Artículo de investigación

A new prospective raw material in Khanty-Mansiysk autonomous area – Yugra (Russia): raw material for production of continuous basalt fiber

Una nueva materia prima prospectiva en el área autónoma de Khanty-Mansiysk - Yugra (Rusia): materia prima para la fabricación de fibra basalte continuada

Uma nova prospectiva de matéria-prima na zona autônoma de Khanty-Mansiysk - Yugra (Rússia): matéria-prima para a fabricação da fibra basalte continuada

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Abstract

According to the results of research works, distribution of rocks of bands of basic composition was found in the Polya - Manya interfluve on the eastern slope of the Prepolar Urals (Khanty-Mansiysk Autonomous Area, Berezovskiy district, in the north-west of the v. Saranpaul) within northern part of the Tagil paleo island arc (Polya and Manya areas) was defined as the most promising for carrying out search works for raw materials for the production of continuous basalt fiber. The use of limestone located near Yatrinsk deposit as a corrective additive significantly improves the quality of raw materials.

Keywords: the Prepolar Urals, ophiolite of backarc basin, a dyke-in-dyke structure, dolerite, raw materials for the production of continuous basalt fiber.

Resumen

De acuerdo con los resultados de los trabajos de investigación, se encontró distribución de bandas de rocas de composición básica en el interfluvio Polya - Manya en la vertiente oriental de los Urales Prepolares (Área Autónoma de Khanty-Mansiysk, distrito de Berezovskiy, en el noroeste del v. Saranpaul) dentro de la parte norte del arco paleo isla de Tagil (áreas de Polya y Manya) El sector se definió como el más prometedor para llevar a cabo trabajos de búsqueda de materias primas para la producción de fibra basáltica continua. El uso de piedra caliza cerca del yacimiento de Yatrinsk como aditivo correctivo mejora significativamente la calidad de las materias primas.

Palabras claves: los Urales Prepolares, ofiolita de la cuenca del backarc, una estructura dique en dique, dolerita, materias primas para la producción de fibra de basalto continuo.

Resumo

De acordo com os resultados do trabalho de pesquisa, distribuição de bandas de rochas de composição básica no interfluve Polya - Manya nas encostas orientais do Ural Prepolar (Área Autônoma de Khanty - Mansiysk, distrito de Berezovskiy, no noroeste do Estado). Saranpaul) na parte norte do arco Paleo ilha de Tagil (áreas de Polya e Manya) foi definido como o mais promissor para realizar pesquisas de matérias-primas para a produção de fibra contínua basáltica. O uso de calcário próximo ao local de Yatrinsk como aditivo corretivo melhora significativamente a qualidade das matérias-primas.

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Palavras-chave: Ural pré-molares, ofiolito da bacia do backarc, estrutura de diques de dique, dolerito, matérias-primas para a produção de fibra de basalto contínua

Introduction

Stratigraphic unit referred earlier to Turvat suit of Late Silurian (Boch et al, 1948), to the lower- and upper-Turvat suite of Early and Late Silurian, respectively (Mezentsev et al, 1964) and undivided Shemur, Pavda and Imenovskiy suites of Late Ordovic – Late Silurian age range (Kirillin et al, 2013), was defined according to the results of geological-surveying works of different years on the Eastern slope of the Prepolar Urals in the Schekurya - Manya interfluve (Khanty-Mansiysk Autonomous Area, Berezovskiy district, to north-west from v. Saranpaul) within the northern part of the Tagil paleo island arc. For the first time the nature of the unstratified rocks of main composition of Manya and Polya cuttings was demonstrated by V. V. Bochkarev (Bochkarev, 1990): he allocated Manya complex of parallel dykes, among which the structures "dyke in dyke" widespread, and the assumption about the spreading nature of the rocks has been made. We have received the geological and analytical data that helped to clarify ideas about the geological structure of the described area:

1) the formation of a complex of parallel dykes and associated rocks has been confirmed as a result of spreading in terms of backarc basin (Kudrin, 2014);
2) U-Pb SHRIMP-II datings with values 465,2±6.5 million years with the zircon gabbros, intruding dyke complex, allowed to assert Llandoverian Age of complex of parallel dykes (Kudrin et al, 2015);
3) Geological map of scale 1:25000 of Polya area has been compiled (Ermak et al, 2015).

Geological Summary

Area of research covers the area of dissemination of subvolcanic and volcanic formations of the basin of Manya and Polya from their contact with gabbroids of Shchekurinsky massif of Platiniferous Belt of the Eastern slope of the Urals to the development of plate deposits of Western Siberia in the structure of paleo island arc sector of the Prepolar Urals.

For the geological structure of the Eastern slope of the Middle, Northern and Prepolar Urals submeridional zonation was set, it was expressed in a natural shift of structural-material complexes from west (from the Main Uralian Fault – MUF) to east, formed as a result of evolution of paleo island arc: ophiolitic Salatim complex of the MUF → Kachkanar hyperbasitic complex → Tagil-Kytlym gabbroic complex → Severorudnichny gabbro–diorite–plagiogranite complex, in combination with volcanic formations, that it breaks. However, such a pattern is violated in some areas: hyperbasitic bodies are widespread among the island-arc complexes with which powerful dyke of dolerite complexes, combined with the volcanic rocks of basic composition are spatial associated.

These include Manya and Polya cuttings on the eastern slope of the Prepolar Urals (Fig. 1) where a complex of parallel dikes penetrated in coastal outcrops, including such a formation as “dyke-in-dyke” (Bochkarev, 1990). Dyke complex here is presented through quite homogeneous clinopyroxenite dolerite, varying from micro- to medium-grained, depending on the power of their additive components. Among the dykes marked rare screens of black aphyric and small porphyritic basalts. From the west dyke complex is broken with amphibole plagiogranites (incut of the road Saranpaul – Neroyka) and massive gabbros of the northern end of the large Schekurya massif (starboard of Manya near the mouth of the brook Tarygya), which intensely differ by their petrogeochemical characteristics from the banded gabbro of Platiniferous Associations (western part of Shchekurinsky massif), and possibly genetically related to a complex of parallel dykes. Schekurya volcanogenic cutting, located to south, was composed through effusive rocks of the Tagil zone with typical island arc petrogeochemical characteristics (Kudrin, 2014); the nature of the relationship of which has not been established.

Ar-Ar (amphibole) age of the gabbros of the eastern part of Shchekurinsky massif is 465,2±6,5 million years, which almost coincides with U–Pb (SHRIMPII) age of zircons in the diorite of the same massif, 461-471 million years. Thus, the upper age bracket of the dyke complex is Llandoverian Age.

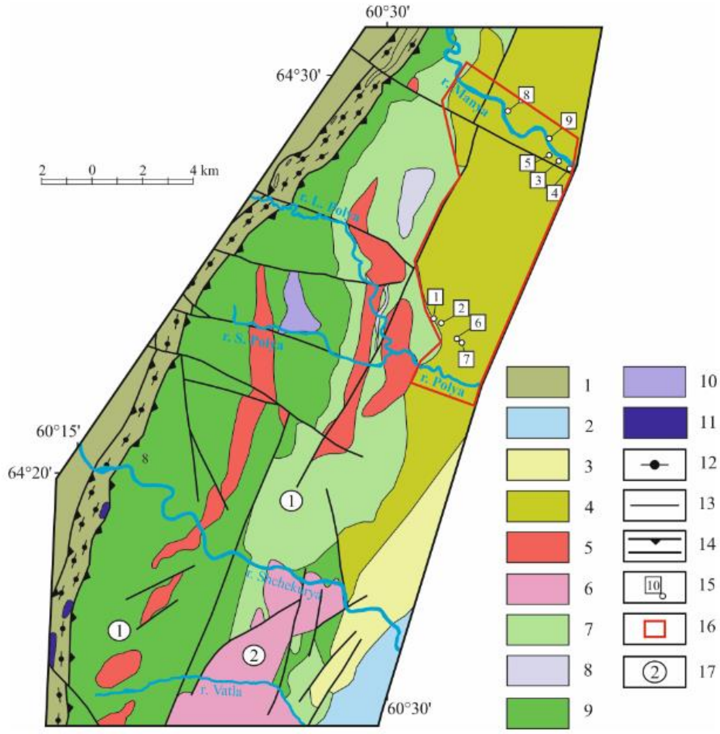

Fig. (1). – Scheme of geological structure of the studied area. It has been compiled using materials by Pavlov M. M. [1990], V.V. Bochkarev (Bochkarev, 1990), N.A. Petenin, [1994], A.V. Chursin [2009]

1 – paleo terrestrial sector of the Urals; 2 – Mesozoic-Cenozoic sediments; 3 – effusions of Soimshorsky layer; 4 – the basalts and dolerites of the complex of parallel dykes; 5 – the plagiogranites of unknown belonging; 6 – diorites of Severorudnichy complex; 7 – gabbroids of Severorudnichny complex; 8 – serpentinites of unknown belonging; 9 – gabbroids of Tagil-Kytlym complex; 10 – hyperbasites of Kachkanar complex; 11 – hyperbasites of Salatim complex; 12 – area of MUF; 13 – geological boundaries; 14 – transverse thrusts and faults; 15 – the sampling points and its numbers; 16 – the studied plot; 17 – massifs: 1 – Shchekurinsky; 2 – Sertyninsk–Shchekurinsky

Petrographic And Petrochemical Characteristics Of The Rocks

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%).

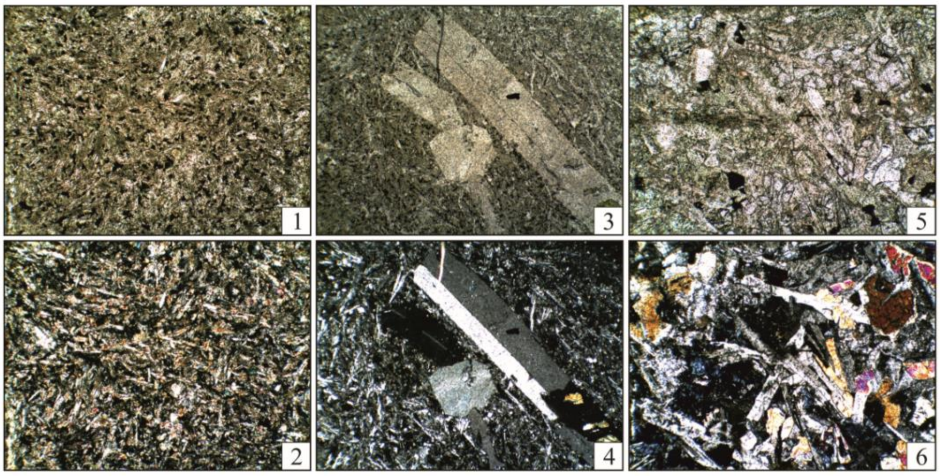

Fig. (2). – Petrographic characteristics of rocks of Manya and Polya cuttings.
Top row: shooting without analyzer; lower – using analyzer
1 – thin section K-88: albitized basalts of screenshots; 2 – thin section K-81/2: porphyritic basalts of screenshots; 3 – thin section K-83: dolerite of dyke complex

Dolerites and basalts are petrochemically (table) completely identical: they are low potassic (K_2O 0,03–0,45%) tholeiites with high content of TiO_2 (1,02-1,52%).

Table. Chemical composition (%) of rocks of Manya and Polya cuttings

Sample	K-38	K-41	K-55	K-60/1	K-61	K-49	K-50	K-81/2	K-88
Number on the map	1	2	3	4	5	6	7	8	9
SiO_2	48,48	46,51	46,86	54,03	51,16	51,13	48,50	53,10	46,47
TiO_2	1,02	1,32	1,52	1,17	1,48	1,23	1,29	1,13	1,35
Al_2O_3	14,03	14,04	12,94	13,31	12,44	12,40	14,53	13,25	12,45
Fe_2O_3	11,59	17,32	19,20	14,44	17,48	16,29	15,53	15,64	18,81
MnO	0,18	0,22	0,24	0,18	0,22	0,29	0,23	0,13	0,39
MgO	8,56	5,96	8,51	5,30	6,34	6,64	6,51	7,18	8,65
CaO	9,46	7,23	3,46	3,62	2,80	5,56	5,44	1,80	4,23
Na_2O	2,90	4,10	3,55	4,72	4,31	4,05	4,10	4,00	3,56
K_2O	0,35	0,03	0,05	0,45	0,04	0,25	0,37	0,03	0,04
P_2O_5	0,13	0,17	0,17	0,17	0,26	0,15	0,20	0,26	0,14

Notes:
1-5 – clinopyroxene dolerites of the complex of parallel dykes; 6-9 – basalts of screenshots

Assessment Of The Suitability Of The Rocks For Basalt Production

It is recommended to use rocks with content of SiO_2 less than 53% for high-tech production (Matveev et al, 2003). Another important criterion of the suitability of basalt rock is acidity index (M_K), which determines the suitability of raw materials for production of mineral fiber:

$$M_k = (SiO_2 + Al_2O_3)/(CaO + MgO),$$

where SiO_2, Al_2O_3, CaO, MgO – the content of the relevant oxides in the raw material or the melt, wt. %. M_K with a value of from 1.7 to 4 is recommended for one-component feed; for the production of continuous fiber – 4,7-6,5 (Matveev et al, 2003).

Volcanogenic formations are petrochemically poorly studied, we have 14 silicate analyses. The calculation of the rocks' acidity index shows that its values vary in a large range (from 3.5 to 7.5) and are in general close to the desired value to the raw materials suitable for production of continuous basalt fiber (Fig. 3).
In comparison with the reference compositions of basalt raw material of the deposits in Ukraine (Berestovetsky) and Georgia (Marneuli) (Matveev et al, 2003) (Fig. 4) rocks of Manya and Polya cuttings match by the content of SiO_2, Al_2O_3, MnO and TiO_2, and high concentrations of Fe_2O_3, MgO, and Na_2O, lower Cao, K_2O and P_2O_5.

One way to improve the quality of basalt raw material for basalt production is additional charging when carbonate rocks (limestone and dolomite) are used as corrective components.

Yatrinskoe deposit of limestone is located in the immediate vicinity of the survey target. Exploration on Yatrinskoe deposit was carried out, during this exploration the chemical composition of rocks was studied: the average values are: $CaCO_3 > 96\%$; $MgCO_3 < 1,3\%$; $SiO_2 + Al_2O_3 + Fe_2O_3 < 1,5\%$ (Nedochetov, 1965). Based on these data, we evaluated the possibility of using Yatrinskoe deposit as a corrective additive for the improvement of the acidity index using the formula:

$$M_k = ((SiO_2 + Al_2O_3) \times x + (SiO_2' + Al_2O_3') \times y)/((CaO + MgO) \times x + (CaO' + MgO') \times x),$$

where SiO_2, Al_2O_3, CaO, MgO – the content of the relevant oxides in the raw materials, wt. %;
SiO_2', Al_2O_3', CaO', MgO' – the content of the relevant oxides in the corrective component, wt. %;
x – the content of the primary component, wt. %;
y – the content of the corrective component, wt. %.

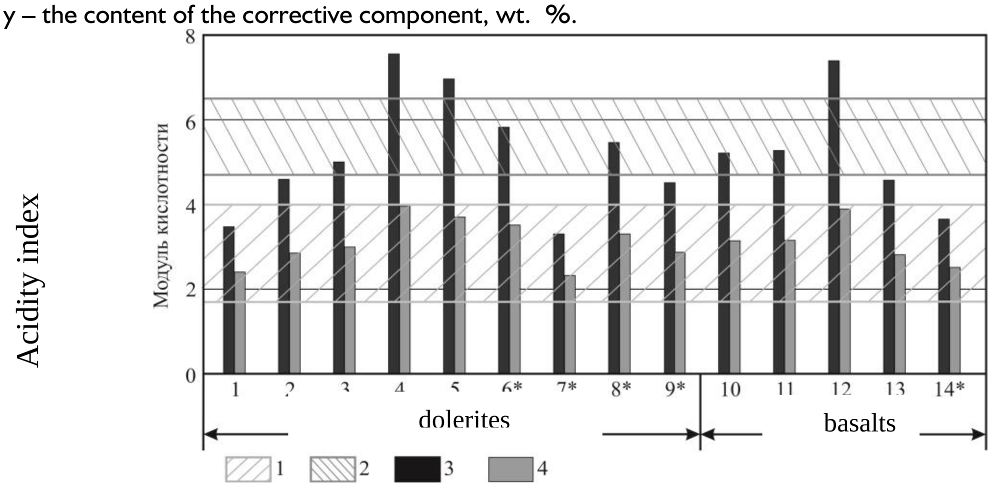

Fig. (3). – The acidity index of the rocks of the dyke complex of Maninsk and Polya cuttings and its change when using corrective additive
(13 wt. % of limestone of Yatrinskoe deposit)

1 – the field of the composition recommended for the production of one-component feed; 2 – the field of the composition recommended for the production of continuous basalt fiber; 3 – acidity index of rocks without corrective additives; 4 – acidity index of rocks subject to corrective additives; * analyses from (Bochkarev, 1990), and the rest - the table

The results of the calculations performed, provided the content of the corrective additives 13 mass. % for the rocks of the complex of parallel dykes, tested in Polya and Maninsk cuttings showed that all the analyzed rock compositions began to satisfy the range of the values of acidity index, required for raw materials for the production of one-component feed.

Deductions

Based on the foregoing, we can conclude that new potential raw material for high-tech production are rocks of the main composition, formed in before Llandoverian Age in terms of back-arc spreading, common in the north-east (submontane) part of the Khanty-Mansiysk Autonomous Area.

Conclusion

Thus, the analysis of available data showed that the rocks of the main composition, common in the vicinity of v. Saranpaul, can be suitable for high-tech production: for the production of one-component feed and continuous basalt fiber.

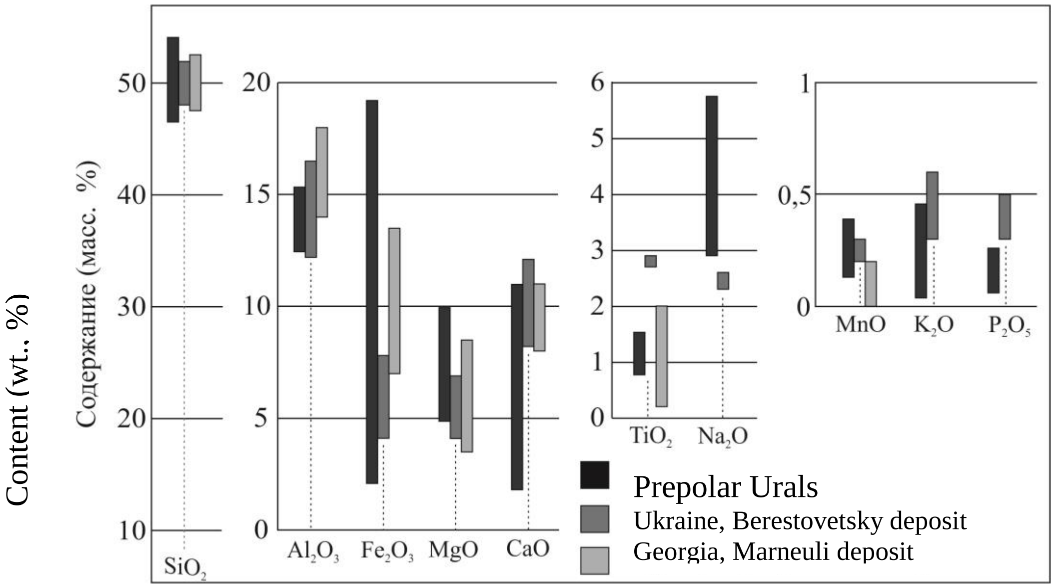

Fig. (4). – Comparison of the chemical composition of rocks of Polya and Maninsk cuttings with the reference compositions of basalts of Berestovetsky (Ukraine) and Marneuli (Georgia) deposits

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