Present and future industrial minerals in Karelia (Russia)

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Karelia is an important non-metallic ore region of Russia and the source of various minerals such as muscovite, feldspar, quartz, shungite, natural stone, carbonate rocks, and rocks for smelting. Numerous industrial mineral deposits in Karelia are of potential interest for joint ventures. Foreign investors have new opportunities here. Firstly, there is a great demand for goods not only in Karelia, but also in Russia and possibly the world market. Secondly, there are guarantees given by the law regarding subsurface mineral rights in Russia and separately in Karelia and the law on foreign investments, which exist in the Russian Federation.

The following lines of research are important: (1) the development of techniques for complete utilisation of all industrial wastes and the production of mineral fertilisers, building materials etc., (2) assessment of highly decorative facing stone occurrences, (3) regional geotechnological evaluation of super clean industrial minerals, (4) assessment of non-conventional types of mineral raw materials, such as biotite, staurolite, andalusite, olivine, tremolite etc.

Through private and government structures the republic of Karelia is striving to develop mineral resources further.

In Karelia, which occupies an area of 172.4 x 103km^2, many Precambrian industrial minerals occur. Analysis provides a basis for subdividing them into a group of industrial minerals (monocrystals and crystalline aggregates) and a group of industrial rocks whose physical, chemical and technical properties are of practical value. They include deposits of the minerals muscovite, feldspar, quartz, kyanite, apatite, graphite, talc, garnet, barytes, fluorite, pyrite, ilmenite, and gemstones, as well as metamorphic, igneous and sedimentary rocks such as natural stone (granite, gabbro, gabbro-diabase, quartzite, marble, conglomerate), quartz porphyry, halleflinta, rapakivi, nepheline and alkaline syenites, talc-chloritic slate, low and high carbon shungite, quartzite, products of rock casting (picrite basalt and pyroxenite), carbonatites, carbonate rocks, and soapstone (Shchiptsov, 1993).

There are 90 deposits and more than 270 promising occurrences of about 25 types of industrial minerals, but only 27 deposits and 7 types are being mined — this refers to the Precambrian industrial minerals.

The pioneer investigations, which began in 1916 at the request of the Construction Department, Murmansk Railroad Agency, were conducted along the Petersburg-Murmansk Railway. The former private companies were involved in feldspar and quartz mining in the Chupa district and prospecting for talc, garnet, kyanite, limestone, mica and other non-metallic deposits.

The main production of industrial minerals in Karelia 1991-92 is shown in *Table 1*.

Deposits and occurrences

A number of deposits and occurrences are characterised briefly here (see *Figure 1*).

Muscovite

High quality muscovite is concentrated solely in the Chupa-Louchi district. A total of 34 deposits are known and Malinovaya Varakka, Plotina and Tedino are being mined. Sheet muscovite reserves are about 70,000 tonnes and 7,100 tonnes of raw muscovite were mined by Karelsluda in 1986-90. Scrap mica, containing tens of thousands of tonnes is dumped. Karelsluda produces the best muscovite in Russia. Raw mica is processed to produce commercial muscovite flakes in four sizes from P-50 (50-100cm) to P-4 (4-25cm).

Of great interest and practical value are the studies on the utilisation of muscovite concentrate and crushed concentrate, including superfine mica, production of fillers, pigments, wallpaper, varnish, paint, cosmetics etc.

Feldspathic materials

Karelian feldspar deposits are represented by various genetic types of granite pegmatite, which are being explored in detail. There are large grained pegmatite reserves, from which feldspathic raw material is conventionally produced by the following active enterprises — Hetolambino (26 veins, 27,000 tonnes of lump microcline, 468,000 tonnes of microcline pegmatite) and Luppiko (12,284 tonnes of pegmatite).

Feldspathic minerals can also be found associated with the following non-conventional rock groups — 1. rapakivi of the Pitkaranta terrain, 2. quartz porphyry of the Rosa-lampi deposit and halleflinta present in the overburden of the Kostomuksha iron deposit, 3. Yeletozero and Elisenvaara alkaline rocks. Non-conventional sources of feldspar may be mined in the near future.

Table 1. Production of industrial minerals in Karelia (tonnes)

Company or mill	*Products*	*1991*	*1992*	*Location*
Karelsluda ore dressing mill	Raw muscovite mica	494.1	300.7	Chupa
	Crushed quartz-feldspathic material	556,000	487,400	
	Lump quartz	6,439	1,505	
	Spar for glass	9,048	6,390	
Onega Mining Company	Granite blocks (m^3)	3,375	2,174	Rybreka
	Stone monuments (pieces)	3,072	4,395	
	Stone products (m^2)	1,560	1,800	
Rusceala lime plant	Limestone powder	18,000	5,300	Rusceala
	Lime	—	2,600	
	Decorative broken stone	—	229,500	
Stone - processing mill	Ornamental stone products (m^2)	352,900	278,300	Kondopoga
	Mosaic plates (m^2)	169,800	—	
Stone smelting and mineral mill	Melted stone	35,600	19,400	Kondopoga
	Mineral wool (m^3)	165,800	—	
	Pegmatite crushed	120,000	55,000	
Shungite mill	Crushed shungite (m^3)	509,200	350,700	Kondopoga
	Non-metallic materials (m^3)	—	84,200	
Pitkaranta Mining	Building crushed stone (m^3)	958,200	734,400	Pitkaranta
	Sand (m^3)	—	255,000	
Shoksha Mining Company	Building broken stone (m^3)	685,00	544,000	Kvartsitny
	Sand (m^3)	—	109,200	
Ladoga Mining Company	Building broken stone (m^3)	201,000	117,200	Pitkaranta
	Facing materials (m^3)	5,750	5,080	
	Pegmatite materials	—	63,876	
	Blocks (m^3)	—	2,092	
Prionezhskoe Mining Company	Building broken stone (m^3)	1,253,200	1,088,100	Derevyanka
Granite Industrial Design Company	Building broken stone (m^3)	135,100	77,100	Pudozh
	Crushed stone (m^3)	488,600	251,700	
	Sand-broken stone mixture (m^3)	—	68,500	
Kostomuksha ore dressing mill	Building broken stone (m^3)	548,400	519,200	Kostomuksha
Medvezhyegorsk broken stone plant	Building broken stone (m^3)	468,200	483,800	Medvezhyegorsk
	Stone (m^3)	—	900	

Because Karelia is rich in feldspathic raw materials, it will remain a major supplier for enterprises located in north-western Russia. These raw materials can be produced from both conventional sources, such as granite pegmatites, and from new ones which are not yet used in industry, but are more efficient than pegmatites.

Quartz

Quartz is found in northern Karelia where the veined bodies consist of differentiated pegmatites with quartz. The Karelian Research Center is offering a project on the investigation of these occurrences which it hopes will be a success.

Kyanite

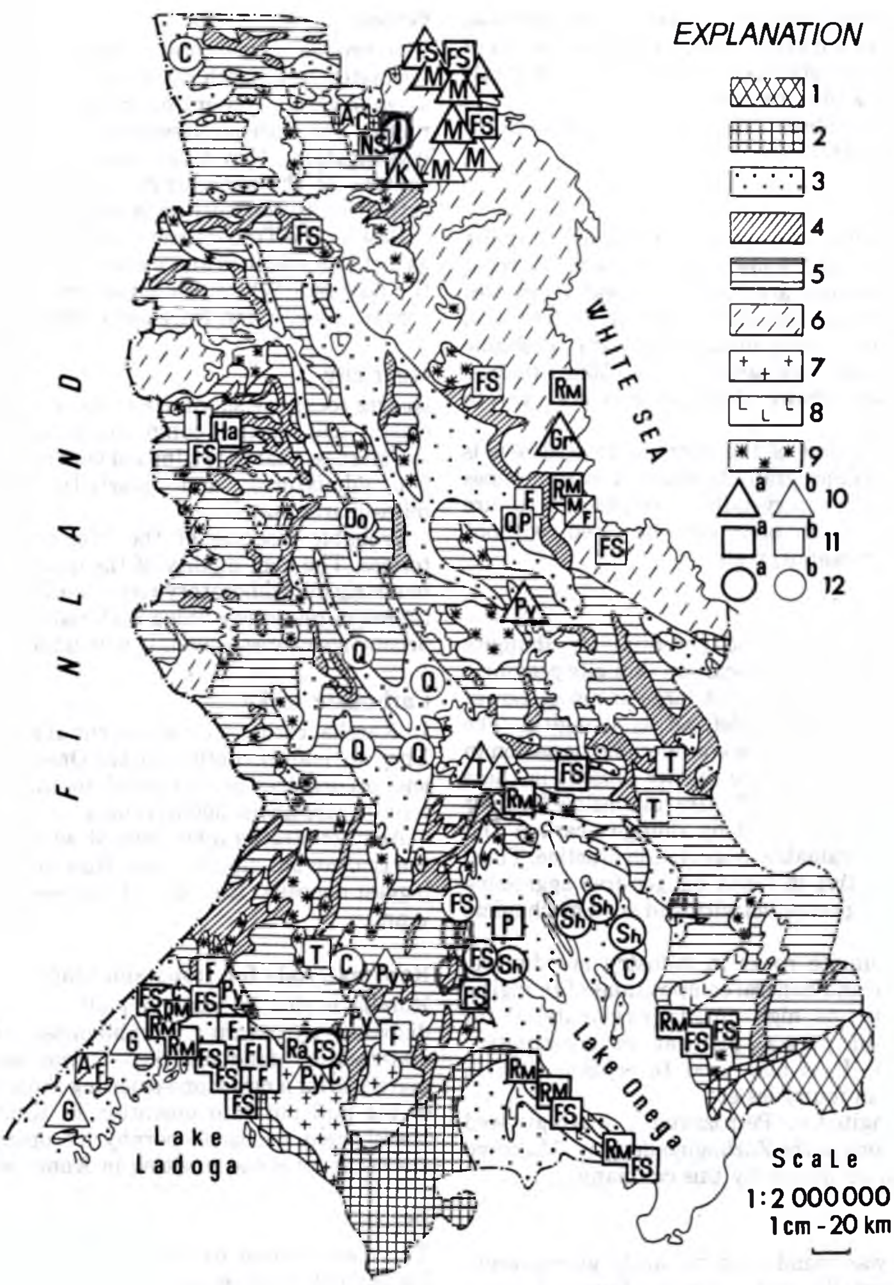
The biggest commercial kyanite ore reserves are concentrated in Hizovaara (northern Karelia). The reserves of the Southern Lens orebody are estimated to be about 4.5m. tonnes.

There is an experimental kyanite quarry in the Hizovaara deposit. Mining operations are carried out under license by IMK (Industrial Minerals of Karelia), a private company (of which the author is one of the founders). A licence is valid till the year 2018.

A group from the Karelian Research Center laboratory have been investigating the different genetic types, namely metamorphic, metasomatic-metamorphic and metasomatic types from lower Archean to Svekofennian activity (Proterozoic).

Talc and soapstone

Karelian deposits fall into three groups — talc-chlorite schists, talc-carbonate rocks, and talc proper in carbonate rocks. Currently there are two large deposits and 10 occurrences of talc-chlorite schist (pot stone). Talc-carbonate reserves are estimated to be more than 130m. tonnes for three deposits.



1 - Phanerozoic rocks.

Precambrian strata:
2 - Vendian and Riphean
3 - Karelian
4 - Lopian
5 - non-divided Lopian and Saamian
6 - Saamian

Intrusive complexes:
7 - Proterozoic granitoids
8 - basalts and ultrabasic rocks
9 - Archean intrusions

Deposits:
10 - metamorphic and ultrametamorphic genesis (a) mined or proven resources (b) potential resources
11 - magmatic genesis (a) mined or proven resources (b) potential resources
12 - sedimentary genesis (a) mined or proven resources (b) potential resources

Industrial minerals:
K kyanite, M muscovite, F feldspar & quartz-feldspar, Gr garnet, T talc, G graphite, A apatite, C calcite, I ilmenite, Py pyrite, Fl fluorite.

Industrial rocks:
Ha halleflinta, QP quartz porphyry, NS nepheline syenite, Q quartzite, SH shungite, Do dolomite, FS facing stone, RM road metal, P pyroxenite, Ra rapakivi.

Figure 1. Distribution of major Precambrian non-metallics in Karelia. Geologic sketch map adapted from Stenar, 1989.

Hydrothermal dolomite reworking gives rise to iron-free talc, which is a most valuable raw material used in the production of ceramics, perfumery, medical goods etc. Probable iron-free talc reserves are estimated at 5-10m. tonnes.

Today active quarries are absent, except for a small open pit in the Murenenvaara deposit.

Graphite

Imbricated, close-crystalline and cryptocrystalline graphite deposits and occurrences are known in southern Karelia. Macroimbricated graphite ores are found in great quantities south of Ihala. The average graphite content of the ore, determined at the most promising sites, is 2.8-4.4%. Probable graphite ore resources are estimated to be 55m. tonnes. Technological studies have shown that the ores are easy to upgrade.

The average graphite content of the microimbricated ores is 8-20%, but in close-crystalline graphite zones it is sometimes necessary to upgrade. Cryptocrystalline graphite ores are difficult to beneficiate. Such ores can be used without beneficiation in foundry, metallurgy etc.

Shungite

The Onega structural zone has good potential for shungite mining. It is a classic Proterozoic, high-carbon shungite province, which covers an area of 9,000 sq. km. A large group of Lower Proterozoic carbonaceous rocks are defined as shungitic. The mineral substrate composition and the considerable variation in the amount of carbonaceous shungitic matter present in these rocks (from a fraction of per cent to 99%) are responsible for their diversity. Peculiar textures displayed by shungite carbon and shungite rocks explain their valuable properties in practice. Thus, shungite carbon is very active in redox oxygen-free aggressive media. Shungite exhibits high conductivity and good mechanical strength.

The ways of using shungite rocks in industry are diverse, depending on the chemical and mineral compositions of shungitic rocks. The rocks are used as high quality raw material for shungisite production, oil paints, pigment in construction material and adsorbents. It is also used to replace coke in metallurgy and graphite in foundries etc.

Recently, Carbon-Shungite Co. (Petrozavodsk) was registered formally. Mining operations in the Zazhogino deposit (Maksovo sheet) are carried out under license by this company.

Fluorite

This industrial mineral was found predominantly in composite Sn-rare metal and polymetallic ores. Potential fluorite-bearing rocks are a new raw material in Karelia.

Sn-rare metal-fluorite ore has an average fluorite content of about 20%. Fluorite is present as phenocrysts, pockets and veinlets. The crystalline-granular aggregates are white, blue, violet, green and brown in colour. The crystals and aggregate clusters vary in size from fractions of millimetres to a few centimetres. Fluorite concentrates were produced by laboratory experiments with 60% fluorite being extracted from the ore.

Apatite

Two groups of terrains are most interesting. The Tikshozero group consists of alkaline ultrabasic rocks with carbonatites (the average P_2O_5 content of the latter is 4.3%) and small titanium-augite pyroxenite bodies with an average P_2O_5 content of 3.5%. Major beneficiation products of the apatite-bearing carbonatites are apatite, calcite, magnetite and mica concentrates. Total apatite and calcite concentrate yield from carbonatite is no less 65%.

The Elisenvaara group, composed of alkaline ultrabasic rocks, is remarkable for its average P_2O_5 content of 3.63%. Major beneficiation products are apatite, Sr- and Ba-bearing feldspar, REE-sphene, and biotite-phlogopite.

Garnet

The proven garnet ore reserves of the Terbeostrov deposit estimated to a depth of 10 metres are 155,500 tonnes, with an average garnet content of about 17%. The deposit is not being mined. The Karelian Research Center is carrying out additional investigations. New data is available which shows that the garnet content of the concentrate is no less than 90%, and garnet extraction to concentrate is no less than 81%.

Besides the Terbeostrov deposit, there also exist metamorphic garnet amphibolites and metasomatic garnetites forming part of the Saamian White Sea series and in the Belomoride-karelide contact zone, north Karelian Archean greenstone structure.

Quartzite

Quartz rocks are subdivided into several groups on the basis of clastic and matrix composition: quartz-cemented quartzitic sandstones, quartzite admixed with other minerals (no more than 5% admixture), and quartzitic sandstones with 5-40% mica-quartz matrix.

Probable reserves of the Metchangjarvi deposit are 20m. tonnes. The high quality of the quartzites was corroborated by industrial and laboratory tests. A mill, which will produce 20,000 tonnes of refractory lining materials and 80,000 tonnes of white decorative coarse gravel, is now under construction.

Carbonate rocks

In Karelia, carbonate rocks occur at several stratigraphic levels. They are mainly confined to the Onega horizon. Over 50 deposits and occurrences are confined to this horizon. The estimated reserves are about 300m. tonnes.

Another stratigraphic level at which carbonate rocks occur is the Ludicovian superhorizon. Rusceala I and Rusceala II are the biggest deposits. Rusceala II has been mined for more than 200 years.

Raw materials for stone smelting

Karelia is rich in basic and ultrabasic rocks such as gabbro, diabases, pyroxenites, amphibolites etc. used as major raw materials in stone smelting. It was necessary to provide raw materials for a new stone-smelting shop, which later became part of big mill put into operation in Kondopoga. Currently, the Havchozero pyroxene porphyrite openpit mine provides raw materials for stone smelting in Kondopoga.

Pyrite

There are several pyrite deposits and occurrences in Karelia. Parandovo (reserves 12.1m. tonnes), Vedlozero (0.8m. tonnes), Nyalmozero (4.4m. tonnes), Hautavaara (17.3m. tonnes), Chalka (0.8m. tonnes), Ulyalega (0.1m. tonnes), and Jolonvaara (2.1m. tonnes) have been prospected.

Ilmenite

Ilmenite mineralisation is related to iron-titanium formations. Suffice it to say that bodies with commercial titanomagnetite ore occur in central Karelia (the Koikary and Pudozhgorskoye deposits) and in northern Karelia (Tikshozero-Yeletozero ultrabasic gabbro-alkaline complex). As an example, the Surivaara ore unit of the Yeletozero terrane is best studied.

Natural stone

Depending on its use, stone falls into two main groups — dimension stone and crushed stone. The latter is used as a major constituent of concrete and as road metal. Currently 12 mills are operating in Karelia to produce about 6.5m. cu. metres of road metal per year.

In Karelia there are 20 proved ornamental stone deposits, some of which are mined (granite, gabbro, quartzite, marble), and about 100 potential ornamental stone deposits (granite, gabbro, quartzite, marble, conglomerate).

Table 2. Age distribution of Karelian Precambrian industrial minerals

Age interval (m. years)	*1*	*2*	*3*	*4*	*5*
1650±50		Rapakivi diamond, nat stone, Ba-Sr fsp	Barytes, fluorite	Quartzite	Apatite
2000±50	Nat stone (gabbro-diabase), gemstones, pyroxene porphyrite	Apatite, carbonatite, neph syenite, pegmatite, gemstones	Fluorite	Shungite, carbonate rocks Graphite	Muscovite, quartz, feldspar, andalusite, gemstones
2300±50		Ilmenite		Shungite, carbonate rocks, talc, nat stone, (marble, qtzite conglomerate)	
2600±50		Nat stone (granite, gabbro)	Talc		
3000±50	Halleflinta, talc-chlorite schist	Nat stone (granite, gabbro)	Nat stone (gabbro-amphibolite, granite), talc		Pyrite, graphite, garnet, quartz, gemstones
>3500					Garnet, kyanite, quartz, nat stone, (gneiss-granite, amphbolite), gemstones

1 Volcanic rocks & minerals; 2 Intrusive rocks and minerals; 3 Metamorphosed magmatic rocks & minerals; 4 Metamorphosed sedimentary rocks; 5 Metamorphic and metasomatic rocks & minerals

In 1993, a competitive bid was announced by the Karelian Committee of Geology for licences for the mining of 8 ornamental stone deposits.

Gemstones

The most widely distributed gemstones are amethyst, sunstone, moonstone, garnet, lydite, corundum, rose quartz, chalcedony and agate. Karelian gemstones are of interest.

Mineral utilisation

The Precambrian age distribution of Karelian industrial minerals is noteworthy (*Table 2*).

The general distribution of Karelian Precambrian non-metallic commercial minerals based on their industrial utilisation as follows:

1. Chemical and agrochemical raw materials (fertilisers, acid-resistant powders etc.). Eg. apatite-bearing carbonatites Tikshozero terrane; halleflinta, Kostomuksha deposit; Parandovo pyrite deposit etc.
2. Metallurgical and thermal insulating materials (fluxes, fireproof materials and thermal insulations). Eg. quartzite, Metchangjarvi; kyanite Hizovaara deposit; talc-chlorite schist, Turgan-Kolvan-Allusta and Kallievo-Murenanvaara deposits.
3. Technical raw materials (dielectric components, abrasives etc.). Eg. muscovite deposits (Plotina, Malinovaya Varakka, Tedino, Karelskoye, Sludozero); garnet, Terbeostrov deposit; quartzite deposits etc.
4. Building materials (building and ornamental stone, fillers, hydraulic additives etc.). Eg. granites (Shatkov Bor, Motorino, Suskujansaari, Ukkomaki, Mustavara, Kelivara, Kachina Gora deposits); gabbro (Nigrozero, Chernaya Salma, Keinoset, Ninimaki, Ropruchei); quartzite (Shoksha); marble (Belogorski, Kovadjarvi, Rusceala); shungite (Nigrozero and Myagrozero deposits); carbonate rocks etc.
5. Glass-ceramic materials. Eg. feldspar, quartz and pegmatite (Hetolambino deposit, Luppiko deposit); quartz porphyry, Rozalambi deposit; nepheline and alkaline syenites, Yeletozero deposit; rapakivi (Ukcu and Juka-koski deposit); halleflinta, Kostomuksha deposit; Ba- feldspar and Sr-feldspar, Raivimaki and Koivomaki terrains.
6. Cementing (binding) materials. Eg. carbonate rocks, Rusceala deposit, Kappeselga deposit, Lake Pyalozero, Chebino, Kautisjarvi, Sovajarvi localities; carbonatites, Tikshozero deposit etc.
7. Raw materials for new industries (fibreglass, mica paper, silicate cotton, molten stone, composite and special materials, bleachers, pigments etc.). Eg. shungite, Zazhogino deposit; pyroxene porphyrite, Havchozero deposit; kyanite, Hizovaara deposit; ilmenite, Yeletozero deposit; talc deposits etc.

8. Raw materials for environmental protection (sorbents, calcifiers). Eg. shungite, Zazhogino deposit; carbonate, Tikshozero deposit, carbonate rocks etc.
9. Coloured precious and ornamental stones. Eg. amethyst, belomorite, corundum, garnet, fuchsite, sunstone, rose quartz, lydite, agate, chalcedony etc.

Goals

Karelia's major goals are as follow:

1. to get rid of the monopoly of production;
2. to find substitutes for conventional products;
3. to seek optimum beneficiation methods and schemes;
4. to outline primary goals in the development and protection of mineral resources;
5. to reveal promising and forecastable types of non-metallics;
6. to reconstruct existing mining and processing companies and to set up new companies with due regard to three factors — material and technical factor (up-to-date mining equipment, reliable quality control system and computer-based operation); social and economic factor; and ecological factor ie. resource saving and low-waste techniques should be employed.

The programme for the study of non-metallic commercial minerals includes petrographic, mineralogical and geochemical assessment closely related to changing geodynamic regimes. This affects both regional and local forecasting of the mineralogical characteristics of the rock complexes which constitute one or another formation (Shchiptsov, 1990).

The polycyclic evolution of Precambrian zones is responsible for some characteristics of the geological structure of the region. It is possible to reveal the system dynamics of interaction and evolution by elucidating the developmental pattern of non-metallics. The non-metalliferous system is largely controlled by lithostratigraphic, magmatic, structural, metamorphic and metasomatic factors.

In Karelia, there are good reasons for distinguishing the Belomorian, Karelian and Ladoga geoblocks as the first-order constituents of the crust of the Fennoscandian field (Grishin et al, 1982). This provides a basis for the concept of the block structure of Karelia's lithosphere. Each geoblock shows a unique evolution of metamorphic processes, which is indicative of various types of metamorphism. According to Volodichev et al (1987), Karelia is characterised by the following types of metamorphism:

1. Ladoga: low-pressure andalusite-sillimanite type.
2. West Karelian: moderate pressure kyanite-sillimanite type.
3. Belomorian-Lapland: high pressure kyanite-sillimanite type.

The last type, characterised by high pressure and slightly increased geothermal gradient values, was responsible for the unique regional pattern of mineral formation in the Belomorian geoblock. This implies that metamorphic complexes, the most sterile geochemically, are related to relatively unique metamorphism. The pegmatites of the muscovite rock association, which contain among other varieties a type of muscovite used in TV-sets, are generally recognised as rocks indicative of the economic significance of the Belomorian geoblock. Granulite-facies metamorphism, characterised by low partial water pressure in the fluid, and regarded as the earliest metamorphism, has been locally reported from the Belomorian geoblock. Increasing temperature and decreasing pressure subsequently gave impetus to the melting processes. As a result, the structures of migmatite terranes were formed on a large scale within a quasi-closed geological system without a substantial addition of major rock-forming components. A general evolutionary pattern of fluid regime is characterised by the increased H_2O and decreased H_2 content of the fluid and a decline in both the H_2/H_2O ratio and the reduction coefficient.

Another example is based on the geological and technological study of kyanite ores from the Kichano-Hizovaara zone. Mineral occurrences of the Hizovaara kyanite deposit reported from the link zone of the Belomorian and Karelian geoblocks have suffered the Belomorian-Lapland kyanite-sillimanite high pressure type of metamorphism. Three types of ores are recognised — metamorphic, metamorphic-metasomatic and metasomatic.

The unique evolutionary pattern of the earth's crust in the Karelian geoblocks is taken into consideration when evaluating non-metallic deposits. The early Archean granite-migmatite areas of ultrametamorphism, which show increased tectono-metamorphic (metasomatic) protoactivity, are characterised by muscovite, feldspar, quartz and kyanite. Some commercial minerals such as apatite, kyanite, graphite and garnet, and commercial rocks such as halleflinta and talc-chloritic slates were formed in Archean granite-greenstone complexes. The Karelian complex contains some commercial rocks, such as low- and high-carbon shungites, quartzites, dolomites and marbles. A number of non-metallics such as apatite-bearing calcitic carbonates and barium- and strontium-bearing feldspars resulted from intrusive activity, as did building materials including granite, gabbro, gabbro- diabase and charnockite.

The following lines of research are important for outlining primary goals in the utilisation and protection of non-metallic commercial minerals (Shchiptsov, Scamnitskaya, 1990; Shchiptsov, Scamnitskaya, Shekov, 1993):

1. The development of techniques for the complete utilisation of all industrial wastes, including sewage, dust and gases, and the production of mineral fertilisers, building materials etc.
2. Assessment of highly decorative facing stone occurrences.
3. Regional geotechnological evaluation of superclean industrial minerals.
4. Assessment of non-conventional types of mineral raw materials such as biotite, staurolite, andalusite, olivine, tremolite etc.

Ecological, technological and economical problems arising in the development of mineral resources may be resolved by state-owned, joint stock and private companies.

Foreign investors have new and great opportunities. Firstly there is a law relating to mineral rights beneath the surface. For example, it is worth citing clause 9 from the Russian Law which was accepted in February 1992: "Clause 9. Users of subsurface land. Use of the subsurface earth can be by persons involved in business activities, regardless of forms of property, including juristic persons and citizens of other countries, unless otherwise stated in the laws existing in the Russian Federation".

Secondly, there are guarantees given by the law on foreign investments existing in the Russian Federation. According to this law, foreign investors have a right to remit profit or a share of profit abroad, to export their production and to import production for their needs without licence (if they have more than 30% foreign investment share in the equity capital of a joint venture). There is a further example from a decree by the President of the Russian Federation on facilitating work with foreign investments (September 27, 1993): " 5. The Council of Ministers - the Government of the Russian Federation - should complete in 1994 negotiations with foreign states for the conclusion of agreements on mutual protection and encouragement of investments and also step up the work with international financial organisations and national banks of foreign states for the attraction of credits for Russian investment projects".

There is, thus, a good legal rule for economic co-operation in the mining industry.

Numerous industrial minerals deposits and occurrences in Karelia are of great interest for joint activity.

More information is available in a publication on Precambrian industrial minerals of Karelia, prepared by the Institute of Geology, Karelian Research Center, Russian Academy of Science, which came out shortly before the International Conference "The Industrial Minerals of the Baltic/Fennoscandian Shield and New Technologies" held in Petrozavodsk, 7-14 September 1993. The staff of the Laboratory for Nonmetal Geology and Technology did their best to write the book and collected data on all types of non-metallic commercial minerals in Karelia.

Acknowledgement

The collected data on industrial minerals of Karelia is being carried out in conjunction with colleagues of the Laboratory for Nonmetal Geology and Technology (Institute of Geology, Petrozavodsk), particularly L. Scamnitskaya, T. Kulmala, V. Pudovkin, and V. Shekov, who should be a co-authors on this paper.

The author would like to acknowledge the exceptional attention given to him by Joyce Griffiths, editor, Industrial Minerals.

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