METALS AND MINERALS

Sweden's contribution to raw material supply in Europe

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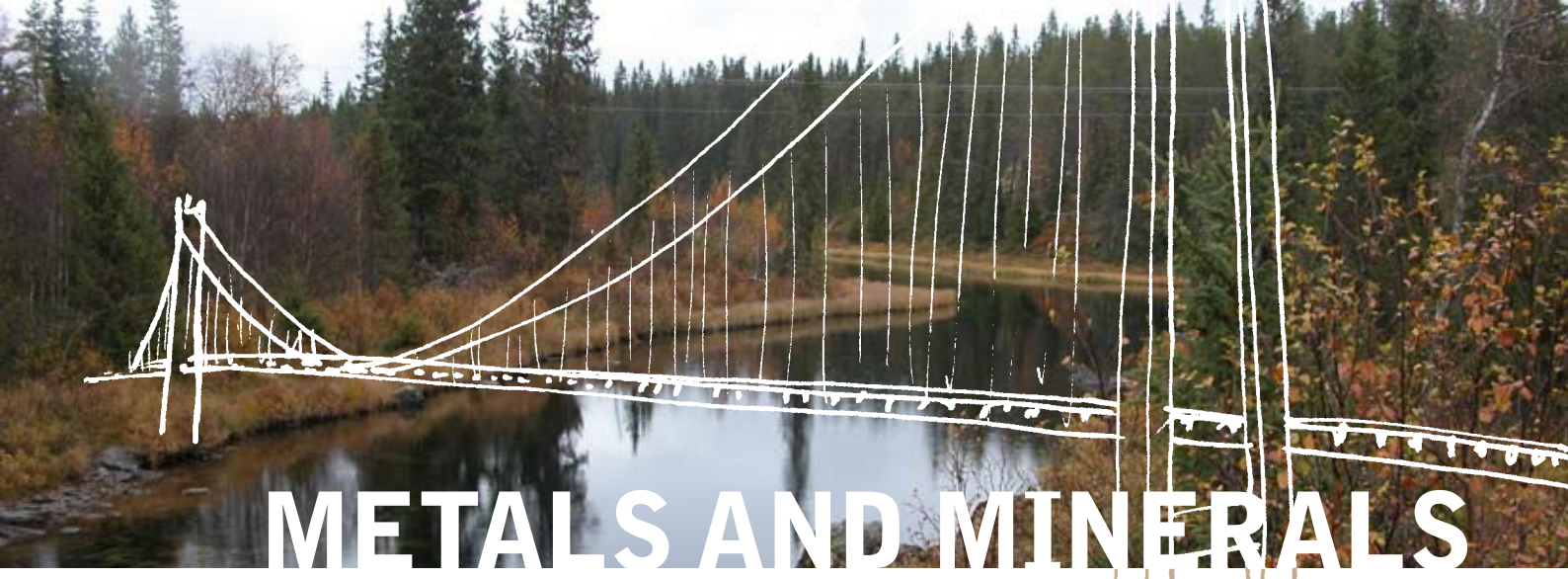


METALS AND MINERALS

Fundamental to our prosperity

If Europe is to remain prosperous – with all that implies for jobs, development and a good environment – it is essential to have a stable supply of raw materials in the form of metals and minerals.

In many respects society is based on knowledge of how to find, mine and use various minerals and metals. An average citizen of the western world uses around 25 tonnes of minerals and metals each year. Minerals and metals are found in many products such as cars, electronic products, refrigerators, computers, mobile telephones, etc.

New applications for minerals that are known to us to a greater or lesser degree also promote development that often results in more environmentally friendly technologies and new job opportunities.

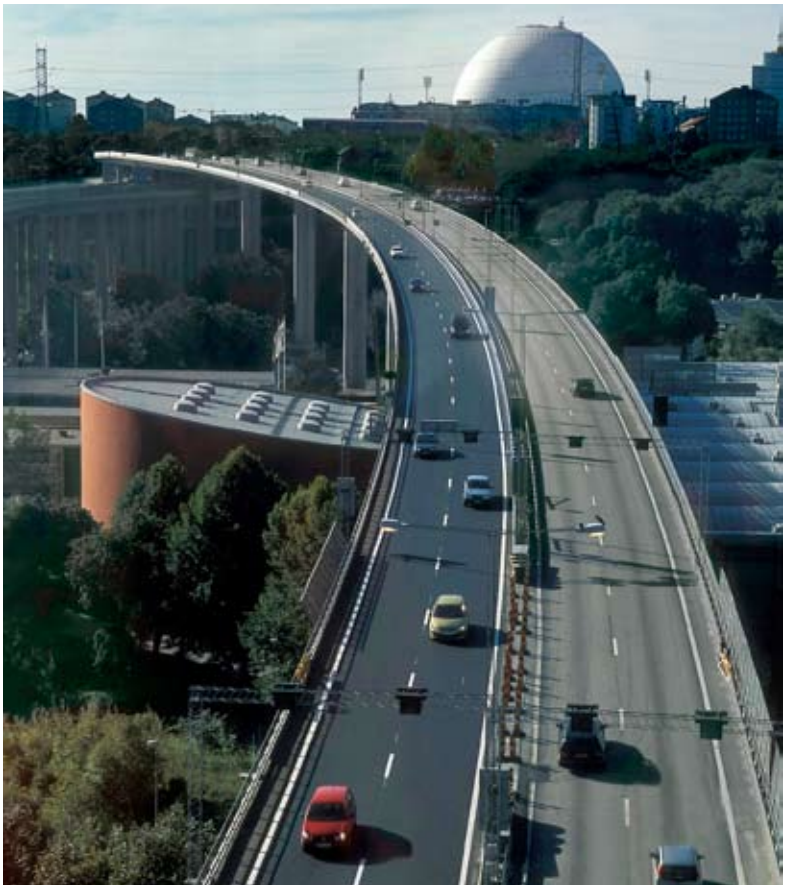
The EU produces about three per cent of the metals consumed worldwide each year. At the same time the EU uses over 20 per cent of the total quantity extracted globally. In other words, the EU is heavily dependent on imported metals and minerals and needs to assure its future supply of these raw materials.

Sweden is of great importance in this context. Sweden forms part of the geological area known as the Fennoscandian Shield, where conditions are highly favourable for potentially minable mineral deposits. Already, Sweden produces large quantities of ore, and there is great potential for expansion of mining activities. Apart from the area's favourable geology, there is also well-established infrastructure for exploration, mining and metallurgy in an economically and politically stable country.

Another factor giving Sweden a competitive edge as a mining country is its systematic approach to sustainable development – environmentally,

economically and socially – pursued within the public sector, private enterprise and the research community.

This publication is about the future challenges facing the EU with regard to the supply of metals and minerals, and why Sweden has an important part to play in this context. The publication provides an overview of the situation in the EU and the rest of the world in terms of production, resources and reserves, as well as future demand for metals and minerals. The publication is based on material on sustainable extraction of Swedish mineral resources that has been produced by the Geological Survey of Sweden at the request of the Swedish Government.



Metals and minerals are used every day – in household goods, appliances, machinery, equipment, computers, electronic products, buildings, bridges, railways, etc. Cars contain steel, zinc and lead, for example.

SIX STRATEGIC FOCAL AREAS FOR SWEDEN

The Geological Survey of Sweden has identified six strategic focal areas for a Swedish contribution to a sustainable European supply of metals and minerals:

1. Geological information for increased exploration
There is need for a concerted effort to expand and develop geological information on the Fennoscandian Shield.

2. Research and development
It is important to assure sufficient and continuous support in the EU and in Sweden for both targeted basic research and for more applied research.

3. Human resources and skills development
With an ageing workforce in the exploration and mining sector, a challenge is to address the human resources and skills development.

4. A simple regulatory framework
Swedish minerals legislation is considered to be well-designed and effective but the aim is, nevertheless, to continuously evaluate and simplify the regulatory framework.

5. Improved infrastructure
Access to strategic infrastructure often decides whether or not a given mining operation will be profitable. Areas covered by the Fennoscandian Shield are sparsely populated, and bearing in mind the common European need for a reliable and sustainable supply of mineral raw materials, there is a compelling case for examining the possibility of EU funding for infrastructure investments relating to mining operations in the Nordic countries.

6. Global development cooperation
Associated with the Swedish mining and steel industry is a cluster of companies that are world leaders in their respective fields. Due to Sweden's position as a mining nation, with efficient public administration and effective regulation in the minerals field, Sweden can make a difference to developing countries in their efforts to achieve fair and sustainable development. This will help to reduce poverty and stabilise markets.

A CHALLENGE

Assuring the supply of metals and minerals within the EU

The EU is heavily dependent on import of ores and minerals. In the light of this, the EU Commission has presented a strategy for assuring a sustainable supply of raw materials.

The Lisbon Strategy, which was launched at a meeting of the EU Council of Ministers in 2000 and revised in 2005, places the focus on growth and employment. The overall aim of the Lisbon Strategy is to make the EU "the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010". A key element in this process is a more integrated industrial policy in support of manufacturing industry in the EU, which is ultimately dependent on a satisfactory supply of raw materials.

In mid-2007, the EU Commission presented a report on the competitiveness of the European non-energy minerals industry. The report revealed a very heavy dependence on imports in the EU.

INTEGRATED RAW MATERIALS STRATEGY BASED ON THREE PILLARS

In parallel with EU's heavy dependence on imported minerals, global demand has risen, particularly in high-growth economies such as China and India. This has led to a sharp rise in prices and competition for mineral raw materials in many developing countries – which has also caused concern about long-term assurance of access to mineral raw materials in the EU.

Against this background and at the instigation of the Council of Ministers for Competitiveness, the EU Commission presented an integrated raw materials strategy based on three pillars in November 2008. The three pillars are to:

(1) ensure access to raw materials from international markets on the same terms as other industrial competitors;
(2) set the right framework conditions within the EU so as to promote sustainable supply of raw materials from European sources;
(3) boost overall resource efficiency and promote recycling to reduce the EU's consumption of primary raw materials and reduce relative import dependence.

Ensuring access to raw materials focuses on European external relations, trade and development actions. Improving the capacity of developing countries to achieve good governance and transparent and sustainable development of mineral resources creates a more level playing field between companies and countries wishing to compete for access to raw materials.

It is also important to improve access to raw materials from European sources. Among other things, the Commission stresses the need to increase the common knowledge base on mineral resources, to increase cooperation between national geological surveys in Europe, particularly as regards exchange of information, and the importance of targeted research and development projects.

Reducing the EU's usage of raw materials by methods including more efficient use of resources and increased recycling and reuse is another important question in achieving sustainable development.

The manufacturing industry in the EU is dependent on an effective supply of raw materials in the form of metals and minerals. The EU Commission's Integrated Raw Materials Strategy is part of the efforts being made to assure this supply.

SWEDEN

A country with great potential

The bedrock of Sweden and the Nordic region is rich in ores and minerals. There are already a number of mines in operation in this area, and the prospects of finding further ore and mineral deposits in commercial quantities are very good.

Sweden is rich in ores because of the geological processes that have created and reshaped the Swedish bedrock. The vast majority of the Swedish land mass belongs to the geological area known as the Fennoscandian Shield. The shield also covers the whole of Finland and north-western Russia, including the Kola peninsula, as well as parts of Norway. The Fennoscandian Shield consists primarily of igneous rocks ranging from one billion to at least two and a half billion years old.

MINERAL DEPOSITS CREATED BY VOLCANISM

The parts of the Fennoscandian Shield covering northern and central Sweden consist of metamorphic and igneous rock types, as well as several generations of intrusive rock types (granite, granodiorite etc.), which intruded deep into the earth's crust, but which have been exposed by erosion at the surface. Volcanism some 1.9 billion years ago caused the formation of Sweden's most important ore deposits in Bergslagen in the centre of the country (iron ore as well as sulphide ore containing copper, zinc, lead, silver and gold), the Skellefte District in northern Sweden (sulphide ore and gold), and the far north of Sweden (iron ore and sulphide ore).

The bedrock in many other European countries is made up of younger sedimentary rocks, particularly limestone and chalk, whose characteristics differ from those of igneous rocks. Ore deposits are found locally in

Ore – a naturally occurring mineral compound from which at least one metal of economic value can be extracted at a reasonable profit.

these sedimentary rocks, for example in Poland and Ireland. Ore-bearing younger igneous rocks are also found in Europe (in Spain and Portugal, for example), but the Nordic countries and the Fennoscandian Shield are in a league of their own in terms of ore potential.

Because of these favourable geological conditions Sweden has become Europe's main supplier of iron ore, and one of the leading producers of gold, copper, lead and silver. There is still great scope for discovering commercially viable ore and other mineral deposits.

EXPLORATION POTENTIAL

Sweden's mineral deposits are relatively little explored, and there has been great interest in prospecting for metals and minerals in Sweden over the last few years. In addition to its favourable geology, there are several other factors rendering Sweden attractive to foreign exploration companies.

Sweden is politically and economically stable, has well-developed infrastructure and effective minerals legislation. In addition, Sweden is committed to providing a good service to exploration companies; the Geological Survey of Sweden has a Mineral Resources Information Office at Malå in northern Sweden, whose role is to provide exploration companies with relevant information.

A COUNTRY WITH MINING TRADITIONS

Swedes have used ore and manufactured metals for around 3,000 years. What began as simple use of bog iron ore is now a well-developed industry, in which ore is extracted at depths of more than 1,000 metres in several places. Much of the country's prosperity is based on the supply of ore and the wealth generated from the Falu mine and the iron ore mines in central Sweden since the Middle Ages, and the northern Swedish mines, which began producing ore about 100 years ago.

Ore extraction in Falun, central Sweden, probably began even earlier than the 11th century. It gradually assumed ever greater economic and political importance. For a time during the 17th century, the Falu mine accounted for two-thirds of total global copper production. The mine was closed in 1992, having been in operation for over a thousand years.

Europe's oldest surviving blast furnace used to produce iron is found at Lapphyttan in Sweden not far from the city of Avesta. It dates back to between 1150 and 1255. For long periods from the mid-13th century to the 19th century, Sweden was one of the world's foremost producers of iron, ex-

A COUNTRY WITH GREAT EXPLORATION POTENTIAL

Sweden is an attractive location for exploration for several reasons:

- Excellent ore potential
- Under-explored by modern standards
- Political and economic stability
- Excellent infrastructure
- Favourable minerals legislation
- Low corporate tax rate
- Excelent databases
- Mining know-how and highly trained personnel

porting large quantities of the metal, particularly in the form of top-quality forging steel.

The deposits at Luossavaara and Kiirunavaara were mentioned for the first time in 1696. The LKAB mining company was founded in 1890. However, it would not be until the 20th century that ore production began in this region. The railway network in northern Sweden was being built at the same time, which also contributed to the upswing in ore production. In the Skellefte District, a remarkable ore deposit was discovered in 1924. The gold-rich Boliden deposit was exploited in Europe's largest gold mine until it closed in 1967. It was mined by the Boliden company which is still active in the region.

By 1910 there were nearly 500 mines in Sweden, producing just under eight million tonnes of ore. As recently as 50 years ago there were about 100 mines, producing some 20 million tonnes of ore. Today, about 50 million tonnes of ore is mined each year at 14 mines, most of which are located in northern Sweden. The total quantity of ore mined to date is estimated to be around 2.7 billion tonnes.

Thanks to its long tradition of ore mining and processing, Sweden has a unique international position in the supply of mining equipment.

WORLD-LEADING MINING INDUSTRY

There is a cluster of companies in the exploration, mining, process engineering and environmental technology sectors that are world leaders in their field. The Swedish resource base has a long tradition of developing efficient and sustainable solutions to meet our metal and mineral needs.

The Swedish mining and ore processing industry has been, and still is, a demanding purchaser of equipment and services. It is also an important driver of national, regional and local economic development. This has helped Sweden to establish a unique international position in the supply of mining equipment.

Moreover, the Swedish mining industry has contributed to the development of the heavy engineering industry as well as small and medium-sized manufacturing and service companies serving the Swedish and global markets. Some examples of companies with roots in the Swedish mining industry are given below.

LKAB is a world class mining company, which has two, more than 1,000 meter deep, underground iron ore mines in the north of Sweden. It is a world-leading producer of upgraded iron ore products, mainly pellets, used in steel manufacturing. Boliden is the second-largest supplier of copper and the third-largest producer of zinc in Europe. Its operations include

SERVICES AVAILABLE TO EXPLORATION COMPANIES

The Geological Survey of Sweden is the Swedish central government agency responsible for matters relating to Swedish geology. One of the survey's most important tasks is to work for sustainable use of Sweden's mineral resources. This includes providing geological information to facilitate exploration in Sweden. Examples of the information the agency can provide are:

- Bedrock data (rock type distribution, age, chemical and mineralogical composition, structures, mineral deposits).
- Aerial geophysical data covering all of Sweden (magnetic, radiation and electromagnetic data).
- Ground geophysical data (magnetic, electromagnetic, gravity and petrophysical data).
- Geochemical data (soil, stream peat, stream sediment and bedrock).

SGU's branch office at Malå (the Mineral Resources Information Office) serves as a one-stop information office for all companies conducting exploration in Sweden. Here, all exploration data for all areas of Sweden collected by way of government-funded activities and by private exploration companies have been merged and stored in archives and databases. The data cover all aspects of modern mineral exploration surveys in Sweden. At Malå there are 8,000 exploration reports, 100,000 maps of various kinds, drill core and drill hole logs, field notes etc., as well as data on 30,000 mineralised boulders from boulder tracing. The National Drill Core Archive contains more than 4,000 km of drill core (around 17,000 diamond drill holes) from all over Sweden.

exploration, mining and processing, as well as smelting and refining. Lundin Mining, with headquarters in Vancouver, Canada, owns the Zinkgruvan mine that has been in continuous operation for more than 150 years. In addition, Lunding Mining has three mines producing copper, nickel, lead and zinc in Portugal, Spain and Ireland.

There are also a large number of Swedish and international companies conducting exploration in Sweden, where the Swedish companies often are subsidiaries to multinational corporations. International Gold Exploration (IGE) is an example of a Swedish exploration company with activities in Sweden and Africa.

Atlas Copco and Sandvik are among the largest companies in the world in the mining and construction equipment sector. ABB is a leading provider of electrical equipment and control systems for mining and metallurgy, Volvo makes trucks, haulers, excavators and loaders, and GIA industries specialises in locomotives, diggers, haulers and ventilation equipment. Malå Geoscience and ABEM Instrument are manufacturers of geophysical instruments for exploration and other applications. There are also a number of consulting firms of Swedish origin possessing specialist skills in the minerals sector. Raw Materials Group and the Swedish Geological for example conduct extensive international activties.

There are several diamond core drilling companies among which Drillcon is the biggest. Tunnelling and shaft contractors include Skanska, NCC and Bergteamet. The main manufacturers of explosives in Sweden today are Kimit (a member of the LKAB group of companies) and Dyno Nobel Sweden which is owned by the Australian company Orica Mining Systems.

The Aitik mine, in the northern part of Sweden, is the largest open-cast copper mine in Europe.

SWEDISH MINES

At the end of 2007 there were 14 ore mines operating in Sweden. Iron ore is mined at Kiirunavaara and Malmberget in Lapland whereas sulphide ore and gold are extracted at the other mines.

Kiirunavaara is the largest underground iron ore mine in the world. Sweden's deepest mine is Renström, where mining takes place at a depth of 1,240 metres. The Aitik mine is one of the largest open-cast copper mines in the world. From 2010, molybdenum will also be mined at Aitik. The mines at Maurliden, Björkdal, Blaiken and Svärtträsk are all of the open-cast type. Most other Swedish mines are underground mines.

Renström, Maurliden and Kristineberg in the Skellefte District are all zinc mines, although other metals are also extracted there. Zinc is also mined at Zinkgruvan, Lovisagruvan and Garpenberg in Bergslagen, central Sweden, as is lead. Some copper is also mined at Garpenberg.

The Svartliden and Björkdal mines are primarily gold mines but gold is also obtained as a by-product at the Skellefte District mines and the Aitik mine.

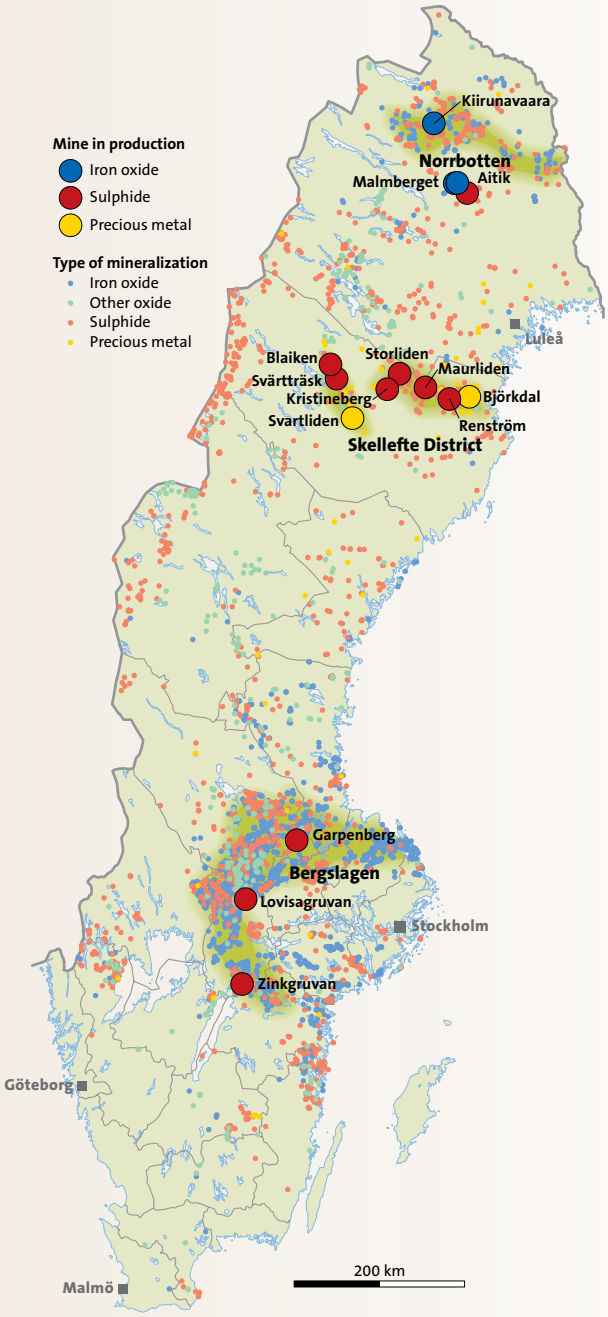
Sweden has no silver mines as such but silver is obtained as a by-product from mining of lead and, in some cases, copper.

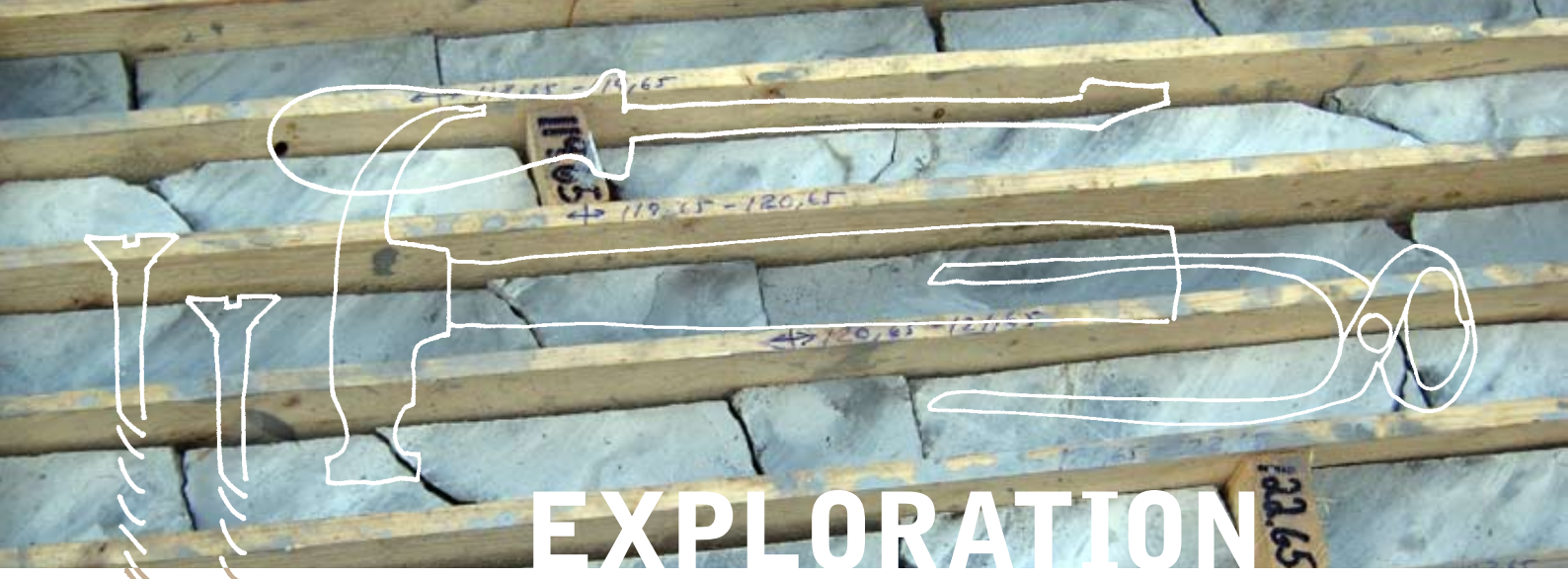
Plans for mining expansion

The LKAB iron ore mines at Kiruna (Kiirunavaara) and Malmberget account for all Swedish iron ore production. LKAB plans to increase the pellets production and is investing in substantial improvements in infrastructure and increased iron ore storage capacity at the Norwegian port of Narvik.

Iron ore will be mined at deeper levels. New main levels will become operational at both Kiruna and Malmberget in a few years' time. This will necessitate the moving of whole cities with homes and infrastructure because of subsidence problems.

New or expanded mining operations are also planned elsewhere in Sweden. Boliden is planning to extend the Aitik mine so as to double copper ore production from 18 million to 36 million tonnes a year. LKAB plans to mine iron ore at Svappavaara south-east of Kiruna. Northland Resources is also planning to mine iron ore in the Pajala area. Dannemora Mineral intends to start mining operations near Uppsala in central Sweden, and Lundin Mining plans to mine copper ore at Zinkgruvan.





EXPLORATION

Potential and scope

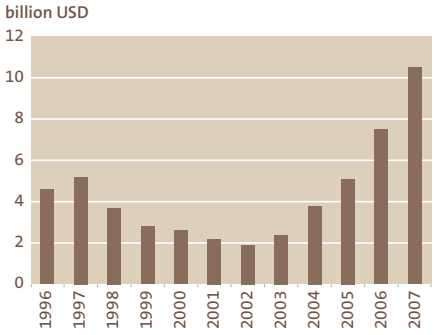
Exploration entails looking for minable ores and minerals. Several factors play a key role in determining where companies choose to explore. One requirement is the right geological conditions; other factors are the political situation, availability of geological information, infrastructure, etc.

The growing demand for metals and minerals has resulted in a sharp increase in exploration around the globe. The total cost of exploration around the world in 2007 was USD 10.5 billion. This is a sharp rise on the USD 7.5 billion spent in 2006, and represents a doubling over two years.

The countries where most exploration is taking place are, in declining order, Canada, Australia, USA, Russia, Mexico, Peru, Chile, South Africa, China and Brazil.

The cost of exploration in Europe in 2007 is estimated at USD 340 million. Almost half of all European exploration took place in Sweden and Finland. Aside from the potential offered by the geology of these two countries, the existence of an established mining industry and a long tradition of mining operations as well as these countries experiences in administrating and regulating exploration and mining activities are most likely contributing factors. Sweden and Finland are also committed to providing exploration companies with the geological information that is relevant to their operations.

Exploration for ores and minerals in Sweden has followed the global trend and risen sharply. USD 92 million (SEK 625 million) was spent on exploration in the country in 2007, compared with USD 49 million (SEK 365 million) the year before.



Total global exploration costs (current prices). In 2005 and 2006 exploration concentrated largely on gold (50 per cent of total exploration costs in 2005 and 42 per cent in 2006). Exploration for base metals has increased; the cost of exploration of this kind accounted for 30 per cent of all exploration costs in 2005 and 38 per cent in 2007. Half of this exploration is to find copper ore deposits. Source: Metals European Group.

Almost 100 exploration companies operate in Sweden. Most of them are fairly small, so-called junior companies. The major part of exploration is conducted by the established mining companies. Exploration is expected to continue at a high level, both for base metals and for more specific rare metals and also energy-producing minerals.

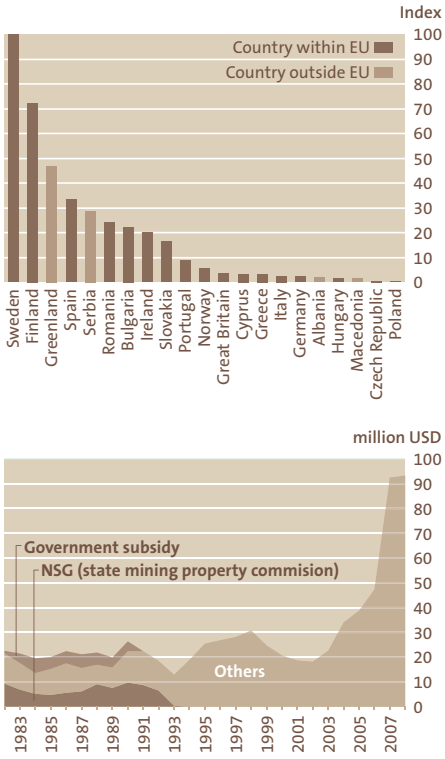
There is fairly little exploration in other European countries apart from Finland and Sweden, even though the geology in some areas offers potential for rich mineral deposits. The reason for the lack of exploration is often a failure to meet one or more of the criteria taken into account by exploration companies when they choose a location for exploration. For instance, there may be problems with complicated legislation, difficulties in gaining access to the land needed to perform surveys or access to geological information. Sweden and Finland are both fairly sparsely populated, which reduces the risk of conflicts over land use as compared with southern and central Europe, for example.

FUTURE EXPLORATION

In late summer 2008 it was estimated that the cost of global exploration in 2008 would total approximately USD 13 billion, which represents a continuing increase. Since then it has become clear that the world is experiencing an economic downturn, with resulting cuts in exploration budgets. On this basis, it is unlikely that more than USD 11 million will be spent during the year. The prospects for exploration after that very much depend on metal prices and the availability of venture capital.

When prices and profitability are low, mining companies tend to cut costs. This tends to affect exploration, which usually involves a large proportion of sub-contractors. Companies primarily engaged in exploration are financed by investors in possession of venture capital. The ongoing global economic turmoil will probably impact the scope for investing in exploration projects and the desire to do so in the near future. The degree of impact depends on the severity and duration of the economic crisis.

In the light of prevailing conditions, with a falling zinc and copper price, there is reason to assume that the exploration activity will peak in 2008, before declining somewhat over the following years. One factor in the equation is that over half of all exploration companies are small enterprises engaged primarily in exploration. Only 30 per cent or so of global exploration is conducted by large mining companies. Medium-sized companies account for the remaining 20 per cent.



Top: Relative exploration costs in Europe in relation to exploration costs in Sweden in 2007. Source: Boliden. **Bottom:** Exploration in Sweden 1982–2007. Just over 40 per cent of exploration projects were primarily aimed at finding copper. This was followed by gold and iron, as well as uranium, nickel, molybdenum, vanadium, lead, silver, tungsten and thorium. New surveys for non-metalliferous "concession minerals" have concentrated on diamonds, alum shale, graphite, wollastonite and oil.

The Geological Survey of Sweden systematically maps the bedrock, soils and groundwater in Sweden.

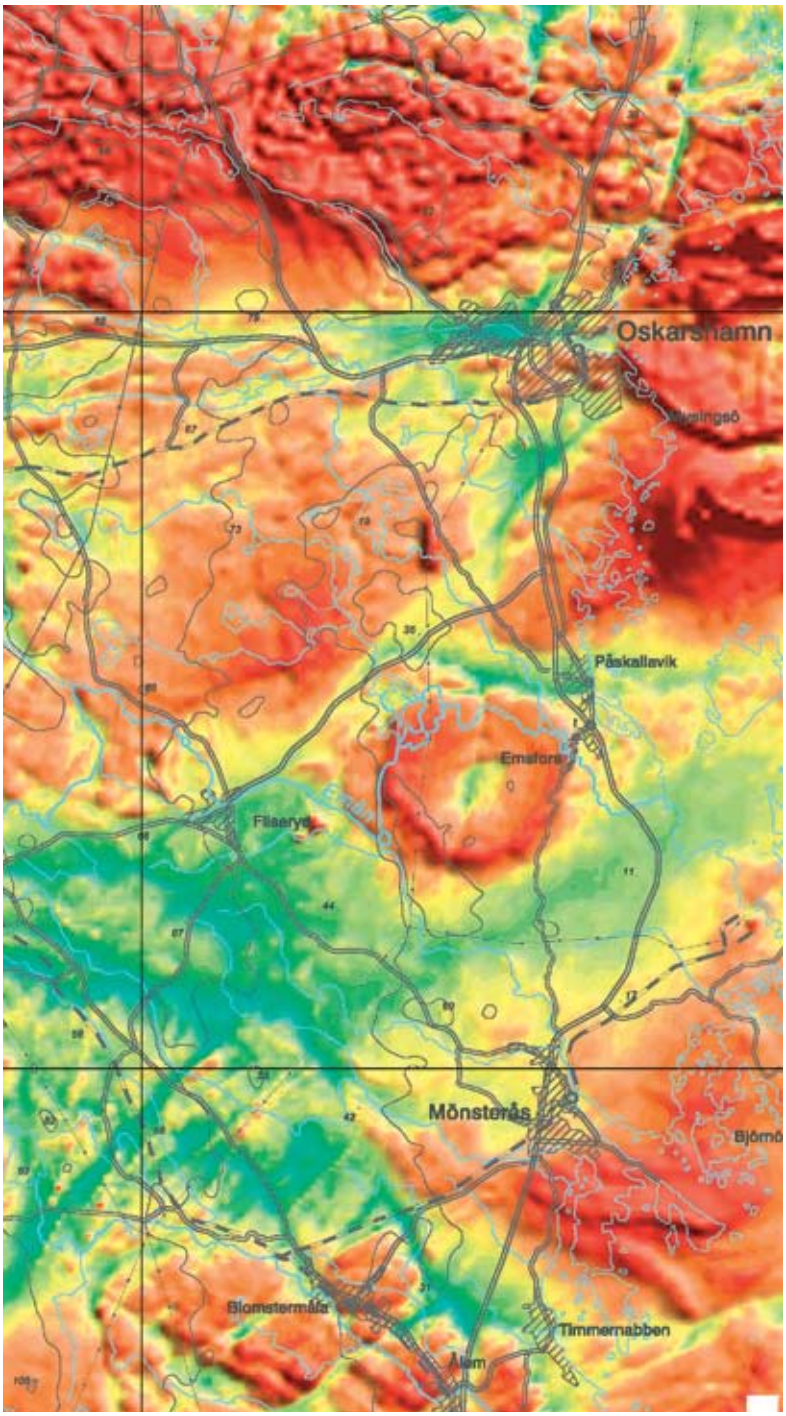
Mining companies account for a larger share of exploration in Sweden than elsewhere. This means that exploration in Sweden is more sensitive to fluctuations in metal prices than global exploration as a whole. Bearing in mind the finds made in recent years, particularly those of nickel and gold, and the fact that several of them will soon begin to be mined, it is reasonable to assume that the bulk of European exploration will continue to be carried out in Sweden and Finland.

GEOLOGICAL INFORMATION – ESSENTIAL FOR EXPLORATION

A number of factors influence the locations across the globe chosen for exploration by exploration companies. Naturally, geological conditions must favour the presence of sufficiently high concentrations of the ores and minerals being sought. Therefore, geological information, preferably in the form of well-developed databases, is essential for exploration. Among other things, geological information describes the various physical and chemical characteristics of the bedrock. It is obtained by mapping, sampling and analysis of the bedrock, at the surface and at varying depths, and by using geophysical methods. Soil strata are also surveyed and sampled in order to trace the source of mineral deposits in the bedrock.

Geological information, general and specific, is also used as an important basis for environmental permit decisions for mining operations, e.g. as regards environmental impacts assessments, site remediation and environmental monitoring.

For Sweden's part, the Geological Survey of Sweden provides good quality basic geological information, with varying scale and coverage in different parts of the country; a systematic survey of the country has been in progress for many years.



The surveys performed by the Geological Survey of Sweden include airborne geophysical mapping. It is performed from a cruising altitude of 60 metres. The data collected provide information on bedrock structures at the surface and at depth – information useful for exploration.

MINES AND DEPOSITS

Production, resources and reserves

Sweden, Poland, Ireland, Finland and Norway are some of Europe's main producers of ores and minerals. A summary is given below of production, resources and reserves in Sweden and Europe.

Sweden produces around 50 million tonnes of ore each year. This makes us one of the leading ore producers in Europe. Iron ore currently accounts for just over half of the Swedish ore production. Ores containing zinc, lead and copper, as well as the precious metals gold and silver, are also mined.

There are also substantial deposits in other countries within the Fenno-scandian Shield. Finland is a major ore producer, particularly of chromi-um, gold and nickel. Norway is the world's main producer of ilmenite (iron titanium oxide).

Other major ore producers in Europe are Poland, Ireland, Portugal, Spain and Greece. Bulgaria, Romania, Austria and Slovakia are other European countries with ore mining activities. The main metals extracted from European ores are copper, lead, zinc, gold, silver, tungsten, nickel, iron, chromium and bauxite (for aluminium production).

Sweden's share of the production of certain metals in the EU in 2007.

Iron	88%	First
Lead	32%	First
Zinc	26%	Second after Ireland
Gold	24%	Second after Finland
Silver	18%	Second after Poland
Copper	9%	Third after Poland and Portugal

RESOURCES AND RESERVES

A mineral deposit, i.e. a mass of naturally occurring mineral material, is classified either as a resource or as a reserve. Unlike a reserve, a resource need not be economically minable. This means that a reserve must have been so well investigated that it is possible to assess its economic potential.

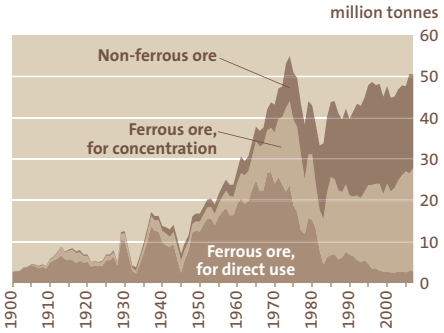
Hence, the term resource represents deposits that are not workable at a given point in time or for which there is insufficient information to assess tonnage and concentrations at an acceptable level of security, for example.

A resource may be reclassified as a reserve after more thorough investigation or due to economic factors, such as increasing world market prices or improved infrastructure in the area in question.

IRON ORE

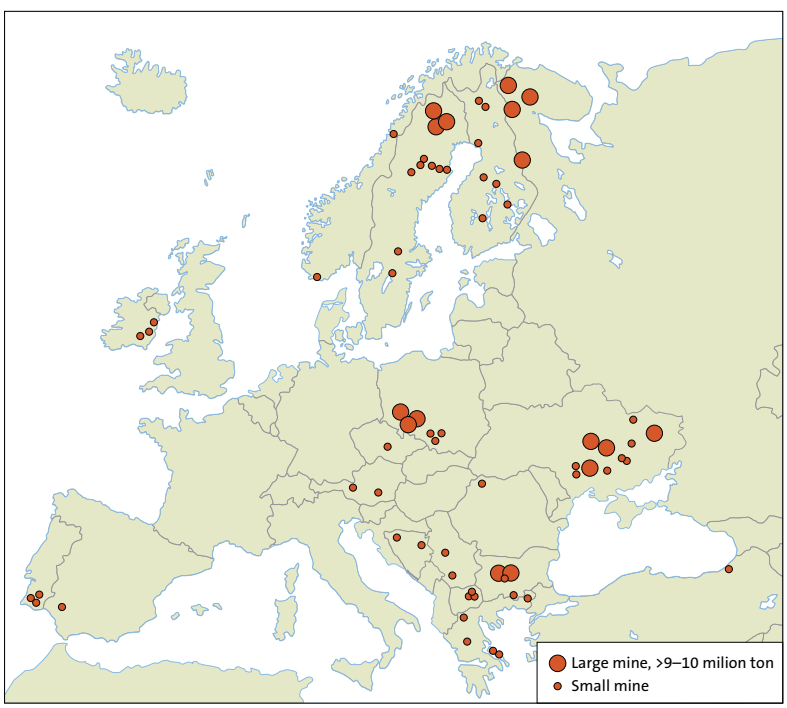
Sweden produced 24.7 million tonnes of iron ore products in 2007. Iron ore is mined at the LKAB mines in northern Sweden (at Kiruna and Malmberget). Some five million tonnes of products are used in Sweden; the remainder is exported, mainly to countries bordering the Baltic Sea and to the rest of Europe. An expansion of iron mining is planned, e.g. in Pajala and Dannemora.

Sweden also possesses the major part of Europe's iron ore reserves. These are estimated to total 1,039 million tonnes, and are expected to last for 46 years at the present rate of extraction. The majority of the reserves are in the mining areas of northern Sweden. Iron ore resources are estimated to total approximately 730 million tonnes.

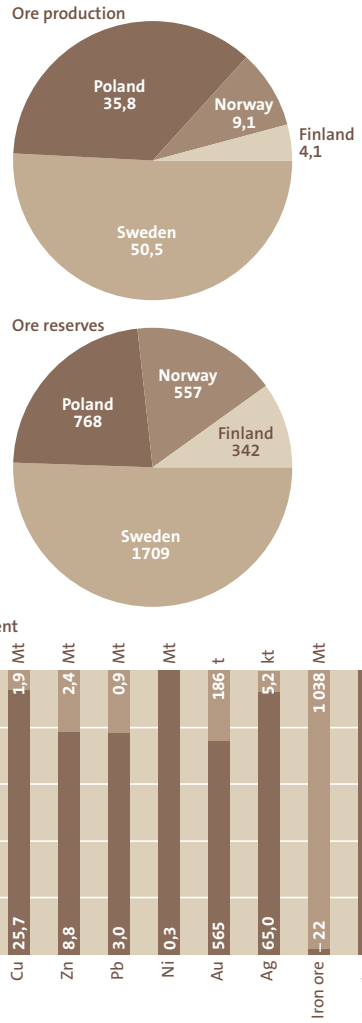


Ore production 2007:
Non-ferrous ore = 22,6 million tonnes
Ferrous ore, for concentration = 25,0 million tonnes
Ferrous ore, for direct use= 2,9 million tonnes

Swedish ore production from 1900 to 2007. Iron ore products account for the major part, with a total of 24.7 million tonnes in 2007.



Mines in Europe. In several respects Sweden is Europe's number one mining nation, both as a leading ore producer and as a world leader in the supply of mining equipment. In 2007, Sweden was the largest producer of iron ore and lead ore in the EU. Sweden is number two in zinc, gold and silver, and number three in copper. Ireland is the largest zinc producer, Poland the largest silver and copper producer, and Finland is the main gold producer. Portugal is the second largest producer of copper.



Top: Ore production in countries bordering the Baltic including Norway – million tonnes. **Centre:** Ore reserves in the Baltic region including Norway – million tonnes. **Bottom:** Ore reserves in the EU – metal content in million tonnes (Mt), thousand tonnes (kt) and tonnes (t) referring to the given figures. The pale brown columns represent Swedens share of the reserves.

OTHER METALS

Reserves of non-ferrous ores in Sweden are estimated at 670 million tonnes, whereas non-ferrous ore resources are estimated to total 1,055 million tonnes. The metals concerned include zinc, copper, lead, molybdenum, silver and gold.

Copper ore is mined at several Swedish locations; the copper content in the ore concentrate extracted in 2007 totalled almost 63,000 tonnes. An expansion of copper mining is planned. In Europe, copper is also found in Poland, Portugal, Bulgaria and Spain. Total European reserves are expected to last for 39 years at the current rate of production.

The zinc content of the zinc ore concentrate produced in Sweden in 2007 was 215,000 tonnes. The concentrate is mainly exported to Europe. Lead is also extracted from zinc ore concentrate and the lead content of the concentrate was 63,000 tonnes the same year.

The main resources and reserves of zinc and lead ore are found in Sweden, Portugal, Ireland, Spain and Poland. European zinc ore reserves are expected to last for 14 years and lead ore reserves for 19 years at the current production rate.

Gold is extracted at a number of mines in Sweden, both as a primary precious metal and as a by-product. The gold content of the concentrate produced from Swedish mines was 5.2 tonnes in 2007. The main producers of gold from European mines are Finland, Sweden and Spain. It is estimated that Europe's total gold ore reserves will last for 34 years.

The silver content of the concentrate produced at Swedish mines was 323 tonnes in 2007. In Sweden, silver is only extracted as a by-product. Poland is Europe's largest producer of silver and the fifth largest in the world. In addition, Poland is estimated to have the world's largest reserves of silver (nearly 45,000 tonnes). Total European reserves represent 38 years' production.

Nickel is found in Greece, Finland and Spain. Greece is Europe's largest producer of nickel. European reserves are expected to last for 10 years. New nickel deposits will soon be mined in Finland, which will probably lead to a substantial increase in estimated reserves. Finland also has the largest reserves of chromium ore in the EU (6.6 million tonnes).

Greece is Europe's main producer of bauxite. Aluminium oxide is produced from bauxite and is then further refined to produce metallic aluminium. Greece also possesses Europe's largest reserves of bauxite, which are estimated to represent 250 years' production.

Norway is Europe's largest producer of ilmenite (iron titanium oxide), having the largest reserves of this mineral in the world (approximately 400 million tonnes). Titanium oxide is extracted from ilmenite and used as a pigment in paints, sun screens and toothpaste, among other things.

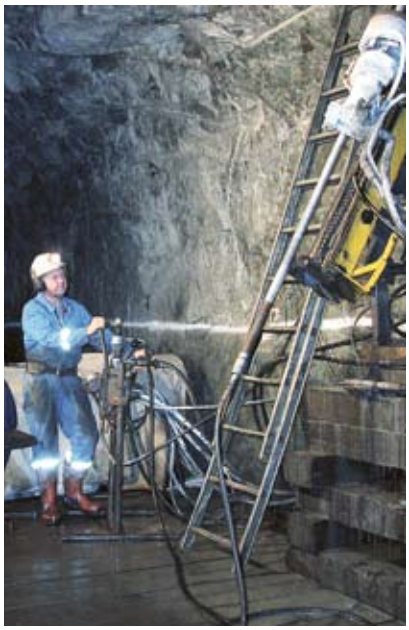
METAL PRODUCTION IN SWEDEN

Several ores are treated further to produce metals in Sweden. Swedish production of lead is around 30,000 tonnes a year, of copper 250,000 tonnes and of silver 347 tonnes. No bauxite is mined in Sweden, but the ore is imported and used to produce around 100,000 tonnes of aluminium annually.

Mines in operation during 2007 in the Baltic Sea region including Norway.
Sources: SGU, GTK, NGU, KGHM.

Mine	Country	Metal(s)	Ore production Mt per year
Kiruna	Sweden	Iron	15,2[1]
Malmberget	Sweden	Iron	9,5[1]
Aitik	Sweden	Copper, gold, silver	18,5
Kristineberg	Sweden	Zinc, copper, lead, gold, silver	0,6
Maurliden	Sweden	Zinc, copper, lead, gold, silver	0,4
Renström	Sweden	Zinc, copper, lead, gold, silver	0,3
Petiknäs[2]	Sweden	Zinc, copper, lead, gold, silver	0,1
Storliden	Sweden	Zinc, copper	0,3
Björkdal	Sweden	Gold	0,09
Svartliden	Sweden	Gold	0,3
Blaiken	Sweden	Zinc, lead, gold	0,3
Svärtträsk	Sweden	Zinc, lead, gold	0,02
Zinkgruvan	Sweden	Zinc, lead, silver	0,8
Garpenberg	Sweden	Zinc, lead, copper, gold, silver	1,2
Lovisagruvan	Sweden	Zinc, lead, silver	0,02
Lubin	Poland	Copper, silver	7
Polkowice-Sieroszowice	Poland	Copper, silver	11
Rudna	Poland	Copper, silver	13
Olkusz-Pomorzany	Poland	Zinc, lead	2,5
Trzebionka	Poland	Zinc, lead	2,3
Kvannevann	Norway	Iron	1,6
Tellnes	Norway	(Iron), titanium	7,5
Kemi	Finland	Chromium	1,2
Pyhäsalmi	Finland	Copper, zinc, gold, silver	1,1
Hitura	Finland	Nickel, copper	0,6
Särkiniemi	Finland	Nickel, copper	0,2
Pahtavaara	Finland	Gold	0,6
Suurikuusikko	Finland	Gold	0,2
Orivesi	Finland	Gold	0,2
Pampalo	Finland	Gold	0,05

1. Iron ore products (mainly fines and pellets).
2. Mine closed in the beginning of 2007.



Core drilling in a mine.

GLOBAL ORE PRODUCTION AND RESERVES

The global iron ore production was 1,645 million tonnes in 2007, of which the total EU production accounted for 28 million tonnes. The four main producing countries in the world are Brazil, China, Australia and India, which account for more than 70 per cent of global iron ore production.

The global production of copper in mines totalled approximately 15.5 million tonnes the same year, of which Chile produced more than one-third. Other major copper producers are Peru and USA.

Zinc production in mines totalled just over 11 million tonnes in 2007, of which China accounts for around 30 per cent. Australia and Peru occupy second and third place among the world's zinc producers.

Lead production in mines totalled about 3.8 million tonnes in 2007, of which almost 40 per cent was mined in China. Other major lead producers are Australia, USA, Peru and Mexico.

Production of gold in mines was just under 2,500 tonnes in 2007. Major gold producers are China, South Africa, Canada, USA and Peru. Apart from China, production in these countries has fallen in recent years. The Chinese production, however, has risen so much that the country became the world's main gold producer in 2007.

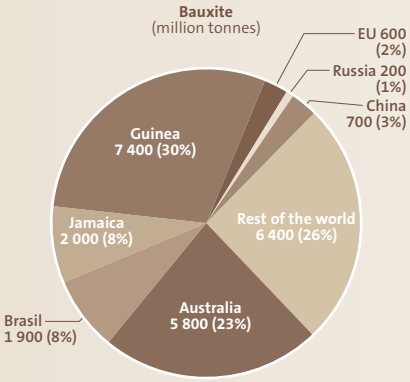
The global silver production in mines totalled just under 21,000 tonnes in 2007. The main producers are Peru, Mexico, China, Australia and Poland.

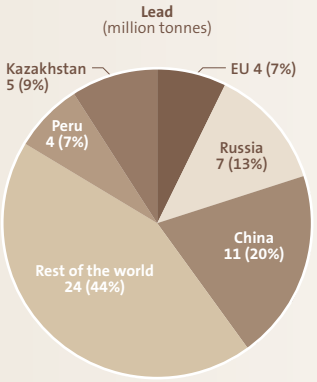
Global ore production 1998–2007 in million tonnes (Mt) and thousand tonnes (kt).

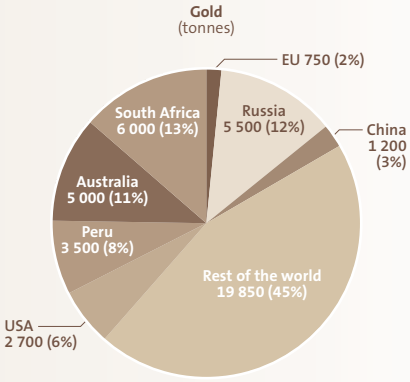
Production	Iron ore (Mt)	Aluminium[1] (kt)	Copper (kt)	Lead (kt)	Zinc (kt)	Nickel (kt)
1998	906	22 654	12 285	3 055	7 632	1 139
1999	884	23 707	12 753	3 011	7 835	1 065
2000	959	24 418	13 233	3 069	8 730	1 137
2001	930	24 436	13 729	3 097	9 005	1 214
2002	986	26 090	13 541	2 831	8 880	1 235
2003	1 074	28 007	12 692	3 139	9 577	1 322
2004	1 184	29 922	14 721	3 101	9 755	1 341
2005	1 315	32 021	15 204	3 629	10 123	1 370
2006	1 498	34 004	15 117	3 707	10 605	1 427
2007	1 645	38 048	15 570	3 820	11 115	1 559

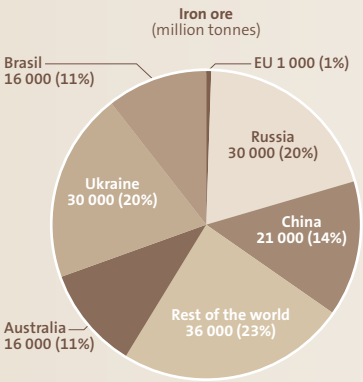
1. Production of refined metal.

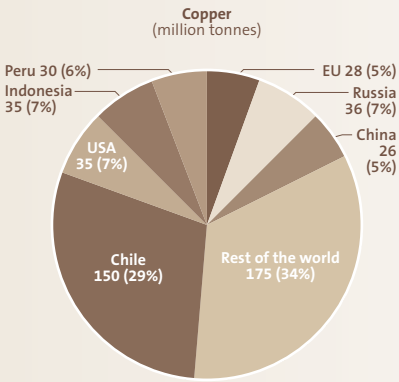
The Chuquicamata mine in Chile is the world's largest open-cast copper mine.

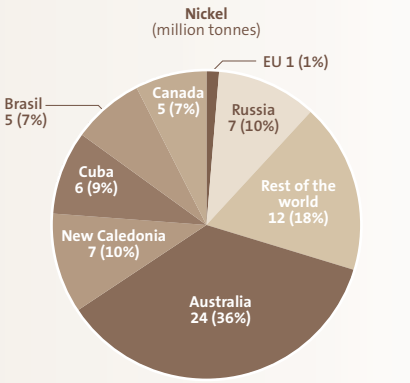


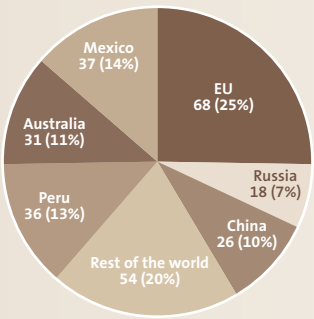


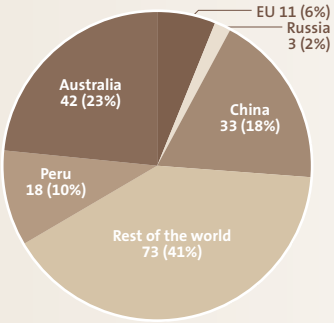












Global reserves of bauxite, lead, gold, iron ore, copper, nickel, silver and zinc.

THE MARKET

Price trends, demand and future needs

The demand for metals is unlikely to fall in the long run. The continuous introduction and use of new technologies boost demand for additional metals, and global development generates a growing demand for metal raw materials.

Global ore production is governed primarily by the demand for metals, which depends on the quantity of metals used. This is in turn influenced by the properties of metals, what they can be used for and their availability and price.

FACTORS INFLUENCING DEMAND

Since metal and mineral prices are set in US dollars, the dollar exchange rate and the market price are the key factors. Another factor bearing on demand is the alternative raw materials that are available if the price rises too much. History has shown that a high price can inhibit demand and instead stimulate trade in other, cheaper, substitutes.

If production exceeds usage, materials are placed in stock. If demand increases, materials will also be sold from stock. Stock levels thus have a dampening effect on market fluctuations.

Global developments are naturally very important. One current example is that of China, which used to be a major exporter of ore. Present developments in China have brought about an increased need for metals for use in domestic production, and China is now a major importer of ore and metal. Other emerging economies such as Brazil, Russia and India also have a growing need for mineral-based raw materials.

The concept of sustainable development encompasses reduced consumption, among other things by increasing the proportion of metals that are recycled and reused. If this can be achieved using new and improved technology, for example, this will naturally impact the market for ores and minerals.

MARKET APPRAISAL

The Geological Survey of Sweden has made an appraisal of future demand for metals. In making the appraisal one challenge was to judge the significance of the global financial crisis that struck in autumn 2008. In the near term it will no doubt have a substantial impact on the forecasts made. In the medium term, too, growth may well be weaker than expected. The appraisals and projections are based on expert opinions, notes from seminars, literature studies and calculations. A summary of the projections is given below.

IRON ORE AND STEEL

In recent years, the sharp growth in demand for steel in China has resulted in increased iron ore production. This has also led to a sharp rise in the price of iron ore products, including pellets, over the last few years.

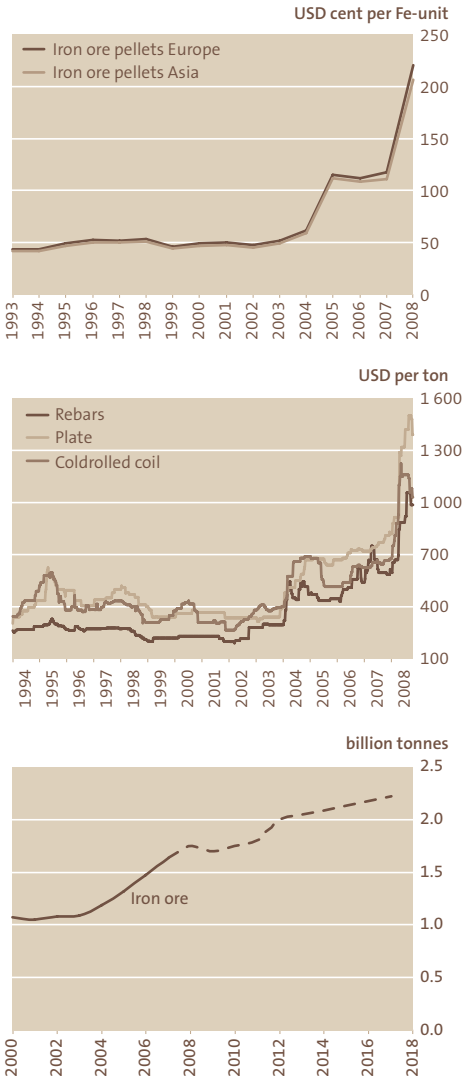
Iron is mainly used to make steel. Steel prices were fairly stable for a lengthy period until 2003. Since then they have risen to keep pace with growing demand. The price of stainless steel has also been heavily impacted by rising nickel prices, since nickel is a key constituent in the commonest types of stainless steel.

Global iron ore production in 2007 was 1,645 million tonnes. The usage of iron ore products was 1,632 million tonnes, and the steel production was 1,344 million tonnes. Global demand for iron is expected to continue to rise, with China remaining the main user.

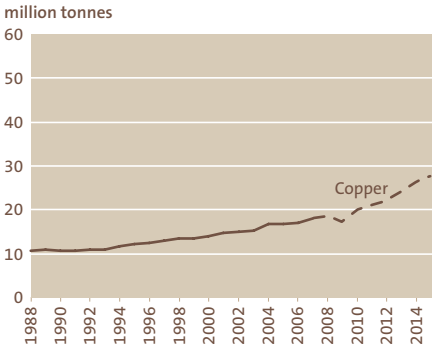
Usage in 2008 is expected to total 1,910 million tonnes of iron ore. By 2015 this figure expected to have risen to 2,130 million tonnes. Iron ore usage in the EU was 177 million tonnes in 2007, i.e. 11 per cent of global usage.

COPPER

Approximately two-thirds of all copper is used in the electrical industry as an electrical conductor, and in the construction sector for water pipes, heat exchangers and the like. Chile is the main producer, accounting for



Top: Price curve for iron ore pellets. **Centre:** Price trend for steel (rebars, plate and cold-rolled coil). **Bottom:** Global iron ore usage 2000–2007 with a projection to 2017.

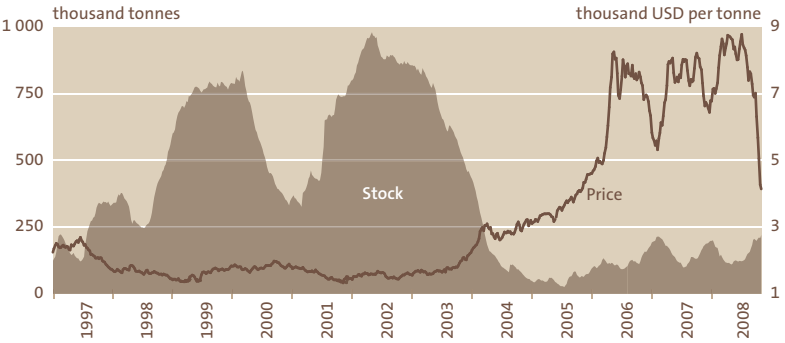


Global copper usage 1988–2007 with a projection to 2015.

more than one-third of all copper ore production. Demand is expected to continue to grow.

Copper prices were stable until 2004, when they rose sharply, peaking in 2006, 2007 and 2008 and then falling sharply in the second half of 2008. The price rise is mainly due to increased demand from China, in combination with speculation in the market.

Copper usage in 2007 was 17.7 million tonnes; usage in 2008 is expected to be 18.3 million tonnes. Further increases are expected over the next few years, with usage projected to reach 28 million tonnes by 2015.



Copper price and stocks.

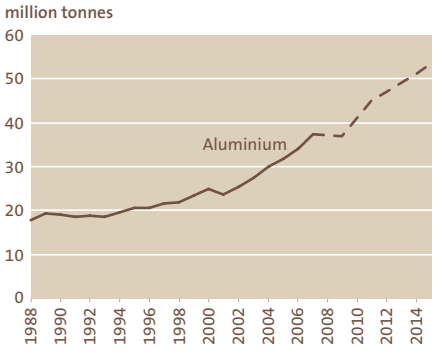
ALUMINIUM

Bauxite is the raw material used in aluminium manufacture. Global bauxite production totalled 193 million tonnes in 2007. The main producer of bauxite is Australia, which is responsible for almost one-third of all bauxite produced.

China is the world's largest manufacturer of aluminium, having virtually doubled its production in three years. China produced 12.6 million tonnes of this metal in 2007. China is also the main consumer, using almost as much aluminium as it produced in 2007 (12.3 million tonnes). Next comes Russia, which produces around four million tonnes of aluminium each year.

Both production and usage of aluminium have risen substantially in recent years. The trend is for an increase in global demand for aluminium, with China providing the main drive.

The global aluminium usage was 38 million tonnes in 2007. That figure is expected to reach just over 50 million tonnes by 2015.



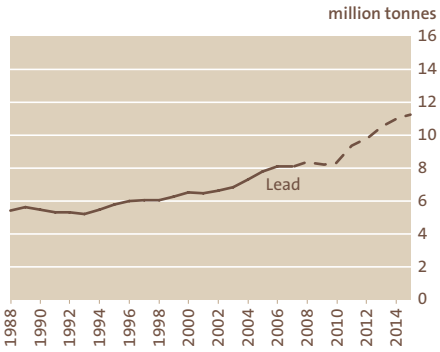
Global aluminium usage 1988–2007 with a projection to 2015.

LEAD

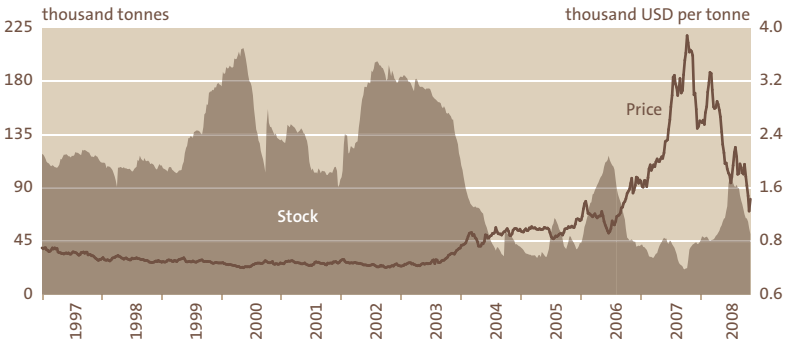
Lead usage is closely related to trends in the automotive industry. Most new cars still have lead acid batteries. Replacement batteries are also needed for older vehicles.

Lead prices have recently fallen dramatically. Moreover, if new types of lead-free batteries with better performance at a reasonable price are developed, this may have a very marked impact on the lead market.

Lead usage totalled almost 8.2 million tonnes in 2007 and is expected to be just under 8.7 million tonnes in 2008. Usage is expected to increase at roughly the same rate as seen in recent years, reaching 11.3 million tonnes by 2015.

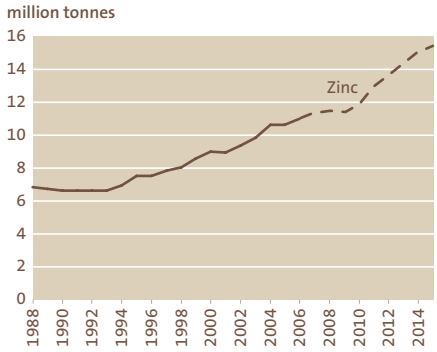


Global lead usage 1988–2007 with a projection to 2015.



Lead price and stocks.

Copper sheeting on a church roof.

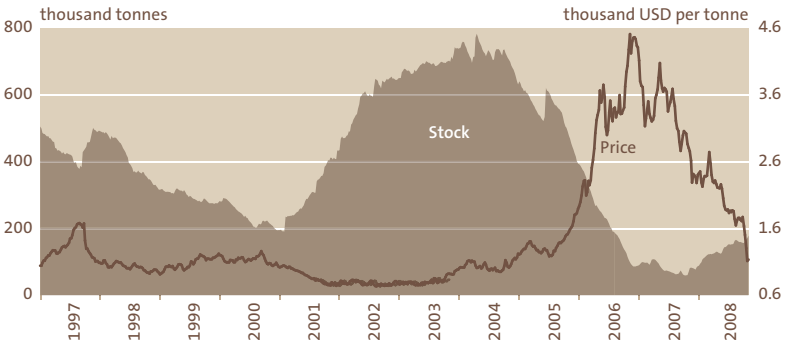


Global zinc usage 1988–2007 with a projection to 2015.

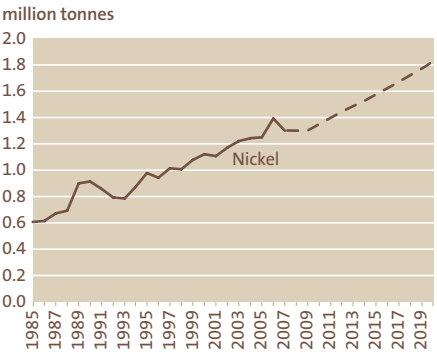
ZINC

Approximately half of all zinc is used in galvanising, which protects steel from corrosion. Therefore zinc usage largely mirrors that of steel. About one-third of all zinc is used in various alloys, including brass and bronze.

The price of zinc has fallen sharply since the end of 2006. The global zinc usage was 11.3 million tonnes in 2007. Usage in 2008 is expected to total 11.8 million tonnes. Zinc usage is expected to increase at the same pace as over the past few years, or somewhat more rapidly, to 2015, when it is expected to be 15.5 million tonnes.



Zinc price and stocks.



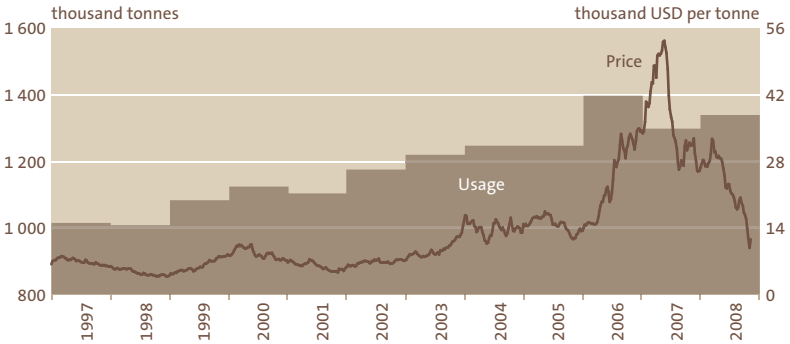
Global nickel usage 1985–2007 with a projection to 2020.

NICKEL

The nickel price trend is very similar to that for lead, peaking around 2007, followed by a sharp fall. Before the fall the price soared from USD 14,000 per tonne 2004–2005 to over USD 52,000 per tonnes in early 2007. Since nickel is used in various alloys, and particularly in stainless steel, this means that the price of the latter also rose steeply, causing a fall in demand. Production of stainless steel using other alloy metals increased, although the steel in many cases was of poorer quality. But the sharp rise in the price of nickel was not solely due to a rising demand for steel; the market had also become highly speculative.

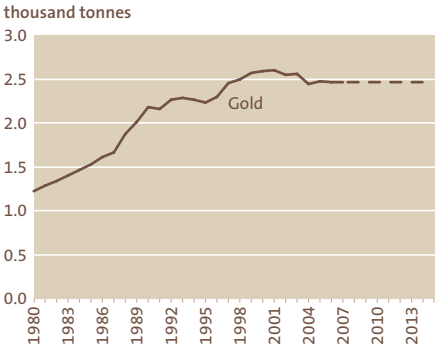
Over a 20-year period nickel usage has increased by an average of 33,500 tonnes a year, except in 2006, when the increase was greater, and 2007 when it was smaller. A total of 1.3 million tonnes of nickel was consumed in 2007. The figure for 2008 is expected to be 1.4 million tonnes. By 2015 it is

estimated that the nickel usage will be 1.5 million tonnes, reaching 1,9 million tonnes by 2020.



Price and usage trends for nickel.

Tin, steel and aluminium are used among other things for tin cans.



Global gold production from mines 1980–2007 with a projection to 2015.

GOLD

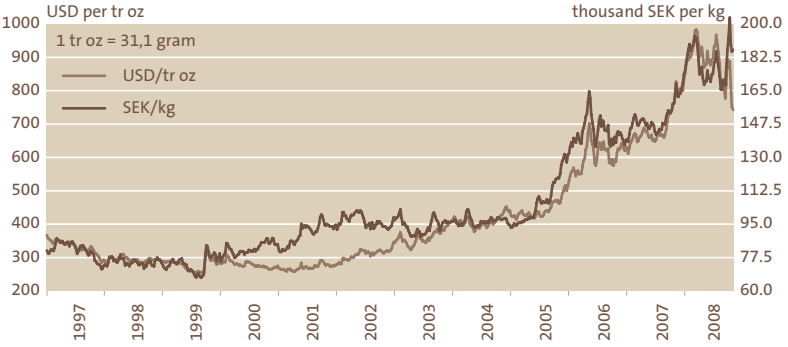
Gold is used primarily to make jewellery; two-thirds of all gold is used for this purpose. The remaining one-third is used in industrial applications (mainly in the electronics industry) or is bought by private investors. Gold is considered a "safe haven" by investors, particularly in times of political unrest and economic downturn, or when currencies decline in value.

Global gold production has been fairly steady over the last ten years, at around 2,500 tonnes a year. Production has not risen, even though the gold price has been relatively high during the latter part of this period. Some 1,000 tonnes of gold is also recycled from scrap each year. This means that a total of 3,500 tonnes of gold is traded each year.

It is estimated that around 160,000 tonnes of gold has been mined around the world through the ages. Some 85 per cent of this gold remains, of which more than half is in jewellery. Less than 20 per cent is in official reserves and about 16 per cent is in the hands of private investors. This gold is put on the market when the price is favourable.

The gold price was fairly stable until 2004, when it began to rise sharply, peaking in the first half of 2008. The price has fallen since then.

Overall, the indications are for production to continue at roughly the same level as over the past few years.



Price trend for gold 1997–2008.

SILVER

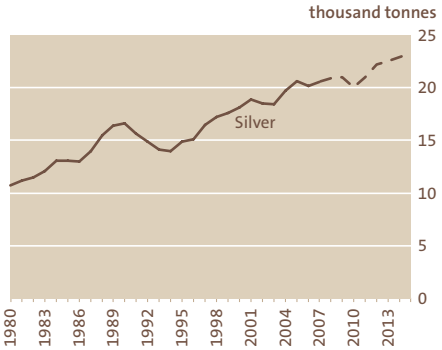
Silver is used primarily in the electronics industry and to make jewellery. It was formerly used in quite large quantities in the photographic sector, but this use has declined with the spread of digital cameras. Silver is also used to make mirrors.

Since silver primarily is a by-product obtained from lead and copper ores, silver production is governed by the trend for these metals.

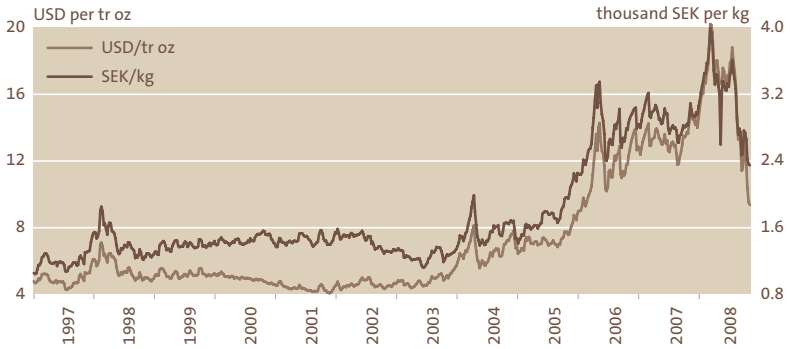
As in the case of gold, the silver price was fairly stable until 2004, when it rose sharply before peaking in the first half of 2008. Since then the price has fallen back to its 2006 level.

It is likely that the use of silver will continue to increase in the electronics industry and in jewellery manufacture.

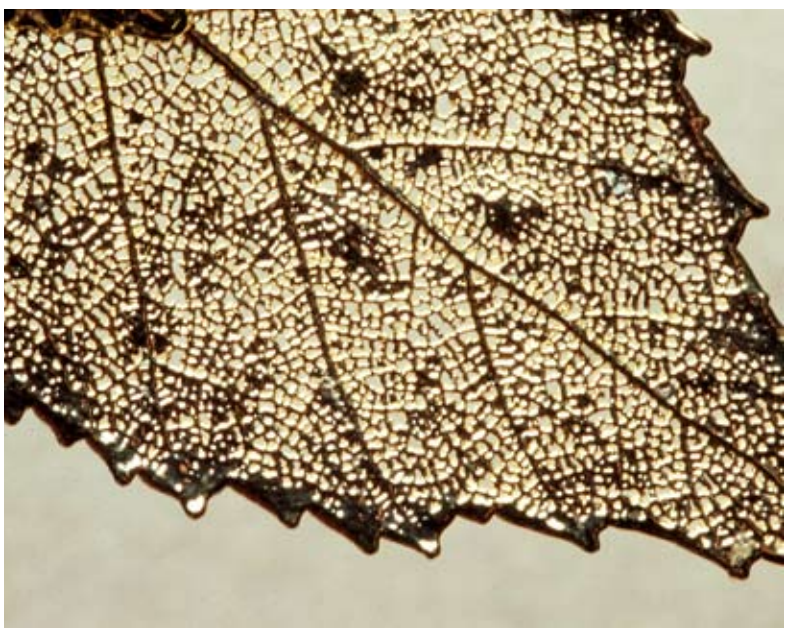
Global silver production was around 18,800 tonnes a year during the period 2000–2003, rising to almost 21,000 tonnes by 2006.



Global silver production from mines 1980–2007 with a projection to 2015.



Price trend for silver 1997–2008.



Jewellery in the form of a gilded leaf.

MORE THAN METALS

Industrial minerals and rocks, dimension stone and aggregates

We need more than metal. Industrial minerals and rocks, aggregates and dimension stone are mined and quarried throughout the world because they are in demand for reasons other than their metal content.

Industrial minerals and rocks are extracted for their specific physical or chemical properties, such as colour, shape and heat or cold resistance. They are used as raw materials or finished products for a wide variety of purposes in most industrial sectors.

In the dimension stone industry, large blocks of rock are quarried. These are then worked into slabs or other suitable forms. Dimension stone is used for paving stones, kerbstones, edging stones, gravestones, cladding on buildings, floor coverings, etc.

Aggregates comprise sand, gravel and crushed stone, and the use of this is intimately related to infrastructure development. Aggregates are mainly used in road construction, pavements, railway ballast and in concrete. The market for aggregates is largely local and regional, but there is a demand in northern Europe and the Baltic countries for hard rock types such as granite and gneiss.

SWEDEN

The industrial minerals and rocks produced in Sweden are limestone, dolomite, dolerite, clay, silica sand, quartz, quartzite, talc and soapstone. Just over 11 million tonnes of industrial minerals and rocks were produced in

2007, mainly in the form of limestone. The pulp and paper industry, mining industry and steel industry use limestone products. These products are also needed for water treatment and lake liming, as well as in agriculture, the food industry and the chemical engineering industry. Limestone is also a key raw material in cement manufacture. The Baltic island of Gotland is the most important source of limestone in Sweden.

In total, around one million tonnes of dimension stone is extracted each year, mainly in southern and central Sweden. About one-quarter of this stone is exported. Many of the varieties of stone are appreciated abroad, are of high quality and have a high market value. Dimension stone possesses unique properties, is long lived and requires minimal maintenance. Dimension stone production has an added environmental value because of the long and energy-efficient life-cycle of natural stone products.

Swedish bedrock, which largely comprises igneous rocks such as granite and gneiss, is often highly suitable for the production of durable rock material. Crushed rock is used, among other things, in the construction of roads, railways and airports and to make concrete. Production takes place throughout the country and totalled over 99 million tonnes in 2007. Most of the material is used within Sweden; only about two million tonnes is exported. However, there is great potential for increased export.

Production of industrial minerals and rocks in Sweden in thousand tonnes (kt).

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Dolomite	426	488	456	490	469	476	574	517	575
Slate (crushed)	14	16	22	27	16	15	16	14	18
Feldspar	34	35	40	37	44	38	30	24	25
Limestone (crushed)	6 604	8 351	8 658	8 520	8 600	8 590	8 934	9 061	9 231
Quartz & quartzite	530	580	371	286	126	221	175	104	144
Quartz sand	518	572	569	564	605	637	691	744	762
Quartzitic sandstone	38	34	5	-	-	-	-	-	-
Talc, soapstone	19	20	14	20	7	8	7	6	7
Olivine	93	83	-	-	-	-	-	-	-
Dolerite	173	177	179	188	180	184	159	153	166
Graphite	61	79	12	-	-	-	-	-	-
Clay	208	244	238	267	253	289	155	311	332
Other industrial minerals	13	13	15	17	18	16	43	6	9
Total	**8 731**	**10 692**	**10 578**	**10 417**	**10 318**	**10 475**	**10 784**	**10 941**	**11 269**

Chisel worker cutting stone. Around 1 million tonnes of dimension stone is quarried every year in Sweden.

Many of the varieties of stone quarried in Sweden are in great demand abroad owing to their high quality.

Production of dimension stone in Sweden in thousand tonnes (kt).

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Diabase and gabbro	223	208	276	190	250	263	253	259	241
Gneiss	436	321	330	282	295	313	306	212	181
Granite	323	306	413	261	224	279	283	318	369
Marble	94	94	105	80	95	62	59	64	83
Other	89	83	94	62	61	64	37	33	36
Total	**1165**	**1011**	**1218**	**875**	**925**	**981**	**938**	**886**	**910**

EUROPE

The EU is an important producer of industrial minerals and rocks. The Union is the world's foremost producer of feldspar (Italy), perlite (Greece, Hungary, Italy) and salt (Germany, France, UK and others) and the world's second-largest producer of bentonite (Greece, Italy, Germany and others), attapulgite (Spain), kaolin (UK, Czech Republic and others), magnesite (Slovakia, Austria, Greece, Spain and others), potash (Germany) and talc (Austria, Finland, France and others).

Perlite is an expanding mineral that is light, white, porous, chemically inert, insulating and fire-resistant. It is used in ceramics, cosmetics and other applications. Bentonite is a clay used to improve soils, as a binder in iron ore pellets and in foundry sand, cosmetics, asphalt, paint, ceramics, etc. Attapulgite is a clay used, among other things, as cat litter owing to its absorptive properties. Kaolin is a white, chemically inert clay used in ceramics, cosmetics and as a coating agent and filler in paper and paint.

Around 35 per cent of the global production of dimension stone is in Europe. Over 80 per cent of European production is in Italy, Greece, Spain and Portugal. Production consists of coarse stone blocks as well as semi-finished products, of which 84 per cent are processed in Italy, Germany, Spain, Belgium, the UK and the Netherlands. More efficient production methods have reduced the quantities of residual stone and it is now possible to process the residues produced into various types of crushed stone or other marketable products.

The EU's main producer of aggregates is Germany, which produced 625 million tonnes in 2006. Other major producers are populous countries such as Spain, France, Italy and the UK. Aggregate is a product that is largely traded locally; the demand fluctuates depending on the state of the construction market.

Production of aggregate.

MINERALS AND DEVELOPMENT

Sustainable growth and reliable markets in developing countries

Global demand for minerals has led to increased interest in the extraction of mineral resources in many developing countries, particularly in sub-Saharan Africa.

For developing countries rich in minerals this represents an opportunity for regional economic growth and a reduction in poverty, but also raises important issues of environmental protection, corruption and human rights.

The EU is heavily dependent on imports of metalliferous minerals, many of which are located in developing countries facing enormous challenges relating to sustainable and transparent governance of their natural resources. There is also the question of the mining industry's social responsibilities for environmental protection and labour rights. In recent years emerging countries, particularly China and India, have shown growing interest in exploration and extraction of mineral resources in developing countries. There is a common European concern that this involvement is designed to secure privileged access to raw materials, resulting in distorted global market conditions in the raw materials industry.

INTEGRATED RAW MATERIALS STRATEGY

The EU Raw Materials Initiative presented in November 2008, proposes an integrated raw materials strategy addressing the importance to EU competitiveness of ensuring access to raw materials from international markets, including the need for reliable and undistorted access to raw materials from developing countries. The initiative recognises EU development policies

as being beneficial both to developing countries and the EU in promoting sustainable growth and poverty reduction as well as European access to raw materials. Capacity building and institutional strengthening for good governance in developing countries contribute to better practices and greater transparency in mining deals and mining revenue, thus establishing a level playing field for all companies in these countries.

SWEDISH MINING FOR DEVELOPMENT

The Geological Survey of Sweden has analysed the potential for contributing to sustainable development of the minerals sector in developing countries by making use of the collective know-how on mineral issues possessed by Swedish trade and industry, public agencies and research institutions.

Associated with the Swedish mining and steel industry is a cluster of companies engaged in exploration, extraction, process engineering and environmental technology that are world leaders in their respective fields. They possess accumulated know-how and have a long tradition of developing effective and sustainable solutions to meet the demand for metals and minerals. Swedish industry helps to achieve sustainable growth in development cooperation by entering into business partnerships with local actors in developing countries, thereby contributing skill, expertise, experience

The Geological Survey of Sweden has trained staff at Angola's state-owned diamond company Endiama, on-site in Angola and in Sweden. This photograph was taken during a study visit to the Swedish Aitik mine.

and innovation while acting with openness and social responsibility. Local presence of Swedish public administration and research give added value for Swedish enterprises active in developing countries. Thanks to Sweden's unique position as a mining country, with efficient public administration and effective regulation in the minerals field, exchange between Swedish public agencies and research institutions and their counterparts in mineral-rich developing countries can make a real difference to these countries in their efforts to build capacity for fair and sustainable development.

HUMAN RESOURCES AND SKILLS

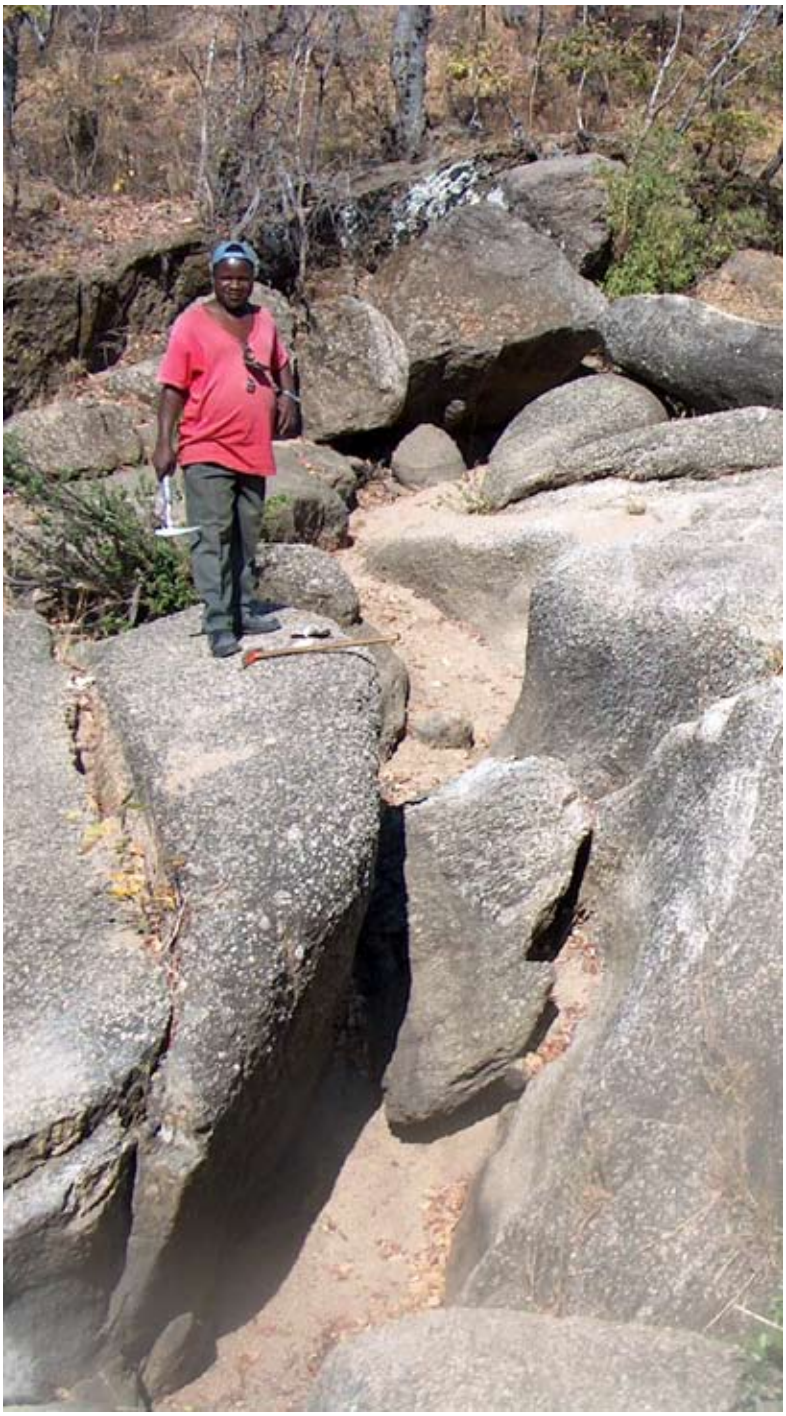
A crucial issue in many developing countries is the lack of skilled staff needed for public management of the mineral sector. The same applies to the mining companies who are in need of trained supervisory staff and technicians to run local operations. Swedish mining industry, research institutions and public administration have the ability to contribute to the human resources development in these countries through institutional co-operation, research and training activities. The creation of links with training establishments in the developing countries is essential as is the training of experts in mining law, techniques, environmental and worker safety, to mention a few. On the local level technical courses on mining equipment and its maintenance is much sought after by the small scale mining enterprises.

GEOLOGICAL INFORMATION IS VITAL

Sustainable development of mineral resources also requires good knowledge and understanding of the geological conditions. Geological information available in databases and maps is a vital part of the national geographical data infrastructure, necessary to attract investors and as a basis for exploration activities and environmental impact assessments.

OPENNESS AND SOCIAL RESPONSIBILITY

The Geological Survey of Sweden has shown that the Swedish resource base has obvious comparative advantages in international development co-operation. By displaying openness and social responsibility, Swedish private enterprise, public administration and research can make a real contribution to fair and sustainable growth in developing countries possessing rich mineral resources. This will help to reduce poverty and stabilise markets, thus improving access to mineral raw materials for European industry.



The Geological Survey of Sweden and other geological organisations have been engaged in a joint project to strengthen the minerals sector in Mozambique. Here, a trainee from DNG – the Mozambique National Directorate of Geological Survey – documents rock samples.

POTENTIAL

For sustainable extraction

A long-term approach is needed in our efforts to assure the supply of raw materials and minerals. This includes more detailed geological information, research and development, as well as supply of expertise and investment in infrastructure.

In the study on which this publication is based, the Geological Survey of Sweden examined the factors influencing sustainable extraction of ores and minerals. The study focused on the situation in Sweden, but many of the issues addressed are common to the whole of Europe.

The Brundtland Commission defined the term "sustainable development" as development that allows people *"...to meet the needs of the present without compromising the ability of future generations to meet their own needs"*.

All aspects of sustainability must be seen in the light of the fact that the mining industry, unlike most others, can only operate where there are suitable mineral deposits. These are deposits that can be extracted in an economically, legally, technically and environmentally acceptable way.

Mining operations impact the environment. Mines, quarries and gravel pits leave scars on nature; residual rock must often be landfilled. Gradual improvements are being made in Sweden and abroad. Abandoned mines and quarries are now being treated in a way that will allow new uses.

Sustainable development is also about reducing the need to mine or quarry new deposits. The principle is not to discard products unnecessarily when they can still be used. When a product is finally disposed of, this must be done in such a way that the material in the product can be recycled.

The Geological Survey of Sweden has identified six strategic focal areas for sustainable Swedish (and Nordic) supply of ores and minerals:

THE CONCEPT OF SUSTAINABILITY
Sustainability has three elements: environmental, economic and social sustainability.

Environmental sustainability is about protecting the environment and finding effective ways of using the earth's resources. Environmental sustainability is most important for our survival.

Economic sustainability means that mankind must not live beyond its means. This requires a sound economy, not only today, but also in the long term.

Social sustainability is about creating strong and sustainable communities. Key elements are fundaments of society, such as laws and rules, culture, social cohesion and scope for personal education and development.

1. GEOLOGICAL INFORMATION FOR INCREASED EXPLORATION

The Geological Survey of Sweden is the Swedish Government's expert body on matters concerning the country's geology and mineral resources. The survey is responsible for producing basic geological information to meet various needs and help to create the right conditions for sustainable development of the country's mineral resources. Methods used to achieve this include systematic surveys, administration, collation and refinement of information already gathered by the Geological Survey itself and by others. Much of this geological information is available via databases.

Geological information on bedrock obtained by way of petrological, geophysical and geochemical surveys, as well as documentation of the ore geology of mines and mining areas is essential to attract investment capital for exploration and implementation of cost-effective exploration projects.

There is a great national need of further mapping, documentation of mines and mining areas and better statistics to minimise the time from investigation to mine. There is also an obvious demand among politicians, public agencies and investors for production statistics on metals and minerals, ore reserves and recources estimates, as well as analyses of market trends.

Geology is not confined to national borders. Sweden's geology is intimately linked with that of parts of Norway, Finland and Russia in the mineral-rich region known as Fennoscandia. Exploration in this area plays a key role in the prospects of assuring the availability of new mineral

The surveys performed by the Geological Survey of Sweden include measuring the gravitational field. These data can be used to map ore-bearing formations, among other things.

deposits that can be mined, thus reducing EU's dependence on imports of important mineral raw materials. As seen above, Sweden and the other Nordic countries have geological survey programmes, but bearing in mind the large sparsely populated areas to be covered, resources are limited and much remains to be done.

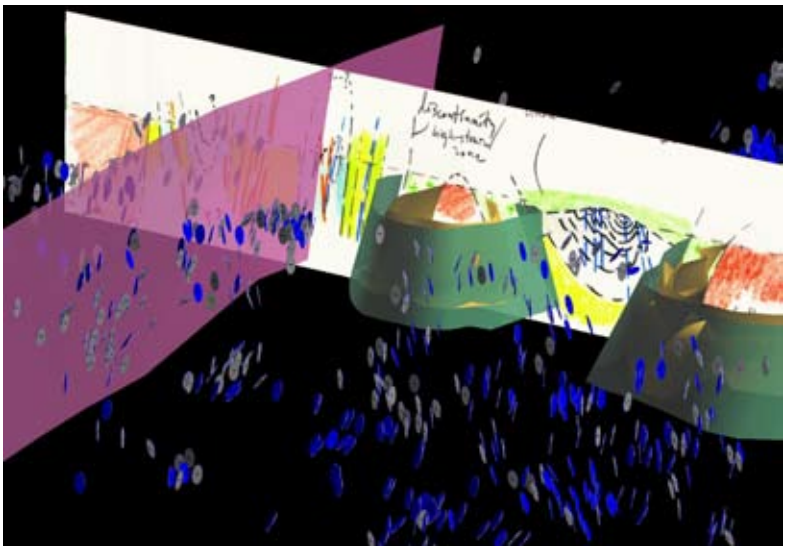
In view of the ore potential existing in the Fennoscandian Shield, the conflicts over access to land for mining and quarrying that are common in other mineral-rich areas of Europe, and the common European need for a reliable and sustainable supply of mineral raw materials, there is a compelling case for a concerted effort to expand and develop geological information available on the Fennoscandian Shield. The Geological Survey of Sweden proposes that the Swedish, Norwegian and Finnish geological surveys be charged with the task of producing a proposal for an EU-funded inter-Nordic project aimed at building up a knowledge base on the Fennoscandian Shield to meet the increase in demand for geological information for exploration purposes.

2. RESEARCH AND DEVELOPMENT

Research and development is essential to the mining industry, as it is for all other industrial operations. It is therefore important to assure sufficient and continuous support, in the EU and nationally, for targeted basic research and for more applied research conducted in collaboration with trade and industry. This applies to the entire production chain – from finding new reserves to extraction, production and site remediation – and is in line with the EU's increased commitment to research and development, for example under the Seventh Framework Programme.

More comprehensive, more frequent and more detailed geological data on the Fennoscandian Shield are needed to meet the needs of the exploration industry.

Applied research in the geosciences is conducted in Sweden at the country's universities, principally at Gothenburg, Lund, Stockholm, Luleå and Uppsala. In addition, long-standing collaboration takes place between universities, private enterprise, trade associations and public agencies in the form of various innovation centres, sectoral research programmes etc. In addition, the Geological Survey of Sweden awards grants each year for targeted basic research and applied research in the geosciences. Since some years a proposal concerning a considerable increase has been urged including grants to ore geological research. In the minerals sector, a Mining Research Programme is currently in progress (2006–2010), as well as a programme for the industrial minerals, aggregates and dimension stone industries (MinBaS II, 2007–2010), for which



Three-dimensional geological modelling (here from the Skellefte district) has gained increased interest in mineral exploration the last few years. Currently Luleå University, Uppsala University, Boliden, Lundin Mining and Geovista are involved in a research project funded by Vinnova and the mining industry jointly.

the Swedish State is contributing half the funding, provided that industry contributes at least as much.

Priority areas for research include developing multi-dimensional geological models to improve our knowledge of deep-lying ores, thereby increasing available ore reserves. A demand for minerals and metals that were previously of no economic interest increases the need for more detailed knowledge of all types of mineral deposits and greater understanding of the various ore-forming processes. Advanced and deepened knowledge of bedrock geology and refined geophysical monitoring methods can provide greater understanding of the structure and properties of the bedrock, and also create new opportunities to locate deposits in areas other than the known ore regions. Greater understanding of rock properties and characteristics is also important as mining depths become ever greater and bring with them a growing importance of worker safety issues as well as technical challenges.

Many complex deposits might be minable if the various constituent metals could be separated out by leaching. This is also of interest from an environmental viewpoint, since unwanted metals can then be removed from the process and isolated as early as the ore dressing phase. The production systems for mining and beneficiation can also be improved by way of lower energy consumption, better yields and minimised environmental

Greater emphasis on geoscience at elementary school, upper secondary school and university is needed to meet the future needs of the exploration industry and the community for knowledge in this field.

impact. For instance, improved rock disintegration can cut costs and reduce incorporation of rock waste, raise ore yields, improve product quality and reduce spillage. Since metals are not really consumed, there is great potential for recycling. Even today, 40 per cent of new steel produced comes from scrap, and there is scope for further recycling of most metals.

3. HUMAN RESOURCES AND SKILLS DEVELOPMENT

The strong increase in exploration in Sweden and elsewhere has revealed a serious shortage of expertise. An ageing workforce in the exploration and mining sector means that up to half of all those working in the industry will have retired within ten years. The situation is similar throughout Europe. The mining industry in Sweden, which also used to recruit personnel from

Finland and other countries, has sought skilled labour in Australia, for example. There is, and will continue to be, a substantial shortage of necessary expertise in all areas of mining, including geologists skilled in exploration.

One problem in this context is that fewer students have been enrolling on natural sciences and engineering programmes (including geosciences) at Swedish universities and colleges in recent years. One way of stimulating interest in these subjects would be to give greater emphasis to geosciences at elementary and upper secondary school level than has hitherto been the case.

Expertise in the field of geosciences is also becoming increasingly important in fields not concerned with natural resources and raw material supply. Some examples are issues of climate, environment, groundwater and "geohazards" such as landslip and landslides. Thus, it is even more essential to emphasise the importance of basic and advanced teaching in the geosciences from elementary school to university level.

4. A SIMPLE REGULATORY FRAMEWORK

The Swedish Minerals Act contains provisions designed to promote exploration and extraction of "concession minerals". Compliance with the Minerals Act is governed by the Mining Inspectorate. There are no restrictions on foreigners obtaining exploration permits and exploitation concessions in Sweden. An exploration permit is granted if there is reason to assume that exploration can lead to the discovery of a concession mineral. A concession is granted if an economically minable mineral deposit has been found and it is not deemed inappropriate for the applicant to be granted the concession requested. The Swedish Environmental Code applies to concessions, which means that an Environmental Impact Assessment (EIA) must accompany concession applications.

For a long-term and capital-intensive industry such as the minerals industry, it is important to have uniform conditions, transparency and reasonable turnaround times. Swedish minerals legislation is considered to be well-designed and effective, with short lead times. The Swedish Government's aim is to continuously evaluate and simplify the regulatory framework to make operations in the sector as efficient as possible.

5. IMPROVED INFRASTRUCTURE

An important – often decisive – difference between mining and other industrial operations concerns the scope for location of operations.

Geology students on an excursion.

Several factors determine whether or not it is economically feasible to start mining operations in a given area. Apart from the need for minable deposits, effective infrastructure is a key factor.

Normally, an industrial plant can be sited close to existing infrastructure such as roads, railways and ports or energy supply systems. Proximity to customers and sub-contractors and the availability of skilled labour also influence the location chosen.

However, for obvious reasons mining must always be located where the mineral deposits are. Access to strategic infrastructure is therefore often the factor deciding whether or not a given mining operation will be profitable. The areas covered by the Fennoscandian Shield are very sparsely populated in comparison with other areas of Europe. Nonetheless, in most cases the road network in Sweden is well developed, thanks to the network of forest roads used by the timber and pulp and paper industries. This makes exploration much easier. Extraction, however, makes greater demands of infrastructure, which must usually be improved or expanded to cope with new or expanded mining operations. Bearing in mind the common European need for a reliable and sustainable supply of mineral raw materials from the Fennoscandian Shield, there is a compelling case for examining the possibility of EU funding for infrastructure investments relating to mining operations in the Nordic countries.

6. GLOBAL DEVELOPMENT COOPERATION

Associated with the Swedish mining and steel industry is a cluster of companies engaged in exploration, extraction, process engineering and environmental technology that are world leaders in their respective fields. Thanks to Sweden's unique position as a mining nation, with efficient public administration and effective regulation in the minerals field, Sweden can make a real difference to developing countries possessing rich mineral resources in their efforts to build capacity to achieve fair and sustainable development. This will help to reduce poverty and stabilise markets, thus improving access to mineral raw materials for European industry.

This brochure is about the future challenges facing the EU with regard to the supply of metals and minerals, and why Sweden has an important part to play in this context. The brochure provides a picture of the situation in the EU and the rest of the world in terms of production, resources and reserves, as well as future demand for metals and minerals. The brochure is based on material on sustainable extraction of Swedish mineral resources that has been produced by the Geological Survey of Sweden at the request of the Swedish Government.

The Geological Survey of Sweden is the central government agency responsible for questions relating to soil, bedrock and groundwater in Sweden.

SGU
Sveriges geologiska undersökning
Geological Survey of Sweden