

BOLIDEN

Metals for modern life

TOMORROW'S
MINES **ARE**
DIGITAL

The need for
metals is
increasing

How mines and
smelters work

Metals are
the key to **future**
energy storage

We produce metals for modern life

Metals are essential for the development of modern societies. Boliden's vision is to be one of the leading companies in the industry in terms of development, productivity and responsibility.

Boliden Garpenberg is one of the world's most modern mines, thanks to its use of world-class technology and equipment. Work is increasingly automated, with control rooms where process operators monitor and manage the situation on large screens.

PHOTO: TOMAS WESTERMARK

Did you know...?

It is estimated that **40 million fully electric vehicles** will be sold every year by 2040. Ninety kilograms of copper, or more, is used in a fully electric vehicle. This is three to four times more than in a vehicle with a combustion engine.


90 KG
Cu

Approximately **7-10 million tonnes of copper** are required to meet the needs of the growing solar energy sector.



The International Energy Agency (IEA) has worked out that half of the measures required to limit the scope of human impact on the climate to **below two degrees** can be achieved through energy efficiency.



BOLIDEN'S OPERATIONS ARE CHARACTERISED by concern for people, the environment and society, and we are among the best when it comes to sustainable mining and metal production. We also enjoy a leading position within metal recycling, and so play an important role in a circular economy.



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Boliden is a metals company with a commitment to sustainable development. Our roots are Nordic, but our business is global. The company's core competence is within the fields of exploration, mining, smelting and metals recycling. Boliden has a total of approximately 4,900 employees and a turnover of SEK 40 billion. Its shares is listed on NASDAQ OMX Stockholm, segment Large Cap.





FROM DISCOVERY TO MARKET

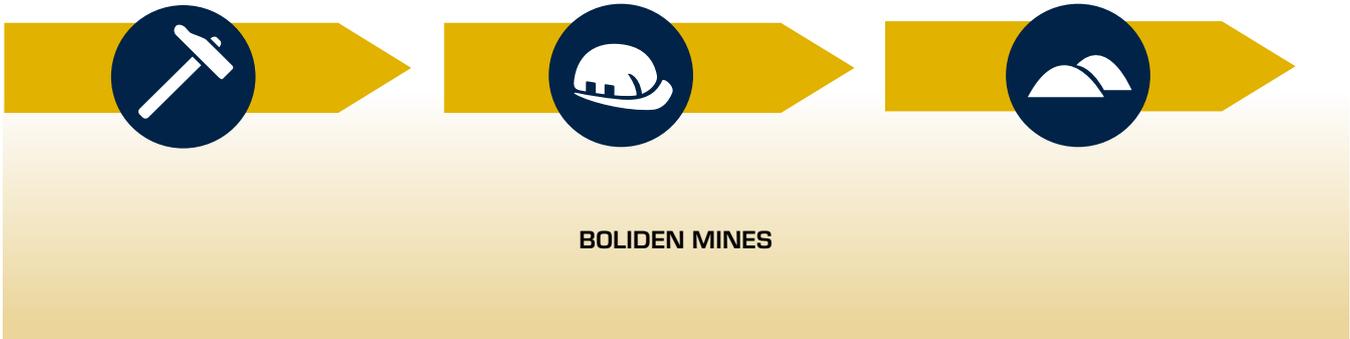


Boliden's business model and responsibility extends through all stages of the value chain for metals – from exploration to recycling. Boliden is, therefore, an important part of a circular economy.

Exploration

Mining

Concentration



Exploration

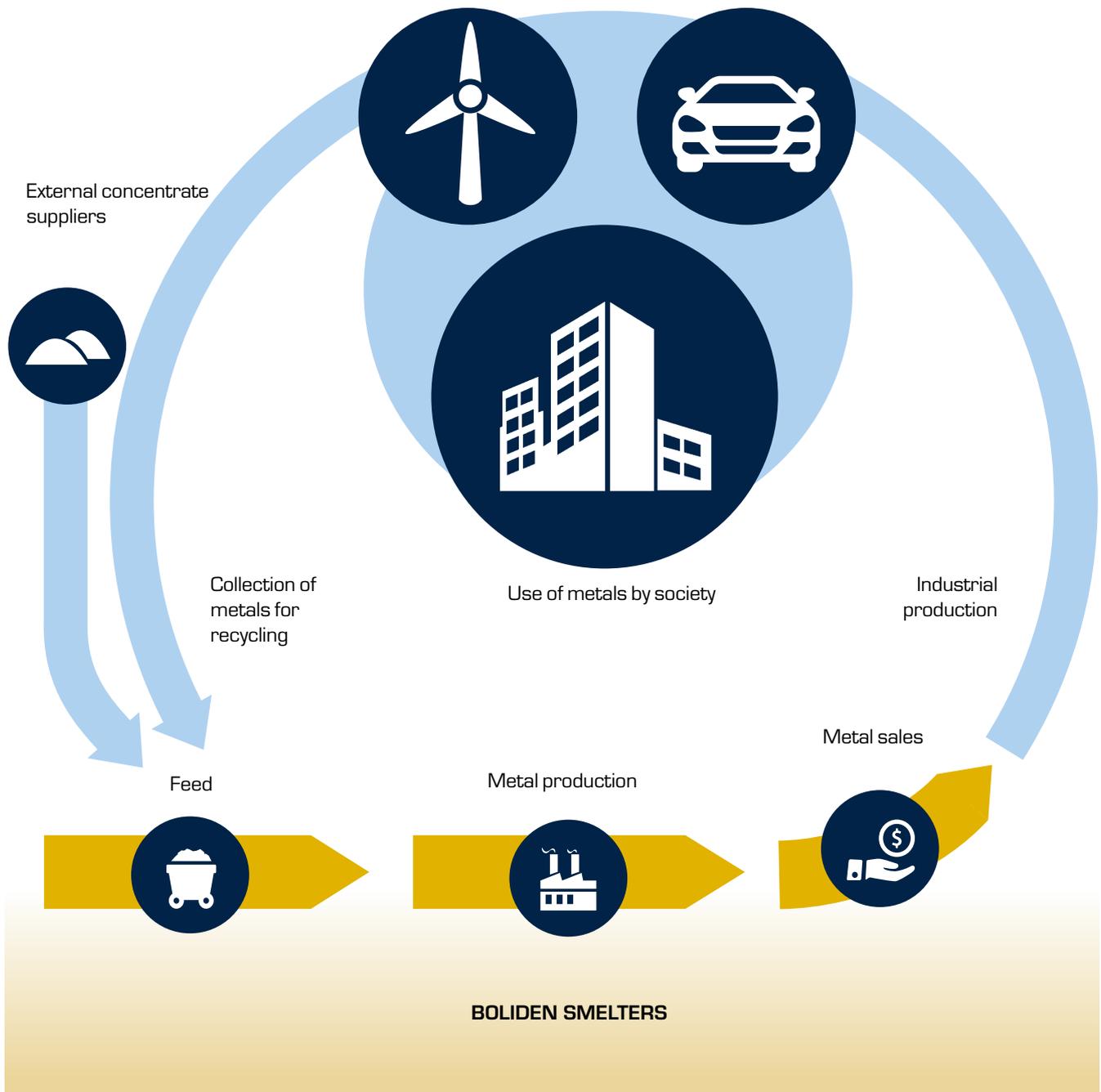
Exploration involves the long-term work of identifying, investigating and analysing mineral deposits in order to map the potential for new mines. In the first instance, exploration takes place in areas that already have mines. The authorities and landowners are kept informed of our exploratory activities.

Mining

Boliden extracts ore from open-pit and underground mines. Thanks to expertise in mine design, technological development and mining methods, a number of mines have world-class productivity. That said, the safety of people and the environment is always our top priority.

Concentration

Mined ore is crushed and transported to concentrators on site in each mining area. There, various metal concentrates are produced, the majority of which are then transported to Boliden's smelters. Boliden has established mobile control rooms at the concentrators where operators have access to process data in real time via wireless technology.



Raw materials feed

The smelters are supplied with metal concentrate from Boliden's mines, as well as with concentrate and secondary raw materials from external suppliers. These secondary raw materials include metals from car batteries and circuit boards from computers and mobile phones, etc. Metals can be recycled without any impact on their quality.

Metal production

Mineral concentrates are refined into pure metals at the smelters. Technical expertise and flexible processes mean that Boliden can produce metals from various types of concentrate. Maximising the production of metals and by-products makes a broader product portfolio possible while reducing waste to a minimum.

Sales

Metals are traded and valued on global exchanges. Most of Boliden's metal production is exported to countries within Europe that have a deficit of metals. Therefore, there are also imports to Europe from other continents.



Zn

Have you ever considered that virtually every single product or service you use is either made of metal or is produced with the aid of metals? Here are some examples.

ZINC

Thanks to its ability to 'self-heal' and protect against rust, zinc is often used as corrosion protection. More than half of the world's zinc consumption is used for surface finishes and rust protection of steel, for example, within the automotive industry and on vessels, bridges and wind turbines.

Cu

COPPER

Electric power and electronics exploit copper's excellent ability to conduct electricity, and almost half of all copper is used for this purpose. Other major applications are in the construction, engineering and process industries. In the automotive industry copper is predominantly used in cooling systems and electronics.

Ni

NICKEL

Nickel resists to corrosion and is used to protect other metals, mainly in the production of stainless steel. Nickel is also an increasingly common component in batteries, including rechargeable nickel-cadmium batteries and nickel-metal hybrid batteries, which are used in hybrid vehicles. Nickel is also used in the construction industry, and in electronic equipment, pipe products, vehicles, metal goods and technology.

Pb

LEAD

Car batteries and other accumulators are currently the largest area of application for lead, and 85 % of all lead is used in various types of lead-acid batteries, as well as in hybrid cars and cars with a start-stop function. Lead is also an efficient damp proofing agent and is consequently used in pipes and electrical cables that are laid underground or in water. Protective equipment for use when working with radioactive substances and x-rays is another application.

Au

GOLD

Gold is used in making jewellery, and also within dentistry and the electronics, space and pharmaceutical industries. Many space satellites have a thin external layer of gold, due to its resistance to electromagnetic radiation and radio waves. Gold is still also used in coins and as an investment object.

Ag

SILVER

Silver is used in jewellery and also in industrial applications, for example, in electronics, solar cells and mirrors and as a catalyst for chemical products. Silver is bactericidal and also resists the accumulation of mould and bad odours. People have therefore started to use silver ions in, for example, clothing materials and keyboards. Water purification is yet another application. Silver, in the form of silver coins and ingots, is also an investment object.

Boliden owns both open-pit mines and underground mines. The geometry and composition of the ore body determine how it is mined and which concentration processes are used.

How a mine works



Drilling

Drilling and blasting

When mining underground ore is accessed by means of ramps and drifts. Holes are drilled into the ore that can measure between 45 and 100 mm in diameter and are 5-25 m deep. The holes are pumped full of an emulsion explosive. Each hole has an individual detonation delay, meaning there can be up to six seconds between the first and last detonation. One charge can produce between 500 and 20,000 tonnes of ore.

At the Aitik open-pit mine, the holes are 16-17 metres deep, and here a normal round produces approximately 700,000 tonnes of extracted rock.



Reinforcement

Loading

At a number of Boliden's underground mines the blasted ore is loaded with the aid of remote-controlled loaders. These can either be controlled entirely by an operator or operated automatically, with loading and unloading being performed remotely by an operator using a CCTV camera system, while transport is conducted automatically via a local WLAN system. At an open-pit mine, the ore is loaded onto mining trucks by excavators.

The ore is then transported to a crushing plant, which may be above or below ground.



Crushing

Reinforcement

At any place in the mine where people are working, systematic safety work is performed through scaling, shotcreting and bolting. During scaling, loose rock is removed from the ceiling and walls using mechanical scalers. The rock surfaces are then sprayed with a layer of steel fibre-reinforced concrete.

Finally, rock bolts are drilled and cast in place in a systematic pattern.

Crushing

The mined ore is crushed into smaller pieces at the crushing plant before being transported first to an intermediate ore storage facility and then to the concentrator.

At an underground mine the crushed ore is carried up through a shaft to the surface using a rock hoist.

At an open-pit mine, the ore is carried by mining trucks up a spiral ramp.



Charging and blasting



Loading and transport

Grinding



Dewatering



Grinding

The valuable mineral is separated from waste rock at the concentrator. The first stage in this process involves adding water and grinding the ore in large mills. A popular method is autogenous grinding, which means that the ore grinds itself without the addition of external grinding media.

The end result is a slurry containing water and finely ground ore.

Flotation

The flotation process is a surface-chemical process, where small amounts of chemicals are used to affect the surface characteristics of valuable minerals, causing them to become hydrophobic. When air is blown into the slurry, the hydrophobic mineral particles adhere to the air bubbles and are carried up to the surface, where they can be removed in the form of a foam. This process is monitored by operators who can adjust a number of parameters, thereby maximising the amount of extracted metal.

Dewatering and concentrate

The mineral is drained and filtered, producing a fine-grained concentrate, which is the mines' end product.

Boliden's mines produce mainly zinc, copper and lead concentrates, which are refined by various processes at smelters, resulting in pure metals. Precious metals are bound to these concentrates and are extracted at the smelters. Find out more on page 16.

Flotation



Concentrate transport



In modern mines, an increasing amount of work is performed with the aid of autonomous machinery and wireless networks. The benefits are increased production and a safer work environment.

TEXT: EVELINA LÖÖV PHOTO: TOMAS WESTERMARK

TOMORROW'S MINES ARE DIGITAL

MODERN MINES are becoming increasingly digitised. Boliden is currently conducting a unique initiative to develop automation in mines. This takes place in a cross-functional programme with employees from various departments, together with external parties such as Volvo, Ericsson, Atlas Copco and ABB. The long-term goal is to streamline mining so that production can continue round-the-clock, all year round.



Peter Burman, in charge of Boliden's mine automation programme, tells us:

"Today, there are distinct peaks and valleys in the production flow in mines. During shift changes, lunches and breaks, production falls significantly. With better production control, productivity could increase by between 10 and 20 per cent. If we use autonomous machinery that operates even when nobody is present, that number increases to between 40 and 80 per cent."

It began with the network

The Boliden mine in Kristineberg has been in operation since 1940. In 2012, the mine was the first in the world to employ a combination of wireless networks, IP telephony and positioning. The network had 100 per cent coverage over a total distance of 35 kilometres. Today, all communication takes place via the network. In the next phase, Boliden installed wireless networks in the Kankberg and Garpenberg mines. The latter is currently Sweden's

most modern mine.

A clear strategy is to avoid specialist solutions that only work in the company's own environment. It must be possible to sell the solutions developed with our various partners on a global market.

"If we take the wireless network as an example, in our case it is an extension of the office network. It is not mine-specific and contains no unique components. The telephones used in the mine are another example. They were actually designed for the healthcare sector, to handle being cleaned with spirits. Their moisture resistance makes them ideal for use in a mine environment," exclaims Peter.

The advantages of positioning technology

Wireless networks allow the use of positioning systems, which have a number of advantages.

"The mine used to be like a black hole, but now we can see what is happening down there in real time. We can do things



like controlling ventilation depending on where in the mine vehicles are located and whether or not they are operating, thus sparing the environment and conserving resources. This technology also leads to reduced emissions, as operators can plan their runs better and use ecodriving,” explains Peter.

Safety the biggest gain

While all of the projects in the mine automation programme have great potential for increasing productivity, the biggest gain is in safety. One example is 5G, the fifth generation of mobile networks, which has been tested in partnership with Ericsson at one of Boliden’s mines. The technology provides shorter response times and better remote control capabilities. Thus the successful implementation of 5G should lead to a safer working environment.

“We will have access to technology that gives us greater scope to remove staff from hazardous areas. Shorter response times are crucial as we prepare to make greater use of remote-controlled machines,” explains Peter.

Another interesting project concerns fire safety and is being conducted together with researchers from Luleå University of Technology, among other institutions. The project is investigating the possibility of using remote-controlled work vehicles, such as fire-fighting units.

“It means we won’t have to risk lives in the event of a rescue operation,” says Peter.

Another project being tested at Boliden’s Kristineberg mine is the rescue function. In an emergency, the system will strip away all production-related information and only show people and rescue chambers. This will allow targeted efforts to help employees in a specific location.

“This not only provides support for operations centre personnel, but also for the emergency services. Just being able to see a 3D view with the people in danger clearly marked before the rescuers go down into the mine is a huge help,” says Peter.

Hottest projects right now

As an early adopter of mine automation, Boliden has taken on something of a client role. The company acts as a test facility and also the standards setter for a number of different projects.

“The highest priority projects at the moment are autonomous trucks and remote-controlled loaders. But fully autonomous mining robots are probably a long way off,” concludes Peter.

Boliden’s operations have a ripple effect



Boliden’s operations make a social contribution in a variety of ways. Its metals are used in society, and the company contributes to employment and regional development in the areas where it operates.

FOR EACH BOLIDEN EMPLOYEE another four jobs on average are created in connection with operations. Therefore, there are currently approximately 25,000 jobs that are a direct or indirect result of Boliden’s operations. Public finances benefit in much the same way. According to our latest calculation, direct and indirect tax payments in Sweden, Finland, Norway and Ireland total MSEK 11,500.

METALS PLAY A KEY ROLE in a long-term sustainable society. 7-10 million tonnes of copper, for instance, are determined to be needed to meet growth within the solar energy sector. At the same time, mines and metals have a particularly noticeable impact on the local environment, with regard to discharges to water and emissions to air, as well as noise, vibrations and heavy traffic. Since 2012, it has been possible to reduce the environmental impact of metal discharges into water by 40 per cent thanks to investments in new purification technology. In parallel to this, there is demand for stable access to energy. As energy production becomes virtually fossil-free in Scandinavia, significantly fewer emissions with climate impact will be generated within the mining and minerals industry, compared with competing companies in countries with a higher proportion of fossil fuels. If we want to reduce climate impact further still, one approach may be the electrification of transport within Scandinavia. The world’s first electric road was inaugurated in 2016. A two-kilometre stretch on which it will be possible to transport goods to and from the Garpenberg mine.



**BRIEF FACTS
ABOUT
GARPENBERG**

LOCATION: HEDEMORA MUNICIPALITY, DALARNA. RESEARCH HAS SHOWN THAT THERE HAVE BEEN MINING ACTIVITIES IN GARPENBERG FOR MORE THAN 2,000 YEARS.

PRODUCTION: 2.5 MILLION TONNES OF ORE PER YEAR.

END PRODUCT: ZINC, COPPER AND LEAD CONCENTRATES, WHICH ARE THEN TURNED INTO PURE METAL AT A SMELTER.

Careful planning from cradle to grave

The new ore body discovered at Garpenberg about 15 years ago laid the foundations for work to expand the mine, which was commissioned in 2014. There is calculated to be enough ore to keep the mine in operation for a while, but already there are plans in place for how it should be reclaimed.

“Thanks to efficient treatment plants and systems that re-circulate process water, we are able to minimise our emissions and discharges from the day-to-day operation. However, our environmental responsibility extends well beyond that. Even before construction work begins on a new mine, we have to plan its closure, and we are also obliged to set

aside funds now to cover the costs of such work,” says Ann-Charlotte Almquist, HR manager with responsibility for quality and the environment at Boliden Garpenberg.

The planned reclamation work includes, among other aspects, enclosing and covering over contamination and materials containing metal. Within the mining area, for example, there is a tailings pond containing residual products from the concentration process. What matters here is ensuring that metals do not leach out of the tailings, and a variety of methods are used to return the site to the natural area it once was.

Find out more on page 24.

Sweden's most modern mine

A record ore deposit turned the mine into an expansive industrial area complete with world-class technology and equipment.

THE 68-METRE-HIGH headframe can be seen from a long way away – a windowless concrete skyscraper with a key role to play in the newly established mining area. Here, over 400 tonnes of crushed ore are raised every hour, with the help of a huge rock hoist that maintains a speed of 17 metres per second. It takes just a minute to raise a load from the deepest level of the mine, which lies approximately one kilometre below the surface.

This is just one of many new investments since Boliden decided to invest heavily in expanding Garpenberg in 2011. The investment, totalling SEK 3.9 billion, which included everything from fixed installations and machinery to advanced IT systems for remote control and automation, has enabled Boliden to streamline mining at Garpenberg, and achieve a production figure of 2.5 million tonnes of ore per year.

“Things looked a lot different when I started as a miner 15 years ago. Back then the mine’s future was uncertain and the entire operation was under threat of closure,” says safety representative Dan Östman, who greets us at the lift down through the mine’s newest shaft.

THIS PART of the mine was commissioned in the spring of 2014, after three years’ intensive expansion work both above ground and below. In addition to Boliden’s own project organisation, around 800 contractors were hired during the comprehensive expansion of operations, which resulted in Garpenberg becoming Sweden’s most modern mine,

and one of the world’s most efficient.

Previously it was thought that mining had started in Garpenberg in the 13th century, but the latest research from Umeå University shows that there was mining in Garpenberg as early as 375 BC. That’s 2,400 years ago! Garpenberg is thus probably Sweden’s oldest mining area still in operation.

Mining today in no way resembles the mining of yesteryear.

“A lot of heavy manual processes have been replaced with computerised machines,” says Dan, pointing to an enormous drilling rig waiting to be serviced at the mine’s fully equipped workshop, which is situated 900 metres below ground.

Nowadays a miner’s most important tool is a joystick or tablet, which is used to control everything from drilling and blasting in underground cavities to loading and crushing the mined ore.

THE SAME IS TRUE of the next stage in the extraction process, which takes place in the adjacent concentrator – a building over 200 metres long to which the crushed ore is transported by conveyors via an intermediate ore storage facility above ground.

General Manager Jenny Gotthardsson is used to guiding industry colleagues and other interested visitors through the state-of-the-art facility. In order to be heard over the deafening noise, she uses a wireless microphone and headset when providing information on the latest developments in the concentrator’s three crucial processes: grinding, flotation and dewatering.

“The principles for this method of separating the correct minerals from the waste rock were first established at the end of the 19th century, but the production methods used have, of course, changed beyond all recognition since then. And they are still evolving today. We are constantly working to fine-tune everything from chemical additives to material flows in order to optimise the process and safeguard the quality of our end products – zinc, copper and lead concentrates,” says Jenny.

She points to a 70 m³ flotation tank and the bubbling grey sludge inside as she explains that the contents are analysed online every six minutes. All this is done automatically and monitored from the control room, which is situated in an office building next to the concentrator.

After the noise of the unmanned production hall, the silence here is palpable. Four process operators sit in front of large screens, keeping a check on the flows and samples and watching for any alarms from the various concentration substations.

“The new facility has generally resulted in a more refined production chain providing greater capacity and a greater degree of automation. This means that we can produce almost twice as much as before with the same number of employees,” says Jenny, before saying that the process remains ongoing.

“That is what is so fascinating about working with process improvements. There is always some little detail you can tinker with in order to be able to extract that little bit more from our rich raw material.”

Metals are an important cornerstone of our modern society, and the fact is that the living standard we currently take for granted is based on our ability to use various metals.

The need for metals is increasing

“ALL INDICATIONS ARE that our need for metals will increase in the future,” confirms Pekka Suomela, Executive Officer at Finnish Mining Association, FinnMin.

There are metals all around us in our everyday lives. They can be found in everything from electronics, vehicles and homes, to major construction projects and the infrastructure that provides us with energy. But while these are always in our immediately vicinity, they are not something we give much thought to. You could even say that metals are so common that they are virtually invisible.

“We take our metals entirely for granted, and most people don’t consider that there are metals in virtually everything, or where those metals come from. We need mines in order to be able to live the way we do,” says Pekka.

There are a number of different factors that mean that we will need more metals in the future. The increase in the global population is an important underlying factor, and together with urbanisation, better living standards and a growing middle class demanding products and services that require metals, this is driving growing global demand.

“If more people around the world want the same living standards as we have in the west, even more metals will be required,” says Pekka.

In Europe and North America, there is also significant focus on technological development, for example vehicles and energy, that may also contribute to an increased need for metals.

“In a global perspective, the need for all types of metals will increase, although the precise situation may be different in different parts of the world. Generalising, I think that the need for base metals, such as iron, copper and zinc, will increase in some parts of Asia, and in the longer term in Africa, while we can expect increased demand for things like lithium and earth metals here in Europe and in North America,” comments Pekka.

CURRENTLY IN EUROPE THERE IS A DEFICIT in metals, and that has been the case for the past 50 years.

“Here in Europe, we are completely dependent on metals from countries outside Europe, but with increased demand globally, the competition for metals may increase,” says Pekka.

There are actually two approaches to meeting the increased demand for metals; new mines and even more metal recycling.

“I’m convinced the solution will be a combination of the two. We’ll see a lot of new mines around the world

and an increase in metal recycling,” explains Pekka.

The EU is positive about developing the mining industry, and there are currently plans for new mines not just in Scandinavia, but also in Greece, Poland and Romania, for instance.

The mining industry is currently part of a circular economy, with metal recycling playing an important part.

“Metal recycling offers huge potential if you look around the world, but in many places there are also huge challenges in creating systematic collection processes and making recycling profitable,” explains Pekka.

The greatest opportunities are currently presented by developing recycling in Europe, where the collection infrastructure has come a long way.

“But regardless of how good we are at collecting and recycling metals, we will still need to add virgin metal to the mix as demand has increased so much,” explains Pekka.



PEKKA SUOMELA
Executive Officer at Finnish
Mining Association, FinnMin.



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Increasing global demand is caused by the global population increase, together with urbanisation, better living standards and a growing middle class demanding products and services that require metals.

Mine concentrates and secondary materials are refined at Boliden's smelters, producing pure metals. These metals are separated using reactions at high temperatures or with the aid of leaching.

How a smelter works

ZINC SMELTER



Metal concentrate

Metal concentrate from mines usually comprises approximately 50 per cent zinc.

Roasting

The concentrate is roasted in furnaces to remove any sulphur. The result is so-called calcine, which comprises approximately 60 per cent zinc. The roasting process can be omitted when using so-called direct leaching.

Leaching

The calcine is leached using sulphuric acid to precipitate and filter out any iron. The result is a zinc sulphate solution containing small amounts of impurities.

COPPER SMELTER



Raw material

Raw material from mines usually comprises approximately 25 per cent copper, while recycling material contains on average around 30 per cent.

Smelting

Smelting takes place in different types of furnaces depending on the raw material and process technology. An upper layer of slag and a lower one of matte, which has a copper content of approximately 55 per cent, form in the furnace.

Converting

The copper matte is tapped into a converter furnace where iron and other impurities, together with sulphur, are separated out. The converter is also charged with scrap metal and, in some cases, black copper – an intermediate product from the recycling of electronics. The result is known as blister copper, which has a copper content of 97-98 per cent.

Purification



Purification

The zinc sulphate solution is purified in three stages, after which it contains approximately 150 grams of zinc per litre.

Electrolytic refining



Electrolytic refining

The zinc is separated from the solution using the electrolytic refining process. The result is zinc cathodes with a zinc content of 99.995 per cent.

Casting



Casting

The zinc is then cast into ingots or so-called jumbos, which can weigh up to four tonnes. The zinc can also be alloyed with other metals in line with customer requirements.

End product



End product

The majority of zinc is sold to steel-works, which use it to rustproof their own products. These products are then used in cars, bridges, high-rise buildings and wind turbines, for example.

PHOTO: STEFAN BERG AND PÄMI KARJALAINEN

Precious metals plant



Precious metals plant

Gold, silver, palladium and platinum are extracted during the process and make a substantial contribution to the revenues of copper smelters.

Electrolytic refining



Anode casting

The blister copper is then processed in an anode furnace to reduce its oxygen content. This increases the purity level to 98-99 per cent and the copper is then cast to form anodes.

Electrolytic refining

The anodes are placed in tanks with steel cathode plates. In the subsequent electrolytic refining process, copper migrates from anodes to cathodes, which ultimately have a copper content of 99.9975 per cent or higher. The cathodes are separated from the steel plates and washed. They are then ready for delivery.

End product



End product

The copper is sold mainly to wire rod and copper rod manufacturers and will eventually be used in the construction industry, for example, or in electrical and electronic products.

Here old mobiles become

Boliden's Rönnskär copper smelter in Västerbotten is a world leader in recycling – thanks to a furnace that resembles a spinning soft drinks bottle.

WE ARE USING more and more electrical and electronic devices in our day-to-day lives. A lot of countries are also introducing legislation on collecting end-of-life electronics. This means that the amount of recycling material is increasing, providing smelters with a new – and plentiful – source of raw materials. The gold content in electronic products varies, but is significantly higher than, for instance, the ore concentrate produced at Boliden's Kankberg gold mine.

Electronics thus account for an important part of Boliden Rönnskär's total metal flow. An e-Kaldo plant, where crushed electronics are melted down in order to recover the metal content, opened here in 2012. The molten metal then continues on through the normal copper process.

SOMEONE who works at the new e-Kaldo plant is process operator Tomas Bäckström.

What is an e-Kaldo plant?

“It is essentially an energy-smart way of recycling electronics and metals. We smelt old electronics here 24 hours a day, 365 days a year.”

What do you mean by energy smart?

“Well, we kick-start the process, but then we don't need to supply any more energy because the heat from the plastic contained in these electronics causes it to melt. The steam produced is transferred to our energy centre and used for district heating and to produce electricity.”

Which part of the process are you responsible for?

“I'm involved at an early stage in the process. Once old electronics have been crushed and sampled, it is brought here for smelting. It is then integrated with the normal smelting process, which results in copper, gold and silver. I monitor the process, making sure that all the levels are correct. We follow a rolling schedule, which involves a lot of preventive maintenance.

It is one of the most independent roles I've had because a lot revolves around thinking for yourself, for example, sampling the molten metal and sending it for rapid analysis. Once the results come back you have to decide what to add or remove in order to ensure molten metal of the best possible quality.”



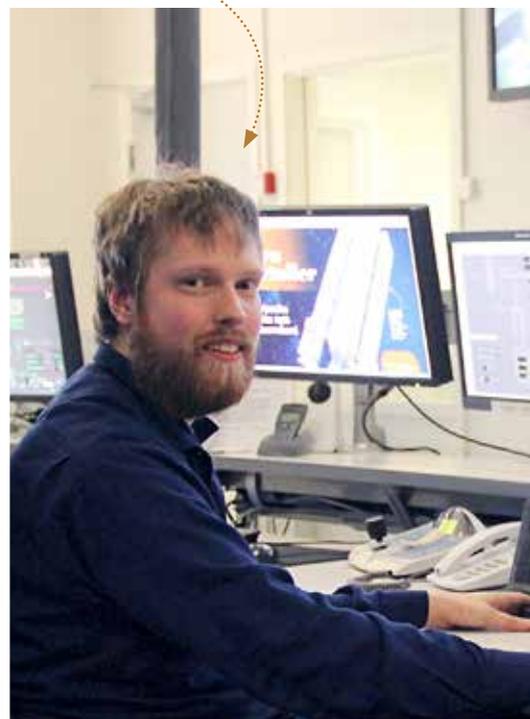
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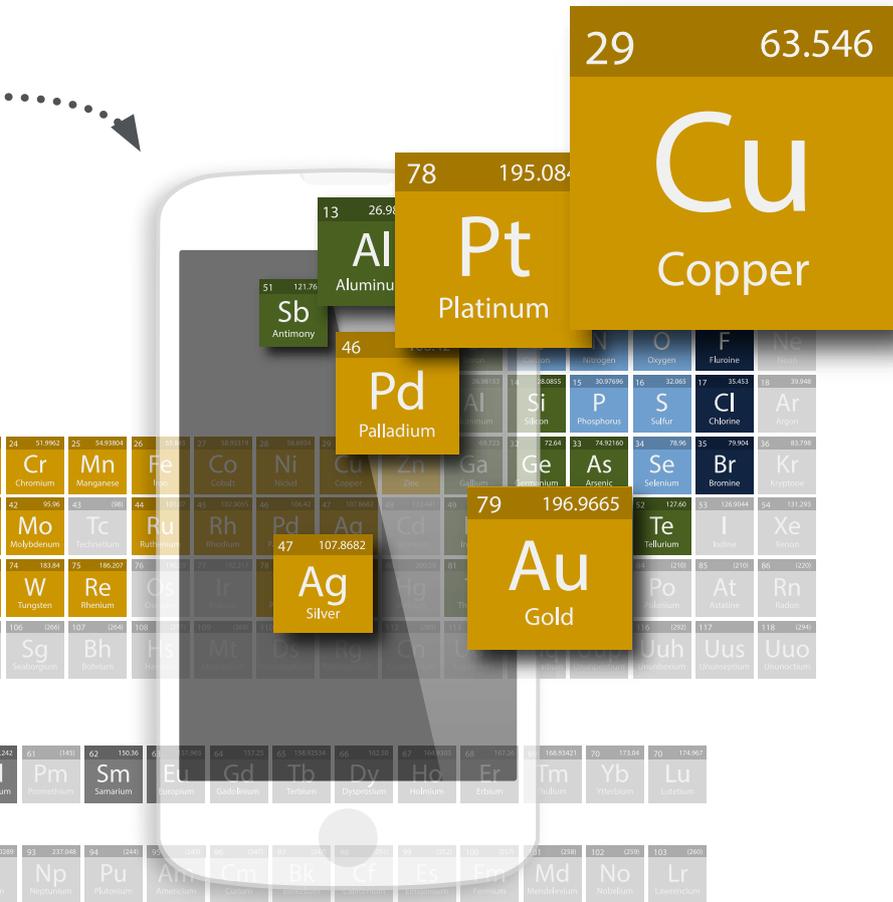
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TEXT: EVELINA LÖÖV
PHOTO: STEFAN BERG, EVELINA LÖÖV,
SHUTTERSTOCK. ILLUSTRATION: TR



new metal



Bergsöe completes the cycle

Boliden's lead smelter in Bergsöe is one of Europe's biggest recyclers of used lead-acid batteries and as such plays an important part in the metal's life cycle.

TEXT: RICHARD CUTLER

AT BOLIDEN BERGSÖE the lead from 4 million worn-out lead-acid car batteries is recycled every year. At least 70 per cent of the lead produced here is sold to the battery industry in Europe and used again.

"Our lead smelter helps recover and recycle a finite resource that is of great importance to modern society but which can be extremely toxic if not handled in the right way during smelting and recovery," says Fredrik Kanth, acting General Manager at Bergsöe.

Minimised environmental impact

Bergsöe seeks to minimise the environmental impact of its emissions to air and water, and the plant exceeds both national statutory requirements and EU requirements. The total lead discharge to water in 2016 was 1.3 kg, compared with 3.5 kg, the level stipulated in the environmental permit. The plant already meets most of the regulations in the EU Industrial Emissions Directive for the Best Available Techniques in the Non-Ferrous Metals Industry, which will become mandatory as of 2020.

Ultramodern systems take care of waste water containing sulphuric acid and scrub process air, including lead-bearing extraction air, and collect filtered particles for recycling externally. Ash from crucibles, casting machines and lead-bearing slag are also processed on site.

District heating from worn-out batteries

Worn-out batteries contain plastic that serves as a reducing agent in lead production. The plastic also gives off heat together with the coke used during the smelting process. The residual heat, equivalent to the annual heating requirement of 2,000 homes, is supplied to Landskrona municipality's district heating system.

DID YOU KNOW THAT...?

Lead is one of the most recycled metals and around 99 per cent of lead-acid batteries are recycled in Europe. The lead in the batteries is fully recyclable. The greater part of the recycled lead is sold back to the battery industry which uses it to make new batteries.



Metals vital for future energy storage

Energy, often in the form of electricity, plays an important role in our everyday life. As electricity is increasingly generated by renewable sources, such as wind power and solar energy, a number of challenges to the energy system are arising. The capacity to store energy between production and when electricity is required needs to be strengthened, and this is where access to metals plays a key role.

THE EUROPEAN COPPER INSTITUTE estimates that energy efficiency measures in properties in Europe would reduce carbon dioxide emissions by 380 million tonnes. That's the equivalent of emissions from 146 million cars. An important factor for achieving this is copper. For each kilogram of copper added to the energy system, the need for newly produced energy falls by 50,000 kWh. Of course, it is not just properties that hold potential. In Sweden, according to ABB, seven per cent of all energy

produced is lost as a result of losses in the transmission and distribution grids.

In parallel, changes in energy production mean that such production is increasingly variable. Solar and wind energy are produced during favourable conditions in contrast to previous systems, when hydroelectric and nuclear power in particular generated even, stable energy production. In order for future energy production to continue to meet demand, large-scale solutions are quite simply required to store energy.

Energy storage – a challenge for the future

Battery technology has been around a long time. For example, we have clocks, cameras, speakers, smoke detectors, tools and household appliances in the home. Within healthcare, there is a great deal of vital equipment that is powered by batteries. Take for instance hearing aids, insulin pumps, pacemakers and defibrillators. However, battery technology has not come so far that it can compensate for a major



Development engineer Risto Alapiha at Boliden Kokkola inspects the new process for extracting silver from zinc concentrate.

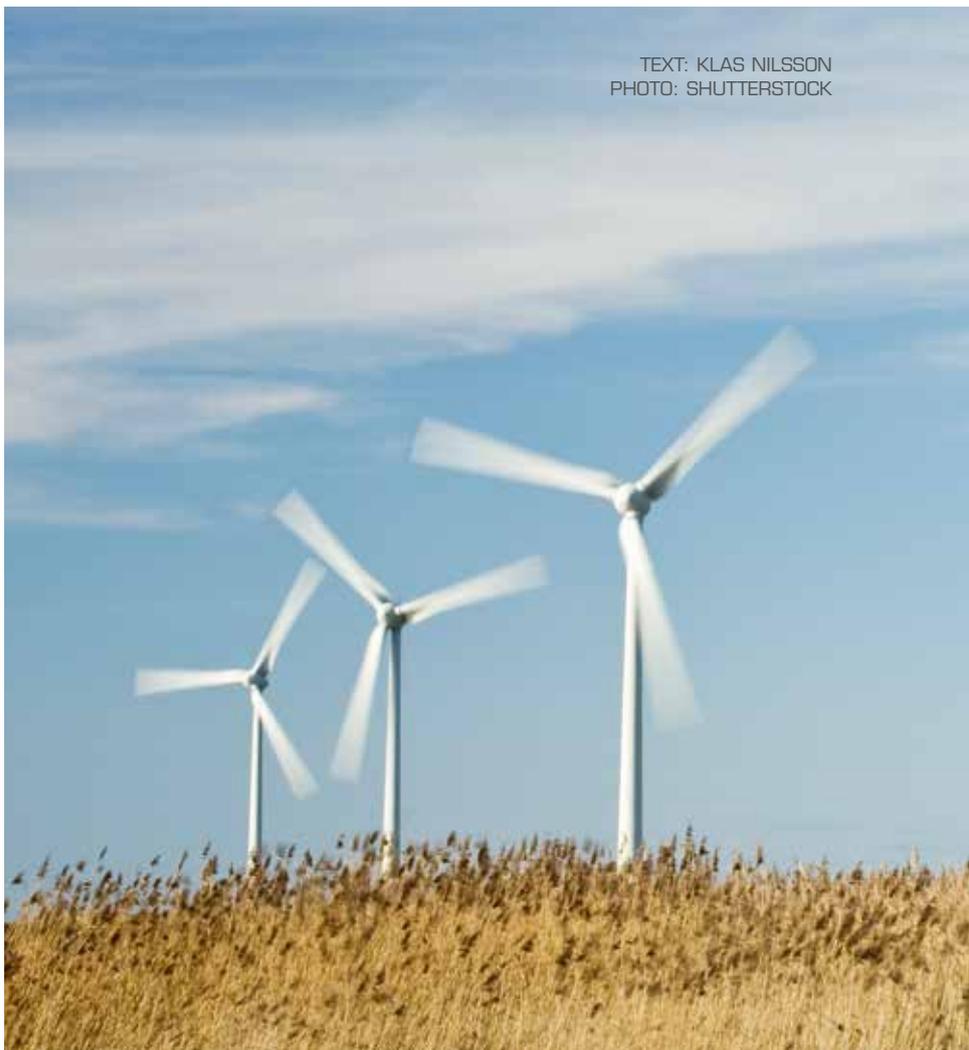
More from the same amount

Extracting more from the material processed by the smelters not only increases profitability – it also guarantees environmental benefits.

revolution in energy production. Society, in its current form, still requires stable energy supply. If energy production changes without an improvement in storage options, there is a risk of more areas than just energy-intensive industry being affected.

There are currently a number of initiatives around the world looking to solve this challenge. Among other things, different battery solutions have been implemented so that wind power plants can even supply electricity when it is not windy. Naturally, many of these solutions are based on different metals, with lithium perhaps the metal that has received the most attention. But cobalt and nickel are also of interest from the perspective of batteries. Cobalt is currently extracted as a by-product, mainly in copper and nickel mines, and due to the high demand and unreliable access, it is on the EU's list of critical materials.

Metals therefore have an important role to play in both energy efficiency and energy storage. Copper in particular is required to achieve the EU's goal of 30 per cent increased energy efficiency by 2030, and various metals are required to facilitate energy storage to a much greater extent than is currently the case.



TEXT: MAARIT FRILUND, PHOTO: PÄIVI KARJALAINEN

SMELTERS are facing a new challenge. An increasing amount of the incoming raw material we use contains substances that interfere with the process used by the smelters to produce their principal metals. These substances have until now been regarded as impurities, but are in actual fact often valuable materials in their own right. With the aid of new technology and improved processes, these materials could also be utilised, providing new and profitable products.

Extracting more metals from the same amount of raw material is not just financially profitable; it also benefits the environment. Once the smelters have processed the raw material and extracted the metal that will be turned into a saleable product, any residual products and waste must be dealt with in a sustainable way. Extracting more metal from the same

amount of material may therefore maximise the number of valuable products, while also minimising the amount of waste produced.

There is a lot to be gained here, and Boliden constantly works to develop technologies and processes that increase the ability of smelters to handle complex materials.

ONE EXAMPLE OF process development along these lines can be found at Boliden Kokkola in Finland. Here, the main products are zinc and zinc alloys, but in 2014 the smelter also began extracting silver from the zinc concentrate.

The new process has been integrated into the existing production flow, with the silver content being extracted using a chemical process called flotation, and filtration.

Someone who works on the silver extraction process is development engineer Risto Alapiha.

“Flotation technology is new to us and so learning how it works and how best to manage it has been extremely interesting. The process also brings new demands to my role, and I have to draw on my specialist knowledge within the field of chemistry,” he explains.

The end product is a silver concentrate, which is sold to external customers or turned into pure silver at Boliden's own smelters.

“Silver concentrate is set to become one of Boliden Kokkola's most valuable by-products. The new process is very important for us because it increases profitability and means that we can better utilise the raw material,” says Jarmo Herronen, General Manager at Boliden Kokkola.

Boliden's prospectors are constantly on the lookout for new deposits.

THE ORE DETECTIVES

TEXT: MONIKA NILSSON, PHOTO: JEANETTE HÄGGLUND AND STEFAN BERG

LOOKING for new mineral deposits or 'exploration' is the foundation for Boliden's operations and a prerequisite for being able to produce metal. This work is carried out by geologists, geophysicists and technicians, who take measurements and conduct surveys out in the field, as well as analyse the information collected. The objective is to identify deposits that contain enough metal to make it worth mining. Such deposits are classed as ore, which is thus an economic term.

"Society is dependent on, for example, copper and zinc for electronics, communication and social development. All mines have a limited life, so to safeguard production at Boliden and to meet demand both in the Nordic region and elsewhere in the world we have to identify new workable mineralisations," explains Jonas Wiik, Boliden's Exploration Director.

IN BOLIDEN'S CASE this means first finding minerals that contain copper, zinc, lead and precious metals, although other metals are also of interest to the company. One example is tellurium, which is excavated at Boliden's Kankberg gold mine and used in solar cells, among other things.

There are numerous different exploration methods used to find mineralisations, including, for example, boulder prospecting, geological mapping in the field, geophysical surveys, geochemical sampling and sample drilling. All collected data is processed and interpreted by Boliden's geo-data department using various computer programs to produce a multidimensional model. Financial calculations are also performed to determine whether or not the deposit is deemed profitable to mine.

All this provides a basis for decision-making about whether or not to continue with more sample drilling with the aim of eventually commencing mining. The path from discovery to mine is a long one, and it often takes many years from the initial surveys until a new mine comes into production.

"We want to know whether there is mineralisation in the bedrock, what sort of mineralisation it is, where and how it is positioned, the volume and the actual metal content. Boliden's strategy is to expand our mining operation, both by opening new mines and increasing the life of the mines we already have. Our objective is for the mines to have a service life of at least ten years," says Jonas.

THERE ARE TWO TYPES of exploration at Boliden. Near-mine exploration takes place close to existing operational mines, while field exploration is conducted in brand new areas where it is thought that the bedrock may contain interesting mineralisations that may form the basis for new mining activities. Boliden conducts field exploration in

FROM
EXPLORATION
TO MINE

Opening a mine is an extensive and expensive process, and, having located an ore deposit, it can take many years before actual mining begins. There are countless interesting exploration finds that never get that far.



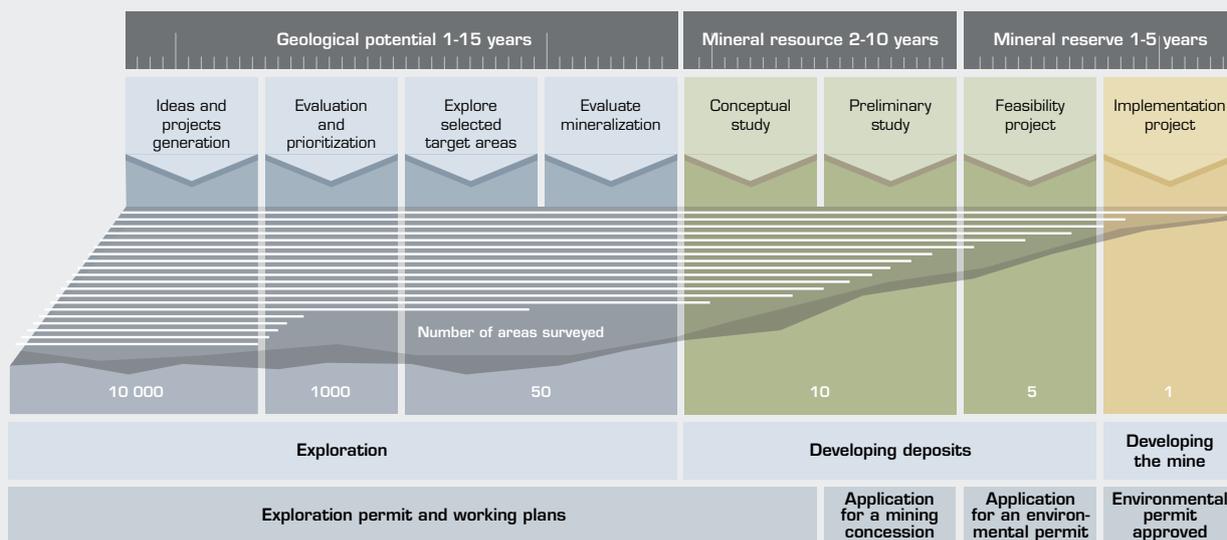
Sweden and Finland.

Work continues all year round, and each exploration project is managed by a group of experts who produce work plans and ensure that work is conducted in accordance with applicable rules and legislation. The group also engages in close dialogue with the Mining Inspectorate of

Sweden (Bergstaten) and the Chief Mining Inspector, who issues permits for sample drilling, as well as with landowners and other stakeholders.

“It is extremely important that we have a positive dialogue with the authorities, landowners and other interested parties, who may include forest owners, reindeer

keepers and homeowners. It is vital that we exercise the utmost caution when it comes to our environmental responsibility and that we always do our share. We will always restore the area in as much as this is possible and rectify any damage that has occurred,” says Jonas.



Closed mine becomes dynamic wetland

TEXT: HELENA ÖRNBERG
PHOTO: BOLIDEN

Money set aside right from the start

Before a new ore deposit can be mined extensive investigations are carried out to determine how the surrounding land and any watercourses will be affected, and how much reclamation work will cost. In Sweden mining companies are obliged to provide a guarantee equivalent to this cost, which

is determined by the Land and Environmental Court. Boliden's provisions for this purpose are based on an assessment of future costs, using current technology and conditions as a starting point. The resulting sum is revised on an ongoing basis, as advances are made in research and technology.

HOW IT WORKS



Kedträsk, September 2012. While draining the open-pit mine, the water was limed a number of times. The water was collected in settling ponds so that the sludge could be dealt with and the water quality controlled.



January 2013. Waste rock and material from the industrial area was deposited in the empty open pit. This work began in January 2013 and was completed in June 2013.



May 2013. The deposited material was covered with peat and a 0.5 m thick layer of till.

Even when planning a new mine you still have to consider how the site will be reclaimed and returned to the natural landscape.

BOLIDEN is responsible for the reclamation of around 30 active and closed mining areas, which all have their own long-term plan for inspections, risk analyses and other activities required.

Some of the closed mining areas have previously been reclaimed, but this work can be improved upon using new knowledge and new environmental technology.

“Boliden’s ambition is always to use the best available technology, followed by continual monitoring and evaluation. We therefore participate in various research projects, on subjects such as the opportunities for using residual products from other industries to prevent oxidation of sulphur compounds. Residual products from the pulp and paper industry are already being used as buffering materials to raise pH levels and precipitate metals,” says Emma Rönnblom Pärson, Manager of Boliden Mines’ Environmental Department.

Conservation and reclamation of mining areas is one aspect of Boliden’s business and runs parallel with its operations. The conditions of the particular area dictate the method used. The most common methods of preventing oxygen permeation and weathering of the material are water cover, advanced moraine cover and elevated ground water levels.

ONE EXAMPLE is the Kedträsk mine, which is located in the Skellefte field in the north of Sweden. Here there was a water-filled open-pit mine, an industrial area and a waste rock dump with oxidised and weathered waste rock that needed to be dealt with. Reclamation of the site began in 2012, and the preferred method in this case was water cover.

“The first step was to drain the water from the open-pit mine. Waste rock was then deposited at the bottom, before material from the industrial area was laid

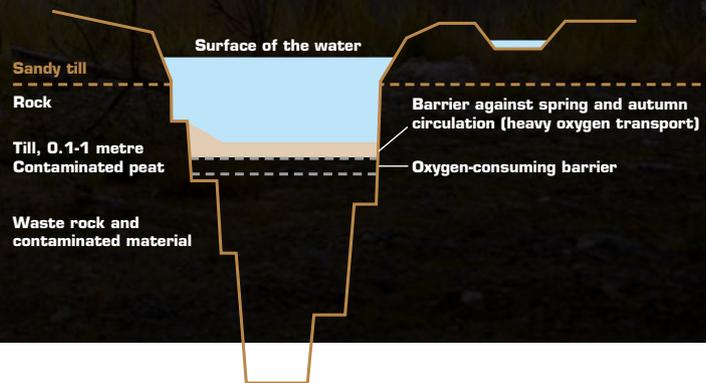
on top. Finally, peat was added. The material was then covered with a 50 cm-thick layer of till,” explains Emma.

The open pit was then filled with water again and is now a lake approximately 5-6 metres deep.

“Water of this depth means we can avoid strong wave erosion of the lake bed, which can have a harmful effect on reclamation efforts,” she continues.

The water purification process generated sludge that was placed in an old shaft at the open-pit mine, and the remaining sludge in the settling pond was covered with bentonite, which was itself then covered with a layer of sandy till. A till barrier was constructed on the upstream side of the sludge deposit to guide surface ground water around the sludge.

“As a final step in the process vegetation is now being established, and areas of the site will gradually become wetland,” concludes Emma.



The film “Tack för lånet” – Thanks for the loan – provides more information on Kedträsk and how Boliden deals with reclamation work. You will find it on Boliden’s website www.boliden.com



June 2013. The area that had previously been an open pit is now filled with waste rock, contaminated material and lime, and has been covered over.



July 2013. As well as monitoring the water quality, regular soil samples are taken to be analysed both on the spot and in a laboratory.



October 2013. Reclamation of the ponds used during the purification process.



September 2014. Reclamation of the Kedträsk site is concluded. Efforts to promote biodiversity continue.

A gilt-edged history

ON 10 DECEMBER 1924 gold fever broke out in Boliden. Test drilling in an area known as Fågelmýran revealed the presence of the Boliden ore body – Europe’s richest ore. A new community, Sweden’s very own Klondike, is established and a gold rush begins. However, this wasn’t the first time this had happened.

Gold fever hit for the first time in Skellefteå and the surrounding area back in the early years of the 20th century. A company was set up to acquire mining concessions and conduct surveys, but that particular venture was less successful and went bankrupt in 1918. A shortage of metal during the latter years of World War I prompted renewed interest in ore exploration in the area. A new type of speculative company, known in Swedish as an ‘emissionsbolag’, was established by the banks.

The Boliden we know today has its origins in one such company, Centralgruppens Emissionsbolag. In November 1924 the first borehole was drilled in the Boliden Area. On examination, the core was shown to contain interesting samples. A number of other holes were drilled before the Boliden ore body was discovered on 10 December.

The community of Boliden rapidly developed close to the mine. In 1926 a set of town plans was proposed, which showed the town laid out in the unique shape of a fan. The mining community took on the character of a well-organised, peaceful and idyllic residential area.



While the world was experiencing the Great Depression in the 1930s, Boliden’s Skellefte operations flourished. This led to economic development in the region and local population growth. The number of employees rose steadily, and by 1935 the workforce numbered 2,500.

Over time more deposits were discovered close to Boliden and more mines opened – so far there have been 30. Activities at the actual Boliden mine continued until 1967.

Margareta’s land hid real treasure

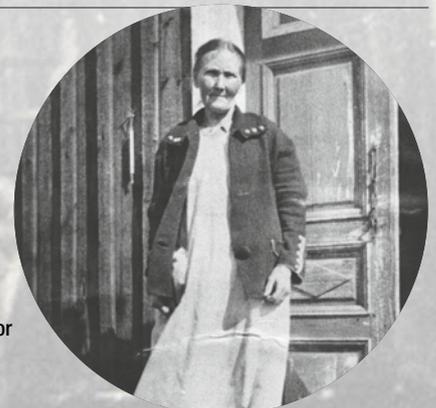
Margareta Lundberg was a widow who had been born in 1866. She lived on a farm called Bjurliden and owned a parcel of land at Fågelmýran, where the original Boliden ore was discovered in 1924.

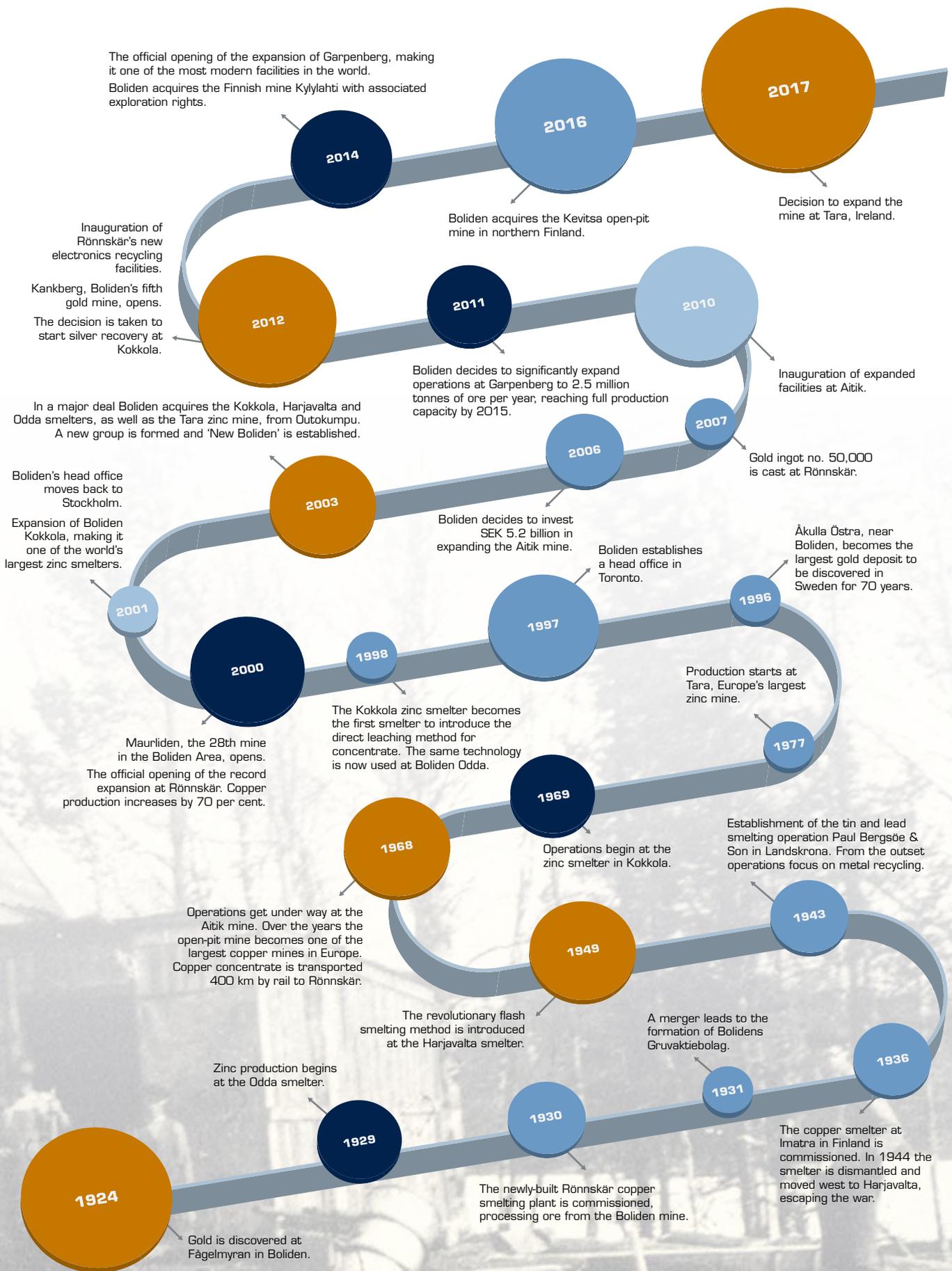
A year later the mining company that had discovered the ore deposit purchased 75 hectares of Margareta’s land for SEK 20,000, which is approximately SEK 500,000 in today’s money. Margareta is said to have imposed a condition on the sale, which was that her male children and grandchildren should be guaranteed employment with Boliden. Her grandson Henry

Lundberg enjoyed a long managerial career with Boliden and eventually became president of steel manufacturer SSAB.

A lot of people said it was a cheap price for the land, but Margareta herself was happy. It pleased her to see thousands of people in employment as a result of the sale of the land, which she considered “worthless”. The district flourished, there were plenty of jobs, and people entertained hope for a better future.

Margareta Lundberg died in 1931.





TEXT: CATRINE JOHANSSON LANTTO
PHOTO: DANIEL OLAUSSON



*“Leadership
is all about
openness”*

**GROW
WITH BOLIDEN**

Erika Fagerlönn, Head of Mine Planning at Boliden Aitik, is one of Boliden's many managers.

ERIKA FAGERLÖNN has been the head of the Aitik mine planning department, i.e. the group that decides which parts of the mine will be worked and when, since 2016. Previously, Erika supervised the mine's drillers and drill service. She was utterly inexperienced in her managerial role, so she wasn't about to just jump in and start bossing around eight different shift teams.

"I began with a very humble attitude indeed. I thought to myself, the employees are all expert at what they do," says Erika.

She realised quickly that there were all kinds of problems to deal with, not least the fact that she only worked daytime hours in her role as supervisor, while shifts went on around the clock. By juggling her working hours, Erika managed to make meeting each shift face-to-face possible, even if only for short periods – something which was much appreciated by the employees.

COMMUNICATION with staff is incredibly important to Erika.

"The management role, for me, means getting all staff involved and

encouraging them to develop themselves. They're the ones who have to do the job, they're the experts. My job is just to be there for them and give them support and opportunities."

This means she doesn't want to just go in and ride roughshod over her staff. Instead, she prefers leadership that involves her staff feeling that they are truly able to contribute solutions and improvements.

"It's all about openness. As a manager, you have to be able to listen and take things on board. Staff provide loads of really good ideas, but only when you show them that you're listening to them and make sure things do actually happen," says Erika.

As a manager, Erika has found the management forum that enables Aitik supervisors to meet up and swap thoughts and ideas to be really useful.

"Without the opportunity to swap experiences and get support from my colleagues and managers, I'd never have done as well as I have. These meetings also clarify what the company expects and demands of us supervisors, and that's helped me to prioritise my work."

Boliden offers several kinds of training courses. New employees are inducted according to a structured process, and all employees receive the training they need to carry out their assignments safely, efficiently and skilfully.

Boliden also has ongoing leadership programmes for managers with a focus on leadership and employee development. A number of statutory training courses are also arranged, as are courses in ethics and how to represent the employer in legal, labour legislation and personnel-related issues.

In order to provide employees with the opportunity to develop both personally and professionally, each employee has an individual development plan that is agreed in consultation with his or her manager. Because it is important for all employees to understand how the value chain is connected, we also arrange courses and study visits to our various units.

Boliden also has a number of group-wide programmes and initiatives such as the Boliden Academy Young Professionals Programme and Women at Work.

5

QUICK QUESTIONS

HOW TO APPLY FOR A JOB AT BOLIDEN

Where can I find out about job vacancies?

All job vacancies within the Boliden Group are advertised on the website www.boliden.com under the Career tab. Click on the heading you are interested in for more information and contact details for the recruiter concerned.

We also use other channels, such as LinkedIn and sometimes advertisements in the press.

How do I apply?

We can only accept applications submitted through the job advertisement's application function. It is therefore important that you submit your application via our website and that you submit separate applications for each position you are interested in.

The first time you apply for a job with us you will need to create a profile if you do not already have one. You can also edit or delete your profile if you no longer wish to keep it.

By creating job alerts you will receive a targeted mail each time we advertise a new job that matches the criteria you have included in your job alert. It is possible to create multiple job alerts if you are interested in a number of different professional categories or sites.

What happens next?

Once you have submitted your application, you will receive confirmation that your application has been received. Once the application period has ended, the selection process begins, unless the advertisement states otherwise.

Once a suitable candidate has been chosen, we will notify all applicants.

How can I contact Boliden?

We can only accept applications submitted through the job advertisements on our website. You can always turn to the named contacts in the relevant advertisement if you have questions about the ongoing recruitment process.



Find out more about Boliden on LinkedIn

BOLIDEN SITES



The Boliden Area

Five mines in a mineral-rich field

Today the area is home to the Renström, Kristineberg and Kankberg underground mines, and the Mauriliden open-pit mines. All the mines, with the exception of Kankberg, produce complex sulphide ores, which contain zinc, copper, lead, gold and silver. Gold ore with a high tellurium content is mined at Kankberg.

The mines in this area supply ore for the concentrator in Boliden, where there are also leaching plants for gold and tellurium production.



Bergsöe

Supporting the lead cycle

Bergsöe is one of Europe's largest recyclers of lead batteries. Its main products are lead and lead alloys. Approximately 60 per cent of the lead produced is sold to the battery industry in Europe, while the remainder is used in the manufacture of e.g. lead sheet and radiation shields.



Garpenberg

Sweden's most modern mine

Complex sulphide ore containing zinc, silver and lead is mined at Garpenberg, along with small quantities of copper and gold.

Metal concentrates from Garpenberg are supplied to Boliden's smelters and to European lead smelters.



Aitik

World-class productivity

Aitik is Sweden's largest and the world's most productive open-pit copper mine. Copper, gold and silver are all mined here. Large volumes and a high level of automation ensure a high level of productivity.



Kevitsa

Boliden's most recent acquisition

The Kevitsa open-pit mine was acquired by Boliden in June 2016. The mine produces ore concentrate containing copper, nickel, gold, platinum and palladium. The operation includes a mine and a concentrator, both of which were commissioned in 2012.



Harjavalta

Copper and precious metals

Harjavalta refines copper and nickel concentrates. The main products are copper, nickel mattes, gold and silver, as well as by-products such as sulphuric acid.



Kylylahti

Boliden's fifth mining area

Boliden acquired the Finnish copper mine Kylylahti in 2014. The mine, which opened in 2012, produces copper, gold, zinc and silver.



Kokkola

Silver production boosts competitiveness

Kokkola produces zinc and zinc alloys, sulphuric acid and silver from mined concentrate. Kokkola is the world's eighth largest zinc smelter. Approximately 85 per cent of zinc production is exported to Europe.





Rönnskär

A world leader in recycling electronics

The main products of the Rönnskär smelting plant are copper, gold, silver and lead. By-products include sulphuric acid and zinc clinker. The plant's recycling capacity is 120,000 tonnes per year.



Odda

Zinc for Europe's steel industry

The Odda smelter produces pure zinc and zinc alloys, as well as aluminium fluoride and sulphuric acid.

The zinc produced is mainly exported to the steel industry in Europe.



Tara

The biggest zinc mine in Europe

The Tara mine is Europe's largest zinc mine and the ninth largest in the world. In addition to zinc, it also produces lead concentrate.

Metal concentrate from Tara is supplied to Boliden's own smelters and to European lead smelters.



Offices

Stockholm: Head office and Boliden Smelters

Boliden: Boliden Mines



Kim wants to win the championship. She couldn't without metals.

Young athletes dream big. But dreams can only come true when all the right conditions are in place. Sharp skates, lighting that lets you practice after school, a bus that takes you to the game. Steel constructions, such as hockey rinks, are often coated with zinc to make them last longer. A thin layer of zinc is enough to fight rust for over 50 years. Kim has what it takes, and so do our metals.

Ag

Zn

Cu

Au

NEW BOLIDEN

Metals for modern life