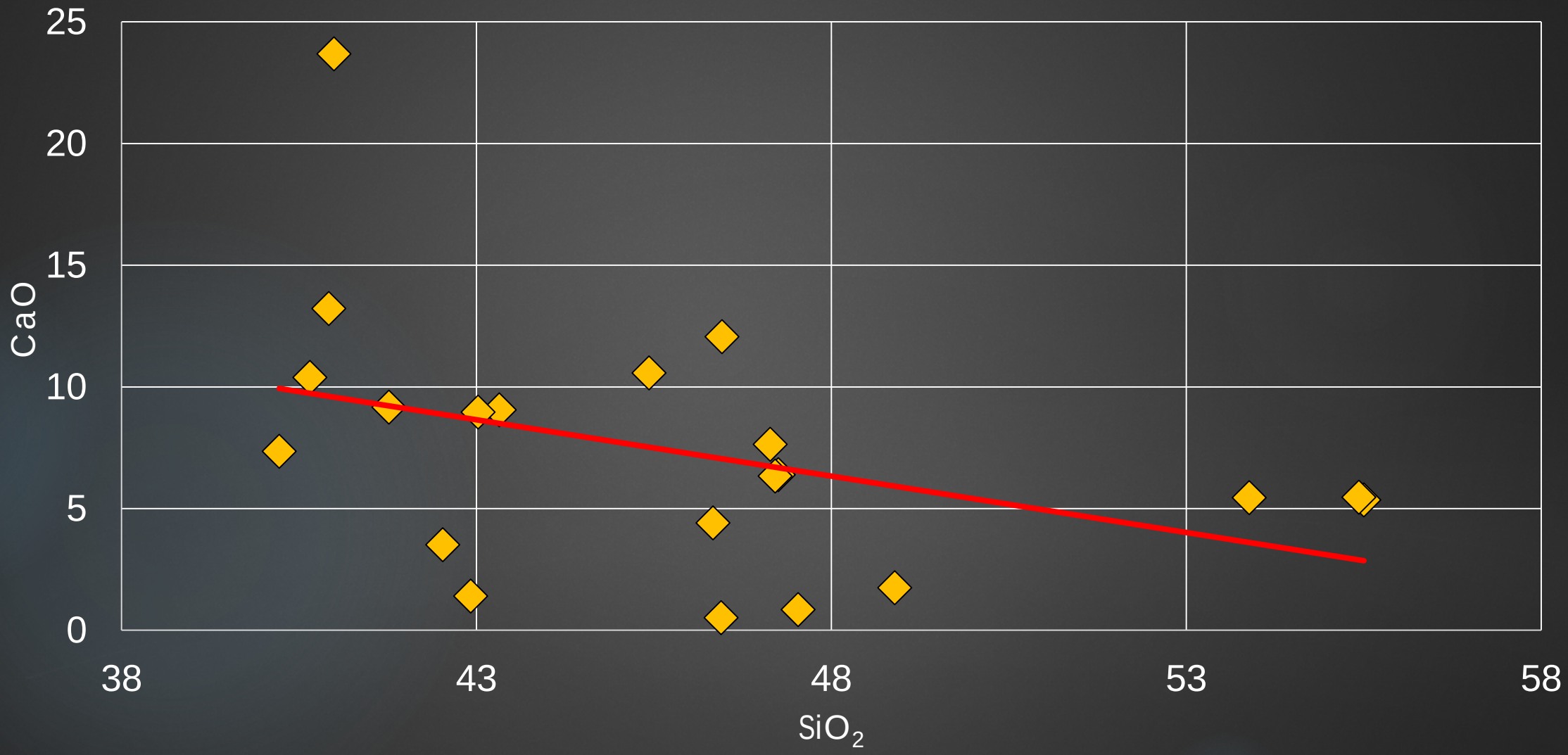
Harker diagram based on lamprophyres samples – Al_2O_3 /SiO_2 *ratios.* The red line indicates a trend

Harker diagrams – MnO/SiO_2



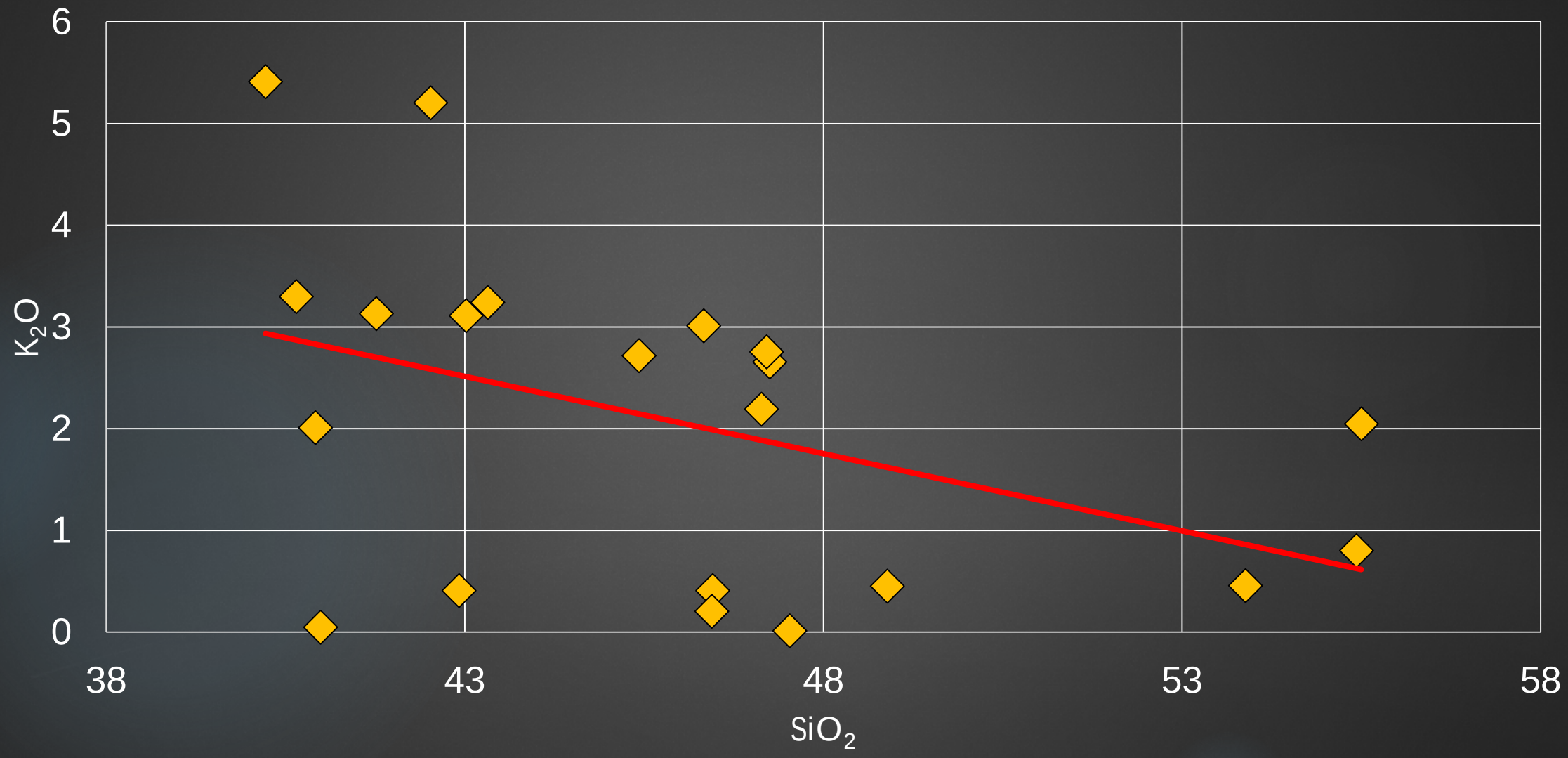
Harker diagram based on lamprophyres samples – MnO/SiO_2 *ratios. T*he red line indicates a trend

Harker diagrams – CaO/SiO_2



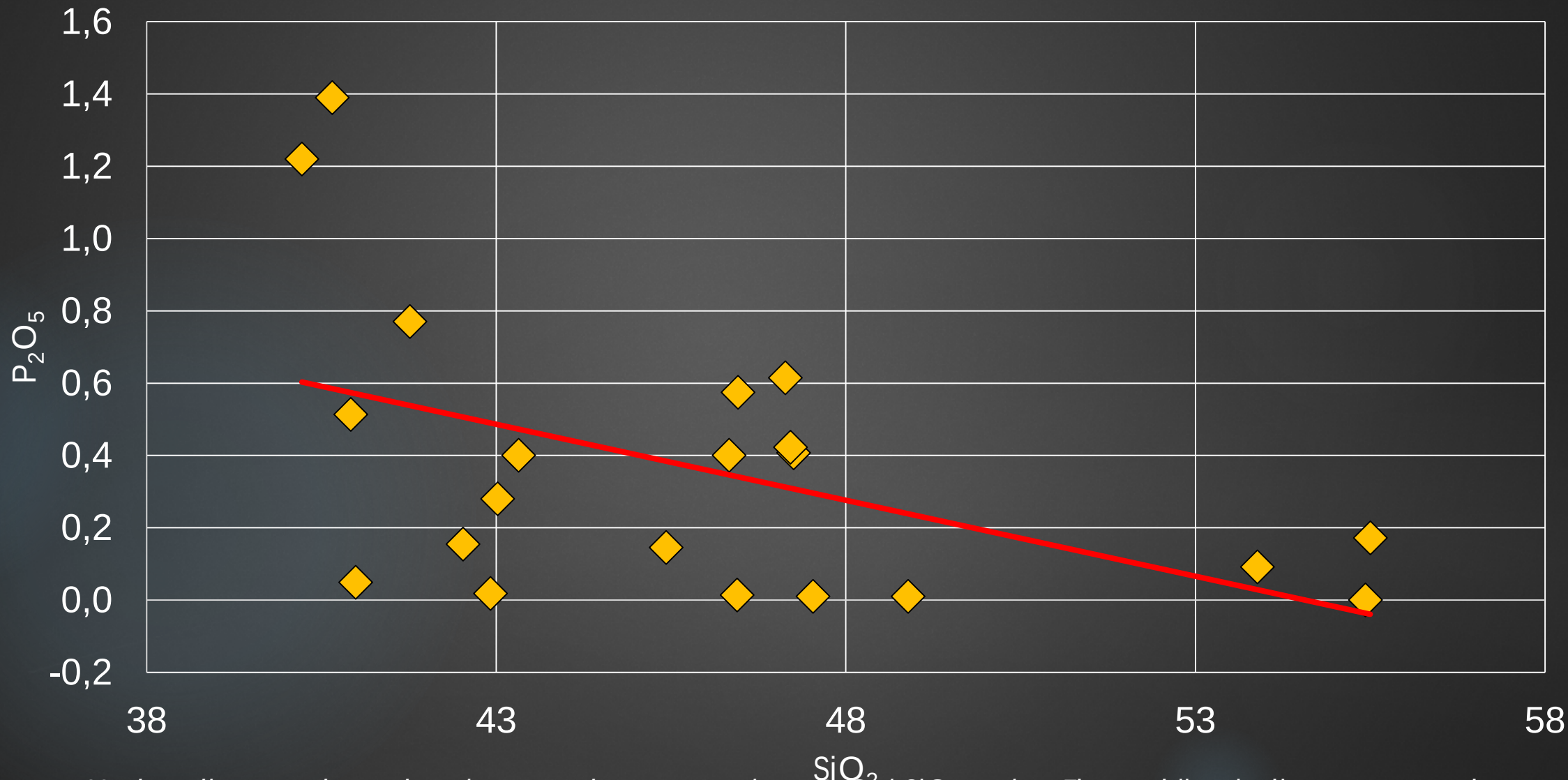
*Harker diagram based on lamprophyres samples – CaO/SiO_2 ratios. T*he red line indicates a trend

Harker diagrams – K_2O/SiO_2



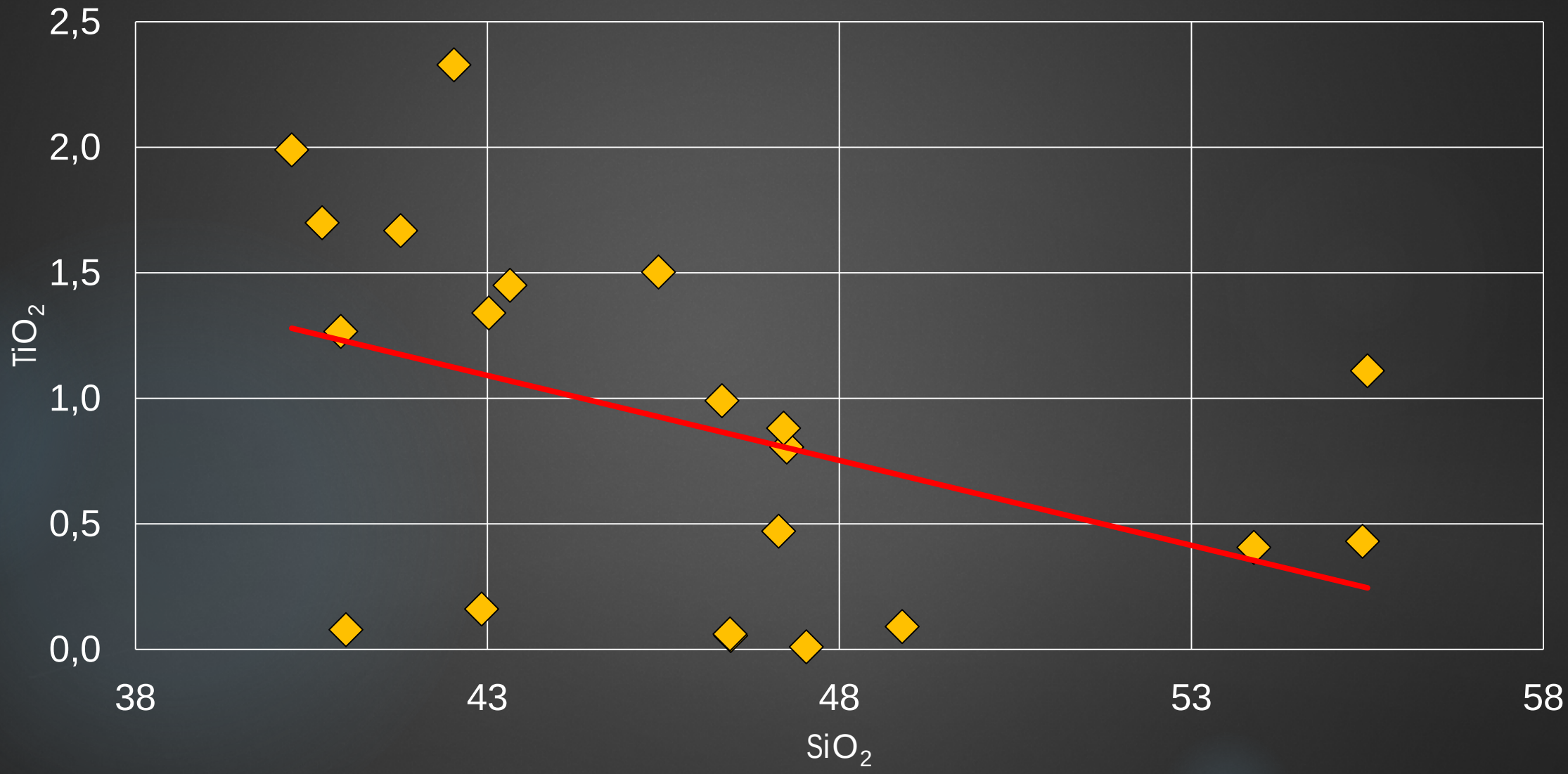
Harker diagram based on lamprophyres samples – K_2O/SiO_2 *ratios. T*he red line indicates a trend

Harker diagrams – P_2O_5/ SiO_2



*Harker diagram based on lamprophyres samples – P_2O_5/ SiO_2 ratios. T*he red line indicates a trend

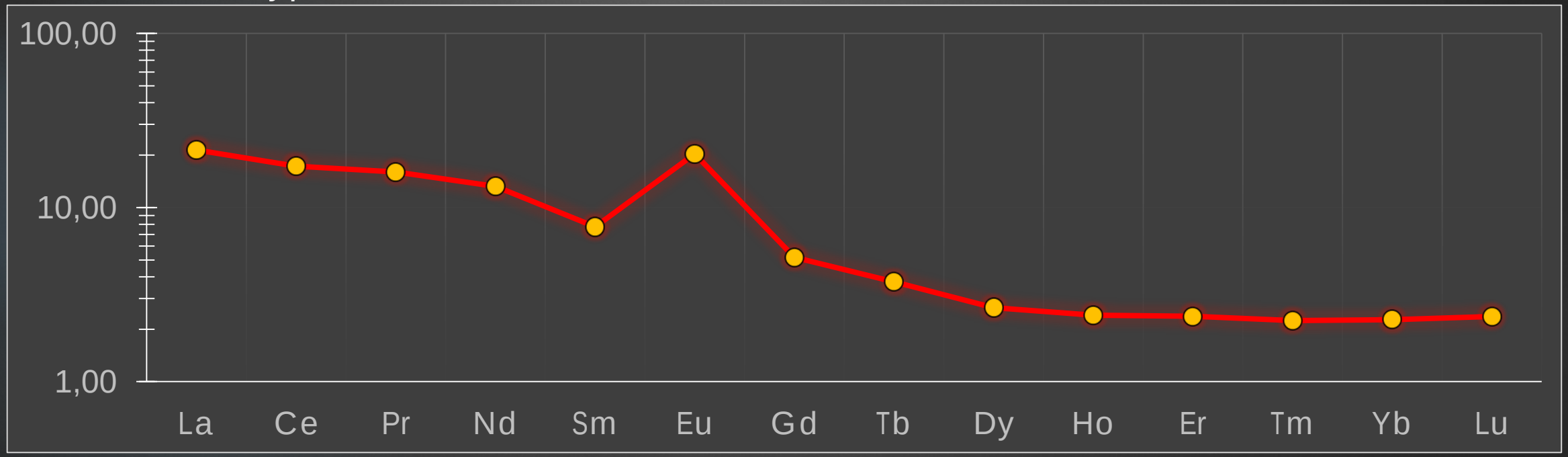
Harker diagrams – TiO_2/ SiO_2



Harker diagram based on lamprophyres samples – TiO_2/ SiO_2 *ratios. T*he red line indicates a trend

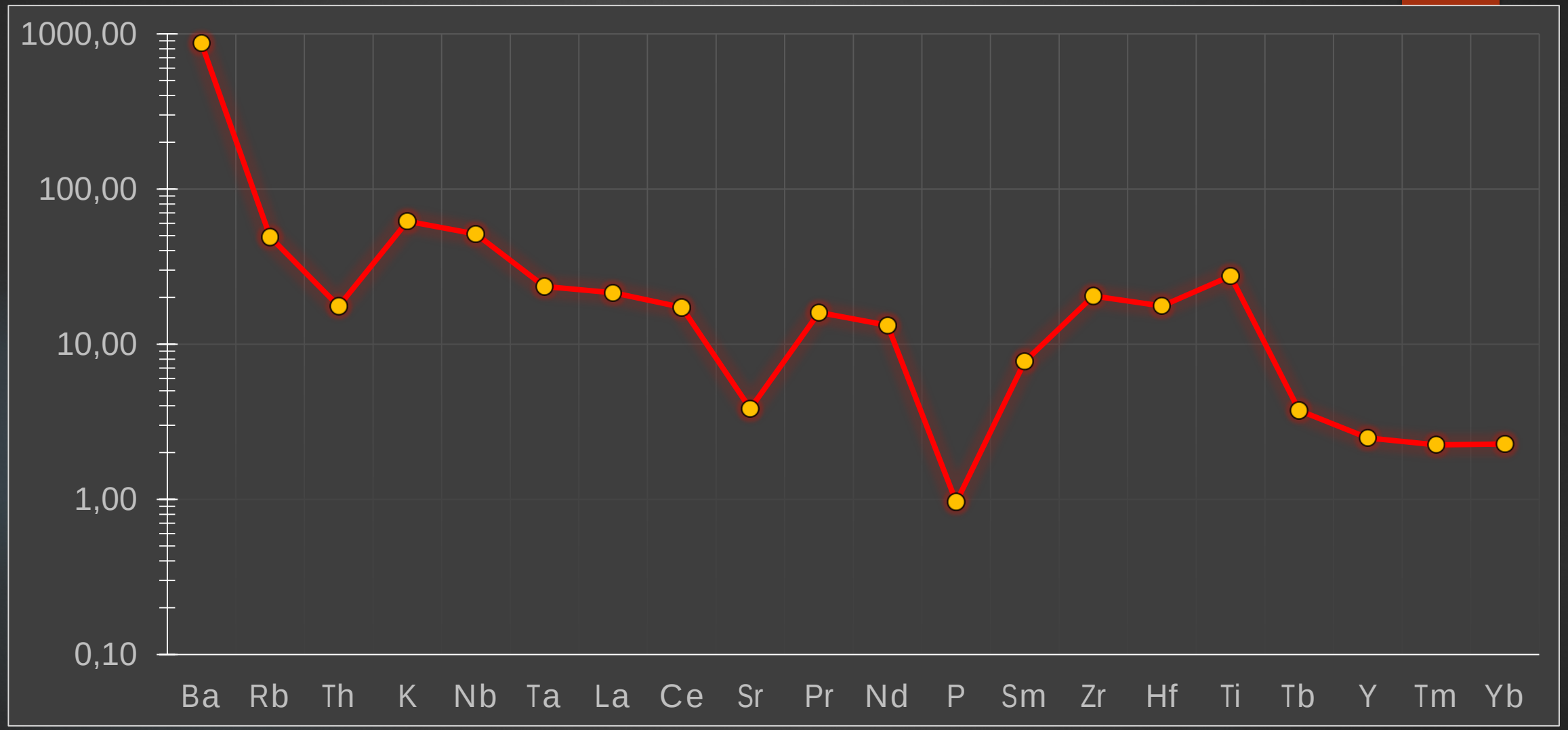
REE, HFSE and LILE amounts

TRE from L shows inclined REE with flat La-Sm, HFSE troughs but high LILE. The acid CL reveal Eu peak (Eu*=3,2; (La/Yb)n=9). Spider and REE diagram reveal elevated HFSE, Sr, Pb the same high LILE closer to anorthosites and pegmatiod charnokites. This suggests that extremely high temperature ML reacted with acid rocks and produced Ca-alkaline L type.



«Spidergram» of average compositions for lamprophyre. REE normalized to chondrites, using order and normalizing values of Nakamura (1974)

REE, HFSE and LILE amounts



«Spidergram» of average compositions for lamprophyre normalized to chondrites, using order and normalizing values of Thompson (1982)

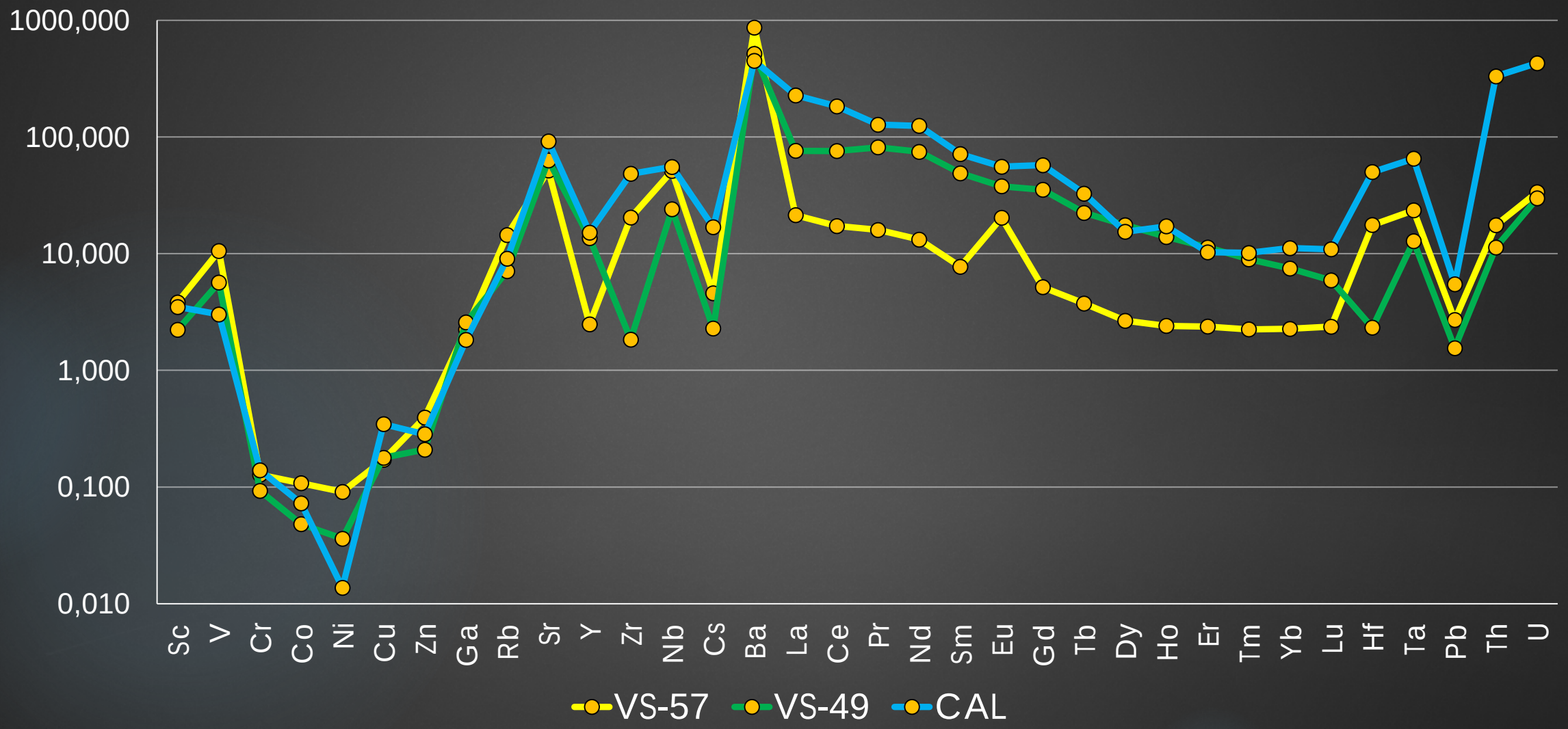
Comparison with Rock's (1991) classification

Two of the founded lamprophyre samples were compared with reference samples from classification of Rock N.M.S (1991).

There are 5 branches of lamprophyric rocks, according to Rock N.M.S:

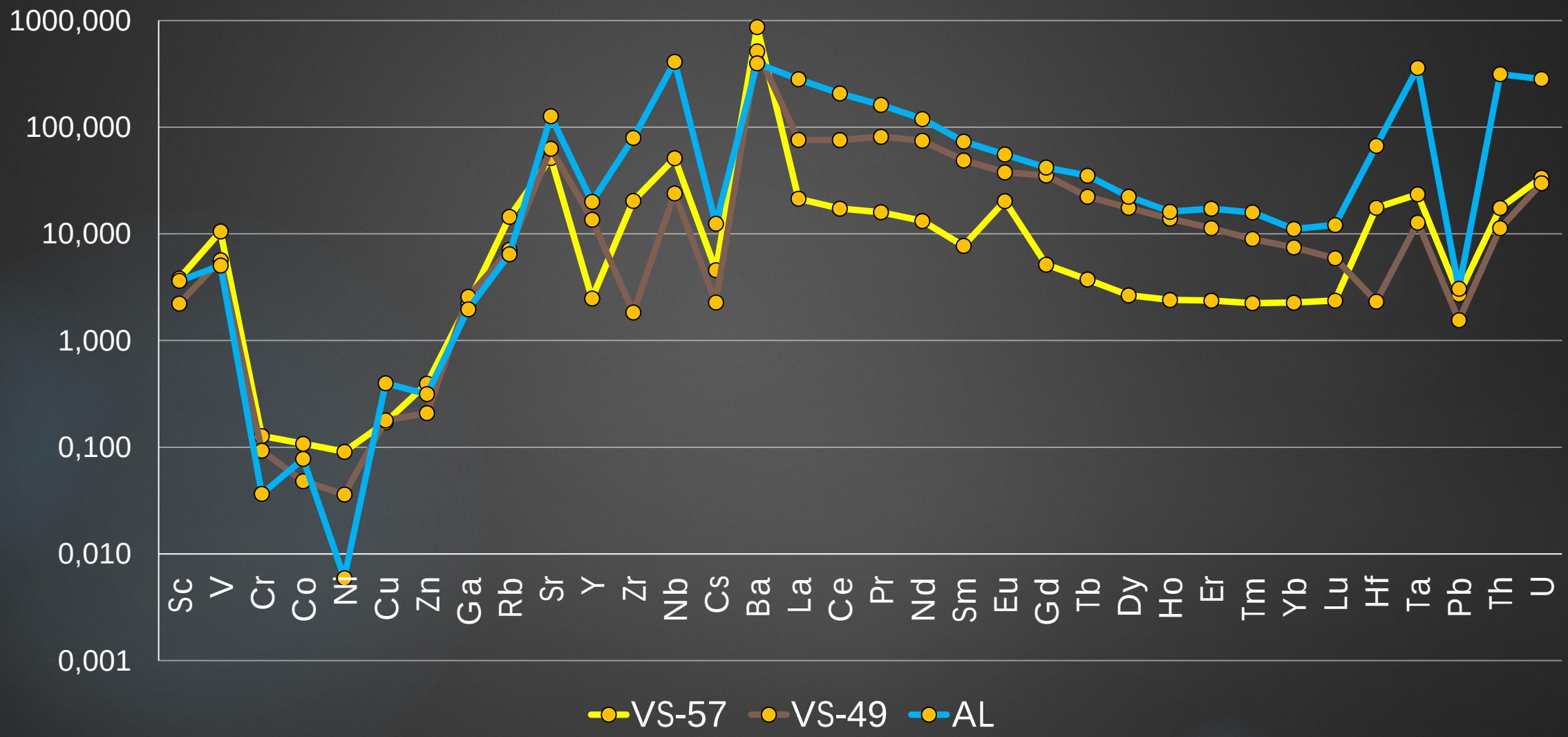
1. Calc-Alkaline (shoshonitic) lamprophyres – (CAL)
2. Alkaline lamprophyres – (AL)
3. Ultramafic lamprophyres – (UML)
4. Kimberlites – (KL)
5. Lamproites – (LL)

Comparison with Rock's (1991) classification



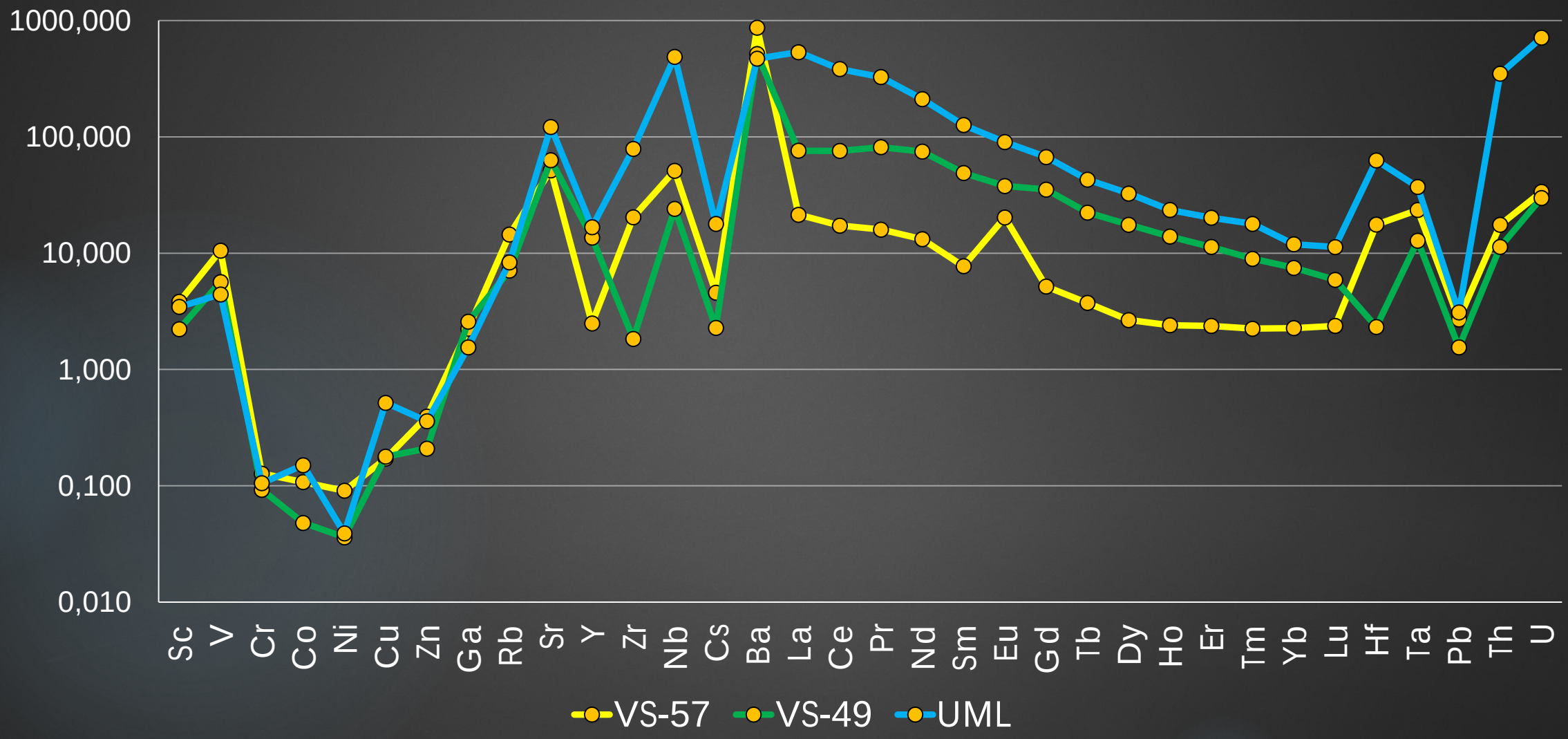
Comparison of samples with CAL lamprophyric rocks. All values normalized to chondrites, using order and normalizing values of Rock (1991)

Comparison with Rock's (1991) classification



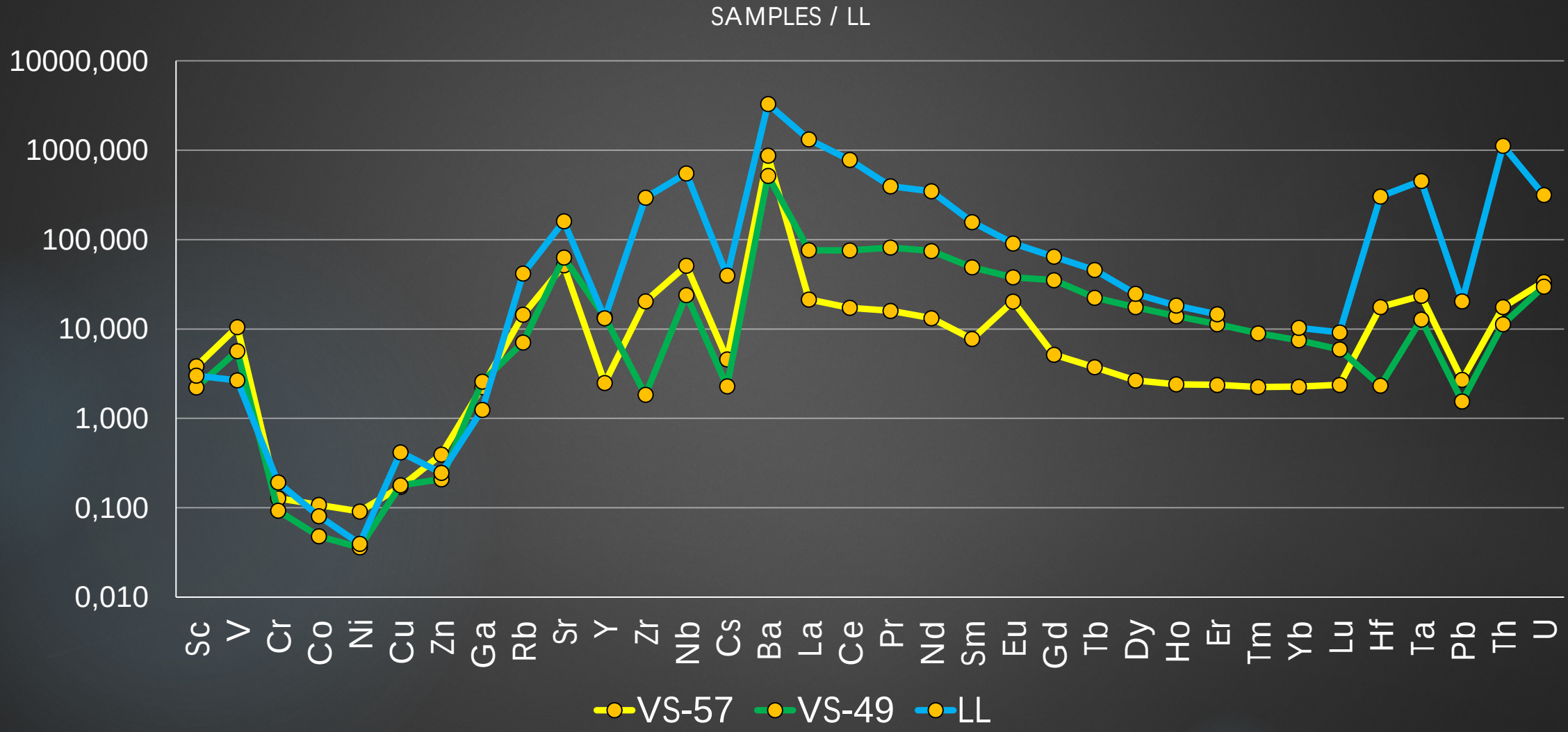
Comparison of samples with AL lamprophyric rocks. All values normalized to chondrites, using order and normalizing values of Rock (1991)

Comparison with Rock's (1991) classification



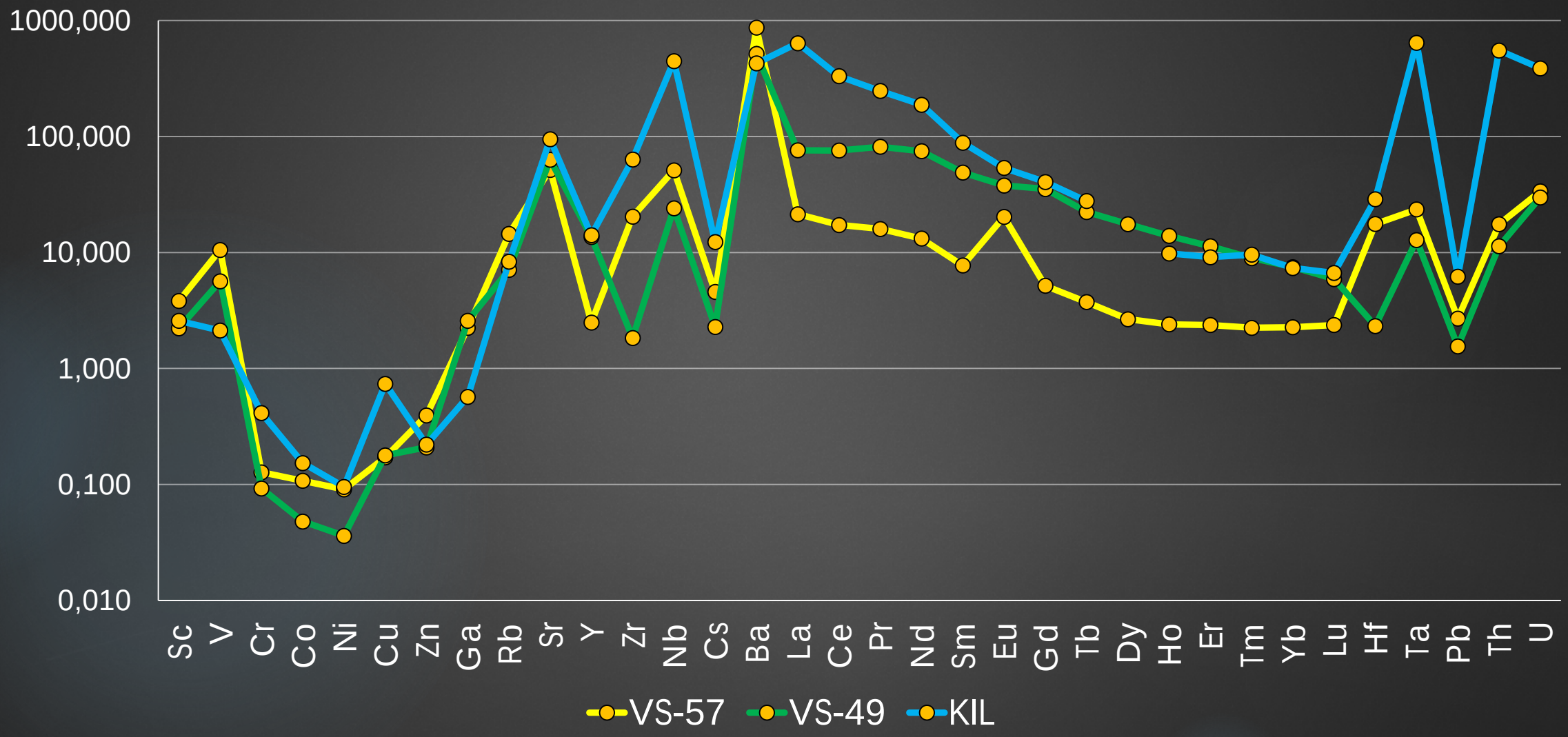
Comparison of samples with UML lamprophyric rocks. All values normalized to chondrites, using order and normalizing values of Rock (1991)

Comparison with Rock's (1991) classification



Comparison of samples with LL lamprophyric rocks. All values normalized to chondrites, using order and normalizing values of Rock (1991)

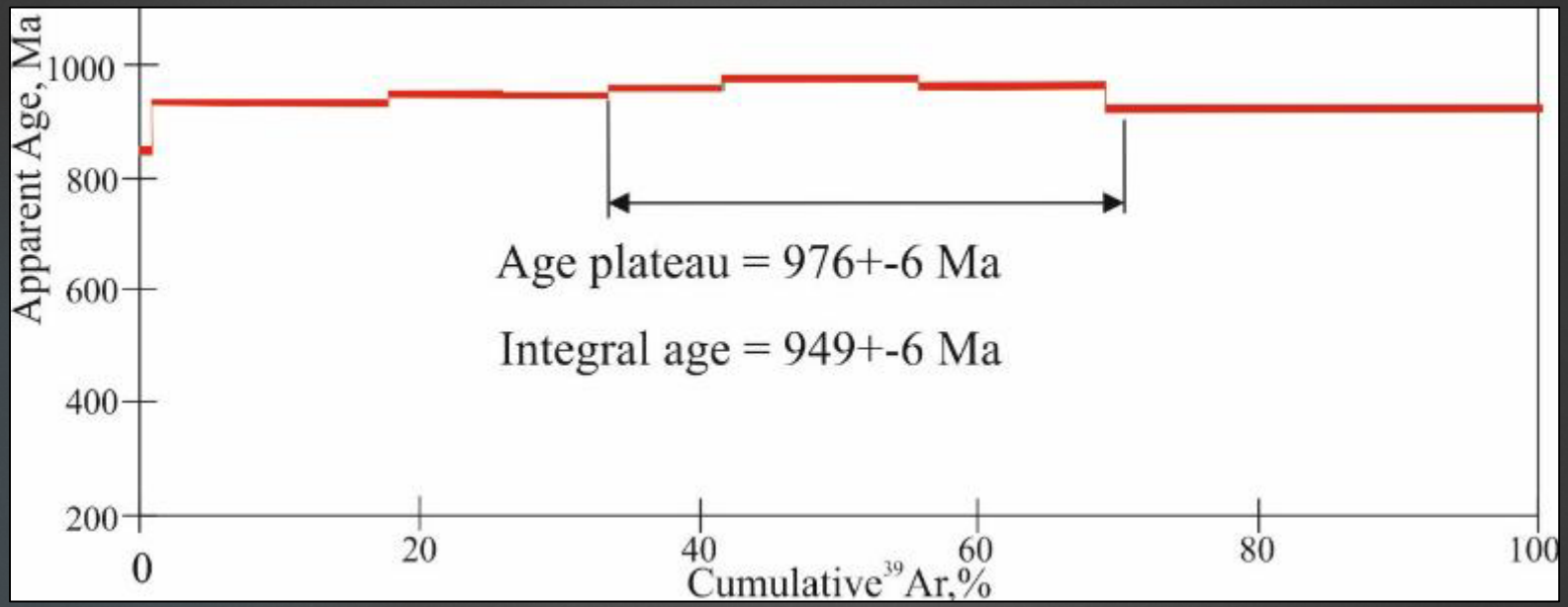
Comparison with Rock's (1991) classification



Comparison of samples with KIL lamprophyric rocks. All values normalized to chondrites, using order and normalizing values of Rock (1991)

Age spectra

Age spectra for phlogopites were obtained from lamprophyres by $^{40}Ar/^{39}Ar$ step heating method. In sample VS-66-2, spectrum reveal intermediate plateaus of 3 stages (32%, 35%, 33%) of cumulative ^{39}Ar with ages 950 ± 6 and 976 ± 6 Ma, respectively.



Age diagram

In the spectrum VS-57 a good plateau 902 ± 9 Ma is distinguished (79% of cumulative ^{39}Ar). Most discordant spectrum VS-52 reveals 4 stages of creation. Most likely the age of L formation is - 976 ± 6 Ma and corresponds to ocean stage. Most likely, 902 ± 9 corresponds to the age of the intensive deformation later event in subduction zone. Further deformation suggests the complex tectonic-thermal history.

Conclusion

We suggest that late Proterozoic ophiolites, which refer to oceanic stage of 1100 Ma, were later incorporated to arc complex with the acid base. At 980 Ma they were subjected to plume event with the creation of ultramafic lamprophyres due to reaction with the crust and then they were hybridized with acid rocks to produce calc-alkaline lamprophyres. Late alteration produced series of secondary minerals.

Thus, the ultramafic, alkaline, and alc-alkaline lamprophyres provide us with more information about the history of ophiolites of the Eastern Sayan.


Thank you for your attention!