significant metal resources are waiting to be discovered in Finland’s bedrock

Towards sustainable mining

Finland’s phosphorus resources are more important than ever
GTK’s new approach brings it closer to customers

It is a privilege for me to work as the Director General of GTK. When I started in this post in February 2015, I joined a research centre whose know-how is appreciated around the world. It is an honour to be a part of the GTK story.

GTK celebrated its 130th year of operations last May. Over the years, the world has massively changed, and GTK has followed suit.

Despite all the changes surrounding us, GTK’s services have always been in demand. GTK has successfully matched the modern needs of customers and society.

Once again, major changes are underway in GTK’s operating environment. We are addressing them with a new strategy and approach enabling maximally effective strategy execution.

The new strategy is based on an extensive in-house dialogue and on a large number of customer meetings. We have utilised the customer feedback to create new growth for GTK through four strategy themes: Mineral economics, Cleantech, Digitisation and Communities.

These are the themes to which we primarily allocate our resources and build our expertise and know-how. We will stick to the best aspects of the GTK everyone knows; it is important to us that we continue to be a leading specialist in ore geology. We will also introduce new opportunities for research, solutions and success together with our customers.

GTK is performing excellently in many areas, but some improvement is needed, too. GTK has streamlined its organisation in order to be more agile and capable of serving customers. We will serve customers through our national profit centres under operative management based in one location. GTK will continue to have a strong presence throughout Finland to serve customers. The regional units based in Espoo, Rovaniemi, Kuopio, Outokumpu and Kokkola will continue as regional offices.

However, GTK does not only operate in Finland. We will strengthen our international project operations to improve our ability to provide our services and add value to customers in Europe and other continents.

Would you like to submit feedback, ask questions or know more about GTK’s fresh approach? We will be happy to give you more information.

Mika Nykänen, Director General
mika.nykanen@gtk.fi

GTK Contact Information

Geological Survey of Finland
www.gtk.fi
Tel. +358 29 503 000
130 years of expertise in Finnish geology

On 21 May 1885, Czar Alexander III of Russia decreed that a geological research institute be established in Finland. The long-gestated dream of an independent research institute in Finland had come to fruition. Based on the declaration given 130 years ago, a Geological Commission was established, which is nowadays known as the Geological Survey of Finland.

After 130 years, geological research continues strong in Finland. GTK has experienced a great deal during its history: the independence of our country, war, rebuilding, urbanisation, internationalisation of Finland and increasingly rapid technological development. GTK has adapted to all these changes.

Today, we are seeking answers to questions preoccupying modern society. Where do we get sufficient raw materials to meet the needs of growing global population? Where do we get required rock material to meet the demands of urban expansion and development of infrastructure? How can we ensure our energy supply without speeding up climate change? And above all, how can we do all this in a sustainable manner so that future generations will be able to enjoy our unique and clean natural environment?

GTK updates strategy and approach

From now on, the operations of GTK will focus on four strategy themes: digitisation, cleantech, communities and mineral economics. The themes will be further specified so that it is possible for GTK to cost-effectively increase the quality of its leading research and expertise, to innovate and create solutions, and to provide added value for its customers.

The strategy execution will be made more effective by establishing 16 national profit centres acting as the backbone of the operations and led by operative management based in one location.

– We focus on customers, which is why the hierarchy of the new organisation is as “flat” as possible. As we are shifting the focus to profit centres and will have a smaller number of managers, we are confident that we will be more agile, which translates into an even better customer service experience, says Mika Nykänen, GTK’s Director General.

Adopting the national organisation model will result in more flexibility in utilising expertise throughout GTK. Customers are served by GTK’s leading experts, regardless of where those customers are based.

The regional aspect will remain a pivotal element of the fresh approach. GTK will continue to work close to its customers throughout Finland, and the regional service and presence through more agile profit centres will give added value to customers. The existing regional units in Espoo, Kuopio, Rovaniemi and Kokkola will continue as regional offices. The GTK Mineral Processing Laboratory (GTK Mintec) will continue to serve customers as usual in Outokumpu.

New management appointed

As part of the fresh strategy approach, GTK’s management will be reorganised and streamlined. One management level will be eliminated. Strategic responsibilities will be defined for the management in accordance with the new strategy.

The following persons have been appointed to GTK management. They will start in their posts on 1 January 2016:

Finland has been ranked first in the survey conducted by the Canadian Fraser Institute among mining companies, which mapped regional investment interests of mining companies. The comparison covers 122 jurisdictions and countries worldwide. Finland improved its rank by three since last year. Other top ten jurisdictions or countries by rank were Saskatchewan (Canada), Nevada (USA), Manitoba (Canada), Western Australia, Quebec (Canada), Wyoming, Newfoundland & Labrador (Canada), Yukon (Canada) and Alaska (USA).

Fraser Institute’s report ranks the countries and jurisdictions based on other criteria, such as political stability and availability of labour. In addition to the investment attractiveness, Finland was assessed the best based on its geological database for third time running. The Geological Survey of Finland plays a significant role in the development of the Finnish geological database and related services.

Read the Fraser Institute report in PDF format:

Finland as the path setter for natural resources economy in 2050

The Finnish government’s natural resources report “Intelligent and Responsible Natural Resources Economy” has been updated. The revamped report updates the policies, strategic aims and, for the development of natural resources economy, the principal activities which are aimed at making Finland the path setter in sustainable natural resources economy.

In the coming decades, the advance of the climate change, global growth and urbanisation will increase competition over natural resources. As an industrialised country, Finland’s national economy is exceptionally strongly based on sustainable use of natural resources as well as on the added value from natural resources and their processing.

Our natural resources together with our competences provide many new sustainable opportunities for responsible production of national added value and well-being also for future generations and products and of services based on high added value for international markets.

Sustainable use of natural resources increases well-being and competitiveness while creating the conditions to uncouple economic growth from non-sustainable use of natural resources and from growth in environmental stress. The switch to the economy of recycling is an attempt to ensure that natural resources are utilised as appropriately as possible.

The report was prepared under the guidance of the government’s ministerial working group on energy and climate policy.

The report in Finnish:

Finland is the world’s most attractive country for mining investment
Towards sustainable mining

Text: Paula Böhling

Green Mining, the first Finnish research and innovation programme for the extractive industries, is about to end. It has required a lot of investments, but it has also produced great results. The programme has given the field a boost.

The Green Mining programme, funded by Tekes – the Finnish Funding Agency for Innovation, has gathered a group of actors in the field of responsible mining operations that is impressive by Finnish standards. The group consists of over 120 actors, including mining companies, suppliers of equipment, technology and services, universities, research institutions, and other parties interested in the field. The programme initiated almost a hundred projects.

– The Green Mining programme is one of the funding tools we have used to execute the Green Mining concept and the objectives of Finland’s national mineral strategy in the field of research and innovation, says GTK’s Research Director Pekka Nurmi.

Finland’s Green Mining concept means continuous development in different areas of mining operations. The goal is to minimise the adverse impacts on the environment and communities throughout the production chain, improve resource efficiency, ensure the availability of raw materials in the future and restore mining areas after mining operations are completed.

– This is the best way to make mining operations more sustainable and acceptable. It is necessary to proceed in phases in all areas.

Finland’s Green Mining concept has also drawn international interest.

Synergies in the system

Nurmi thinks that the Green Mining programme has been a great success for the entire mining sector and GTK as well.

The funding has even exceeded expectations. The budget goal was 60 million euros, but the amount has already risen to 120 million.

– The programme has had a great impact on the development of research and innovation in the mining sector, and simultaneously on the development of the services in the sector. The cooperation between researchers and companies operating in the mining sector has strengthened in Finland and internationally. This has created synergies that benefit the entire sector, Nurmi sums up.
In Tekes’ preliminary evaluation of the programme, its positive results included networking, the results of the research projects and the development of the sector’s technological expertise and knowledge base.

Research throughout the mining chain

GTK has participated in 17 projects and acted as a coordinator in approximately half of them. The research topics have ranged from mineral exploration and enrichment processes to mine closure. Mine water management and other environmental issues were also included, as were social issues. The total funding received by GTK’s projects was EUR 12 million.

According to Nurmi, one of the most important achievements of the programme was that it allowed GTK to promote its strategic objectives.

– We have been able to carry out extensive research at every stage of the mining chain, expand our network of international contacts and develop our competence. We have moved closer to our goal of becoming a leading European specialist in mineral resources and their sustainable use, Nurmi estimates.

GTK already had many international contacts, but their number has grown further. Projects have involved partners e.g. from Sweden, Australia and Canada.

Two EU programmes also fund themes that support the Green Mining operating model: Horizon 2020 and ERA-MIN. Basic research is conducted in the Academy of Finland’s Mineral Resources and Material Substitution programme.

The Green Mining Programme

The main objective of the Green Mining Programme (2011–2016) is

- To make Finland a global leader in responsible and profitable mining
- To create new fields of business that require top expertise to complement the traditional and growing mining industry and to provide export opportunities for Finnish mining companies
- To create new startups in the sector and help companies in other fields to develop products and services for the mining sector
- To make Finnish mineral research the best in the world in the chosen sectors

Further information:
Geological research and exploration for new mineral resources are demanding, especially in northern regions. The environment is delicate, and mineral deposits are often covered by thick layers of glacigenic sediments and mire. The NovTecEx (Novel Technologies for Greenfield Exploration) project, carried out by GTK and the University of Oulu, developed more cost-effective and environmentally friendly operating models for exploration.

– Careful planning of work, light but efficient field and analysis methods, and efficient data analysis all help to reduce environmental impacts, says GTK’s Senior Scientist Pertti Sarala.

– We have obtained new methods for sampling, processing samples and mineral recognition, processing geological data and the results of the analyses, and interpreting airborne measurement data. Audio-magnetotelluric methods (AMT) and 3D modelling were developed for detecting deep bedrock structures.

In sensitive natural areas, samples can also be taken from peat, plants, snow and water. The UltraLIM (Ultra Low-impact Exploration Methods in the Subarctic) project developed the use of these "ultralight" geochrmical methods.

GTK has already adopted some of these new methods. Sarala hopes that companies will also utilise the results and include these new methods in their service portfolios.

Supporting research and exploration

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Research publication (pdf)
http://tupa.gtk.fi/julkaisu/specialpaper/sp_057.pdf
A databank about mine closure

Closing a mine properly is an essential part of sustainable mining operations.

- The planning for closing a mine should begin at the same time the actual mining operations are being planned, GTK’s Senior Scientist Päivi Kauppila emphasises.

The Closedure (Mine Closure Technologies Resource) project developed a wiki-based data resource to help authorities, consultants, mining companies and other concerned parties.

The website presents a detailed assessment of different closing methods, their positive and negative aspects and their applicability to different sites.

Other topics include the process and objectives of mine closure, closure plans, responsibilities, interaction, statutory requirements, mine water management and treatment, and waste management.

The general principles of closing a mine can be applied globally. The website contains examples that shed light on how mines have been closed in different environments.

- As far as I know, there are no other sites that are as comprehensive as ours, Kauppila says.

The website is produced by GTK and VTT Technical Research Centre of Finland in cooperation with mining companies and maintained by GTK.


Sustainable development tools for companies

The broad-ranging SAM (Sustainable Acceptable Mining) partnership project produced tools for mining and mineral exploration companies to support their sustainable development activities. GTK’s Researcher Mari Kivinen introduces two of them: water footprint and stakeholder engagement.

Water footprint is already used by, for example, the Finnish forest industry, and now it was for the first time applied to mining operations as well.

- A water footprint indicates how much water enters the mine, how much water leaves the mine and the quality of the released waters compared to the quality of waters in the surrounding environment. This tool gives companies a better idea of the water situation in a mine and issues that may require improvement. The water footprint also helps in communication and supports the evaluation of life-cycle impact, Kivinen explains.

Stakeholder engagement is aimed particularly for the use of mineral exploration companies. The model makes it easier for these companies to take local residents, companies and other actors into account, which potentially increases the responsibility and acceptability of the sector in the long term.

- Taking care of the environment and taking different interest groups into account have a direct impact on how ready people are to accept your operations, Kivinen says.

The participants in the SAM project coordinated by VTT Technical Research Centre of Finland include Finnish Environment Institute, GTK, the University of Helsinki and a number of companies.

http://virtual.vtt.fi/virtual/sam/

Developing sustainable beneficiation processes

GTK Mintec, GTK’s mineral processing unit in Outokumpu, conducts ore beneficiation research and develops mineral processing methods in cooperation with the industry, service and technology providers, universities and research institutions.

- In eight Green Mining projects, we have strived to develop more resource-efficient and environmentally friendly beneficiation processes and methods to exploit natural resources as well as side streams and waste materials produced by extractive and metal industry, Senior Scientist Raisa Neitola explains.

She thinks that the programme has had an impact on competence development and networking in particular. Cooperation has been diverse and the needs of companies have also been taken into account.

During these projects, we have discovered themes that we can continue to develop by focusing research, or as research commissioned by companies. Achieving results that can be utilised commercially, however, requires long-term research and often involves conducting pilot projects.

- In the Arsenal (Arsenic Control in Mining Processes and Extractive Industry) project, we had the opportunity to participate in research aimed at developing the process of a nickel bioleaching facility for the Mondo Minerals mining company.

Mondo Minerals is expanding its operations in Outokumpu. The company is making a huge investment in building a new nickel processing facility.

Management of arsenic and nitrogen compounds in mining areas and beneficiation processes has also turned out to be a topic that companies are interested in developing.

http://virtual.vtt.fi/virtual/sam/
Finland’s phosphorus resources are more important than ever

Text: Kari Ahokas

Without phosphate fertilisers and feedstuffs, food production would plummet globally. Finland is the only EU country with significant phosphorus production and notable mapped resources. Their importance will increase, because new risks have emerged concerning the supply security of large phosphorus producing countries. GTK has created the first comprehensive survey of Finland’s phosphorus resources.

Without phosphorus there would be no life. Phosphorus cannot be replaced by other substances in fertilisers or feedstuffs. Without phosphate fertilisers, global food production would plummet.

The fact that phosphorus is necessary is not a new thing. However, because of emerging risks concerning the supply security of large phosphorus producing countries, the EU added phosphorus to the list of critical mineral raw materials in 2013 due to its dependency on imports.

– For instance, the rise of China as the world’s largest phosphorus producer with a share of over a third of the global market and the fact that China has imposed export duties have contributed to the trade political risks related to the supply of phosphorus, says GTK’s Geologist Akseli Torppa, who specialises in critical raw materials and alkaline rocks.

The securing of the phosphorus supply is made even more difficult by the fact that Morocco, the owner of the world’s largest phosphorus resources, is located in the politically unstable region of North Africa. The fourth largest producer is Russia, but their trade relationships, let alone other relationships, with the West are not particularly good at the moment.

Previously, the lion’s share of the world’s phosphorus production originated in the United States. At that time, the availability of phosphorus was not considered as uncertain as it is today.

The first comprehensive survey

The EU is dependent on imported phosphorus. Finland’s phosphorus resources are unique in the entire of Western Europe. We are the only EU state with phosphorus production and significant phosphorus resources.

According to GTK’s survey, Finland’s reported phosphate rock resources amount to 2,360 million tonnes. The average phosphorus (P₂O₅) content is 4.0 per cent.

The data of the survey, which is the first of its kind, derives from GTK’s recent surveys of promising phosphorus areas and from previous reports. The surveys were conducted using geophysical measurements, drilling and drill sample enrichment tests.

– In addition, some data originates from our own analysis databases, says Geologist Panu Lintinen, who conducted the survey.

– High phosphorus concentrations have been observed and analysed in past decades in different areas of Finland when exploring for other types of ores. Because phosphorus has not ever been as critical as it is today, information about high phosphorus concentrations has not led to further investigations, Lintinen explains.

According to Lintinen’s estimation, the data about global phosphorus resources is generally not reliable and not of as high quality as the survey conducted in Finland.

– It must be remembered that there are also differences in the quantity of data and therefore the reliability of the data concerning Finland’s resources. The survey is, however, based on the best current data, Lintinen says.

According to the latest statistics by IFDC, the International Fertilizer Development, the world’s total phosphate resources are approximately 287.5 billion tonnes. Compared to this, Finland’s resources amount to less than one per cent of the world’s phosphate resources.
Production only in Siilinjärvi

In terms of volume, the largest known phosphate deposit is located in Siilinjärvi, where Europe’s only phosphate mine operates. Yara, known especially for their fertilisers, mines apatite ore and uses it to produce almost a million tonnes of apatite concentrate, which is used as the raw material for phosphoric acid and phosphate fertilisers. The phosphate concentration of the apatite ore excavated in Siilinjärvi is approximately 4.2 per cent. The ore’s apatite concentration is approximately ten per cent.

- The total amount of phosphate rock in Siilinjärvi is 1,617 million tonnes. Of this, 888 million tonnes have been measured and indicated. In addition, the amount of inferred resources is 729 million tonnes.

- Yara created their resource estimation according to the international JORC code, which means that is very accurate, GTK’s Lintinen says. It is also becoming even more accurate.

- We are continuing to survey the Siilinjärvi deposit. Two geologists from our research unit work with drilling, says Pasi Heino, the Chief Geologist of Yara’s Siilinjärvi mine. Currently, the apatite concentrate from Siilinjärvi covers approximately half of the phosphate needs of Yara’s European operations, and the company plans to increase its self-sufficiency in phosphorus. Therefore it is important to, for example, increase the number of analysis points in the area of potential resources to increase the reliability of data and to allow classification of the resources as measured and indicated.

- We have also submitted an ore exploration permit application to allow us to map better the areas south and north of the deposit and also the areas outside that which we currently own, says Teija Kankaanpää, Production Manager of Yara’s Siilinjärvi mine. Currently, Yara is only excavating on the land the company owns.

The Siilinjärvi deposit is 14.5 kilometres long, and 900 metres wide at the widest point. Its depth is not known yet. The deepest observed point so far has been 800 metres underground. The maximum depth in Yara’s mine plan is 400 metres.

Exceptionally pure

The value of Siilinjärvi apatite and the majority of Finland’s most significant phosphorus resources lies in their purity. Finland’s phosphorus resources are magmatic. This means that, for example, the heavy metal concentrations are clearly lower than in sedimentary phosphorite, which accounts for almost 95 per cent of the known phosphorus resources. The cadmium concentration of sedimentary phosphate is usually over 60 milligrams of cadmium per kilogram, while the concentration in magmatic deposits can be less than one milligram.

- A large portion of phosphates ends up in fertilisers, where the cadmium concentration has been limited in EU legislation. As a fertiliser manufacturer we are naturally satisfied with the Siilinjärvi apatite, where the heavy metal concentrations are low even for magmatic phosphate, Teija Kankaanpää says.

Finland’s other significant phosphorus deposit is the Sokli reserve in Savukoski.

- There the phosphate ore is bound to the weathered soil. With a phosphorus concentration of 11.2 per cent, the deposit is slightly richer than the one in Siilinjärvi, Panu Lintinen says.

Like the Siilinjärvi mine, Yara also owns the ore in Sokli. The company itself has estimated that there is 190 million tonnes of ore in the reserve. On September 2015 Yara made a preliminary decision to halt development of its Sokli mining project, due to the anticipated profitability of the project being below Yara’s requirement. Yara may re-evaluate the project in the future.

“Without phosphorus there would be no life.”

Map of Finland’s phosphorus deposits and occurrences.
GTK has surveyed the carbonatite veins south of Sokli, which also contain weathered bedrock rich in phosphorus. GTK is continuing to survey the potential area.

In addition to Siilinjärvi and Sokli, most of Finland’s known reserves are concentrated in the gabbros of Southern Ostrobothnia. However, the phosphorus content of known gabbros is lower than Finland’s average. Therefore GTK’s Panu Lintinen believes that these gabbros will not be commercially utilised in the near future. However, Lintinen says that apart from Southern Ostrobothnia, the phosphorus concentration of gabbros has been studied very little.

– Surveying gabbros might reveal new deposits that are rich in phosphorus, Lintinen says.

Lintinen also thinks the Iivaara Alkaline massive is also interesting in regards to phosphorus. The surveying in Iivaara is in its early stages, partly because the deposit is located in a Natura nature protection area where, as you can understand, we have to proceed carefully. For this reason, we do not have an estimation of the size of the deposit yet.

Lintinen also mentions another interesting deposit, which is located in Kortejärvi in the municipality of Pudasjärvi. GTK has surveyed the carbonatites of the region since 2010 using geophysical measurements and drilling. An estimation of the size of the Kortejärvi deposit will be carried out in 2015.

International opportunities

Even on an international scale, Finland’s magmatic phosphate deposits are very pure. On the other hand, the phosphorus concentration of our deposits is not particularly high on the global scale.

What happens when the ore deposits with higher concentrations have been depleted and the price of phosphorus necessary for food production inevitably rises? It will then be viable to utilise deposits with lower concentrations commercially as well. When this happens, Finland’s deposits will become more important.

– The situation in all mining operations is that companies have already started utilising poorer deposits because the better ones have been depleted. In Finland and in Siilinjärvi we have utilised ore with lower phosphorus concentration since 1979, when the mine began operation under Kemira’s ownership, Teija Kankaanpää from Yara says.

GTK’s Akseli Torppa also says that there is global demand for Finnish geological expertise related to phosphorus.

– The significance of phosphorus deposits related to magmatic and alkaline rocks as sources of phosphorus production is constantly increasing. GTK and other Finnish actors have long-term experience of this rare phosphate ore type in particular.

GTK is participating in phosphate-related cooperation projects in, for example, Mongolia. Torppa himself has participated in a project that surveyed Mongolian phosphorous deposits that share similarities with the Siilinjärvi and Sokli deposits.

– We are also trying to establish cooperation in Saudi Arabia where we have already carried out a few commissioned jobs related to phosphorus ores, Torppa says.

The need for phosphorus increases with the standard of living

Running out of phosphorus is not the most topical problem. According to Lintinen, the known resources might last as long as 300–400 years.

– It is possible that after the rich deposits deplete, the price of phosphorus will increase due to increase production costs, and this in turn will reduce consumption, Lintinen speculates.

On the other hand, consumption may increase because the need for food is increasing even faster than the population is growing. When the standard of living improves, people increase the amount of meat in their diets, often reducing the amount of vegetables. This increases the need for phosphorus in fertilisers for livestock grain fodder and the mineral feed given directly to animals.

All in all, because phosphorus is not a renewable resource and recycling it has proven to be difficult, it is expected that in the future Finland’s phosphorus resources will be utilised more than now.
Towards intensified innovation collaboration – New knowledge and innovation community: EIT Raw Materials

Text: Saku Vuori

The European Institute of Innovation and Technology (EIT) funds the European innovation cluster that focuses on raw mineral needs. One of the cluster’s six sites will be established in Otaniemi, Espoo. GTK has participated strongly in gathering and preparing the winning consortium.

During the first five years, the EIT will invest about EUR 270 million in the EIT Raw Materials innovation cluster. The investment aims at creating new business in the minerals industry by activating the commercialisation of research results, supporting start-ups and organising versatile training. The aim is to create 10,000 new jobs and 50 viable start-ups in Europe, as well as to train 8,000 new entrepreneurs.

The cluster consists of over 120 companies, universities and research institutes from different regions of Europe. Finland is represented by Outotec, Metso, Spinverse, FIMECC, Aalto University, University of Oulu, Lappeenranta University of Technology, VTT and GTK. In addition to Espoo (Finland), the EIT Raw Materials cluster will have offices in Luleå (Sweden), Leuven (Belgium), Cracow (Poland), Metz (France) and Rome (Italy). The association to be founded for the Innovation Cluster will be located in Berlin.

GTK will complement the expertise of the consortium primarily in the fields of mineral exploration, Mineral processing, Environmental and social issues in mining, and Mineral information management areas. We aim to contribute in developing new methods, processes, technologies, services, digital and mineral products in addition to enhanced use of research infrastructures.

GTK sees the EIT Raw Materials community as a “double opportunity”. First of all, the community provides a chance to participate in building “a European centre of excellence and the core of innovation” and to provide a contact point for our own customers and partners with this community and its services. On the other hand, GTK can act as gateway for European actors both to Finland and Finnish actors in minerals sector. Furthermore, our international project exports to developing mineral-rich economies could also serve as bridgeheads to find new business or collaboration opportunities.

The central beneficiaries in this framework are Finnish and international commercial organisations and public sector agencies, as well as other international actors (e.g. funding agencies).

State of the art

EIT Raw Materials is in its ramp-up phase that include definition of legal status, internal organisation and working methods. EIT Raw Materials has selected a CEO to run its operations and the preparation of a business plan, including an ambitious portfolio of activities from education to business creation, with clear targets and deliverables that aim to have both market and social impact. Actual operations will be start in early 2016.

http://eitrawmaterials.eu/
Significant metal resources are waiting to be discovered in Finland’s bedrock

Text: Timo Hämäläinen

GTK has evaluated resources of selected metals in Finnish bedrock to a depth of one kilometre. The assessments reveal significant undiscovered resources of several important metals such as copper, zinc, molybdenum, gold and platinum-group metals (PGM).

GTK started its studies in 2008 by assessing platinum-group metal (PGM) deposit potential. After that, GTK has assessed nickel, copper, zinc, cobalt, lead and gold resources. Approximately half of Finland’s molybdenum potential has been estimated.

— This year, we have finished the assessment of Finland’s chromium resources. Next year, we will assess titanium, iron and vanadium resources. During 2017 and 2018, we will estimate the undiscovered phosphorus and rare earth element (REE) resources, says Geologist Kalevi Rasilainen.

Copper, nickel and zinc are the most common metals extracted from Finland’s bedrock. These are also the metals with the largest undiscovered resources. There is a 50 per cent probability that the undiscovered deposits contain at least 9.6 million tonnes (Mt) of copper, 5.0 Mt of nickel and 1.8 Mt of zinc.

The GTK estimate of the copper resources contains volcanogenic massive sulphide deposits, porphyry copper deposits and Outokumpu-type deposits, which are important to Finland. We have also estimated copper in PGE resources in layered intrusions, synorogenic intrusive nickel resources and komatiitic nickel resources.

The evaluation of nickel resources is limited to Proterozoic synorogenic intrusions and deposits related to Archean and Proterozoic komatiitic volcanic rocks. The ore type of Talvivaara mine’s Ni-Zn-Cu-Co deposit, for example, is not included because no other similar deposits are known. Therefore it is impossible to create the necessary statistical model.

Precious platinum group metals

Compared to copper, nickel and zinc resources, the estimated undiscovered precious metal resources are relatively small. However, their techno-economic value is often great. Platinum group metals, for example, are

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Summary of known and estimated undiscovered resources of the assessed metals in Finland. The known and excavated palladium resources, for example, amount to 280 tonnes palladium metal. By the end of 2013, there were 273 tonnes of palladium left in the known resources. There is a 50 per cent probability that at least 12,000 tonnes of palladium exist in resources that are still undiscovered.
needed for many modern energy and IT applications.

– The metal resources in Finland’s bedrock are increasingly important for the European industry, which is currently importing almost all of the metal it requires from outside Europe. We are importing a lot of metals to Finland as well, even though we have many mines, says Senior Scientist Pasi Eilu.

There is a 50 per cent probability that at least 5,600 tonnes of undiscovered platinum and at least 12,000 tonnes of undiscovered palladium exist in Finland’s bedrock. This is a large amount compared to the known resources of 280 tonnes of palladium and 111 tonnes of platinum.

– According to our estimate, approximately two per cent of Finland’s platinum and palladium resources have been discovered so far, Eilu says.

Eilu and Rasilainen note that the assessment does not tell how much of the estimated undiscovered resources will eventually be discovered.

Everything cannot be estimated

GTK’s researchers use a three-stage method developed by the U.S. Geological Survey. First, deposit types are identified and the appropriate ore deposit models are selected. If necessary, new models are created. The models are based on known deposit types, for which metal concentrations and the deposit size are known. The evaluation is only targeted on areas where the geology “allows” certain ore types to occur.

– It is likely that Finland’s bedrock also contains a relatively high amount of rare hi-tech metals, such as lithium, rare earth elements (REE), tantalum, and niobium. Presently there is, however, so little information about the ore types containing them that it is difficult, and in places impossible, to give a reliable estimate of the undiscovered resources, Rasilainen states.

Models are used to estimate how many deposits of a certain type there can be in a chosen area and how large those deposits might be. The estimated number of undiscovered deposits is presented with the confidence level of 10, 50 and 90 per cent. Finally, the metal content of these deposits is calculated by using the deposit size and metal content data (grade-tonnage model) of similar well-known deposits.

– We utilise all the information we have about the geology of any area we are evaluating – the bedrock, ore deposits, indicator minerals, and geochemical and geophysical survey data. The evaluation is always carried out by a group of experts who specialise in the ore deposit type being assessed and are familiar with the bedrock of the area and the mineral exploration that has been carried out in the area. A group can sometimes consist of over ten people, Rasilainen says.

GTK’s published assessments are available at the following addresses:


The map image displays an overview of the possible locations of nine different ore deposit types. The locations of a number of ore deposit types overlap and, on the other hand, there are many areas where it is likely that none of these deposit types occur.

"Next year, we will assess titanium, iron and vanadium resources."
New research strategy strengthens the development of extractive industries

Text: Timo Hämäläinen

The Ministry of Employment and the Economy published Finland’s research strategy for extractive industries in the spring. The goal of the strategy is to ensure that we will have high-level research and leading expertise in Finland also in the future.

The persons who have drawn up the strategy are convinced that with high-quality research we can accelerate the growth of sustainable businesses via revolutionary and radical technological innovations in addition to service and system-level innovations.

The research strategy for extractive industries has received impetus from the European Commission’s Raw Materials Initiative and the EU’s Horizon 2020 research programme that supports it. The programme seeks, for instance, new solutions to secure the supply of vital industrial materials and the technological development of extractive industries, as well as to promote recycling and the replacement of raw materials with other materials.

Following the EU Raw Materials Initiative, Finland has drawn up a national mineral strategy, in 2010, and the government has drawn up a report on natural resources for the parliament (2010, revised 2014). In addition, the Ministry of Employment and the Economy published an action plan to make Finland a leader in sustainable extractive industry in 2013. The research strategy for extractive industries published now is one of the actions specified in this plan.

A large number of actors in the sector have participated in preparing the strategy, including representatives from the industry, research institutions, universities and various stakeholders.

Many challenges and opportunities are alike in different industries.

We want to create a common direction and aim for research and education for the future, says GTK’s Senior Specialist Saku Vuori, who acted as the secretary of the group.

Research produces solutions

According to the strategy, the primary vision of research is to create new sustainable growth to Finland and to enforce our global competitiveness. This requires high-quality applied and scientific research.

In the future, the primary focus of research will chiefly be on demand-driven problem solving in the minerals industry value chain. However, we also have to broaden research activities into material cycles, the mineral economy cycle and the way it is linked to industrial designing and recycling. In order for the strategy’s vision to succeed, we need to develop our systemic thinking and our ability to produce systemic solutions, Vuori says.

The strategy specifies the main themes for research, allowing us to focus our national resources on the specified areas. The primary areas of research are material cycles, digitisation, clean-tech, and new business models.

New research challenges include sustainable life-cycle thinking, social acceptability, risk and impact management, measuring technologies and intelligent systems.

More international cooperation

According to the strategy, research cooperation with partners in Finland and internationally is crucial.

The level of internationality can change between different projects depending on the nature of the research. It is clear that in the future basic re-
search in particular will be increasingly internationally challenged, meaning e.g. more competition on research funding in addition to benchmarking evaluations to ensure it is high quality, Vuori says.

The goal of the strategy is to establish cooperation with leading researchers, universities and research institutions in the field. We need to expand our network of international partners in order to secure quality and continuity.

– Many Finnish universities, companies and research institutions participated in an application consortium (EIT–RM–KIC), which has been designated as a Raw Materials Knowledge and Innovation Community by the European Institute of Innovation and Technology (EIT). This opens up new possibilities for international cooperation, Vuori says.

The strategy names exploration technologies, mining and enrichment technologies, hydrometallurgy, "untraditional" metal alloys, and the management of water systems and utilisation of minor flows as the most important areas of international research.

The prerequisites for research cooperation with Finnish actors are good because, in general, many challenges and opportunities are alike in different industries. Materials, energy and water efficiency, renewable energy solutions, recycling, material technology, digitisation and the industrial internet are e.g. areas of shared interest.

**Fixing the funding**

The strategy presents a number of suggestions for securing funding for research because it is one of the most important factors guiding research. We have also done benchmarking Europe for examples of how to enable good research ideas to “take a shot”. Excellent approach is the Marie Sklodowska-Curie actions – Research Fellowship Programme that can grant, 'sensu lato' funding for top research based on an idea alone.

– As far as funding is concerned, it is essential to ensure long-term commitment in addition to that the investments are focused correctly. The right position in relation to, and interaction with, the EU is also a requirement, Vuori says.

**GTK active in many fields**

In the long term, extractive industries are expected to contribute more strongly into the Finland’s economy. Research is conducted by research institutions, universities, universities of applied science and companies. According to Vuori, Finland has good prerequisites to participate in international research cooperation projects of high quality.

– We have a lot of expertise with research communities, companies and authorities. Many of our equipment manufacturers and service providers are among the best in the world. With this new strategy, we want to clarify a shared view of how we can secure the future of the sector.

The role of GTK is to act as an expert in the geo-sector and to develop innovative solutions for the needs of sustainable use of natural resources, excavation operations, energy supply, the environmental sector, construction, and land use. GTK brings geoscientific expertise to multidisciplinary research cooperation and works actively in international research and project operations.

– One of the six EIT–RM–KIC sites will be established in Otaniemi, Espoo, right next door to our office. It is a good example of new opportunities opening up for the mineral sector. As an active partner of this community, we can continue to participate in developing things that matter to us, Vuori says.
Arctic experts

Text: Jaana Ahlblad

In a research project funded by Tekes and four mining companies, GTK is studying the suitability of un-manned aerial vehicles (UAVs) for mineral exploration, and the University of Lapland is examining legal issues related to the method: where drones can be used and how high are they allowed to fly. The project is testing equipment for mineral exploration companies; GTK is not planning to acquire the equipment.

The results are promising. According to GTK’s Research Professor Vesa Nykänen, mounting equipment to measure disturbances in the magnetic field on a drone meant that only four hours were needed to perform a task that would take people on foot a week to complete. The accuracy seems to be approximately the same.

This drone survey is just one form of cooperation that GTK and the University of Lapland are planning – if it is up to Vesa Nykänen and Research Professor of Natural Resource Law Jukka Similä. According to Similä, one of his most important tasks of the university’s Arctic Centre is to promote cooperation between the region’s institutes.

Mining operations will increase in the north

There are currently three operating mines in Lapland. They have been established around deposits discovered by GTK. The professors believe that mining operations will increase in the north. We have, for example, the potential for platinum group metals, which the EU has added to its list of critical metals.

- In addition to the current gold deposits in Kittilä and Sodankylä, there is the possibility of discovering more gold reserves, Vesa Nykänen says.

If a mining company is considering establishing a mine in Lapland, the residents of the area must be included in the process from the beginning in addition to the authorities, Nykänen and Similä state. Everything should be based on transparency – the company should explain what it is doing and why.

- There are a number of interests and fears related to how the land areas of a municipality are used and how mining operations affect tourism, explains Jukka Similä.

How will Lapland be approached?

According to Similä, companies can influence on obtaining social licence regionally.

- One example is reindeer farming. If a mining company tries to find solutions that have as little impact as possible on the grazing and routes of reindeers, it helps in obtaining social licence, Similä says.

According to Similä, discussing the risks is also beneficial: when a municipality builds the infrastructure needed for the mine and private individuals invest in apartments, it would be good to divide the risks in a reasonable way in case the operation slows down and people have to find jobs elsewhere. Money could be out into a risk fund through taxes or some other way.

- Companies have already started to participate a little in building the infrastructure. For example, in the case of the Sokli phosphorus mine, the government and the company have discussed sharing the costs of road construction, explains Similä.

He goes on to state that the social impact of mining operations should be evaluated in advance in the same way as their environmental impacts. The way of life of the Sami population and other local residents must be taken into account in the decision-making.

According to GTK’s Research Professor Vesa Nykänen (at left), social licence for mines is based on understanding why mines are needed in the first place. Jukka Similä, Professor of Natural Resource Law from the University of Lapland, reminds companies planning on opening a mine that their communication should be transparent from the start.
Social licence is a necessary, but difficult concept. It is not granted by anyone, the requirements for getting it are not clear-cut and, once acquired, it can be lost surprisingly quickly. A permit granted by the authorities is a whole different matter, comments Similä.

Full benefit from minerals
Professor Similä describes natural resources law as matching different interests. This branch of legislation includes not only mining operations, but also various other forms of utilising natural resources.

We should find a reasonable balance between the actions of individuals and society. The basic level is specified by area zoning and environmental regulations, but we also need voluntary action to promote social licence.

If Similä could change something about natural resource law, he would emphasise life-long resource efficiency of materials and things.

We should take full benefit out of the resources we dig up. We have to think carefully about how companies could utilise waste produced by other companies. Mining authorities could evaluate resource-efficiency for the early life-cycle of minerals.

Follow information benefits all
Professor Nykänen, who is researching the development of mineral potential mapping, is grateful for the current instructions, according which the information produced by companies during mineral exploration should be available to everyone. The material is submitted to the government annually, and the mining authorities keep them until the mineral exploration permit or mining licence expires.

Similar practices are used in, for example, Australia.

We also need voluntary action to promote social license.
The need for minerals and metals produced from primary mineral sources will keep increasing for a long time despite increased efforts to recycle them.

Industrial nations have awoken to the fact that their economies cannot be based on a linear model where things and materials are dumped in landfill. Instead, we are now trying to increase recycling and energy efficiency and aiming for a circular economy.

GTK’s Research Professor Raimo Lahtinen thinks that despite the increase in recycling, the production of primary minerals will continue for a long time.

– Minerals produced from primary sources will be needed for at least as long as there are poor people that are struggling for a livelihood and who want to reach the same standard of living we have in Western countries, Lahtinen says.

A circular economy cannot function without a primary economy.

Recycling has its own problems and limitations. In many new products, for example, increasingly complex metal alloys are used, and this makes recycling more difficult. Even when we are able to separate the metals from each other, the production costs can become much higher than when producing virgin metals.

– Recycling does not make sense if it uses an unreasonable amount of natural resources or causes an unreasonable amount of emissions. In this case, we must improve the prerequisites for recycling through planning and research, Lahtinen states.

Primary metals are also needed because it is difficult, or even impossible, to build systems that are so tightly closed that all the recyclable material

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**Minerals and material properties**

- Primary raw materials
  - Mining and extraction
  - Processing/Refining
  - Production/Remanufacturing
  - Consumption
  - Collection

- Secondary raw materials
  - Residual waste

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Lahtinen believes that in the long term logical surveys, in cooperation with other Nordic geo-technologies and mineral alloys have had a great impact on GTK’s operations. As late as the 1990s, GTK focused on surveying copper, zinc, nickel, cobalt and gold deposits. Recently, GTK has also started to survey critical metal and hi-tech metal resources. GTK surveys these metals independently as well as in cooperation with other Nordic geological surveys.

Despite the many challenges, Lahtinen believes that in the long term the industrial sector will have sufficient raw materials.

Concern about the availability of metals

Industrial countries are particularly concerned about the availability of certain metals used in new applications. Europe was reminded of this vulnerability in 2009, when China tried to limit exports of rare earth elements. The following year, a working group designated by the European Union published a list of fourteen raw materials that are critical to acquire. This list was revised 2014 and now includes 20 CRM’s.

A raw material is classified as critical if it has a significant impact on the EU’s economy and the risk that it may become unavailable is great. These raw materials (2014) include antimony, beryllium, borates, chromium, cobalt, coking coal, fluorospar, gallium, germanium, graphite, indium, magnesite, magnesium, niobium, phosphate rock, platinum group metals, heavy rare earth elements, light rare earth elements, silicon metal and tungsten. So far, many of these materials have only been produced in China, Russia and some African countries. A critical raw material cannot usually be replaced with another material.

The uncertainty of raw material supply and the development of new technologies and mineral alloys have had a great impact on GTK’s operations. As late as the 1990s, GTK focused on surveying copper, zinc, nickel, cobalt and gold deposits. Recently, GTK has also started to survey critical metal and hi-tech metal resources. GTK surveys these metals independently as well as in cooperation with other Nordic geological surveys.

Despite the many challenges, Lahtinen believes that in the long term can be reused. In factories this might be possible, but not in society.

– Material will always be wasted – in production, use and recycling, Lahtinen says. Copper, for example, is easy to recycle, but some of it is simply lost because of wear. Some of it is also buried in different kinds of structures.

In new energy applications, such as electric cars, wind farms and solar panels, we now use new elements that were not used very much earlier. Therefore we cannot recycle these metals yet. Recyclable material becomes available only when the products reach the end of their life cycle. This might take decades.

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A new version of the bedrock map of Finland to be published

In addition to bedrock types, the map includes an interpretation of geological development, which is why it is called “The Geological Map of Finland – Bedrock”.

The designers of the map have utilised DigiKP, a digital database of Finland’s bedrock maps, and Finstrati, the Finnish database for stratigraphic geological units in their work. DigiKP and Finstrati were completed in 2009.

– The database used as the basis of the map is more advanced than before. There are more tectonic descriptions and they are more detailed than before, Senior Scientist Mikko Nironen says.

The map displays the rock type, its age, tectonic province and the name of the stratigraphic unit for the selected area when the specifying the stratigraphy is possible. Stratigraphy indicates the order of layering of cemented rocks and sediments.

– Mineral explorers can utilise the classification, if they are trying to find an ore that follows a certain stratigraphic unit. Based on this information, they can delimit potential areas and get hints for areas of other interesting ore deposits, Nironen says.

– The Archaean continent broke up 2.0 billion years ago and oceanic basins formed on the edges of the remaining continent. The basins started to close 1.95 billion years ago. Large areas of Earth’s crust, called tectonic provinces, finally merged together and formed a continent 1.9 billion years ago. The map is based on this merging.

Years of work

The map contains everything we know about the bedrock and rock types in Finland. In addition to GTK’s own material, we have used the data collected by Outokumpu Oy and its successors as well as material produced in universities.

– This map is the result of years of cooperation. In addition to a core team of four people, all GTK’s units have participated in creating it, Nironen says.

The map’s database has been created and named according to international recommendations, which guarantees that it will be usable also in the future. Similar map databases have been published, for example, in Australia, United States and Canada.

When the map is ready, it will be available for free at GTK’s website. According to Nironen, the map database will be updated every few years when necessary.

A new geological map of Finland at the scale of 1:1,000,000 will be published in autumn. The bedrock map that has been used until now dates from 1997. The new map updates the old map with current data.
Aiming to become number one in education

Text: Jaana Ahlblad

Finland has the potential to become a major power in the education and research related to the extractive industries. This is the estimate of Professor Juha Pekka Lunkka from the University of Oulu.

The first plans have already been laid out.

– Fennoscandia has been nominated as one of the regions where it is possible to find minerals critical to the EU. In my opinion, Europe has given Finland a great responsibility. There is now demand for high-quality education and research.

According to Juha Pekka Lunkka, a significant step in the right direction would be for universities to agree on their focus areas. Establishing the Oulu Mining School (OMS) faculty of extractive industries a year ago was one concrete strategic decision.

According to Lunkka, the majority of Finland’s ore potential is located in the northern and eastern Finland, which makes it natural to locate the faculty of extractive industries in Oulu, the “capital of northern Scandinavia”.

– This is the only faculty of its kind in Europe, because our operations are also supported by other similar fields of research in the university. Our starting point is science, but we also take a business point of view into account.

Joining forces in research

In order to reach the top, we must improve the level of education and operations across the entire chain. This requires the efforts of all parties.

– The industry is much more than mere mineral exploration. Other fundamental areas include mining engineering, mineral processing, end products and mining environment management.

According to Lunkka, all Finnish actors should support the idea of shared high-quality research infrastructure. The University of Oulu, four other universities and GTK have already founded the Finnish Geosciences Research Laboratory (SGL) hosting cutting-edge equipment for geoscientific research.

The University of Oulu and GTK have a long tradition of cooperation. The latest form of cooperation is the joint professorship of applied geophysics. The first person elected to the joint professorship is Dr. Elena Kozlovskaya.

– Geophysical survey equipments are also quite expensive. We are currently working with GTK to figure out how to acquire them for more extensive shared use, Professor Kozlovskaya says.

Lunkka would like to see more joint professorships in the faculty. He emphasises that a small country should definitely use shared research resources when different parties have similar needs and strategies.

Interest in northern Finland

– The ore potential of the arctic regions is now greatly reflected in theses and other research, says Dean of Education Eero Hanski.

– For example, I am currently supervising a doctoral thesis on nickel ore in northern Finland. The thesis is almost finished and will provide more detailed information for mineral exploration, Hanski, who is Professor of Geochemistry, explains.

Juha Pekka Lunkka says that international and domestic cooperation is also required in education, because the resources of individual universities are not sufficient despite competent people.

– When the resources of education, and basic and applied research are used efficiently and the meaning of the entire value chain is well understood, Finland can become the global leader in education related to mining industries, Lunkka says. ■
GTK Mintec – a one-stop service house

Text: Timo Hämäläinen

Research services related to beneficiation technologies from bench to pilot plant scale. GTK Mintec provides its customers with all types of research related to mineralogy and beneficiation technology. We have laboratories and a full scale pilot plant under the same roof.

GTK Mintec is one of the leading mineral processing research institutes in the world. It provides high-quality research services related to mineral processing to its customers across the globe. Over 50 per cent of GTK Mintec’s customers come from outside of Finland.

– We can offer the entire research chain beginning with mineralogy. We research and develop solutions for all unit processes related to beneficiation, such as grinding, flotation, the heavy media separation methods, and the entire production process, Division Manager Asse Marjasvaara says.

GTK Mintec has extensive experience in the research of different materials, especially ores containing precious or base metals and rare earth elements, as well as industrial minerals.

– We are also familiar with methods suitable for and related to recycling and contaminated soil treatment. Beneficiation methods are used, for example, to extract precious metals from metal industry’s waste materials, Senior Scientist Raisa Neitola says.

Effectively and economically

GTK Mintec conducts both extensive and small-scale research. Instead of large-scale pilot plant process testing, a customer might only be interested in the functionality of an individual unit.
process or the mineralogical characterisation of a sample.

In mineralogical research we analyse the valuable materials in the sample and find out to which minerals the valuable materials are bound. The research helps to decide which combination of unit processes is the best for extracting the minerals.

Unit processes such as crushing, grinding, flotation, dewatering, magnetic separation and gravity separation are researched during the laboratory testing.

The sample size in the laboratory tests varies from a few kilograms to tens of kilograms, and in the minipilot scale the sample sizes are at least a few hundred kilograms.

The pilot plant allows us to study the entire production process in a realistic environment. The typical sample size is 20–300 tonnes and material is continuously fed into the process. The length of a test run period, including preparation and cleaning stage, is approximately 1 month. In the largest test run so far, over 15,000 tonnes of material was fed into the process during a six-month period.

The test runs provide us with information on what kind of equipment and processes are best suited for beneficiation. The goal is to extract the valuable minerals as efficiently and economically as possible in an environmentally friendly way. Based on the results, the customer can, for example, make a profitability calculation for the project, Marjasvaara says.

In addition to new projects, GTK Mintec supports other companies, for example by helping companies in the mining and metal industries in developing beneficiation processes. This results, for example, in a better process. Customer relationships often last for years, even decades.

With environment in mind
GTK Mintec participates in a number of national and international joint projects that often aim for development of sustainable exploitation of raw materials.

The purpose of the Green Mining project, for example, is to develop environmental technology for the mining industry. The goal of the EURARE initiative (European Rare Earth Resources Initiative), funded by the EU, is to map Europe’s rare earth element resources and to create a sustainable plan to secure the availability of rare earth elements in Europe.

– We work in close cooperation with research institutes, universities, laboratories and companies. These projects provide our staff with a great opportunity to improve their competence, Raisa Neitola says.

– We have advanced mineralogical research equipment and mineral processing facilities. If necessary, we couple the services of GTK’s other units, such as the research laboratory located in Espoo. Our cooperation with equipment manufacturer Outotec Oyj ensures that we stay in the front line of mineral processing technology.

GTK Mintec develops its operations continuously. This development is guided by an audited ISO 9001 management system. The operation of VTT Labtium Oy, which is responsible for chemical analysis, has been audited according to ISO 17025 quality standard and their operation meets the CAN P 1579 criteria. Labtium performs all required chemical analysis for GTK Mintec, and they function in the same building.
Minerals4EU improves the quality and volume of mineral data in Europe

Text: Veli-Matti Jalovaara

Several projects have been established during the past years in Europe with the goal of providing more extensive and harmonised mineral data to facilitate e.g. EU decision-making. The GTK-coordinated project “Minerals Intelligence Network for Europe (Minerals4EU) is one of the most ambitious of those projects; it was completed in August 2015.

The goals of the two-year project (www.minerals4eu.eu) were set very high, and the project involved more than 200 experts from 26 European countries including a total of 30 researchers from GTK. Over the two years, the project successfully got several aspects of mineral data into shape.

What did the project achieve?

The Minerals Intelligence Infrastructure for Europe (M4EU) is a non-profit foundation, consisting of a few employees. The plan is to launch it on the premises of EuroGeoSurveys and to cater to data needs related to European mineral resources, both primary and secondary. Through the Minerals Intelligence Network, the foundation will further maintain and update mineral data created in EU projects along with national information. The network has members from Geological Survey organisations and from other relevant organisations, including industry.

The European Minerals Knowledge Data Platform includes a portal that offers easy access to mineral data. In addition to map service displaying the mineral deposits and mines in Europe, the portal also provides occurrence-specific documents related to mineral material, enabling users to make their own analyses from a huge amount of data.

The European Minerals Yearbook helps users to allocate and prioritise mineral-related research and projects. The yearbook includes statistics (production, import, export, mineral resources, ore reserves, mineral exploration, etc.) about more than 65 primary minerals in 40 European countries. Regarding secondary raw material, the data is organised into 13 categories that represent mineral-based waste flow.

The yearbook covers ten years of primary mineral production and foreign trade. This is the first time that country-specific statistics of this extent have been compiled with respect to mineral resources, ore reserves and mineral exploration. Due to this, the yearbook only covers the year 2013 for said themes.

One of the goals of the project was to anticipate the future supply and demand for minerals, particularly in regard to critical minerals. The scenarios drawn up in the project will be made available through the portal.
New publications

Overview of lithium pegmatite exploration in the Kaustinen area in 2003–2012
http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_220.pdf

Geophysical signatures of mineral deposit types in Finland

Discovery potential of hi-tech metals and critical minerals in Finland

Kemi Mine: Envimine project – Developing environmental and geodynamic safety related to mine closure in the Barents region
Väisänen, Ulpu (ed.); Hirvasniemi, Hannu; Kouri, Pentti; Kupila, Juho; Lauri, Laura; Raisänent, Marja Liisa. 2015. Report of Investigation, vol 218.

Quantitative assessment of undiscovered resources in orogenic gold deposits in Finland

Novel technologies for greenfield exploration.
http://tupa.gtk.fi/julkaisu/specialpaper/sp_057.pdf

New computational methods for efficient utilisation of public data

Photo: Esko Koistinen, GTK
Ancient groundwater found in Northern Karelia

A Finnish–German research team has found ancient groundwater that is 30 million years old on average. The water was hidden in Outokumpu’s bedrock for tens of millions of years before it ended up in the researchers’ bottles.

The discovery was made in a 2.5 kilometre-deep drill hole, the Outokumpu Deep Drill Hole, which is the deepest hole in Finland. The research results were published in the Geochimica et Cosmochimica Acta journal.

Under Finland’s conditions, it usually takes from tens to hundreds of years for groundwater to change. However, when the water flows deep into the bedrock through crevices, it can become trapped for a long time. It seems that this happened in Outokumpu millions of years ago.

During a period of millions of years, Outokumpu’s ancient groundwater developed into quite a cocktail. Its salinity is as high as 70 grams per litre, which is twice as high as the salinity of ocean water.

The age of the groundwater was hinted at by the presence of noble gases, which include, helium, neon, argon, krypton and xenon. Their atoms of a certain mass, isotopes, are created as the result of the breakdown of radioactive elements that naturally occur in rocks. These elements include uranium, thorium and potassium. When the isotope concentration of noble gases in the water is measured, it is possible to calculate the time it has taken for them to accumulate.

In Outokumpu this varies from four million to 60 million years. The age of most findings is approximately 30 million years. At that time, Outokumpu’s 1.9 billion year-old bedrock had already eroded to its present level.

Eurare sets basis for European Rare Earth Element industry

The EURARE project funded by European Commission is to set the technological basis for the development of a European Rare Earth Element (REE) industry. It will safeguard the uninterrupted supply of REE raw materials and products crucial for sectors of the EU economy in a sustainable, economically viable and environmentally friendly way.

The scientific and technical objectives include the definition and assessment of exploitable REE mineral resources and REE demand in Europe; the development of sustainable and efficient REE Ore Beneficiation, Extraction and Refining Technologies, to produce high grade REE concentrates, pure REE oxides, REE metals and REE alloys suitable for use in downstream industries; the development of a strategy for safe REE mining and processing; the field demonstration of the technologies, and the identification of novel sustainable exploitation schema for Europe’s REE deposits.

In the project GTK is mainly involved in describing the potentially exploitable EU REE resources as well as identifying the REE demand in Europe, in developing the ore beneficiation technologies with the ores from advanced European REE deposits, and environmentally characterising the tailings and process waters, in demonstrating the beneficiation technologies in pilot plant scale, and in assessing the technologies developed and demonstrated in the project and comparing them to the environmental, health and safety (EHS) European and international polices and current industrial practice.
A bedrock outcrop and boulder observation mobile app is available for mobile phone and tablet use. The application published by GTK is available on the Google Play store under the name "Kapalo".

The application requires a mobile phone or tablet with at least Android 4.2.2 (Jelly Bean). Photos taken with the application will be saved in the /internalstorage/Pictures folder. The application comes with usage instructions and documentation for geological content.

The application requires GPS to get the user’s location; Wi-Fi network location will not suffice. You can also use the Kapalo application without positioning.

An Internet connection is required if online maps are to be used. It is also possible to utilise offline maps in the app as .tpk (tile package) files. These should be saved into the root folder of the mobile device’s internal storage, where the "kapalo.sqlite" database functioning as the storage platform of observations is also located.

GTK has evaluated gold resources in the dominant deposit type of the Finnish bedrock, orogenic gold, to a depth of one kilometre.

Altogether, 32 areas that could contain undiscovered orogenic gold deposits were delineated in Finland. The areas are expected to contain approximately 90 undiscovered deposits.

At the 50% level of probability, the undiscovered orogenic gold deposits in Finland contain at least 750 tons (t) of gold. Comparison to the known resources indicates that about 70% of the orogenic gold endowment in Finland occurs in poorly explored or yet undiscovered deposits.

In more detail, eight areas (‘permissive tracts’) were delineated for the Archaean, 13 for the Palaeoproterozoic Karelian, and 11 for the Palaeoproterozoic Svecofennian parts of Finland. Altogether, the 32 permissive tracts cover 110,000 km², which is 33% of the total land area of Finland.

The single most important known resource of gold in Finland is the Suurikuusikko orogenic gold deposit (Kittilä Mine) in Central Lapland. Other significant known gold resources are rare in Finland; most of them are located in northern Finland, where gold occurs as a potential by-product in platinum-group deposits.

More than half of the undiscovered orogenic gold resources are located within permissive tracts in the Palaeoproterozoic Karelian greenstones of central and northern Lapland. In southern and Central Finland, nearly half of the undiscovered gold resources are estimated to be in the adjacent Häme and Pirkkala supracrustal belts. The main hosts to orogenic gold in the Archaean bedrock of Finland are the Hattu, Kuhmo-Suomussalmi and Oijärvi greenstone belts, mainly in eastern Finland.
The GTK is carrying out a training programme to improve the capacity of the Afghanistan Geological Survey (AGS) to map and evaluate the country’s mineral resources.

– The goal of the project is to improve the Afghanistan Geological Survey’s ability to use modern geophysical methods for surveying and evaluating mineral resources, says GTK’s Senior Scientist, Project Manager Heikki Vanhala.

Ten AGS geophysicists have participated in practical field training in Finland. The training covers the entire mineral exploration process from planning and using geophysical instruments to interpreting and reporting the results.

The geophysicists participating in the training used a variety of geophysical methods to survey a mineral potential area in Southern Finland. In addition to measurements, the trainees processed the data into maps, profiles and geophysical models, and interpreted the results. Theoretical training was provided during the field periods and in separate training sessions.

Other AGS personnel and representatives of Afghanistan’s Ministry of Mines and Petroleum (MoMP) have come to learn about Finnish mining operations and GTK’s way of promoting and supporting sustainable extractive industry.

– Afghanistan is believed to have great mineral resources, but they are not known very well. The Afghan authorities believe that the extractive industry can have a great potential contributing to the economic development and growth of Afghanistan, Vanhala says.

The cooperation project spanning 2013–2017 is funded by the Finnish Ministry for Foreign Affairs.

The role of the AGS is to be a national geoscience centre. It assists the Ministry of Mines and Petroleum on policies related to minerals, water resources and geology.
Mining cluster – an essential contributor to the lucrative mining operations

It is globally known and proven that there has always been economic growth and wellbeing in the areas of mining operations. Growth and wellbeing can be noticed in the local economy in the communities around the mines and wellbeing is also seen in countries where the mining industry has a significant role. For example, the economies of Australia, South Africa, Chile and Canada rely strongly on mining and the metallurgical industry.

The businesses contributing locally to mining operations form together a mining cluster. This cluster can include direct employment effects and the impact of investments in local infrastructure, supply of goods and services, engineering, consultancy, machinery and technology development, energy and water supply, logistics and transportation.

Furthermore, the mining cluster can include downstream processing of mine products such as smelting and refining of metal concentrates, and indirect effects on the local economy such as housing, schools and health care. The cluster can also include research activities in universities and research institutes, and vocational training.

The cluster view shows that the mining industry has a much wider impact than the mining operation itself. The growth of the mining sector enables the viability and growth of the cluster companies providing technologies, equipment and services for the whole value chain from mines to metals.

Nowadays, a significant portion of the sector is based on knowledge and technology-intensive businesses.

The mining cluster also has an important positive effect on employment. In Finland it has been estimated that the mining employment multiplier is between 2 and 3. The same positive effect can be shown in mining-related government infrastructure investments where the multiplier effect can be from two to three times the government investment.

There are several mining clusters around the world. Clustered industries reinforce and enhance competitive advantage when cluster companies are at the same time consumers, competitors, partners, suppliers and sources of research and development.

One example of mining clusters is the Ontario Mineral Industry Cluster in Canada, which includes exploration companies, mine operators, service and equipment suppliers, labor, training and educational institutions and associations. Research shows that the innovation and commercialisation of new technologies take place at a greater rate in clusters, ultimately enabling the export of products and services outside the clusters.

Finland and Sweden are often referred as benchmarks in clustering, with their international engineering and technology companies that have successfully contributed to the success of a number of clusters in other countries and continents through their branches.

Sweden and Finland certainly have several technology companies known worldwide such as Atlas Copco, Sandvik Mining and Construction, Normet, Metso and Outotec, whose success is historically based on the close cooperation of mining operations locally in Sweden and Finland.

In Finland it has been estimated that the mining employment multiplier is between 2 and 3.

Kari Knuutila
D.Tech. Senior Vice President and Chief Technology Officer
Outotec Oyj
Mineral Deposits and Exploration

MDaE is an online map service covering Finland. It contains mineral deposits and mines, outcrop observations and drilling sites, ore boulders, radiometric ages, mining registry, geological, geochemical and geophysical maps and nature conservation areas.

New features in the application are full compilation pdf reports, 3D models and shaded elevation model. The pdf reports will give the complete information content of all the prospects, mineral deposits and mines with figures and references. Database and service will be updated whenever new data (e.g. resource estimate) is available or a new deposit is found.

This version of the web application is optimised for mobile devices and pc.

http://gtkdata.gtk.fi/MDaE/index.html