INDUSTRIAL MINERALS DEPOSITS OF THE FENNOSCANDIAN SHIELD (THE FODD PROJECT)

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МЕСТОРОЖДЕНИЯ ПРОМЫШЛЕННЫХ МИНЕРАЛОВ ФЕННОСКАНДИНАВСКОГО ЩИТА (ПРОЕКТ FODD)

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Разработана как один из результатов международного проекта Fennoscandian Ore Deposit Database – База данных рудных месторождений Фенноскандии (FODD) ГИС-система «Промышленные минералы Фенноскандинавского щита», включающая информацию о 35 видах минерального сырья в пределах данной территории. В целом представляются 576 месторождений промышленных минералов, а именно по каждой стране следующим образом – Норвегия 119 месторождений, Швеция – 225, Финляндия – 119 и Россия – 115. Издана карта промышленных минералов Фенноскандии М:1:2000000, предназначенная для стратегического планирования направлений разведки полезных ископаемых и исследований в области экономической геологии. Участниками проекта являются представители Геологических служб Норвегии, Финляндии и Швеции, Института геологии КарНЦ РАН, Геологического института КНЦ РАН и ГУП «Минерал».

A new map product, Industrial Minerals Deposits of the Fennoscandian Shield is presented. The map is a result of cooperation between the Geological Surveys of Finland, Norway and Sweden, SC Mineral, Saint Petersburg, Karelian Institute of Geology, Petrozavodsk, Russia and the Kola Science Center, Apatity, Russia. The purpose of the map is to show the most significant industrial mineral deposits of the Fennoscandian Shield and includes active mines and quarries, past producers, potential deposits and showings. About 10-20 %, with some variation between countries, of all registered industrial mineral deposits in each country`s national database is plotted on the map. In total 576 deposits, 119 in Norway, 225 in Sweden, 119 in Finland and 115 in Russia, are shown on the map. These deposits illustrates the variation in type and distribution of industrial minerals deposits in the Fennoscandian Shield, and their location in different geological provinces. In total 35 different commodities are plotted. The most common group of commodities comprise carbonates, feldspar, quartz, olivine, talc and magnesite, which together make up 65% of the total. The map will in due course be accompanied by an online database where the deposits and their most important information will be presented on an interactive map.

The industrial minerals map of the Fennoscandian Shield (Fig. 1) is a continuation of the FODD project (Fennoscandian Ore Deposit Database) it covers the same area and has the same geological base map as the Fennoscandian ore deposit map of the (Eilu et al 2013). The deposits are grouped into 5 size classes according to our best knowledge-of- size and tonnage.

Finland. In 2011 there were 33 active industrial mineral and industrial rock mines and quarries in Finland. Raw material of Palaeoproterozoic calcitic marble deposits of southern Finland are used for cement, fillers and paper pigments (Hyypiämäki, Ihalainen, Parainen, Tytyri, Kalkkiranta, Mustio). Dolomitic marbles are mined for agricultural use (Punola, Otamo, Vesterbacka, Matkusjoki, Reetinniemi, Matara, Ankele). Proterozoic soapstone hosted talc is mined from four open pit mines in eastern Finland. Finland has been the largest talc producer in Europe for decades. Finnish talc concentrate is used mainly in paper and pulp as well as paint and coating industries (Horsmanaho-Pehmytkivi, Lahnaslampi/Punasuo, Mieslahti-Pitkäperä, Uutela). Finland is the only European producer of wollastonite, a by-product from crystalline limestone deposit of Ihalainen at Lappeenranta. Industrial rocks are mined for rock wool and cement production, from six deposits. The Archean carbonatite hosted apatite deposit Siilinjärvi in eastern Finland is the biggest active industrial mineral mine in Finland and the only active phosphate mine in western Europe. Apatite concentrate is used in fertilizer plant nearby. Quartz is produced from three deposits (the main – Nilsia) of which one in south western Finland is also producing feldspar (Sälpä/Kyrkoberget). In addition, there are industrial mineral deposits, which are not currently in production like diamondiferous kimberlites and kaolin deposits at Virtaaslampi, south-eastern Finland, hard rock lithium deposits in western and southern Finland and world class phosphate deposit Sokli in northern Finland.

Norway. The unique geology of Norway, with belts of diverse metamorphic Caledonian allochthonous units lying above diversified crystalline Precambrian basement within a core of a continental collision zone, favours the formation of certain industrial minerals deposits such as the most important olivine, limestone, nepheline syenite, talc, ilmenite, quartz, feldspar, anortosite, magnetite with apatite as well as graphite is mined (Traelen). Norway is the world's leading producer of olivine and produces about 50% of the world annual production. The map contains several olivine occurrences with indicated resources in excess of 50 Mt. Until recently there were 3 olivine producing mines, however presently only one is active (Åheim (Gusdal bruddet). Talc – Altermark (active mine), feldspar (potassium) - Nedre Øyvollen, Svanvik, Glamsland (active mine). The Norwegian limestones occur essentially in two geological settings, one as part of the Cambro-Silurian succession of the Oslo rift and one as the part different tectonic units in the Norwegian Caledonides. The limestones of the Oslo rift are all low metamorphic marble that is used for cement production and agricultural use. The occurrences comprise several tens of deposits of high grade marble that is raw material for GCC (ground calcium carbonate) and some that burned for PCC (Participated calcium carbonate) production (active mine - Lillebukt karbonatitt, Hole Kalkverk Hovedbrudd, Bjørntvet, Dalen-Kjørholt, Visnes, Glærum, Meldal kalk, Tromsdal, Høylo, Hestvika, Akselberg, Øyjorda, Kjøpsvik). The Norwegian quartz deposits occur as rock forming quartzites, hydrothermal quartz and as part of pegmatites all with a very variable purity (Svanvik, Litangen, Bøleråsen, Mårnes). In Norway there are several potentially large deposits of apatite (Kodal, Misværdalen, Lillebukt karbonatitt}. They occur in various geological settings, alkaline intrusions within the Caledonian orogenic belt, as part of layered intrusions of the Bjerkreim-Sogndal intrusion, and as alkaline intrusions of the Oslo rift.

Russia. The Kola Peninsula comprises the following important industrial minerals provinces. On the central eastern Kola, the 1.9 Ga Keivy terrain contains some of the world's largest kyanite deposits (Vorgelurta, Tavurta, Tyapysh-Manyuk, Chervurta, Nussa, Manyuk and others). Kyanite deposits (the best natural refrectory) are unique in terms of resources

and the quality of raw material. They are accompanied by deposits and occurrences of sillimananite, garnet, veined quartz. The Devonian alkaline Khibiny complex hosts some of the largest apatite deposits and is perhaps one of the most important industrial mineral provinces within the Fennoscandian shield. The OJSC Apatit enterprise, which is located on the Kola Peninsula, was the leading producer of apatite concentrate in Russia and one of the world's leading suppliers of phosphate raw material; its core activities were the mining and beneficiation of apatite and nepheline-syenite ores at 10 deposits (Partomchorr, Kyelporr, Kykisvumchorr, Yuksporr. Apatitovy Tsirk, Eveslogchorr, Rasvumchorr, Koashva, Oleny Rychei, Njorkpahk), nephtline is aluminium raw materials and raw material for the production of potash, technical glass Another massif containing a wide range of industrial minerals, besides Khibiny, is the Kovdor intrusion, where apatite, rare-metal ores with baddeleyite (ZrO_2), phlogopite and vermiculate are commercial minerals. Other alkaline-ultrabasic intrusions analogous to Kovdor – Seblyarvi, Vuoriyarvi, Sallanlatva, Lesnaya Varaka, Afrikanda, Turij Mys and others also contain a wide range of industrial minerals such as apatite, phlogopite, baddeleyite, titanomagnetite, barite, olivines and so on. Ceramic feldspar deposit KuruVaara is mined.

The Northern part of Karelia comprises a number of feldspar, muscovite, quartz, kyanite and large garnet deposits (Belomorian province). The south eastern Karelia, the northern part of the Lake Onega, is the only place in the world where shungite rocks are mined (Zazhoginsnskoe deposit – Zazhogino and Maksovo quarries). Shungite rock unique by composition, structure and properties. It is an original by structure natural composite with uniform distribution of highly-dispersion crystal silicate particles in amorphous carbon matrix. Average size of silicate particles is about 1 micron. The rocks in the deposit contain about 30 per cent of carbon and 70 per cent of silicates. The rock is characterized by high hardness, density, chemical resistance and electrical conductivity. It possesses a number of unusual physical, chemical, physical-chemical and technological properties. The properties of shungite are quite original which explains its very often unexpected applications. The graphite deposit Ihala, east of the lake Ladoga, was discovered. The probable reserves of the ore field includes about 6.4 Mt tons of graphite. A thick trending Melomais quartz vein zone was discovered in the eastern Karelia. It is large enough to be considered as the unique potential quartz occurrence in the Fennoscandian Shield.

Sweden. The largest industrial mineral deposits of Sweden are carbonate rock deposits, comprising Paleozoic limestone deposits and Early Proterozoic crystalline carbonate rock deposits. Currently, there are approximately 20 carbonate deposits in operation (Gäsgruvan, Albrunna, Bro Dacker, Karleby/Uddagärden, Gullhögen/Vämb, Ullstorp, Brunflo, Jutjärn, Ignaberga, Järsta, Kallholen, Forsby, Klinthagen St. Vikers, Stucks and others). Quartz and feldspar have been produced from several hundreds of minor deposits known from all over the country (Flätungebyn/Ämnebyn, Ulerud, Valön/Kilane, Forshammar/Limbergsbo). Only the largest deposits are shown on the map. Large talc, olivine and magnesite deposits associated with ultramafic rocks are found within the Caledonian thrust nappes of Sweden. Current production of soapstone and talc occurs at Handöl. Fluorite-mining is planned at the Storuman sandstone-hosted fluorite deposit. Several small fluorite occurrences are known but not exploited. Graphite is also known from several small occurrences but only a few has been, or are, of economic size. The most promising prospect is currently at Nunasvaara, in the Kiruna area, and several deposits around Kringeltjärn, central Sweden. Apatite is present in large quantities in the apatite-iron-ores in the Bergslagen and Norrbotten areas but apatite extraction has been minor (Gruvberget, Leveäniemi, Kirunavaara, Malmberget). In addition,

minor occurrences of high alumina silicates, mica, anthophyllite, nepheline, wollastonite, garnet, beryll and clay minerals are also presented in the map.

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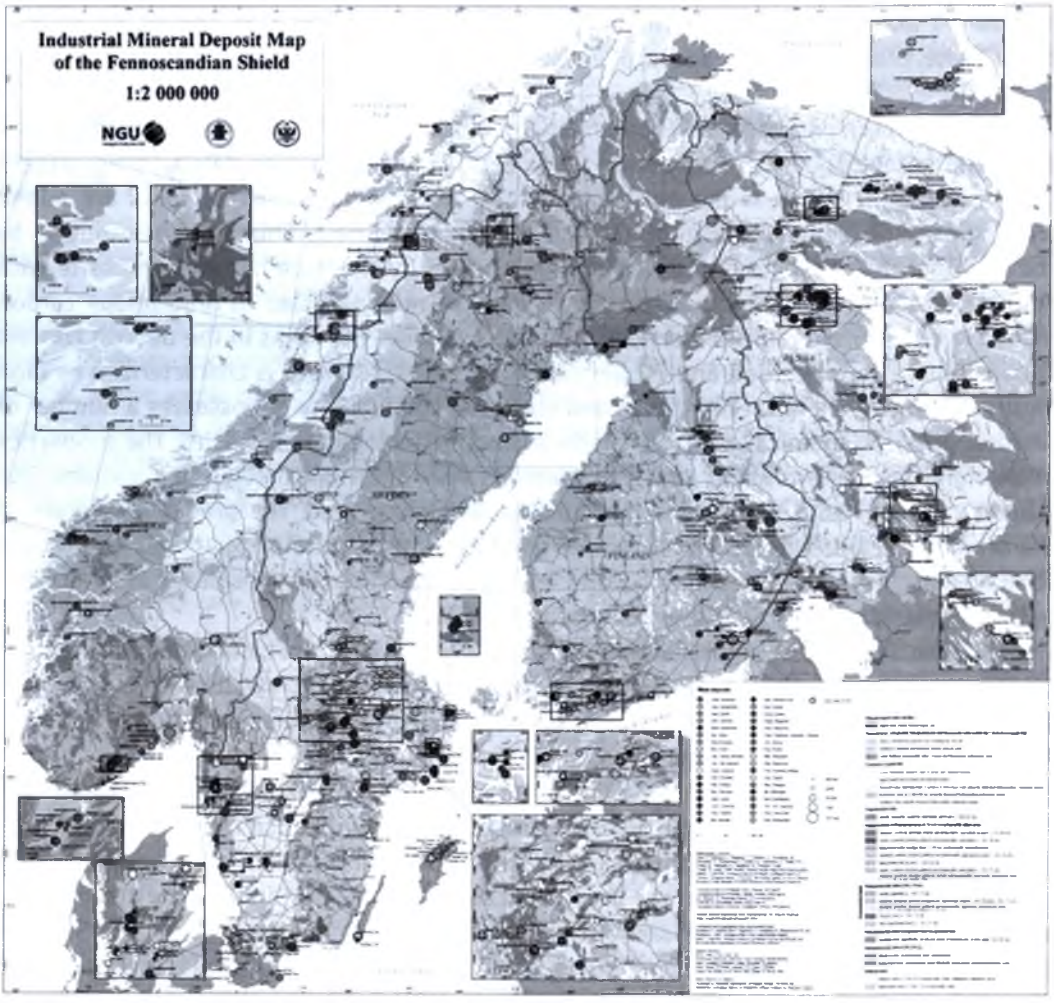

Fig 1 Industrial Minerals Map of the Fennoscandian Shield