LA-ICP MS Characteristic of Geochemical Composition of Veins Rocks from the Central Part of the Khibina Massive in Kola Peninsula, Northern Russia

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Abstract: This paper discusses the vein rocks located in the central part of Khibina Mts.. These rocks are located on the border of two zones: ore and external. In the ore, zone is present titanite-nepheline bodies whilst in the outer zone are massive-syenites “khibinites”. The veins can be divided into: mikrosyenites, melteigites and other rock types (e.g., tinguaite). The results of LA-ICP MS (laser ablation of inductively coupled plasma mass spectrometry) indicate that these rocks are associated with deep zones which formed as a result of injection of primary magma and contamination of fluids during migration, where there have hydrothermal processes. Rock-forming minerals, their corrosion and accessory minerals indicate these processes, too.

Key words: Khibina Massive, Kola Peninsula, vein rocks, geochemistry.

1. Introduction

Khibina Massive is a central intrusion, located near the Imandra, Umbozero Gully Lakes, in the central part of Kola Peninsula on the northern part of Baltic Shield. These intrusion is late Devonian [1-5], surrounded by Archean migmatitic gneisses of Kola series and metasediments of Imandra-Varzuga complexes [6-8]. There is a multi zonal massive with characteristic, specific mineralization. In the central part is located an ore zone with titanite-apatite-nepheline bodies which accompanied alkaline syenites-khibinites from the occurrence zone. These syenites are massive rocks with grey color and visible alkali-feldspar with aegirinites (Fig. 1). In the contact of these zones, they are present a numerous mineral veins, represented by the tingualites, melteigites and mikrosyenites. These rocks are studied in the paper.

2. Methods

It was make the observation in the Malaya Belaya Valley near Ramzaya Pass and in other region at the Bolshoi Vudiyavr Lake. The 150 samples were taken and make the microscopic observation used a polarised cross and reflected light (Leica DM 2500P) and electron scanning microscope (Hitachi SU6600) with EDS (energy dispersive X-ray spectrometry). In selected samples was make the LA-ICP-MS (laser ablation inductively coupled plasma mass spectrometry) analysis (model ELAN DRC II, Perkin Elmer with laser microsonde (LA) LSX-500, of CETAC). The microscopic observation was made in the Optical and Electron Microscopy Laboratory in Geology and Litosphere Protection Department, Earth Science and Spatial Management Faculty at the Maria Curie-Skłodowska University in Lublin, whilst the LAICP was make in Environment Analytic Laboratory in Geochemistry and Environment Protection Faculty at the Jan Kochanowski University in Kielce, Poland.

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Fig. 1 Geology map of the Khibina Mts. with the samples localization.

3. Results

3.1 Microscopic Observations

In the occur of the veins, rocks are present massive syenites with a nepheline-aegirine urtites and apatite-nepheline ores. Massive syenites usually have large crystalline structure, dense, disordered texture, rare radiant and directional. Background of massive syenites form the automorphic nepheline crystals (up to 25% vol.), orthoclase (up to 24% vol.) and apatite (up to 15% vol.) among which are the needle of aegirine-acmite (up to 21% vol.), and xenomorphic crystals of eudialite (often with numerous inclusions these last crystals-to 15% vol.), plagioclases (acid varieties to 10% vol.). In these rocks, they are also subordinate to a maximum of 15% vol.: ilmenite, titanite, magnetite, arfvedsonite, riebeckite, astrophyllite, aenigmatite, lorenzenite and others (Fig. 2).

Nepheline-aegirine urtites are gery-black-grennish rocks with the visible on the background a nepheline cristtals with accompanied plagioclases, aegirines acmites with accesoric minerals. It has a large-crystalls, pseudotrahYTE structure. The apatite-nepheline ores it are a green-brownish color (with red tint). There are massive rocks with nepheline crystals and tytanitem with addition of apatite. In these massive syenites is present a numerous of mineral veins (Table 1) such as: tinguaites, melteigites and microsyenites.

Syenite veins have a massive texture, fine crystalline structures. These veins are the largest group of rocks. Form the veins of both a sharp contact and (often) those which have blurred boundaries are plastically deformed, with budinage structures. They are usually microsyenites (ijolites) with an increased amount of mafic minerals (up to 70% vol.), are rich in

(a)

(b)

Khibinite rock ((a) thin section, crossed pollars; (b) the polished sample of rocks)

(c)

(d)

Urtite rock ((c) thin section, crossed pollars; (d) the polished sample of rocks)

(e)

(f)

Titatnite-nepheline-apatite ore mineralization ((e) thin section, crossed pollars; (f) the polished sample of rocks)

(g)

(h)

Microsyenite rocks (thin section, crossed pollars, sample: (g) 14CH02, (h) 19CH02)

(i)

(j)

Tinguaitite rocks (thin section, crossed pollars, sample: (i) 23CH02, (j) 02CH10)

(k)

(l)

Melteigite rocks (thin section, crossed pollars, sample: (k) 08CH02, (l) 02CH03)

Fig. 2 Microphotographs of typical rocks from studied area.

Table 1 Planimetric composition of studiem rocks.

No. of sample	Planimetric composition (% obj.)					Name of rock
	Ne	K-fs	Pl	Dark	Others	
07CH02	25	24	5	30	15 (ap)	Foidic syenite (khibinite)
08CH02	3	7	4	69	7 (ol) 10 (ap)	Melteigite
10CH02	20	30	0	35	7 (ap) 8 (zr)	Foidic syenite (khibinite)
11CH02-II wyp.	10	12	0	71	8 (ap)	Ijolite
11CH02-I wyp.	7	41	9	39	4 (ap)	Foidic syenite (khibinite)
13CH02	24	10	0	37	17 (ap) 12 (zr)	Foidic syenite (khibinite)
14CH02	17	14	0	58	2 (ap) 9 (zr)	Ijolite
15CH02	2	55	0	34	9 (ap)	Foidic mikrosyenite
16CH02-II wyp.	13	16	0	71	0	Foidic syenite (khibinite)
16CH02-I wyp.	39	0	0	55	7 (ap)	Ijolite
17CH02	3	25	0	72	0	Foidic syenite (khibinite)
18CH02	15	15	9	55	6 (ap)	Melteigite
19CH02-I wyp.	13	57	0	27	4 (ap)	Foidic syenite (khibinite)
19CH02-II wyp.	6	18	0	52	24 (ap)	Foidic syenite (khibinite)
20CH02	1	38	0	55	6 (ap)	Foidic syenite (khibinite)
21CH02	1	12	0	84	4 (ap)	Ijolite
22CH02-I wyp.	3	20	3	28	48 (zr)	Foidic syenite (khibinite)
22CH02-II wyp.	0	91	0	5	5 (ap)	Foidic syenite (khibinite)
23CH02	5	22	1	72	0	Microsyenite-tinguaite
24CH02	11	20	0	45	11 (ap) 13 (zr)	Foidic syenite (khibinite)

ore minerals, mainly from the group of oxides of iron and titanium with admixtures of sulfides (including copper). Such melanocratic variety of syenite more often found in repeated vein fillings. The background are the crystals of orthoclase rarely microclines (under to 55% vol.), and aegirines (under 53% vol.) with arfvedsonite (24%), ith addition of apatite (24%), nepheline (39%), eudialite (do 48% obj), acid plagioclases (Ab, Lb, 9% vol. of rocks), and ilmenite, titanite with sulphides (pyrite and chalkopyrite). The apatite is rich with strontium-calcium compounent. Near these minerals is present the inclusions of fluorite.

Tinguaite has a beautiful greenish color, nematoblastic, fibroblastic structure, radial, dense texture. Matrix consists of radial concentrations of aegirine and astrophillite (up to 45% vol.). Near these minerals are orthoclase (22%), nepheline (5%), and titanite (up to 3% vol.). The rocks have also magnetite and ilmenite (up to 4% vol.). These minerals form narrow blades supporting aegirynes. These veins are most frequently met in the central part of Khibina. In

the background of these rocks, they are present a radial conglomerates of aegirine with astrophyllites (under 45% vol.).

Melteigites there are veins have sharp contacts with host rocks. They have lepidomorphous-crystallic structures, massive, poikilite, porphyritic textures. Phenocrystals of minerals are augite with addition of diopsides (to 24% vol.), and nodules, usually made up of olivine (rich in Fe, Fig. 4) with rims of Fe-biotite and phlogopite (Fig. 3). Matrix is composed of apatite (up to 10% vol.), nepheline (up to 15% vol.), orthoclase (up to 15% vol.) and plagioclase (up to 9% vol.). Less frequently rocks are pyroxenites occurring in what are called pyroxene (augite) suns (79% vol.). In melteigites, pyroxene is sometimes characterized by structures such as radial augite sun. The presents pyrites have a small addition of Ni (0.5 wt.%) and Cd (0.2 wt.%).

3.2 LA-CP Analysis

In the Tables 2 and 3, it is resent results of analysis

(a) The photograph after La ICP analysis on theilmenite and augite. (b) Olywine with micas corona.

Fig. 3 Microphotographs from electron microscopy (SE) of samples rock.

(a) Projection of olywine from the melteigite rocks. (b) Pyroxene projection from the analysed samples.

Fig. 4 EDS analysis of selected minerals.

Table 2 Chemical composition of rocks used by the LA-ICP-MS (reference material: polymetallic sulphide MASS-1, USGS).

Sample	Pb	Cu	As	Zn	Cd	Ni	Co	Ag
mg/kg (ppm)								
21CH02	15,508	3.3	24	208	23	84	11	< 1
	15,827	31	35	101	30	30	6	< 1
	15,744	33	2	233	25	10	5	< 1
	15,867	37	32	218	24	231	25	< 1
08CH02	15,888	345	25	40	24	34	17	< 1
	15,919	36	35	215	24	8	1	< 1
	15,895	32	36	234	24	8	1	< 1
	15,899	38	36	243	25	8	1	< 1
14CH02	< 1	2	< 1	< 1	< 1	2	< 1	< 1
	< 1	< 1	< 1	24	< 1	2	< 1	< 1
	< 1	2	< 1	30	< 1	2	3	< 1
18CH02	< 1	2	< 1	8	< 1	3	< 1	< 1
	< 1	1	< 1	20	< 1	7	7	< 1

Table 3 Chemical composition of rocks used by the LA-ICP-MS (reference material: REE element sof the glass matrix NIST 612).

Sample	Pb	Cu	Ni	Co	Ag	Ti	Eu	Gd	Ce
	mg/kg (ppm)								
16CH02	3	1,420	13,029	1,103	15	316	1	2	28
	< 1	26	37	7	< 1	199	13	25	771
	< 1	8	16	< 1	< 1	95,207	1	4	131
	< 1	16	19	25	< 1	4,434	3	9	91
15CHCH	24	56	53	77	3	28,387	27	78	2,275
	23	57	61	72	< 1	42,221	3	7	269
	48	109	111	178	5	52,081	< 1	3	103
23CH02	3	< 1	< 1	< 1	< 1	246	< 1	< 1	1
	3	2	2	< 1	< 1	240	< 1	< 1	4
	2	312	696	2,341	2	871	< 1	< 1	6
	3	36	9	23	< 1	640	1	1	48
	4	2	< 1	1	1	214	< 1	< 1	< 1
	3	36	7	4	< 1	153	< 1	< 1	4

selected rock samples from the study area. In the veins samples is present a higher content of Pb and Zn (samples 21CH02 and 08CH02). In samples: 16CH02 and 15CH03 was measured a high contents of Ti, Ni and Ce.

4. Conclusions

Describe veins rocks from Khibina have advanced syenitization processes. The primitive mineral association has a corrosion in rocks veins. This was a product of mixed chemical composition of veins materials with occur rocks. The melteigite rock probably is a differentiation product in the intrusive magma and migration of basic derivates with contamination of syenite fluids. These fluids make unstable the ol-opx association (Figs. 3 and 4). In next step, a cpx minerals was crystallized which was make aegirinization (secondary processes). It can provide the numerous structures disintegrating, crowns reaction in olivine and pyroxene around, and relatively high content in the background a nepheline and feldspar. In addition, vein rocks fill the various discontinuities accompanying the transition zone which is undoubtedly limit ore occurrences and khibinites. This causes multistage migration of fluids in zones splits and enrichment rock core in the phase associated with the crystallization of residual and

after-magmas processes [4]. Hence, are visible in the area of various multiple fill the same vein different generation and the presence of carbonate minerals found in many rocks in Khibina [3, 9, 10] and the enrichment of these rocks in the elements cerium group. In addition, the activity associated with hydrothermal after-magmas processes involves the enrichment of these rocks Zn-Pb sulphides and minerals, for example, fluorite.

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