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On the history of mineralogenic studies and development of Arctic Karelia

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Abstract. The paper focuses on the mineral resources of the Karelian Arctic. Arctic districts are linked to the White Sea. The White Sea is connected via the White Sea-Baltic Channell with the Baltic, Caspian and Black seas. All the above districts have state railways and highways connecting Karelia with South and North Russia. A retrospective review of the history of research and mastering of mineral resources is given. The current state of mineral raw base of the northern regions of Karelia is shown. The mineral potential of three areas in Arctic Karelia is of great value as there are many deposits and occurrences and a variety of mineral reserves and resources to be developed there. The Lopian epoch witnessed the formation of the deposits and ore occurrences of several ore formations: molybdenum-porphyry, gold-porphyry and others. Big noble-metal ore bodies in Olanga Group layered intrusions and similar but smaller-scale occurrences in the Kuzema lherzolite-gabbro-norite complex were formed in the Sumian epoch. The Svecofennian metallogenic epoch is mainly represented by rare-metal pegmatite formation and complex noble-metal occurrences in their aureoles and shear-zones. Garnet ores were formed in a favourable setting with medium-temperature high-pressure metamorphism and a great contribution of metasomatism associated with acid leaching under kyanite-muscovite- and quartz-muscovite-facies conditions. Kyanite is an industrial mineral used in the refractory and ceramic industries and aircraft motor production. In Russia, no kyanite ore deposits have been mined yet. Nizhnekotozero anorthosites from the Belomorian mobile belt are a new type of feldspar deposits. A pyroxenite-gabbro-alkaline formation with carbonatites is represented by the Yeletozero, Tikshozero and Vostochny massifs in North Karelia. It is proposed to develop a target program aimed at forming a state order for prospecting and appraisal, exploration deposits on precious and rare metals, industrial minerals.

1.Introduction

In the 1980s, the concept of the "Arctic Russian Federation" was officially introduced. The zone originally consisted of three northern districts of the Republic of Karelia: Belomorsk, Louhi and Kem, but they were later excluded. In the 21st century, in accordance with a decree no. 287 of 27 June, 2017, approved by the President of the Russian Federation, these districts, known as Maritime Karelia, again became part of Arctic Russia mainly because they are located near the White Sea, which is linked to the Arctic Ocean. The decree was adopted and a decision to develop the Arctic regions of Russia was made. Arctic Karelia has a favourable geographic location, a relatively well-developed infrastructure, a moderate climate and exuberant mineral resources. Therefore, it is steadily becoming more attractive for potential investors. The main economic goal of Karelia and other Arctic regions of the Earth is to develop the raw materials complex.

The Louhi District is the largest northernmost district of the Republic of Karelia with Louhi Town as its centre (population about 4 000). The district has a population of over 14.700 and covers an area of 22.5 thousand sq^2. It is the only district in Karelia which extends from the state border on the west to the White Sea on the east. Its northern part adjoins the Arctic Circle. The seashore stretches for about 150 km.

In the 14th-17th centuries, the region was a trade route between Osterbothnia, a Swedish province in the upper Gulf of Bothnia, and Maritime Russia.

The Kem District is located mainly in the Kem River basin. It adjoins the White Sea over a long distance and stretches as far as the Kem Tract boundary. The City of Kem, the administrative district centre with a population of about 11 000 is a White Sea port, from which one can get to the Solovets Islands, covering a distance of 45 km. The district area is about 8 000 km^2. Its population is up 20 000.

Pioneer settlers from Novgorod came here in the 12th century. They were attracted by the Solovets Monastery, the centre of the White Sea Region. The main occupations of the settlers were sea animal (mainly seal) hunting and fishing. In the 18th century, the Kem Volost (administrative unit) became a fishing, navigation and ship-building centre.

The Belomorsk District lies in southeastern North Karelia. It covers a total area of 13 000 km^2 and has a population of about 20 000. 9700 people of that number live in the City of Belomorsk, the administrative centre of the district located in the Vyg River delta.

All three Arctic districts of the Republic of Karelia are linked to the White Sea, the famous "Cold Sea", the cradle of the Russian Fleet and the Motherland of world's known captains, navigators, fishermen and sea hunters. The White Sea is connected via the White Sea-Baltic Channell with the Baltic, Caspian and Black seas.

All the above districts have state railways and highways connecting Karelia with South and North Russia.

2. History of exploration and development of mineral resources

The development of North Russia's mineral resources began in Arctic Karelia. In the 10th-11th centuries, large-scale mica production was launched here to supply muscovite to domestic and foreign markets.

In Maritime Karelia, salt, known locally as *moryanka*, was produced for many years. In the 15th-18th centuries, dozens of salt works, owned mainly by the Solovets Monastery, operated on the White Sea coast. Commercial pearl collecting on many rivers was a common occupation of locals. There was a pearl-collecting company on the Keret River which operated for a long time.

The construction of the Murmansk Railway, launched from the north at Romanov-on-Murman and from the south from Petrozavodsk, was essential for the revival of North Russia's mineral production.

Dramatic events in Russia in the early 20th century, such as World War I and revolutions, resulted in an economic collapse. Great efforts were needed to restore the national economy. Electrification required tremendous quantities of essential electrical engineering materials such as native mica (muscovite). A Commission for the study of Russia's Natural Production Forces (KEPS), headed by Academician A.E.Fersman, was formed. In 1919, the commission published I.I Ginsburg's brief report on mica [1], in which Karelia's old mica production areas were specified and recommendations for the renewal of mica production were presented. In May 1920, President of the Russian Academy of Sciences, A.P. Karpinsky, Head of the KEPS Raw Materials Commission A.E. Fersman and Chief Geologist of the Geological Commission (Geolcom) A.P. Gerasimov visited Karelia and the Kola Peninsula. It was the first step to the study and use of the White Sea Region's pegmatites as a source of quartz-feldspar, muscovite and other raw materials near the Murmansk Railway.

P.A.Borisov has contributed greatly to the provision of the mineral raw materials base for the ceramic industry in North Russia [2]. He coined the name *ceramic pegmatite* for this mineral. In 1922, a private quarrying company was established at Chupa (Chupgorn) and a few pegmatite deposits were discovered. The company started commercial muscovite and feldspar production. Soyuzslyudkombinat Company was founded later, and mica production at Chkalov, Popov Navolok, 8th of March, Chernaya Salma, Krivoye Ozero, Khetolambina, Panfilova Varakka, etc. was launched. The annual production rate was 40-60 000 t [2]. In 1932, for the first time in the Soviet Union, core drilling was first used there for pegmatite vein prospecting.

In the Chapter «Regional geochemistry» of the Section «The eastern Fennoscandian Shield» A.E.Fersman discusses the Maritime Region's localities, briefly describing big actinolite, almandine, epidote, scapolite, plagioclase and beautiful blue kyanite clusters in the Kem and Soroka districts. In 1925, he studied the White Sea Region's pegmatites. In the second revised and supplemented edition of "Pegmatites. Volume 1. Granitic pegmatites" he described the mineralogy and geochemistry of North Karelia's pegmatites [3].

Geologists of the Directorate for Mining Raw Materials of the Karelian-Kola Region, among them P.A. Borisov's disciples such as N.I. Ryabov, G.N. Buntin, L.A. Kosoy, P.V. Sokolov, V.A. Tokarev, L.Y. Kharitonov, N.A. Volotovskaya, V.N. Numerova et al., have contributed greatly to the discovery of big economic non-metalliferous deposits.

Owing to the well-planned prospecting-and-appraisal and prospecting of muscovite, conducted by the Northern Geological Prospecting Expedition and a great muscovite potential, the Belomorsk Mica Pegmatite Province became the Soviet Union's second mineral raw materials base, being inferior only to the Mamskaya Province in Eastern Siberia. The Belomorian Province, covering an area of 350 x 30-50 km^2, extends from the Leivoiva area on the north-east to the Belomorsk area on the south-east. Its near-axial segment consists of Chupa Suite aluminous gneiss productive for muscovite. There are several pegmatite provinces, such as Yensk, Chupa-Louhi and Kem-Belomorsk pegmatite districts, where 10 economic sheet mica deposits and many pegmatite occurrences [4] are located. In 1946-1996, geologists of the scientific institutes (KSC and KarRC RAS, VSEGEI, VIMS), higher institutions (LGI and LGU) and industrial geological prospecting organizations of Geological Surveys and mining concentration plants (Karelslyuda, Kovdorslyuda) revealed the main factors that control micaceous (and ceramic) pegmatites and their evaluation criteria.

Furthermore, the Northern Geological Prospecting Company conducted systematic mining under subdued landscape conditions. Originally, the prospecting shafts were 10–100 m deep. Dozens of mine shafts were driven. Exploitation was carried out by Karelslyuda Mining Concentration Plant.

As a result of considerable changes in the mica market situation in the 1990s [5], the mining industry infrastructure and the geological facility system have been irreversibly destroyed, social problems arose, raw materials standards were revised [4, 6] and commercial interests were focused on deficient fine-scale low-Fe mica and prospecting of profitable mica deposits. Large-scale structural drilling to a depth of 900-1200 m at Plotina and Rikolatva and prospecting-and-appraisal and exploration drilling to a depth of 300-700 m were conducted here. In the 1980s, the Northern Geological Prospecting Company drilled up to 30000 linear meters, making up 25% of the total amount of scheduled drilling operations conducted by Sevzapgeologia Company.

The story of the study of Karelia's kyanite occurrences, showing a transition from their evaluation for aluminium and silumin production is instructive. Eventually, kyanite has become a valuable industrial mineral. Its chemical and physical properties are essential mainly for the refractory and ceramic industries.

The first steps to a geological final report on Karelia's kyanite occurrences were made in 1929. The studies were ordered by Sovnarcom of the USSR in connection with aluminium ore prospecting and the launching of the aluminium industry for aircraft production. Several kyanite occurrences were discovered in North Karelia by V.S. Artamonov, P.A. Borisov, V.A. Tokarev and L.Y. Kharitonov in 1929-1934.

The geological structure of the area was preliminarily described by P.A. Borisov and N.A. Volotovskaya [7]. Its rocks were divided into six units, and the Khizovaara suite, which later became part of the Tikshozero (Pebozero) series of the Lopian complex on the Regional

Stratigraphic Scale, was recognized. Geological prospecting of kyanite deposits was conducted in 1940-1941 but was suspended because of the war. Prospecting continued in 1952-1953. The USSR State Committee for Reserves approved balance kyanite ore reserves within deposits considered as standard in terms of kyanite and harmful impurity concentrations and resources within deposits appraised as standard in terms of kyanite concentrations and non-standard in terms of harmful impurity concentrations and in pillars (Protocol 8578 of 4 December, 1953) [8].

In the 1930s, a programme on abrasives was announced in the Soviet Union. Therefore, the prospecting and appraisal of garnet ore occurrences became a pressing issue. It was proposed to use Karelia's localities for this purpose. P.A. Borisov drew attention to the Shueretsk District located on the Karelian shore of the White Sea. As a result, the Terbeostrov garnet ore deposit was discovered and appraised. For various reasons, the deposit was not mined, although its reserves were approved and tests for abrasives were positive. The garnet ore reserves of this deposit remain state balance reserves entitled *Abrasive raw materials* to this day [8]

In 1937, Karelian garnet was used for compiling a mosaic map of the Soviet Union consisting of various gemstones. On the map, 80 almandines from the Kitelä deposit indicated industrial companies and pyrope-almandines from the Terbeostrov deposit were part of the national flag of the Soviet Union on the North Pole. The map is now exhibited in V.N.Chernyshov Museum of Geology at VSEGEI [9].

Pioneer attempts to appraise Arctic Karelia for gold were made in the early 20^{th} century. Elevated gold concentrations of up to 1.5 and 11 g/t were revealed at the Shueretskoye copper deposit, in Shirkojärvi quartz veins and in White Sea falhbands [10], respectively.

In post-war years, pioneer metallogenic studies in Karelia, including its northern areas, were conducted. As a result, a series of metallogenic and forecasting maps, including special maps for molybdenum (1954) and nickel (1963) was compiled. At the same time, CZTGU (P.P. Dudinov, M.E.Staritskaya, V.N.Pliev et al.) began to classify the field materials obtained during geological survey, prospecting and research. The cadastres of various useful mineral deposits and occurrences were compiled.

In 1971, the Maiskoye gold deposit was discovered in the Kuolajärvi Structure, Louhi District and over ten gold-uranium occurrences were revealed later.

In 1974, TKE SZPGO staff members (Rabinovich Y.I., Korsakova M.A., Korovkin V.A. et al.) produced a 1: 500 000 scale metallogenic-forecasting map of the Karelian-Kola Region for copper, gold, base metals, pyrite and kyanite.

By the late 20^{th} century, many gold occurrences had been reported from other parts of Arctic Karelia (Lehta and Shombozero structures, White Sea Region) and the Lobash molybdenum deposit. Lobash-1 gold deposit had been prospected and their reserves had been approved by the State Committee for Reserves (GKZ) [11].

In North Karelia, geochemical and general prospecting of platinoids associated with gold were carried out under GDP-50 and GGS-50 in Olanga Group layered massifs, and prospecting of a quartz-vein type of gold in the Paanajärvi area and a gold-sulphide type at Kukasozero was attempted.

In 2001, VSEGEI compiled a 1:000 000 scale computer map of Karelia's Precambrian gold potential [12] which also shows gold prospects in North Karelia.

At the turn of the 20th and 21th centuries, large-scale geological prospecting and exploration for platinum-group metals were conducted in Arctic Karelia (Norit, Nornickel and Karelmet OJSCs). As a result, big promising PGM and gold occurrences, such as the Olanga Group of layered intrusions and Klimov Ore Zone were discovered. At the same time, the Canadian company Dia Met Minerals Ltd started drilling to verify magnetic anomalies for kimberlites in the Sokolozero prospect, Louhi District, where diamonds and their associated minerals, such as pyrope, chrome-diopside and chrome-spinellids, were found in heavy concentrates by the Central Kola Expedition..

By now, metallogenic studies in Arctic Karelia, conducted for almost a hundred years, have resulted in the discovery of several metallogenic useful mineral deposits and many promising ore occurrences that were formed mainly in the Lopian (2.7-2.8 Ga), Sumian (2.5-2.4 Ga) and Svecofennian (1.9-1.75 Ga) metallogenic epochs.

The Lopian epoch witnessed the formation of the deposits (d) and ore occurrences (o) of several ore formations: molybdenum-porphyry (d.Lobash, Mo – 0.06%, reserves – 140 000 t); gold-porphyry (d. Lobash-1, Au – 0.46 g/t, reserves – 34.4 t; Cu – 0.2%, reserves – 126 000 t); sulphide copper-nickel mafic-ultramafic (o. Tristun, Ni – 0.1-0.5%, Cu – 0.1-1.14%); sulphide copper-nickel-cobalt with Au and Ag (o. Kivguba, Ni – 0.09-0.6%, Cu – 0.1-1.85%, Co – 0.12-0.56%, Au – up to 0.9, Ag – up to 10 g/t) in Khetolambina peridotite-gabbro-anorthosites and their metamorphosed derivatives; PGM low-sulphide ultramafic-mafic with Ti and V (o. Travyanaya Guba, TiO_2 – 1.8-4.4%, V_2O_5 – 0.17-0.29%, PGM+Au – 1.58 g/t; o. Sumashevskoye) in the peridotites and other ultramafic rocks of the Palojärvi differentiated massif; gold-sulphide-quartz (o. Verkhniye Kichany) [13].

Big noble-metal ore bodies in Olanga Group layered intrusions (∑Pt, Pd, Au – up to 20 g/t, reserves 74.3 t, resources - ~200 t) and similar but smaller-scale occurrences in the Kuzema lherzolite-gabbro-norite complex (Panfilov Hill and Chupa) were formed in the Sumian epoch.

The Svecofennian metallogenic epoch is mainly represented by rare-metal pegmatite formation (o. Vizipoluostrov, Askijärvi, Nb 15-20%, Ta – 1%, Y - 2-3%, Zr - 2-10%, U - 1.3-1.9%) [14] and complex noble-metal occurrences in their aureoles and shear-zones: Klimov ore zone (Ni – 0.3–0.5%, Cu – 0.3–1.0%,Pd – 0.2–1.4 g/t, Pt – 0.1–0.3 g/t, Au – 0.3–0.6 g/t; resources: Au – 36.4 t, Pt–19.5 t, Pd–27.9 t, Cu – 316 000 t, Ni – 340 000 t), Khizovaara, Kartesh, Stepanova Lamba, etc. [15].

The Maiskoye gold deposit (Au – 1-n100 g/t, reserves - 0.2 t, resources – 5.7 t, 51 kg of gold have been produced) seems to have been formed polychronously: Rb-Sr (isochrone 1610±30 Ma) [16], Re-Os for native gold and chalcopyrite – 397±15 Ma [17].

The 1980-90s of last centure saw another burst of interest in garnet ores in Karelia, and some steps to appraise new ore localities were taken. Garnet ores were formed in a favourable setting with medium-temperature high-pressure metamorphism and a great contribution of metasomatism associated with acid leaching under kyanite-muscovite- and quartz-muscovite-facies conditions. This predetermines the eastern part of North Karelia, as the territory with the greatest potential and good garnet prospects, and here a large garnet occurrence "Vysota-181" has already been discovered. With respect to Vysota-181, it should be stressed that the occurrence is located in the mineralogenically promising Khizovaara Ore Field. Practical interest in the field is steadily growing because kyanite, muscovite and staurolite ores were discovered there.

Kyanite is an industrial mineral used in the refractory and ceramic industries and aircraft motor production. In Russia, no kyanite ore deposits have been mined yet. The economic prospects of the Mezhozernoye deposit are as good as those of the Khizovaara Ore Field; the deposit is promising for low-Fe scale muscovite production. Additional commercial quartz products from muscovite dressing waste and associated quart sand production make it possible to recommend the launching of the deposit-based waste-free production with a reduction in expenditures on the maintenance of the spoil heaps and tails. According to the US Geological Survey, the global mica production in 2014 was 1130 000 t. The milled mica (including micronized muscovite concentrates) demand is observed to grow [18].

Nuzhnekotozero anorthosites from the Belomorian mobile belt are a new type of feldspar deposits. There are several industrial rock types in this area, where grey anorthosites with up to 15% melanocratic minerals are well-defined; highly basic plagioclase (up to 74% An) is a major rock-forming mineral. The results of the preliminary technological assessment characterize anorthosites as a multipurpose raw material, which is a potential mineral resource base [19].

A pyroxenite-gabbro-alkaline formation with carbonatites is represented by the Yeletozero, Tikshozero and Vostochny massifs in North Karelia. The Suurivaara ore prospect of the Yeletozero massif is the most promising zone for ilmenite. In the 1950s, several mineralized bodies with titanium-bearing magnetite and ilmenite were sampled and appraised here at a prospecting-and-exploration stage of operations. Alkaline syenites are of great practical value [20].

The Karbonatitovoye deposit was revealed at the Tikshozero massif and studied. Apatite-bearing carbonatite, occurring in an area of about 2 km^2, is a complex ore type. Calcitic carbonatite is a major variety (CaO content 35.11 – 51.80). High-Ca and Mg-Ca carbonatites with apatite differ in petrochemical characteristics.

In the past few decades, the attention of many mineralogists and collectors has been attracted by pink corundum occurrences in North Karelia (Khitostrov, Dyadina Gora, Varatskoye, Nogrozero and Notozero). The Khitostrov occurrence, discovered in 1968 by the Prospecting Survey Team of the Northern Expedition of the Northwestern Territorial Geological Department headed by E.P.Chuikina, is the best-known and well-studied.

3. Mineral potential of Arctic Karelia

The mineral potential of three areas in Arctic Karelia is of great value as there are many deposits and occurrences and a variety of mineral reserves and resources to be developed there (Fig. 1)

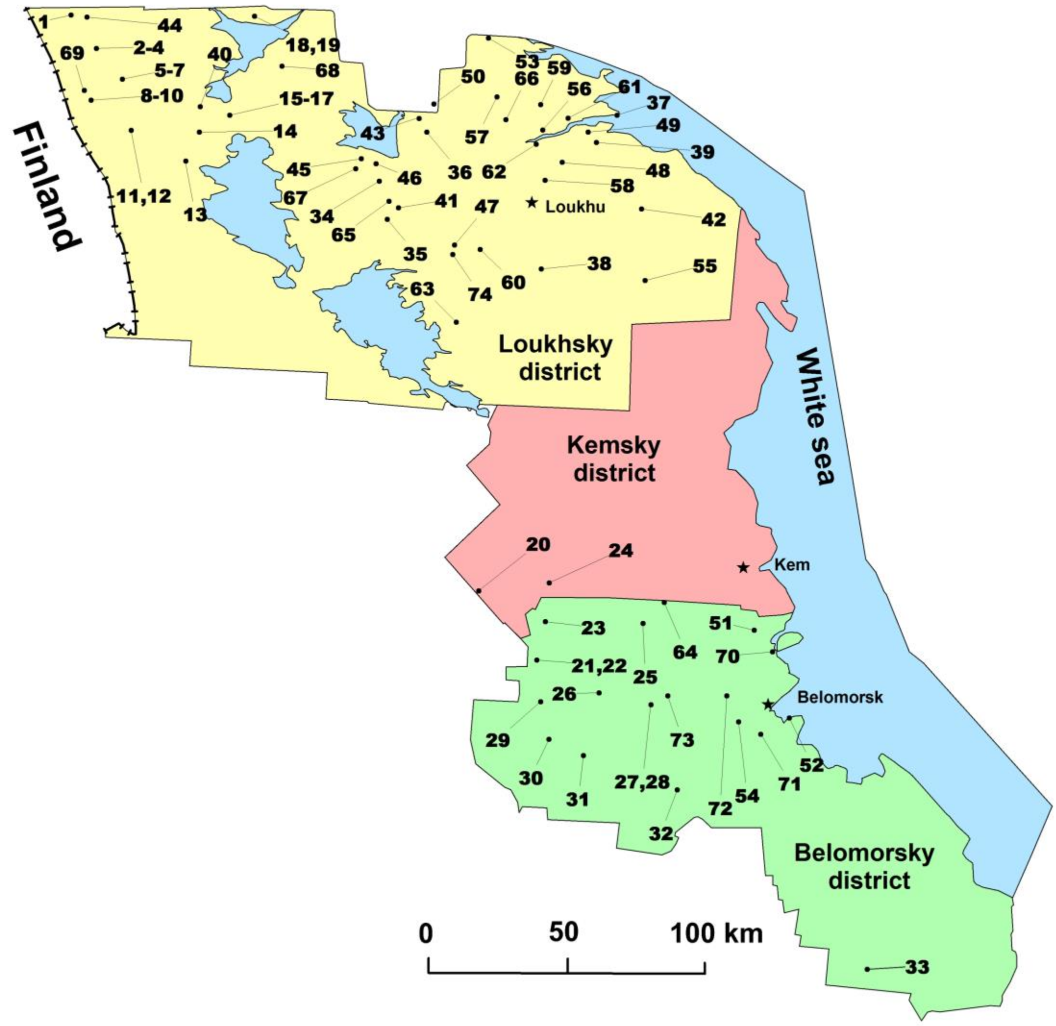

Figure 1. *Map showing the distribution of metal and industrial mineral deposits and occurrences in the Arctic region of the Republic of Karelia. Compiled by V.V.Shchiptsov, V.I.Ivashchenko*

1 – Au deposit Mayskoe, 2-12 – U-Au occurrences of Pana-Kuola structure 2 – Lagernoe, 3 – Ozernoe, 4 – Kvartsevoe, 5 – Sieppi, 6 – Isosieppi, 7 – Kautio, 8 – Albite-1, 9 – Heiknvara, 10 – Ristiniemi, 11 – Korpela, 12 – Suvalampi; 13-17 – noble metals occurrences of Olanga layered intrusions group: 13 – Kyvakka, 14 – Tsipringa, 15-17 – Lukkulaisvara (15 – Nadezda, 16 – Vostochnoe, 17 – Cherep); 18, 19 – rare metal pegmatites: 18 – Vyzypolyosrtov, 19 – Askiyarvi; 20 – Mo porphyry deposit Pyayavara; 21– Cu-Au porphyry *deposit Lobash-1, 22 – Mo porphyry deposit Lobash; 23-31 – Au occurrences of Lehta structure: 23 – Yuznaya Synda, 24 – Kolgevara, 25 – Maslozero, 26 – Vylyalampi, 27 – Shuezersky Cu-Mo-Au deposit, 28 – Rigovaraka, 29 – Zhelezny Vorota, 30 – Nigalma, 31 – Tunguda, 32 – Au Paiozero; 33 – Ni Pulozero; Eletozersky massif: occurrences 34 - Nb,Ta,La,Ce,Y,Zr,Hf,Be Eletozerskoe; 35 – Zr,Hf,Ce Chreroe; 36 – Au Ryaboyarvi; 37 - Au,Ag,Cu Medvezhya Gubka; 38 - PGM,V,Ti,Fe Travyanaya Guba; 39 – Cu, Ni Klimovskoe*

Industrial Minerals: 40 – Sokolozero diamond area; 41 – Surivara Ilm; 42 – Nikonova Varaka Qu; 43 - Stepanovo Ozero Qu; 44 – Mayskoe Qu. Tikshozero massif: 45 – Carbonatitovoe Ap, Ca; 46 – Vostochnoe Ilm, Ap. 47 - Hizovarskaya structure (Yuznaya Lense Ky, Qu, Py; Severnaya Lense; Vostochnaya Lense; Garnet ore occurrences Gr: 48 - Plotina; 49 – Levin Bor; 50 – Yniyarvi; 51 – Kozhruicheiskoe; 52 – Kuzostrovskoe; 53 – Nigrozero; 54 – Udinskoe; 55– Engozerskoe. Muscovite deposits (My, Qu): 56 – Malinovaya Varaka; 57 – Tedino; 58 – Slyudozero; 59 - Karelskoe; 60 – Mezhozernoe. Deposits Mi, Peg: 61 – Hetalambina; 62 – Chkalovskoe; 63 – Pirtima - My, Peg; 64 – Ohtinskoe Pole; 65 - Eletozero Fsp, Ne; 66 – Niznee Kotozero Fsp; 67 – Shapkozerskoe Ol, Du; 68 – Hankus Ol; 69 – Sovayarvinskoe- Carb; 70 – Terbeostrov Gr, Ky; 71 – Slyudyanoy Bor Fsp, peg; 72 – Torlov Ruchey; 73– Roza Lampi Fsp; 74 – Vysota181 Gr, Ky, Stav

Ap – apatite, Ca – calcite, Du – dunite, Fsp – feldspar, Gf – graphite, Gr – garnet, Ilm – ilmenite, Ky – kyanite, Mc – microcline, Ms – muscovite, Ne – nepheline, Ol – olivine, Peg – pegmatite, Py – pyroxene, Q – quatrz, St – staurolite, Carb – carbonates

The mineralogeny and mineral potential of the area is formed of metalliferous (Mo, Cu, U, Au, Ag, PGM, rare metals and REE) and non-metalliferous useful minerals (diamond, apatite, garnet, graphite, diatomites, ilmenite, carbonate rocks, quartz, quartzite, feldspar (ceramic pegmatite), feldspar (non-conventional types), kyanite; muscovite, olivinites (olivine), dunite and gemstones [21].

The Cu-Mo Lobash deposit was appraised as a big one, the reserves are large enough for the long-term operation of a mining concentration plant supplied with ore produced by the open-pit method.. Copper-molybdenum-porphyritic formation is the most representative for the entire Karelian region. Both known deposits in the Arctic zone of Karelia belong to this formation type. It is recommended to carry out assessment work at the Päävaara field, 32 km north-west of Lobash. In connection with the problem of the resource base of rhenium in Russia, the revaluation of both molybdenum deposits for this strategic and extremely expensive metal seems to be topical.

On the basis of the gold ore and complex (Au, Pt, U, Mo, Re, Se) ore objects known here, the Kuolajärvi structure predicts the possibility to identify Au-U Rompas type occurrences in neighboring Finland [22] and promising occurrences with high contents of rhenium.

On layered intrusions of the Olanga group, it is necessary to continue prospecting-and-appraisal workl and exploration for platinum group metals and gold. The price of the issue lies not only in the assessment, but also in the development of promising complex (Pt, Pd, Au, Cu, Ni) deposits with the aim of making a real economic contribution to the development of the mining industry in Karelia, as well as the North-West region as a whole.

The Tikshozero zone could provide a basis for the formation of a big low-waste, economically profitable mining province in North Karelia. It could become an efficient model system of the integrated use of mineral resources.

Today highly pure quartz, which is used in fiber-optic communication lines, the production of quartz glass and other industries, is in great demand on the world market [23, 24]. There are prerequisites that in the Arctic regions of Karelia, on a number of occurrences, together with the widespread milky-white quartz, it is possible to reveal such varieties of quartz, from which in the process of enrichment one can obtain highly pure quartz. However, serious geological studies and technological testing are needed.

Kyanite is a very important industrial mineral. In Russia, kyanite ore deposits have not been mined yet, although refractory materials are in considerable demand.

Low-Fe muscovite from the Mezhozerny locality was mentioned above as a new potential source fine-scale muscovite.

The dimension stone and crushed stone potential of Arctic Karelia is great. Over 23% of peat reserves and forecasted resources are located in the Belomorsk District.

4. Conclusions

The extraction and processing of useful minerals contribute to the economic wealth of all prosperous territories of the Russian Federation. In the marginal regions of Russia, mining is a major industry which provides up to 75% of all jobs. The small- and medium-scale mining business development concept in Arctic Karelia should be based on a principle which takes into account all useful minerals, including those totally controlled by the Federal authorities.

A target programme, aiming at forming a state order for prospecting and prospecting-and-appraisal exploration (gold, platinum, rare metals, REE and industrial minerals), is needed.

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