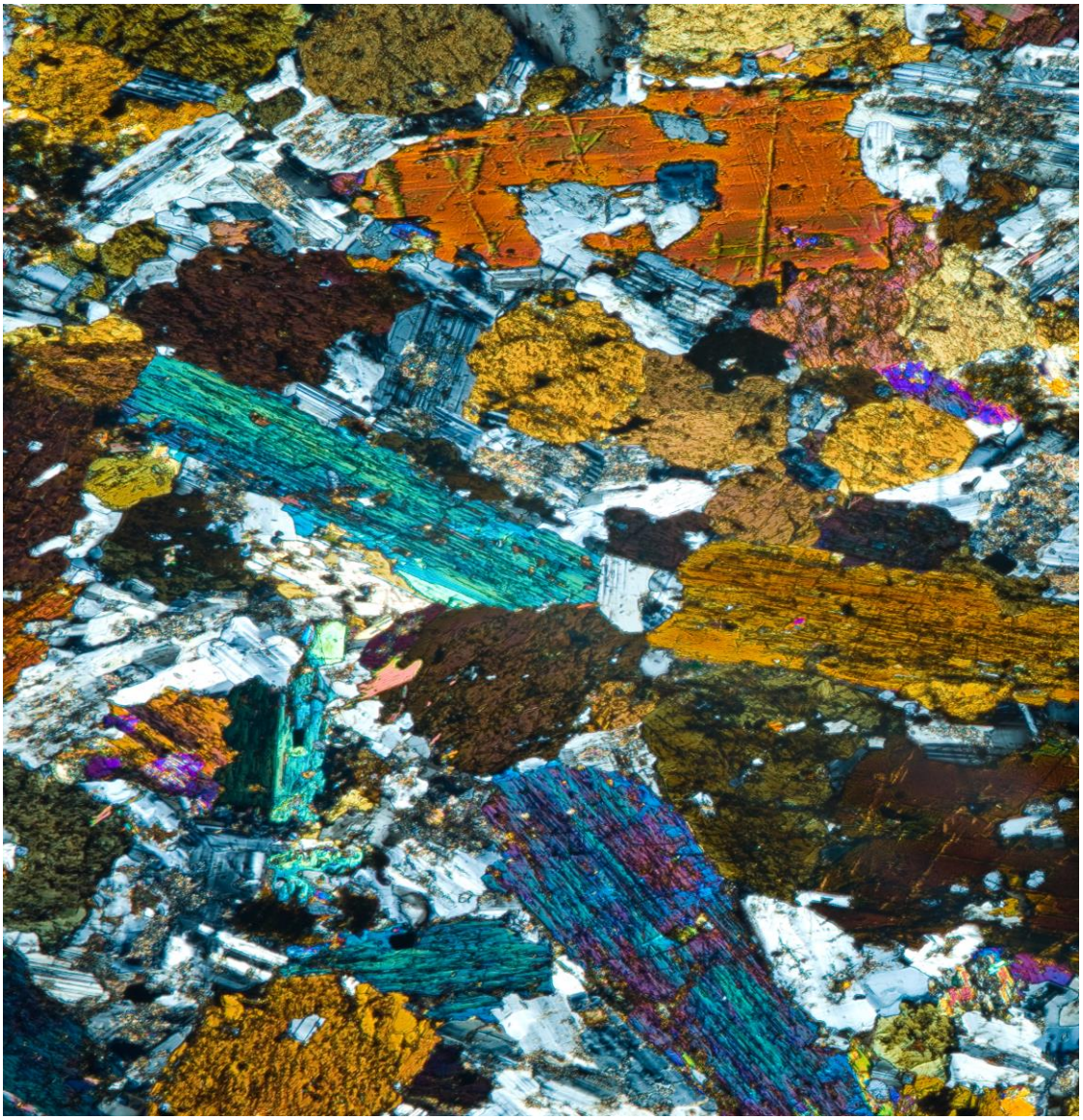
Finnish Mining Cluster



SUOMI
FINLAND

Executive summary

With 42 active mines, 32 active projects and a strong metal and machinery cluster, Finland is a recognized player in the global mining industry. Finland may not be among the largest mining countries in the world, but it is certainly among the most attractive and stable.

Finland has performed consistently well in the Fraser Institute's annual surveys of mining companies, ranking **among the five most attractive mining destinations for several years**. In the latest 2015 edition, Finland moved to the top position as the most attractive jurisdiction in the world for mining investment.

Finland's strengths as a mining destination include excellent geological databases, ore resources especially in Northern Finland, high educational level and engineering know-how, strong infrastructure, and a very stable political and social environment.

The unique geodata gathered over decades makes Finland a relatively easy country to explore and develop mining resources. Finland has one of the most extensive geological databases in the world and is one of the few countries in the world which have been completely mapped geophysically.

Finland has several unique deposits, including the Sakatti copper-nickel-PGE deposit, Länttä Lithium deposit, Kittilä gold mine, Kevitsa nickel mine, Siilinjärvi apatite mine, Kemi chromite mine and Outokumpu copper-cobalt deposit.

Finland has a modern, transparent and straightforward mining legislation. All required documents, procedures as well as current fees for exploration and mining permits are available at the Finnish Safety and Chemicals Agency (Tukes).

Finland has a strong mining cluster consisting of mines, major global technology companies, SMEs and organisations providing education, R&D and innovation services to mining. Finland has a long mining tradition and is the home of several global mining technology companies, such as Metso, Outotec, Sandvik and Normet. Finnish mining technology companies excel especially in sustainable and technologically advanced solutions for high productivity. Finland also has a unique cluster of companies developing and offering Internet of Things (IoT) technology to several industries, including mining. These solutions are expected to gain traction as the mining industry discovers the benefits provided by intelligent mining and machinery.

Finnish engineering companies have developed major innovations, such as Variable Speed Drives and Flash Smelting of copper, and also perfected technologies in the

drilling, crushing and refining of minerals. Finland is an engineering country and innovations are constantly under development, with new ones being commercialized.

The strength of Finnish machinery industry forms a solid base for anyone in the mining value chain to operate in Finland. The strong cluster of companies offering subcontracting services to mines and mining technology companies makes operating in Finland easy.

Finland has a clear national strategy to promote intelligent and sustainable mining; national programs such as the Green Mining program of the Finnish Funding Agency for Innovation (Tekes) support the development of sustainable solutions to the global marketplace. The aim of the Finnish mineral strategy is to develop Finland to become the leader in the sustainable extractive industry. Industrial Investment Ltd, a government-owned investment company in Finland, implements the strategy through a mining investment program. Industrial Investment Ltd has invested a total of EUR 43 million in nine early stage mining companies operating in Finland.

The Finnish mining industry cluster is international by nature and continues to operate as a major player in the global mining community.

1 Finland as a mining country

Finland has had hundreds of operating mines since the 1530s and experienced a major mining boom already in the early 1900s thanks to the discovery of copper inside a mountain in the town of Outokumpu. With 42 active mines, 32 active projects and a strong metal and machinery cluster Finland is today a recognized player in the global mining industry.

In recent years Finland has ranked consistently in the top 5 attractive mining destinations in the Fraser Institute's annual surveys of mining companies. In the latest 2015 edition, Finland moved to the top position as the most attractive jurisdiction in the world for mining investment. Scoring well in the rankings is proof of Finland's attractive geology, world-class regulatory environment, highly competitive taxation, absence of political risk or uncertainty, and a fully stable mining regime. It takes a long time to develop a mine and hence it is of utmost importance that the country of choice is stable and has modern, predictable and transparent legislation.

1.1 Ore resources in Finland

The Fennoscandian shield has strong similarities to the Canadian and Australian shields indicating strong mineral potential. Fennoscandia is already one of the most significant mining regions in Europe. However, despite centuries of exploration and mining, it can still be regarded as under-explored.

Most of known ore resources and operating mines are located in Northern Finland, but there are important mineralisations also in central and southern Finland.

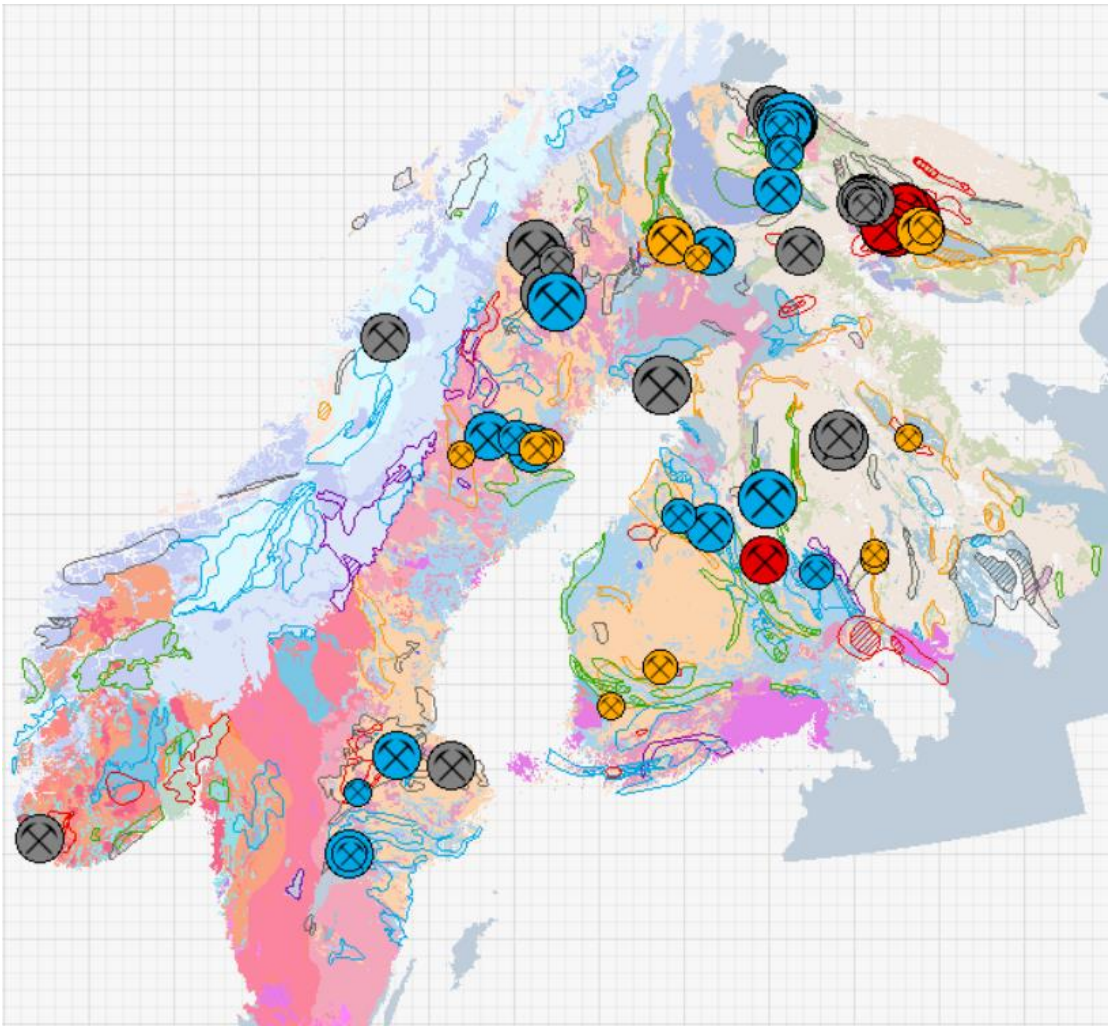


Figure 1: Fennoscandian Mineral Deposits. *Source: Geological Survey of Finland – GTK)*

The following examples demonstrate Finland's mining potential:

- Sakatti – one of the most significant copper-nickel-PGE deposits in Europe
- Kittilä (Suurkuusikko) – the largest gold mine in Europe
- Kevitsa – a significant nickel mine in the EU
- Siilinjärvi – the only apatite mine in Western Europe
- Kemi – the only chromite mine in the European Union
- Länttä – one of the only lithium deposits in Europe
- Outokumpu – globally unique copper-cobalt deposit
- Sotkamo silver mine project

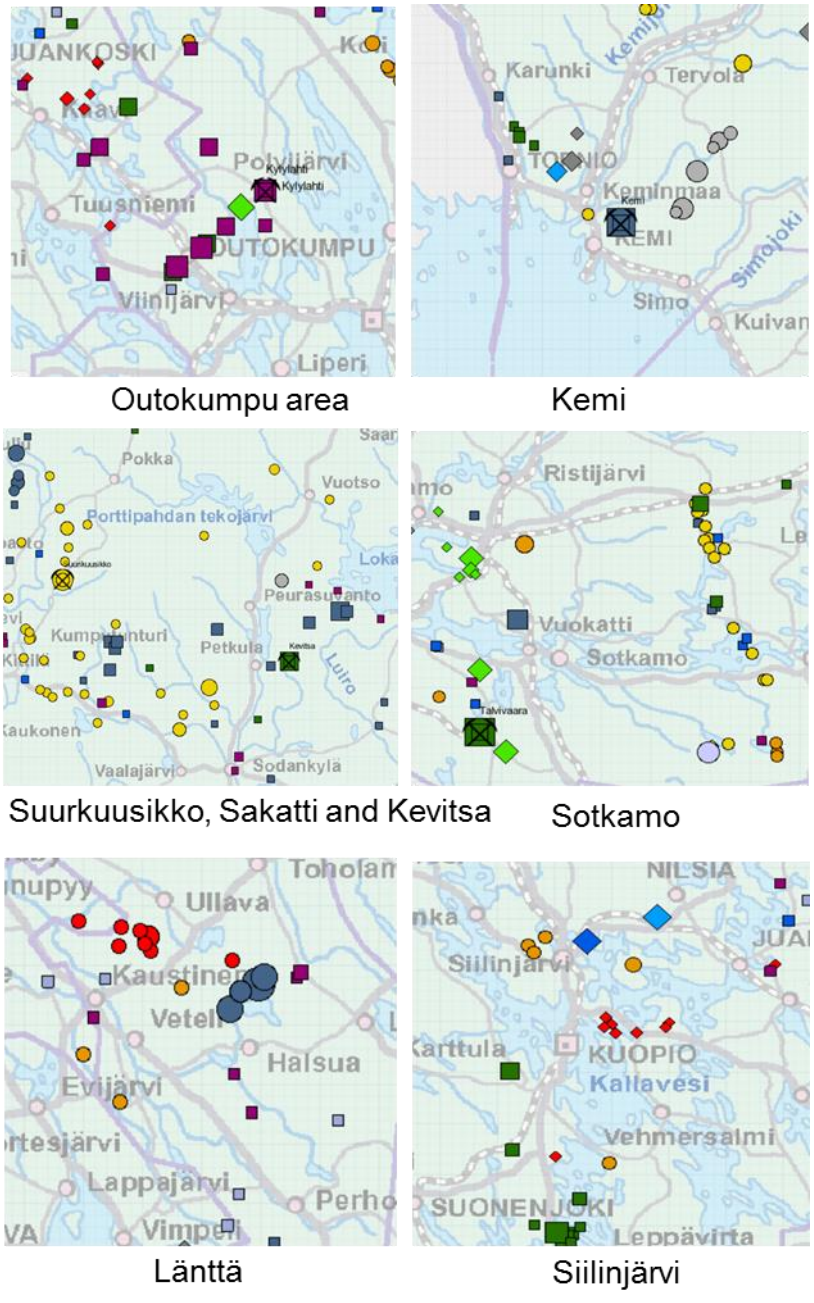


Figure 2: Significant Deposits in Finland. Source: Geological Survey of Finland - GTK

1.2 Geological data

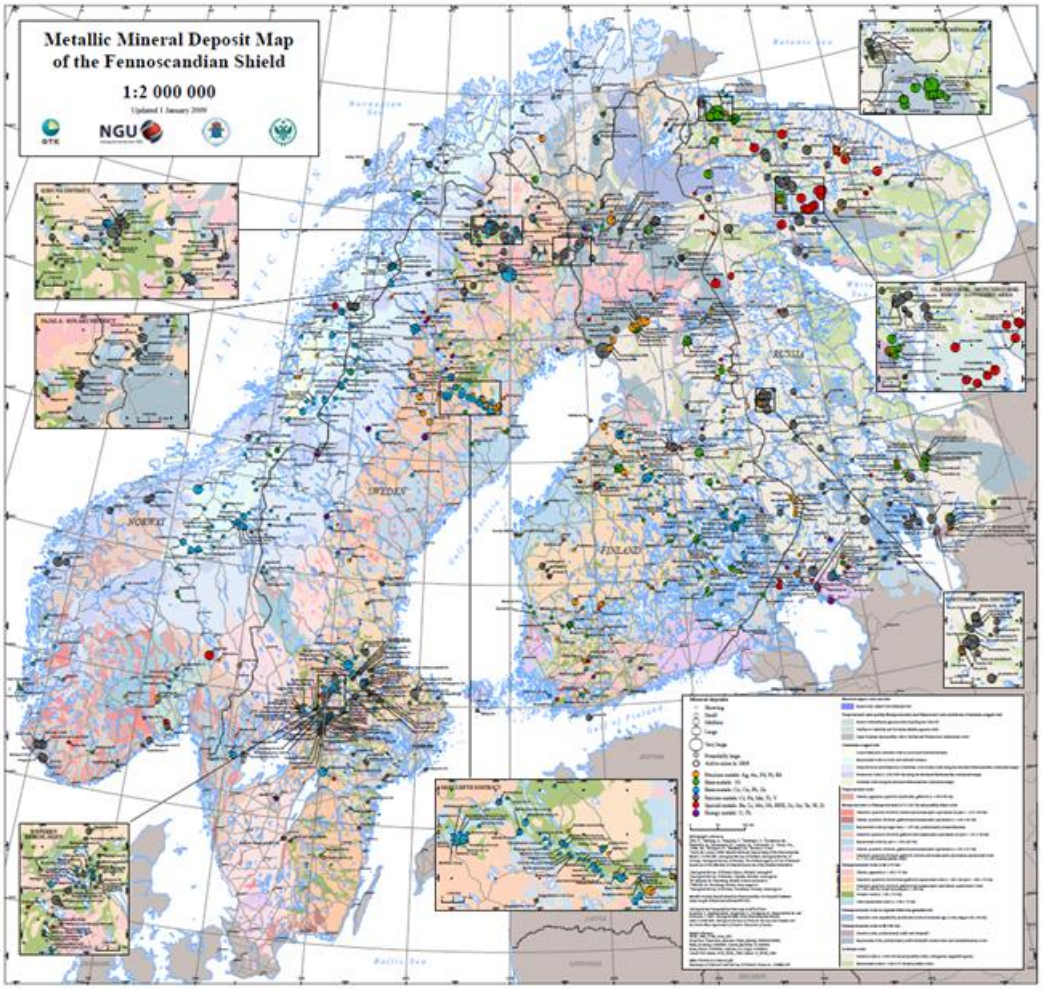


Figure 3: Fennoscandian Shield: Source: Geological Survey of Finland - GTK

Finland has one of the most extensive geological databases in the world and is one of the few countries in the world which have been completely mapped geophysically. This makes Finland a relatively easy country to explore and develop mining resources.

Geological Survey of Finland (GTK) is responsible for national drill core archives, gathering data and maintaining the geological data bases. Most of the data is also available in English, making exploration and mine development easy for international companies. GTK also maintains unique online maps, which show the mineral

deposits, mines and drilling sites in Finland. GTK also offers a comprehensive selection of geological data sets, such as bedrock observations, the locations of bedrock boreholes, boulder observations, radiometric ages, mining register, and geological, geochemical and geophysical maps as well as metallogenic areas. Materials are regularly updated and available at www.gtk.fi .

1.3 Finnish mineral strategy – aiming to become a leader in the sustainable extractive industry

Finland has a clear national strategy to promote sustainable and minimum impact mining. The general target is to improve resource efficiency. The key objectives of the Finnish mineral strategy are to promote domestic growth and well-being, offer solutions for global challenges faced by the minerals chain, and mitigate damage to the environment.

The strategic policies have been implemented by Tekes' five-year Green Mining programme during 2011-2016 and by the additional funding of mining projects approved in 2012.

Focus areas of the national plan:

- Water management and water technology
- Utilization of tailings and waste rock
- Energy efficiency
- Safety

Sustainability will continue to be the key driver also in the future, following the principle of the triple bottom line – socially, economically and ecologically sustainable operations.

Operating environment in Finland

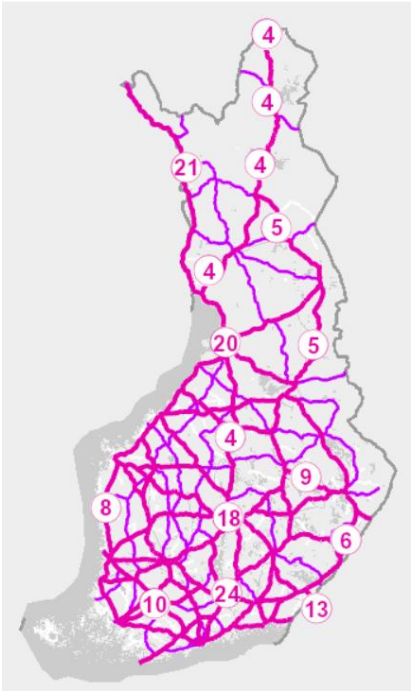


Figure 4: Finnish Road Network including major highways. Source: Finnish Traffic Agency

The Finnish government gives mining a high priority and emphasizes transparency and predictability in all procedures. Mining is long-term operation and mining companies need to have strong trust that the operating environment is stable and the legislation is predictable for the whole lifecycle of the mine. The Mining Act of Finland is now 5 years old and is currently being reviewed by all stakeholders to collect feedback and to ensure open dialogue between the ministry, the industry and all stakeholders.

The mining industry in Finland is also supported by Industrial Investment Ltd, a government-owned investment company in Finland. Industrial Investment Ltd implements the Finnish mineral strategy through a mining investment program and has invested a total of EUR 43 million in nine mining companies operating in Finland. Current direct investments in mining companies include the Keliber lithium mine project and Sotkamo Silver project. The investments are part of a financing package, put together with, and on the same terms as private investors. In every case, Industrial Investment Ltd remains a minority shareholder, and their share of the total investment round cannot exceed 50%.

Finland has strong infrastructure with an extensive road, rail, port and data network covering the whole country. For example, mobile phone network coverage is among the highest in the world and mobile phone charges among the lowest.

Helsinki, the capital of Finland, is placed in the top 10 cities in the EIU Liveability Ranking, which is based on a range of factors, including stability, healthcare, culture, education and infrastructure. This reflects the nature of the cities in Finland. Many mining companies and mining technology companies operate outside the capital, but can still enjoy many of the same the benefits as the companies in major cities.

Finland's assets include competitive energy prices and strong energy infrastructure, a stable political and social environment, and long-term policies that are predictable and transparent. These strengths are clearly reflected in the outstanding scores Finland receives year after year in the annual Fraser surveys.

1.4 Mining Act of Finland – procedures and permits

"In order to find mining minerals, everyone has the right, even on another's land, to conduct geological measurements and make observations and to take minor samples, provided that this does not cause any damage or more than minor inconvenience or disturbance"

Mining Act of Finland, Chapter 2, Section 7

Figure 5: Steps in exploration and mining permits

Procedures, permits and reporting are based on the Mining Act of Finland (621/2011), which is also available in an English translation to facilitate the operations of non-Finnish companies in Finland. However, one must note that the legally binding versions are the Finnish and Swedish versions of the mining act.

Finnish Safety and Chemicals Agency (Tukes) decides on the applications filed for permits and rights, and runs the mining register in Finland. All required documents,

procedures as well as current fees are available at www.tukes.fi in Finnish, Swedish and English.

Permits and rights related to exploration and mining fall under three categories: Reservation, Exploration and Mining.

Reservation

A reservation grants a privilege as regards the submission of an ore prospecting application. It does not entitle the applicant to perform exploration.

A privilege based on a reservation notification becomes valid once the reservation notification has been submitted in compliance with the provisions of the Mining Act of Finland.

The notification must include a necessary and reliable account of the party making the reservation, borderlines of the reservation area and measures in preparation of the ore prospecting permit application and their schedules.

Exploration permit

An exploration permit grants the right to explore the structures and composition of geological formations on the permit holder's own land and on land owned by another landowner within the area referred to in the permit (exploration area). It does not authorize the exploitation of the deposit. It does, however, provide the holder with a privilege for the mining permit, which in turn provides the right to exploit the deposit.

An exploration permit may be extended for a maximum of three years at a time. In total, the permit may remain valid for a maximum of 15 years.

Mining permit

A mining permit is required for the establishment of a mine and the undertaking of mining activity. A mining permit also entitles its holder to perform ore prospecting within the mining area.

A mining permit is valid until further notice, but may also be issued for a fixed term for a justified reason. A mining permit valid for a fixed term can be extended for a further period until further notice or for a maximum of 10 years at a time.

1.5 Skilled workforce, research & development & innovation in Finland

Finland is one of the best places in the world to live and work. Finland is known for its professional, trustworthy, pragmatic and process oriented workforce that is ready to take initiative. Finland has a highly educated workforce and English is widely spoken.

Finland has a high educational level and engineering know-how, which is reflected in the global scale of Finnish mining technology companies. Finland has one the highest post-secondary education levels in the world and ranks in the top 10 countries in the social progress and democracy indexes. Finland also ranks in the top 10 countries in terms of patents in force per capita, which is again reflected in Finland's high ranking in the Global Innovation Index.

Non-Finnish expertise is naturally also needed, so it is important that bringing international workers to Finland is easy and that the immigration procedures are simple. Foreign nationals need to have a residence permit to stay in Finland for three months or longer, and a residence permit if working in Finland during a shorter stay. The process is straightforward and immigration services are available for assistance.

Finland has a strong and multi-level education and research network for mining and ore processing:

- 7 universities offering geology or mining process technology education and research.
    - Helsinki (2), Turku, Tampere, Lappeenranta, Oulu
- 3 Universities of Applied Sciences offering mining education.
    - Kajaani and Lappi offer mining education
    - Centria offers mining chemistry education
- More than 10 vocational schools and adult educational institutions offering studies in mining.
- Innovation support by national organisations GTK, Tekes and VTT (Technical Research Centre of Finland Ltd).

The availability of professional personnel for the mining industry has been one the key focus areas for the Finnish government since 2011 and the development of

mining education is still continuing.. The latest university level faculty, Oulu Mining School (OMS), was established in 2014 by the University of Oulu and focuses on the research and education in Geosciences (Geology and Mineralogy, Quaternary Geology, Applied Geophysics), Mining Technology, and Mineral Processing.

GTK Mintec is Europe's leading facility for ore beneficiation research and mineral processing studies conducting research from mineralogical studies to pilot scale testing.

Figure 6: GTK Mintec facility in Kuopio. Source: Geological Survey of Finland - GTK

2 Mines in Finland

Geological Survey of Finland (GTK) and Finnish Safety and Chemicals Agency (Tukes) keep track of active mines and projects in Finland. As of September 2015, there are 42 active mines and 32 active projects.

The most important minerals mined today in Finland include chromium, nickel, gold, copper, zinc and platinum metals, phosphate/apatite, calcite and talc. Exploration and active development is also ongoing for vanadium, lithium and silver.

2.1 Active metal ore mines and current projects

Below are listed the current active Base Metals (green), Precious Metals (yellow), Diamonds (red) and Other Commodities (grey) ore mines in Finland. The map in the next page shows the exact location of each mine marked with symbol colours.

Base Metals

	Mine	Owner
1	Riikonkoski copper, gold	Taranis Resources Inc.
2	Kevitsa nickel, copper, PGE	First Quantum Minerals Ltd
3	Sakatti nickel, copper, PGE	AA Sakatti Mining Oy
4	Sodankylä nickel, copper, PGE	Magnus Minerals Oy
5	Läntinen Koillismaa (LK), nickel, PGE	Finore Mining Oy
6	Kuhmo nickel	Boliden Kylylahti
7	Talvivaara nickel, zinc, copper	Terrafame Mining Oy
8	Pyhäsalmi zinc, copper, pyrite	First Quantum Minerals Ltd
9	Kylylahti copper, gold, zinc, nickel, cobalt	Boliden Kylylahti
10	Outokumpu copper	FinnAust Mining Plc
11	Hammaslahti copper	FinnAust Mining Plc
12	Valkeisenranta, nickel, copper	Boliden Kylylahti

Diamonds

	Mine	Owner
1	Kuhmo	Karelian Diamond Resources Plc

Precious Metals

	Mine	Owner
1	Iso-Kuotko gold	Agnico-Eagle Ltd
2	Hanhimaa gold	Dragon Mining Ltd & Agnico-Eagle Ltd JV
3	Kittilä gold	Agnico-Eagle Ltd
4	Kettukuusikko gold	Taranis Resources Inc.
5	Naakenavaara gold	Taranis Resources Inc.
6	Kutuvuoma gold	Aurion Resources Oy
7	Rompas gold	Mawson Resources Ltd
8	Suhanko-Konttijärvi PGE	Gold Fields Arctic Platinum Oy
9	Kuusamo gold	Dragon Mining Ltd
10	Laiva gold	Nordic Mines Ab
11	Antikanperä gold	Belvedere Resources Finland Oy
12	Hirsikangas gold	Belvedere Resources Finland Oy
13	Ängesneva gold	Belvedere Resources Finland Oy
14	Kopsa gold	Belvedere Mining Oy
15	Piilola gold	Mineral Exploration Network (Finland) Ltd
16	Taivaljärvi silver	Sotkamo Silver AB
17	Pampalo gold	Endomines Oy
18	Hattu Belt gold	Endomines Oy
19	Seinäjoki gold	Nortec Minerals Corp.
20	Osikonmäki gold	Belvedere Resources Finland Oy
21	Orivesi gold	Dragon Mining Ltd
22	Jokisivu gold	Dragon Mining Ltd
23	Kaapelinkulma gold	Dragon Mining Ltd

Other Commodities

	Mine	Owner
1	Kolari iron, gold, copper	Hannukainen Mining Oy
2	Kemi chromium	Outokumpu Chrome Oy
3	Mustavaara vanadium	Mustavaaran Kaivos Oy
4	Otanmäki vanadium, iron, titanuim	Vuorokas Oy

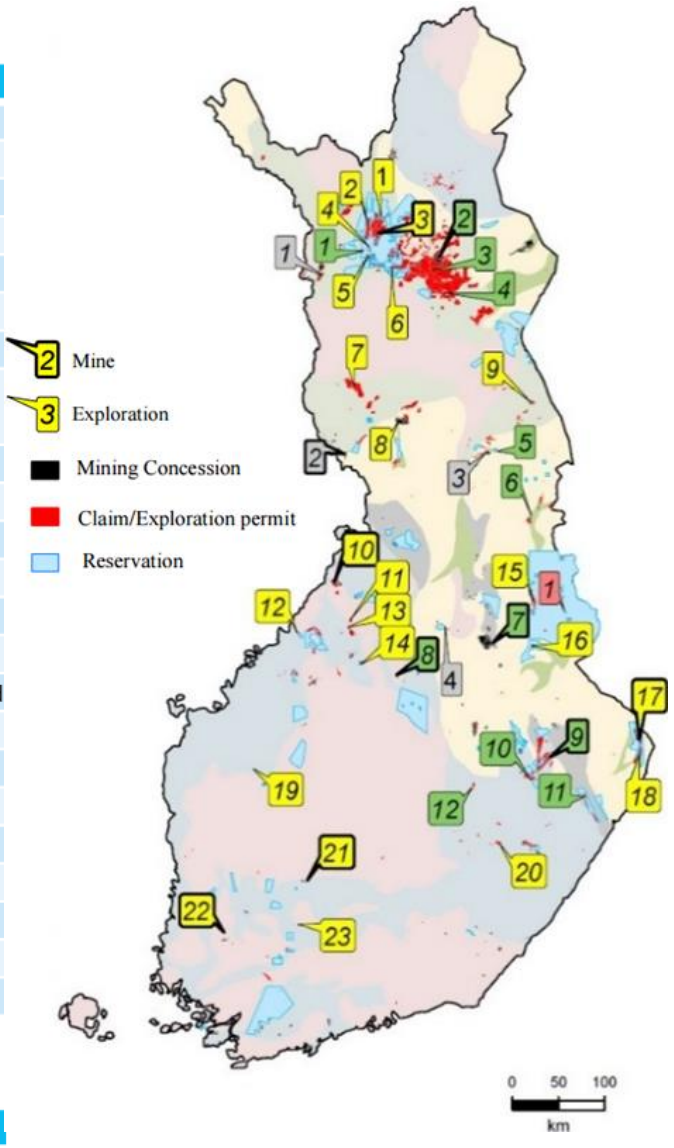


Figure 7: Active metal ore mines and current projects in Finland. Source: GTK

2.2 Active industrial mineral mines

In addition to active metal ore mines, there are plenty of active industrial mineral mines in Finland. The map below shows the locations of active apatite, calcite, dolomite, talc, quartz, feldspar, industrial rock, gemstone and precious stone, and wollastonite mines as well as current calcite and lithium projects (as of 2014).

Apatite

	Mine
1	Siilinjärvi
2	Sokli – *project (on hold)*

Calcite

	Mine
1	Tytyri
2	Mustio
3	Hyypiämäki
4	Limberg-Skräbböle

Calcite and Wollastonite

	Mine
1	Ihalainen

Dolomite

	Mine
1	Rantamaa
2	Kalkkimaa
3	Reetinniemi
4	Matara
5	Ryytimaa
6	Vesterbacka
7	Siikainen
8	Ankele
9	Siivikkala

Dolomite and Calcite

	Mine
1	Ruokojärvi
2	Putkinotko
3	Matkusjoki
4	Sipoo

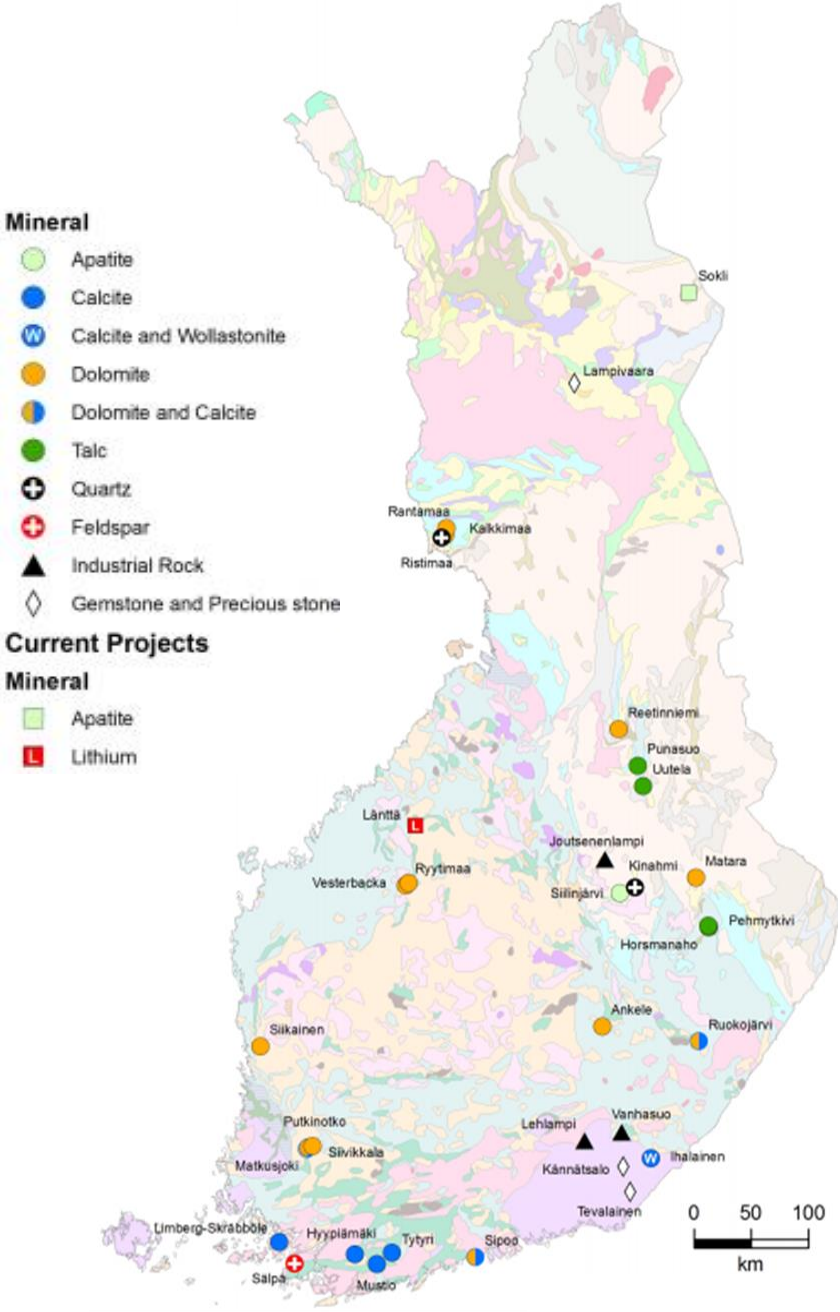


Figure 8: Active industrial mineral mines in Finland. Source: GTK / Tukes

1)

Talc

	Mine
1	Punasuo
2	Uutela
3	Horsmanaho
4	Pehmytkivi

Industrial Rock

	Mine
1	Joutsenenlampi
2	Lehlampi
3	Vanhasuo

Gemstone and precious stone

	Mine
1	Lampivaara
2	Kännätsalo
3	Tevalainen

Quartz

	Mine
1	Ristimaa
2	Kinahmi

Feldspar

	Mine
1	Sälpä

Lithium

	Mine
1	Länttä – *project*

2.3 Most important ore and industrial mineral mines

The most important ore mines in Finland include the following mines (in the order of ore mined (kilo tonnes) in 2014):

- Siilinjärvi (apatite)
- Kevitsa (metallic ores)
- Kemi (metallic ores)
- Limberg-Skräbböle / Parainen (carbonite rock)
- Pyhasalmi (metallic ores)
- Ihalainen (carbonate rock)
- Kittilä (metallic ores)
- Kylylahti (metallic ores)
- Horsmanaho (talc)
- Pampalo (metallic ores)

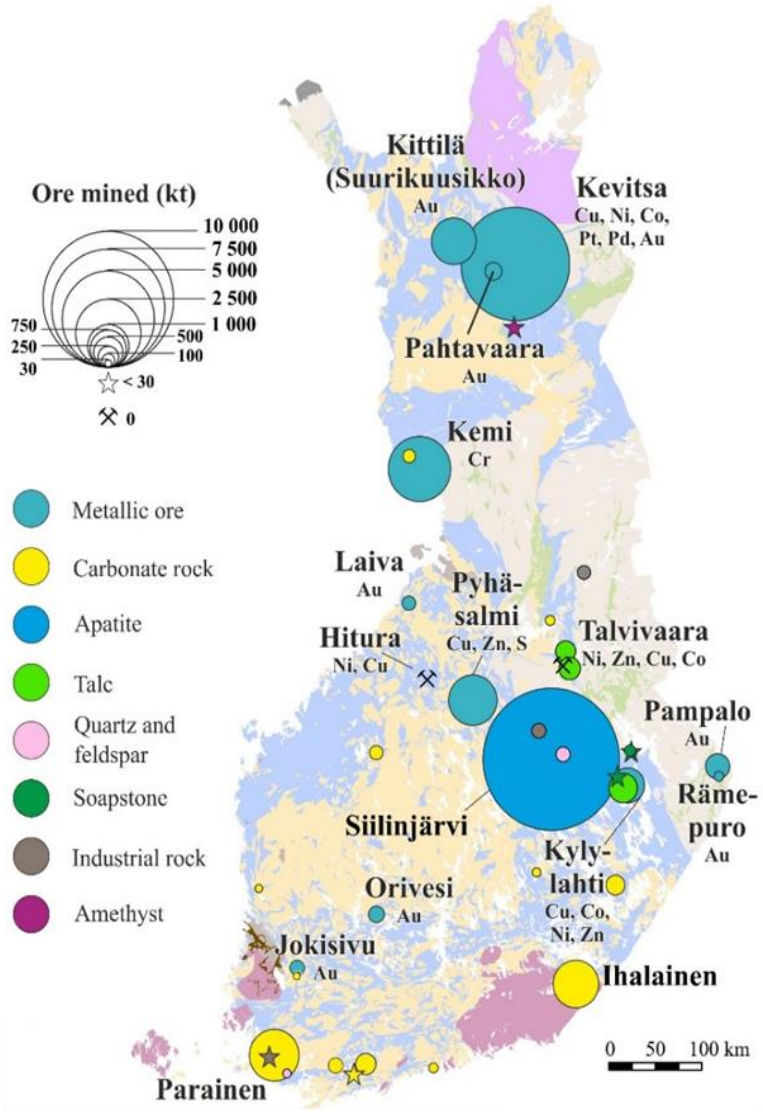


Figure 9: Mines in Finland 2014. Source: GTK

As can be seen in Figure 9, **apatite, metallic ore and carbonate rock** encompass the most important ore mines in Finland.

Most important industrial mineral mines in Finland include the following mines (in the order of ore mined (kilo tonnes) in 2014):

- Siilinjärvi (apatite)
- Limberg-Skräbböle / Parainen (calcite)
- Ihalainen (calcite, wollastonite)
- Horsmanaho (talc)
- Uutela (talc)
- Tytyri (calcite)
- Punasuo (talc)
- Ruokojärvi (calcite, dolomite)
- Hyypiämäki (calcite)
- Kinahmi (Quartz)
- Joutsenenlampi (industrial rock)
- Ryytimaa (dolomite)

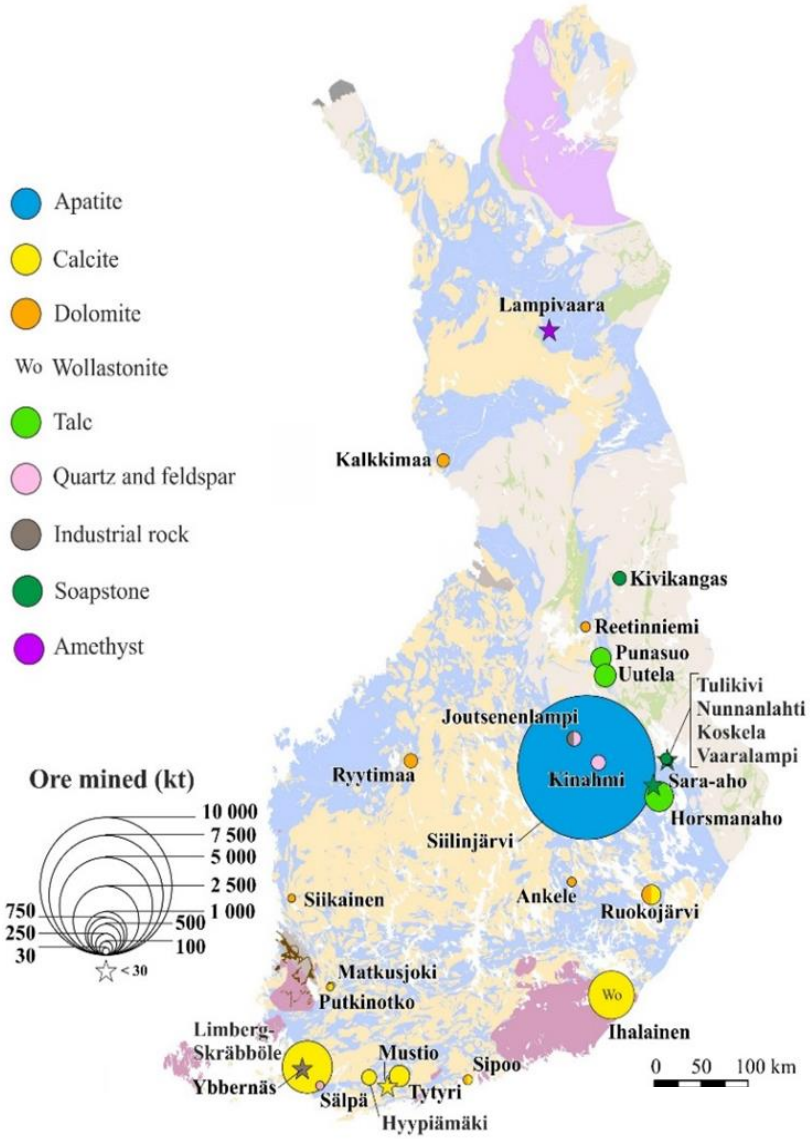


Figure 10: Industrial mineral and rock, soapstone and gem mines in Finland 2014. Source: GTK

Figure 10 shows that **apatite** is also the most important industrial mineral mined in Finland, along with **calcite** and **talc**.

3 Finnish technology and service offering to the mining industry

Finland has a strong mining and machinery industry cluster, which supports every aspect of the mine lifecycle from exploration and planning to operation and closure.

Finland is an engineering country. Finnish engineering companies have developed major innovations, such as Variable Speed Drives and Flash Smelting of copper, and also perfected technologies in the drilling, crushing and refining of minerals. It has been estimated that Finland and Sweden provide approximately 80% of the technology used in underground mines worldwide. Most of the equipment for mines in Finland is provided by Finnish OEM and engineering companies. For example, more than 50% of the equipment in Agnico-Eagle Suurkuusikko gold mine is Finnish technology.

The total Finnish offering of technology and services for the mining industry is summarized in Figure 11.

Figure 11: Finnish mining industry offering divided into main groups and sub-groups

3.1 Offering main groups

Finland is a fairly small country in terms of population but there are **over 200 Finnish companies** that offer services or products for the Mining sector. Consulting services form the largest offering group, followed by Equipment providers and Supplies & consumables providers.

Finland has a very strong history in equipment manufacturing and subcontracting and it can also be seen in the mining industry. The big Finnish equipment manufacturers such as Metso, Outotec, Normet, etc. also provide complete solutions to support their equipment offering. Finland has many very specialized subcontractors for mining equipment manufacturing and these contractors' technologies are often specifically designed for manufacturing parts for mining use.

Finland has been called ”a rock breaking nation” due to its long history in crushing hard rock. The pioneers in this field include, for example, Sandvik Mining (formerly Tamrock) in large equipment and Robit Plc in consumables in the form of drilling bits for different applications.

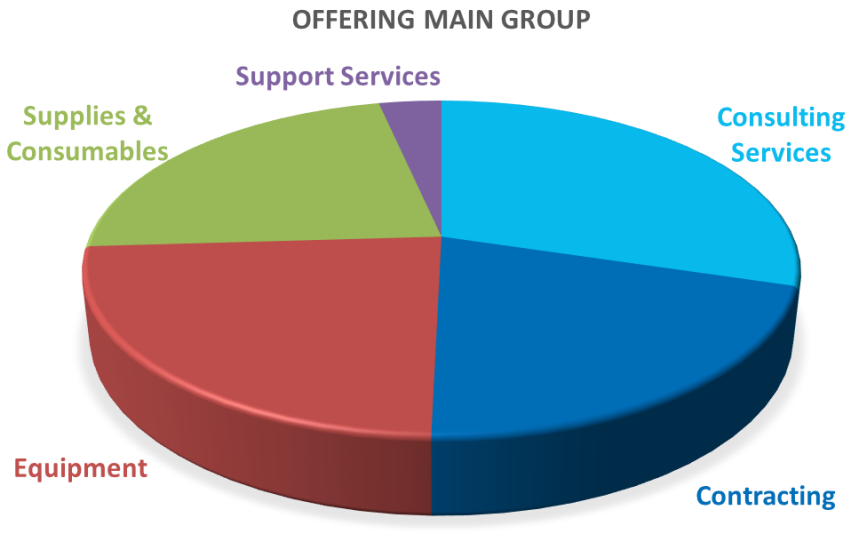


Figure 12: Share of Finnish companies by offering main groups

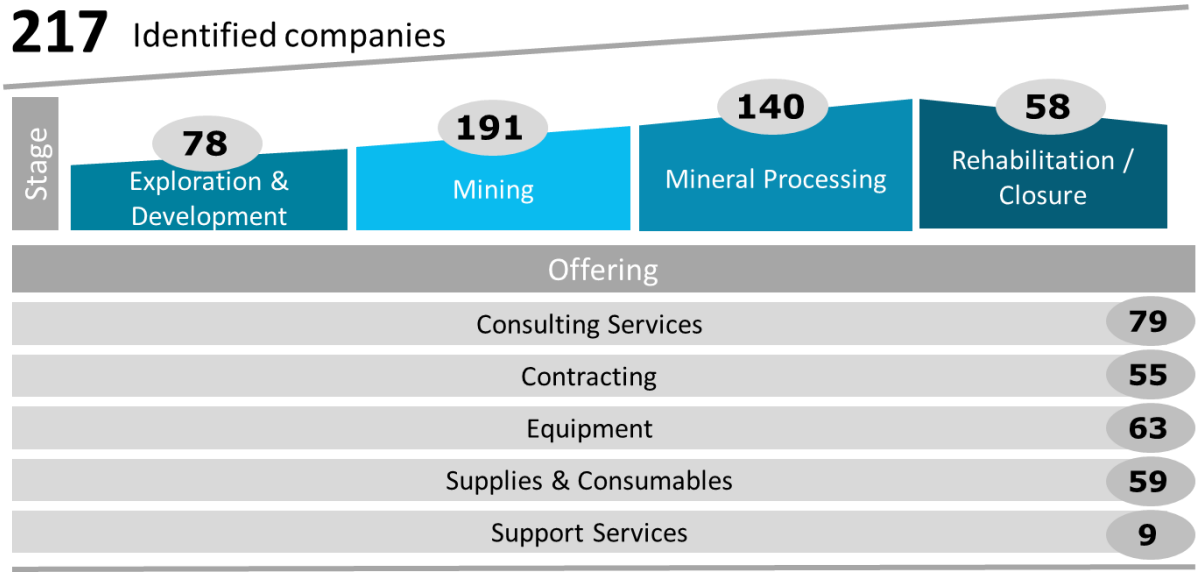


Figure 13: Many firms have a broad offering for multiple stages in the mining industry life cycle.

3.2 Offering target stages

The mining and **mineral processing stages** of the whole mining life cycle are clearly the major target activities of the Finnish mining sector companies and their offering. However, there are plenty of companies also targeting exploration and development as well as the mine closure and rehabilitation stages.

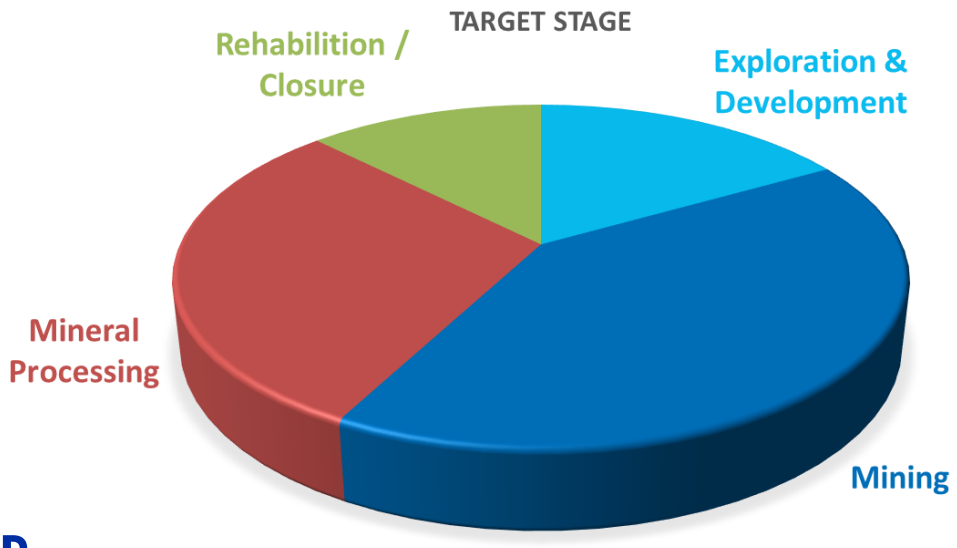


Figure 14: Share of Finnish companies targeting each stage in the mining life cycle

Most of the equipment manufacturers are targeting the mining and mineral processing stages. Engineering and consulting companies are offering their services broadly to the whole mine life cycle from development to rehabilitation. There are also many engineering, design and R&D companies with very specialized competences to serve the equipment manufacturers in the mining industry.

	Exploration & Development	Mining	Mineral Processing	Rehabilitation / Closure
Consulting Services	40	69	59	32
Contracting	17	48	35	8
Equipment	18	56	37	17
Supplies & Consumables	15	51	35	13
Support Services	4	8	5	4

Figure 15: Firms target multiple stages. Mining is the most popular target stage, while consulting services are the most common type of offering.

3.3 Offering target groups

The majority of the Finnish companies in the mining sector are targeting intermediate and major mining companies together with equipment manufacturers and contractors. Large companies such as Sandvik, Metso, Normet and Outotec are supplying the major companies directly. Many of the small and medium-sized companies are a valuable part of these supply chains and offer innovative and highly specialized solutions.

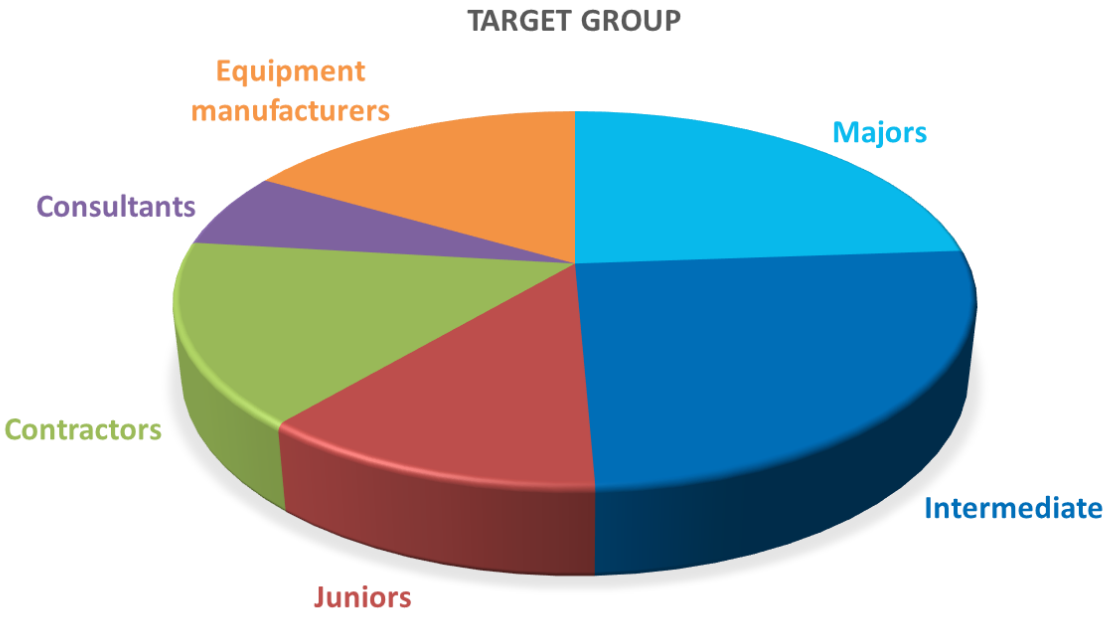


Figure 16: Finnish firms in the mining industry by share of target groups

3.4 Examples of Finnish companies by each offering for each target stage

Below are examples of Finnish firms and their offerings targeting various stages in the mining life cycle.

1) Consulting, engineering and design services

Figure 17: Consulting services providers have the widest clientele: 89% of the 79 identified consulting firms target more than one stage in the Mining industry.

2) Contracting

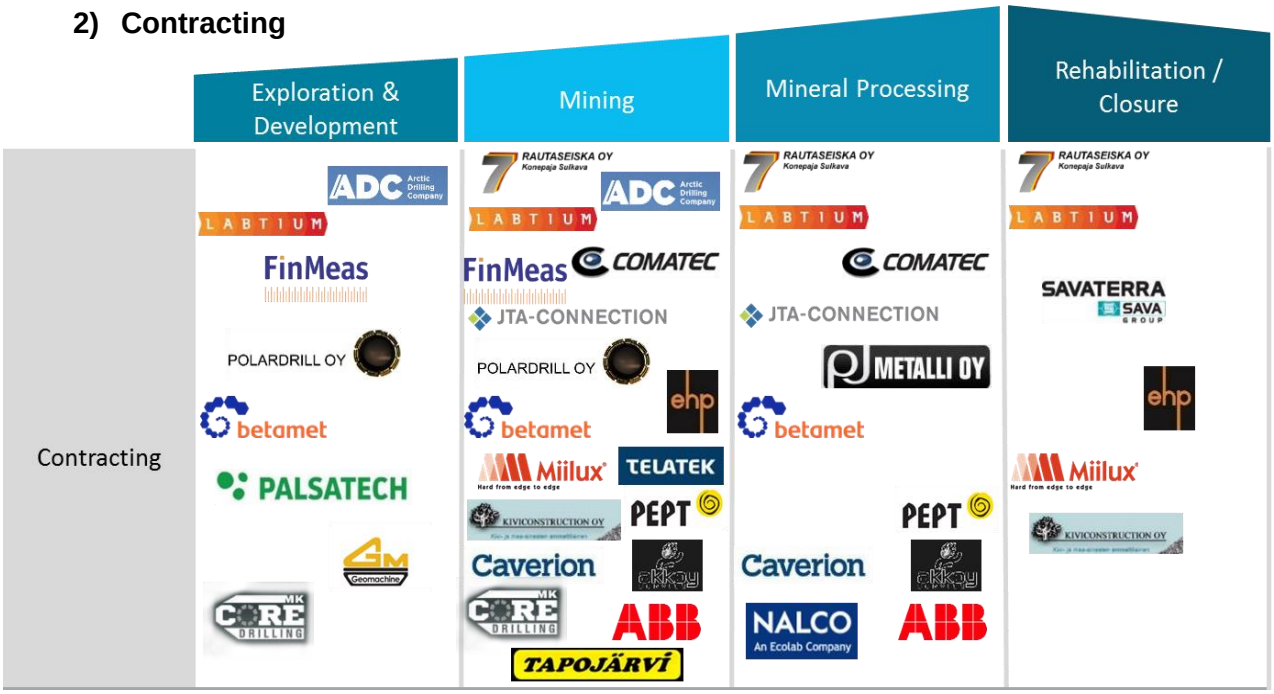


Figure 18: Contracting firms have the widest offering with 52% also providing other services/products for the Mining industry.

3) Equipment

Figure 19: 89% of the 63 firms offering Equipment target the Mining stage

4) Supplies and consumables

Figure 21: Supplies & consumables providers are most focused with their offering.

5) Support services

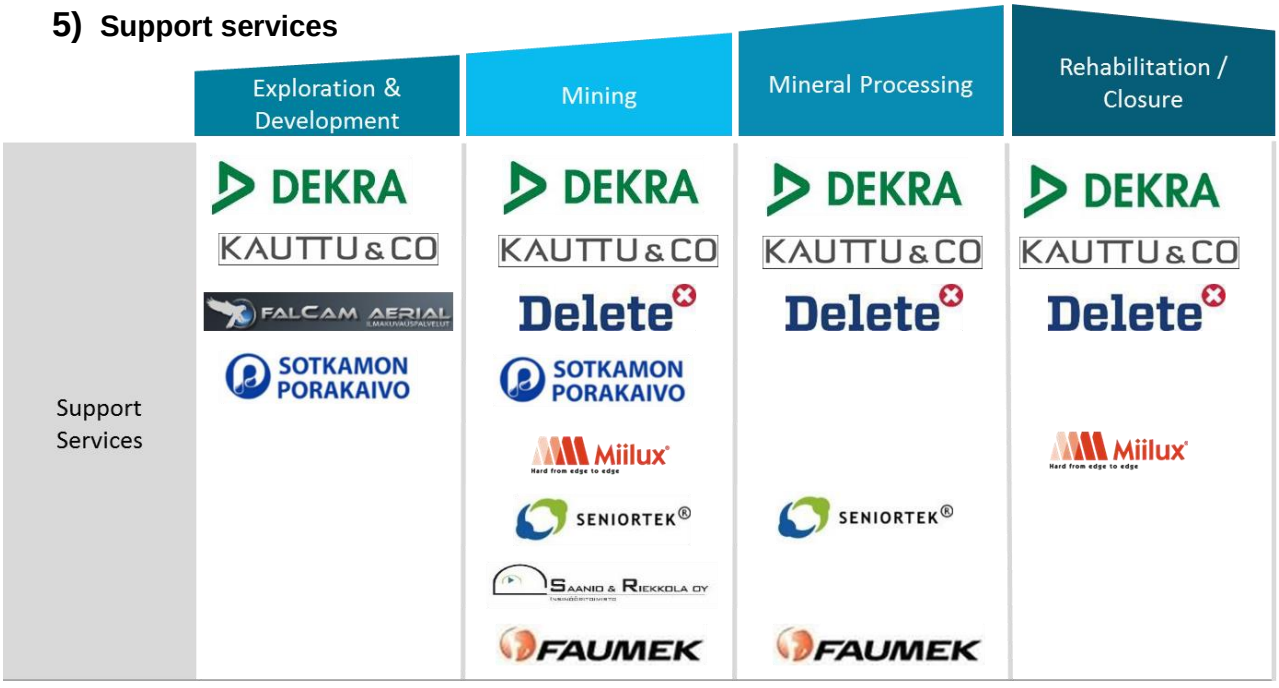


Figure 22: There are also firms offering Support services especially for the Mining industry.

3.5 Finnish technology and service offering in the future

The large international mining companies keep evolving and bringing the smaller companies into the international mining scene as subcontractors or partners. SMEs are agile and innovative and can often develop new solutions significantly faster and more efficiently than large corporations, which is one the many reasons why it is beneficial for large corporations to form alliances with SMEs.

Finland is a rich source of innovations for the mining sector. For example, there are already many very high tech water treatment companies and new innovative companies are constantly emerging. These include equipment manufacturers and also environmental surveying, measuring and consulting companies. These companies can form clusters and create an offering for minimizing the environmental impact of mining projects. This development is in line with the national mineral strategy and is also well supported by projects such as Green Mining in Finland.

Another example is the SPECIM hyperspectral imaging technology, which offers significant advances in airborne mineral mapping and drill core sample analyses benefiting consultants, contractors, juniors and mining companies.

A very interesting development is the increasing involvement of Big Data and IoT companies in the traditional industries. The Finnish big data companies are very advanced and already operate in several traditional industry sectors including mining. This technology will be more and more used in order to achieve intelligent and minimum impact mining, but also for simply higher efficiency in mining.

Finland’s dynamic engineering sector will continue to provide innovations to the mining industry also in the coming years.

4 Sources and Useful Links

Geological Survey of Finland (GTK) (www.gtk.fi)
Finnish Safety and Chemicals Agency (Tukes)
(http://www.tukes.fi/en/Branches/Mining/)
Ministry of Employment and Economy (http://www.tem.fi/kaivannaisohjelma)
Finnish Industry Investment Ltd (www.teollisuussijoitus.fi)
ProKaivos (http://www.prokaivos.fi/)
Team Finland Mining Program (www.exportfinland.fi/team-finland-mining-program)
Tekes Green Mining Program www.tekes.fi/green-mining)
Finnish Transport Agency (www.liikennevirasto.fi)
Public Employment and Business Services (www.te-services.fi)
Ministry of Foreign Affairs (http://formin.finland.fi)
University of Eastern Finland (www2.uef.fi/fi/kaivostutkimus)

Interviewed industry experts:
Ms Anita Alajoutsijärvi, Agnico-Eagle Finland Oy
Mr Jari Hietala, Ahma Environment Ltd and Ahma Engineers Ltd
Mr Terho Liikamaa, Tukes
Mr Georg Meissner, Specim Spectral Imaging Ltd
Mr Pekka Nurmi, GTK
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