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*Geology*

# Petrology, Geochemistry and Formation Conditions of Pre-Alpine Metabasites of the Loki Crystalline Massif (the Caucasus)

**Irakli Gamkrelidze[*], David Shengelia[*], Giorgi Chichinadze[**], Tamara Tsutsunava[**], Giorgi Beridze[**], Tamara Tsamalashvili[**], Ketevan Tedliashvili[**], Irakli Javakhishvili[**]**

[*]*Academy Member; Alexandre Janelidze Insititute of Geology, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*
[**]*Alexandre Janelidze Institute of Geology, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*

**ABSTRACT. The Loki crystalline massif is an inlier of the pre-Alpine basement within the northern marginal part of the Beiburt-Sevanian terrane. The massif is represented by autochthonous Upper Devonian gneissose quartz diorites, allochthonous pre-Upper Paleozoic Upper Gorastskali (mélange), Lower Gorastskali (ophiolite), Moshevani and Sapharlo-Lok-Jandari overthrust sheets of metasediments, metabasites and by Late Variscan granites crossing all these rocks. The object of our research was the pre-Alpine metabasites of the allochthonous complex of the Loki crystalline massif (LCM). The latter, with the exception of ophiolite sheet, has experienced metamorphism during the Caledonian and overthrusting during the Bretonian orogeny. However, the presence mainly of a tectonic contact between metamorphic sheets and Late Variscan granites indicates a renewal of the overthrusting at a later time, possibly during Early Cimmerian (Indosinian) orogeny. Metabasites are developed to a various extent as concordant bodies of various thickness are observd in all overthrust sheets. Only the Lower Gorastskali (ophiolite) overthrust (obducted) sheet is entirely composed of weekly metamorphosed basites. The latter has been studied in detail from both petro-mineralogical and petrogeochemical viewpoint and the study of the metabasites of the other overthrust sheets was inadequate. For comprehensive investigations of basic rocks of overthrust sheets of the massif, the appropriate methodologies were applied: microscopic study of thin sections and petro- and geochemical analyses of the samples. Obtained data were plotted on different petrogeochemical diagrams and spidergrams. According to the diagrams petrogeochemical characteristics of metabasites of the overthrust sheets of the Loki massif, expressing some differences from each other, correspond to normal alkali, alkali and tholeiitic series. They are disposed in the field of intraplate and island-arc basalts and very rarely in the field of enriched basalts of mid-oceanic ridges (E-MORB). According to the petrogeochemical features, the metabasites of the Lower Gorastskali overthrust sheet differ from the metabasites of other overthrust sheets of the massif and is composed only of the weekly metamorphosed basites: noncumulative gabbro and parallel dikes. The latter, in the form of separate scales, occur in the Upper Gorastskali and Sapharlo-Lok-Jandari overthrust sheets.** *© 2018 Bull. Georg. Natl. Acad. Sci.*

**Key words:** the Loki crystalline massif, metabasites, petrogeochemistry

The Loki crystalline massif (LCM) is exposed in South Georgia and it is an inlier of the pre-Alpine basement within the northern marginal part of the Beiburt-Sevanian terrane [1]. LCM is represented by autochthonous Upper Devonian gneissose quartz diorites, allochthonous pre-Late Paleozoic overthrust sheets of metasediments, metabasites and also by Late Variscan (Sudetian) postmetamorphic granites cutting Upper Devonian quartz diorites and in places Lower and Middle Paleozoic metamorphic schists as well[2, 3] (Fig 1). Upper Devonian quartz diorites are exposed only in deep gorges and hypsometrically higher position is occupied by Late Variscan granites that have apparently a laccolith-like shape (Fig.1).This is correctly shown already on the State geological map of 1959 (scale 1: 50 000) compiled by research workers of Geological Institution of the Georgian Academy of Sciences and officials of the Georgian Geological Administrations led by P.D. Gamkrelidze and U.I. Nazarov.

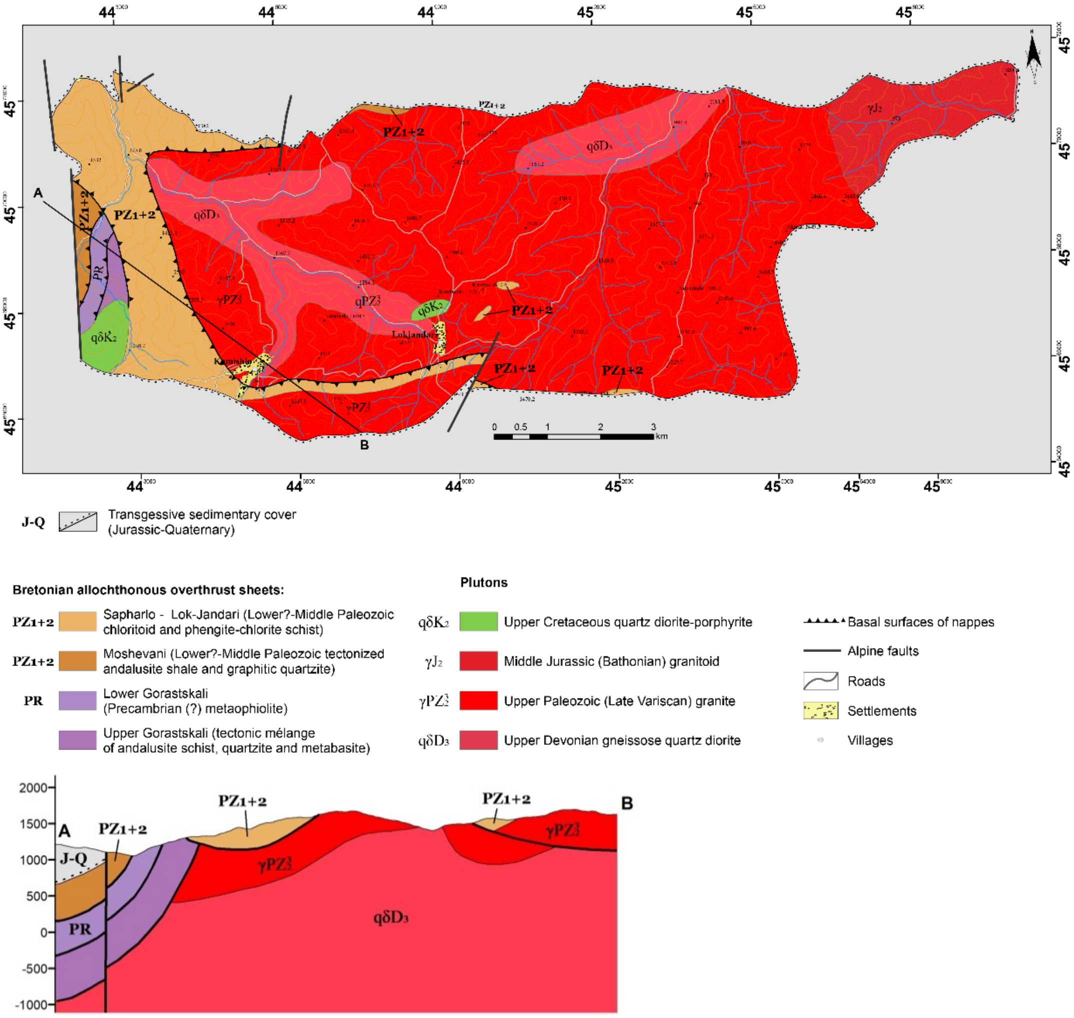


**Fig.1.** Geological map and cross-section of the Loki Crystalline Massif.

The pre-Jurassic age of crystalline rocks is determined by the transgressive bedding of Liassic terrigenous deposits on them and numerous geochronological determinations (see below).

Within the LCM, four overthrust sheets are distinguished (see Fig. 1). They differ in composition and degree of metamorphism of their constituent rocks, and often in the orientation of the schistosity and plication developed in them [2, 3]. With the exception of Lower Gorastskali (ophiolite) sheet they have been metamorphosed during the Caledonian orogeny and then experienced overthrusting (obduction) during the Bretonian orogeny. Just at that time, apparently was formed a mélange of the Upper Gorastskali overthrust sheet. However, the presence mainly of a tectonic contact between metamorphic sheets and Late Variscan granites indicates a renewal of the overthrusting at a later time, possibly during Early Cimmerian (Indosinian) orogeny. Weak metamorphism of ophiolite sheet was connected apparently with dissipative heatarising during its obduction.

The allochthonous-imbricate structure of the LCM was confirmed by M.B.Abesadze et al. [4], who identified 7 overthrust sheets of metamorphites and three overthrust sheets of granitoids. Structure of the metamorphic complex mapped by these authors, with some exceptions, in general, coincide with the data of [2].According to the authors of this article, distinguishing of granitoid allochthonous sheets does not reflect the real picture.

The pre-Alpine metabasites to different extent are spread in all overthrust sheets of the LCM.

According to the tectonic position the lowermost is the Upper Gorastskali (mélange) scheet (see below). Then follows the Lower Gorastskali overthrust sheet that is exposed in the vicinity of the Moshevani and Gorastskali confluence (see Fig.1) and is represented by the metabasites of the ophiolitic complex. In particular noncumulative metagabbro and parallel dikes of basites represented by weekly metamorphosd gabbros, gabbro-diabases, diabasesand their schistose varieties. Most of the gabbrosis a massive medium-grained rock with a relict gabbroic structure. There are also areas represented by alternation of dark and light microbands. Massive and banded varieties of gabbro have an identical mineral composition. The primary magmatic minerals are Cpx, $Pl^{50-70}$ and Hbl brown (mineral abbreviations after D. Whithey and B. Evans [5].The figures for the symbols of iron-magnesian minerals ($Act_{24}$) - the total iron content of Fe / (Fe + Mg) %, and for plagioclase ($Pl^{38}$) - the content of the anorthite molecule). In microband gabbro small areas with altered rock of rodingite type [2, 4], where a lot of fine grains of the andradite-grosular series garnet, sphene, carbonized mass, tremolite (actinolite), ore mineral, chlorite, talc, prehnite and serpentine are observed. Serpentine, according to the X-ray study, is represented by an amianthus-asbestos that replaced the amphibole. In contrast to the gabbro, diabases are represented by 0.5-25m thick parallel dikes. These are predominantly fine-grained rocks with a well-preserved ophitic structure. There also occur varieties with a porphyry structure. Porphyroblasts of ferro-magnesian minerals are completely replaced by carbonate and ore minerals or actinolite, as well as by talc, chlorite, carbonate and actinolite hornblende. Green hornblende occurs less often. The process of hydrothermal metasomatism is intensively manifested in diabases, but the products of regional metamorphism in comparison with gabbros are less spread. Diabases, as a rule, are cut by carbonate veins. Their clusters and nests are also frequent. Rarely, they are cut by vein bodies of plagiogranite porphyries.

In the basites of the Lower Gorastskali sheet following mineral associations are established: Act+Ab+Chl+Carb+Ep+Sf, Chl+Ab+Act, Carb+Chl+Phr+Ab. Regional metamorphism of the basite complex of the sheet corresponds to the lowest stage of greenschist facies. Data on the age of basites are very scarce and only by analogy with the ophiolitic complex of the Dzirula massif [3, 6 - 8] their age can be conditionally considered as Precambrian.

Far back in 1953 G.M. Zaridze and N.F. Tatrishvili [9] considered that the basites of the southwestern part of the LCM participate in composition of melanocratic basement on which the parent rocks of the metamorphic schists were deposited. Later, G.M. Zaridze [10] expressed the opinion that the LCM basins form a basaltic oceanic bed of Paleozoic geosyncline.

According to M.B. Abesadze et al. [4], the composition of the basites of this complex corresponds to basalts of oceanic-island arcs and intraplate oceanic basalts.

Questions of the petrogeochemistry of the metabasites of the Lower Gorastskali sheet in the presented paper are not considered, since they are described in detail by I.P. Gamkrelidze et al. [2, 3, 6, 11, 12].In particular, it is shown that the entire basite complex of the sheet is considered as a fragment of the ophiolitic association.It covers a transitional part of the second and third layers of the oceanic crust. In particular, the upper non-cumulative part of the gabbro component of the third layer (where clinopyroxene and brown hornblende occur, peridotite intercalation and indicator mineral of olivine cumulates are absent) and above the lowermost part of the complex of parallel (diabase) dikes of the second oceanic layer.

The Moshevani overthrust sheet is exposed at the confluence area of the Gorastskali and Moshevani rivers and to the north on the left bank of the Moshevani river (see Fig. 1). Crenulated andalusite-mica schists, metagabbros, plagioclase amphibolites, chlorite-actinolite-carbonaceous and calcite-epidote-chlorite schists and occasionally epidosites represent the greatest part of the sheet. The rocks of this sheet belong to the high-temperature greenschist facies and partially to the beginning of the epidote-amphibolitic facies. Conventionally they are dated as the Lower Paleozoic [2].The concordant metabasite bodies are intensely schistose. The thickness of their exposures in places reaches 50-60 m. Primary structure of the rocks is not preserved. Dark-colored magmatic minerals are not observed; plagioclase is completely saussuritized, carbonized and prehnitized. In the metabasites of the Moshevani overthrust sheet, microprobe analysis established following mineral associations of regional metamorphism: $Pl+Hbl_{green}+ Hbl_{blue-green}+Chl+Ep$, $Chl_{35-38}+Act+Ab+Cal$.

The northwestern, youngest Sapharlo part of the Sapharlo - Lok-Jandari overthrust sheet, is exposed in the basins of the rivers Moshevani and Karasu (see Fig.1). K-Ar age of rocks is 296-340 ± 10 Ma [6, 14] and probably corresponds to the Lower-Middle Paleozoic. Most of it is represented by alumina-enriched metamorphites– quartz-chloritoid-chlorite-phengite schists. The latter also contains actinolite-chlorite-epidote-albiteschists, epidosites and rarely metabasites.The intensity of regional metamorphism of rocks is limited by the greenschist facies biotite and garnet subfacies [2, 6, 14, 15]. Metabasites occur as 1-15 m thick concordant bodies and mainly are schistic. In the rock, a gabbro or gabbro-diabase structure is detected. Of the primary minerals, only saussuritized and prehnitized porphyraceous plagioclase is preserved, and the brown hornblende is almost entirely replaced by green and blue-green hornblende. In the metabasites, microprobe analysis established following mineral associations: $Act_{24-35}+Chl+Ab+Ep+Pl^{38-42}+Hbl_{55}$ and $Act_{72}+Chl_{64-69}+Ab^{2}+Cal_{98}+Ep$.

The Lok-Jandari older part of the Sapharlo –Lok-Jandari overthrust sheet occupies the largest part of the exposure of the LCM metamorphic complex.It is widely spread in the Lok-Jandari and Moshevani river ravines, where the width of its exposure reaches 2000m (see Fig. 1).By analogy with the metamorphites of the Sapharlo overthrust sheet, the parent rocks of the Lok-Jandari sheet may be of Lower-Middle Paleozoic age. The sheet is represented mainly by chlorite-fengite-quartz-graphite schists. In places, there occur small (rarely several tens of meters) flakes of metabasites. Following mineral associations are established in them: $Act_{36}+Chl+Ep+Ab+Cal$; $Act_{40}+Act\text{-}Hbl_{35-42}+Chl_{42}+Pl^{5-13}+Cal_{99}+Ep$;$Act_{41}+Act\text{-}Hbl_{38-45}+Chl+Ep+Hbl^*_{41-48}+Pl$; $Act\text{-}Hbl_{45-47}+Chl_{40-43}+Pl^{11}+Cal_{100}+Ep+Hbl^*_{53}$; $Chl_{39}+Ep+Pl^{37*}+Hbl^*_{45-48}$; $Act\text{-}Hbl_{39}+ Chl_{40}+Pl^{3}+Ep+Cal$; $Act\text{-}Hbl_{43}+Chl_{33-34}+Ab+Cal_{100}+Ep$.Most of the mineral associations correspond to the biotite subfacies of the greenschist facies of regional metamorphism, and the smaller part corresponds to the high-temperature chlorite-sericite and low-temperature garnet subfacies of the same facies. In the sheet, superposed contact metamorphism caused under the influence of the Late Variscan granites is also established [13].

The lowermost Upper Gorastskali overthrust sheet, for its very peculiar structure, is considered as a tectonic melange [3]. The greatest part of this sheet is represented by fragments of all other overthrust sheets.

For investigations of basic rocks of overthrust sheets of the massif the appropriate methodologies were applied: microscopic study of thin sections and petro- and geochemical analyses of the samples. Analytical investigations of 37 samples were conducted in the Complex Laboratory of the Institute of Geology. Content of petrogenic elements and RE in the rocks were analyzed by XRF Spectrometer “SPECTROSCOUT Geo”.

The Content of petrogenic elements and RE of 11 key samples from pre-Alpine metabasites of the Moshevani and Sapharlo-Lok-Jandari overthrust sheets of LCM are represented below in the Table.

The obtained data were plotted on different petrogeochemical diagrams and spidergrams. The following diagrams were applied:($Na_2O$+$K_2O$)-$SiO_2$, AFM, $TiO_2$-$K_2O$, $P_2O_5$-Zr and Y-La-Nb (Fig.2).Correlation between the existing and drown versions was performed.

In the ($Na_2O$+$K_2O$)-$SiO_2$ diagram, the figure spots of the Moshevani overthrust sheet form independent fields, and of the Sapharlo- Lok-Jandari sheet are scattered chaotically.

**Table. Content of petrogenic elements and RE of metabasites from Sapharlo – Lok-Jandari and Moshevani overthrust sheets**

| | I | | | II | | | | III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| № | 4-17 | 5-17 | 134-6 | 13-17 | 14-17 | 19-17 | 15-10 | 19-10 | 20-10 | 130-98 | 64-98 |
| $SiO_2$ | 44.57 | 44.32 | 45.03 | 44.5 | 45.14 | 44.07 | 45.9 | 42.17 | 42.2 | 43.12 | 42.95 |
| $TiO_2$ | 2.648 | 2.22 | 2.51 | 2.108 | 1.298 | 2.451 | 2.178 | 2.661 | 1.909 | 1.781 | 2.32 |
| $Al_2O_3$ | 13.3 | 13.53 | 13.34 | 12.91 | 12.33 | 13.1 | 15.81 | 12.81 | 7.413 | 12.02 | 12.68 |
| $Fe_2O_3$ | 12.06 | 12.47 | 12.34 | 10.07 | 11.99 | 10.53 | 10.75 | 11.28 | 11.83 | 14.22 | 12.05 |
| MnO | 0.23 | 0.27 | 0.20 | 0.34 | 0.28 | 0.20 | 0.15 | 0.17 | 0.51 | 0.19 | 0.28 |
| MgO | 8.68 | 7.36 | 8.53 | 4.89 | 7.46 | 8.67 | 3.41 | 11.76 | 7.49 | 8.96 | 9.76 |
| CaO | 9.03 | 9.50 | 9.32 | 13.38 | 12.67 | 10.31 | 10.29 | 10.66 | 10.67 | 10.11 | 10.42 |
| $Na_2O$ | 1.15 | 2.06 | 1.38 | 2.25 | 1.29 | 2.56 | 3.63 | 0.75 | 0.81 | 0.73 | 0.72 |
| $K_2O$ | 1.59 | 0.83 | 1.35 | 0.62 | 0.60 | 0.65 | 1.31 | 0.54 | 0.08 | 0.72 | 0.81 |
| $P_2O_5$ | 0.57 | 0.76 | 0.60 | 0.67 | 0.14 | 0.58 | 0.62 | 0.61 | 0.51 | 0.18 | 0.44 |
| $Cr_2O_3$ | 0.04 | 0.01 | 0.02 | 0.02 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 |
| $V_2O_5$ | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.03 | 0.06 | 0.05 |
| $SO_3$ | 0.03 | 0.09 | 0.08 | 0.16 | 0.05 | 0.02 | 0.06 | 0.01 | 0.20 | 0.15 | 0.08 |
| Sr | 263.5 | 314.70 | 189.2 | 465.7 | 351.9 | 541.7 | 549.6 | 390.7 | 299.2 | 229.7 | 345.6 |
| Ba | 484.1 | 293.80 | - | 289.2 | 288.1 | 262.2 | 776.6 | 305.3 | 40.3 | 197.3 | - |
| Ni | 146.6 | 28.31 | 149.6 | 48.1 | 83.5 | 112.9 | 132.6 | 119.1 | 121.6 | 67.2 | 98.76 |
| Cl | 410.5 | 354.40 | - | 435.5 | 438.4 | 475.5 | 453.4 | 362.5 | 363.6 | 306.5 | - |
| Zn | 117.9 | 125.40 | 150.5 | 163.8 | 176.1 | 126.5 | 122.9 | 122.4 | 14580 | 133.3 | 139.8 |
| Zr | 207.2 | 298.40 | 123.5 | 430.4 | 78.9 | 210.1 | 192.7 | 249.4 | 147.6 | 103.5 | 151.6 |
| Ce | 81.8 | 210.30 | - | 106.8 | 33.0 | 62.7 | 69.0 | 74.9 | 41.2 | 46.0 | - |
| Rb | 42.3 | 27.47 | 23.37 | 19.5 | 15.3 | 16.6 | 30.7 | 14.3 | 2.2 | 18.8 | 15.56 |
| Nd | 121.3 | 70.39 | - | 72.4 | 46.2 | 121.5 | 134.5 | 154.0 | 20.1 | 105.6 | - |
| Cu | 27.3 | 131.70 | 39.9 | 75.3 | 28.5 | 36.7 | 58.3 | 8.3 | 1700 | 67.0 | 60.01 |
| Y | 24.4 | 32.16 | - | 80.6 | 23.2 | 25.4 | 32.3 | 28.0 | 15.4 | 35.8 | - |
| Co | 39.9 | 35.01 | 41.8 | 17.9 | 27.7 | 32.7 | 30.1 | 40.0 | 71.1 | 38.0 | 57.54 |
| Pb | 5.3 | 6.45 | 55.0 | 15.0 | 5.8 | 9.8 | 7.7 | 5.2 | 18.8 | 9.0 | 10.34 |
| Ga | 19.4 | 16.96 | - | 19.5 | 17.8 | 14.5 | 17.5 | 17.0 | 40.9 | 16.5 | |
| Nb | 58.8 | 77.32 | - | 23.0 | 3.9 | 60.9 | 76.6 | 64.0 | 39.3 | 2.8 | - |
| La | 37.8 | 9.36 | - | 9.4 | 9.5 | 27.8 | 33.9 | 39.2 | 43.5 | 9.7 | - |
| Cs | 6.8 | 6.51 | - | 6.5 | 6.7 | 6.4 | 6.8 | 6.7 | 12.7 | 6.8 | - |
| As | 6.7 | 5.93 | - | 10.8 | 15.2 | 34.2 | 35.3 | 10.7 | 55.3 | 10.0 | - |
| Th | 6.4 | 8.01 | - | 3.5 | 2.2 | 6.8 | 8.7 | 8.4 | 2.0 | 2.4 | - |
| Ta | 3.6 | 3.64 | - | 3.6 | 3.5 | 3.5 | 3.5 | 3.6 | 4.5 | 3.6 | - |
| Hf | 8.5 | 9.68 | - | 10.6 | 4.0 | 5.4 | 7.1 | 7.7 | 17.4 | 8.5 | - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hg | 7.1 | 2.51 | - | 2.5 | 5.0 | 6.1 | 4.6 | 2.4 | 3.0 | 2.5 | - |
| Bi | 1.0 | 0.96 | - | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.0 | - |
| Sn | 2.1 | 7.37 | - | 2.2 | 2.2 | 2.0 | 2.1 | 2.1 | 2.2 | 2.1 | - |
| Sb | 2.0 | 2.16 | - | 2.1 | 2.1 | 1.9 | 2.0 | 2.0 | 2.3 | 2.1 | - |
| W | 2.0 | 4.44 | - | 7.4 | 2.1 | 1.9 | 2.2 | 1.9 | 104.1 | 5.5 | - |
| U | 2.1 | 2.94 | - | 1.1 | 0.8 | 1.1 | 0.9 | 2.1 | 0.9 | 0.8 | - |
| Tl | 0.8 | 0.83 | - | 0.8 | 0.8 | 1.1 | 1.1 | 0.8 | 0.8 | 1.0 | - |
| Mo | 0.8 | 0.79 | - | 0.8 | 1.6 | 0.7 | 0.7 | 0.8 | 3.3 | 1.1 | - |
| Se | 0.6 | 0.58 | - | 0.3 | 0.6 | 0.6 | 0.7 | 0.6 | 0.7 | 0.6 | - |
| Br | 0.4 | 0.34 | - | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 1.2 | 0.4 | - |

I –Sapharlo part of the Sapharlo-Lok-Jandari overthrust sheet, II – Lok-Jandari part of the of sheet, III – Moshevani overthrust sheet;

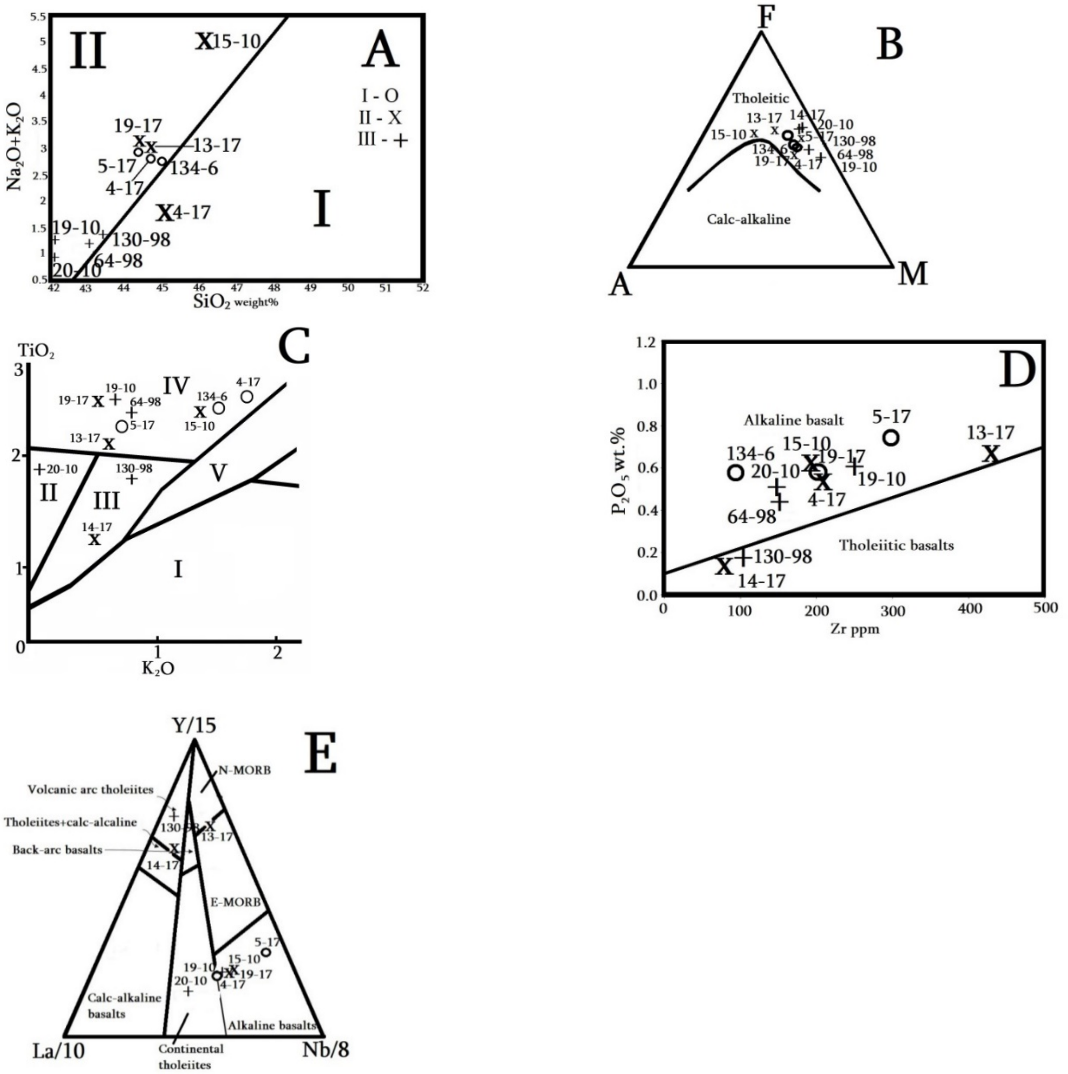


**Fig.2**. Discrimination diagrams for pre-Alpine basites of the LCM. Overthrust sheets: I – Sapharlo part of the Sapharlo-Lok-Jandari overthrust sheet, II – Lok-Jandari part of the sheet, III – Moshevani overthrust sheet;

A –fields of basites of normal (I) and increased alkalinity (II)[16]);

B - fields of basites of tholeiitic (I) and calc-alkaline (II) series; C – fields of rocks: I – island arc basalts, II – normal tholeiitic basalts of mid-oceanic ridges, III – enriched basalts of mid-oceanic ridges. IV – intraplate basalts, V – basalts from the zones of activation of platforms [17].

D – alkaline and tholeiitic basalts fields [18].

E – the La/10-Y/15-Nb/8 diagram: a tool for the discrimination of volcanic series and the demonstration of mixing processes and/or crustal contamination[19].

The analyzed rocks of these overthrust sheets are disposed in the field of basites of increased alkalinity. In the AFM diagram, the composition of the rocks of all the sheets corresponds to the basites of tholeiitic series while on the $TiO_2$-$K_2O$ diagram the great majority of the spots are disposed in the field of the basites of the platform activation zone. In the $P_2O_5$-Zr diagram, figurative spots, with a few exceptions, are located in the field of alkaline basites. On the discrimination diagram Y-La-Nb, most spots are disposed in the field of alkaline basalts and continental tholeiites and occasionally in the field of calc-alkaline tholeiites, volcanic tholeiites and E-MORB.

Thus, the metabasites of the Sapharlo- Lok-Jandari and Moshevani overthrust sheets by composition correspond to the basites of increased alkaline, normal alkaline, alkaline and tholeiitic series. Figure spots are disposed in the field of intraplate and island-arc intraplate basalts and extremely rarely in the field of enriched basalts of mid-oceanic ridges.

As noted above, the Lower Gorastskali overthrust sheet is represented only by a part of the ophiolitic complex – the upper non-cumulative part of the gabbro and the parallel diabase dikes. Consequently, according to the geological position and the petrological and geochemical characteristics, the metabasites of the Lower Gorastskali sheet differ sharply from the metabasites of the Sapharlo-Lok-Jandari and Moshevani overthrust sheets.

**Conclusions.** According to perto-geochemical study of metabasites of the overthrust sheets of the LCM the following conclusions are drawn:

The metabasites play a subordinate role in the Sapharlo-Lok-Jandari and Moshovani overthrust sheets of the LCM, whereas the Lower Gorastskali sheet is composed only of weekly metamorphosed basites.

The metabasites of the Sapharlo-Lok-Jandari and Moshovani overthrust sheets, according to petro-geochemical characteristics, correspond to the basites of the normal alkaline, alkaline and tholeiitic series.

The figure spots of the basites are disposed in the field of intraplate and island-arc basalts and extremely rarely in the field of enriched basalts of the mid-ocean ridges (E-MORB).

According to the petrogeochemical features, the basites of the Lower Gorastskali sheet differ from the metabasites of other overthrust sheets of the LCM. This sheet is composed of metabasites of the ophiolite complex (non-cumulative gabbro and diabase dikes).

Basites of the ophiolite complex in the form of individual scales are also found in the melange and extremely rarely in the Sapharlo-Lok-Jandari overthrust sheet.

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*გეოლოგია*

# ლოქის კრისტალური მასივის (კავკასია) ალპურამდელი მეტაბაზიტების პეტროლოგია, გეოქიმია და ჩამოყალიბების პირობები

ე. გამყრელიძე*, დ. შენგელია*, გ. ჭიჭინაძე**, თ. წუწუნავა**, გ. ბერიძე**, თ. წამალაშვილი**, ქ. თედლიაშვილი**, ი. ჯავახიშვილი**

**აკადემიის წევრი, ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ალექსანდრე ჯანელიძის სახ. გეოლოგიის ინსტიტუტი, თბილისი, საქართველო*
***ივანე ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ალექსანდრე ჯანელიძის სახ. გეოლოგიის ინსტიტუტი, თბილისი, საქართველო*

ალპურამდელი ლოქის კრისტალური მასივი შიშვლდება ბეიბურთ-სევანის ტერეინის ჩრდილოეთ ნაწილში და შედგება ზედადევონური ავტოქთონური კვარციანი დიორიტებისგან და ალოქთონური გვიანპალეოზოურამდელი ზედაგორასწყლის (მელანჟის), ქვედა-გორასწყლის (ოფიოლიტების), მოშევანისა და საფარლო–ლოქ-ჯანდარის მეტასედიმენტებისა და მეტაბაზიტებისგან, რომელთაც, ოფიოლიტური ფირფიტის გამოკლებით, განიცადეს მეტამორფიზმი კალედონური ოროგენეზისის, ხოლო შარირება - ბრეტონული ოროგენეზისის დროს. გარდა ამისა, ლოქის მასივში განვითარებულია ყველა ჩამოთვლილი ქანების გამკვეთი გვიანვარისკული გრანიტები, რომელთაც ლაკოლითის მსგავსი სხეულის ფორმა აქვს. ამჟამად მეტამორფულ ფიქლებსა და გვიანვარისკულ გრანიტებს შორის არსებული უმეტესად ტექტონიკური კონტაქტი მიუთითებს შარირების განახლებაზე, როგორც ჩანს, ადრე-კიმერიული (ინდოსინიური) დანაოჭების დროს. ჩვენი შესწავლის ობიექტს წარმოადგენდა ლოქის მასივის ალოქთონური კომპლექსის ალპურამდელი მეტაბაზიტები. ისინი დამორჩილებული რაოდენობით სხვადასხვა სიმძლავრის თანხმური სხეულების სახით გვხვდება ზემოთ დასახელებულ ფირფიტებში, გარდა ქვედაგორასწყლის (ოფიოლიტების) ფირფიტისა, რომელიც შედგება მხოლოდ ბაზიტებისგან. ქვედაგორასწყლის ფირფიტა პეტრომინერალოგიური და პეტროქიმიური თვალსაზრისით ჩვენ მიერ დეტალურად იყო შესწავლილი, რასაც არ შეესაბამებოდა დანარჩენი ფირფიტების შესწავლილობის დონე. სტატიაში წარმოდგენილია მოშევანის და საფარლო–ლოქ-ჯანდარის ალპურისწინა მეტაბაზიტების პეტრომინერალოგიური და გეოქიმიური კვლევის შედეგები და განსაზღვრულია მათი გენეზისი. პეტროგეოქიმიური დიაგრამების (**$Na_2O+K_2O/SiO_2$, AFM, $TiO_2/K_2O$, $P_2O_5/Zr$** და **Y-La-Nb**) მონაცემებით დადგენილია, რომ ალოქთონური მეტამორფული ფიქლების მეტაბაზიტები თავსდება ნორმალურ-ტუტე, ტუტე და ტოლეიტური სერიის ბაზიტების ველებში და ძირითადად შეესაბამება ფილებსშიდა ან კუნძულთარკალურ ბაზალტებს, ხოლო იშვიათად - შუაოკეანური ქედების ბაზალტებს. ქვედაგორასწყლის ოფიოლიტური ფირფიტის ბაზიტები გეოლოგიური და პეტროგეოქიმიური მონაცემების მიხედვით, მკვეთრად განსხვავდება სხვა ფირფიტების მეტაბაზიტებისგან და შედგება მხოლოდ ოფიოლიტური კომპლექსის სუსტად მეტამორფიზებული ბაზიტებისგან: არაკუმულატური გაბროსა და პარალელური დაიკებისაგან, რომლებიც ცალკეული ქერცლების სახით გვხდება აგრეთვე ზედა გორასწყლისა და საფარლო–ლოქჯანდარის ალოქთონურ ფირფიტებში.

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