

# SWEDEN

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A supplement to Mining Journal

# Exploration and mining in Sweden

## SWEDEN: AT A GLANCE

Constitutional monarchy with very stable parliamentary democracy within the European Union (but not the euro).

**Geography:** a Nordic country on the Scandinavian peninsula sharing land borders with Norway (west) and Finland (northeast). The Baltic Sea and the Gulf of Bothnia lie to the east, and the Kattegat, Skagerrak and Öresund straits to the southwest.

**Area:** 450,000km<sup>2</sup> (including lakes and rivers); fifth-largest country by area in Europe and the largest in northern Europe.

**Length:** 1,570km; extends from approx 55°N to 69°N.

**Width:** about 500km (max)

**Climate:** temperate (though temperatures vary greatly from north to south). The coastal areas in the south belong to the warm temperate zone while most of the country has a cold temperate climate. Relatively mild winters are a result of proximity to the warm Gulf Stream of the Atlantic.

**Terrain:** Forest covers more than half; lakes and rivers occupy a further 9%. More than 10% of the land area is mountainous, mainly along the border with Norway.

**Capital:** Stockholm

**Population:** 9.2 million

**Population density:** about 20 people/km<sup>2</sup> (over 80% live in urban areas; highest density in the Öresund region in southern Sweden, and in the lake Mälaren valley near Stockholm).

**Infrastructure:** very good, with highly developed transportation and communication systems. The road and highway network is well developed, as are railroads, airports, electricity grids, IT-infrastructure and mobile phone coverage.

**Corporate tax structure:** competitive (28%)

**Work force:** highly skilled

**Mining:** evidence of activity for at least 1,000 years and has benefited the economy for several hundred years. The strong mining tradition has boosted research and development of industrial infrastructure in the mining regions. Swedish suppliers of mining technology are among the global leaders and the country offers a well-developed support infrastructure, including transportation companies, maintenance services and drilling companies.

**Education:** primary education system extends for nine years, with a voluntary secondary three-year education. Higher education is offered at about 50 universities, university colleges and other institutions. Some 30% of the population aged 30-64 has higher education credits equivalent to a minimum two years of full-time study.

**Mining education and research:** at several institutions, including: Luleå University of Technology, Bergsskolan in Filipstad, Royal Institute of Technology (KTH) and Högskolan Dalarna in Borlänge. Companies such as LKAB and Boliden, with their own research facilities and laboratories, also perform mining-related research.

**T**HE Geological Survey of Sweden (SGU) is the Swedish central government agency responsible for all matters relating to Swedish geology. The agency falls under the Ministry of Enterprise, Energy and Communications. One of SGU's key tasks is to work for sustainable use of Sweden's natural resources. This includes producing data and other material to assist exploration in Sweden.

SGU has several roles in this context. It can offer mineral explorers a range of basic geological data:

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

Sweden is one of the EU's leading producers of ores and metals. It is, for example, by far the biggest producer of iron ore in the EU, and among the leading ones when it comes to the base metals copper, zinc and lead and the precious metals gold and silver.

## EXPLORATION

The Swedish state conducted exploration until 1992, but now exploration is in the hands of private enterprise. Some SEK625 million (US\$92 million) was spent on exploration in the country in 2007, compared with US\$49 million the year before. Almost 100 exploration companies operate in Sweden. Most of them are fairly small, although the major part of investment comes from established mining companies.

Intensive exploration in Sweden during the past few years means many old prospects have been upgraded with new information. This gives an excellent opportunity to take the projects to a higher level.

## MINERAL RESOURCES INFORMATION OFFICE

SGU's branch office at Malå (the Mineral Resources Information Office) serves as a 'one-stop' information office for all those conducting exploration in Sweden. Here, exploration data for all areas of Sweden collected by government-funded activities, in addition to much data from private exploration companies, have been merged and stored in archives and databases.

The data cover all aspects of modern mineral exploration surveys in glaciated terrain, including exploration reports, low-altitude airborne and ground geophysical data and geochemical data. 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 20,000 mineralised boulders from boulder tracing. The National Drill Core Archive contains more than 4,000km of drill core from government-funded and private exploration. Use of the material can save exploration companies time and money.

## SGU – 150 YEARS ON

The SGU was founded in 1858 when Sweden was on the threshold of its industrial revolution. Its expanding

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industry needed ores, minerals and dimension stone for building material.

In 1862, SGU published its first map (scale 1:50,000), which showed both bedrock and soils. In 1917, SGU started mineral exploration.

In 1928, the first major geophysical project started with a magnetic survey of Sweden, and in 1955 SGU's first trial airborne geophysical survey was conducted. Regular air surveys began in the 1960s and a unique geophysical database was established.

Between 1960 and 1974, exploration was by far the dominating activity at SGU. During the Iron Ore Inventory Programme of 1963-1972, SGU investigated 75 iron-ore deposits in Norrbotten County, 14 of which were new discoveries.

From 1974 until 1992 SGU and a state-owned company, SGAB, conducted exploration for the State Mining Property Commission. In 1992 the government decided to end all state-funded exploration. In 1993, SGU's Mineral Information Resources Office opened at Malå.

Following the new instructions to SGU from the government in 2008, activities focused on three core areas: supplying geological information, sustainable use of natural resources and knowledge development.

## EXPLORATION FOCUS

Sweden is attractive for exploration due to its:

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

## IRON-ORE DEVELOPMENT

### Northland Resources

In the Pajala area situated north of the Arctic Circle in northern Sweden, close to the Finnish border, there are several iron-ore deposits. They were originally investigated by SGU in the 1970s, and have now been investigated by Vancouver-based Northland Resources.

The company has been working primarily on three deposits in Sweden: Stora Sahavaara, Tapuli and Pellivuoma. An environmental impact assessment has been undertaken and the company has applied for an environmental permit to start mining the Stora Sahavaara and Tapuli deposits. The company is planning to start open-pit mining at Tapuli in 2009 or 2010.

In a first phase, mining is scheduled at 2Mt/y to produce a concentrate initially. A production increase then will take part in 2011/12 to 5Mt/y when a second mine is planned to be opened. That would be Stora Sahavaara or Hannukainen on the Finnish side of the border. By 2012/13 another increase in production is planned to take place in order to reach a production rate of 13Mt/y.

### Dannemora Mineral AB

The Dannemora iron-ore mine is known to have been in operation as early as the 14th century. It is situated some 110km north of Stockholm in the north-eastern part of the Bergslagen mining district. The mine was in operation until 1992, when it was closed due to the weak price of iron ore. The company estimates that there are at least 28Mt of ore left in the mine.

Initial financing was secured during 2008 through a fundraising of SEK155 million. Dannemora has received permission to start mining through an exploitation concession and received its environmental permit in mid-2008.

Much of the necessary preparation work was completed before the mine was closed: there is already access to the mine through a ramp system, and both the main haulage levels and the main shaft with its head frame are present. As the mine is partly filled with water (up to 315m in depth) there remains some pumping to be done, and ventilation, electricity etc must be installed before mining can start. The uppermost orebody is situated at a depth of 170m.

The products from the initial mining will be lumpy ore and concentrate. Total investments during the first four years are calculated at SEK840 million. This will include the mine crushing, sorting and concentrating plants, which will use mainly magnetic separation as

the ore is largely magnetite. The magnetite has manganese content of 1.8%, and ore production is aimed at 1.5Mt/y.

There is a railway from the mine to the harbour of Hargshamn on Sweden's east coast.

### Grängesberg Iron Ore Co AB

London-based Mikula Mining Ltd has acquired a 67% interest in Grängesberg Iron Ore Co AB (GIOG), a subsidiary of Swedish junior Roslagen Resources AB. Mikula has committed to invest £3.5 million (US\$24 million) in GIOG to conduct feasibility studies on a restart of the Grängesberg iron-ore mine and development of the Ekströmsberg iron-ore deposit. The Grängesberg iron-ore mine was the largest iron-ore producer in central Sweden before it was closed in 1989.

Ekströmsberg, which is situated in northern Sweden, west of Kiruna, has reported resources of more than 100Mt at 40% Fe. The company has acquired exploration permits for several known iron-ore deposits, including Norberg in the Bergslagen mining district and Tjärrojäkka and Åkosjegge in the Kiruna area.

### Luossavaara-Kiirunavaara AB

Luossavaara-Kiirunavaara AB (LKAB) runs two iron-ore mines in the northernmost part of Sweden: Kiruna and Malmberget. The ore at both mines is predominantly magnetite, and the company has processing and pelletising plants at both Kiruna and



Pelletising plant and concentrating plant in Kiruna

Photo: LKAB



Dannemora iron mine

Photo: Dannemora Mineral

## DANNEMORA

MINERAL AB

**Dannemora Mineral AB\* is a public limited Swedish mining and exploration company, with the main objective to recommence mining operations in the Dannemora iron ore mine. The Company also engages in exploration activities with the objective to increase the iron ore base locally and regionally.**



The head frame and process plant at the Dannemora mine.

The Dannemora iron ore deposit is fully permitted. It is located in Central Sweden, some 100 km north of Stockholm City and 35 km west of the Port of Hargshamn from where ore shipments is planned to take place.

The Dannemora iron ore mine is one of the oldest in Sweden. For several centuries it was one of the most important iron ore producers in the country and in Europe. Due to low iron ore prices the mine was closed down in 1992.

The ore processing plant is scheduled to be operational in first quarter of 2010. Production in the mine and plant will then gradually work up to full capacity by late 2011/early 2012. The annual production is estimated to be 0.75 Mt lump ore and 0.75 Mt fines. Dannemora Mineral has now entered the final phase in its funding of the Dannemora iron ore project.

\*Quoted on First North, an alternative market, operated by the different exchanges within OMX

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## SALA SILVER MINE

The mining industry in Sweden has a long history, with the earliest records dating as far back as the 13th century.

In 1512, the Sala silver mine at Salberget was mentioned by the Swedish King Sten Sture in a written decree to miners. Production peaked during the mid-16th century, mostly due to king Gustav Vasa who understood the importance of the silver deposit for the Swedish economy and the wealth of the royal family. During the reign of his two sons Erik and Johan, production at the Sala silver mine stagnated, and during the 1570s several large collapses occurred in the mine, further reducing production.

In 1591, Duke Karl hired experienced miners from Germany to organise and plan mining at Sala in accordance with German mining traditions. The Germans introduced completely new mining methods, included better organisation of miners, sinking of new shafts for hauling ore and equipment, as well as for pumping of water and underground mining in open stopes.

Between the early 17th century and mid-19th century, several new shafts were sunk as the mine deepened. Queen Christina's shaft became the main shaft and when it reached its final depth of 257m it became the deepest shaft ever to be created by fire setting alone.

Production at the mine steadily declined from the early 17th century. In 1887 the state finally terminated its interests in the silver mine and handed it over to a private company. Mining ceased in 1908 following a strike when the pumps were turned off and the mine was partially flooded (although there was some exploratory work in the late 1940s). During its life, the Sala mine produced close to 14.5Moz of silver, making Sala the fifth-highest historic silver producer worldwide.

Today, the historic mine is accessible by tourists down to the 155m level, where evidence of the practice of breaking rock by means of fire is still visible.

Several attempts to locate additional mineral resources in Sala were made after the closure of the nearby small Bronäs mine in 1962. Extensive exploratory work in the 1980s led to the discovery of a small extension of the Sala orebody, but it was considered too small at the time for mining.

In 2005 a new attempt at locating additional mineral resources commenced by Tumi Resources Ltd of Canada. By studying the structural geology of the Bronäs and Sala ores, a previously-unknown mineralisation was discovered west of the Sala mine. The total dimensions of the discovery is yet to be determined but resource-grade intercepts of silver-zinc mineralisation up to 45m wide have been made along an 800m interval. The mineralisation remains open along strike as well as at depth.



Queen Christina's shaft

Photo: Tumi Resources

Malmberget, as well as at Svappavaara.

Production in 2007 was 24.7Mt, up 1.9Mt from 2006. The pellets' share of production was 18.8Mt (76%). For the first three quarters of 2008, ore production was 18.0Mt, somewhat lower than the 18.3Mt in the same period of 2007. Production was interrupted in the Malmberget mine due to a fire in February, which necessitated repairs, and normal production was not resumed until April.

Deliveries were 17.5Mt and stocks were 2.2Mt as of end-September 2008.

The new SEK6 billion concentrator (KA3) and pelletising plant (KK4) in Kiruna produced their first pellets in May 2008, and the plant was inaugurated in June. With the new plant in operation, LKAB is reaching record levels of pellets production.

Recently, the LKAB board decided on investments totalling SEK12.4 billion in a new main level at the Kiruna mine.

With operations going down to greater depth, an expansion of the deformation zones at the surface will have an increasing impact on future planning for the city of Kiruna. Much of the central parts of the city will have to be moved to a safer site, including the church and the town hall. This will require another SEK12.5 billion.

The new main haulage level will be in operation in 2012. Unlike current and former haulage levels it will have tracks of European standard width, 1,435mm. By that time, production is calculated to be 35Mt/y of crude ore in the two LKAB mines.

Via its subsidiary Minelco, LKAB has been granted a permit for test mining of 50,000t of iron ore at the Gruvberget iron-ore deposit near Svappavaara.

LKAB is planning to make Gruvberget an open-pit mine with a maximum annual production of 2Mt of magnetite products. An application has been

submitted to the environmental court in order to obtain permanent permission for that production. From earlier investigations, the mineral resources are known to be at least 27Mt of magnetite and hematite. A test programme is under way to verify further extension at depth and to the north.

In Malmberget, there is new interest in the old mining dumps. A test programme is under way to determine whether the dumps can be included in the feed to the concentrator in Malmberget.

LKAB is continuing its efforts to improve logistics from the mines to the ports, and new locomotives and ore cars are replacing the older trains. The new trains are 750m long and capable of carrying 6,500t.

The loading and unloading terminals are being improved. The latest terminal, building of which is in progress, is at the harbour of Narvik in Norway where ten underground silos are being constructed in caves, which will allow the trains to be emptied when running.

Through the investments in production and logistics, LKAB will have the capacity of producing some 30Mt/y of pellets. The new level will secure mining in Kiruna to 2035.

## BASE- AND PRECIOUS-METALS EXPLORATION

### Boliden AB

Boliden is carrying out a large exploration programme focused mainly on its mines and the surrounding areas. In-mine exploration has been reported to be successful at Garpenberg and the Boliden area. Field exploration is concentrating on base metal and gold in the Skellefte field and on base metals in Dorotea, Norrbotten and Bergslagen. Some 20 projects are under investigation using geochemistry, deep-penetrating electromagnetic geophysics and diamond drilling.

### Lundin Mining Corp

Lundin Mining's exploration in the vicinity of Zinkgruvan has been focused on the new discoveries at Dalby and Finnafall. At Dalby, a high-grade Zn-Pb-Ag mineralisation has been discovered which is situated at great depth. A 41m section of drill core assayed 13.4% Zn, 10.2% Pb and 179g/t Ag.

### Dragon Mining Ltd

Dragon Mining performed diamond drilling during the summer of 2008 on the deeper parts of the orebody at the Svartliden mine with a total of 4,460m in 28 holes. The results so far show an extension to the depth with good gold content indicating a possible future underground operation at Svartliden.



Photo: Boliden

Aitik open-pit copper mine

**Base Metals**

1. Ahmavuoima copper, gold, cobalt
2. Viscaria copper, zinc
3. Rakkurijärvi copper, gold, iron
4. Norrbotten copper, gold
5. Liikavaara Östra copper, gold
6. Aitik copper, silver, gold
7. Majves copper, gold
8. Ballek copper, gold
9. Jervas copper
10. Uma copper, zinc, lead, silver
11. Notträsk nickel, PGE
12. Storbodsund nickel, copper, cobalt
13. Ersmarksberget zinc, gold
14. Eva zinc, copper, silver
15. Rönnbäcken nickel
16. Lainejaur nickel
17. Storliden zinc, copper
18. Remdalen copper, zinc, gold
19. Rackejaur zinc, copper, silver, gold
20. Svärträsk zinc, lead, silver
21. Vindelgransele zinc, copper, lead, silver
22. Stekenjokk zinc, lead, copper, silver, gold
23. Maurliden zinc, copper, silver, gold
24. Kristineberg zinc, silver, copper, gold, lead
25. Norrliden zinc, copper
26. Petiknäs zinc, silver, lead, copper, gold
27. Renström copper, zinc, lead, silver, gold
28. Östra Åkulla zinc, silver, copper, gold, lead
29. Boliden copper, gold
30. Långträsk zinc, copper, lead, silver
31. Lappvattnet nickel
32. Ormsjö lead, silver
33. Lövstrand lead
34. Rörmjärberget nickel
35. Hoting nickel, copper
36. Bellviksberg zinc, lead, silver
37. Granberget zinc, lead
38. Rockliden copper, zinc, lead, silver, gold
39. Storkullen zinc, gold
40. Slättberg nickel
41. Falun copper, gold
42. Garpenberg zinc, silver
43. Lovisagruvan zinc, lead, silver
44. Dingelvik copper, silver
45. Zinkgruvan zinc, lead, silver, copper
46. Tomtebo
47. Vittunn
48. Sala

**Iron**

49. Kiirunavaara
50. Mertainen
51. Gruvberget
52. Leveäniemi
53. Stora Sahavaara
54. Malmberget
55. Grängesberg
56. Dannemora

**Gold**

57. Grundträsk
58. Vargbäcken
59. Älgträsk
60. Barsele
61. Björkdal
62. Stortjärnhobben
63. Svartliden
64. Fäboliden
65. Enåsen
66. Solvik
67. Gladhammar

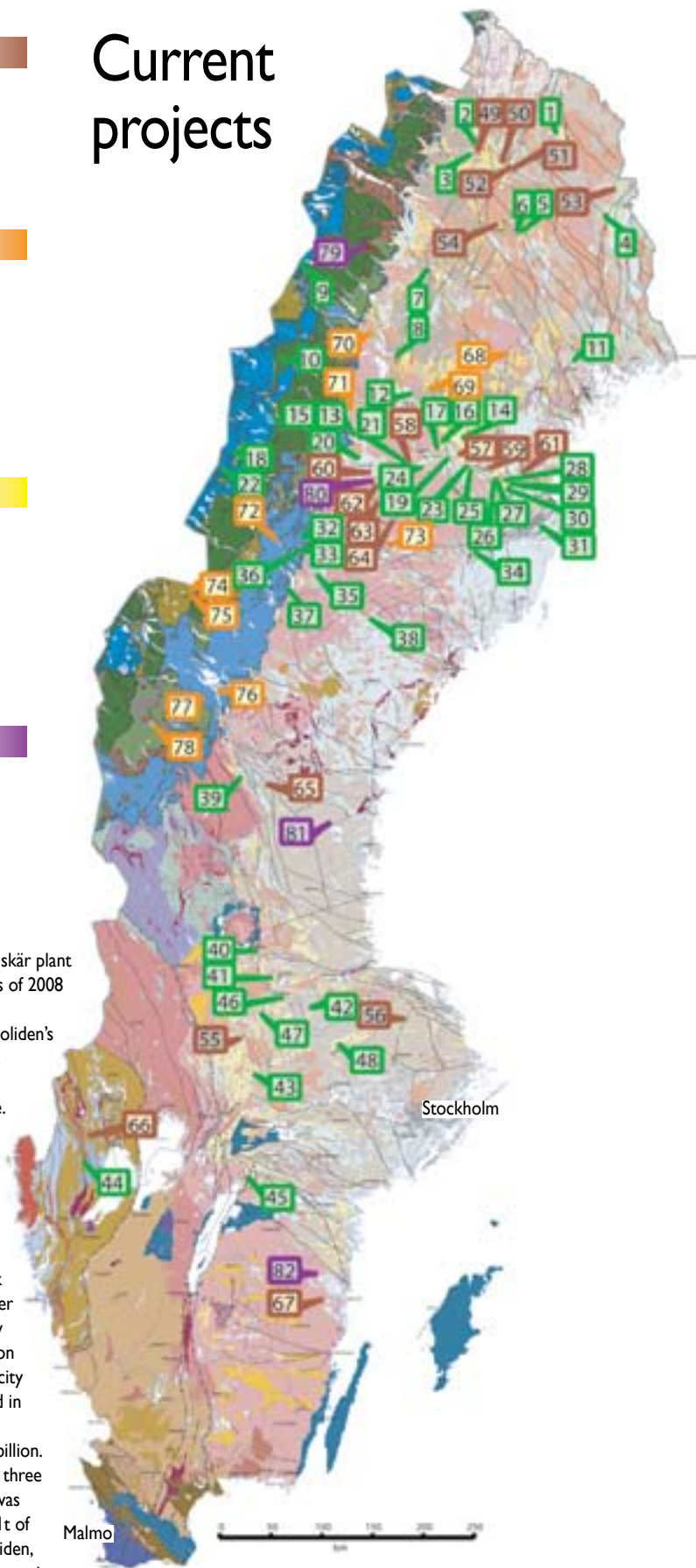
**Uranium**

68. Kvarnån
69. Norr Döttern
70. Pleutajokk
71. Duobblon
72. Täsjö
73. Björkråmyran
74. Lilljuthatten
75. Hotagen
76. Viken
77. Southern Östersund Area
78. Storsjö

**Other Commodities**

79. Routevare titanium, iron
80. Storuman fluorite
81. Sumässjön vanadium
82. Olserum REE

# Current projects



**IGE Nordic AB**

IGE Nordic is involved in a number of joint ventures and also has a number of its own prospects. The company recently has reported on drilling from its Rönnbäcken nickel project where 95 drill holes (14,981m of a 16,000m drilling programme) have been completed.

**MINE DEVELOPMENT**

**Lapland Goldminers AB**

In April 2008, Lapland Goldminers performed a feasibility study for its Fäboliden gold project situated 40km from the town of Lycksele in northern Sweden. A mill will be constructed at Fäboliden which will process 4.6Mt/y. Mining will start in 2011 in an open pit and then continue underground. Reserves for the open pit are estimated at 22.9Mt at 1.2g/t Au (as at April 2008) and for the underground mine at 30.5Mt at 1.07g/t Au.

**Avalon Minerals Ltd**

Avalon Minerals is planning to reopen the Viscaria copper mine in the Kiruna area in northern Sweden.

**MINING**

**Boliden**

Boliden operated five mines in Sweden during 2008, and one (Tara) in Ireland. The company also owns the Rönskär copper and lead smelter and the Bergsöe secondary lead plant in Sweden, the Harjavalta copper plant and Kokkola zinc works in Finland, and the Norzinc zinc works in Odda, Norway.

Production at the Rönskär plant for the first three quarters of 2008 was 169,130t of copper.

The northernmost of Boliden's mines is the Aitik open-pit copper mine close to the Malmberget iron-ore mine. At Aitik, construction is under way of a new concentrator and mining plant to double production from the present 18Mt/y to 36Mt/y. In addition to copper, Aitik will also produce gold, silver and molybdenum. The new plant should be in operation in early 2010 and full capacity is scheduled to be reached in 2014. The investment is anticipated to total SEK6 billion.

Production for the first three quarters of 2008 at Aitik was 12.76Mt, containing 32,791t of copper. In the town of Boliden, the company runs a concentrating plant serving the mines of the Skellefte district.

The mines run by Boliden in the Skellefte District are Kristineberg, Maurliden and Renström. Production for the first three quarters of 2008 was 967,000t, containing 29,635t of zinc and 7,615t of copper.

The southernmost of the Boliden mines are the

two that form the Garpenberg operation in the Bergslagen district of central Sweden. The two mines (Garpenberg and Garpenberg North) are connected to each other via a drift, and are considered as a single operation. Higher production, together with higher grades, is contributing to record output. As a

greater part of the mining takes part in the Lappberget area, where the richer ores are mined, it has been necessary to use backfill in order not to leave any ore in the mine. For that purpose, a paste-filling facility has been built at the concentrating plant.

For the first three quarters of 2008, production at Garpenberg was 1.01Mt, containing 59,837t of zinc, 20,608t of lead and 95,534 kg of silver.

**Lundin Mining**

Lundin Mining runs the Zinkgruvan zinc-lead mine some 60km south of the city of Örebro. The Zinkgruvan mine has been in continuous operation since 1857. During the first three quarters of 2008, ore sent to the concentrator totalled 668,857t. The metal content of the concentrates produced during the first three quarters of 2008 amounted to 50,595t of zinc, 25,784t of lead and 1.32Moz of silver.

In Zinkgruvan, a copper-ore deposit is being prepared for mining that is planned to start in 2010. A second crusher will be installed underground and a new ramp, which is under construction, will give access to the ore. In the concentrator, a new copper flotation section is under construction.

**Dragon Mining**

Dragon Mining's Svartliden gold mine is situated 40km northwest of the town of Lycksele in northern Sweden. During the first three quarters of 2008, 33,000oz of gold was produced in the carbon-in-leach plant, exceeding expectations, with utilisation over 96%.

**Gold-Ore Resources Ltd**

Gold-Ore Resources operates the Björkdal gold mine near the city of Skellefteå. The mine produced 28,000oz of gold in fiscal 2008. Material for processing is taken from three sources: underground, open pit and stockpiled ore at the surface. Gold-Ore is considering a higher underground production, moving from present test mining to commercial mining by accessing more levels.

**Lovisagruvan AB**

At Lovisagruvan, near the former iron-ore mine of Stråssa in the Bergslagen mining district, production for the first three quarters of 2008 was 20,245t of lead ore, an increase of 70% compared with the same period in 2007 (17,200t).

River in northern Sweden

Photo: www.bildstrom.net



**SRK SWEDEN**

**SRK Consulting target the Nordic Region**

SRK Consulting is opening an office in Skellefteå, northern Sweden, bringing the services of a global mining consultancy to the Nordic Region.

Increased exploration and development activity throughout the area has presented an excellent opportunity for SRK to work with a growing number of mining and exploration companies of all sizes.

SRK is in the process of recruiting personnel from all mining related disciplines with a view to commencing business in the second quarter of 2009.

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## URANIUM

Why have several companies shown considerable interest in Swedish uranium prospects during the past few years?

Sweden is the fifth-most active uranium exploration country in the world based on reported projects (after Australia, Canada, US and Mongolia). Uranium prospectivity is identified across a 2-billion-year time window, and includes many good examples of a range of uranium deposit styles, with geological ages and settings similar to those in major uranium provinces in Australia, Canada and Southern Africa.

There is no ban on uranium mining in Sweden but the municipal government of the area where a specific project is located retains a right of veto for uranium mining projects.

Uranium exploration in Sweden started more than 100 years ago. It is known that Mr AE Nordenskiöld mined uranium at Billingen in 1898/99. What he was looking for was the yellow secondary minerals used as an agent in glassware. This mine is still the only commercial uranium mine in Sweden.

Modern uranium exploration in Sweden dates to the end of the Second World War. Direct and indirect state financed exploration was then carried out until 1986.

### Precambrian basement

Swedish uranium occurrences are of two main types: Precambrian basement hosted and Cambrian to lower Ordovician sediment deposits. Styles of mineralisation



Drill cores with alum shale

Photo: Aura Energy

20m thick, but greater thicknesses occur (up to 100m). The extent of the shale in Sweden is estimated to over 18,000km<sup>2</sup> and can be considered to be the largest uranium resource in Europe.

The term alum shale was introduced more than 300 years ago to refer to particular parts of this black shale from which the alum salt (K Al (SO<sub>4</sub>)<sub>2</sub> + 12 H<sub>2</sub>O) was extracted. The formation is dominated by black shales with an organic carbon content ranging up to 20%.

That the Scandinavian alum shales are remarkable for their content of uranium has been known since the turn of the last century.

in the Precambrian basement include mostly intrusive or hydrothermal vein-related uranium occurrences. Most larger occurrences seem to be epigenetic. One area, Duobblon in the north, is part of the acid volcanic-related spectrum. Several areas have been considered for more detailed exploration. Mineralisations most often occur in the form of pitchblende or uraninite.

### Scandinavian alum shales

Low-grade black shales of Middle and Late Cambrian and locally of earliest Ordovician age are developed extensively in Scandinavia. This shale facies composes a characteristic formation that can be recognised from Finnmark in northernmost Norway to Skåne (Scania) in southernmost Sweden. In general, the unit is about

The local occurrence within the shales of kolm lenses containing up to 5,000ppm U was reported by Nordenskiöld in 1893.

Generally, the shales contain about 150-300ppm, varying for different parts of the alum shale regions. More recently it has been discovered that the shales contain unusually high concentrations of other trace elements, particularly vanadium, molybdenum and nickel, in addition to rare earth elements. Alum shale generally shows a sympathetic relationship between uranium and the other metals.

A facility for test mining of uranium, Ranstad in Västergötland, was in operation between 1965 and 1969, during which it produced 210t of uranium. A refinery test plant for uranium was constructed to

## CONTINENTAL PRECIOUS MINERALS

In the Östersund district in northern Sweden, Continental holds exploration licences covering 143km<sup>2</sup> of Alum shale. The results in the table below are based upon 61 drill holes within a 3km<sup>2</sup> area known as the Viken licence. These holes penetrate the thick black shale which is uniformly mineralised down to 150-200m, containing, uranium, nickel, molybdenum and vanadium as shown in the plots (Figure 1, right). This extensively-explored area corresponds to less than 10% of Continental's licences in the Östersund district. The drilling (>70 holes) on these peripheral licences demonstrates a very much larger regional potential.

In southern Sweden, Continental hold several licences covering Alum shale in which the hydrocarbon content is present (ie 'Shale oil'). The shale was mined, processed and recovered *in situ* for oil during and after the Second World War (1942-1966). These extensive shale units are currently undergoing drill testing. The potential of the shale resources of oil were estimated by the Geological Survey of Sweden at 685Mt. In the easternmost part of the county of Närke, the oil yield values increase to almost 8wt%.

In addition, Continental holds eight hard-rock uranium deposits (11 licences) all in the Precambrian basement. These are situated in the central and northern part of Sweden. During the 1950s to 1985, SGU performed extensive fundamental surveys on these deposits. The indicated resources of these 'hard rock uranium' deposits contain more than 5,000t of uranium (AH Phillips July 2005 NI 43-101 technical report).

### VIKEN BLACK SHALE HOSTED METAL CONTENTS

Inferred resources	Shale	U <sub>3</sub> O <sub>8</sub>	V <sub>2</sub> O <sub>5</sub>	MoO <sub>3</sub>	Ni
Tonnes (000s)	1,166,135				
lb/t		0.33	5.57	0.71	0.62
Grade %		0.017	0.278	0.035	0.031
lb metal/oxide (000s)		437,046	7,146,994	899,801	796,967

G Harron April 2008. NI 43-101 (NB: for indicated resources see original document)

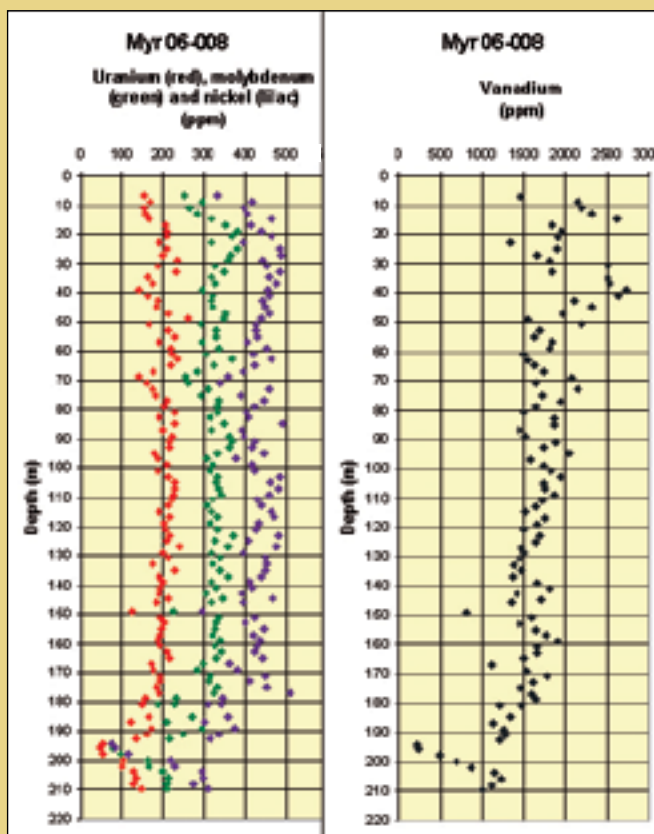


Figure 1. Viken drill hole No 06-008. U, Mo, Ni and V content

## MAWSON RESOURCES: URANIUM EXPLORATION

The Swedish state undertook uranium exploration from the early 1960s through to the early 1980s. Approximately US\$45 million (in the currency of the day) was spent exploring for uranium with a view to self-sufficiency, ranking Sweden 20th in terms of global uranium exploration expenditure. The exploration effort was highly successful in identifying 'high merit' uranium prospects, and included the mining of 215t of  $U_3O_8$  from Ranstad over four years in the late 1960s. This legacy of state-run exploration and historic data in Sweden gave Mawson a strong head start when beginning uranium exploration four years ago.

Sweden is the second-highest uranium-consuming country on a *per capita* basis through its extensive utilisation of nuclear power. The first reactor was commissioned in 1964 and today approximately 50% of the country's power comes from ten nuclear reactors, the remainder being contributed by hydro power, wind power and biofuel combustion.

Currently, Sweden is one of the most actively-explored countries for uranium worldwide, with over 15 companies registering uranium exploration claims. The Swedish Mining Act provides a clear investment environment and allows for uranium exploration. Despite a controversial history, there is no ban on uranium mining in Sweden today and the current government has stated it will review all uranium

mining projects in light of the relevant legislation and environmental standards. The municipal government of the area where a specific project is located retains a right of veto for uranium mining projects.

Mawson's uranium exploration focus is on the Hotagen uranium province in central western Sweden, where 95% of the prospective ground is held by the company. Hotagen is home to numerous significant vein and breccia related uranium deposits, including Mawson's Kläppibäcken deposit where a 2008 drill campaign increased the indicated resource to 3.3Mlb at a grade of 0.08%  $U_3O_8$  and included intersections of 38.9m at 0.16%  $U_3O_8$ . Summer field programmes have discovered a large number of new uranium mineralised bedrock sites, highlighting the potential of the Hotagen province to host a major deposit.

Mawson believes Sweden fulfils the prospectivity and political requirements of a risk-aware exploration company. The European Union has the world's greatest *per capita* consumption of nuclear power, and relies for its uranium supply on countries that lie outside the geopolitical region. The bedrock is prospective for a range of deposit types, and both Sweden and Finland have a long history of uranium exploration and mining. Through its strong and committed community presence, Mawson become part of Sweden's progressing energy debate.

treat the ore and a method was developed for extraction. The final recovery of uranium – at the end of the 1970s, after further refinement of the process – was about 85%.

### Service for uranium exploration companies

The Geological Survey of Sweden explored for uranium between 1968 and 1986, and approximately 2,000 anomalies were followed up. Several prospects were drilled but, due to political decisions made at the beginning of the 1980s, all uranium exploration stopped.

All exploration data, from field notes and airborne radiometrics to drill core assays and project reports, are today available at the Mineral Resources Information Office at Malå.

Mineral Resources Information Office, Malå

Photo: SGU



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The National Drill Core Archive

Photo: SGU

## MINERAL HUNT

Since 1967 there has been a national competition called *Mineraljakten* ('mineral hunt'). All members of the public, except professional explorers, can participate. The annual total prize money is around US\$40,000, and the intention is to receive indications of new areas of metals and industrial minerals potential, with the ultimate aim being to develop mineral projects, thereby creating jobs in remote areas.

Exploration companies participate in the evaluations of the best finds. The Mineral Hunt has resulted in the location of several deposits and prospects, and some of them have been mined. For example, the Tjärnberget zinc-copper deposit and the Lilljuthatten uranium prospect in Jamtland province were found in the 1970s. Graphite at

Kringeltjärn in central Sweden was mined in the 1980s, and the Harnäs gold deposit in western Sweden was mined in the 1990s.

A recent example is the Storkullen zinc-gold project in Jamtland province, which was found by Harriet Svensson and Siv Wiik during the 2007 Mineral Hunt. The exposed bedrock includes a 2.5m interval of high-grade zinc-rich massive sulphide adjacent to a pyritic and siliceous felsic gneiss. In addition to the very high zinc grades, high-grade gold was analysed from the siliceous gneiss, emphasising the precious metal potential of the mineralised outcrop and surrounding claims. The massive sulphide mineralisation is open on the southwestern, northwestern and southeastern contacts. Hansa Resources now runs the project.

## SWEDISH MINERALS ACT

The Act is applicable to exploration and exploitation on land regardless of its ownership.

### Exploration permit

An exploration permit is granted for a specific area where there is a likelihood of a successful discovery being made. It should be of suitable shape and size and no larger than may be assumed can be explored by the permit holder in an appropriate manner.

A permit shall not be granted, however, if it is obvious that the applicant has not the opportunity or intention of conducting appropriate exploration or has earlier shown to be unsuitable to conduct exploration work.

An exploration permit is valid for a period of three years from the date of issue. After that, on application, it may be extended by another period of up to a maximum of three years if suitable exploration has been carried out within the area. In exceptional cases,

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The new main level will be the seventh since underground mining began in Kiruna in 1962. The investment will ensure that LKAB can deliver high quality products until about 2035.



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Drilling in wintertime

Photo: Aura Energy

the period of validity of the permit may be further extended but for no more than a total of four years, and in extreme cases by a further maximum of five years. This means that the longest possible valid

period for any one permit is 15 years.

Exploration and exploitation cannot be carried out in national parks. Such activities are also seldom permitted in certain areas, for example within 200m of any inhabited building, and within certain areas in the Swedish mountains.

Before the beginning of any exploration work that can have a significant impact on the natural environment, notice of consultation shall be made to The County Administrative Board in accordance with the provisions in the Environmental Code.

Before exploration work begins, the permit holder must set up a working plan. The plan shall contain a description of the work intended, a timetable and an assessment of the impact on private rights and public interests.

The explorer has to submit security for the compensation of damage and encroachment from exploration work. Before any work can start the sum of security has to be guaranteed.

When an exploration permit is terminated without the granting of an exploitation concession within the exploration area, the permit holder shall – if he is carrying on exploration work professionally – within three months at the latest provide a report of exploration performed.

#### Exploitation concession

A concession is valid for a definite area, decided on the basis of the extent of the deposit, the purpose of the concession and other circumstances. A concession shall be granted if a mineral deposit has been found which can probably be exploited economically.

The Environmental Code shall be applicable in matters concerning the granting of a concession, which means, *inter alia*, that an Environmental Impact Assessment shall be contained in an application.

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An exploitation concession is granted for a period of 25 years unless the applicant requests a shorter period of time. The concession period is extended by ten years at a time without application if regular exploitation is in progress when the period of validity expires. When mining, the holder of an exploitation concession must pay an annual minerals fee to the landowners of the concession area and the state. The fee is 2 parts per thousand (ie 0.2%) of the average value of the concession minerals mined, 1.5 per thousand of which is paid to the landowners to be distributed among them in proportion to their share of the concession area. The remaining 0.5 parts per thousand (0.05%) is paid to the state to be used for research and development in the field of sustainable development of mineral resources.

#### OTHER LEGISLATION

Among the acts with provisions affecting the activities referred to in the Minerals Act are the following:

- Environmental Code, Miljöbalken
- Planning and Building Act, Plan och Bygglagen
- Act concerning the Cultural Heritage Management, Kulturminneslagen.

#### Swedish Environmental Code

The Environmental Code is applicable to all citizens and economic operators undertaking operations or measures that conflict with the objectives of the Code. The rules of the Code apply to all whose activities are potentially detrimental to human health or the environment, damage the natural or cultural environment or deplete biological diversity. The rules apply to all kinds of impacts on the natural environment, whether large or small.

They also apply to the housing environment and the built environment and to all other places to which the public has access. All operations that give rise to emissions to land, water or air are deemed environmentally-hazardous and must therefore comply with the rules.

The provisions of the Environmental Code apply to operations and measures that affect the environment

and human health even where these are covered by other legislation. Its rules and the provisions of other legislation are thus applicable in parallel.

The purpose of the provisions concerning land management is to specify important areas of interest to community development that are to be given priority when decisions are made concerning land use. The interests referred to in the provisions are to be protected as far as possible from such changes in land use as would be detrimental to them.

The provisions concerning land management take into account both conservation interests and utilisation interests. In specific areas, these conservation and utilisation interests may be designated national interests by the government, which means that they enjoy even stronger protection against modification.

The provisions on national interests apply mostly to very large areas. They are therefore not intended to prevent the development of urban areas and local industry or total defence installations or the extraction of certain substances and materials.

#### ENVIRONMENTAL IMPACT STATEMENTS

An environmental impact statement must be prepared by an operator before a permit application related to environmentally-hazardous activity is submitted and must be attached to the application. The cost of preparing such statements is borne by the operator. Together with a regulated consultation process, the assessment should provide the best possible decision guidance data from the point of view of the environment and health.

The purpose of the environmental impact statement process is to detect knowledge gaps and increase understanding of the environmental, health and natural resource issues involved in the project.

An environmental impact assessment is to accompany any application for a permit relating to environmentally-hazardous activity and health protection. Environmental impact statements are therefore required under other legislation, such as the Minerals Act.

## USEFUL CONTACTS

For **geological and mineral information:**  
**Geological Survey of Sweden (SGU)**  
**Mineral Resources Information Office**

Skolgatan 11  
SE-930 70 MALÅ  
Sweden  
Tel: +46 (0)953 346 00  
Fax: +46 (0)953 216 86  
E-mail: [minko@sgu.se](mailto:minko@sgu.se)  
Web: [www.sgu.se](http://www.sgu.se)

Orders for **published maps and papers** can be placed through Customer Services at SGU's head office in Uppsala. This includes digital data from regional geophysics, ongoing geochemical mapping programmes and Quaternary geology.  
**Geological Survey of Sweden (SGU)**  
**Customer Services**

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Fax: +46 (0)18 179 210  
E-mail: [kundservice@sgu.se](mailto:kundservice@sgu.se)  
Web: [www.sgu.se](http://www.sgu.se)

For enquiries concerning exploration permits and other matters with regard to the Minerals Act and related **legislation/regulations**, contact:

**Mining Inspectorate**  
Bergsstaten  
Varvsgatan 41  
SE-972 32 LULEÅ  
Sweden  
Tel: +46 (0)920 23 79 00  
Fax: +46 (0)926 95 07  
E-mail: [mineinspect@bergsstaten.se](mailto:mineinspect@bergsstaten.se)

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