Artículo de investigación

Polinsky support structure on the eastern slope of the prepolar urals (Russia)

Estructura de apoyo polinsky en la pendiente oriental de los urales prepolares (Rusia)

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Abstract

Based on the results of geological mapping, petrographic and analytical studies, a detailed study of the Polinsky site on the Eastern slope of the Prepolar Urals was carried out: 10 main structural and real complexes were identified, their complex characteristics was presented.

Keywords: Prepolar Urals, paleo island arc area, geological mapping, gabbro, granodiorite, plagiogranite, dolerite, petrochemistry, geochemistry.

Resumen

Con base en los resultados del mapeo geológico, estudios petrográficos y analíticos, se realizó un estudio detallado del campo de Polinsky en la vertiente oriental de los Urales Prepolares: se identificaron 10 complejos principales tanto estructurales como reales, se presentaron sus características complejas.

Palabras clave: Urales prepolares, área del arco de la isla paleo, mapeo geológico, gabro, granodiorita, plagiogranita, dolerita, petroquímica, geoquímica.

Resumo

Com base nos resultados do mapeamento geológico, estudos petrográficos e analíticos, foi realizado um estudo detalhado do sítio de Polinsky na vertente leste do Ural Prepolar: foram identificados 10 complexos estruturais e reais principais, e suas características complexas foram apresentadas.

Palavras-chave: Pré-molares dos Urais, área de arco de ilha paleo, mapeamento geológico, gabro, granodiorito, plagiogranito, dolerito, petroquímica, geoquímica

Introduction

The survey target is situated on the eastern slope of the Prepolar Urals (Khanty-Mansiysk Autonomous Okrug, Berezovskiy district) within the northern part of the Tagil paleo island arc. Map area is bounded (Fig. 1) by the Main Uralian Fault (MUF) from north-west, the road Saranpaul–Neroyka (area of 34,5-23,5 km), West Siberian Plain from south-east, rivers Bol'shaya Polya and Polya from south-west. Most (north-western) part of the territory is a fragment of a large heterogeneous Shchekurinsky massif, which is a northern representative in the chain of mafite-ultramafite intrusions of the Platiniferous Belt of the Urals. The south-eastern part of the area is composed of basalts and dolerites of the complex of parallel dykes.

METHODS OF WORK

The area is covered by a network of map routes, distance between which is on average 150-200 m, 58.3 lin. km were got over and 614 observation points were described, including 137 indigenous ways out. The observation points are located at route lines 100 m apart, information obtained in the observations between the points was recorded. The binding points are made in three ways – visual, half-instrumental and instrumental. Geological map was compiled based on observations (Fig. 1). Field documentation and float sampling have been performed.

Analytical studies included sample preparation, petrographic study of thin sections, determination of petro- and geochemical features of rocks by methods of x-ray spectrometry and ICP-MS analyses.

X-ray fluorescence (instrument SRM-18, analysts N.P. Gorbunova and L.A. Tatarinova) and ICP-MS (instrument ELAN-9000, analysts N.N. Adamovich, D.V. Kiseleva) tests were performed in the Laboratory of physical and chemical methods of research of mineral matter, Institute of Geology and Geochemistry, UB RAS (Ekaterinburg).

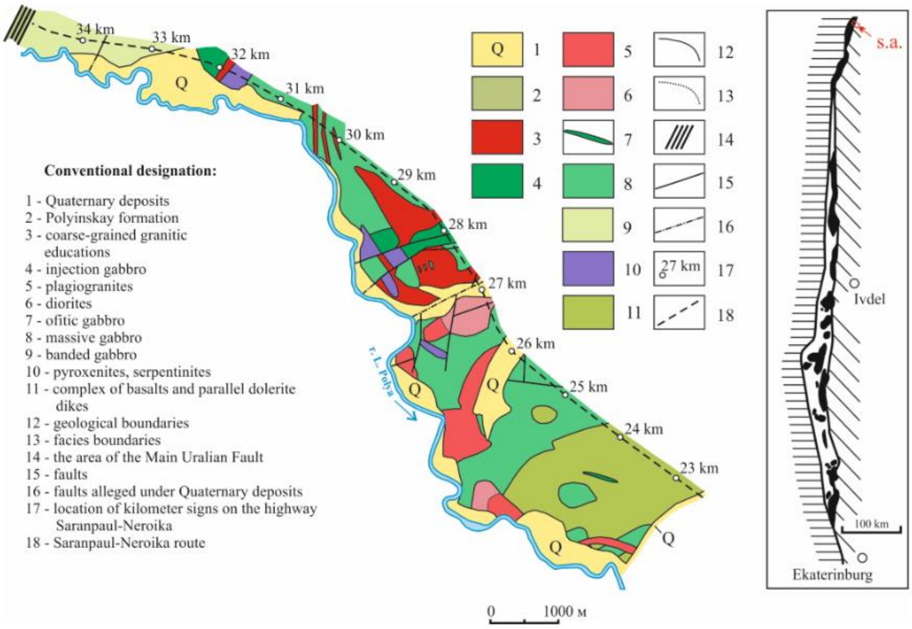

Fig. (1). – Position of the study area (s.a.) in the structure of the Platinum Belt of the Urals and geological map of the territory

GEOLOGICAL STRUCTURE OF THE TERRITORY

The results of the mapping allow speaking about more complex structure of the territory than it was thought previously (Bochkarev, 1990): 10 main structural-material complexes were marked (Fig. 1). The following sequence of their formation is based on geological observations.

1. The most ancient rocks of the study area are interstratified metavolcanics of the MUF, among which conventional bodies of ultrabasites of Salatimsky complex are distinguished.
2. The earliest bodies of the rest of the territory are the rock of ultrabasic composition (pyroxenites and serpentinites) that make up the three bodies in the north-western part of the area. They predominantly have tectonic constraints (the tectonic contacts have been observed in the original bed in the north-west body). The enclosing rocks are represented by massive and banded hornblende gabbro and coarse-graded granite like bodies. Xenoliths of pyroxenites are commonly observed in hornblende and banded gabbro.
Body composition of the rocks changes from kosvite (in the south-western part) to wehrlite (in the north-eastern part) within the north-western body.

Kosvite has panidiomorphic grained structure. It is complexed with rounded grains of diopside up to 5 mm. Pyroxene is intensely replaced by chlorite and tremolite. There is a significant amount of fine pulverized ore mineral (up to 4%) in the rocks, which is confined to the areas of the development of tremolite and chlorite.
Wehrlites are characterized by panidiomorphic grained structure. They are composed of olivine (40%) and augite (60%). Olivine forms rounded, highly fractured grains up to 5 mm. Augite is larger than 5 mm, has rounded and short-prismatic grains; the mineral is weakly pleochroic from colorless to pale green, irregularly replaced by flaky chlorite. There is serpentine in the intergranular space.

Ultramafites of the south-eastern body are located in the fault zone and have completely lost their primary form. They are coal-black *serpentinites*, complicated by multiple gliding. They are 90% serpentine: loopy rounded shapes due to the replacement of olivine grains and fiber – when replacement of pyroxene. Apparently, the composition of the original rock meets wehrlite. Ore mineral composes considerable volume of rock, forms small dust-like scattered granules; its appearance is caused by serpentinization.

3. Common in the south-western part of the area dolerites compose the complex of parallel dykes. Intrusive contact with massive hornblende gabbro and coarse-grained granite-like bodies was documented in incut of the road Saranpaul–Neroyka between 24 and 25 km. In addition, large xenolith of dolerite in massive hornblende gabbro has been mapped, and also observed the contact of the dikes of the complex with the fall in the north-west at angle 70°. Screens of black basalts are often presented among the dolerites, the number and size of which increase in south-eastern direction. Geological structure formed by the dolerites and basalts reflect their origin in terms of extension of the Earth crust. Schekurya volcanogenic cutting, located to south, was composed through effusive rocks of the Tagil zone with typical island arc petro- and geochemical characteristics (Kudrin, 2011; Kudrin, 2014); the nature of the relationship of which has not been established.

Two rock types – pyroxene dolerite and pyroxene-plagioclase basalts comprise the complex. The first ones form dyke bodies of different capacities, the second – present as xenoliths (screens); processes of low-temperature metamorphism and albitization overlaid the rocks.

Pyroxene dolerites (Fig. 2, 3) are of rarely- and small pseudoporphyritic (1,5-4 mm) with dolerite and ophitic microstructures of the main mass. In the porphyritic secretions there is plagioclase, rarely – pyroxene. Pyroxene (30-50%) in the dolerites of the north-western part of the square is augite, in the dolerite of the south-eastern part – diopside. Hypidiomorphic short-prismatic augite is pleochroic, it changes its color from pale green to pale yellow and colorless, the size does not exceed 0.7 mm. Diopside is colorless, it forms hypidiomorphic short-prismatic grains up to 0.3 mm. Prismatic idiomorphic, long-prismatic crystals up to needle plagioclase (40-55%), has usually barely pronounced zonal structure, grain size up to 0.5-0.7 mm. Ore mineral (10-15%) is abundant, evenly distributed.

Albitized dolerites are the product of intensive transformations (the primary outlook of the rocks is sometimes set by the presence of relicts of poorly zoned plagioclase among albite epidote mass). They consist of albite, epidote and ore mineral. Albite (65%) forms thin lathlike radial-rayed isolations, which penetrate the relicts of primary plagioclase; the size of radial–rayed aggregates is up to 0.8 mm. Epidote (30%) forms thin lathlike isolations among needles of albite; large fine-grained aggregates are up to 2 mm, unevenly distributed in the rock; thin runs. Ore mineral (5%) forms both the pulverous grains and large grain of square section.

Basalts (Fig. 2, 2) have a porphyritic structure (in porphyritic secretions of grains of plagioclase and/or pyroxene), the bulk is intersertal with microlites lathlike plagioclase, often with the same orientation of the grains.

Albitized basalts (Fig. 2, 1) represent the felt of interwoven lathlike grains of albite (50%), which are located between the small (0.3 mm or less) grains of actinolite (20%). The grains of albite are often split (like the horsetail), of different orientation, the length of the needles is up to 1 mm (on average 0,3-0,4 mm), xenomorph. Ore mineral (10%) is pulverous, evenly distributed in the rock. It is noted that the development of an even pale green, slightly pleochroic fibrous chlorite (20%).

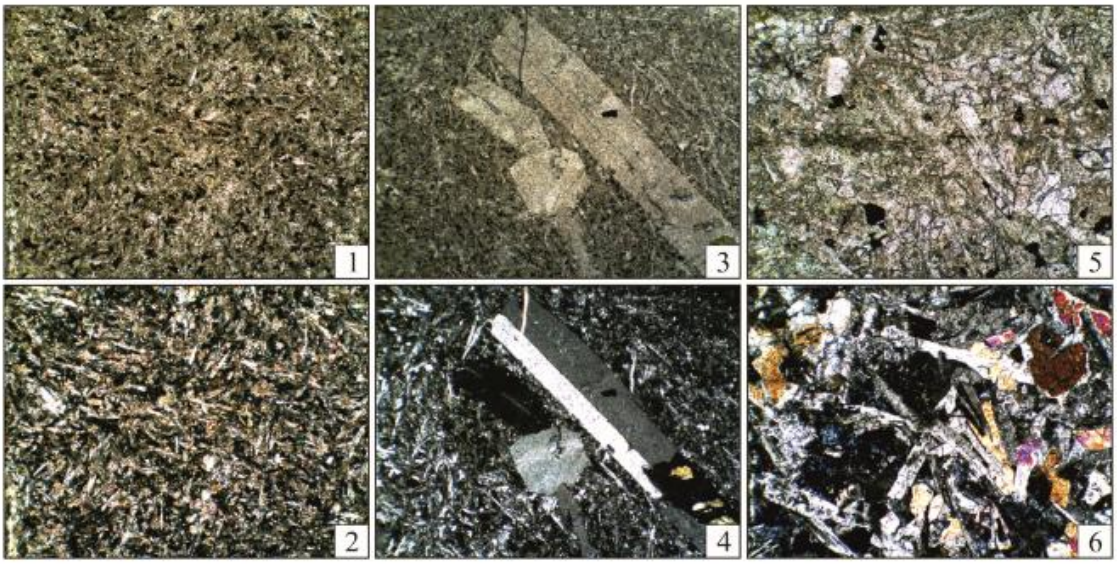

Fig. (2). – Petrographic characteristics of rocks of Manya and Polya cuttings.
Top row: shooting without analyzer; lower – with analyzer
1 – thin section K-88: albitized basalts of screenshots; 2 – thin section K-81/2: porphyritic basalts of screenshots; 3 – thin section K-83: dolerite of dyke complex

4. *Banded gabbro* are common in the interval of 32.8-33.4 km of the Saranpaul–Neroika highway, the appearance of which is largely determined by the effect of low-medium-temperature metamorphic processes (Kudrin et al, 2015). We matched them from the second phase of formation of the Tagil-Kytlymsky complex.

The rocks have prismatic grained structure with elements of gabbro. They are composed by hornblende (up to 70%) and plagioclase (up to 30%). Hornblende has hypidiomorphic prismatic and short-prismatic contour, with no crystallographic restrictions. The grain size is 1.5 mm. Pleochroism is from dark bottle-green and bluish-green to pale green with a yellowish contrast. Grains are elongated in one direction, forming banded texture. Plagioclase forms small (0.7 mm) rounded grains completely replaced by saussurite. Rocks are enriched with small grains of apatite.

5. Massive *pyroxene, pyroxene-hornblende and hornblende gabbro* are widespread throughout the area, have gradual transitions between each other, and visually indistinguishable, their xenoliths are occurred in plagiogranites, diorites and the coarse-grained granite-like bodies of the area. The rocks are characterized by change in composition from melanocratic to leucocratic differences in the prevalence of mesocratic. We compare the rocks with the I-st phase of formation of the Severorudnichny complex (Kudrin, 2011; Kudrin, 2014).

The distribution of all rock types is clearly reflected in the magnetic field – areas of positive magnetic field over intrusive bodies of gabbro correspond to hornblende differences, of negative magnetic field – pyroxene differences.

All gabbro medium-grained are with a predominance of ophitic structures (ophitic, subophitic, poikilophitic, gabbro-ophitic) over gabbro. There are pyroxene, hornblende and plagioclase in the composition. The pyroxene content is 30-60%, the mineral is from rounded without crystallographic contours and from xenomorphic to hypidiomorphic short-prismatic and idiomorphic, colorless. It corresponds to diopside, the size of grains is 1.5-4 mm, it is replaced by pale green fibrous amphibole, brown horn blende, brown biotite, fibrous chlorite with varying degrees of intensity. Hornblende (35-40%) is of secondary nature as it develops in the pyroxene, completely replacing it and forming pseudomorphs. Rounded grains dominated, hypidiomorphic short- and long-prismatic crystals; grain size up to 1.5 mm can be occasionally occurred. Pleochroism is from bluish green to pale green with yellowish contrast. It is replaced by chlorite and epidote. Plagioclase (20-60%) forms automorphic long-prismatic crystals, prismatic and tabular grains

with a size of 1.5-4 mm, characterized by a simple and polysynthetic twinning, zonal structure is often observed. Ore minerals content is uneven (from isolated grains up to 5%), usually confined to the biotite.
6 and 7. *Hornblende plagiogranodioites and hornblende plagiogranites* are widespread in the central part of the area, occur in contour of single bodies with facies mutual transitions and forming small stocks (Fig. 1). We compare the rocks with the II-d phase of formation of the Severorudnichny complex (Kudrin, 2011; Kudrin, 2014); have a very close petrographic parameters and similar mineralogical composition.

Rocks have subophitic microstructure with elements of granite. There are of plagioclase (65-70%), hornblende (15-20%) and quartz (10-20%) in composition. The grains of plagioclase are automorphic and hypidiomorphic prismatic, and tabular, have poorly marked zonal structure: the central zones are completely replaced by saussurite and pale-green chlorite; grain size is less than 1.5 mm. Hornblende is hypidiomorphic, rarely idiomorphic. It has pleochroism from bluish green to pale yellowish green. It to a lesser degree is replaced by fine-grained aggregate of epidote and chlorite. The grain size does not exceed 1.5 mm. The distribution of quartz is extremely uneven, the size of grains is up to 2 mm, usually with cloud and mosaic extinction, it is possible that part of the quartz is of secondary nature.

8. Dykes of pseudoporphyritic hornblende and ophitic pyroxene gabbro are distributed mainly in south-eastern and central part of the area, set among the hornblende gabbro and in the field of dolerites development, have a capacity of up to 10 m and the north-western stretch, falling close to the vertical. Ophitic pyroxene gabbro is visually very similar to the young dykes of the Northern Ural, is highlighted in the Ivdelsky complex of the late Devonian-early Carboniferous age.

9 and 10. The injection of gabbro and coarse-grained granite-like bodies were occurred in the north-western part of the area. Metasomatic nature of the injection of gabbro (a kind of «alternation» of melanocratic, leucocratic and other gabbro in combination with a dike- and vein-like forms of granitic composition, there are giant grained differences, hornblendite etc.) has no doubt. Bodies of coarse-grained «granites» we also consider as the result of intensive metasomatic activities. The following information tells in favor of it:
- «granites» are spatially related to the bodies of injection gabbro;
- they often form a narrow (first tens of meters) of a linear bodies that is not coherent with coarse and giant-grained rock structure;
- the placement of the bodies is often controlled by zones of fractures (as well as the injection of gabbro);
- large euhedral grains of quartz in the «granites» are more like porphyroblastic allocations, rather than pseudoporphyritic structure.

PETRO- AND GEOCHEMICAL CHARACTERISTIC OF ROCKS

Results of studies of igneous rocks of Sertynya and Schekurya sites were involved for geochemical typification of the species (Kudrin, 2011; Kudrin, 2014).

Ultrabasic rocks of MUF are characterized by low contents of trace elements – below the threshold of sensitivity of the used analytical method (ICP-MS) (with the exception of chromium and nickel). We matched them with Salatimsky complex.

All remained hyperbasites are characterized by a composition corresponding island-arc complexes sharply differ in content of rare earth elements (REE): the samples selected from area of distribution of banded gabbro are markedly enriched in REE with the predominance of light over heavy and comparable to the gabbroids of Tagil-Kytlymsky complex (Shmelev, 2005; Kudrin, 2014), others are identical to the composition of ophiolites of gabbro complex of Khorasursky block (Shmelev, 2005). The composition of samples of ultrabasites selected from the area of the massive gabbro is comparable with the geochemical features of the dolerites back-arc complex (Kudrin, 2014).

As already noted, three types of gabbro are common in the studied area, varying in textural characteristics, while having a very similar mineralogical composition: banded, massive and injection gabbro. The last are the result of intensive metasomatic development, which microcomponent composition has not been studied. Banded gabbro has also experienced a considerable influence of metamorphic processes (Kudrin et al, 2015). Massive gabbro are the freshest magmatic rocks of the basic composition of the studied area. Features of the microelement composition of banded gabbro (Fig. 3, top) clearly show that there are two varieties among them. One responds to the peculiarities of microelement composition of Tagil-Kytlymsky complex (Shmelev, 2005; Kudrin, 2014). Gabbroids of the second type were previously not known within Schekurya site of the eastern slope of the Prepolar Urals. The distribution of trace elements (especially REE) indicates full correspondence with the previously described ultrabasites and ophiolites of gabbro complex of Khorasursky block (Shmelev, 2005).

All studied samples of massive gabbro are similar by the peculiarities of microelement composition of (Fig. 3, bottom) and responds gabbroids of the I-st phase of formation of the Severorudnichny complex (Shmelev, 2005; Kudrin, 2014).

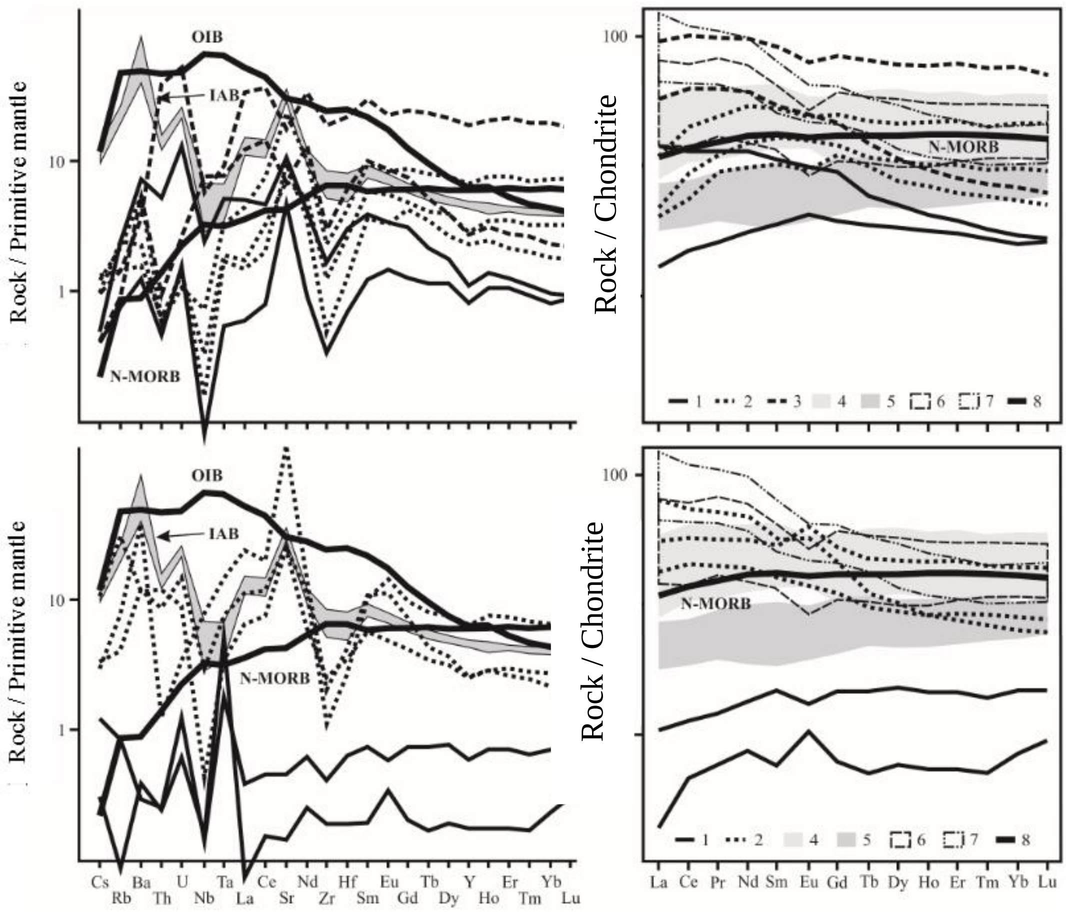

Fig. (3). – Geochemical typification of gabbroids and ultrabasites Polyiansky site
(regulation on the composition of primitive mantle (McDonough & Sun, 1995) and chondrite (Evensen et al, 1978))
Top: 1 – ultrabasites of the habitat of striped gabbro; 2-3 – banded gabbro
Below: 1 – hyperbasites from the area of massive gabbro; 2 – massive gabbro
4-7 – compositions fields of magmatic rocks from (Kudrin, 2014); 8 – reference compositions of basalts of different geodynamic settings

Dolerites and basalts are petrochemically completely identical: these are tholeiites with high content of TiO_2 (1,02-1,52%), which correspond to the compositions of basalts, trachybasalt, and andesibasalts trachyandesites (Fig.4), while having a sodium type of alkalinity (K_2O 0,03-0,45%).
Microelement composition of rocks of Manya and Polya cuttings detects the characteristics of the compositions of N-MORB basalts both by the nature of the normalized contents of REE and by spider diagram (Fig. 5).

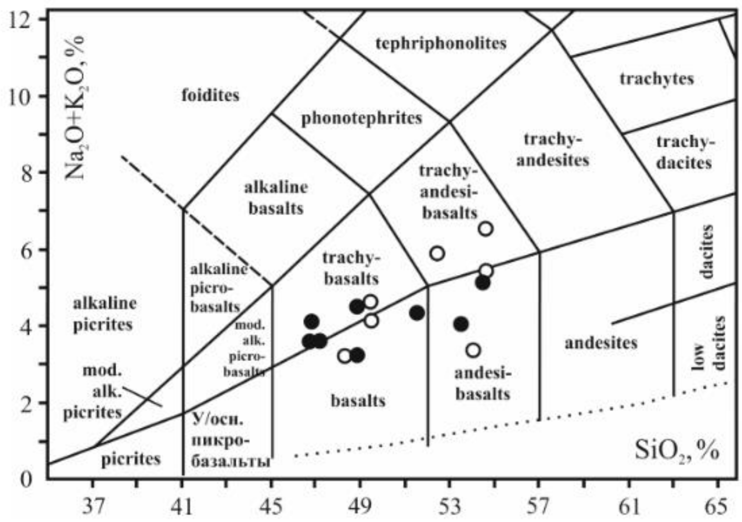

Fig. (4). – Petrochemical characteristic of rocks of the parallel dikes complex.
TAS classification diagram (Zhdanov et al, 2009)
1 – our data; 2 – by (Bochkarev, 1990)

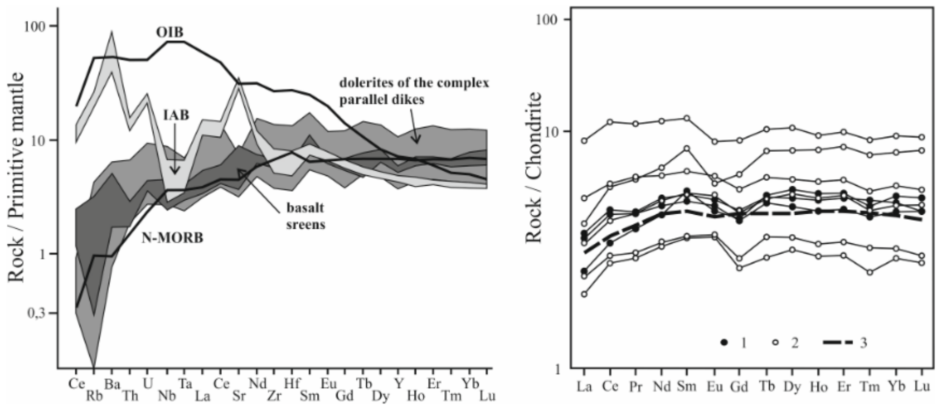

Fig. (5). – Geochemical typification of rocks of the parallel dikes complex
(normalization to the composition of primitive mantle McDonough & Sun, 1995) and chondrite (Evensen et al, 1978))
1 – basalts of screenshots; 2 – dolerites of parallel dikes complex; 3 –N-MORB-type basalts
OIB – ocean islands basalts; IAB – island-arc basalts; N-MORB – mid-ocean ridges basalts, N-type

The Mariinsky complex of parallel dolerite dykes of Tagil-Magnitogorsky zone of the Middle Urals, described in several publications (Ivanov & Berzin, 2013; Ivanov et al, 2012; Ivanov et al , 2012; Petrov, 2007; Smirnov & Ivanov, 2010).
which has back-arc-spreading nature, is the closest to the dolerite of Polya site by the petro- and geochemical characteristics and structural-geological position.

DEDUCTIONS

Thus, the study of geochemical features of magmatic rocks of Polya site allowed:
- to confirm and to detail the amount of previously allocated structural-material units of the Schekurya block;
- to justify presence of the ultrabasic rocks, which are part of the ophiolite back-arc complex in the structure of Polya section of the ultrabasic rocks, which are part of the ophiolite complex back-arc;
- to find rocks of ultrabasic and basic composition in the structure of Schekurya block, which we compare with ophiolites of gabbro complex of Khorasursky block, which in turn are likely to be formational analogue

to the West of the Mariinsky complex, formation of which is associated with the magmatism of forearc basin (Volchenko et al, 2007).

CONCLUSION

First of all, it should be noted that the established spatial distribution and relationships of allocated structural-material complexes of the mapping territory follows the model of island-arc stage of development of the Urals and the formation of platinum-bearing rocks of the association, considered in (Volchenko et al, 2007).

We believe the assumption of non-magmatic origin of granite-like formations important for understanding the geological structure of the eastern slope of the Prepolar Urals. Not considering this fact, there is the point of view of the existence of numerous granitoids of different geodynamic and geochemical types – low-strontium, collision, ophiolite, high-strontium, etc. (Shmelev, 2005).

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