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Europe faces the challenge of sustaining its non-energy raw materials supply

Europe has a long history in mining of non-energy raw materials and the EU remains an important, nearly self-sufficient, producer of industrial minerals and aggregates. Production of many metals is small although their consumption is high, and many important or critical raw materials are not produced at all. The decrease in mining is the result of a long history, which includes a legacy of state ownership and incipient protectionism, complex land ownership and mineral rights, and the fact that the land area available for extraction is constantly decreasing. Additionally, many European countries as well as the EU believed that free global markets would supply an untroubled flow of non-energy raw materials to its industry.

The rapid increase in world market prices of metals from 2002 to 2008 and the identification of economically important raw materials with a high supply risk was a turning point for the EU policies and public awareness. All this development led to the launch of the Raw Material Initiative in 2008 by the European Commission. An important step was taken in 2009 with the start of a large EU FP 7 project, ProMine. The EU’s growth strategy, Europe 2020, launched in 2010, comprises also the Innovation Union flagship initiative, in which raw materials are included. The Commission is considering the launch of an Innovation Partnership on Raw Materials, which would lead to a substantial increase in research and development activities, including exploration and extraction.

Thus, there has been a clear shift in the EU’s raw material strategy. However, the central question for the future remains: how to answer to the resource demands of Europe. Import will continue to be important in the future but Europe’s geological potential should be better exploited. Better recycling, new raw materials and new technologies for low grade deposits are continuously being developed, but without increasing exploration investments and improving access to land, self-sufficiency will not increase. There are still large areas in Europe where it is possible to find deposits at the surface. For example, in Finland less than 4% of bedrock is outcropping. The EU also needs a sound geological estimation of deep mineral deposits and predictive modelling of geology in three dimensions (3D) down to mineable depth (1–3 km). Most member states have provided more than a hundred years of near-surface geological and geophysical data for the mining industry. Now it is time to provide the same information in 3D, especially of known ore belts.

Raimo Lahtinen
Research Professor
Green mining increasing in the entire cluster

The mining industry is becoming one of Finland’s growth drivers. At the same time, sustainable operations are being developed throughout the entire cluster.

GTK’s Research Director Pekka Nurmi describes green mining as a method of operating efficiently, in a way that saves resources, and takes into consideration both ecological and social perspectives.

– We need the best possible expertise to ensure that there will be raw materials
for future generations, he adds.
The long-term objective of the Finnish mineral strategy is to make Finland a global pioneer in the ecologically efficient mineral industry. According to this vision, the mineral sector is becoming one of the foundations of the Finnish national economy.

In order to reach these goals, the GTK produces information in cooperation with VTT Technical Research Centre of Finland and various universities.

“The purpose of green mining is to improve the material and energy efficiency of raw materials in the whole production chain. Green mining means also better utilisation of by-products by collecting them and utilising them in an energy-efficient way with low emissions. Finnish technology is a key to this, says Pekka Nurmi.

THE OBLIGATION TO KEEP SEARCHING
Mineral resources are non-renewable, but minerals and metals can be recycled. The life-time of products made from them can be very long. Higher living standards have resulted in a rapid increase in the use of minerals and metals. Recycling cannot cover the global demand.

“It is very important to keep efficiently looking for new mineral resources. It is our duty to future generations, Nurmi remarks.

Minerals and metals will not run out. There is a vast amount of deposits which have lower levels of concentration, and they can be located deeper underground or in difficult locations, or are more difficult to enrich.

“The ore always needs to be found. Prospecting requires good technology and investment. The key aspect of green mining is efficient prospecting for new deposits and developing new solutions for utilising them, Nurmi emphasises.

The solutions aim to minimise environmental impacts and problems caused to communities in the whole production chain. At the same time, the working environment is improved by developing new working methods, procedures and safety.

“It is possible that in the future people will not be working in mines apart from maintenance, Nurmi says.

The mines of the future could also be invisible when everything is done underground. Green mining includes the plan of action for the time when the ore deposit is exhausted and mining ends. The mining industry is obligated to follow a number of guidelines and standards. Green mining is a holistic approach that contains a lot of details. An example of this approach in Finland is the Talvivaara mine in Sotkamo where the new bioheap leaching method is used.

“We need to utilise geoinformation as well as possible, because this might lead to, for example, finding new reserves of high-tech metals. Finland has high-tech metals needs in, for example, the IT sector, Nurmi says.

NATURAL RESOURCES ACCOUNTING
One of GTK’s central tasks is maintaining an accounting system of Finland’s geological resources. The system contains information about our natural resources, their locations and an assessment of the...
The Finnish Funding Agency for Technology and Innovation wants more SMEs to work in the cluster, Keskinen says. The development of organisations and the development of working life and safety in the mineral sector are also among the goals of the programme. The budget of Tekes’ Green Mining Programme is approximately EUR 60 million, of which Tekes’ share is 50 percent. The rest should be provided by companies, research institutes and universities. The programme will be carried out during 2011–2016.

According to Keskinen, the goal to become a global leader by 2020 is realistic, because it means that expertise is sought in chosen areas. These areas are prospecting for new mineral resources and utilising them, and mining technologies, which are among the most energy-efficient and environmentally friendly in the world.

- People from around the world come to learn about our schooling system because of our success in the Pisa surveys. We could achieve the same status in the mining industry, Keskinen says.

WHAT IS GREEN MINING?

- Producing minerals in a material- and energy-efficient way
- Identifying new raw material deposits and developing environmentally friendly solutions for utilising them
- Minimising environmental impacts throughout the production chain
- Developing new methods and ways of working
- Restoring mining areas after mining operations are completed
Efficient processes protect nature

–Metso is constantly striving to develop the eco-efficiency of its customers’ processes. The new solutions use less energy than before per every produced tonne, says Jari Riihilahti, Director of technology management at Metso’s Mining and Construction Technology.

Another common trend in Metso’s sectors is reducing the usage of water in processes. This has helped to increase eco-efficiency over time. The goals of the mining industry include reducing energy consumption and CO₂ emissions, increasing production efficiency, improving safety and the utilisation of raw materials, and cutting down on the amount of waste.

–The constantly increasing price of energy forces us to create more efficient solutions. Current products are more efficient than the older ones, but they have to be even more efficient in the future, Riihilahti says.

Customers also value factors such as reducing noise and the amount of dust and improving safety. Metso manufactures various solutions for crushing and grinding rock and ore.

–In the mining sector energy-efficiency is one of the most significant challenges. The new material solutions of the future will enable creating more environmentally friendly processes. Harmful materials will be avoided and new more sustainable solutions will be implemented, Riihilahti says.

In Europe, EU directives and national permit practices set requirements that also guide the development of equipment and solutions. These requirements will further increase in the future. According to Riihilahti, customers are extremely environmentally conscious and customer cooperation is a key factor. To create a good result, solution providers and their partners need to be pioneers.

The solutions aim to minimise environmental impacts.

Water – the problem of mines

VTT Technical Research Centre of Finland participates in the research related to the green mining theme with an extensive variety of research programmes. It is able to utilise an impressive number of technologies. VTT is already conducting its own research programme—Green Solutions for Water and Waste. It started at the beginning of 2011 and it concentrates on water and utilising waste.

–We can utilise this same expertise in Tekes’ Green Mining Programme. This means that we are already conducting research related to the theme, and the applicable parts of the research will be linked with Tekes’ research programme, says Erja Turunen, Vice President of Strategic Research at VTT.

The value of VTT Technical Research Centre of Finland’s Green Solutions for Water and Waste project is approximately EUR 12 million.

In the Green Mining Programme, the goal of VTT is to develop new enrichment methods and especially methods related to utilising waste flow, such as gangue and other waste flow of mining operations. Other research subjects include issues related to water in mines, different capturing technologies and solutions related to the treatment of large bodies of water. The treatment of large material flows provides development opportunities and opportunities for developing new services related to, for example, monitoring and logistics.
Kemira has a strong standing in the mining sector in North America, the Nordic countries and Africa. For this sector, Kemira produces, for example, hydrogen peroxide, aluminium and iron products, salt and coagulants, organic polymers, as well as flocculants and regulators. “We are a significant supplier of chemicals for bioleaching methods. In these processes bacteria remove the metal from the minerals and therefore it is essential to ensure the well-being of the bacteria,” Kaj Jansson, Vice President of technology at Kemira remarks. Outotec is also strongly participating in work related to the green mining theme: it is one of the leading equipment suppliers for the mining and metallurgy industries. It specialises in enrichment plant equipment and development. “We are a significant supplier of chemicals for bioleaching methods. In these processes bacteria remove the metal from the minerals and therefore it is essential to ensure the well-being of the bacteria,” Kaj Jansson, Vice President of technology at Kemira remarks.

Outotec develops enrichment plants

Outotec is also strongly participating in work related to the green mining theme: it is one of the leading equipment suppliers for the mining and metallurgy industries. It specialises in enrichment plant equipment and development. “Development of the grinding process, for example, and the improvement of the energy-efficiency of the project through grinding control and control automation, is an area in which we do a lot of development work. Grinding uses the most energy in the process, and we monitor the whole production chain from the mine to the finished metal,” Kari Knuutila, Chief Technology Officer at Outotec.

“Outotec can also improve yields. In short, we can help enrichment plants to improve the yield of metals so that less of the valuable material is lost in enrichment sands and waste. For this purpose we develop online analytics and measurement techniques that improve process control. Reducing the overall use of water in mines includes neutralising and recycling treatment and process waters. According to the green mining concept, improving process reliability results in less downtime. This means that the machinery can be run more evenly and emissions can be more easily controlled. Often emissions are related to downtime during runs or the process, Knuutila says.”

Outotec is also responsible for operations and maintenance. Outotec’s development projects include remote monitoring of metallurgical and enrichment plants. “Nowadays profitability and eco-efficiency are tied together. When usability and reliability are maximised, running times are as long as possible and production efficiency is at its best. Using less energy and materials also increases financial performance, Knuutila adds.”

According to Knuutila, the metallurgy industry already uses pioneering solutions, but technologies can always be improved. “Customers have learned to expect new solutions from Outotec. The price of energy creates pressure to develop energy solutions. Foreign emission regulations become more and more strict, which effects operational reliability. Ore with a low concentration requires increasingly more accurate process control, Knuutila explains.”

Bioleaching with Kemira’s chemicals

Kemira has a strong standing in the mining sector in North America, the Nordic countries and Africa. For this sector, Kemira produces, for example, hydrogen peroxide, aluminium and iron products, salt and coagulants, organic polymers, as well as flocculants and regulators.

“We are a significant supplier of chemicals for bioleaching methods. In these processes bacteria remove the metal from the minerals and therefore it is essential to ensure the well-being of the bacteria,” Kaj Jansson, Vice President of technology at Kemira remarks.

Kemira supplies sulphuric acid, lye and lime for controlling the pH level. “When the bacteria have dissolved the metal into water, the pH level of the water must be increased with lye or lime in order to flocculate the metals in the water. Usually the extraction is enforced in flocculation pools by using polymers. From the waste waters of the mine and the refinery, heavy metals are extracted using iron or aluminium products, Jansson explains.”

Kemira is also conducting studies and product development of its own related to the green mining theme. “Because the goals of green mining include sustainable mining, recycling water from mines, extracting heavy metals from waste water, removing odours and saving energy during the grinding process these are suitable research subjects for Kemira. The effects of decreasing the use of water in the processes for the current mining chemicals are also being studied, Jansson explains.”

8 Geoforum 2/2011
ProMine is the European Commission’s most ambitious effort to date in the arena of exploration and efficient use of mineral resources within the EU. It seeks to identify cleaner ways to produce, substitute and recycle critical rare metals. With an initial €11 million in Commission funding (and €17 million in total funding), ProMine has assembled 28 partner agencies from eleven EU countries, including six national geological surveys, six universities and more than a dozen corporate and state research arms. GTK coordinates ProMine and reports to the Commission on the activities of the hundreds of researchers involved.

Notes ProMine Project Manager Juha Kaija of GTK: “The goal is getting the most ‘bang for the buck’ in such multilateral research projects. That requires tight coordination of participants, a clear research focus and a stable set of project milestones to keep ProMine on track. Europe has lacked a coherent metals and mineral policy in the past, but this work evidences that successful cooperation is not just possible, but can deliver valuable results. We have been extremely fortunate to have such excellent partners and commitments to work in good faith.”

ProMine clusters tasks under three main objectives. Each cluster has two Work Packages (WPs).

Cluster 1: To develop a Pan-European Geographic Information System (GIS) containing known and predicted metallic mineral resources and assessments of potential resources, including strategic metals and minerals not currently produced in Europe (WP1). To develop 3D and 4D models of ore deposits and mineral districts to boost exploration of deep-seated mineral resources (WP2).

Cluster 2: To create new, high-value, mineral-based nanoproducts (WP3), and to develop efficient methods for mineral extraction and processing with low environmental impact (WP4).

Cluster 3: To perform life-cycle analyses of developed products, define their economic, environmental and social impacts at the European scale (WP5), and to disseminate findings among stakeholders, industry and the public (WP6).

The feasibility of the specific techniques and approaches demonstrated in the WPs will contribute to a more dynamic European mining sector and increase cooperation across disciplines and industries. The project is structured around five model sites within Europe. Findings from Cluster 1 WPs can be used by Cluster 2 WPs, which in turn, feed into Cluster 3 WPs.

WP1
Pan-EU GIS databases. To develop Pan-EU databases for mineral endowments and predictive resource assessment, WP1 has focused on applying new database management techniques to metallogenic data and satellite imagery in identifying EU metal resources (including new strategic metals such as Ga, Ge, In, Li, Nb, Ti, Ta, PGEs and REEs), as well as selected industrial minerals and sites with mining and metallurgical residues.

The architecture for a Mineral Deposit (MD) database and an Anthropogenic Concentration (AC) database has been established, so the focus has shifted to feeding in country data to each database. Participants can request information on minerals of specific interest (e.g. rhenium, olivine, schwertmannite) in addition to the initial strategic raw materials suggested.

Explains WP1 leader Daniel Cassard,
BRGM “The MD database is now ready for over 30 countries. The most exciting part of the work now starts with the preparation of maps of pan-EU mineral potential and second-stage calculation of predictivity (favourability) maps for selected commodities in the most promising areas. When the AC database is complete at the end of the first quarter of 2012, it should be possible to identify the most striking sites in the EU for critical commodities.”

**WP2**

**3D and 4D modelling of four mining belts.** The WP2 group is involved in visualizing in 3D and 4D, the key spatial, geological, geophysical, geochemical and financial parameters of four major active mining belts of Europe: the Fennoscandian Shield, the Forsudetic monocline of Poland-Germany, the Southwest Iberian belt of Portugal-Spain, and the Hellenic belt of northern Greece. Information on geology, magnetics, gravity, seismics, radiation and hyperspectral data are being used to create robust 3-dimensional models extending down 1 to 5 kilometers, as well as develop 4D models in each belt. The 4D approach has been widely adopted by European mining companies, in part, through ProMine promotion.

**Timo Mäki**, chief geologist for Pyhäsalmi Mine Oy notes that ProMine has been a great benefit for mine site exploration. The Pyhäsalmi mine in Finland is currently conducting exploration at depths between 1,000 and 2,000 meters. Complicated deformation makes the geological modelling work challenging. “ProMine has provided us with access to the best modelling expertise for our exploration efforts around Pyhäsalmi. At Pyhäsalmi, we are using seismic and deep electromagnetic methods in combination to locate new mineralizations around the mine. We share the interest of our ProMine partners in extending mine life and developing systems that have wide application throughout Europe in locating new deposits. This is not easy work. We had to drill thousands of holes to build a good 3D model – and 4D-modelling is even more challenging!”

**WP3**

**Nano-scale products.** Industries and researchers are cooperating in the development of five products: spherical rhenium and rhenium alloys (aerospace); metal fibres for abrasion (metal fabrication, woodworking) and conductivity (high-tech applications); nanosilica for construction materials; schwertmannite (pigments, ceramics, water treatment); and nanosilica-based coatings (additive manufacturing, paper). All the products are manufactured directly from mineral resources or from mineral industry by-products.

The first major progress has been seen in studies of nanosilica, with promising results in the areas of “superconcrete” for construction and coatings for paper and board. Work has proceeded on methods of producing rhenium alloys which will be used in production of alloys with extreme performance abilities. There are some very intriguing studies on schwertmannite, a material produced by bacteria. The studies so far have led to production...
of yellow and red pigments, and lacquer samples (primary coat and gloss paint) have been manufactured. In the study on acid mine drainage treatment, Cu/C nanoparticles were separated to create a conductive ink for abrasives. All five products are ready for pilot-scale testing.

**WP4**

**Ecoefficient technologies.** Projects involve treatment of mining waste products, as well as identification of co-processing routes for production of metals using pyrometallurgical or biohydrometallurgical processes. This work package, supported by the Polish and Swedish mining industries, provides WP1/WP2 and WP3 groups with suggestions on methods for processing raw materials and byproducts and looks at processing of tailings piles and contaminated process waters in order to recover metals.

WP4 recently took on two new industry-side partners with bioreactor expertise. The technical feasibility of bioleaching at high solids content (25%) using a new type of bioreactor and agitation system is being tested, along with new approaches to metal recovery from bioleaching solutions.

WP4 leader Patrick d’Hugues, BRGM points out: “The EU25 countries supply less than 10% of Europe’s metal consumption, and the ores we have to work with are often more complex and available in lower grades or smaller tonnages than elsewhere. The new techniques we are developing can substantially alter this picture as they provide scaling flexibility, reduced environmental impact and allow for parallel production of secondary metals.”

**WP5**

**Life-cycle assessments.** Environmental conditions are assessed at model sites before and after ProMine products are extracted and produced. The efficient use of mineral resources is achieved through improved planning of the extraction and site closure processes, better use of byproducts and reducing the volume and toxicity of waste streams. Other ProMine WPs are supported: products developed in WP3 are derived from secondary resources/waste materials, and the work of WP4 is geared to recovery of secondary metals and mitigation of environmental impacts.

Currently, baseline conditions at all model sites have been defined based on a set of 15 selected sustainability performance indicators, and the potential for extraction of critical metals from waste stored at abandoned mines or generated at operating mines has been demonstrated. The impacts on the sustainability of the mines has also been discussed.

Reports WP5 leader Bertil Grundfelt, Kemakta Konsult AB “The planning and start-up of the life-cycle assessments (LCAs) is in full swing. The plan is to use our LCA results to evaluate the potential effect of the products and eco-efficient production methods from Cluster 2 on the sustainability of the model site operations.”

**WP6**

**Publishing, reporting and meetings.** This package is focused on collection, integration, distribution and discussion of the findings of other WPs. The work includes arranging training courses, demonstration workshops, conferences and stakeholder workshops at the five ProMine model sites.

The European Commission is intensely interested in the findings and final products of ProMine. “The creation of new intellectual property through cooperation of state research institutes and private-sector innovators is a new operational model for the minerals extraction sector,” says Juha Kaija.

**WHERE TO NEXT?**

ProMine scientific coordinator Gabor Gaál of GTK sees ProMine as just the beginning: “ProMine enjoys very high visibility in the European Commission and has become the flagship project of the Raw Material Initiative. We expect all of our five, high-value, mineral-based products to be green-lighted at the 5th Progress Meeting in Seville in November 2011. We are particularly proud of several major technical breakthroughs. The Seville meeting is important because it gives ProMiners a chance to review our overall progress after 30 months, finalize our progress report for Commission and suggest spin-off projects from the knowledge gained through ProMine.”

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**Lithologies**
- Malic volcanic and clastic rock
- Skaneberg conglomerate
- Öldömanberget sandstone
- Öldömanberget conglomerate
- Ölbergberget conglomerate
- Bäverhjält conglomerate
- Feltic siltstone
- Vargfors sandstone

**Solid 3D-voxel-model of the sedimentary Vargfors basin located on the contact to the ore-bearing horizon in the Skellefte district and location of a resistivity profile. Based on ProMine modeling.**
Critical metals supply and eco-friendly mining: Finland’s national minerals strategy takes shape

Finland’s national minerals strategy is geared to advancing Finland’s metallic ore mining, aggregate and natural stone production, and companies supplying minerals technology and services. Large increases in production have opened a door to new business opportunities and demanding a rethinking of national priorities.

A metal critical for a country’s industries and technologies should be obvious, but as every geologist knows, what something is depends on when it is. In WWI, for instance, nickel was seen as a strategic metal as it was crucial in bronze and brass armaments. Copper, a metal that has been in use for millennia, recurs over and over as a critical metal every time new uses emerge (e.g. electronics and refrigeration). Cobalt, known for its ancient uses as a blue pigment, debuted on the strategic metal list in the 1960s with recognition of its importance in high-performance metal coatings and car tires. Hard-to-fabricate titanium became strategic when it started to be used in Soviet and US military aircraft in the 1980s. More recently, niobium emerged as a critical inner material for superconducting cables used in imaging magnets and particle accelerators, while shrinking microprocessors and smart phones pushed up demand for heat-tolerant tantalum.

Today’s strategic metals, although still tied to politics, scarcity and geological distribution, are most likely to reflect the emerging technologies and trends of the 21st century. The shift to wind power creates demand for permanent magnets made with such rare earth metals as dysprosium, neodymium, terbium, europium and yttrium. Electric vehicles depend on lithium and cobalt for batteries. Nanotech, thin-film technologies and additive manufacturing all are affecting demand for gallium, germanium, indium, selenium, silver and tellurium.

In 2010, German Economy Minister Rainer Brüderle observed that Europe, which imports over 70% of its critical metals faces two types of threat: traditional disruptions of supply from socio-political instability in producer countries, and long-term environmental country risk arising from unsustainable mining practices. Finland is moving to answer these challenges on both fronts.

STRATEGIC VISION

GTK research director Pekka Nurmi coordinated Finland’s national minerals strategy project. The initial long-term view published in 2010 charts a path for development of the minerals sector until 2050. Notes Nurmi: "Like the rest of the EU, we are virtually self-sufficient in aggregates and industrial minerals. But the EU’s biggest concern – the lack of access to metals – is not the problem we face in Finland. We have a number of active mines at the moment, and major new mines are expected to open in the coming decade. In addition, GTK’s recent permissive tract mapping and various imaging methods suggest considerable undiscovered ore reserves. Thus, the national policy challenge is to keep up with a logarithmic increase in ore production volumes. From a level of just 4 million tons of metallic ores mined in 2005, we expect to exceed 70 million tons a year by 2020."

"There is an increase in world-scale mining in Finland. The new Talvivaara Mine accounts for over 2% of global nickel output. AEM’s new Kuitjää Mine is the biggest gold producer in Europe. Kevitsa is one of the world’s largest unexploited sulfide nickel deposits. Ore exploration is quite active in Finland at the moment and new world-class discoveries in coming years would not be surprising."

The shift has encouraged the government to reinstate the minerals sector as a cornerstone of national economic development. Unlike the past, however, when the industry was firmly in the hands of the
Finnish state, most mining operations today are privately owned and operated by international companies. Finland has the world’s newest mining law and the government’s policy platform refers specifically to the importance of developing the minerals sector. The Ministry of Employment and the Economy, which provides oversight and guidance on issues related to development of the mining sector, is promoting a loose network of companies and agencies under the banner of “Finnish mining cluster.” The ministry coordinates with the EU on minerals policy to assure Finnish policies advance EU goals.

**GOOD KIND OF JOBS CRISIS**

Finland’s mining sector directly employs about 3,500 people full-time, as well as thousands of related jobs involving construction, equipment manufacture and technical/scientific services. Finland’s problem at the moment is finding enough qualified personnel. With mine-related employment set to double, Finnish universities must train a new generation of engineers and technologists specialized in environmental technology, process design and mining techniques.

Local governments are also contributing to the effort. Lapland, a key region for mining, has projects for gold, phosphorus, iron ore, copper, uranium, nickel and platinum metals. The village of Sodankylä, for example, has started a school for miners and expanded public services to support the Kevitsa and Pahtavaara mine projects. Local impacts can be readily quantified. Kittilä, another Lapland village known largely as a tourist destination, is now the site for Agnico-Eagle’s new gold mine, which provides 375 full-time jobs and over 100 jobs for local subcontractors. The village has seen an inflow of new residents working for the mine, and three local jobs are created for every mine job. The local unemployment

> The EU’s lack of access to metals is not the problem we face in Finland.
The main metallogenic zones of Finland.

Mineral resources

EU Action Plan

The EU is generally self-sufficient in construction minerals such as rock aggregates, and a globally significant producer of many industrial minerals. However, the EU only accounts for about 3% of world production of metallic metals, so it is highly dependent on imports.

The HWWI Index of World Market Prices of Commodity prices detected an aberrant run-up in metals prices in 2005, when prices of several critical metals such as tin, copper, nickel, lead and iron ore spiked to levels double their 2003 levels. China, the de facto centre of global manufacturing, appeared to have an insatiable appetite for raw materials, while speculators bought commodities aggressively. Over a three-year period, metals prices soared to highs 5-8 times above their historical averages before collapsing in 2009.

The insecurity motivated the Raw Material Supply Group of the European Commission to produce its initial Raw Materials Initiative (RMI-1) in 2008. At that time, national governments were requested to work with their geological surveys to produce assessments of available metallic ores and minerals, as well as report on how they planned to contribute to EU goals.

This led to the more-detailed RMI-2 released in 2010. RMI-2 provides an action plan for improving access to primary resources, including formulation of an EU-wide minerals strategy, measures to stabilize global trading, promotion of exploration and research on mineral processing, as well as increased recycling and identification of substitute materials.

The European Commission adopted the proposed strategy in February 2011.

For more information: http://ec.europa.eu/enterprise/policies/raw-materials/index_en.htm
Important updates to Fennoscandian Ore Deposit Database

Cooperation of the geological surveys of Norway, Sweden, Finland and Russia in recent years led to the release of the Fennoscandian Ore Deposit Database (FODD), updated annually since 2008. It was complemented with a 1:2,000,000 scale Metallogenic Map of the Fennoscandian Shield in 2009. New data and data manipulation tools were added to FODD in autumn 2011.

FENNSCADIAN ORE DEPOSIT DATABASE

FODD is a numeric database of metallic mines, deposits and significant occurrences in Fennoscandia. It contains information compiled from over 1,600 active and historical mines, deposits and significant occurrences across the region, including 338 deposits in Finland, 157 deposits in Norway, 243 deposits in Russia and 878 deposits in Sweden. Over half of the listed deposits have never been exploited, including 53 large unexploited deposits and 57 potentially large deposits in the database based on the relative value of the in situ metal contents. The leading deposit types are Ni, Fe, V, Cr, Au, PGE, Ti, Zn, Cu, U, Nb, Mo, Be, Li, Co, Pb, Zr and Ta.

The FODD contains information on location, mining history, tonnage and commodity grades with a comment on data quality, geological setting, age, ore mineralogy, mineralization, genetic models, and primary data sources.

THE FENNOSCADIAN METALLOGENIC MAP

Areas of metal deposits and probable future metal ore discoveries in the Fennoscandian Shield. The metallogenic map contains 168 major metallogenic areas, including 24 areas that cross international borders. The most important metal areas are with potential for ferrous metals (Fe, Mn, Ti, V, Cr); copper, zinc and lead precious metals (Ag, Au, PGE); nickel and cobalt; and high-tech metals (e.g. Li, PGE, REE, Ta, Zr).

GTK senior geologist Pasi Eilu reports: “The latest update includes descriptive details of deposit data from Norway, and updates on currently active mines and exploration projects. Also included are short descriptions of metallogenic belts; these will be linked as pdf files on the Fennoscandia map server.”

Fennoscandia map server: http://en.gtk.fi/ExplorationFinland/fodd/
In 2008, GTK launched a project of quantitative assessment of commercially important metals. The assessment followed the three-step system used by the US Geological Survey, whereby models for deposit types are selected, the places (permissive tracts) where such deposit types may occur are identified, and statistical methods are applied to estimate the number of deposits and ore tonnages.

In the first stage of the project, platinum-group metal resources in layered mafic-ultramafic intrusion-hosted Ni-Cu-PGE deposits in northern Finland were estimated. The PGE assessment indicated that the layered intrusions in northern Finland also contain notable nickel resources, a metal not traditionally mined in Lapland. The second stage was assessment of nickel resources in magmatic Ni-Cu sulphide deposits. Two deposit models were constructed for this work. The first model was based on Ni-Cu deposits hosted by Svecofennian mafic-ultramafic intrusions in central and southern Finland and the second model on Ni-Cu deposits hosted by komatiitic rocks in the Archean and Paleoproterozoic greenstone belts of Eastern and Northern Finland. The model for intrusion-hosted deposits used data from 40 deposits hosted by Svecofennian intrusions in Finland, Sweden and Norway. The model for komatiite-hosted deposits used nine deposits in Finland, Sweden and Russia. Important Ni ore types that could not be modelled due to sparsity of data include the Talvivaara-type deposits in eastern Finland and Kevitsa-type deposits in Lapland.

For statistical analysis, GTK researchers used computerized Monte Carlo random sampling simulations based on grades and tonnages of known deposits to produce a probability distribution of the quantities of contained metal in the undiscovered deposits. The assessment predicted that the modelled permissive tract areas contained 66 intrusion-hosted deposits and 33 komatiite-hosted deposits. The median tonnage estimate (50% likelihood) for intrusion-hosted deposits was 480,000 tons (slightly more than the amount in known deposits), while the median tonnage for komatiite-hosted deposits was 270,000 tons, or about six times known resources. The results of the assessment will be published by GTK this year.

Notes geologist Kalevi Rasilainen: “The USGS three-part method is applicable to many types of ore deposits. One of its early uses was in Alaska to estimate undiscovered mercury and tin resources. Here we focused on nickel, but other metals are of obvious interest. In addition to the completed assessment of undiscovered platinum group metal resources, assessments of Finland’s copper, zinc and gold resources are ongoing.”

Into the Unknown, Again

GTK recently completed the second stage of national metallic ore assessment focused on undiscovered nickel resources. In the past, the lion’s share of nickel has been extracted from mines in central and southwestern Finland. The new wave of assessment identifies “permissive tracts” where the local geology permits occurrence of a given type of ore deposit. The work constitutes an important first step in exploration for undiscovered deposits and estimating future supplies.

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The expanding hi-tech industry, particularly in electronics and energy technology, has an urgent need for metals that formerly have not been used to any larger extent. With rapidly growing demand, the price on the global market for many of these hi-tech metals has skyrocketed in just a couple of years.

The elements regarded as hi-tech metals are lithium, cobalt, indium, gallium, germanium, niobium, tantalum, titanium, the rare earth metals group, and platinum metals group.

European Union regards many of these metals critical raw materials, since they are almost entirely imported from outside EU. Within EU the most promising region for ore deposits is Fennoscandia.

Geologically the Finnish bedrock has propitious conditions for hi-tech metal deposits, indicated by several minor known deposits. With cobalt mining going on and mining projects under way for platinum metals, GTK is studying the potential for other hi-tech metals in a research project lasting altogether four years. At present the third year of research is under way.

“We are still investigating a number of ore-critical sites, particularly for rare earth metals (REE). At the same time we continue to collect background information about other hi-tech metals and follow up the global situation, says Olli Sarapää, senior scientist at the GTK office in Rovaniemi and in charge of the hi-tech metal research project.

FIELD WORK MAINLY ON RARE EARTH METALS

“We used geophysical methods to localize interesting sites for closer study; after that we have a geochemical approach. We have studied the regional geochemistry, investigated the terrain and taken samples for analysis from the bedrock and from drilling core storages. Chemi-

FINNISH BEDROCK HIDES COVETED HI-TECH METALS

The GTK sees quite a good potential to discover especially lithium, niobium, tantalum, titanium and rare earth metals. It is already well known that the potentials for cobalt and platinum group metals are good.

Finland has a bedrock in which the potential is good to discover deposits of some of the most desired hi-tech metals needed by industry today. The GTK sees quite a good potential to discover especially lithium, niobium, tantalum, titanium and rare earth metals. It is already well known that the potentials for cobalt and platinum group metals are good.

13 metre wide gold-rich hematite-quartz vein, which contain 3.3 ppm gold and 400 ppm REE in the Mäkäräselkä of Tana belt.
cal and mineralogical analysis have been done on samples from about 20 sites, Sarapää says.

The results from the investigations will become public at the end of next year.

– The field work has mainly been concentrated on the hottest global issue: rare earth metals. A potential area for them is Tana Belt, the zone between the granite-belt and the greenstone-belt in Lapland, with emphasis on the Vuotso region. In addition to gold deposits, there are indications of rare earth metals in weathered rocks in that area, but no ores have yet been found, Sarapää explains.

– Another potential area is around the Sokli phosphate deposit in eastern Lapland. In addition, alkaline stones have been investigated in Pyhántä and Kuusamo. Particularly rapakivi granite regions are interesting from the point of view of rare earth metals.

Among other hi-tech metals the potential is good to discover lithium, titanium and niobium deposits.

The most promising deposits of lithium-bearing spodumene are situated in western Finland. The mining project under planning in Länttä has not yet been realized. Titanium was mined together with vanadium in the Otanmäki mine some 30 years ago. Deposits are known also in several other places.

– The most promising niobium deposits are in the Sokli area. Also the potential to discover tantalum is relatively good, as there are known deposits. There are also indications of indium, but no known deposits, Sarapää says. No indications of gallium or germanium have been found in the Finnish bedrock.

SEPARATION AND PURIFICATION DIFFICULT AND MESSY

For all hi-tech metals mining production has not increased fast enough to cover the growing demand. There is no shortage of the elements per se. With market prices for the metals rising ten, twenty or thirty times over in just a few years, mining of poorer ores can become profitable.

For rare earth elements the situation has become extreme in a very short time. China accounts for over 95 per cent of the global production, after having driven the competitors out of the market by increasing the production. With a rapidly growing domestic demand of these metals, the Chinese government last year cut the export quotas drastically, leading to worldwide efforts to find alternative sources.

– Globally there are lots of projects under way, with some really big ones in USA, Australia and Canada. This could very well lead to a future situation with over-production of light rare earth metals. Right now everyone runs in the same direction, trying to establish new production, Sarapää notes.

Rare earth metals are in fact not particularly rare. They can be found quite frequently, but rarely in concentrations high enough to form ores. The separation and purification of the elements is complicated, since the process is both difficult and messy. Outside China there are very few plants that have the skill to do it, in Europe there is one: Silmet at Sillamäe in Estonia.

– When developing new production of rare earth metals from mining to the final product, the refinery for separation and purification of the metals takes two thirds of the total costs for the whole project, Sarapää says.
Hi-tech metals used in highly specialized fields of application

All hi-tech metals are key ingredients in a broad range of hi-tech products, from smartphones and wind turbines to optic fibres, hybrid cars and solar cells. In many of the cases the key metal cannot be replaced with other solutions.

The lightest of all metals, lithium, is needed for the manufacturing of lithium-ion batteries – the rechargeable batteries in all portable electronics and the power source in hybrid and electric cars. In addition, lithium is used in ceramics, glass and industrial grease. With car manufacturing moving towards electric vehicles, the demand for lithium is expected to grow many times over and lots of new production is under planning all over the world.

Niobium is an exceptionally hard metal with use mostly in alloys. Even a tiny amount of niobium improves the strength of steel. Superalloys containing niobium are temperature stable and used for instance in jet engines. Niobium is also a component in superconducting alloys, used for the magnets in MRI scanners.

Tantalum is a hard, corrosion resistant metal with high conductivity of heat and electricity. The main use is for electronic components in equipment such as mobile phones, DVD players and computers. It is also widely used as minor component in alloys.

Titanium has the highest strength-to-weight ratio of any metal. It is a component in many strong, lightweight alloys for use in industrial processes, aerospace and military equipment, vehicles, medical prostheses and implants, mobile phones, sporting goods, and so on. Titanium dioxide is used as white pigment and is also a photokatalyst.

Indium is a relatively rare metal with a rapidly growing use in liquid crystal displays and touchscreens. It is also used in thin-film solar cells.

Almost the entire world market for gallium is for use in semiconductors, where gallium arsenide is a premier material for electronic components. Germanium is an important semiconductor material with major end uses in fiber-optic systems and infrared optics, but also as a catalyst and in solar cell applications.

NO SUBSTITUTE FOR RARE EARTHS IN HIGH-STRENGTH MAGNETS

The rare earth metals consist of the 15 lanthanide elements in the periodic table plus the chemically related yttrium and scandium. These 17 elements have a large variety of hi-tech applications.

The largest growth sector for rare earths is for use in high-strength permanent magnets, where neodymium, samarium and dysprosium are used. No substitute for them has yet been found. High-strength magnets are used for instance in wind turbine motors, electric cars and other electric engines, but also in disk drives for computers and portable electronics.

Lanthanum has an important and extensive use as catalyst in the oil refining industry and as additive in diesel oil. Praseodymium, neodymium and cerium are also used as catalysts in the oil industry.

Europium, lanthanum and yttrium have phosphorescent properties and are used in energy-saving light bulbs, plasma televisions and computers. Europium gives the red colour on the TV-screen.

Erbium, europium, terbium and yttrium are used in fibre optics.

Cerium is used in polishing powders for the glass screen in televisions and computers and also for UV-shielding protective glasses. It is also used in car catalysts and fuel cells.

Many of the rare earth metals have applications in metal alloys, ceramics, glass and in lasers.
Drilling in Outokumpu reveals deep secrets

Drilling deep into the bedrock is an adventure that always results in new information. This was the case in the Outokumpu Deep Drilling Project, where a 2.5 km deep hole was drilled for research purposes in an area well known for its metal ores. The results show that host rocks of the Outokumpu type deposits can be located with reflection seismics and that they might be much more common in the area than previously assumed.
The Outokumpu Deep Drilling Project was carried out from 2004 to 2010 as a research project coordinated by GTK. It was an attempt to combine both the economic and scientific aims of deep drilling in a Precambrian bedrock area.

The project has resulted in a great variety of interesting results, and more are expected, since the hole is used as a so-called deep geolaboratory, where the collecting of information continues. The site is open for use by national as well as international research groups. So far, teams from nine countries have participated in the research collaboration.

In addition to new knowledge on the interpretation of seismic reflectors, the results from Outokumpu confirm the presence of highly saline gas-bearing fluids and a deep biosphere completely of its own kind.

Other results show that the layer of pegmatitic granite from two kilometres downwards is thicker than expected – at least 500 metres. The bedrock is under high stress and, as a consequence, the granite section of the drill core was broken into disks. When analyzing temperature gradients and heat flow in the hole, paleoclimatic effects from the glacial period could be seen in the results.

DEEP DRILLING WITH RUSSIAN EXPERTISE

In a seismic reflection survey, the FIRE project that ran from 2001 to 2005, one important observation was that the Outokumpu ore belt is characterized by very strong seismic reflectors in the upper crust, covering an area much wider than the outcropping ore belt. It was suggested that strong reflectivity may be associated with the host rocks of the sulphide deposits. Drilling was the only way to clarify this assumption.

– The Outokumpu province consists of marine sediments deposited in an ancient sea west of the Archaean craton. Most important, there are slices of oceanic mantle within the sediments. The slices and blocks of mantle rocks have developed into serpentinite, skarn rock and quartz rock, the host rocks of the Outokumpu type deposits, explains Ilmo Kukkonen, Research Professor at GTK and scientific director of the Outokumpu Deep Drilling Project.

– We wanted to understand the deep structure of the ore province and reveal the nature of the seismic reflectors in Outokumpu. We also wanted to understand the occurrence, composition and origin of saline fluids and gases, and the possible existence of a deep biosphere in the crystalline bedrock, as well as the vertical variation of different parameters, for which the borehole provided unique opportunities.

The expensive and challenging deep drilling project became possible when it was included in an agreement on debt conversion between Finland and Russia. The drilling project had a price tag of USD 8 million. The leading Russian deep drilling contractor Nedra G.N.P., well-known for the 12.2 km deep Kola Superdeep hole, and the commerce chamber Machinoexport S.E. were hired to be responsible for the drilling.

The Outokumpu Deep Drilling
Outokumpu’s ore potential is still high.

The drilling site at Outokumpu was chosen close to the ore belt, where the strong seismic reflectors are near the surface. The drilling was carried out in 2004–2005. It resulted in a 2,516 metre deep borehole, cased through the upper 40 metres of sediments and uncased from there down. Thus there is direct access to the bedrock at any depth for logging and taking samples. The drilling produced about 60 tons of drill core with a diameter of about 10 centimetres.

− The hole did not penetrate any ore, but the strongly reflecting structures at a depth of one to two kilometres turned out to be serpentinite and skarn rocks, host rocks of the Outokumpu type sulphide ores, Kukkonen says.

− This suggests that the abundant reflectors in the area may represent the host rock type. If so, it would imply that there is still significant ore potential deeper down in the bedrock. Previously the Outokumpu ore belt was explored by drilling typically to a depth of about 300 metres, but there has also been deep drilling with several holes down to about one kilometre.

The promising results from Outokumpu in using reflection seismsics as a tool in ore exploration lead to the HIRE project, applying high resolution reflection seismsics. Between 2007 and 2010, altogether 15 important Finnish ore mining and exploration targets were surveyed with this technique. Data was acquired to a depth of five kilometres and lots of formerly unknown geological structures with ore potential were detected. The results from HIRE are under interpretation at the moment.

ISOLATED SALTY WATERS DEEP DOWN

Essential issues in the Outokumpu Deep Drilling Project were to analyze the deep water chemistry and to investigate the penetration of water in the rock. Due to increasing pressure with increasing depth, pores and fractures are efficiently closed by the weight of the rock. As a consequence, the hydraulic permeability decreases rapidly with depth. Surprisingly few fractures seem to be hydraulically active.

− The pressure in the hole is such that a pressurized water sample taken at a depth of one kilometre releases about half of its volume as gas when the pressure is released at the surface. About half of the gas volume is methane, 40 per cent is nitrogen, and the rest is oxygen, helium, some hydrocarbons and hydrogen sulphides, Kukkonen says.

− At the moment we are trying to find out the origin of the gases. For instance, helium could originate from radioactive decay in the bedrock, or it could be helium originating from the birth of Earth.

The groundwater in the upper layers of the bedrock is fresh only to a depth of a few hundred metres. Deeper down the water in the fracture zones of the bedrock is salty due to electrolytes dissolved from the rock. It typically contains calcium, sodium, potassium and chlorine ions.

− Our investigations show that the saline fluids in the deep hole are isolated from the surface waters. The fluids are probably the result of a long-term interaction between the deep water and the rock. With extremely low permeability of the rock, the fluids can remain isolated in closed fracture systems for very long periods, Kukkonen says.

The scientists hope to be able to determine the age of the fluids at different levels by analyzing the isotope composition for dissolved noble gases, in particular helium. Studies of this kind from elsewhere have shown deep fluids with residence times of tens of thousands of years.

A DEEP WORLD FOR MICROBES

Micro-organisms were detected in the sampled fluids at all depth levels in the hole. They were mainly sulphate-reducing bacteria and methanogenic archaea, but in addition there are numerous previously unknown species.

− The species of microbes vary with the depth. The organisms are anaerobic and most of them probably get energy by reducing sulphate and producing methane. But we don’t know yet whether methane in the deep fluids is a microbial metabolic product or nourishment for microbes, Kukkonen says.

− It is well known that microbes are common underground and there seems to be a deep biosphere also in Outokumpu. According to some estimates, up to half of the total biomass on earth may exist in subsurface ecosystems. A deep biosphere can exist in temperatures up to 120°C, which in Finland would correspond to a depth of five to seven kilometres.

At the surface the average ground temperature in Outokumpu is 5°C but the bottom hole temperature at 2.5 km is 40°C. Both the temperature gradient and heat flow density increase significantly when going deeper than 1.5 km.

− Thermal conductivity of the rock is low, which means that very little heat is conducted from inside of the earth up to the surface. The increased temperature gradient and heat flow density can be attributed to a paleoclimatic effect. The rock still remembers glacial periods with lower surface temperatures during the last 100,000 years, Kukkonen explains.

− We have calculated that the average surface temperature at that time was three to four degrees below zero. The cold wave of the ice age is still there in the rock, although significantly reduced.
Logging during drilling breaks

In addition to investigation of the drill core, the Outokumpu Deep Drill hole was logged already during drilling breaks at about every 500 metres. Some twenty different methods were used for the electrical, magnetic, density, and radiometric properties. Also the hydraulic permeability was tested and the pressurized fluid samples were taken.

Several international teams participated in the post-drilling studies and the topics included seismic properties, metamorphic grade, and fluid inclusions of the core, organic compounds in graphite- and sulfide-bearing schists, temperature and heat flow, borehole and surface seismic reflection surveys, hydrogeology and deep biosphere.

Special attention has been paid to hydrogeology and deep biosphere studies.


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<th>Depth (m)</th>
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A glance at the latest discoveries in the deep drill hole of Outokumpu. The borehole temperature and salinity of the fluid has varied after the end of drilling. Temperature variations are due to gradual disappearance of drilling-induced thermal disturbance. Electrical conductivity is a direct measure of the fluid salinity. The fluid electrical conductivity has been increasing after the end of drilling when the hole was flushed clean and filled with fresh water. Saline fluid enters the borehole from five fracture zones at depths of about 2,450, 2,300, 715 and 970 metres.

On the right, the columns represent the frequency of hydraulically conductive fractures and on the left the borehole lithology (blue: metasediments; green and orange: ophiolite-derived serpentinite and skarn rocks; pink: pegmatitic granite).
## COMING EVENTS

<table>
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<tr>
<th>Year</th>
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<tr>
<td>2011</td>
<td><strong>SES 2011</strong> – First Sustainable Earth Sciences conference and Exhibition organized by the European Association of Geoscientists and Engineers (EaGE), Valencia, Spain.</td>
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<td></td>
<td>8.–11.11. SES 2011 – First Sustainable Earth Sciences Conference and Exhibition organized by the European Association of Geoscientists and Engineers (EaGE), Valencia, Spain.</td>
<td>Valencia, Spain</td>
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<td>15.–17.11. 7th International Rare Earths Conference. Hong Kong.</td>
<td>Hong Kong</td>
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<td>2012</td>
<td><strong>World Goldpanning Championships. Pilgrim’s Rest, Mpumalanga, South Africa.</strong></td>
<td>Pilgrim’s Rest, South Africa</td>
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<td>13.–14.1. Technology Days 2012. Dipoli (Aalto University School of Science and Technology), Espoo, Finland.</td>
<td>Espoo, Finland</td>
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<td>6.–11.2. 10th International Kimberlite Conference. Bangalore, India.</td>
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<td>4.–7.3. Prospectors and Developers Association of Canada: Annual Convention. Toronto, ON, Canada.</td>
<td>Toronto, ON, Canada</td>
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<td>2.–5.4. International Conference &amp; Exhibition Geosciences: Making the most of the Earth’s resources. European Association of Geoscientists and Engineers (EaGE) and EurAsian Geophysical Society (EAGO), Saint Petersburg, Russia.</td>
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### New Mining Act entered into force on 1 July 2011

In accordance with a Government proposal, the new Mining Act entered into force on 1 July 2011. The new Act superseded the former Act, which entered into force in 1965. The Act includes provisions concerning the rights and obligations of parties engaged in ore prospecting, mining and gold panning, both during their operations and as termination measures are taken, including aftercare.

While securing the preconditions for mining and ore prospecting more effectively than before, the new Act takes account of environmental issues, citizens’ fundamental rights, landowners’ rights and municipalities’ opportunities to influence decision-making. The Act reconciles various public and private interests and thereby, as a whole and insofar takes due account of the various competing interests.

Mining authority duties were transferred from the Ministry of Employment and the Economy to the Finnish Safety and Chemicals Agency Tukes. The mining authority is responsible for granting permits and supervising compliance with legislation. Mining authority duties will be handled at the mining unit established by Tukes in Rovaniemi. [www.tukes.fi/en/](http://www.tukes.fi/en/)

The Ministry of Employment and the Economy promotes the use of mineral resources by securing a favourable operating environment for mineral exploration and mining activities. The Ministry’s actions are based on the Mining Act and the Mining Decree of 1965. A review of the Finnish mining law is currently under way.
Academic dissertation on the Archean and earliest Paleoproterozoic granitoid suites

The four papers summarized in this thesis deal with the Archean and earliest Paleoproterozoic granitoid suites observed in the Suomussalmi district, eastern Finland. Geologically, the area belongs to the Kianta Complex of the Western Karelian Terrane in the Karelian Province of the Fennoscandian shield. The inherited zircons up to 3.440 Ma old together with Sm-Nd and Pb-Pb data confirm the existence of previously anticipated Paleoarchean ‘protocrust’ in Suomussalmi. The general timeline of granitoid magmatism is similar to that of the surrounding areas.


The dissertation is available from GTK publication sales: [http://en.gtk.fi/GeoInfo/Publications/Publication-sales.html](http://en.gtk.fi/GeoInfo/Publications/Publication-sales.html)

GTK exports expertise to Mongolia

Mongolian bedrock is rich in minerals that the country wants to exploit more efficiently. GTK participated in a ICI (Institutional Cooperation Instrument) project, funded by the Finnish Ministry for Foreign Affairs, to help Mongolia to map and exploit their natural resources and earth metal deposits. The project started in late 2009 and ended with this ceremony.

The opening ceremony for a new mineral technology laboratory was held in September 2011. The project focused on updating equipment in the mineral processing laboratory and training its personnel both in Mongolia and in Finland at GTK’s mineral processing laboratory located in Outokumpu. The purpose of the project was to provide the management of the Central Geological Laboratory (CGL) with training in good governance and management.

From left: GTK’s Director General Elias Ekdahl, the President of the Republic of Finland Tarja Halonen, the wife of the president of Mongolia Khajidsuren Bolormaa, the Minister of Mineral Resources and Energy D. Zorigt, Director of CGL B. Batjargal (partly visible), GTK’s Export Director Mika Räsänen.
GTK rebuilds the mineral occurrence data delivery services for new interoperability demands

TEXT Jouni Vuollo

By the end of 2012, GTK will combine separate mineral occurrence databases into a single entity that is based on global geostandards (GeoSciML and EarthResourceML) and classifications related to them. Viewing and download services based on the database will be built for various purposes.

Significant areas of use of geostandards include the dissemination of information in both the EU’s INSPIRE directive and The Raw Materials Initiative (RMI). These platforms set new standards for the quality and dissemination of geological data and the metadata related to it. RMI has two particular points for data delivery:

- The sustainable supply of raw materials based in the EU requires that the knowledge base of mineral deposits within the EU be improved.
- The Commission recommends better networking between the national geological surveys to facilitate the exchange of information and improve the interoperability of data and their dissemination.

The CGI Council (Data Model Collaboration Group) and its working groups, working under the IUGS Commission, is responsible for creating unified and internationally-accepted standards for disseminating and harmonizing geological data. The Mineral Resource INSPIRE data specification is based on these global standards. Implementation of this content into GTK’s databases is also a central objective in the further development and creation of content for the mineral occurrence information system. GTK current commodity databases include Au, Zn, Ni, PGE, U, Cu, industrial minerals, and a combination of previous ones: FODD and ProMine.

Green: current databases; yellow: new database and web-services.


GeoSciML = Geoscience Markup Language is a GML Application Schema that can be used to transfer information about geology – http://www.geosciml.org/

EarthResourceML = Earth Resource exchange language (see – http://www.earthresourceml.org/)

FODD = The Fennoscandian Ore Deposit Database – http://en.gtk.fi/ExplorationFinland/fodd/

ProMine = EU project, which develops minerals into nanoparticles – http://promine.gtk.fi/
New publications

Building an intelligent and responsible natural resource economy

For an industrialised nation, the Finnish economy is based exceptionally strongly on added value obtained from natural resources. Finland has e.g. significant reserves of aggregate, minerals and peat. Other important natural resources include clean water and arable and undeveloped land. The Finnish Government has submitted a report on building an intelligent and responsible natural resource economy to the Parliament.

Against the backdrop of intensifying global competition, natural resources are a great opportunity for Finland. According to the report Finland must, however, generate wellbeing and wealth in more sustainable ways. The natural resources policy must be based on an understanding of which operational models for the use and protection of natural resources will generate success in the future. The report is based on Finland’s Bioeconomy Strategy and Minerals Strategy, but it also brings together several other perspectives (including water economy, ecosystem services, material and energy efficiency) to form a coherent whole.


The report is available at the Ministry of Employment and the Economy: Strategy and Foresight/Mika Honkanen, tel. +358 10 606 4904

The mineral sector will be one of Finland’s success factors in the future

Finland’s Mineral Strategy was published in October 2010. The purpose of the strategy is to strengthen one of the foundations of the Finnish national economy. Finnish and international preconditions for development in the medium term and until 2050 have been assessed in the project.

The strategy includes a list of proposals on how to develop the mineral sector. The goals are, for example, to strengthen the mineral sector, ensure the availability of raw materials, reduce the effects on the environment and improve productivity, as well as to improve R&D operations and strengthen competence.

In recent years, new mines have been opened in Finland, in Eastern and Northern Finland in particular. The volume of metallic minerals excavation is estimated to multiply by the end of the decade. At the same time, the mining industry creates long-term jobs for as long as decades.

The Mineral Strategy has been drawn up as commissioned by the ministerial working group on climate and energy policy. The Ministry of Employment and the Economy assigned the Geological Survey of Finland to carry out the project in practice. The mineral strategy is available at www.mineraalistrategia.fi/etusivu/etusivu_files/84608401427464240/default/FinlandsMineralsStrategy.pdf
Geoscience for Society : 125th Anniversary Volume


This 125th Anniversary Publication of the Geological Survey of Finland (GTK) aims at elucidating, through 33 short articles, the current focus of research and development at GTK. We have defined our current strategy to cover three areas of societal impact: (1) mineral resources and raw material supply, (2) energy supply and the environment, and (3) land use and construction, which also form the subsections of this anniversary publication, in addition to a section on geodata management and database development.

Suhanko seismic reflection profile and integrated geological-geophysical model of the Portimo area


In 2003, about 14 km of common midpoint (CMP) seismic reflection data were recorded on the Suhanko high resolution test line in northern Finland. The principal observation of the seismic measurement was the conspicuously clear separation of the Archaean basement complex and the Proterozoic lithologies due to their differing acoustic properties. The seismic measurement results suggest new targets for further exploration of the contact type Cu-Ni-PGE mineralization at the basal contact of the Suhanko Intrusion.

Impacts of Mining and Quarrying on the Finnish Economy


The economic interaction between the mining and quarrying industries and their consumer industries in Finland was modelled with the basic-price supply and use tables normally used for the national economy. In the use table, the use of domestic products and imported products were separated. The structures of the supply and use tables complied with the European System of Accounts (ESA 95). In the tables, economic activity was divided into industry classes in accordance with the EU-standard NACE Rev. 1.1, and economic interaction was divided into product categories in accordance with the EU product classification standard CPA2002. The impact-analysis results can be used both in corporate, strategic decision-making processes and in political decision-making.

GTK publication sales [http://en.gtk.fi/Geoinfo/Publications/Publicationsales.html]
A new mining act and mining authority in Finland

TERHO LIIKAMAA

On 1 July 2011 a new mining act entered into force in Finland. Despite the recent, and sometimes heated, public debate, ore prospecting and gold panning continue.

Finnish mining legislation was reformed to respond to the changes in the operational environments of mines in both Finland and Europe that have taken place over the last five decades. Better than it did before, the act also takes into consideration points of views other than the interests of mining companies. According to the new law, the authority responsible for granting mining and ore exploration permits and supervising compliance with legislation will change from the Ministry of Employment and the Economy to the Finnish Safety and Chemicals Agency (Tukes). Another visible change in the customer service provided to mining companies is that from last summer, the services of the mining authority have also been available in Rovaniemi.

Apart from a few details, the differences in the contents of the old and new mining acts are not, however, nearly as great as the public debate has suggested. The old mining act entered into force in 1965. The mining authority has, however, complemented the old mining act by applying several other laws alongside it. The new mining act thus only encompasses practices already applied in permit consideration. More comprehensive hearing of citizens and landowners has already been a reality for several years.

In order to consolidate the societal acceptability of the activities and various interests of society, it is important also to take into account other societal objectives related to, for example, land use, environmental protection, healthy living conditions of the citizens, and their chances of influencing the decision-making related to their living conditions.

The new mining act tries to find balance between different socio-political objectives. The mining act sets more precise regulations for operations, but also guarantees opportunities for operations and continuity of operations on statutory level. Ore prospecting and mining permits are granted if the permit applications and operations comply with legislation. The aim has been to reconcile the act with other legislation, in order to form a consistent entity.

It is still difficult to give a final assessment of the positive and negative impact of the new mining act. We need to apply the act in co-operation with the mining authority, environmental authorities, landowners, municipalities and naturally with companies carrying out ore prospecting and mining. We need constructive co-operation so that all the parties feel that the law is fair. The mining act can be amended if necessary.

In addition to Helsinki and Tampere, Tukes now also has an office in Rovaniemmi, where the headquarter for the mining authority is situated. The mining authority also serves its clients in Tukes’ office in Helsinki.

Due to the numerous changes that have taken place in recent years, the mining authority is behind in processing ore prospecting and mining permits. Thanks to the more clarified legislation and increased resources, the mining authority should catch up with the work within a year and be able to give preliminary information on the processing times.

Terho Liikamaa is Chief Inspector of Mine, Finnish Safety and Chemicals Agency (Tukes)
Mineral resources

Mining and Exploration News 2011

Hannu Makkonen

Talvivaara Mining Company Plc’s nickel production at Talvivaara during the first half of 2011 was 8,166 t (3,339 t in 2010) and zinc production 14,005 t (8,535 t in 2010). Expected nickel production for 2011 is around 22,000 t. A uranium off-take agreement was signed with Cameco Corporation in February 2011.

In the first half of 2011, gold production at Agnico-Eagle Mines Ltd’s Kittilä Mine was 71,128 ounces. Proven and probable gold reserves total approximately 4.9 million ounces from 32.7 million tonnes grading 4.6 g/t. Results of the recent exploration drilling continue to indicate reserve growth (e.g. 7.1 g/t gold over 21.0 meters true width at 850 meters below surface). A feasibility study regarding a 50% increase in mill throughput is expected to be reviewed in the fourth quarter of 2011.

Gold production during the first half of 2011 from the Dragon Mining Ltd’s Mines in Finland, Orivesi and Jokisivu was 12,751 ounces. Exploration is directed at enlarging the reserves and resources at the existing mines, as well as expanding the resources at Kuusamo (Juomasuo, Hangaslampi) to enable the project to advance to a feasibility study.

Belvedere Resources Ltd’s Hitura Nickel Mine produced 1,057 t of nickel in the first half of 2011. A 5,000 m drill programme was carried out for the open-pit expansion at Hitura. Extending the open pit to the south of its current margins could add significantly to the operating life of the mine.

Altona Mining Ltd’s Kylylahti Cu-Au-Zn-Ni-Co Mine decline is approaching the 1,000 meters of advance mark (end of July 2011) and is scheduled to hit first ore in October. The Luikonlahti mill refurbishment programme is approximately 40% complete (end of July 2011) and on track for an early 2012 start up.

Endomines AB’s Pampalo Gold Mine produced 8,040 ounces of gold during the first half of 2011. Exploration includes a low-altitude airborne geophysical survey over the Karelian Gold Line. Construction of the Nordic Mines AB’s Laiva Gold Mine is progressing on schedule and the production start up is scheduled for 2011. The proven and probable ore reserves based on drilling results until the end of 2010 reached a total of 12.9 million tonnes with an average gold content of 1.85 g/t.

First Quantum Minerals Ltd’s Kevitsa Ni-PGE-Au project has remained on schedule and will achieve commercial production in mid 2012. The significant increase in the Kevitsa ore reserve means that at the currently planned processing rate of 5.0 Mtpa, the mine life would be extended to over 30 years. Scaling the production up to 10 Mtpa has been scoped.

Gold production during the first half of 2011 from the Lapland Goldminers AB’s Pahtavaara Mine was 11,848 ounces, a 10% increase compared to 2010. An updated geological model for the Länsi mineralization shows the possibilities to increase the mineral resources.

Inmet Mining Corporation’s Pyhäsalmi Zn-Cu-pyrite Mine produced 7,300 t (+ 6% compared to 2010) of copper, 16,500 t (+ 29%) of zinc and 384,200 t (+ 15%) of pyrite during the first half of 2011.

Outokumpu Chrome Oy’s Kemi Chromium Mine has annual output of 1.3 Mt. The project to double the mine output as part of ferrochrome production expansion is ongoing. Kemi Mine will be the biggest underground mine in Finland after the investment. The research report by GTK indicates that the chromite-bearing intrusion extends to a depth of 2 – 3 km, possibly even to a depth of 4 km.

Northland Resources S.A.’s ongoing DFS on the Hannukainen Iron-Ore Copper Gold (“IOCG”) Project continued during the first half of 2011 including a >10 km drilling programme. The project remains under budget and on schedule, and is expected to be completed in December 2011.
Active Mines and Current Projects

September 2011

**Precious Metals**
1. Iso-Kuotko gold - Agnico-Eagle Ltd
2. Hanhimaa gold - Dragon Mining Ltd
3. Kitilia gold - Agnico-Eagle Ltd
4. Kettukuaisiko gold - Taranis Resources Inc.
5. Naakenvaara gold - Taranis Resources Inc.
6. Pahtavaara gold - Lapland Goldminers Ab
7. Kiekerömaa gold - Tertiary Minerals Plc
8. Suhanko-Kottijärvi PGE - Gold Fields Arctic Platinum Oy
9. Kuusamo gold - Dragon Mining Ltd
10. Laiva gold - Nordic Mines Ab
11. Hirskangas gold - Belvedere Resources Finland Oy
12. Kopala gold - Belvedere Mining Oy
13. Taivaljärvi silver - Sotkamo Silver AB
15. Pampalo gold - Endomines AB
16. Osikonmäki gold - Belvedere Resources Finland Oy
17. Haveri gold - Lapland Goldminers Ab
18. Orivesi gold - Dragon Mining Ltd
19. Jokisivu gold - Dragon Mining Ltd
20. Kaapelinkulma gold - Dragon Mining Ltd

**Base Metals**
1. Riikonkoski copper, gold - Taranis Resources Inc.
2. Kevitsa nickel, copper, PGE - First Quantum Minerals Ltd
3. Sodankylä nickel, copper - Anglo American Exploration B.V.
5. Kuhmo nickel - Altona Mining Ltd
6. Kuhmo nickel - Anglo American Exploration B.V.
7. Talvivaara nickel, zinc, copper - Talvivaara Mining Co.
8. Hitura nickel - Belvedere Mining Oy
9. Pylktalmi zinc, copper, pyrite - Inmet Mining Corp.
10. Rautavaara nickel, zinc, copper - Western Areas NL & Magnus Minerals Oy JV
11. Kylylahti copper, gold, zinc, nickel, cobalt - Altona Mining Ltd
12. Valkisentunturi, Särkiniemi nickel, copper - Altona Mining Ltd

**Diamond**
1. Kuusamo - Sunrise Resources Plc
2. Kuhmo - Karelton Diamond Resources Plc
3. Kaavi-Kuopio - Sunrise Resources Plc
4. Kaavi - Mantle Diamonds Ltd & Firestone Diamonds Development JV

**Other Commodities**
1. Sokli phosphorus, niobium - Yara International ASA
2. Siivakkalehto iron - Tertiary Minerals Plc
3. Kolari iron, gold, copper - Northland Resources Ab
4. Romsdal gold, uranium - Mawson Resources Ltd
5. Rana uranium - Mawson Resources Ltd
6. Mustavaara vanadium - Mustavaara Kaivos Oy
7. Kemi chromium - Outokumpu Chrome Oy
8. Purasuuo talc, nickel - Mondo Minerals Oy
9. Alumen talc - Tale de Luzencq
10. Läntä lithium - Keliber Resources Ltd
11. Koivusaarenneva ilmenite - Kalvimit Oy
12. Sillínjärvi phosphorus - Yara International ASA
13. Eno uranium - Mawson Resources Ltd
14. Tammela lithium, tin, tantalum - Norotec Minerals Corp.
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