geo foorumi

GTK
Geological Survey of Finland stakeholder magazine 2/2018

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The Battery Revolution is the moment for Finland

A recent report by the IPCC suggests that climate change is accelerating. Reducing traffic emissions, which are responsible for over 20% of global CO_2 emissions, would be one of the most important means to reach the goals for sustainable development. There is no doubt that the age of the internal combustion engine is drawing to a close. Car manufacturers are investing huge sums to develop electric vehicle (EV) manufacturing. Batteries are becoming more effective and much cheaper. It is expected that within the next 5 to 10 years, an EV will be less expensive than a normal car meeting the strict emission limits. In addition to EVs and consumer electronics, batteries will be needed, for instance, in heavy transport, machinery and bicycles. Smart grids will also need batteries for energy storage and balancing peak consumption.

Recent forecasts indicate that the demand for batteries will grow exponentially. Within the next 15 years, the global market would need something like one hundred new battery gigafactories to make the Battery Revolution possible. China has taken the lead in battery manufacturing, followed by other Far East countries and the USA.

Huge quantities of raw materials are needed to produce batteries. As a direct consequence, a boom in battery mineral mining is projected to occur. The metal markets for copper, nickel, lithium, cobalt and graphite are predicted to benefit the most. A global race for the market share of raw materials supply is now already underway. Cobalt is particularly critical, because its production is largely concentrated in the Democratic Republic of Congo and most cobalt refining takes place in China.

An ambitious objective is to make Europe a global leader in sustainable battery production. A great deal of effort and organization has already taken place to develop this plan. Such a large increase in battery manufacturing will require a much larger extraction, processing and refining capacity to supply at least a reasonable part of the future raw materials demand from Europe.

This is an important moment for Finland to become one of the key battery industry players in Europe. A multi-billion euro business based on the battery industry, covering the whole value chain from mining, processing, chemicals production and manufacturing to recycling can be established and further developed. This development will be supported by existing knowhow and technological expertise.

Raw materials provide a firm foundation for the development. Finland is the only European country where significant resources of all the key battery minerals exist, and most of them are already produced. Furthermore, Finland has existing capability for processing and refining.

GTK has set a strategic goal to build a much better understanding of the national potential for battery minerals. In particular, cobalt mineral systems and their best exploration and effective processing techniques will form a special focus in the next few years. GTK also welcomes partnerships and projects across the whole battery ecosystem to speed up innovations and business development.

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GTK

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Subscription requests and change-of-address information may be submitted by email to **satu.ojanen@gtk.fi.**

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Geodata about the seabed is needed to build infrastructures

When the plan is to build an offshore wind farm or build a submarine gas pipeline, it is necessary to understand the soil type and building capacity of the seabed. For example, when working on sea lanes, it is important to know whether the depth of the lane can be increased by dredging or blasting rock.

The European Marine Observation and Data Network (EMODnet) project, coordinated by the Geological Survey of Finland (GTK), responds to needs for information by compiling and standardising information on the soil types of seabeds in Europe and the sedimentation rates of matter descending to the seabed. The project has compiled soil type maps produced by GTK of seabeds in Europe at the scale 1:100,000 that depict the topmost seabed layer. These maps are now ready. The material offers a representative overview of the distribution of soil types on the seabed, on the basis of which it is possible to deduce the building capacity of the seabed.

Maps of bedrock layers on the seabed, coastal processes, geological risks and natural resources of the seabed will also be produced at the scale 1:100,000. Natural resources of the seabed include metallic minerals and rock material, as well as hydrocarbons in sedimentary rock in the bedrock layer, i.e. oil and gas.

In the third phase of the ongoing EMODnet project, the aim is to compile map material at a much more accurate scale than the current 1:100,000 as background material for future needs. When the project ends in spring 2019, all material at the scale 1:100,000 will be freely available to all.

Detailed marine environment planning is more important than ever before, as marine environments are being used more than before and any overlapping needs of users may result in conflicts. In 2009, the European Commission launched the EMODnet project to provide decision-makers and users of marine environments with relevant information about the geology, biology and chemistry of seabeds.

The total budget of the two-year EMODnet Geology project funded by the European Commission and coordinated by GTK is EUR 4.5 million. The project involves 39 organisations from 30 countries, most of which are national geological survey institutions. The third phase started in spring 2017 and has now reached the halfway mark. ■

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EMODnet Geology scheme: *www.emodnet-geology.eu*

EMODnet scheme: *www.emodnet.eu*

EMODnet
European Marine Observation and Data Network

Finland's bedrock may contain significant lithium reserves

The largest lithium reserves are estimated to be in the zone extending from Central Ostrobothnia to South Ostrobothnia

The Geological Survey of Finland (GTK) has evaluated lithium (Li) reserves in Finnish bedrock to a depth of one kilometre. The assessment consists of reserves in lithium-caesium-tantalum (LCT) pegmatite-hosted deposits. This is the only important lithium deposit type in Finland.

GTK narrowed down 19 areas that may include LCT pegmatite reserves. GTK estimated that these 19 areas include seven previously undiscovered lithium deposits.

According to GTK's assessment, the lithium reserves contained by Finland's undiscovered lithium deposits contain at least 510,000 tons of lithium, at a probability of 50 per cent. When compared with the volumes of known mineral deposits, more than 90 per cent of the metal content of Finland's lithium deposits is located in poorly surveyed or completely undiscovered deposits.

Lithium reserves are mainly located in Ostrobothnia. Finland's only well-known lithium reserves are located in six deposits in and around Kaustinen in Central Ostrobothnia. In total, these deposits in Kaustinen contain 45,500 tons of lithium.

The total area of the 19 potential areas defined by GTK is 22,404 km^2, comprising roughly seven per cent of Finland's land area. Even though these areas are located in different parts of Finland, GTK estimates that more than 90 per cent of yet undiscovered lithium reserves are located in the area of Kaustinen or the surrounding Ostrobothnia lake district.

GTK has surveyed undiscovered mineral reserves in Finland's bedrock since 2008. It uses the three-stage method developed by the U.S. Geological Survey, in which estimates of the metal volumes contained by undiscovered mineral deposits are presented at three different levels of probability.

Areas that may include the mineral deposit types included in the survey are defined on the basis of their deposit models. The number of undiscovered mineral deposits located in these areas is estimated, and their metal volumes are calculated on the basis of the metal content of well-known deposits. However, the assessment does not estimate how many as yet undiscovered deposits could be discovered in the future.

The results of the assessment were published in GTK Bulletin 406:
Rasilainen, K., Eilu, P., Ahtola, T., Halkoaho, T., Kärkkäinen, N., Kuusela, J., Lintinen, P. & Törmänen, T. 2018. Quantitative assessment of undiscovered resources in lithium–caesium–tantalum pegmatite-hosted deposits in Finland. Geological Survey of Finland, Bulletin 406.

Online publication:
http://tupa.gtk.fi/julkaisu/bulletin/bt_406.pdf

Give feedback on the magazine

We want to make our magazine Geofoorumi even more interesting to our readers. Your feedback is valuable to us.

- What articles did you find interesting and why?
- What kinds of articles would you like to read?
- What do you think is good about the magazine and what should we improve?
- We would also like to know whether you have read Geofoorumi before and how you got your hands on the magazine.

Please send your feedback to: *viestinta@gtk.fi.*
Please write *"Feedback on Geofoorumi"* as the message subject.

We appreciate your feedback – many thanks in advance!

Valuable battery minerals are hidden deep in Finland's bedrock

GTK increases the surveying of battery minerals

Finland's bedrock offers promising potential for discovering minerals used in batteries. As demand increases, the Geological Survey of Finland (GTK) is increasing its research and survey activities for battery minerals.

Text: Timo Hämäläinen

Batteries are used to store electric energy in various mobile devices, such as smartphones, tablets and laptops. They are also needed in electric cars and in power grids, in which electric energy is increasingly being produced using wind and solar power.

– Electricity is close to making a real breakthrough in all mobile applications, says **Pasi Heino**, Head of Unit, Ore and Industrial Minerals at GTK.

Electric technologies increase the demand for cobalt, lithium, graphite and nickel, in particular. In addition, small volumes of dozens of other minerals are required to manufacture batteries.

Finland is a rare producer of cobalt

Cobalt has a broad range of applications. It is particularly used in metal alloys and coating agents that need to withstand high temperatures, corrosion, wear and oxidation. Cobalt is also known as a colouring agent. In the plastic and petrochemical industry, cobalt is used as a catalyst.

– Currently, the demand for cobalt is increasing most rapidly in the battery industry. The demand for battery minerals is expected to increase tenfold by 2022 and a further sevenfold by 2030, Heino says.

To ensure supply, cobalt-containing minerals are actively being explored in Finland and in other parts of the world. In Europe, Finland and Sweden have the highest potential for discovering cobalt-containing minerals. In 2012–2016, Finland and Poland were the only EU states in which cobalt was produced.

> *" Cobalt does not appear on its own.*

Cobalt does not appear on its own. Usually, it is mixed with nickel or copper.

In Finland, Terrafame produces cobalt at the Talvivaara mine in Sotkamo alongside nickel, zinc and copper sulphide products. Boliden produces cobalt as a by-product at the Kylylahti copper mine in eastern Finland and at the Kevitsa copper and nickel mine in Lapland.

The first lithium mine about to open

Lithium is produced globally either in saline solutions or it is extracted at mines. Its production is divided fairly evenly between these two methods. The global production volumes of lithium are fairly low, considering the known mineral resources.

In Finland, Keliber Oy owns a significant lithium deposit in central Ostrobothnia. The company is preparing a technical and financial survey and an environmental impact assessment procedure for a mine. If the permit process goes as planned, the company's lithium mine will open in 2019, alongside the production of lithium carbonate. As the demand for lithium is increasing, Keliber has a lead over many other projects.

Keliber's lithium mine would be the first of its kind in Europe. The company would produce roughly five per cent

of all lithium carbonate sold in global markets and suitable for use in batteries. Currently, it is mainly produced in China.

Lithium minerals are also being explored in other parts of Finland. Finland's lithium reserves are located in spodumene-containing pegmatite. GTK has surveyed extensions of the known Kaustinen lithium province. Promising findings have been discovered tens of kilometres south of the previously known deposits. For example, GTK has conducted surveys and drillings in Veteli.

– Finland has a high potential for discovering more lithium reserves related to pegmatites, Heino says.

Promising graphite deposits

Natural graphite is one of the 27 critical raw materials listed by the European Commission. A raw material is considered to be critical if it is highly significant for the EU economy and it has a high availability risk. Cobalt is also on the same list.

China is the key producer of many critical raw materials. In total, 69 per cent of all graphite is produced in China. India accounts for 12 per cent and Brazil for eight per cent.

Australian Beowulf is currently exploring graphite from the Finnish bedrock. The company is looking for minerals in Heinävesi in Central Finland.

GTK provides mineral explorers with full-range services

As part of its basic operations, GTK surveys Finland's mineral potential. Currently, its surveys are focused on lithium, graphite, cobalt, nickel and copper. Later, GTK will shift its focus more extensively to cobalt, while lithium and graphite surveys will also be continued.

– The aim of research on battery minerals is to bring new investments in Finland. We are continuously working to discover new deposits. We are also surveying already discovered deposits, partly together with companies operating in the field, Heino says.

This year, GTK has, for example, conducted drillings in Rautalampi in Central Finland to identify the graphite potential of two deposits. In autumn, GTK conducted drillings in Central Ostrobothnia to identify the lithium potential of a deposit.

According to Heino, GTK will increase its resources to identify the potential of battery minerals in 2019. Its work is supported by the additional funding of one million euros granted by the Ministry of Economic Affairs and Employment.

This additional funding is targeted at GTK's core operations. GTK produces data on attractive and potential mineral exploration locations. Most of its digital data are freely available.

– GTK has extensive experience in and a successful history of mineral research. By continuously updating its data collected over several decades, GTK is in an excellent position to survey the mineral potential, model mineral deposits and evaluate mineral reserves, Heino says.

GTK Mintec provides its customers with all types of surveys related to mineralogy and mineral processing technologies. Laboratories and a testing facility are all located under one roof. ■

Finland wants to become number one in the battery markets

Finland is striving to become number one in European battery markets. The Finnish Government provided GTK with additional four-year funding of one million euros per annum for research on Finland's battery mineral potential.

– With this additional funding, we want to speed up the development of the industrial cluster formed around battery technologies in Finland, says **Riikka Aaltonen**, senior adviser on mineral policy at the Ministry of Economic Affairs and Employment.

Aaltonen points out that a mining cluster has formed in Finland over several decades which lays a solid foundation for expertise in battery technologies: research, mining, service companies, equipment construction and further processing.

– Most importantly, battery minerals are also located in our bedrock. Value chains can easily be built on this strong base. Versatility produces synergy benefits and helps the industry to withstand any market fluctuations.

A transparent permit process

The Finnish Safety and Chemicals Agency (Tukes) is the primary permit authority for mineral exploration and mining operations. Permits are granted on the basis of the Mining Act.

According to Aaltonen, all permit applications for mineral exploration and mining operations pass through a single process, whether they concern battery or other minerals. The only exception is uranium. Applications for its exploration and use are subject to special regulations.

– Based largely on EU legislation, the environmental permit process is fairly cumbersome. Then again, it is also transparent. Companies have easy access to the rules and requirements of the process. There are rarely any delays in the promised processing times.

Aaltonen's views are supported by the Fraser Institute's annual review Permit Times for Mining Exploration in 2017, where Finland and Sweden alike are given high scores in "timeline certainty" and "transparency."

To speed up the permit process, environmental authorities have tested a new type of a permit application process. During advance negotiations, all the authorities needed in the permit process meet the company in question to discuss the permit.

– The parties involved meet face to face. As a result, the company gets a complete view of the permit conditions. What is more, the authorities obtain a detailed picture of each other's requirements and the project.

There is also an ongoing project with the aim of assigning permit and monitoring processes to a single authority. The goal is to make these processes easier. The new cross-governmental and multidisciplinary LuoVa unit will start operating on 1 January 2021. ■

Finncobalt aims to open a cobalt mine

Finncobalt aims to start the production of cobalt and nickel chemicals that are used in batteries. Its deposit is located in Outokumpu, in the area of a former copper mine.

Originally, Outokumpu Oy entered the deposit into production in the mid-1980s. However, the sudden decline in the price of cobalt forced the company to interrupt the use of the deposit. After this, the deposit has changed hands many times over. Finncobalt acquired rights to the deposit in 2016.

During its history, the deposit has been surveyed in detail. Its nearly horizontal plate is located 150 metres above the previously excavated copper deposit. To inventory the deposit, more than 20,000 metres have been drilled. Outokumpu Oy dug a tunnel of 2,100 metres for production.

– The deposit is now known in sufficient detail for the final profitability survey. Negotiations over funding are currently in progress, says geologist **Markus Ekberg**, one of the three shareholders of the company.

Finncobalt aims to produce cobalt and nickel chemicals from enrichments by means of tank dissolution. In addition, the mine is expected to produce copper enrichments for smelting plants.

The company uses GTK Mintec's services to develop the process.

– GTK Mintec already carried out process development and testing for the previous owner. In addition, GTK has taken an active part in the geological modelling of the Outokumpu zone. We will now use this research and expertise to develop our operations, Ekberg says. ■

Environmental impact plays a key part in the lifecycle of mining operations

Text: Sami Lehtinen

The environment can be protected by ensuring that the mining area is able to recover after the mine is closed. Photo: Teemu Karlsson, GTK

Mining has various impacts on nature and the environment. This is why it is vital to supervise and ensure that operations remain under control throughout the lifecycle of a mine.

The environment can be protected, for example, by using all mining-related extractive waste and by ensuring that the mining area is able to recover after the mine is closed.

Use of extractive waste increasing

In excess of 99 per cent of all material extracted from a mine can end up as waste or forms waste material, and most of the waste volume comes from metallic mineral mines. In total, Finnish mines produce 90 million tons of waste rock and tailings per year. Waste rock is produced when rock material is removed from around ore. Valuable metals are separated from the ore using physical and chemical processes, and the remaining material is called tailings.

– The downside of tailings is its difficult storage. Final disposal may be expensive and cause adverse environmental impacts. However, the use of tailings has been studied and it has undisputed potential. It is very important that the potential use of tailings is already addressed when establishing a mine, says **Soili Solismaa**, geologist at the Geological Survey of Finland (GTK).

The potential to use waste rock and processing tailings is ultimately affected by a number of factors, such as their composition and quality, the location of the mine relative to applications of further processing and use, the costs of logistics, the legislation, as well as research and innovation. Extractive waste have normally been regarded as extra material, but the mindset is about to change.

– This change in attitudes results from greater environmental awareness, feedback obtained from the general public and also from various national and international directives, standards and regulations. Research plays a massive part. For example, GTK has for a long time surveyed the potential of using mining extractive waste. Currently, more and more mines have a utilisation plan, says **Akseli Torppa**, geologist at GTK.

Early characterisation of waste rock pays off

Waste rock is one of the most significant mining extractive waste. It comprises rock removed from around minerals. Tens of millions of tons of waste rock are generated in Finnish mines every year. In some cases, it can be used in construction, for example. However, the mining infrastructure is the most

important application for waste rock. High-quality waste rock can also be sold as infrastructure material outside mines, but this must be separately indicated in mining permits.

Waste rock may also cause adverse impact on the environment. It may discharge hazardous, acidic and metal-containing seepage water. Even if waste rock does not cause any metal-containing seepage, waste rock piles are often sources of nitrogen emissions that cause eutrophication. Nitrogen originates from residues of explosives that are inevitably carried to waste rock piles. Nutrient emissions are particularly problematic in regions low in nutrients, where eutrophication is emphasised.

– Currently, the aim is to control the adverse impact caused by seepage water by dumping hazardous waste rock on a waterproof base, from where seepage water can be collected and forwarded for processing. It is important to characterise any waste rock resulting from mining operations as early as possible before any mining is started by using drill core samples taken in the mineral exploration phase. In this way, the structure of waste areas, water treatment solutions and the use of waste rock can be planned better, says T**eemu Karlsson**, geologist at GTK.

Closing a mine on the environment's terms

In the end, mines are simply temporary work environments. Once all the minerals required have been recovered, it is time to stop mining and close the mine. When closing a mine, it is important to ensure that the extractive waste facilities are closed properly and the mining area is remediated to the original state. This ensures that the environmental impact of the mine is as low as possible, and there can be no unnecessary adverse impact.

Closing a mine is a complicated process consisting of many stages. To facilitate this process, GTK has continuously developed tools and methods for sustainable mine closure by creating a mine closure handbook and a digital mine closure technologies resource. Currently GTK is leading an EIT RM funded project in which an advanced digital planning and management tool for continuous mine closure is developed together with domestic and European partners (www.closurematic.com). ■

Pöyry invests in the comprehensive management of mining waste

Pöyry operates in all fields of mining waste management. Pöyry specialises, for example, in defining the properties of seepage water, identifying storage requirements, designing waste area structures, surveying the building capacity of the ground and planning the closure of mining waste areas. The results of all work stages and reasons for each solution used are always entered in a mining waste management plan.

– The storage of mining waste has a significant impact on land use, which is why social and financial impacts on local communities need to be identified. The management of mining waste is part of the financial optimisation of projects. The disposal of financially valuable elements and usable materials that can be separated should be prevented. The circular economy has for long been part of mining waste management, and mining waste will be used in more diverse ways in the near future, says **Päivi Picken**, senior environmental consultant at Pöyry.

Picken points out that Finland has significant expertise in mining waste management, even though the field can be fragmented at times. Interaction between technical design, financial estimates and environmental surveys should be developed. Pöyry also aims to spread globally recognised and accepted operating methods, as they communicate sustainable operations and help to obtain financial support. ■

"The tool is ideal in the first stage of mineral exploration. It helps in discovering new interesting locations that companies can explore in greater detail.

An online tool for evaluating regional mineral potential

The Mineral Prospectivity Modeller (MPM) Online Tool developed by the Geological Survey of Finland (GTK) helps companies to evaluate the mineral potential in different parts of Finland.

Text: Timo Hämäläinen

– Mineral exploration companies can use the MPM Online Tool to identify where they should start looking for specific minerals, says **Maarit Middleton**, senior scientist at GTK. The MPM Online Tool is freely available online at http://gtkdata.gtk.fi/mpm/. It runs on the most common browsers. No additional software is needed to use the tool. According to Middleton, no freely available service of this type has ever been published anywhere else.

Fuzzy logic

The MPM Online Tool uses the geographic information system (GIS), geophysical, geochemical and bedrock data produced by GTK and derivatives of these spatial datasets. The modelling of the mineral potential is based on a 1:200,000 bedrock map and raster layers based on it. The map is supplemented by glacial till geochemistry, magnetic, electromagnet and radiometric data. All datasets are available in GTK's map services.

– The tool combines these different datasets into a mineral prospectivity map using fuzzy logic. All data sets are scaled from zero to one, from non-prospective to prospective. The mineral potential can be defined by combining these values using fuzzy logic operators. According to Middleton, users can get the most out of the tool if they first briefly study the basics of fuzzy logic. Information is available from the MPM Online Tool site. The "Tool help" offers detailed instructions on how to use the software.

– The efficient use of the tool requires a good understanding of the mineral system in question. For junior mining companies and their exploration managers and chief geologists, this should be no problem. When exploring nickel minerals, for example, the expert needs to understand what geological, geochemical and geophysical data are relevant, Middleton says.

Development continues

The MPM Online Tool is the product of a two-year development project. The MPM research project focused on Lapland which is one of the most active mineral exploration areas in Europe.

– The tool is ideal at the first stage of mineral exploration. It helps to pinpoint new interesting locations that companies can explore in greater detail, Middleton says.

Users can verify the prospectivity models by testing them with existing mineral deposits. Currently, this type of verification is possible if the mineralization type in question is an orogenic gold, a magmatic nickel-copper, a PGE containing metals of the platinum group or a mineralization of the IOCG type.

– At the moment, assesment of the model performance is only possible for these predefined mineral types. However, prospectivity models can be created for many other deposit types. We are hoping to receive feedback from users on what spatial dataset and mineralization types should be added to the MPM Online Tool. In this way, we can best maintain the tool and develop it to be even better and more comprehensive, says Middleton encouragingly. The total budget of the MPM project was EUR 508,000. Business Finland and the European Regional Development Fund funded 90 per cent of the budget, while internationally operating mineral exploration organisations covered the remaining 10 per cent. Nine researchers from GTK took part in the project. ■

Leverage from the EU 2014–2020
European Union
European Regional Development Fund

Finland aims to be the leading country in battery production

A new company called Finnish Minerals Group is speeding up the development of the battery business in Finland. The goal is to create a battery cluster that covers the entire value chain.

Text: Timo Hämäläinen

– Finland has excellent opportunities to build the leading ecosystem for battery production in Europe, CEO **Matti Hietanen** says.

Finnish Minerals Group was founded in May 2018, when the Finnish Government reorganised its holdings of mining operations and centralised its mining investments in a new holding and development company.

The company is the main shareholder of Terrafame Oy, which is continuing the mining operations of the bankrupted Talvivaara Sotkamo Oy. The company went bankrupt due to problems related to watercourses and the environment, among others.

– In only a couple of years, Terrafame has resolved the previous environmental problems and increased its production volumes as planned. Its profitability has improved, and its last year's operating margin showed a profit, Hietanen says.

Terrafame has obtained EUR 350 million of funding for mining operations and investments from private investors. Currently, the company is making preparations for building a battery chemical plant, an investment of some EUR 200 million.

– The design process for the chemical plant has proceeded on schedule, and the EIA procedure is underway. Project preparations have taken roughly 18 months, and production is expected to start in two years, Hietanen says.

The battery chemical plant will process the currently produced nickel and cobalt minerals into battery chemicals. The planned production capacity is high, even on an international scale: 170,000 tons of nickel sulphate and 7,500 tons of cobalt sulphate per year.

New projects in progress

The development of the battery cluster is one of the main tasks of Finnish Minerals Group. Terrafame's battery chemical plant project fits the company's goals perfectly.

– We are an active owner and developer of selected companies. Our goal is to increase the processing rate of battery minerals in Finland and channel more capital into the industry, Hietanen says.

The company obtained a capital of EUR 46 million from the Finnish Government for developing the mining and battery industry. In its investment activities, Finnish Minerals Group works together with private investors who believe in the opportunities offered by the industry in this digitalising world.

In addition to Terrafame, Finnish Minerals Group is the shareholder of Keliber Oy, Ferrovan Oy and Sotkamo Silver Oy.

Keliber aims to start the production of lithium carbonate in the Ostrobothnia region during the next few years. In summer 2018, the company published its final profitability report, according to which the lithium project is clearly profitable.

Ferrovan is planning to open a plant in Raahe to manufacture vanadium from waste metal produced at steel mills.

Vanadium is used as a blend component in high-strength steels and as a catalyst in the chemical industry. New energy solutions help to increase demand, as vanadium is used as an element in redox flow batteries. Batteries store electricity in grids where energy is produced using wind or solar power.

– Ferrovan's project is an excellent example of the principles of the bioeconomy, Hietanen says.

The entire value chain under control

Finland is in an excellent position to become a significant producer of battery minerals and chemicals in Europe.

– Finland is the largest producer of nickel and, when the Keliber mine starts its production, the only producer of lithium in the EU. We are also the only EU state with cobalt production. What is more, Finland has potential manganese and graphite deposits.

In the value chain of battery making, the manufacture of battery chemicals follows the production of raw materials. Of all the companies operating in Finland, Norilsk Nickel Harjavalta makes nickel sulphate and Freeport Cobalt Oy produces cobalt sulphate and other cobalt compounds used in batteries. Keliber aims to produce lithium carbonate and hydroxide.

Batteries are assembled by a number of companies, Valmet Automotive being the largest with its car assembly plant in Uusikaupunki.

– Nearly the entire value chain, from the production of raw materials to their use and recycling, is represented. However, we do not have the middle stage involving cathodes and their pre-cursor materials or cell manufacturing. However, several development projects are

Terrafame produces metals that are used, for example, for stainless steel and electric vehicle batteries.

underway to fill this gap, says Hietanen.

The strong and versatile cluster allows companies to be based close to raw material producers and to set up efficient supply chains.

– The fairly low price of energy supports the production of battery minerals and chemicals. We also have the competence and people we need.

According to Hietanen, the industry inevitably also needs foreign investors and businesses with the right experience and expertise in order to develop.

– The market is growing fast. Annual sales of electric cars in Europe are estimated to reach five million in 2030. The currently planned production volume of battery capacity is not even close to meeting the demand.

Booming demand for batteries is a challenge

Finnish Minerals Group is an active member of the EU Battery Alliance, which is preparing a strategic action plan for improving battery markets in Europe.

– A key goal of the EU Battery Alliance is to help the Commission to set up proper financial instruments to support companies to invest in production plants and to develop their operations.

According to Hietanen, Finnish Minerals Group can participate in profitable battery mineral projects in Finland as a partner and partial financier. However, the company does not seek to become the main financier in projects.

In addition to Finnish Minerals Group, the Finnish battery cluster, the opportunities of companies and expertise in the field are being developed at universities and research institutions, such as the Geological Survey of Finland (GTK) and VTT Technical Research Centre of Finland. Business Finland creates new growth by helping companies to expand internationally and by supporting and funding innovation.

– I'm certain that Finland has a lot to give to develop battery operations in Europe. To maintain the competitiveness of the European automotive industry, we need to have a functional battery cluster that is able to respond to the growing demand for batteries, Hietanen says. ■

"The currently planned production volume of battery minerals is not even close to meeting the demand.

Photo: Mike Birdy, Pexels

International groundwater project shares Finnish expertise in Vietnam

GTK's participation in groundwater research projects in developing countries brings advantages on many levels. Included are the promotion of sustainable water management practices and capacity building in the target country.

Text: Heidi Taustila

Currently running is Viet MAR (Managed aquifer recharge to ensure sustainable groundwater availability and quality under ongoing climate change and fast economic development in Vietnam), a 3-year project, which started in March 2018.

– The Viet MAR project is being conducted under the Institutional Cooperation Instrument (ICI) of the Ministry for Foreign Affairs of Finland. The participants of the project include GTK, the Sub-Institute of HydroMeteorology and Climate Change (SIHYMECC), and the Center for Water Resources Warning and Forecast (CEWAFO), tells Project Manager **Jaana Jarva**, Senior Scientist in Environmental Geology Unit at GTK.

High-level, interdisciplinary research will help in surviving future problems

The coastal districts of the Binh Dinh province in the South Central Coast region of Vietnam are low-lying areas. They suffer from water shortage problems, which are increasing due to climate change impacts and socio-economic development. According to Jarva, the geological and hydrogeological conditions of the coastal areas are suitable for MAR (Managed Aquifer Recharge). In addition, groundwater is the main water resource for livelihoods in the coastal cities of the Binh Dinh province.

MAR has been widely applied around the world for decades. As it has turned out to be a feasible, environmentally friendly and cost-effective solution in enhancing sustainable water management, it has been chosen to be implemented within the Viet MAR project.

– Basically, the point is to collect clean water in the rain season, store it, and use it in the dry season. Of course, it is not as simple as it sounds, describes **Philipp Schmidt-Thomé**, Head of International Cooperation at GTK.

As Jarva points out, the main objectives of the Viet MAR project include studying current hydrological conditions and finding out the possibilities MAR could provide in the Binh Dinh province.

– Within this project, we can evaluate the different possibilities to apply MAR in Vietnamese hydrogeological and climatological conditions, and then adapt the feasible methods in other areas in Vietnam, and in other countries as well. We are indeed expecting positive results, says Schmidt-Thomé.

– Furthermore, the project aims to improve the local capabilities to implement a full-scale MAR, as well as improve communication and raise awareness of sustainable water management in Vietnam, elaborates Jarva.

Cooperation enables a vast range of expert services

Projects such as Viet MAR present an excellent possibility for GTK to both develop and share its know-how.

– At present, GTK works in cooperation within a consortium or pool of partners. In this way we can offer a vaster range of expert services as well as gain benefit from the Finnish know-how on a larger scale that would not be possible if we worked independently, says **Jussi Ahonen**, Head of the Groundwater Unit at GTK.

However, due to years of successful work in mining and mineral sectors, GTK has become a household name around the world. Ahonen finds the good reputation useful in furthering new groundwater projects.

– Finland's water sector share in the international commercial market is quite narrow, although Finland has for decades actively worked in the water sector through development projects. In order to be able to participate in the future procurement of, for example, World Bank Group financed projects and programmes, we are in the process of obtaining a fair number of upgraded international references, explains Ahonen.

– GTK is proud to represent Finnish expertise and trustworthiness abroad. At the same time, we intend to support small and medium-sized Finnish companies to expand their international business, summarises Schmidt-Thomé. ■

What is Managed Aquifer Recharge (MAR)

- Represents a viable method for sustainable water management
- Applies intentional and controlled infiltration of surface water or harvested rainwater into aquifers
- The purpose is to increase water quantity and /or to improve water quality of an aquifer
- Other environmental applications besides enhancing water supply exist, e.g. flood impact mitigation, saline intrusion control, and managing land subsidence
- MAR has also proven to be a feasible option to enhance sustainable water management in changing climate conditions and in extreme weather events globally

River water may interact with the aquifer and have an influence on groundwater quality. Research professor Daniele Pedretti (GTK) and groundwater expert Hoang Van Duy (CEWAFO) are taking field measurements by the Con river. Photo: Jaana Jarva, GTK

The groundwater level level and its seasonal changes are fundamental knowledge in MAR feasibility studies. Geologist Kristiina Nuottimäki (GTK) conducts groundwater level measurements at the Tan Anh well field with CEWAFO groundwater experts Dang Tran Trung and Hoang Van Duy. Photo: Jaana Jarva, GTK

Viet MAR 2018–2021

- MAR is applied to ensure sustainable groundwater availability and quality under ongoing climate change and fast economic development in Vietnam
- Location of case study: Quy Nhon in the Binh Dinh province in South Central Coast region of Vietnam
- Main objectives: to gain a thorough understanding of the geological and hydrogeological features of the case study aquifer in different climatic conditions; to determine the different requirements and potentials of MAR; to improve the capability to implement MAR; and to improve communication and raise awareness of sustainable water management
- Participants: GTK, SIHYMECC (Sub-Institute of HydroMeteorology and Climate Change), CEWAFO (Center for Water Resources Warning and Forecast), and associated partner companies, i.a. Turku Region Water Ltd.
- GTK´s key contacts: Project Manager Jaana Jarva, Kristiina Nuottimäki, Daniele Pedretti, Nina Hendriksson, Samrit Luoma

The MinSysFin project:

Mineral system models for supporting mineral exploration in Finland

A service related to mineral systems in Finland will be available via GTK's website in 2019.

Text: Ferenc Molnár

The formation and preservation of mineral deposits are the result of complex interplay between various geological processes acting on different scales. Mineral system models summarize our views on these processes and highlight the importance of those time-dependent geological settings that favour the deposition, modification and preservation of certain types of ores. In Finland, application of the concept of mineral systems to exploration started a little over ten years ago.

The Academy of Finland's MISU programme, launched in 2014, gave a big push to this research. As a result, GTK, together with the University of Oulu, received support for studying the mineral systems of magmatic sulphides and orogenic gold in Finland. This gave birth to the Mineral Systems and Mineral Prospectivity in Finnish Lapland (MinSysPro) project in cooperation with universities and research institutions of several other countries, as well as mining companies operating in Finland.

The development of a mineral system model starts with understanding of the geological evolution in the area being studied. Next, the aim is to define and identify those factors that reveal something about the origin of the mineral deposit, the passage of metals from their sources to those locations where they occur in economically significant concentrations, and the relative and absolute timing of processes creating favourable conditions for ore formation, as well as to recognise footprints of those processes in the rocks that associate with the formation or modification of deposits. Even if a large and comprehensive database is available, a specific piece of data significant for research may be missing. In these situations, researchers turn to known mineral belts and their individual deposits and study the area's geological evolution from regional-scale to micron-scale levels.

The analysis of minerals and rocks has taken great leaps forward during the past 10–15 years, so that universities and research institutions have access to modern equipment. Detailed research can also be conducted in GTK's laboratory centre, which also hosts the Finnish Geosciences Research Laboratory. In these laboratories, even new applications of analytical procedures can be developed.

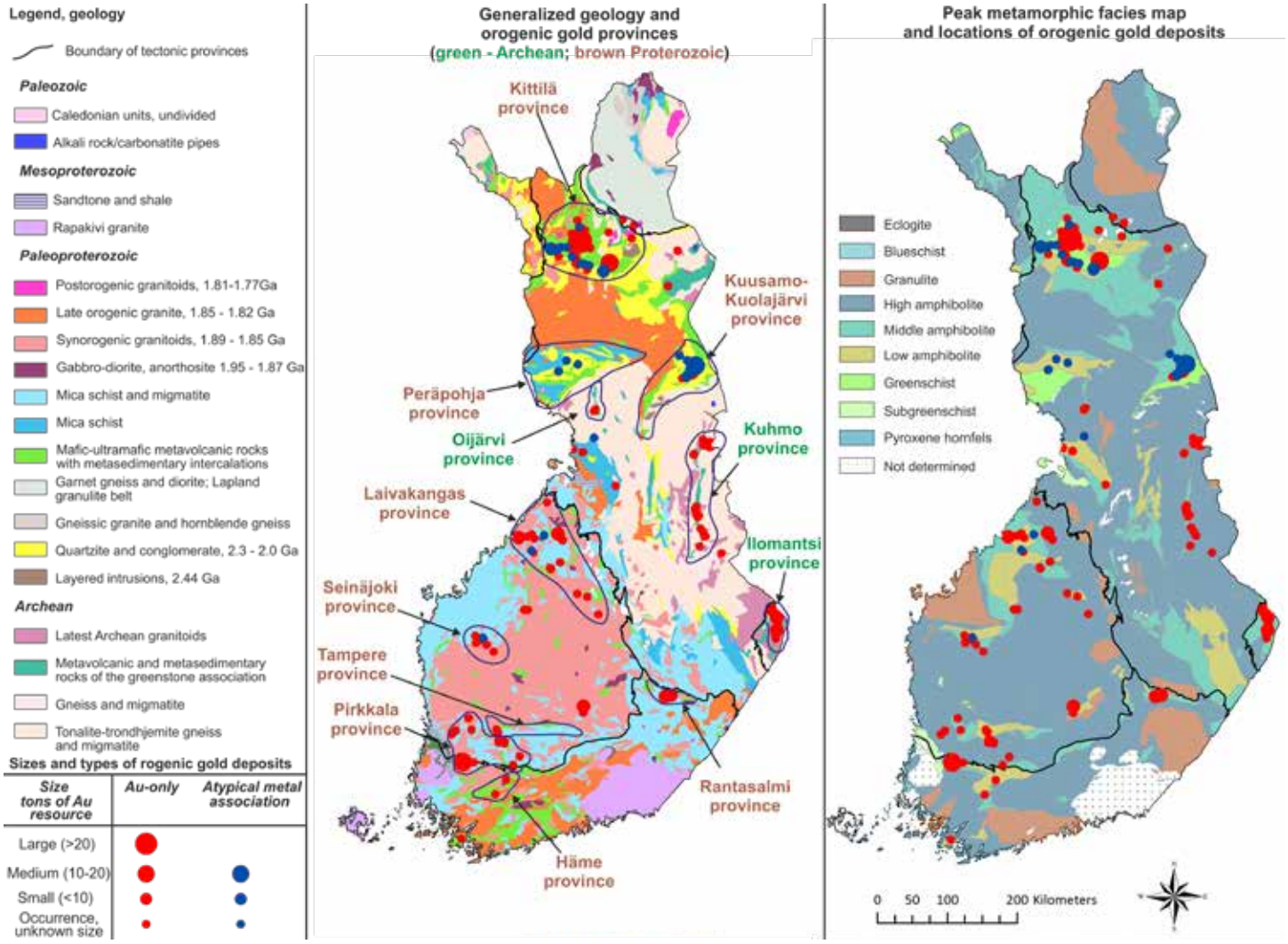
Mineral system models save time and money

Currently, GTK is working on the development of a WEB service summarizing knowledge of major parameters in various types of mineral systems. The aim is to provide organised databases and links to other databases, as well as access to on-line services and experts in specific fields in order to support companies to select targets in an early stage of exploration in Finland.

The modules of the WEB service under development will introduce the crustal architecture and geological structures controlling the formation of mineral belts and deposits in Finland, the timing of ore-forming events during the geological evolution of major mineral belts, the primary and secondary footprints of ore-forming processes, mineral potential assessment and prospectivity maps and available services supporting further detailed mineral system analysis.

Among the economically important mineral resources, the orogenic gold mineral systems in Finland will be presented at first, and the WEB service for magmatic Ni-Cu-Co-Pge and other mineral systems will be developed during the forthcoming years.

The development and use of mineral system models requires diverse expertise and a broad cooperation network among experts. Using these models, we can better delineate areas where valuable minerals can probably be discovered. This saves time in setting up exploration projects, and thus also saves money. One of the biggest achievements of our research in orogenic gold systems was the development of a prospectivity map that indicates areas with a high probability for occurrences of undiscovered gold deposits in Lapland. ■



Results from the Rompas-Rajapalot project

Text: Sami Lehtinen

Mawson Resources has worked with GTK for more than six years. This cooperation has focused on understanding the origin of mineralisation and surveying the mineral distribution in the ground. The main goal of mineral research is to discover mineral deposits and plan as cost-efficient and comprehensive a mining strategy as possible.

– Research conducted in cooperation is useful, as it enables the exchange of expertise and knowledge, as well as advanced and varied research methods. In our Rompas-Rajapalot project, we have already discovered significant mineralisation. Now, our task is to determine the quantity of minerals in the ground and how they can be extracted as cost-efficiently as possible, says **Nick Cook**, President of Mawson Resources.

Mawson Resources considers the partnership with GTK to be both inspiring and educational. Joint projects produce volumes of new information for the field of geology and also for Finland. ■

Leverage from the EU 2014–2020
European Union
European Regional Development Fund

Biochar offers new opportunities for the remediation of mining environments

Mining operations always cause changes in the environment. The magnitude and quality of these changes depend, for example, on the type of ore, the processing technique, the amount of mining waste and the location of the mine site.

Text: Kristina Karvonen

In addition to reducing impacts during active mining operations, Finnish legislation defines that mine closure and remediation should already be addressed when mine planning and permitting processes start.

The correct closure and remediation of mining waste facilities are integral parts of environmental impact management.

The most significant and the most long-term environmental impact of mining operations is associated with the disposal of mining waste, sulphide-bearing tailings and waste rock, in particular, and the resulting metal leaching and acid rock drainage.

Interaction between sulphide minerals, oxygen and water, together with bacterial activity, causes the weathering of rock material and the oxidation of sulphides, resulting the acidification of seepage waters.

In addition to acid mine drainage, dust generated from the topsoil of the waste area can cause environmental loads in surrounding areas due to the lack of cover material or an insufficient cover solution.

The use of glacial till is the most common solution to cover mine waste facilities in Finland.

Its efficiency is affected, above all, by its thickness and water conductivity.

Vegetation also has an impact on the water status of till cover through evaporation and water movements in tree root systems.

High-quality till is not always available, and transportation costs can be high.

– Due to the inorganic composition of till and its poor water-containing capacity, its properties as a sealing layer and also its greening potential in landscaping do not always meet the required criteria when considering optional cover solutions for waste rock piles and tailings impoundments. Modern landscaping calls for solutions that also contribute to greening. There is demand for new cover solutions, and related research is being conducted to an increasing extent, says geologist **Raija Pietilä**.

Biochar and its diverse uses

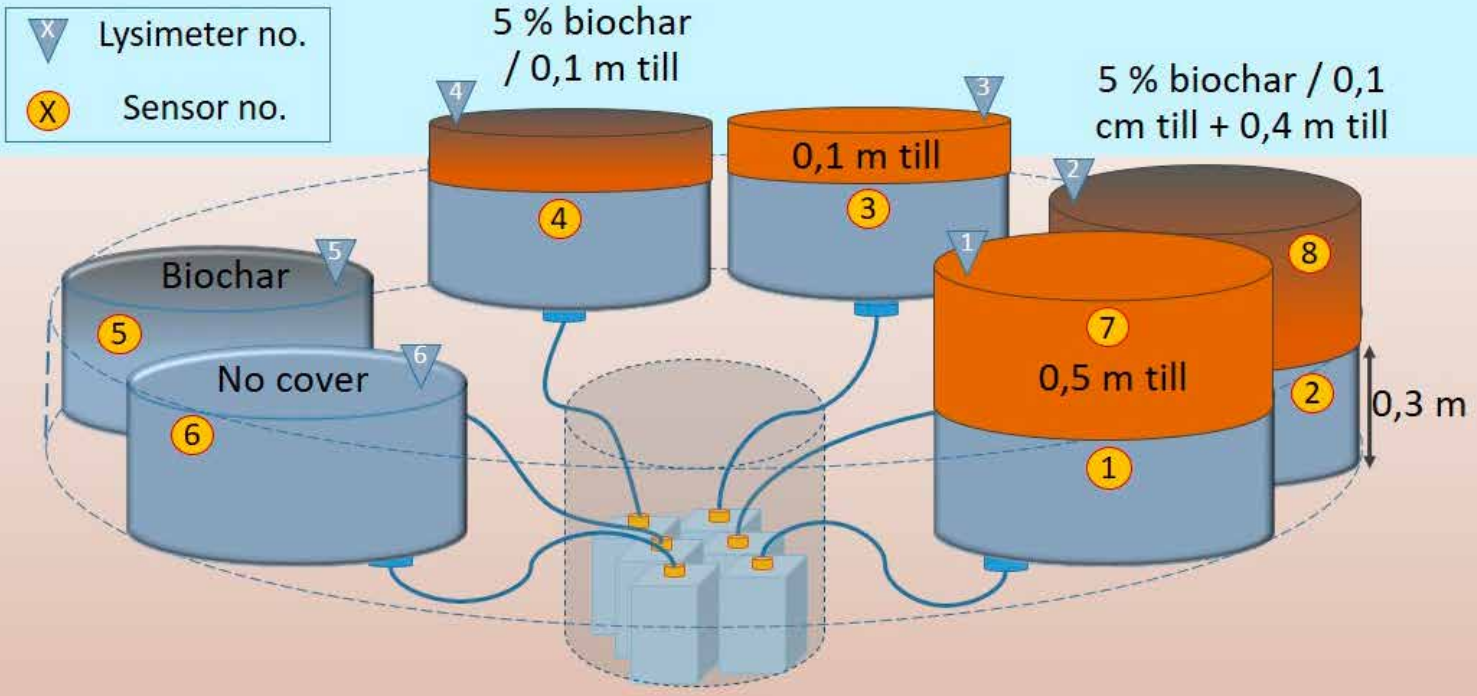
Biochar is charcoal produced from biomass via pyrolysis. It effectively binds water and nutrients, and withstands drought.

As biochar also helps to regulate the volume of carbon dioxide in the atmosphere, it is regarded as one solution in climate change mitigation.

When used as a raw material in soil improvement, its effectiveness is based on its ability to improve water retention, the binding of hazardous substances and the recycling of nutrients. Biochar was not studied actively in Finland before the 2000s, and Nordic research on its use in mining environments is only taking its first steps.

– The use of biochar as a cover material offers new opportunities for the treatment of mining environments, Pietilä says.

The use of low-sulphur tailings improved using biochar in cover solutions can reduce the volume of cover material transported from other locations, as well as the environmental impact. Biochar can also improve the properties of till. This in turn decreases the thickness of the cover layer and the need for any virginal soil. The use of composted material produced from other industrial by-products and municipal waste in the production of biochar contributes to the growth of a sustainable circular economy.



The field study of Rautuvaara tailings consists of six lysimeters which all have different cover solutions.

The Biopeitto project, coordinated by the Geological Survey of Finland (GTK), is seeking new solutions for mineral waste cover structures and landscaping in northern climate conditions, considering the needs of the mining industry and environmental aspects.

– The aim is to improve the long-term sustainability, stability and greening of dry cover and to reduce erosion. Another purpose is to improve the water management of the cover and its carbon and nutrient balance, project leader Pietilä says.

The project consists of several parts, such as the planning of test structures and greening solutions, the production of biochar, the testing of materials, the laboratory, greenhouse and in-situ testing of cover structures and landscaping solutions.

Funded by the European Regional Development Fund (ERDF), the three-year Biopeitto project started in summer 2017. In addition to GTK, its partners include the Natural Resources Institute Finland (Luke) and the Oulu Mining School at the University of Oulu. It is also funded by Hannukainen Mining Oy and Agnico Eagle Finland Oy, while Noireco Oy acts as the biochar producer. Raw material for the pyrolysis process has been obtained from Levin vesihuolto Oy, Suomen hyötymurskaus Oy and Stora Enso Veitsiluoto Mill. Rautaruukki Oyj has enabled field research in the Rautuvaara tailings area. Rautaruukki also delivers the till used in the test field from a nearby area.

Of the three work packages of the Biopeitto project, GTK is responsible for project management and biochar testing in cover structures of mine waste, while Luke is in charge of the production of biochar and its use together with paper mill sludge in landscaping

Biochar tested in cover structures of mine waste areas

– The goal of GTK's work package is to test biochar-based cover solutions that support the circular economy for mine waste facilities by studying the suitability of biochar in cover structures using laboratory and field tests, says research scientist **Anna Tornivaara**, who leads GTK's work package.

Test results will be presented during and after the project in various publications and in the Wiki-based open access database focused on mine closure technologies. This database is maintained by GTK. During testing, the ability of biochar to bind hazardous elements and to improve the technical properties of cover material, such as the water retention capacity, will be studied and optimal mixing ratios between different cover materials will be assessed.

Biochar has been selected for the test mixtures on the basis of usability and availability, considering the secondary raw materials of mining processes or other industrial fields. Cooperation with companies is hoped to lead to the innovative development of regional business activities.

The project is making use use of research data on the most potential cover structures, cover materials and mixing ratios.

–We have placed special focus on the practical feasibility of cover structures, such as the availability and cost-efficiency of different materials, Tornivaara says.

To support this research, a survey related to the use of biomaterial in cover solutions has been sent to mining companies, the authorities and other parties operating in the sector in Finland and Sweden. This will help to place focus on any problems and optional solutions associated with the reme-

The greening of waste areas is being studied in the Rautuvaara tailings area under natural conditions by using different cover solutions, seed mixtures and plants.

diation planning, implementation and costs of mine waste management.

– Leaching studies are being conducted as long-term column tests in GTK's laboratory, Tornivaara says. The test consists of ten columns 40 cm in height and 10 cm in diameter. The columns contain till, tailings from Rautuvaara and pyrolysed bio-based materials at different mixing ratios. Water is pumped into the columns at a low speed. The chemistry of seeped water is analysed and water parameters (pH, EC, redox) are measured. In this way, any differences in mixing ratios and their impact on the quality of drainage can be assessed and optimal mixing ratios for suitable cover solutions can be identified.

– The project is being piloted in the Rautuvaara tailings area in Kolari, where we are studying the functionality of a till cover improved with biochar. On-site studies on long-term behaviour are being conducted by using field lysimeter tests, Tornivaara continues.

Five lysimeters of 30 cm in height and 1 m in diameter filled with tailings have been covered with different materials or material mixtures of different thicknesses. The sixth lysimeter will remain uncovered. The materials used in the cover structure tests have been characterised to identify their chemistry and mineralogy. Characterisation helps to identify the acid generation potential and hazardous substance content of specific materials and to assess their solubility. Electric conductivity, temperature, moisture and oxygen sensors have been installed in the cover solutions. Results are being saved to the data-logger established in the test area. Water samples seeped through the cover layers and lysimeters will be collected in separate containers, and the water samples will be measured and analysed at regular intervals.

New solutions for landscaping

The landscaping of tailings areas and waste rock piles is challenging. Mine waste facilities are susceptible to erosion resulting from surface runoff, and building a growth layer to protect the pile requires proper planning. Often, the minimum requirement for the growth layer is its water retention, as moisture is poorly retained by rock material. The high saline content of rock material reduces water activity down to a level where only rare plants are able to use it. In addition, the waste material of extractives may contain high concentrations of metals that are toxic to plants and imitate nutrients.

–From the points of view of plants and greening, a sealing layer that contains organic matter and water-retaining material is needed on top of rock material, Pietilä says.

In mine waste areas, biochar added to the cover layer retains water, which plants can then use, improving the success of the growth layer. In addition, water evaporated from plants reduces the seepage of water down into lower layers in the waste pile or tailings impoundments. Another material studied in the project is paper mill sludge, which is a by-product from the forest industry. It has been used, for example, in sealing structures at landfill sites because of its low costs and

water infiltration capacity. It also neutralises acidity.

The aim of Luke's work package is to develop a sealing and landscaping solution based on biochar and paper mill sludge for waste rock piles. The solution needs to be suitable for the demanding conditions of northern regions. The goal is to improve biochar production skills in the region and help northern companies to develop or start business activities in the sector. Using greenhouse tests, the aim is to identify the most promising layers and mixtures of cover materials for landscaping research. Pot tests conducted in greenhouse conditions will serve to identify the impact of till and biochar on the growth of different types of plants. The success of plants and, in particular, the development and physiological state of roots, will be monitored, while their nutrient state and that of the growing material will be studied by means of laboratory analyses.

The landscaping and greening of the cover layer will be tested in a pilot project, for which information on the properties of the materials has been collected using preliminary tests in the greenhouse. The greening pilot has also been established in the Rautuvaara tailings pond. Using the information obtained, the water and nutrient status of the sealing layer will be modelled (3D) and the model will be compared to the success of plants. These models will then be calibrated and validated using column tests.

– The goal of the landscaping package is to build a solution that combines the efficient separation of waste material, greening and effective landscape design, Tornivaara says.

– The starting point of the project is that the combination of biochar and paper mill sludge is a functional cover solution from the environmental point of view when closing mine waste areas, says Pietilä.

The water-retaining layer reduces the contact of seepage water with waste material, and it can be used by plants. Here, paper mill sludge, biochar and the vegetation layer play a key part.

In addition to improving water quality in the catchment areas and reclamation, the aim is to better blend mine waste areas in the surrounding landscape and to improve the carbon balance of these areas. Innovative technologies will produce a carbon-neutral solution that may have significant impacts on the regional economy and the environment.

– The production of biochar and the use of paper mill sludge are also solutions of the circular economy that can reduce the volume of wastes, Pietilä says in conclusion. ■

The tailings material in the lysimeters was installed at the same level as the tailings surface in Rautuvaara in spring 2018.

AgriAs project develops purification methods for European agricultural soils with elevated arsenic concentrations

The AgriAs project project is summarizing national and European databases and developing recommendations and guidelines for the sustainable management of As risks in agricultural areas. Arsenic removal technologies will be developed and demonstrated. Biological tools will be applied to manage ecological, environmental and human risks.

Research institutes, universities and companies from five European Union countries are participating in the project which is financed under the ERA-NET Cofund WaterWorks 2015 and coordinated by GTK. The French study site is a historical area of destruction of World War I chemical ammunition located in a sensitive zone both for agriculture and groundwater. The German site is characterized by 800 years of mining and ore processing.

In the stakeholder workshops of AgriAs, the interaction and discussions between farmers, authorities and researchers have been active. Recommendations will be compiled in close cooperation with authorities and stakeholders. The two study sites, Verdun in France and Freiberg in Germany, exhibit As contamination in agricultural soils. Over 1 billion shells and projectiles were fired in Europe during World War I. After the war, over 3 Mt of abandoned and unexploded ammunition had to be destroyed in northeast France for safety reasons. At many destruction sites, topsoil contamination is still severe.

After 800 years of mining in the Ore Mountain region in Saxony (Germany), 288 km² of agricultural soils show values exceeding the German action value of 50 mg/kg As. The centre of historical mining in Freiberg mainly shows concentrations above 320 mg/kg. Alluvial soil in the floodplains along rivers in this region has As concentrations from 80 to 320 mg/kg due to drainage water from mining tunnels and discharged process water and sediments from ore processing. Recommendations have been given by the German authorities for the treatment of As-rich soils for agriculture and gardening.

Agricultural topsoils contain more arsenic on average in central and southern Europe than in northern Europe. Most of the high values observed are of anthropogenic origin, but the natural geochemical background plays a role in ore districts. Contamination from mining activities, ammunition, wood preservatives, insecticides and herbicides has increased arsenic concentrations in the European environment. ■

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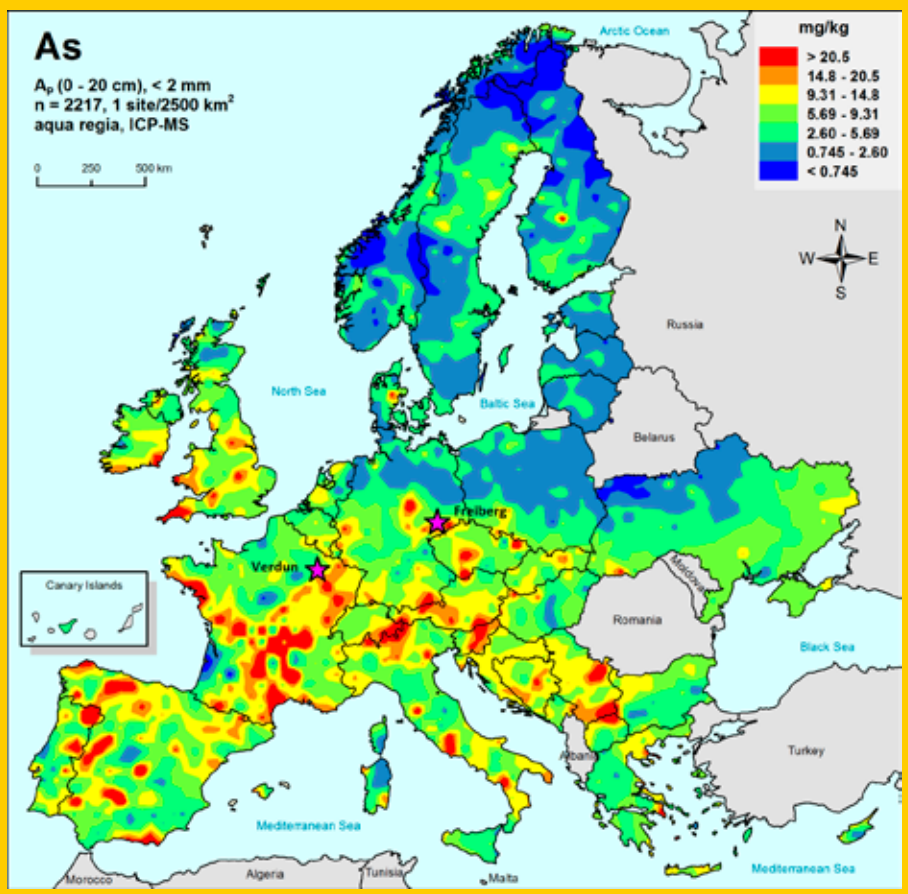


Arsenic concentrations in agricultural soils (0–20 cm).
Source: GEMAS data [1] modified at the Geological Survey of Finland, aqua regia extraction of the <2 mm size fraction.
Verdun and Freiberg are the study sites of the current AgriAs project.
Arsenic concentrations in soil are higher on average in central and southern Europe compared to northern Europe.

[1] C. Reimann, M. Birke, A. Demetriades, P. Filzmoser, P. O'Connor, "GEMAS Data Set. Geochemistry of Europe's Agricultural Soils." Part B., Geologisches Jahrbuch Reihe B 103, 2014.

Survey results are important, also when assessing Finland's carbon reserves and any changes in them

The surveys of peat reserves will focus on areas where the surveys conducted best supplement GTK's data on mires and peatlands and serve the data needs of society and businesses.

Annually, approximately 20,000 hectares of mires and peatlands are surveyed in the whole of Finland. The aim is to identify the type and thickness of peat layers at intervals of roughly 125 metres over a level network of survey points. These survey points are positioned using GPS. Peat layers are drilled using lightweight manual drill equipment until the hard mineral layer is reached. In addition, the mire type based on vegetation, the drainage situation and the type and number of trees are defined at each survey point. Animal and plant species with a particular nature or protection value, as well as key isotopes, are identified and attached to the survey material. The surveyed mires are classified in accordance with the natural state classification of the national mire strategy.

After basic surveying, sample sets are taken from mires that are potentially suitable for peat production and best supplement the regional geochemical material, extending from the surface to the bottom, for laboratory examinations. These samples help to determine the water, ash, sulphur, nitrogen and carbon content, the amount of dry matter and the thermal value, together with a wide array of element analyses at the most representative sites. The analysed data represent the regional geochemistry and background concentrations of mires and offer opportunities, for example, to determine the energy content of carbon reserves and identify any regional heavy metal anomalies.

When all survey results are available, a significant part of this data set will be updated in GTK's online peat reserve service (www.gtk.fi/turvevarat). The service includes mire-specific and regional data on all the mires surveyed by GTK.

GTK's Hakku service (http://hakku.gtk.fi) lets you search for and start using a range of geological data products. It includes previously published municipality-specific peat survey reports in PDF format. So far, more than 450 reports have been published regarding different parts of Finland.

Survey results are also important when assessing Finland's carbon reserves and any changes in them. Carbon resources in Finland's peat reserves are roughly nine times larger compared to living trees, and more than two-thirds of carbon in Finland's soil is stored in peat. GTK's peat surveys play a central part when assessing the future development and opportunities of the bioeconomy, carbon accumulation and carbon reserves. In addition, survey results can be used in mire drainage, forest cultivation in mire areas, agricultural planning, risk assessments of acid sulphate soils and in defining the value of mires when selling, purchasing or redeeming them. GTK's peat surveys are also significant in modern land use planning, such as in regional planning processes. ■

A firm grip over geomaterials

Changes in the value chain involving the use of minerals present challenges to all parties in the field. The Geological Survey of Finland (GTK) is responding to these challenges by increasing its research on geomaterials and applied mineralogy.

Text: Timo Hämäläinen

– Minerals are everywhere around us. They are part of our everyday life. We use minerals when we do the laundry. Our windows are made of silica, many different minerals are needed to make batteries, and our roads are founded on crushed stone, **Alan Butcher** says.

Butcher started working at GTK in spring 2017 as Professor of Geomaterials & Applied Mineralogy. Through his appointment, GTK can broaden its current areas of research and expert services.

Geomaterials include minerals, rocks, sediments, soil and dust, as well as all the materials made from them, such as cement, glass, bricks and metals.

Applied mineralogy is needed to resolve any problems encountered in mineral exploration, mining and ore processing. More recently, however, you may see references to applied mineralogy in diverse fields, such as medical geology, extraterrestial geology, forensic geoscience and construction.

– GTK's expertise puts us in an excellent position to participate in various studies. At the moment, we are considering what we should do next. We cannot focus on everything; we need to make choices.

Currently, the data and expertise produced by GTK are used particularly in mineral exploration, mining, societal construction, the design of geoenergy plants, water and environmental protection, and the planning of nuclear waste disposal.

Processing piles of waste

Like Butcher, senior scientist Dr **Simon Michaux** brings international experience to the organisation. Michaux started working at GTK in spring 2018. Both have already had long careers working in other countries, for example, in Australia.

Michaux develops mineral informatics at GTK. The aim is to collect data about minerals located in Finland and consider how they could be used in the best possible way.

– In addition to deposits deep in the ground, we are interested in secondary sources, such as adjoining rocks from mines, piles of waste and industrial side streams, Michaux says.

Michaux is also leading a geometallurgical project for battery minerals at GTK, in which surveying and development focus on the value chain of the battery business, ranging from mineral exploration to the recycling of raw materials. The project is led by Aalto University and, in addition to GTK, it involves the University of Oulu and various mining companies.

– The project is funded by state-owned Business Finland, which aims to create new growth by helping companies to expand internationally and by supporting and funding innovation activities. Our clear goal is to produce concrete results, Michaux says.

Value chains in turmoil

Michaux and Butcher believe that the level of recycling will increase rapidly. They agree that developing the circular economy is one of the key drivers that improve the ability of European companies to produce battery minerals for European markets.

– However, we need to keep in mind that minerals still need to be explored and extracted from the ground. We cannot fulfil the need for industrial minerals using recycled materials, not even if we recycled all electrical and electronic equipment, Butcher says.

In any case, recycling is changing industrial value chains. The circular economy requires that products are originally designed with an eye on any reuse of components and the recycling of materials.

Michaux is talking about a revolution in mining.

– Over time, mining and the recycling of minerals will walk hand in hand. When companies prepare profitability calculations, they are increasingly considering the entire value chain, from the extraction of raw materials and the processing of minerals to recycling. Seeing the big picture may produce completely different results than placing focus on the maximised supply of main components.

– Geologists have a lot to give when analysing all the different elements contained by minerals, including penalty elements, Michaux says.

Technological development and the resulting changes in the demand for raw materials may also change what we consider to be valuable minerals and what kinds of deposits are worth exploring and processing. For example, cobalt has so far mainly been produced as a by-product of other materials. However, plans are underway to establish a mine in Finland exclusively for the production of cobalt.

According to Alan Butcher and Simon Michaux, specialists should work in closer cooperation to develop mineral production chains. Large-scale interaction would help to resolve problems related to the sufficiency of minerals and to produce innovation.

Butcher and Michaux believe that, during the next decade, completely new types of batteries will be developed, requiring completely new battery minerals.

Butcher calls for cooperation and interaction between different parties, such as geologists, mining companies, producers of mineral products, manufacturers of end products and product designers.

– Interaction between geologists and product designers would certainly be a fruitful source of innovation. If we knew what they wanted, we might be able to find the raw materials needed and produce minerals by design.

Getting ready for changes

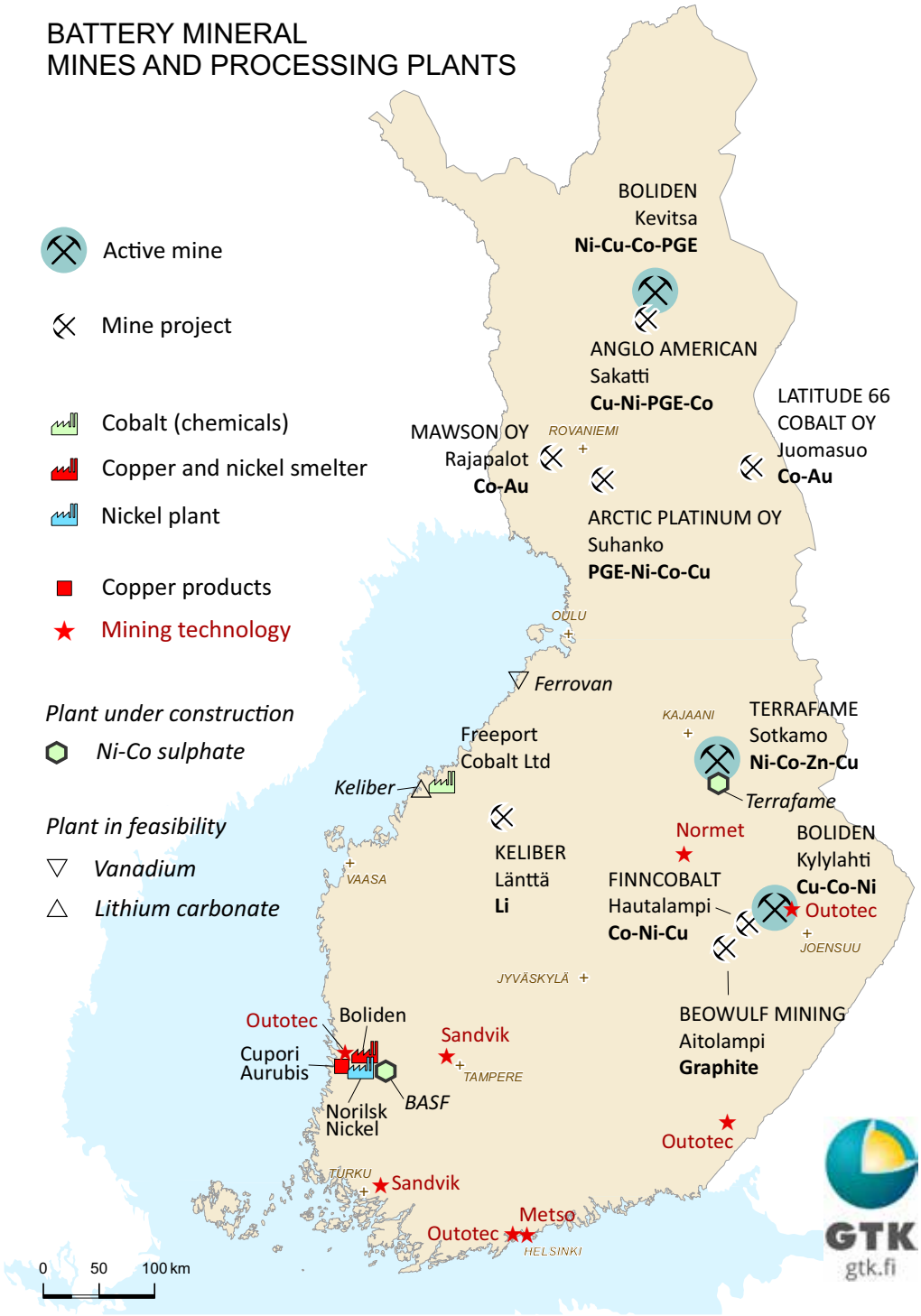
Butcher and Michaux speak highly of GTK's research resources and versatile analysis equipment.

– We can quickly characterise any type of geomaterial. A full understanding of minerals and mineral textures is a key factor when developing suitable methods for mineral processing.

Butcher is also impressed by GTK's digital geological map material, which covers the whole of Finland. The material is updated and specified constantly according to new research results and needs.

Michaux wants to point out that GTK Mintec is one of the leading mineral processing research institutions in Europe. Mintec provides its customers with all types of surveys related to mineralogy and mineral processing technologies. It studies the entire production process in realistic simulated conditions at its testing facility. A typical sample size ranges from 20 to 300 tons.

– We are expecting significant changes in business models, technologies and markets related to the use of minerals. GTK is ready for these changes. The high level of geological expertise in Finland offers excellent opportunities to build ecosystems that cover the entire value chain, Butcher and Michaux say.



New publications

Development of the Paleoproterozoic Svecofennian orogeny: new constraints from the southeastern boundary of the Central Finland Granitoid Complex.
Mikkola, Perttu; Hölttä, Pentti; Käpyaho, Asko (eds) 2018. Geological Survey of Finland, Bulletin - Bulletin de la Commission Géologique de Finlande, vol. 407

http://tupa.gtk.fi/julkaisu/bulletin/bt_407.pdf

Quantitative assessment of undiscovered resources in lithium–caesium–tantalum pegmatite-hosted deposits in Finland
Rasilainen, Kalevi; Eilu, Pasi; Ahtola, Timo; Halkoaho, Tapio; Kärkkäinen, Niilo; Kuusela, Janne; Lintinen, Panu; Törmänen, Tuomo 2018. Geological Survey of Finland, Bulletin - Bulletin de la Commission Géologique de Finlande, vol. 406

http://tupa.gtk.fi/julkaisu/bulletin/bt_406.pdf

Sm–Nd and U–Pb isotope geochemistry of the Palaeoproterozoic mafic magmatism in eastern and northern Finland
Huhma, Hannu; Hanski, Eero; Kontinen, Asko; Vuollo, Jouni; Mänttäri, Irmeli; Lahaye, Yann 2018. Geological Survey of Finland, Bulletin - Bulletin de la Commission Géologique de Finlande, vol. 405

http://tupa.gtk.fi/julkaisu/bulletin/bt_405.pdf

4th National Colloquium of Geosciences, Turku, 14–15 March 2018: Abstract Book
Skyttä, Pietari; Eklund, Olav (eds) 2018. Erikoisjulkaisut - Special Publications, vol.101

http://tupa.gtk.fi/julkaisu/erikoisjulkaisu/ej_101.pdf

Water quality prediction of mining waste facilities based on predictive models
Muniruzzaman, Muhammad; Kauppila, Päivi M.; Karlsson, Teemu 2018. GTK:n arkistoraportit.

http://tupa.gtk.fi/raportti/arkisto/16_2018.pdf ■

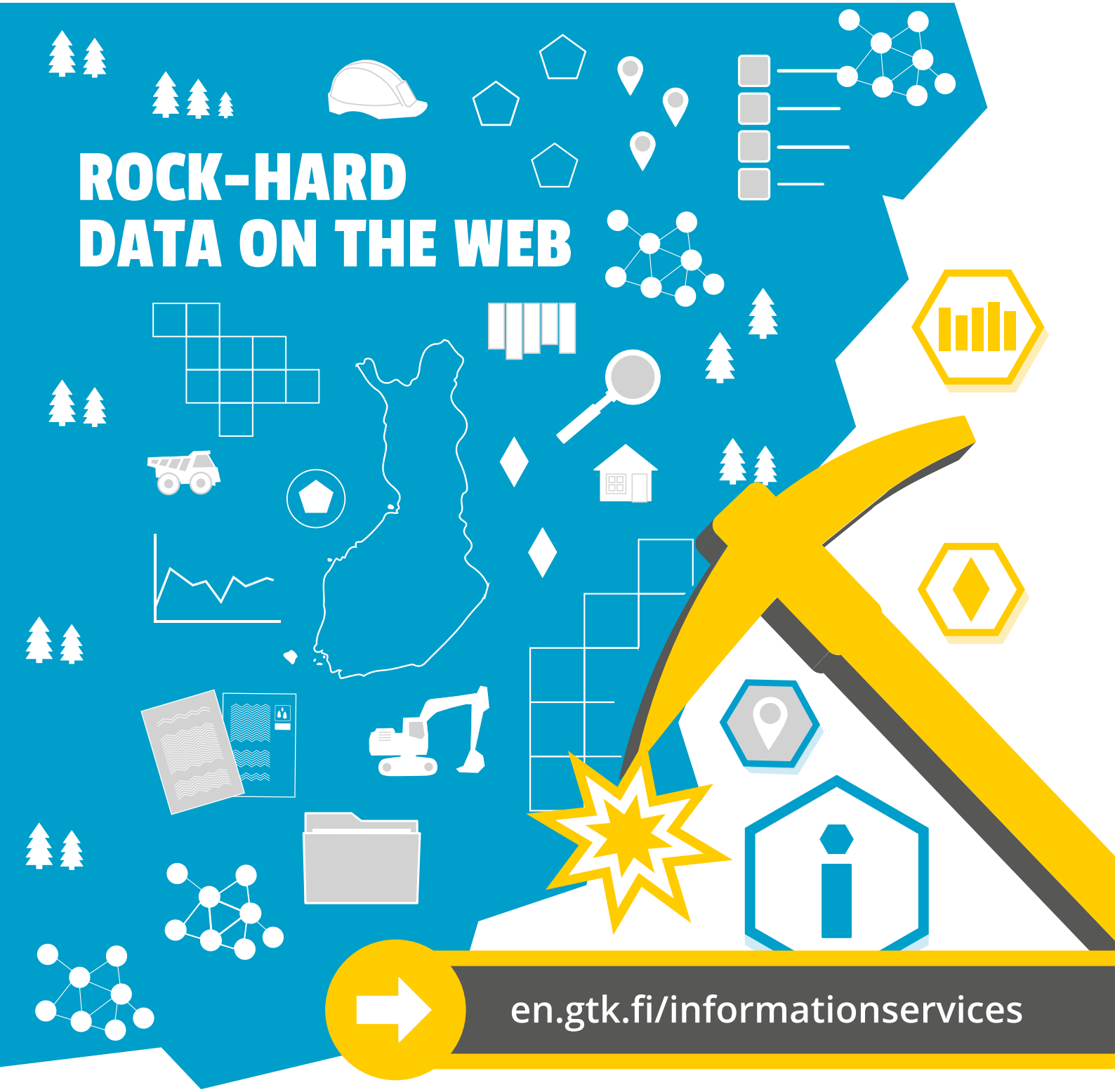
Photos: Taina Järvinen, GTK

Saku Vuori appointed Director of Science and Innovations at GTK

Saku Vuori, PhD, has been appointed as the Director of Science and Innovations at the Geological Survey of Finland (GTK). He will start in his new position on 1 January 2019.

The Director of Science and Innovations is responsible for leading the scientific and innovative activities at GTK. He will promote GTK´s high-quality research and scientific competence and enhance collaboration with domestic and international universities, research institutes and businesses. A crucial part of the work is fosteringan inspiring environment for research and innovation activities. The Director of Science and Innovations reports to the Director General and is part of the Director General's management team. The current Director of Science and Innovations, **Pekka Nurmi**, will retire in June 2019.

Vuori has been working at GTK since 2003. He has a strong background in Finland's and the EU's mineral policies and mineral exploration. Other areas of expertise are mineral industry associated sustainability assessments in addition to bedrock mapping and geochemistry. Vuori has a degree in geology and a PhD in geology. ■



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