Unusual metasomatites (phyolithites) in the Kolvitskiy gabbro-anorthosite rock mass: composition and structural position

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How to cite this article: Terekhov E.N., Makeev A.B., Baluev A.S., Konilov A.N., Van K.V. Unusual metasomatites (phyolithites) in the Kolvitskiy gabbro-anorthosite rock mass: composition and structural position. Journal of Mining Institute. 2021. Vol. 248, p. 232-242. DOI: 10.31897/PMI.2021.2.7

Abstract. Complex mineralogical, geochemical, and geological-structural characteristics of a rare collection stone of violet color, phylolithite, in the southwestern part of the Kola Peninsula. This is a metasomatic rock formed under the conditions of brittle deformations on gabbro-anorthosites of the Paleoproterozoic Kolvitskiy rock mass. As a result of potassium metasomatism, the plagioclase of the initial rocks was replaced by a fine-grained mica aggregate of muscovite-phengite composition with inclusions of Va-aluminoseladonite (up to 20-30 microns). Ba-aluminoseladonite contains 6.6-10.5 % by weight of BaO. Manganese is the only chromophore that accumulates in the rock during metasomatism. It is manganese that provides the purple-violet color of pseudomorphs of mica according to anorthite. The phylolithites is depleted by REE and has a positive Eu-anomaly. The phylolithites are confined to the areas of fracturing of the north-eastern strike, located in the zone of dynamic influence of the north-western closure of the Onega-Kandalaksha rift of the Riphean age. Other formations (injection conglomerates and lamproites) are also associated with the formation of this structure, which owe their origin to an intense fluid flow.

Key words: phylolithites; muscovite; gabbro-anorthosite; Onega-Kandalaksha rift; accommodation zone; Riphean; injection conglomerates

Acknowledgement. The work was carried out in accordance with the plans of basic research of the Institute of the Russian Academy of Sciences with the financial support of the Russian Foundation for Basic Research, grant N 19-05-00256.

Introduction. In the southwestern part of the Kola Peninsula, among the gabbro-anorthosites of the Kolvitskiy rock mass, the age of formation and metamorphism of which is close to 2450 million years [13, 20], there are unusual purple rocks that compose metasomatic zones – phylolithites (Fig.1). This manifestation has not been the object of close attention by researchers, it is occasionally mentioned in popular science literature under the name “Kola charoite”, in a scientific article [6] and in the proceedings of the meeting [30]. The composition and genesis of these rocks, as well as their structural position, and, accordingly, the importance of phylolithites for understanding the geological evolution of this area remain unexplored. The fact that these formations are confined to the Onega-

Kandalaksha graben of the Riphean age, as well as their secondary nature in relation to the rocks of the granulite complex, allows to link their formation with the evolution of the White Sea rift system of the Neoproterozoic age [25].

An important element of the continental rift systems in general [10, 12, 36] and the White Sea system in particular [25] is the presence of shallow discharges-detachments that determine both the structure-forming processes and the material transformations of the basement rocks caused by fluids that are mobilized during decompression and tectonic exhumation of the recumbent wings of large discharges [23, 35]. Such a model of the evolution of

Fig.1. Polished sample of phylolithite

Fig.2. Structural position of phyloliths (muscovite-phengite metasomatites) in the closure zone of the Riphean rift (according to [28] with additions)

- 1 – presumably Paleozoic (Devonian deposits); 2 – Riphean deposits: on land (a), in the White Sea (b);
 3 – granite-gneiss; 4 – anorthosites (a), eclogites, and eclogite-like rocks (b); 5 – early Riphean lamproite distribution field; 6 – location of phyloliths; 7 – Devonian alkaline intrusions: rock masses (a), dikes (b), explosion tubes (c); 8 – shifts (a) and main discharge (b);
 9 – structural lines and shallow faults; 10 – modern uplifts: rift shoulders (a), accommodation zones (b); 11 – suspected faults.
 The inset shows the formation of ring structures at the end of a growing crack (experimental data) according to [14]

the earth's crust during rift formation allows to take a new look at the problem of the structural-material relationship between the metamorphosed basement and the cover rocks and to link the development of new formations in the basement with the evolution of rift deflections.

The purpose of this work is to study the features of the composition and structural position of the phyloliths, as well as to compare them with other rocks that are the products of structural and material transformations during the evolution of the White Sea rift system.

Research. The main mass of phyloliths is found in the area of Cape Kataranskiy in the south-western part of the Kola Peninsula. Small manifestations are known in the western part of the Ilinskaya Bay and on the Srednyye Ludy Islands within the Kandalaksha Bay (Fig.2). The phyloliths are confined to fractured zones (the azimuth of the strike is 30-50° NE), which are well distinguished in the coastal cliffs, in the area of the exits of the gabbro-anorthosites of the Kolviskiy rock mass with an age of 2.45 billion years [20]. The thickness of individual fracture zones varies from 0.5 to 15 m.

The process of phylolithization of the initial rocks affects the entire fracture zone and extends beyond it in massive rocks at a distance of up to 1 m. Phylolithization develops exclusively by plagioclase, while dark-colored minerals are almost unchanged. Gabbro-anorthosites in this place are large-gigantic-grained (Fig.3, a, b). The size of individual hypersthene grains sometimes reaches 25 cm, and the most vivid samples of phyloliths are confined to the contacts of large crystals, while the pyroxene crystals themselves are often irritating differences, which additionally decorates this ornamental stone. The development of phylolithization zones is extremely uneven. The color of pseudomorphs varies from light lilac to inky purple, with the brightest color-near the grains of dark-colored minerals. In contrast, pseudomorphoses are lighter in the monomineral differences of anorthosites (Fig.3, c, d). Phylolithization is zonal: the most intense color is confined to the first meters of the fractured central part, along the periphery the purple color of the rocks gradually disappears, and in some cases the rocks remain massive without noticeable superimposed fracturing. They

Fig.3. Initial gabbro-anorthosites (*a, b*) and fracture zones composed of phylolithites (*c, d*)

preserve the primary structures of igneous rocks. The newly formed aggregate is quite soft, so high-quality polishing of samples is achieved in rare cases.

Gabbro-anorthosites composing a lopolite-like structure, as well as underlying and overlapping garnet amphibolites and eclogite-like rocks, respectively, are considered in many works, which are mainly devoted to deciphering the conditions of granulite metamorphism and the age of formation of the initial rocks [3, 13, 32]. The regressive stages of the formation of these complexes associated with the exhumation and formation of Riphean and younger structural ensembles have not been practically studied, with rare exceptions [2]. Within the entire granulite belt, a large number of various small pegmatite veins are found, representing the stage of its exhumation, and in the area of the development of phylolithites, dikes of lamproites of Riphean age and Devonian lamprophyres are developed [1, 21, 29].

The initial rocks on which the phylolithites developed were anorthosites and gabbro-anorthosites. Most of them have a banded, gneiss-like look (Fig.3, *a*), but some of them have massive textures with veins of gabbro-pegmatites (Fig.3, *b*). Monomineral anorthosites are very rare in the Kolvitskiy rock mass. There are gradual transitions between anorthosites and gabbro-anorthosites, and according to petro-geochemical data, they also do not differ fundamentally. In melanocratic differences, there are more components such as FeO, MgO, K₂O and Cr. Phylolithites develop on both sides, but in massive samples they are more spectacular. Taking into account that the rocks are large-gigantic-grained and unevenly colored, the sample of phylolithites has a composite character, i.e. several differences with the brightest color were selected, and after crushing the rock was quartered with further abrasion for chemical analysis.

Petrogenic elements in the phylolithite were determined in the laboratory of the Geological Institute of the Russian Academy of Sciences using the S4 PIONEER X-ray spectrometer (Bruker AXS, Germany), and trace elements were determined by the ICP-MS method using the Element 2 mass spectrometer (Thermo Fisher Scientific of GmbH, Germany). The mineral compositions (about 50 points) were determined at the Institute of Experimental Mineralogy (IEM) of the Russian Academy of Sciences using a Camebax electron microscope with an energy-dispersive spectrometer Link-860. In the Laboratory of Isotope Geochemistry and Geochronology of the Institute of Geology of Ore Deposit, Petrography, Mineralogy and Geochemistry of the Russian Academy of Sciences (performed

by V.A.Lebedev), the K-Ar age of the phylolithite was determined. The study of the radiogenic argon content in mica was carried out on the MI-1201 IG mass spectrometer by isotope dilution using ^{38}Ar as a tracer; the determination of potassium was carried out by flame spectrophotometry. To determine the nature of the violet color of muscovite-phengite from the phylolithite of the Kola Peninsula, the capabilities of the collective research center of the Institute of Geology of the Komi Republic of the Scientific Center of the Ural Branch of the Russian Academy of Sciences (Syktyvkar) were used. Samples of muscovite-fengite preparations were studied by the following methods: X-ray phase, IR spectroscopy, and electron paramagnetic resonance.

Results. In most petrogenic elements, the phylolithites are very close to the gabbro-anorthosites, but they show a noticeable increase in MnO and K_2O compared to the initial rocks. The content of Li, Ni, Rb, and Ba – elements that are characteristic of mica-muscovite-increases from trace elements in phylolithites (Table 1).

Table 1

Chemical composition of gabbro-anorthosite (initial rock) and phylolithite

Oxides, elements	Gabbro-anorthosit		Phylolithite	Oxides, elements	Gabbro-anorthosite		Phylolithite
	87/3	86/1	TfI (bulk)		87/3	86/1	TfI (bulk)
SiO_2	50.25	48.38	50.15	Sr	329	423	191
TiO_2	0.41	0.23	0.14	Y	9	9	2.4
Al_2O_3	23.68	27.52	23.57	Zr	51	22	9
Fe_2O_3	5.31	4.62	3.92	Ba	198	131	665
MnO	0.08	0.06	0.39	La	5.8	6.2	1.36
MgO	3.22	2.85	5.26	Ce	9.7	7.3	2.81
CaO	12.43	14.28	6.24	Pr	–	–	0.36
K_2O	0.45	0.11	3.89	Nd	3.5	2.7	1.65
Na_2O	3.48	2.27	2.09	Sm	0.5	0.6	0.47
P_2O_5	0.03	0.03	0.03	Eu	1.2	0.68	0.44
П.п.п	0.65	0.71	3.86	Gd	1.4	0.51	0.43
Li	9.1	9	32	Tb	–	–	0.07
Sc	1.6	18	14.6	Dy	–	–	0.43
V	100	151	65	Ho	–	–	0.08
Cr	95	73	368	Er	0.4	0.6	0.26
Co	15	15	36	Tm	–	–	0.04
Ni	49	89	227	Yb	0.3	0.3	0.27
Cu	13	17	35	$(\text{La/Yb})_n$	12.6	13.4	3.4
Rb	2	2	128	Eu/Eu*	4	2.6	3

Note. Oxides in %, trace elements in g/t.

In the initial rocks (Fig.4), the REE content is very low, which is typical for gabbro-anorthosites [24, 26]. In phylolithites, the rare-earth elements are uniformly reduced, while the ratio $(\text{La/Yb})_n$ also decreases due to the more intensive removal of LREE (plagioclase substitution) (Table 1). The positive europium anomaly ($\text{Eu/Eu}^* = 3$) remains high, which correlates with the high barium concentration in the phylolithites. Rocks with a positive Eu/Eu^* anomaly are enriched with barium, which indicates the participation of reduced fluids [27].

Using the VEGA TESCAN electron microscope (IEM RAS), the mineral composition of the phylolithite was determined: anorthite, albite, oligoclase, microcline, K-Na-feldspar, diopside, muscovite-fengite, biotite, Ba-aluminoseladonite, garnet – grossular-almandine-pyrope, chlorite – corundophyllite, amphibole – magnesian ferrochermakite, REE carbonate, Fe-Mn-Mg-Ca-carbonate, pyrite (Fig.5), their chemical composition is characterized (Tables 2, 3).

Fig.4. Chondrite-normalized REE distributions in the phylolith and initial rocks
1 – 87/3 gabbro-anorthosite; 2 – 86/1 anorthosite;
3 – TfI phylolith

Fig.5. Electron microscopic images (BSE mode) of metasomatite (A), garnet with inclusions of chlorite, Muscovite-phengite, microcline (B)
(b, d – mode SE)

Grt – garnet (light gray), points of analysis (1, 8, 9, 33, 34, 36, 45, 46); Cpx – clinopyroxene diopside (gray), (39-41, 49-51), Chl – chlorite (grey), (31, 35, 38, 43, 47); Amp – amphibole (gray), (6a, 7, 32); Sel – Ba-aluminoseladonite (white), (2, 3, 22); Ms – Muscovite-phengite (dark gray), (6, 21, 23, 25, 37, 44); Bt – biotite (gray), (1); Ab – albite (black), (4, 42); An – anorthite (gray), (4, 5, 7, 24); Kfs – microcline (gray), (2); Pl – oligoclase (gray), (5a, 9a)

The textures of the initial rocks are very diverse, but they are always large-giant-grained differences. The primary minerals are clinopyroxene-diopside, hypersthene, and plagioclase. The presence of anorthite, albite, and K-spar, which are not typical for the initial gabbro-anorthosites [32], indicates the high-temperature nature of the transformations antecedent to the formation of micas. Areas of phylitization develop by plagioclase, and depending on the intensity of the transformation process, its crystals are almost completely replaced by a mica aggregate – muscovite-phengite with small inclusions of Ba-aluminoseladonite (up to 20-30 microns), Ba-aluminoseladonite contains 6.6-10.5 % by weight of BaO. Manganese is the only chromophore that accumulates in the rock during metasomatism, namely manganese (Table 2), the content of which is 0.09-0.64 % by weight of MnO, provides a purple-violet color of pseudomorphs of mica (muscovite-fengite) by plagioclase. Samples of muscovite-fengite preparations were studied using the following methods: X-ray phase, IR spectroscopy, and electron paramagnetic resonance. The results of the study clearly showed that the violet chromophore of the muscovite-fengite color is trivalent manganese. In the literature, a similar conclusion about the presence of Mn^{3+} in mica was made in 1977 after studying the nature of the color of pinkish muscovite from Precambrian metamorphic rocks of New Mexico [34].

The composition of garnet (grossular-almandine-pyrope) with 34-60 % Pir is very unusual (Table 3). Its idiomorphic secretions suggest that it is a secondary metasomatic

garnet. The maximum pressure values (11-13 kbar) were calculated from such high – magnesian garnets-this is the metamorphism of the granulite facies [32]. Dark-colored silicates do not change much during this process, although the appearance of chlorite-corundophyllite is associated with the replacement of amphibole (magnesian ferro-chermakite). Judging by the gross chemical composition of the phylolithite samples, they are significantly enriched in K₂O (4 % by weight) relative to 0.1-0.2 % in the initial gabbro-anorthosite, i.e., the rocks were subjected to K-metasomatism. The initial gabbro-anorthosites are abnormally depleted of rubidium (2 g/t), so its high concentration (128 g/t) in the phylolithite also indicates the process of metasomatic substitution.

Table 2

Chemical composition and crystal-chemical coefficients of micas of metasomatized anorthosites

Oxides	Point of analysis																
	2	3	22	6	13	15	18	21	23	25	26	27	37	44	1	16	19
SiO ₂	52.98	55.23	55.65	46.68	45.86	47.99	48.83	45.95	47.05	46.22	46.14	46.63	45.17	44.76	36.85	37.94	38.19
TiO ₂	0.64	0.73	0.69	0.16	0.07	0.26	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.41	3.83	4.29
Al ₂ O ₃	20.02	18.52	19.58	28.22	30.94	29.78	29.77	31.29	30.28	31.50	34.04	33.87	31.85	30.82	15.20	15.36	15.68
FeO	0.04	0.25	0.16	1.62	0.81	0.98	0.76	0.08	0.36	0.34	1.03	1.35	1.22	1.62	10.65	10.61	11.17
MnO	0.14	0.10	0.00	0.43	0.47	0.00	0.09	0.21	0.23	0.32	0.03	0.17	0.26	0.64	0.00	0.04	0.20
MgO	0.00	0.09	0.14	2.86	1.31	2.25	1.37	1.72	2.28	1.01	0.83	1.13	0.58	0.89	14.15	15.52	15.65
CaO	0.87	0.28	0.00	0.45	0.13	0.07	0.54	0.00	0.22	0.29	0.32	0.08	0.00	0.04	0.00	0.12	0.10
Na ₂ O	0.44	0.33	0.30	0.15	0.11	0.07	1.20	0.00	0.18	0.61	0.27	0.37	0.13	0.21	0.09	0.50	0.26
K ₂ O	11.83	13.01	12.17	11.27	11.42	11.44	9.70	10.65	11.52	10.53	11.18	10.48	10.71	10.38	10.15	10.18	10.36
BaO	10.50	6.57	8.33	0.19	0.19	0.00	0.07	0.37	0.45	0.03	0.16	1.52	0.75	0.31	0.00	0.00	0.32
Total	97.46	95.11	97.02	92.03	91.31	92.84	92.44	90.27	92.57	90.85	94.00	95.60	90.67	89.67	91.50	94.10	96.22
Si ⁴⁺	3.748	3.889	3.859	3.263	3.210	3.286	3.333	3.220	3.246	3.222	3.126	3.131	3.185	3.193	2.819	2.821	2.792
Ti ⁴⁺	0.034	0.039	0.036	0.008	0.004	0.013	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.254	0.214	0.236
Al ³⁺	1.669	1.537	1.600	2.325	2.552	2.404	2.395	2.584	2.462	2.588	2.718	2.680	2.647	2.591	1.371	1.346	1.351
Fe ²⁺	0.002	0.015	0.009	0.095	0.047	0.056	0.043	0.005	0.021	0.020	0.058	0.076	0.072	0.097	0.681	0.660	0.683
Mn ²⁺	0.008	0.006	0.000	0.026	0.028	0.000	0.005	0.013	0.013	0.019	0.002	0.010	0.016	0.039	0.000	0.003	0.012
Mg ²⁺	0.000	0.009	0.015	0.298	0.137	0.230	0.139	0.180	0.235	0.105	0.084	0.113	0.061	0.095	1.614	1.720	1.706
Ca ²⁺	0.066	0.021	0.000	0.034	0.010	0.005	0.040	0.000	0.016	0.022	0.023	0.006	0.000	0.003	0.000	0.010	0.008
Na ⁺	0.060	0.045	0.040	0.020	0.015	0.009	0.159	0.000	0.024	0.082	0.036	0.048	0.018	0.029	0.013	0.072	0.037
K ⁺	1.068	1.169	1.077	1.005	1.020	0.999	0.845	0.952	1.014	0.936	0.966	0.898	0.963	0.945	0.991	0.966	0.966
Ba ²⁺	0.291	0.181	0.226	0.005	0.005	0.000	0.002	0.010	0.012	0.001	0.004	0.040	0.021	0.009	0.000	0.000	0.009
Al ^{IV}	0.218	0.072	0.105	0.729	0.786	0.700	0.662	0.780	0.754	0.779	0.874	0.869	0.815	0.807	0.927	0.965	0.973
Al ^{VI}	1.451	1.465	1.496	1.596	1.766	1.703	1.733	1.805	1.707	1.809	1.843	1.812	1.832	1.784	0.444	0.381	0.378

Note. Analyses 2, 3, 22 correspond to the composition of micas of the Ba-aluminoseladonite series; analyses 6, 13, 15, 18, 21, 23, 25, 26, 27, 37 belong to the series of muscovite-fengite; 1, 16, 19 – phlogopite-eastonite.

Table 3

Chemical composition and minals of metasomatite garnets, % by weight

Oxides	Point of analysis															
	1	8	9	12	14	16	20	29	30	33	34	36	45	46	3a	8a
SiO ₂	39.57	38.78	38.85	39.22	39.42	39.28	39.21	39.71	39.69	39.56	39.03	39.12	39.28	39.26	38.65	39.02
TiO ₂	0.00	0.00	0.17	0.14	0.00	0.03	0.00	0.00	0.16	0.00	0.00	0.04	0.04	0.00	0.06	0.05
Al ₂ O ₃	22.39	21.97	22.07	22.27	22.33	22.24	22.21	22.49	22.45	22.41	22.11	22.17	22.27	22.24	21.89	22.09
FeO	16.89	23.75	21.19	18.99	18.83	19.27	18.93	14.53	14.71	15.78	19.83	18.53	17.48	18.03	25.24	22.24
MnO	0.05	0.49	0.27	0.18	0.34	0.22	0.30	0.50	0.13	0.19	0.83	0.45	0.01	0.35	3.69	5.06
CaO	6.75	6.03	5.80	6.57	7.21	6.44	6.50	6.66	6.52	6.20	5.39	5.46	5.58	5.81	7.61	9.10
MgO	14.35	8.98	11.61	12.61	11.85	12.51	12.57	16.10	16.37	15.84	12.82	14.16	15.32	14.26	2.91	2.44
Total	100.00	100.00	99.96	99.98	99.98	99.99	99.72	99.99	100.03	99.98	100.01	99.93	99.98	99.95	100.05	100.00
Alm	34.95	50.72	44.70	39.70	39.40	40.31	39.68	29.81	30.14	32.49	41.60	38.63	36.19	37.50	55.21	48.44
Sps	0.10	1.06	0.58	0.38	0.72	0.47	0.64	1.04	0.27	0.40	1.76	0.95	0.02	0.74	8.17	11.16
Grs	17.92	16.52	15.70	17.62	19.36	17.29	17.48	17.53	17.14	16.38	14.51	14.60	14.82	15.51	21.36	25.43
Pir	52.95	34.19	43.67	47.00	44.21	46.66	46.97	58.90	59.81	58.14	47.95	52.63	56.55	52.88	11.35	9.48

Note. The first 14 analyses correspond to the composition of the garnet of the grossular-almandine-pyrope series; 3a, 8a belong to the spessartin-grossular-almandine series.

Fig.6. The White Sea paleorift system and genetically related fluid-metasomatic formations

1 – Vendian cover; 2 – Riphean; 3 – Early Precambrian basement; 4 – rift structures; 5 – faults; 6 – phyloliths; 7 – injection conglomerates.

Manifestations: 1 – Cape Kataranskiy; 2 – Srednyye Ludy archipelago; 3 – Kiy-islands; 4 – Pokrovskoye village

The manifestation of phylolithites is located within the Poryegubskiy lamproite field, whose rocks are characterized by ultra-high concentrations of K_2O and are, according to some data, 1750 million years old [21], according to the other – 1200 million years old [7]. However, both of these age boundaries can be associated not only with post-plate magmatism in the Baltic Shield [28], but also with the stages of Riphean or Pre-Riphean rift formation [17]. Moreover, in the Baltic region, early rift structures are known, the basal deposits of which are older than 1650 million years [19]. There is also one of the areas (pockets) of the distribution of Devonian lamprophyre dikes (see Fig.2). The K-Ar value of the age of the 1320 million-year-old phylolithite mica indicates the time of the metasomatic development of the gabbro-anorthosites, which probably coincides with the main stage of the northwestern strike formation of the White Sea rift system [25].

The Onega-Kandalaksha graben is the largest structure in the White Sea rift system, formed, according to modern data, due to horizontal sliding along the system of shallow discharges falling to the northeast (Fig.6). According to some data, within the Onega-Kandalaksha graben, the current depth of the foundation sinking and the thickness of the Riphean deposits reaches 8 km [11, 25]. Accordingly, the uplift of the rift shoulder was very significant, which contributed to the decompression

fluids formation. The main fault controlling the development of this graben is the discharge along its western side. According to geophysical data and modern morphostructure, this discharge can be clearly traced from the mouth of the Onega River to the Sredniye Ludy archipelago [11, 15, 25]. The recumbent wing of this discharge experiences uplift, which is expressed in the appearance of highly metamorphosed rocks and positive gravitational anomalies on the surface. In the area of the Sredniye Ludy archipelago, the observed fault experiences an alternating inversion of its fall, and in the segment of the Sredniye Ludy – Kandalaksha archipelago, it falls to the southwest. According to the geological data (the Sredniye Ludy archipelago and the islands in the Porya Bay, where the granulite complex rocks are exposed), it is obvious that the Onega-Kandalaksha Riphean graben closes in the area of the archipelago and does not continue further to the northwest, as is often shown on small-scale maps [5]. Therefore, the area of the Srednyye Ludy Archipelago and Cape Kataranskiy on the mainland of the south-west of the Kola Peninsula can be considered as a zone of dynamic influence of the Riphean graben closure area. Naturally, the question arises about the time of the fault formation to the north-west of the Sredniye Ludy archipelago. It is probably of Devonian age, updated at the present stage. Previously, this segment of the rift was called the Kolvitskiy Trough [25]. Within the limits of this trough, according to seismic survey data, shallow-lying deposits are distinguished, which can also be considered as Paleozoic [8]. But a more important argument for the Devonian age of the Kolvitsky Trough is the dike fields associated with its northern and southern closures. These are the Kandalaksha area (more than 200 Devonian dikes) and the Lake Dolgoe – Kasyan Island area (more than 100 dikes) (see Fig.2). Thus, the Sredniye Ludy archipelago is the junction of the Riphean and probably Devonian grabens. It is the areas of rift deflections closure and the places where the inversion of structural-forming faults occurs (the so-called accommodation zones) that are characterized by the presence of areas of increased fracturing, pseudotachylites, dikes and metasomatites of various compositions, as well as increased concentrations of hydrocarbon emanations [9, 25]. A characteristic feature of the framing of the Onega-Kandalaksha rift is conglomerate-like rocks of non-sedimentary genesis. They were first described in the Kandalaksha region, where rounded boulders and pebbles of granulites in sandy-carbonate cement form a plast-like intrusive body (the Telyachii Island) [33]. In the southern part of the Sredniye Ludy archipelago, a vein-like body was observed, composed of rounded fragments of gabbro-anorthosites. The role of cement here is played by hornblende, which probably crystallized directly from the fluid (Fig.7, *a*). At a deeper level, among the eclogite-like rocks, vein-like bodies of hornblendites are distinguished, which were also formed under the influence of fluids penetrating through cracks into the rocks of the granulite complex (Fig.7, *b*).

Fig.7. Rift formations in the rocks of the crystalline basement
Fluidizates in the rocks of the granulite complex (*a-b*): *a* – injection conglomerate-breccias, the fragments are represented by anorthosite, the space between them is filled with coarse-grained hornblende (arch. Sredniye Ludy); *b* – injection veins represented by hornblende among eclogite-like rocks (Kataranskiy Cape area, Pedunikha Bay). Injection conglomerates in the recumbent wing of the main discharge of the Onega graben (near the village of Pokrovskoye) (*c-d*): a crack- fault among granite-gneisses (*c*), falls under the Riphean graben (*d*), it contains lenses of injection conglomerates

Numerous rock outcrops associated with the formation of the Onega-Kandalaksha graben are known on its southwestern flank near the island of Kiy – the village of Pokrovskoye (see Fig.6). These are injection conglomerates confined to the basement rocks: amphibolites and granite-gneisses [4, 18]. Conglomerates form lenses and low-power layers confined to tectonic zones falling towards the Riphean graben (Fig.7, *c, d*). The semi-rolled fragments of the host rocks are unevenly distributed in the draining aphanite mass of gray-green or almost black color with a shell-like fracture and a greasy gloss on the fracture. In the cuts, it can be seen that the cement mass consists of a fine-grained sandy material. The clastic fraction of cement consists of grains of quartz, plagioclase, microcline, pyroxene, amphibole, garnet, biotite and ore mineral. Cement is represented by calcite and to a lesser extent by glass, which occurs in the form of lenses or shells around the grains. Within the limits of carbonate cement, micro-loads of analcime were diagnosed, for which the formation temperature is higher than 450 °C [31]. The glass has a main-ultrabasic composition, and in some analyses the K₂O content reaches 5 % by weight. By the fact of the glass presence, conglomerate-breccias are close to pseudotachylites [22]. At the same time, their large thickness, the main-ultrabasic composition of the glass, and the presence of high-temperature neoplasms allow to consider them as a special type of rocks – fluidizates formed during the flow of incandescent suspension masses inside the earth's crust [16]. At the same time, the age of the newly formed zircon grains is 1200 million years, which corresponds to one of the phases of the formation of the White Sea rift system [25].

Conclusion. Rocks of unusual violet color are formed by gabbro-anorthosite due to metasomatic replacement of plagioclase by muscovite-phengite fine-grained aggregate. The increased content of manganese in metasomatic rocks determined their unusual purple color, and high concentrations of K₂O are typical for formations that are synchronous to the formation of the Onega-Kandalaksha graben. To the south of the phylolithites distribution there is a graben, and on land there is an annular structure typical of the closure of rift deflections and shifts (see Fig.2, cut). This type of structure is formed at the end of faults experiencing shear deformations, and it is within their limits that stress discharge occurs, which is expressed in the formation of local thrusts and crushing zones of different orders. Phylolithites are also found on the islands of the Sredniye Ludy archipelago. These islands are considered as a kind of reference structure of accommodation in rift zones, where the main displacement changes its polarity, and there are increased tectonic stresses (see Fig.2). At first glance, it seems paradoxical that alkaline dikes (lamprophyres and lamproites) are confined to these areas (i.e., compression zones). However, the study of alkaline dikes in the Kandalaksha Bay showed that these are extremely fluid-saturated formations, which are formed in the form of dikes and explosion tubes, only in those places where the fluid cannot freely reach the surface [29]. In areas where the rifts are wide open, there are no alkaline dikes, and pseudoconglomerates or injection conglomerates can form in the degassing areas [18, 25]. Therefore, the formation of phylolithites formed by gabbro-anorthosites under the influence of alkaline fluids is also associated with the development of this rift system in the Middle Riphean time.

The authors express special gratitude to the Candidate of Geological and Mineralogical Sciences P.V.Lyutov for determining the nature of the color of the phylolithite.

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The authors declare no conflict of interests.

The paper was received on 28 January, 2021.

The paper was accepted for publication on 29 March, 2021.