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SECTOR REPORTS

State and outlook of the mining industry

Mining Industry
– Sector Report 2018 | Heino Vasara

SECTOR REPORTS

Description sheet

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Abstract

Mining industry is highly cyclical, influenced by the trends in raw material prices on the world market. The current economic situation of Finnish mines is quite good. Increased mining operations have also created new technology companies and boosted the growth of SMEs. Mines located in Finland constitute a good customer reference for SMEs aiming at the international market. From the perspective of international mining companies the Finnish technology and service providers are often quite small. Networking and collaboration with companies that serve as drivers offer opportunities in internationalisation and passing on sector-specific expertise. The mines improve Finland's raw material self-sufficiency, but refining of metals in this country is still dependent on raw material imports. The growing threat of resource nationalism is one of the reasons why self-sufficiency in metal concentrates has to be increased to ensure that the operations of the downstream industries will continue.

In 2016 the turnover of metal ore and industrial mineral production totalled about EUR 2 billion and it employed directly about 4 500 persons in Finland. In 2016 there were ten active metal ore mines and 27 industrial mineral mines in Finland. Most of the active mines and mining projects are located in eastern and northern Finland. Mining investments totalled about EUR 240 million, showing a clear increase from the year before. Investments in ore prospecting started to grow as well. The society needs mineral raw materials, and without effective ore prospecting no new mines will be opened to replace the depleting mines. Many of the active mines have expanded their operations. In 2016 a total of 28 million tonnes of ore was quarried from the Finnish metal ore mines and the production of usable rock for industrial minerals totalled 15 million tonnes. Measured by the quarrying volume the three largest mines in Finland were Kevitsa, Talvivaara ja Siilinjärvi. All of these are open quarries.

Mining has long traditions in Finland. The advantages we have include the good geological knowledge base, ore potential and infrastructure, high level of education, and social and economic stability. Mining is a global business. A good deposit combined with thorough and responsible groundwork makes it easier to attract external financing. The prices of certain metal may rise in the near future, also because of the new technologies that are being developed. New business opportunities for companies may be created relating to sustainable solutions to sustainable mining, side streams management, water treatment and social perspectives, or to other new technologies. Mining operations must be further developed in an environmentally, socially and economically sustainable manner while promoting dialogue with the other economic activities.

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Greeting

The mining industry has gone through challenging times over the past several years. Now as the world economy is yet again growing steadily, the demand for raw materials is increasing. During economically difficult times, the specific development areas of mines have been measures to increase productivity in order to improve profitability as well as contributions to environmental investments.

In addition to mining activities, Finland has strong technological expertise in mining machinery, as well as significant metal refining activities and metal industry. Investments in renewable energy and energy storage increase the need for basic raw materials, but also increase demand for new raw materials such as cobalt and lithium. The mining and metallurgy industry also sees new possibilities in the circular economy, which comprises cross-sector and cross-value chain activities, and in the utilisation of side streams.

High-quality exploration and new findings secure the future and create a new foundation. Today, the number of active exploration taking place in Finland is growing as is the number of actors that are involved in the sector.

This report presents the present state and future of the Finnish mining sector.

Helsinki, 08 February 2018

Ilona Lundström
Director General
Ministry of Economic Affairs and Employment of Finland

Contents

Foreword

The starting point for the sector reports publication series is to collect and combine material from different sources into sector-specific basic information packages which present the views of experts. These are intended to help small and medium-sized businesses in decision-making. At the end of 2017 and in early 2018, a total of 5 sector reports will be published. These reports will cover renewable energy, the mining sector, the social and health care sector, tourism, the software sector and technical consultation.

The reports are available free of charge on the MEE Business Sector Services web page at www.temtoimialapalvelu.fi. The short-term outlooks for these sectors are supplemented and updated twice a year in Business Sector Prospects reviews. The key figures for each sector group by company size category are available to the public on the Sector Online information system at http://www2.toimialaonline.fi/. The goal is for sector reports and the Sector Online information system to form a basic information package that supports the planning and handling of company projects as well as in determining labour market training needs.

The mining industry's sector report examines the sector's current news, structure, markets, economic issues, development needs and future outlooks. The sources used include the latest information materials and the views of the sector's companies. The report is intended for companies, financiers as well as to fulfil the needs of organisations and stakeholders that serve the sector.

The outlook for the mining industry both in Finland and globally is more positive than previously. The mining sector has proved to be a new client segment for technology suppliers and service providers. Metallic mineral mines have improved Finland's self-sufficiency with regard to refining activities. Political risk factors and resource nationalism of various countries as well as growing logistics costs further increase interest in Finland's mining industry. The mining industry help maintain the competitiveness of refining plants located in Finland. The sector's companies operate predominantly outside of growth centres, which has helped create jobs specifically in Northern and Eastern Finland. Problems have also arisen as growth has taken place, and a great deal of criticism has been voiced for mining activities. Mining companies are tasked with proving the positive overall effects of their activities in the area their establishment is in and for minimising the harmful environmental and social impacts as well as harmful effects on other industries in the area.

The report was put together by a working group led by the MEE's Senior Adviser for Mineral Policy Riikka Aaltonen. During the preparation of the project, responsibility for drafting the report was divided between the Geological Survey of Finland (GTK), MEAE Business Sector Services and the Finnish Mining Association's Executive Director Pekka Suomela. At the GTK, Mari Kivinen has headed writing work and authors have included Asko Käpyaho, Juhani Ojala, Janne Hokka and Harry Sandström. Jussi Pokki has been responsible for creating maps. Additionally, numerous colleagues commented on the content of the text. GTK's strong contribution produced new content for the report. I want to thank the representative of Tukes with whom I have had many discussions and who provided materials.

In addition to the aforementioned parties, I would like to thank those who have written previous reports for the excellent templates they have provided. The tight timetables last autumn made the work very intense. The main objective while working on the report has been to update information. I hope that this report encourages the sector to take part in constructive discussion and activities as well as serves those who are interested in the sector.

Rovaniemi 31 October 2017

Heino Vasara
Head of the mining sector

1 Industry structure

1.1. Industry companies in Finland

Table 1 presents metallic mineral mines located in Finland. Four of these are gold mines. Other mines produce chromium, copper, nickel, zinc, sulphur, cobalt, silver and platinum group metals (PGM). Foreign enterprises own the majority of metallic mineral mines. Two metallic mineral mines are owned by Finnish enterprises. The reason for this is that Finland does not have the needed capital for mining activities. Finland does not have sufficient domestic capital funding for the mining sector, and for this reason over the past few years the majority of investments have come from international sources.

Table 1: Finland's metallic mineral mines 2016. Source: Tukes.

Mine, municipality	Company name	Name of the parent company	Key valuable minerals	Average number of personnel
Kittilä (Suurikuusikko), Kittilä	Agnico-Eagle Finland Oy	Agnico-Eagle Mining Ltd. (CA)	Gold	459
Kemi, Keminmaa	Outokumpu Chrome Oy	Outokumpu Oyj	Chromium	457
Jokisivu, Huittinen (concentrating plant in Sastamala)	Dragon Mining Oy	Dragon Mining Ltd. (AU)	Gold	81
Orivesi, Orivesi (concentrating plant in Sastamala)	Dragon Mining Oy	Dragon Mining Ltd. (AU)	Gold	
Pyhäsalmi, Pyhäjärvi	Pyhäsalmi Mine Oy	First Quantum Minerals Ltd. (CA, UK)	copper, zinc, sulphur, iron	226
Talvivaara, Sotkamo	Terrafame Oy	Terrafame Group Oy	zinc, copper, nickel	626
Pampalo, Ilomantsi	Endomines Oy	Endomines AB (publ) (SE)	Gold	76 (2015)
Kylylahti, Polvijärvi (concentrating plant in Kaavi)	Boliden Kylylahti Oy	Boliden AB	copper, cobalt, nickel, zinc	133
Kevitsa, Sodankylä	Boliden Kevitsa Mining Oy	Boliden AB	copper, nickel, PGE	393

In 2016, industrial minerals were excavated at 27 underground or open-pit mines in Finland. Active production is not performed at all licensed industrial mineral mines every year. Carbonate rocks were excavated from 13 mines and other industrial minerals from 14 mines.

Table 2: Industrial mineral mines and quarries in Finland Source: Tukes.

Municipality (underground/ open-pit mine)	Company name	Name of the parent company	Key valuable minerals	Average number of personnel
Paltamo (Reetinniemi)	Juuan Dolomiittikalkki Oy		dolomite	
Huittinen (Matkusjoki, Putkinotko, Siivikkala), Lappeenranta (Ihalainen), Savonlinna (Ruokojärvi), Lohja (Tytyri), Parainen (Limberg-Skräbböle), Sipoo, Vimpeli (Ryytimaa), Raasepori	Nordkalk Oy Ab	Rettig Group	calcite, dolomite, wollastonite	407
Tornio (Kalkkimaa), Pieksämäki (Ankele)	SMA Mineral Oy	SMA Mineral AB (SE)	dolomite, quartz	32
Salo (Hyypiänmäki)	Salon Mineraali Oy	Omya Oy	calcite	13
Kimito (Sälpä), Siilinjärvi/Kuopio (Kinahmi), Kimitoön (Kyrkoberget)	Sibelco Nordic Oy Ab	Sibelco Group	feldspar, quartz	74
Siilinjärvi	Yara Suomi Oy	Yara International ASA (NO)	Apatite	899
Sotkamo (Uutela, Punasuo), Polvijärvi (Pehmytkivi, Horsmanaho)	Mondo Minerals B.V. Branch Finland	Mondo Minerals B.V. (NL)	talc, nickel	
Lapinlahti (Joutsenenlampi), Mäntyharju (Lehlampi), Savitaipale (Metsäasianniemi), Salo (Sallittu), Parainen (Ybbernäs)	Paroc Oy Ab	Paroc Group Holding group	industrial stones	368

Finland has significant mining technology and service expertise, but the expertise is fragmented. A few large, leading companies that are drivers of business have been identified. The lack of medium-sized companies that are drivers of business is believed to slow down the SME sector's growth and internationalisation. The centralised ownership structure of the mining sector and the market position of global actors result in challenges for such things as commercialisation where the importance of customer expertise, customer insight and direct contacts is emphasised. Commercialisation cycles are long in the capital intensive,

slowly developing mining sector. The importance of pilots and test projects is emphasised as is that of a sufficient understanding of the mining sector and professional expertise.

According to the reports, the change in the way mining companies operate, the development of procurement practices and the outsourcing of work open up new business and service model possibilities. Mines operate with a smaller and lighter organisation than previously and the supplier network is given added responsibility. The domestic market is small in size, but functions well as a reference market. Companies view northern Finland, Sweden and Norway as an extended domestic market, as operating principles are largely the same and the actors and operating methods are familiar. Additionally, the actors in the region have engaged in cooperation and distances between sites are short.

From the perspective of large, global mining companies, Finnish technology suppliers and service providers are small, which means that networking and cooperation with companies that are drivers of business is an opportunity to internationalise. When planning international business operations, it is important to note that international clients do not buy just technology, but also require a service network. Networking and cooperation are also seen as an opportunity in transferring mining sector expertise between companies.

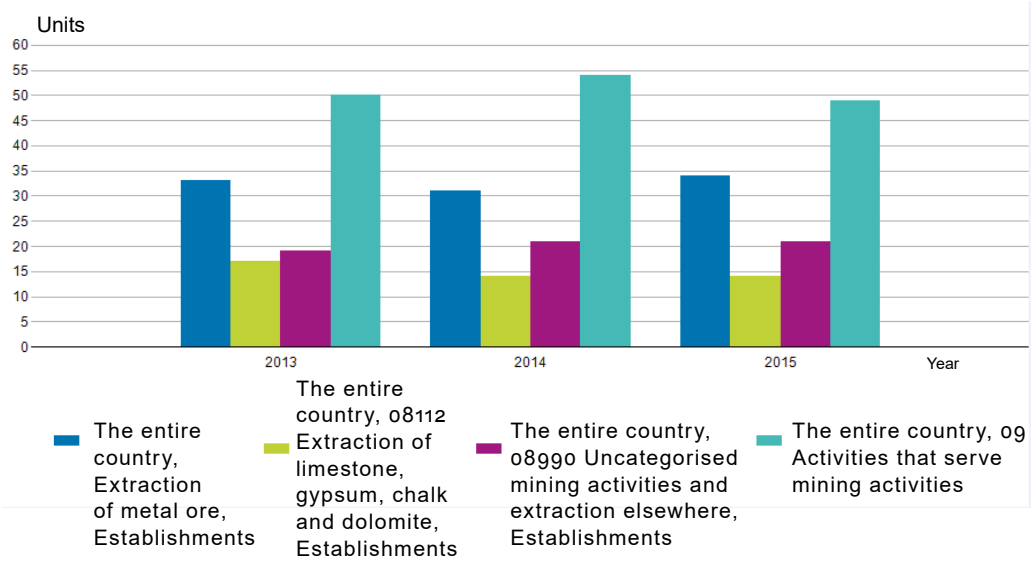
Four key development proposals have been drawn up on the basis of a company survey and interviews: 1) increasing customer insight, 2) support for networking, 3) support for the commercialisation stage, 4) development forum to support the coordination of networking and development measures.

1.2 Establishments in Finland

According to Statistics Finland, in 2016, enterprises classified under Mining of metal ores (TOL 07) operated in 34 establishments in Finland's municipalities. Three enterprises in 12 establishments carried out excavation of limestone, gypsum, chalk and dolomite (TOL 08112). The number of establishments falling under the 'Other mining and quarrying n.e.c.' group (TOL 0899) was 21. Companies that provided mining support service (TOL 09) were located in 49 establishments. The number of enterprises that provided mining support services grew from the previous year.

In the case of enterprises operating in the mining industry, statistics based on Statistics Finland's industrial classification are indicative, because enterprises that carry out mining operations are also classified under industry groups other than those mentioned here.

Figure 1: Number of establishments in 2013–2015 Source: Statistics Finland's Register of Establishments annual statistics (TOL 2008)



1.3 Regional distribution of the sector

Mari Kivinen GTK

There are an abundance of interesting areas for mining activities and exploration in Finland (Figures 3 and 4). The greatest materials of interest in Northern and Eastern Finland are metallic minerals, whereas in Southern Finland mining focuses on industrial minerals, especially carbonate rocks (i.e. limestone). In Eastern Finland talc and soapstone deposits are of the greatest importance. Metallic mineral mines are the largest mines in Finland with regard to volume of ore extracted. The one exception to this is the apatite mine in Siilinjärvi. Apatite is used in the production of fertilisers as a source of phosphorus. Figure 5 depicts the difference in extraction volumes between open mines in Talvivaara, Kevitsa and Siilinjärvi and underground mines in Kemi Pyhäsalmi and Kittilä. In addition to large mines, there are also an abundance of metallic and industrial mineral mines in Finland that extract small and medium volumes of ore. The majority of these are located in Eastern and Southern Finland. The most important utilisable metal extracted from these metal mines is gold and the most important industrial mineral extracted is carbonate (i.e. limestone).

As Figures 3 and 4 show, there are numerous exploration and mining projects currently underway in Finland. Before actual mining activities can be launched, the exploration and planning along with licence processes can easily last 20 years for one site. The expectation for launching of activities at a mine that has already previously been active and is being reopened or at sites where investigations and preparations have progressed a long way is that that the timetable will be shorter. Figure 3 aims to describe the preparation stage of projects that are currently underway, in other words how far along each site has gotten in preparing for mining activities. The main focus of exploration projects is on locating mineral deposits and carrying out a resource assessment. In practice, an effort is made to determine

whether the deposit contains an adequate amount of valuable materials for it to be viable to proceed to the planning of mining. If the decision is made to plan a mine, the main focus of the project will shift to the design of technological solutions and the assessment of environmental impacts, which go hand in hand with the licence application process. However, at the same time, the investigation of the characteristics of actual mineral deposit will continue and the resource assessment will be further specified. The conditions for further planning are determined with feasibility studies, which proceed from a preliminary feasibility assessment to a detailed feasibility assessment. If the detailed feasibility assessment is in favour of opening a mine and the licence, funding and technical solutions are ready, the enterprise can make a decision to open a mine. After this, actual construction can begin.

There are currently five projects in Finland, which are quite close to the launch of actual mining activities: The Taivaljärvi silver mining project (Sotkamo Silver Aktiebolag), the Hautalampi cobalt and nickel mining project (Alandra Oy), the Keliber lithium mining project (Keliber Oy), the Hannukainen iron mining project (Hannukainen Mining Oy) and the Kaapelinkulma gold mining project (Dragon Mining Limited). Dragon Mining is preparing to open the Kaapelinkulma mine during 2018. The plan is to process the ore at the same company's production centre in Vammala. Also the size of the mineral resources in the Pahtavaara gold mine and the possible reopening of the mine are being investigated at the moment (Rupert Resources Limited). There are three projects currently in the preliminary feasibility assessment stage: the Sakatti copper and nickel deposit (Anglo American Plc.), the Otanmäki iron, titanium and vanadium deposit (Otanmäki mine Oy) and the Lahtojoki diamond deposit (Karelian Diamond Resources Plc.) Additionally Sokli, Suhanko and Mustavaara are currently inactive mining projects and the Laiva gold mine in the midst of a stoppage.

There are also exploration projects underway. The majority of projects are related to gold and base metals, but also to for example graphite and lithium. In addition to the projects shown on the map, exploration permit data listed in Tukes-maintained mining registry (the map shows that a exploration permit is valid or an application for an exploration permit has been submitted) indicates that there are also other exploration projects underway or pending. The number of applications for exploration permits also indicates that that interest in exploration has grown in Finland once again.

Figure 2. Active mines in 2016. The figure depicts the volume of ore extraction at various mines; the number of tonnes of ore extracted at a mine and the size of the circle drawn at the mine are directly proportional. The mine itself is located in the centre of the circle. Information source: TUKES, GTK. Map drawn by: GTK.

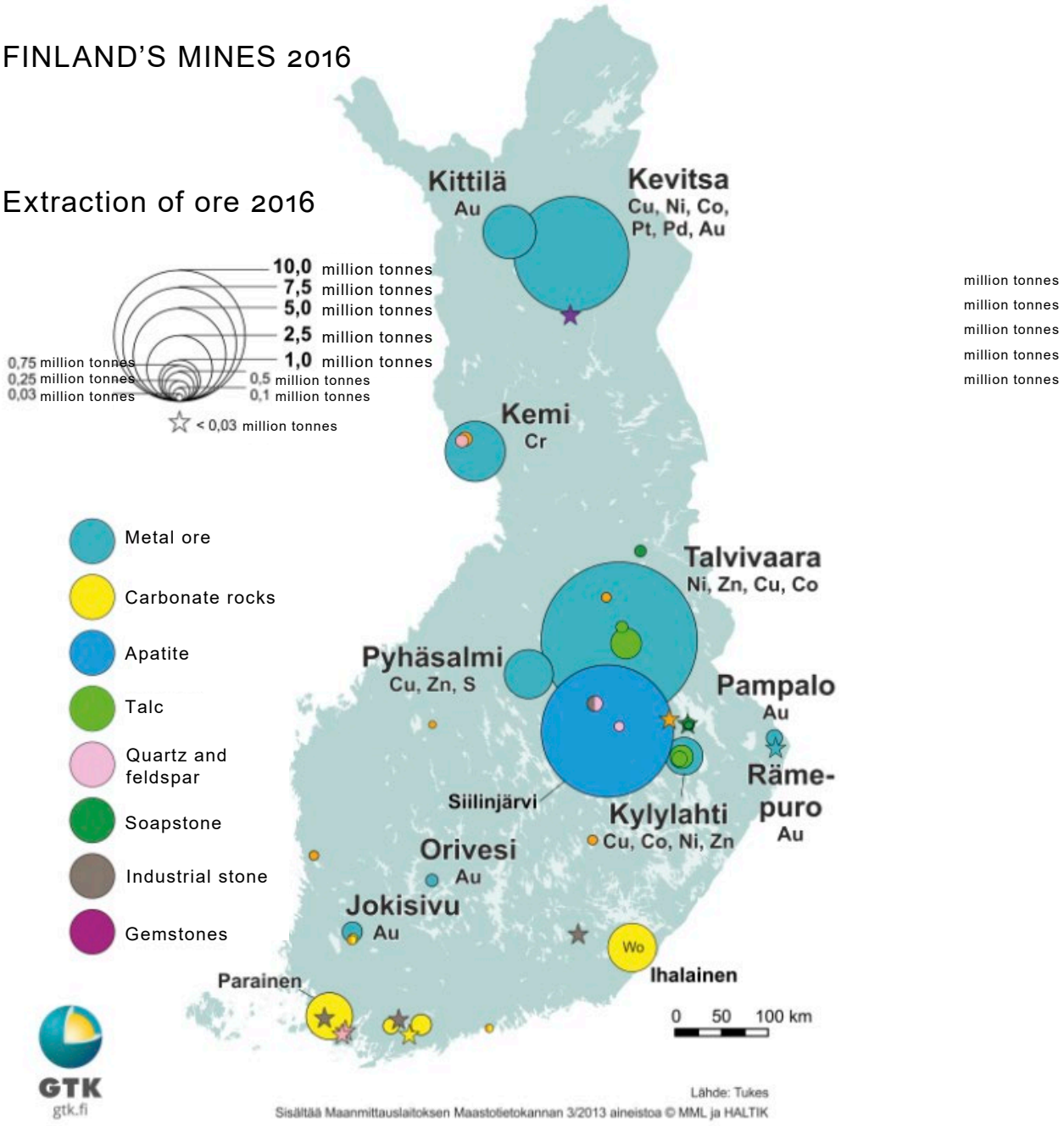


Figure 3. Current exploration and mining projects in autumn 2017. The section in the box is presented in more detail in Figure 4. Information sources: Communication by companies and contact with companies, TUKES. Map drawn by: GTK.

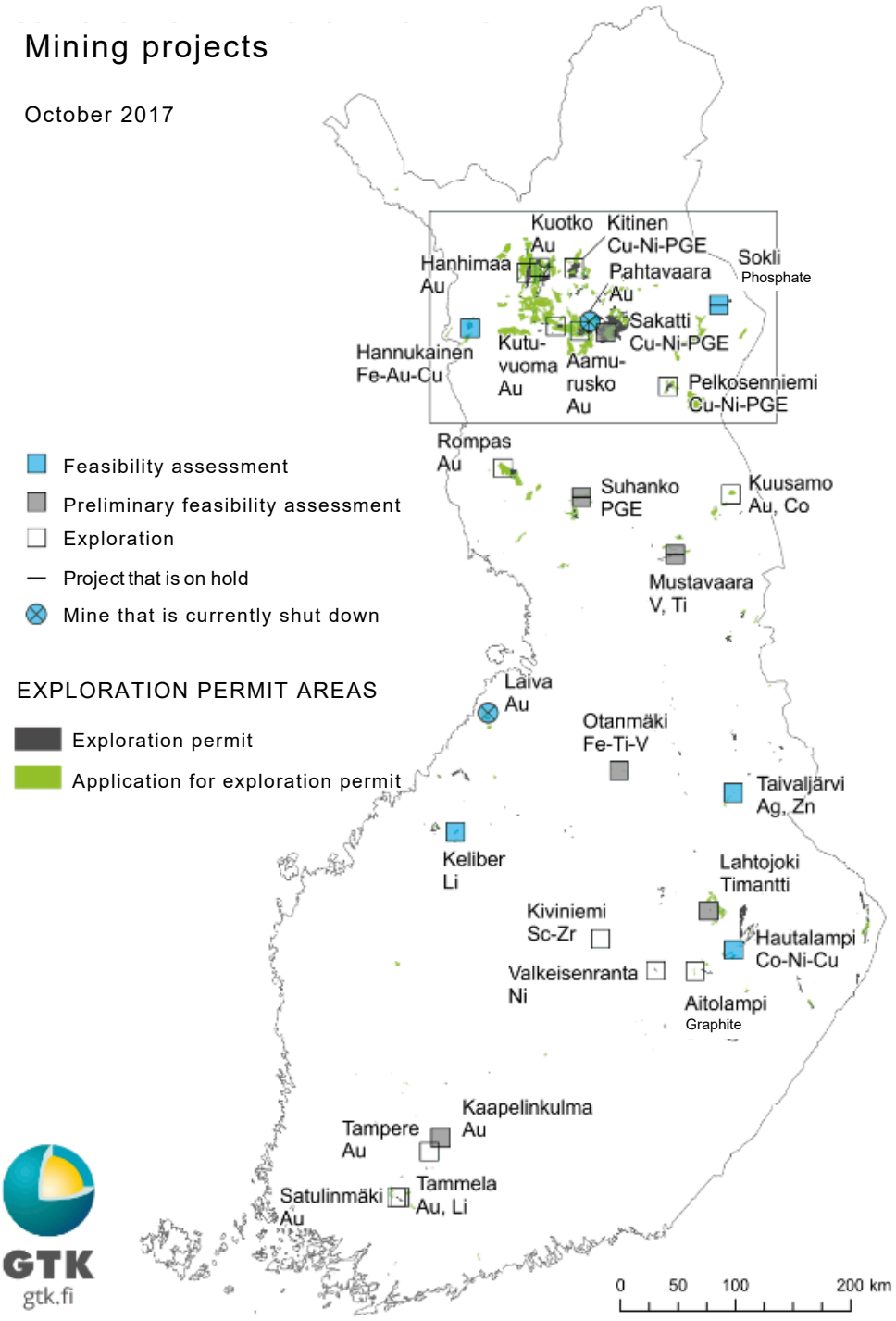
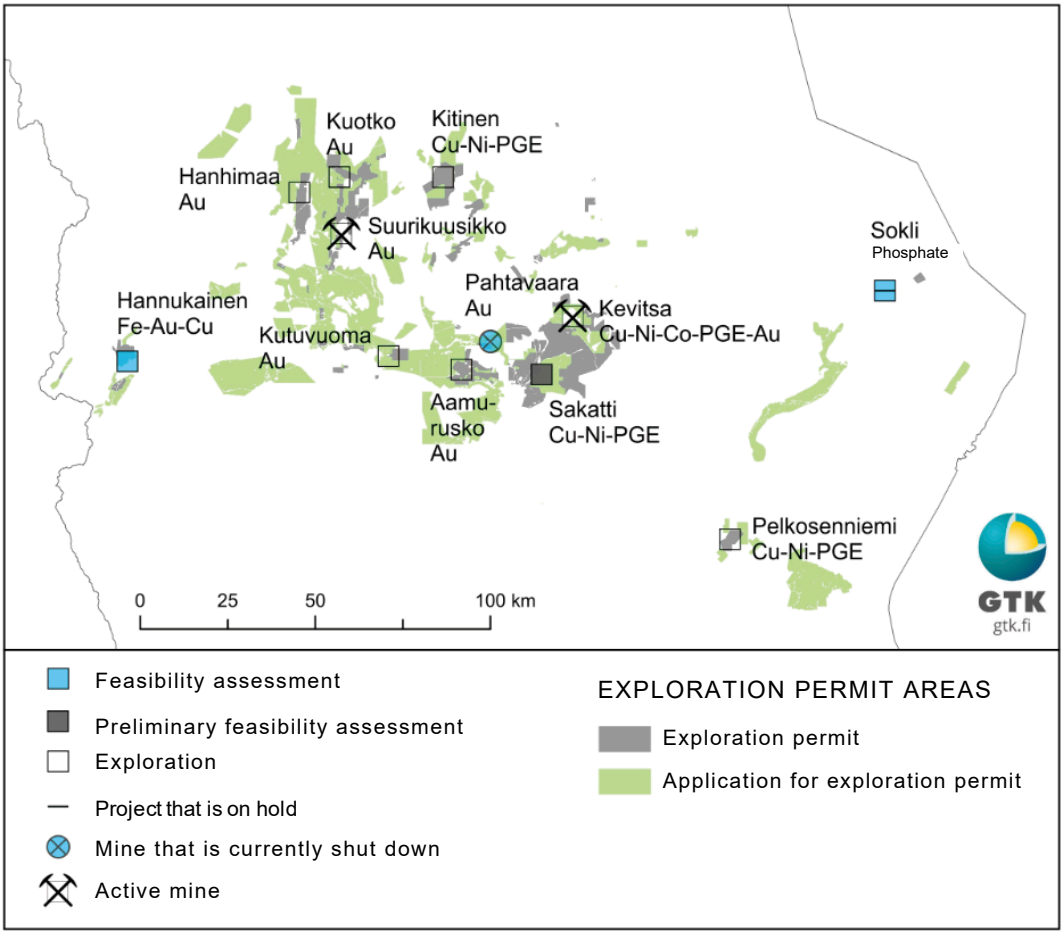


Figure 4. Current exploration and mining projects in autumn 2017 in the Lapland region. Information sources: Communication by companies and contact with companies, TUKES. Map drawn by: GTK.



2 Production volumes and logistics

2.1 Production volumes

In 2016, a total of 79.8 Mt of ore and waste rock was extracted from Finland's metallic mineral mines. Of the extracted material, ore accounted for 28.3 Mt and waste rock for 51.4 Mt. The extraction of ore grew from the previous year by 33 % and that of waste rock by 30 %. The extraction of waste rock was decreased for example by underground extraction.

In 2016, Kevitsa extracted 39.6 million tonnes of metal ore meaning 50% of the total amount extracted. Talvivaara extracted 32.6 million tonnes of metal ores, which was 41% of the total metal ores and associated waste rock extracted in Finland. Talvivaara's share of extraction volumes grew significantly from the previous year. Other metal ore mines where the total volume of extraction exceeds a million tonnes are the Kemi chromium mine (2.1 Mt.), the Kittilä gold mine (2.5 Mt.) and the Pyhäsalmi mine (1.4 Mt.).

Figure 5: Extraction of metal ores and associated waste rock 2004–2016 Source: Tukes.

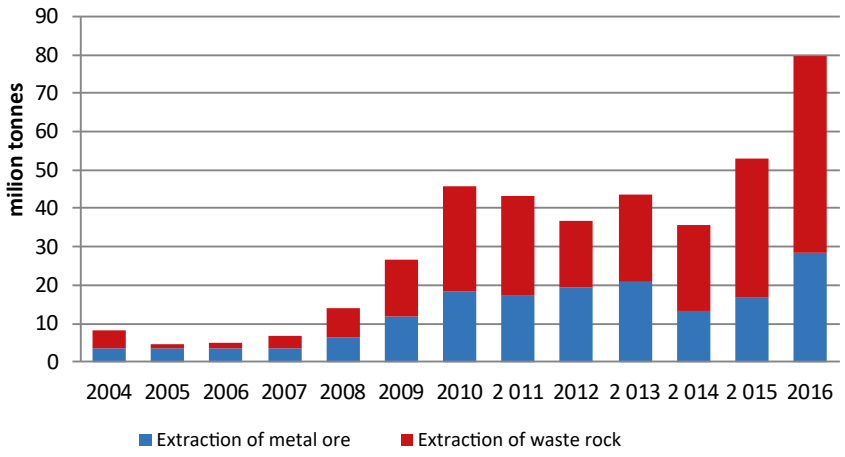


Table 3: Extraction of metal ores and associated waste rock 2009–2016 Source: Tukes.

tonnes	2009	2010	2011	2012	2013	2014	2015	2016
Extraction of ore	11,845,051	18,191,462	17,213,074	19,591,999	20,846,551	13403495	16869885	28314264
Extraction of waste rock	14,795,402	27,590,444	26,113,162	17,232,758	22,786,745	22414874	36009984	51446976
Extraction, in total	26,640,453	45,781,906	43,326,236	36,824,757	43,633,296	35818369	52879869	79761240

The most important metals produced were chromium, zinc, copper, nickel, cobalt, gold and silver. In 2016, production of metal concentrates totalled 2.25 Mt. The production of metal

concentrates declined a bit from the previous year. In 2016, a total of 11,153 kg of gold and 118,180 kg of silver were produced.

Figure 6: Production of metal concentrates in Finland 2007-2016.
Source: Tukes, GTK, Ministry of Economic Affairs and Employment.

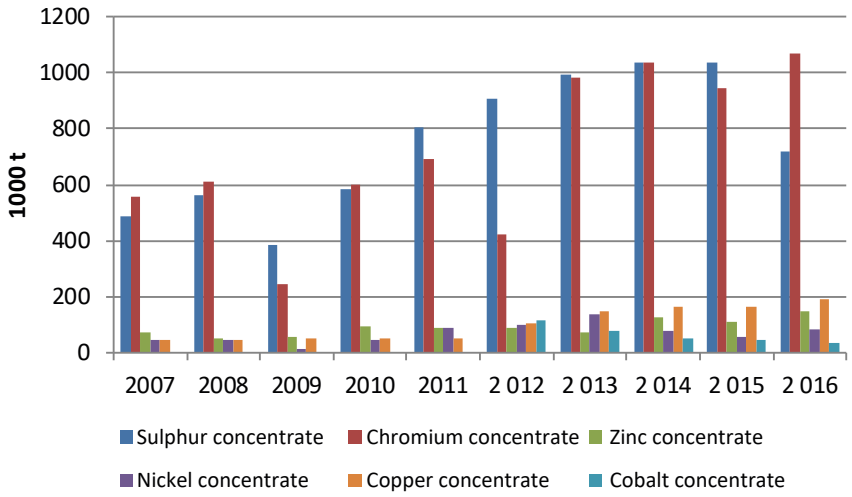


Table 4: Production of metal concentrates in Finland 2010–2016.
Source: Tukes, GTK, Ministry of Economic Affairs and Employment.

tonnes	2010	2011	2012	2013	2014	2015	2016
Sulphur concentrate	584,085	804,884	909,299	994,155	1,035,637	1,039,671	719,102
Chromium concentrate	598,000	692,527	425,217	981,752	1,034,750	946,188	1,070,281
Zinc concentrate	95,305	87,974	89,026	72,910	126,801	108,303	149,981
Nickel concentrate	43,151	91,196	99,089	137,911	77,425	55,585	84,073
Copper concentrate	50,709	48,668	104,393	145,758	163,016	165,021	193,349
Cobalt concentrate			117,819	76,210	51,258	44,419	35,463
Total	1,371,250	1,725,249	1,744,843	2,408,696	2,488,887	2,359,187	2,252,249

Extraction of industrial minerals includes the extraction of carbonate rocks and other industrial minerals. Other industrial minerals include apatite, talc, quartz and gemstones. In 2016, a total of 15.2 Mt of industrial mineral ores were extracted from mines in Finland. The ore extraction volume decreased 0.5 million tonnes from the previous year. The volume of waste rock extracted in turn grew by 1.8 million tonnes from the previous year. In 2016, the Siilinjärvi apatite mine was the third largest mine in Finland in terms of extraction volume. A total of 28.3 million tonnes of ore and waste rock were extracted.

Figure 7: Industrial minerals; extraction of ore and waste rock 2004–2016. Source: Tukes.

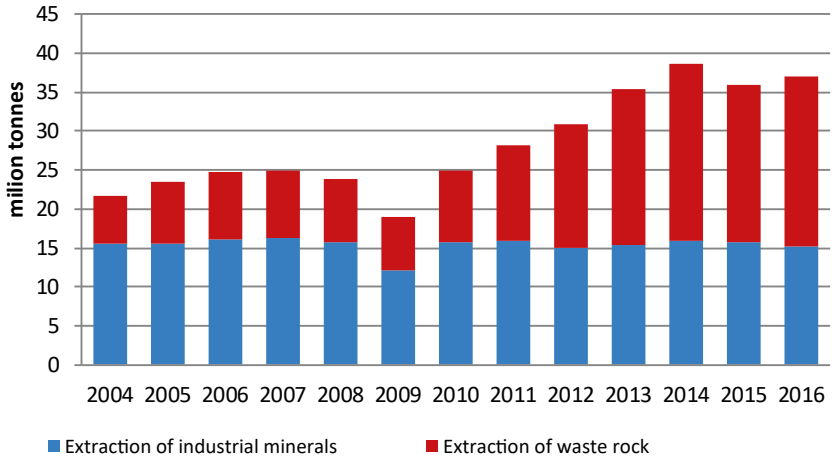


Table 5: Industrial minerals; extraction of ore and associated waste rock 2010–2016. Source: Tukes.

tonnes	2010	2011	2012	2013	2014	2015	2016
Extraction of ore	15,655,442	15,967,678	15093327	15447331	15859564	15719963	15167539
Extraction of waste rock	9,242,542	12,117,724	15830526	19994664	22824380	20127739	21873273
Extraction, in total	24,897,984	28,085,402	30,923,853	35,441,995	38683944	35847702	37040812

According to Figure 8 and Table 6, the overall production of raw material for stone wool, apatite concentrate, talc. quartz, mica concentrate, feldspar and biotite totalled 1,614,698 tonnes in 2016.

Figure 8. Production of industrial mineral concentrates and products in Finland 2007–2016. Source: Tukes, GTK, Ministry of Economic Affairs and Employment.

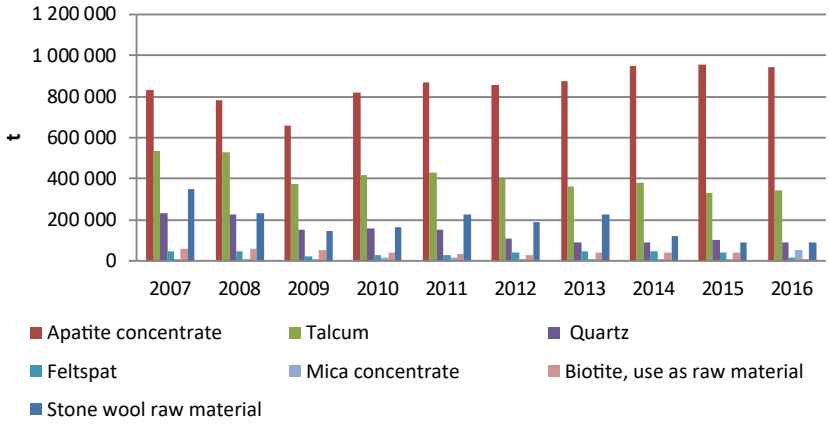


Table 6: Production of industrial mineral concentrates and products in Finland 2009–2016. Source: Tukes, GTK, Ministry of Economic Affairs and Employment.

tonnes	2010	2011	2012	2013	2014	2015	2016
Apatite concentrate	817,289	869,694	858,005	877,189	946,234	956,564	939,531
Talc	419,345	429,494	396,332	361,840	380,821	332,174	345,739
Quartz	160,545	153,159	111,183	90,131	87,903	103,587	92,813
Feldspar	28,013	26,292	43,124	47,636	46,233	38,026	18,549
Wollastonite	12,100	11,500			0		
Mica concentrate	13,809	12,896	12,112	11,244	11,973	11,836	52,310
Industrial biotite	37,850	31,504	27,493	42,150	41,973	38,169	10,843
Raw material for stone wool	161,734	223,584	188,896	226,926	122,822	88,280	87,680
Magnesite sand					12,276	22,390	54,227
Soapstone products					20,369	17,430	13,006
Total	1,650,685	1,758,123	1,637,145	1,657,116	1,670,604	1,608,456	1,614,698

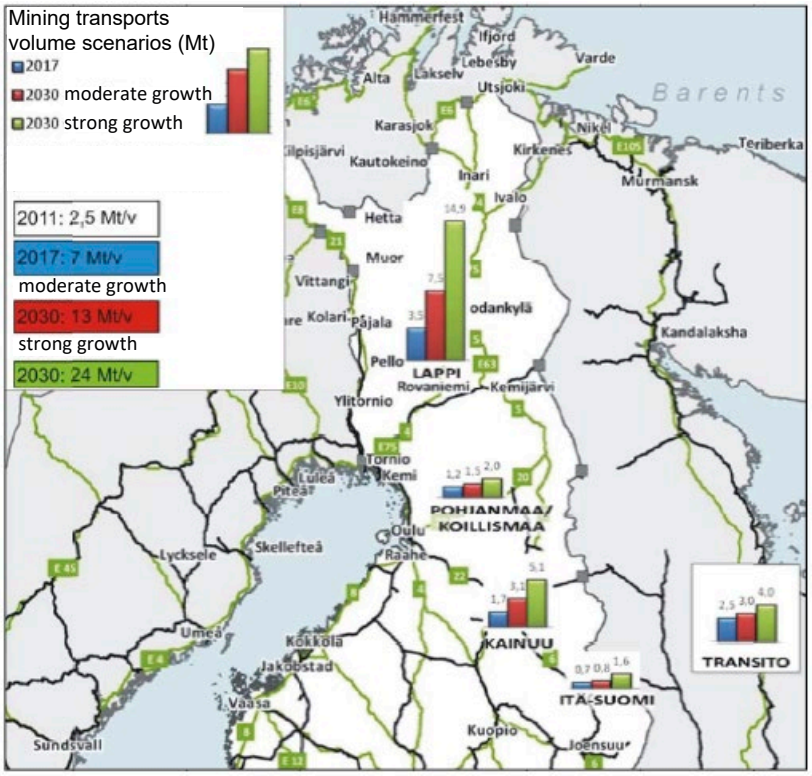
2.2 Industry logistics

Cost-efficient logistics is one of the prerequisites for profitable mining activities. Transport services are used for transfer of materials within the mining area as well as for the delivery of products from the mining area to refining plants. Additionally, arranging transport for consumables, such as explosives, chemicals and fuels, needed by mines in a cost-efficient manner will impact the cost-effectiveness of mining activities. At the mining site, excavated material is hauled by mining trucks, specialised transport equipment and conveyor systems. Mining companies make decisions on the route selections for transports according to the current market situation. The construction of new roads and railways takes time due to their need of land use plan, environmental impact assessment and financing processes.

The transport routes and methods used by the mining industry for the transport of their products depend on the mineral or metal produced, the degree of refining and the production volume. As a rule industrial minerals are refined in Finland, small amounts of metal ores are transported for example to other parts of Europe and to Asia for refining.

New mines also require that new roads leading to the mines are built and improved. The Finnish Government has made a decision-in-principle on supporting infrastructure projects for mines. The post-financing model can be applied to the construction of roads and railways. Based on this model, the Government repurchases the roads and railways after the mining activities have been launched. The public state-maintained road ends at the boundary of the mining concession. The mining company builds the road network within the mining concession. According to a decree that entered into force in 2013, to maximum permitted weight for articulated vehicles that travel on Finland's road network is 76 tonnes.

Figure 9. The volume scenarios for mining transport in 2017 and 2030. Source: Finnish Transport Agency 2013.



According to current information, products will be transported from mines mainly to domestic production plants or to Europe for refining. The necessary consumables will also as a rule be brought from domestic sites as well as from Scandinavia and Europe. Transport routes used follow current roads to the Bothnian Bay's harbours and the refining plants at the west coast. For this reason, developing current transport routes via the Bothnian Bay's and Kvarken's harbours is the most affordable options for increasing transport needs. The transport needs and the operative conditions for existing and new mines can, as a rule, be secured by developing the current transport network. In order for new mines to open and operate the construction and improvement of roads leading to them will require investments. Additionally, the increase in heavy mining transport on the busiest sections of the main transport network may require investment for increasing the capacity, traffic safety and load of roads.

3 The European Union's minerals policy

Mari Kivinen and Asko Käpyaho GTK

In 2008, the European Commission published the Raw Materials Initiative (RMI), the purpose of which is to focus political attention on the uninterrupted availability of raw materials in the EU area. The premise for the initiative was to reduce the strong dependency of the European industry on imported mineral raw materials and to reduce the financial impacts of possible interruptions in import. Mineral raw materials and their availability are indeed the focus of the initiative. The RMI can be considered the starting signal for the growing political attention given to minerals in the EU as well as in Finland over the past decade. This has reflected on the drafting of national minerals strategies and the targeting of research funding both nationally and at the EU level. After the RMI was published, Finland was the first EU country to draft its own national minerals strategy in 2010. The Raw Materials Supply Group is a group of experts that advises the Commission on matters concerning raw materials and monitors the implementation of the Raw Materials Initiative.

The RMI also influenced the drafting of the European Commission's Critical Raw Materials list. The list has influenced the targeting of policy measures and research funding. Critical raw materials refer to those raw materials that are crucial to Europe's economy and industry, but the availability of which includes a significant risk. The list was published for the first time in 2011 and was then updated in 2014. The newest update was published in September 2017, at which time phosphorous, scandium, tantalum and vanadium were added to the list. This list is favourable to Finland in that many of the raw materials listed are produced in Finland or deposits containing these have been identified in our bedrock.

Figure 10 Raw materials considered critical according to the 2017 listing (European Commission).

2017 CRMs (27)			
Antimony	Fluorspar	LREEs	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs	PGMs	Vanadium
Coking coal	Indium	Phosphate rock	

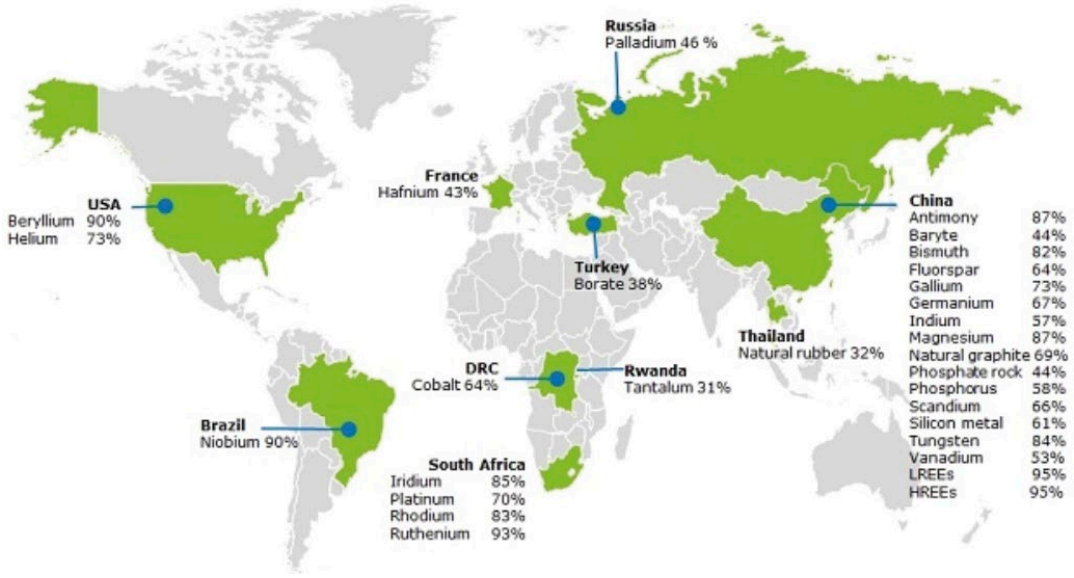
In 2012, the EU Commission launched the EIP on Raw Materials (EIP-RM). The objective of this innovative partnership was the acceleration of innovation activities by combining the private and public research, development and innovation chain throughout Europe. New members have recently been appointed to the EIP-RM's high-level steering group,

the Sherpa group and its operative working groups, and Finnish representatives from universities, research institutes and companies are among these members. The objective is for the groups to also be able to influence the content of the upcoming 9th framework programme (after the EU's Horizon 2020 programme), so that research and innovation activities related to raw materials would continue to be highly prioritised in the EU's agenda. It seems clear that the Commission will continue to consider research and innovation activities concerning the circular economy of raw materials a priority also in coming years. This in turn will shift the focus of research to the themes of secondary raw materials, the recyclability of materials, reuse and improved product design. .

The EIT-RawMaterials innovation community, which was established in 2015, has also strongly influenced the minerals sector's research funding. The objective of the EIT-RawMaterials community is to improve the efficient transfer of research data to society, so society can utilise this in the form of new products and business and can train new entrepreneur-oriented people. EIT-RawMaterials, which includes several Finnish actors is one of the EU's key instruments for developing innovation activities related to minerals. The EIT-RawMaterials' annual project application rounds have stimulated the minerals sector's project activities and at the same time increased the popularity of minerals sector's training in the EU area. Companies, research institutes and universities act as partners in the EIT-RIM and the next project application will close in February 2018.

Additionally, the ERA-MIN network for mineral sector financiers and national research programmes operates in the EU area. Business Finland is a member of the network. The network's most recent funding application period closed at the end of September 2017. Additionally the network still plans to have two application periods by 2020, but it is still unclear how Finland will take part. The application rounds focus on multinational cooperation projects, and project topics can focus on any stage of a mineral product's lifecycle from exploration to recycling. ERA-MIN-funding is part of the Horizon 2020 funding programme (the 8th framework programme).

Figure 11. Critical raw materials production clusters. Source: European Commission.



4 Investments, capacity and product development

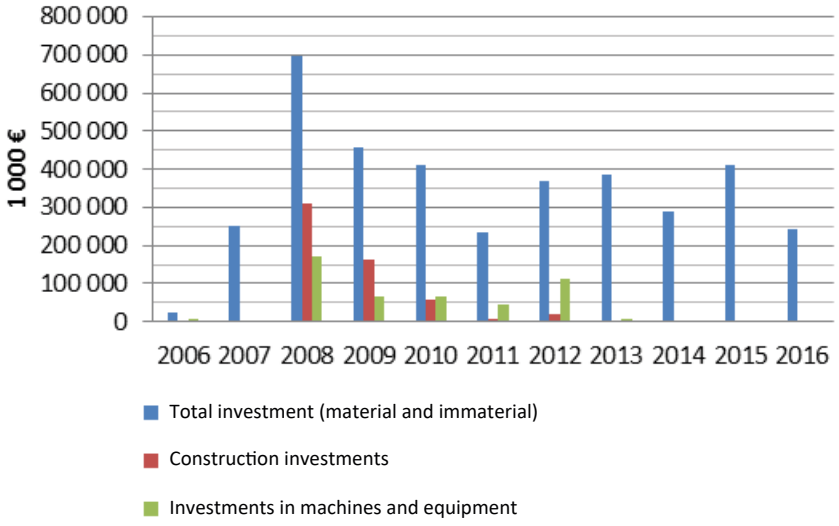
4.1 Investments in the industry

In 2016, investments in mines located in Finland totalled approximately 240 million euros. This was 54 % more than the previous year. The most recent investment is the order made by Sotkamo Silver for a plant building and its construction, which is around 6.5 million euros in value.

Other costs include for example compensation to the landowner pursuant to the Mining Act. At the early stage of exploration, companies pay landowners a 20 euro per hectare annual compensation for the exploration area. The fee rises as exploration continues to 50 euros/hectare. Once the mining area is established the landowner is paid 50 euros perhectare annually as excavation fee. Additionally, the landowner will be paid a production dependent excavation fee of 0.15% of the calculated value of the metals that are excavated and utilised during the course of the year.

According to Statistics Finland's financial statement statistics, there were 23 enterprises in the extraction sector, and their total investments were 243 million euros in 2016. Construction investments totalled 0.3 million euros and investments in machinery and equipment 2.4 million euros.

Figure 12: Investments in the 'mining of metal ores' sector (TOL 07) Source: Sector Online, Statistics Finland.



4.2 Capacity

Of Finnish metal ore production, only the production of chromium concentrate is sufficient for the needs of the domestic refining industry. In 2016, the degree of self-sufficiency in

nickel, zinc and copper concentrates was around 42%, 14% and 31% respectively. The new mines will improve the degree of self-sufficiency. Production of sulphur concentrate – used in the production of sulphuric acid, among others – exceeds domestic demand.

Table 9: Share of domestically produced concentrates of those refined in Finland in 2016. Source: Tukes and the National Board of Customs

2016	Production in tonnes	Refined, tonnes	Share of concentrate production from the concentrates refined,%
Iron concentrates	0	3,516,035	0.0
Chromium concentrate	1,070,281	1,071,735	99.9
Copper concentrates	193,349	629,277	30.7
Nickel concentrates	149,981	359,200	41.8
Cobalt concentrates	35,463	36,095	98.2
Zinc concentrates	84,073	605,973	13.9

4.3 Exploration as the mining sector's research and development activities

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Mining satisfies current raw materials demand caused by consumers need of products. Exploration is the only way to secure the availability of raw materials in the future. If we compare it to technology companies in general, exploration is part of a mining company's research and development work. An exploration permit is partly the same as a technology sector patent, as it secures the company's exploration idea in the same manner the other secures a user and production idea. With regard to long-term continuity, it is especially important to aim at identifying completely new mineral deposits (i.e. grassroots exploration) in addition to the development of known deposits.

As a rule, mining activities at one site are limited, although the utilisation of ore can continues for decades or even centuries, as the minable ore is not a renewable resource and there is only a certain amount of it to be mined. However, unlike those of many other industries, the majority of the mining sector's products can be recycled: for example, copper and gold can in practice be recycled endlessly and they retain their value from one generation to the next. Metal products are already now recycled efficiently. However, the supply of recycled products is not enough to cover demand especially as long as the raw material needs of China and other growing economies continue to grow. Thus, products from mining activities will be needed for a long time to come.

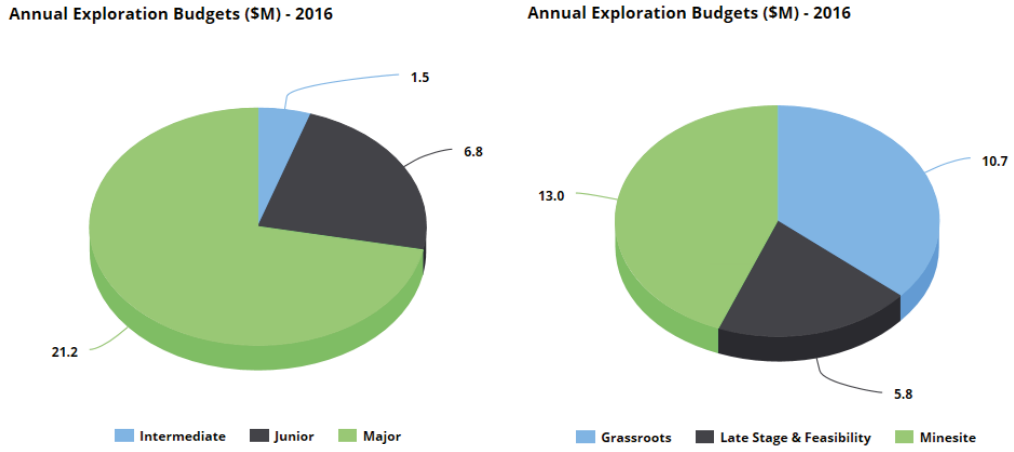
Exploration in its entirety is a long process that can last up to decades. It is a natural sciences and economic assessment process, and in addition to natural resources, it is influenced by economic, environmental and many social factors. During exploration, the information gathered on the soil and bedrock can be utilised in versatile ways such as in planning land use and conserving the environment. Exploration is cyclical by nature and strongly follows the

development of metal prices on the world markets. This cyclicality influences in particular the activities of junior companies, which depend on external funding. Exploration in areas where mining activities already exist will help in maintaining the established industrial and economic structure and reduce the structural changes caused by termination of mining activities. This is especially the case if R&D activities lead to new ore finds and the continuation of mining activities.

Both mining companies and junior companies carry out exploration in Finland. The majority of these are registered abroad. Mining companies may already have established mining activities in Finland or alternatively in other countries. Junior companies in turn focus on finding and investigating potential new sites. The search strategy is also often different. Large and medium-sized mining companies predominantly search for large, long term and cost-efficient deposits and can cover large exploration areas in a short amount of time. The strategy of small junior companies can for example be to search for new deposits in areas where little or no exploration has taken place or focus their search in the areas surrounding a known deposit. The strategy of junior companies is rarely to establish actual mining activities, but to sell the mineral rights of a promising deposit or a potential exploration area to other exploration companies or an actual mining company. This is because explorations and mining activities are very different business-wise, and mining activities require significantly larger resources and different expertise than exploration or identifying places for exploration.

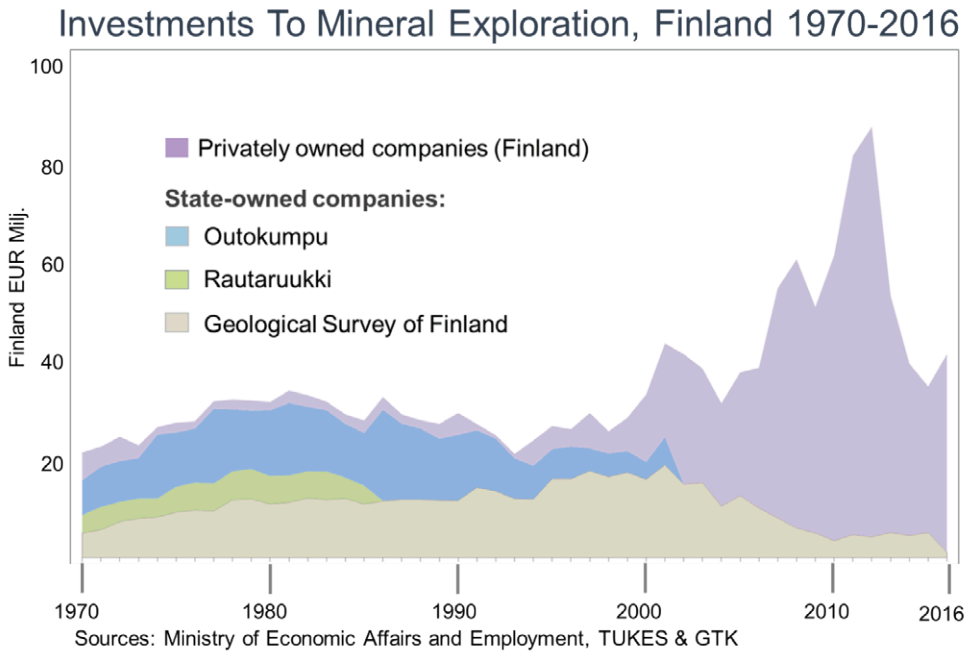
As Figure 13 indicates, investments by large international companies contribute nearly three-fourths of the monetary investments for exploration in Finland. Additionally, a significant part of exploration is carried out at already existing mines in order to extend their mine life. However, it is worth noting that a large share of fund is used on researching new deposits (grassroots). The majority of mines opened in Finland during the 2000s utilise ores found in the 1980s. There have also been some new discoveries recently. The most significant of these have been Sakatti in Sodankylä and Rompas in Ylitornio. Of these, Sakatti was found by a large international mining company (Anglo American) whereas Rompas was discovered by a junior company (Mawson Resources).

Figure 13. The enterprise structure for exploration and the targeting of exploration activities in Finland in 2016. Source: S&P Global



The Finnish Government's role in exploration has decreased significantly during the 2000s (Figure 14). Today, the only State agency that takes part in exploration is the Geological Survey of Finland. The GTK's area of focus has shifted in the 2000s from active exploration to the assessment and modelling of areas that potentially have ore. The agency's key objective is to assess the raw material potential of Finland's bedrock and to show the mining industry areas that may potentially contain ore or deposits as well as to produce the information materials on Finland's bedrock that the mining industry needs. This differs from the activities of exploration companies, which aim to located mineral deposits and determine their economic feasibility. The GTK's activities predominantly focus on ore potential areas that are not being intensively explored by companies. Thus, GTK activities specifically support grassroots exploration.

Figure 14. Investments in exploration in Finland 1970–2016.



An average of 50-60 new deposits are found annual worldwide. Only one or two large-scale, long term and low cost deposits (Tier 1 deposits) are discovered each year. Over the past 30 years, gold has been the most searched metal. 33% of the world's exploration costs are used for the exploration of gold. The popularity of gold is based on its utilisation potential in different scopes from a one-man mine dug by shovel to a massive industrial mine that extracts tens of millions of tonnes each year. Exploration for base metals as well as exploration for bulk products (iron and coal) both eat up 24% of the capital invested in ore exploration. Exploration is going through a revolutionary stage in the western countries as it has become more difficult to find high grade deposits that are at the surface and are large in size. Companies generally believe that they are more likely to find such deposits in sparsely populated areas and in under explored and geologically favourable developing countries.

From an international perspective, the cost level for exploration has doubled over the past decade and is ten times what it was one hundred years ago. Exploration method has developed and is now more technology-centred, labour costs have increased, exploration activities have moved to even more sparsely populated areas, and the primary focus of exploration has shifted to deep exploration from old mining areas. The costs for exploration for deep ores increase as the required technology becomes more complex. Drilling costs grow exponentially and better depth dimensioning is required of measurement devices, which in part has also enhanced research and development work in the technology sector. Especially seismic measurements as well as artificial intelligence and automation in the form of various measurement robots have developed a great deal over the years.

Exploration activities are research activities, in which the success is determined by the bold experimentation of new ideas. Exploration has developed from work with a hammer and ocular observations over the decades to its present form, which includes a continuous increase in the use of computers and various modelling programs and new laboratory methods that facilitate the varied analysis of samples. The effective utilisation of materials requires joint interpretation, the development of concepts related to enrichment of ore, as well as a comprehensive vision of geological processes, that lead to the creation of mineral deposits. In the future, exploration will include a growing amount of completely new technologies, real-time production of materials and crowdsourcing, artificial intelligence and robotisation. For example, the interpretation of very large materials with robots will be an aim in the future. However, geological expertise and the management of the mineral system will remain the basis for everything.

A list of critical raw materials has been published in the EU for the area's industry since 2011. Nearly all the raw materials listed as metals or minerals that are imported from outside the EU. Securing the availability of these poses a large risk. Many of the raw materials that are considered critical are so-called technology raw materials. These either do not have established production in western countries or the west has not invested in their exploration or the development of their mining activities. Deposits of these raw materials are also often difficult to process and thus technologically and economically difficult to utilise. There are no large amounts of these raw materials in circulation in society so that demand could be covered through recycling. Additionally, recycling technologies for critical raw materials have not yet been developed. We need innovations and R&D activities not only in exploration but also in improving the efficiency of recycling, if we want to secure the long term availability of critical raw materials.

Before the mid-1990s, exploration was predominantly carried out by the State and State enterprises invested significant amounts in exploration. Today, the situation has been reversed and exploration is enterprise-driven as are mining activities. Other changes have included that exploration costs have grown significantly as has the market's cyclical nature, which impacts in particular the activities of junior enterprises. The development of technology related to exploration has been and will continue to be significant. In the long term, especially the importance of new ore findings will be emphasised, but these are less appealing from a company's viewpoint because the risk is greater than in discoveries may

at known sites. It is also challenging to get funding for the investigation of this type of sites as they require patience from financiers so drilling and testing can be carried out.

Exploration differs from other research and development activities in that the idea of new ores is centred on a place not a technology. However, at this moment Finland's public funding instruments are not suited for supporting location-dependent research and development activities.

Table 10: The number of enterprises involved in exploration in Finland, investments in exploration, number of kilometres drilled and mining investments. Source: Ministry of Economic Affairs and Employment and Tukes

	2011	2012	2013	2014	2015	2016
Number of companies	40	45	38	41	42	41
Exploration investments, MEUR	81	86.8	52.8	39.1	34.5	41
Metres drilled	369,000	366,000	179000	142000	130000	178000
Mining investments, MEUR	555	320	200	190	157	242

Status and importance of the industry in the future

By the European Union's standards, Finland is a significant actor especially in the production of chromium, cobalt, platinum group metals and fertilisers. Finland's gold, nickel and talc mining is also significant in scope by European standards.

During the mining boom of the 2000s, people got the impression that mining activities are new to Finland. However, Finland has a longstanding tradition of mining activities. The first mine that produced iron was opened in Ojamo, Lohja in 1530. A total of more than 1,000 metal ore, industrial mineral and carbonite rock mines have been active in Finland. By 2008, 1,057 mines had been active, of which 423 have been metallic ore mines. In total, mines produced 1,241 million tonnes of materials from 1530 to 2008. Of the mines that are presently active, activities began at Pyhäsalmi mine in 1962. Production was initiated at the Kemi chromium mine in 1968. Mining activities have been an establish sector in Finland, which will also be needed in the future.

As new technologies are developed, the need for new raw materials arises. Natural metal concentrates found in the bedrock are called mineral deposits. If the deposit can be utilised in an economically viable manner it is referred to as ore. New technologies thus has an influence on the development of deposits into ore, although the grade and deposit characteristics do not change. A profitable mineral deposit forms the basis for mining operations. Factors that influence the feasibility of utilising metal deposits include the world market for metals, the grade of ore and production costs. Mining activities can be restarted in an already closed mine as technologies are developed and prices rise. Exploration can also be carried out at known sites that have already been investigated. Exploration is a long-term process often lasting decades. General economic conditions affect the mining sector.

As mining investments require large amounts of capital mining companies appreciate stable, predictable and transparent policies. Skilled labour force is also a pull factor for

investments. Finland has accessible geological data, infrastructure, a safe investment environment and good ore potential. Finland's Government has taken on a number of measures to enhance mining activities; these have included training of skilled personnel, building the necessary infrastructure and providing funding for the sector's research. Finland's stable conditions have significantly improved its standing in international rankings.

The activities of global mining industry enterprises and the development of the Chinese markets have had an impact on how the prices of metals have evolved. Strong fluctuations in the price of iron concentrate has caused problems for the sector's mining enterprises. For example, LKAB's mine in Kiruna can endure fluctuations in the price of ore better than small mines can.

Import restrictions or national interests may pose a threat to Finland's access to raw materials for refining of metals as we are import-dependent. The metal refining facilities located in Finland are material and energy-efficient and have low-emission. Increasing the domestic production of metal concentrates is essential in order to secure the continuation of the metallurgy industry.

The price of metals may rise in coming years for example due to new technologies and new metal needs. If export prohibitions continue, we can expect to see a rise in the price of metals. Existing reserves buffer price development and the impacts may only be evident after some time. There is a large supply of iron ore available in comparison to its consumption, as China has produced more steel than there is a demand for: approximately twice as much as the EU in total and there is no end for the overproduction in sight. They have preferred to sell steel at a low price to Europe rather than make less of it. This has caused problems for factories in western countries. The European Commission has intervened in the matter and decided on import tariffs.

As mining activities grew swiftly in the 2000s, not enough attention was given to generation of capital and monitoring of costs. Financiers lost faith, and the financing of mining activities became more difficult. The mining industry's financial risks were not taken into consideration sufficiently during the investment stage. The prices of raw materials rose which increased the production costs of mines. The mining industry has responded by shifting the focus from growth to improving margins.

At the end of the previous mining boom in 2015, many mines closed down due to being unprofitable or going bankrupt. Significant changes in ownerships also took place. At total of five mines in Finland and on the Finnish border closed down. Some of the mines that terminated their operations were so-called economic cycle mines, which have terminated their activities numerous times over the course of their lifecycle (Hitura mine, Kirkkoniemi mine and Pahtavaara mine).

In addition to prices on the world market, the metal-content of ores, extraction, mineral processing costs and logistics will influence the feasibility of a mine. As is with all business, in the mining sector the advantages of being an experienced enterprise or actor include gained competence and a fine-tuned enterprise culture in establishing and managing mines. New actors and investors often learn the hard way, which can prove to be expensive.

Enterprises are now focused on developing more feasible projects and other reserves are sold. Savings, productivity and the management of capital improve the likelihood of new investments. The most significant business risks in the mining and metallurgy industry included the improvement of productivity, targeting and availability of capital, social permits, resource nationalism, management of capital, unstable pricing and exchange rates, infrastructure and accessibility, distribution of benefits, expertise requirements as well as the availability of water and energy.

Exploration has increased in Finland. In 2016, a total of 41 million euros was invested in exploration, which was 19 % more than in 2015. Enterprises that engage in exploration drilled a total of 178 kilometres, which is 37 % more than the year before. More than half of investments in explorations were used for areas near mines in brownfield sites. Increased exploration in the future will create the foundation for finding new mining deposits to replace depleted reserves. Notable increases are expected in the number of actors, the volume of exploration and the amount of drilling. Most exploration currently takes place in Northern and Eastern Finland.

The impacts of mines on the regional economy are seen as especially significant. Municipalities often have to invest in a great amount of basic services and for this reason the financial benefits to municipalities are retrospective in the form of taxes paid by employees. The availability of skilled labour for growing mining activities is important even from a general perspective, and it is important that the significance of the mining sector is consistently highlighted. Discussions held with educational institutions have indicated a concern for the appeal of the sector.

Regional economy impacts will be visible indirectly. The mining industry provides a multitude of different professions and work opportunities. The image of the sector's labour market is becoming more diverse and the area's population structure will become more balanced. The area will additionally gain new expertise. The mining industry will also increase the diversity of the area's industrial structure and create growing and new business opportunities for companies operating or now being established in the area. A diverse industry structure will increase the area's appeal and ensure that the existing services remain there.

Sustainable mining industry solutions for minimising environmental impacts include energy-efficiency, recycling, water treatment and technologies. The development of Nordic routes has been especially important in the Bothnian Bay area in directing goods flow from roads to railways and shipping.

Increasing the coordination and interaction of industries is crucial with regard to regional development. A diverse business and industry structure and an appealing image can help improve and influence the area's accessibility outside of growth centres. Having to justify the acceptability of mining activities will challenge the industry to change its way of thinking. It is not enough that mining enterprises demonstrate that their mines will not cause harm to the surrounding areas and communities. The overall impact on the area must be a positive one.

Mining companies must also be able to prove their reliability to the surrounding community. It is important that mines are open in their communication and interaction in order to gain acceptance. One way to promote acceptance and develop interaction is to hold actual

open house events and allow visitors to see the mine and its activities. The Finnish Mining Association's member companies have introduced the TSM, a mining industry responsibility system developed in Canada. The system will allow Finnish mining operators to develop the procedures for issues of social and environmental importance. This is the first time the TSM system, which was developed by the Mining Association of Canada, has been adopted outside of Canada.

The Arctic Environmental Impact Assessment programme gathers information on existing good EIA practices that can act as an example for other actors operating in the Artic region. The complexity and sensitiveness of the Nordic area must be taken into account in the Arctic region's mining activities. More research and development work will be carried out on minimising the environmental impacts of activities. In particular, the water balance and water processing have become important topics to consider. Environmental issues at mines will become an increasingly important part of the industry in the future both with regard to legislation and the acceptability of activities. Environmental, social and financial sustainability must be requirements in mining activities also in the future. The EU's continuously evolving legislation on environmental matters will require larger economic resources and human resources from companies and authorities. The monitoring and anticipation of legislative development and compliance with more stringent environmental licence requirements will require resources. The licensing procedure has experienced prolonged processing times for both environmental and water economy licences.

The largest research themes cited in Sitra's report on research and development projects were production process, management of waste and side streams, environmental reports, multifaceted research, measurement and monitoring technologies, local relationships and other industries as well as business concepts. In addition to these themes, the utilisation of ICT and automation in the sector creates possibilities for small and medium-sized businesses. Occupational safety and the management of safety risks are valued very highly at mines. New technology is also needed for the more effective concentration of ore from poor deposits. The energy needs of mines can at least partially be met with local renewable energy. The functionality and effectiveness of innovations designed for other sectors such as the pulp and paper industry should be examined more closely in the mining industry. Solutions created as the result on long-term development work could also be applicable for resolving some the challenges faced by the mining industry. The wheel need not be invented again. In the EIT RawMaterials' financing portfolio for 2018 Finnish organisations are listed as participants in 100 projects. The overall objective for 2018 is for EIT RawMaterials to provide approximately 65 million euros in funding to innovation activities of which 6 million euros would come to Finland.

Inquiries, other information/sources

Current topics in the mining sector www.prokaivos.fi

Geological Survey of Finland (GTK), http://www.gtk.fi

Ministry of Economic Affairs and Employment, http://tem.fi/en/frontpage ,

Mining Finland growth plan http://www.miningfinland.com/

Mining Finland is a programme that gathers Finnish mines and mining technology providers as a cluster committed to green and sustainable mining. We network the companies to be able to provide larger synergic services across the whole value chain for the international mining industry. Mining Finland also assists international investors looking for investment opportunities in Finland.

The Finnish Mining Association.http://www.prokaivos.fi/kaivosteollisuus-ry/
The association is a union and cooperation organisation for companies in the mining and extraction industry.

The Federation of Finnish Technology Industries. Status and outlook report 3/2017 http://www.teknologiateollisuus.fi/en

TUKES. http://www.tukes.fi/en/Branches/Mining/
Tukes has been the surveillance and permit consideration authority in Finland as of 1 July 2011, as referred to in the Mining Act (621/2011). The authority duties are attended to in our offices in Helsinki and Rovaniemi.

Tukes decides on the applications filed for permits and rights, and runs the mining register in Finland. In the mining surveillance, we use reporting, enquiries, surveillance visits and the initiatives taken by the relevant actors.
The mining authority's report on the current status of exploration and the mining industry 2016.
http://www.tukes.fi/Tiedostot/kaivokset/tilastot/English_Tukes_mining_in_Finland_2016.pdf

Business Finland, https://www.businessfinland.fi/en/for-finnish-customers/home/
At Business Finland, we create new growth by supporting companies to go global, as well as funding innovations. Our top experts speed up the identification of business opportunities around the world and help transform them into global success stories.

Sitra; https://www.sitra.fi/en/
Your fund for the future. We are proud of half a century of successful co-operation already. Come and join us!

Responsible mining activities. https://www.kaivosvastuu.fi/in-english/

What is the Finnish Network for Sustainable Mining?

The Finnish Network for Sustainable Mining provides a neutral forum for companies operating in the mining industry to interact with their communities of interest. As the focus is on self-regulation, the network does not emphasises the role of authorities, but rather cooperation with industry and its surrounding society. The network makes it possible to share information and experiences as well as promotes the building and introduction of more responsible operating methods. The facilitated cooperation results in concrete operating models, reports and other methods that will help the mining industry act operate in a more responsible manner.

Ministry of Economic Affairs and Employment
www.tem.fi/en

Ministry of Agriculture and Foresty
www.mmm.fi/en

Ministry of the Environment
www.ym.fi/en

Centre for Economic Development, Transport and the Environment
www.ely-keskus.fi/en/web/ely-en/

Business Finland
www.businessfinland.fi/en

Ministry of Economic Affairs
and Employment of Finland