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SWEDISH NONFERROUS METALS INDUSTRY

REPORT FOR UNIDO
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11 JULY, 1986

HISTORICAL BACKGROUND

The history of Swedish non-ferrous metals industry dates back to the early Middle Ages. Stora Kopparberget (in English Big Coppermountain) is probably the oldest mining company in the world still operating and its Falu mine is surely the mine which has been operated for the longest consecutive period of time, at least 900 years. The oldest extant certificates and charters of Stora Kopparberg are from 1288 and 1347. In the middle of the 17th century two thirds of the total European copper production came from the Falu mine and the yearly output was around 2000 tons of copper.

The second most important mine was the Sala silver mine which reached its peak of production in the late 16th and early 17th century. During the 16th and 17th centuries these two mines played a central role in Swedish economy and politics. State revenue came primarily from these two operations and they were the foundations for an expansive and aggresive Swedish foreign policy.

Swedish industrial growth, which began in the middle of the 19th century, was for a long period of time based on domestic resources: iron ore, timber and hydro electric power. Since the second world war, however, this situation has gradually changed. From that time domestic reserves of minerals and domestic markets were not sufficient to sustain continued economic growth. The Swedish mining and metals industry opted for two ways to secure a stable supply of raw materials:

- Direct investment in foreign mines and cooperation with mining companies abroad
- To obtain minerals in exchange for mining technology and know-how.

The first way has proved to be difficult mainly because the mining companies could not raise the capital necessary to locate and open new mines in foreign countries. Another reason is that the Swedish state has not been able to give the economical, political or military guarantees that the mining companies wanted. The second strategy has been more successful. By combining the long experience of the mining companies, particularly from underground mining, with the skills of the Swedish machine industry, several important mining equipment manufacturers have emerged. This process was facilitated by the close ties between several of these companies; they belonged to the Wallenberg financial group. Some of them are now world market leaders, e g Sandvik and Atlas Copco in drill bits and mining drills, Skega and Trelleborg in rubber linings and NitroNobel in explosives.

NON-FERROUS METALS AND THE SWEDISH ECONOMY

Mining

Deposits of zinc, lead, copper, silver, gold and tungsten are currently being mined. See Figure 1. Production in recent years are shown in Table PGT. The ownership structure of the Swedish non-ferrous metals industry is highly concentrated.

- ***Boliden*** is the dominating producer of copper, zinc, lead, silver and gold containing mineral concentrates and the only producer of copper, lead, silver and gold metals in the country.

In addition to Boliden there are four minor mining companies operating in Sweden:

- ***Vieille Montagne***, a Belgian company in the Union Miniere group, produces zinc and lead concentrates.
- ***LKAB Viscaria***, a subsidiary of LKAB, produces copper concentrates. The Viscaria mine, however, is currently negotiated to be sold to the Finnish mining and smelting group Outokumpu.
- ***Statsgruvor***, another LKAB subsidiary , is the only producer of tungsten concentrates.
- ***Stora Kopparberget*** still produces some amounts of copper, lead and zinc concentrates in the ancient mine at Falun.

Most of the around 20 mines producing non-ferrous ores in Sweden are comparatively small and the ore grades are low. The ***Aitik*** open cast copper mine produces approximately 11 Mt ore per annum. It is the biggest copper mine in Europe and operates with a copper content of 0.4 per cent.

Most of the lead ore, 1.5 Mt/year, is mined at the ***Laisvall*** underground mine, which is the biggest lead mine in Europe. The other mines produce complex sulphide ores and the production levels vary from 70 to 600 kt ore/year. Out of the total production of 19 Mt ore in 1984 60 per cent was mined in 2 open cast mines and the rest in 18 underground mines. There are 21 mines and 12 concentrators in operation in 1986.

Boliden ranks number 10 in Western World mine production of both lead and zinc, while its rank in silver, gold and copper is 15, 16 and 24 respectively.

Smelting and refining

The following metals are produced: copper, lead, silver gold, aluminium, silicon and ferro alloys. See Figure 2. Production is given in Table PMT. The last three are produced only from imported raw materials.

- The production of copper, lead and precious metals from ores is concentrated to the Rönnskär works near Skellefteå controlled by ***Boliden.***
- An aluminium smelter owned by the ***Gränges*** group is situated in Sundsvall.
- A plant producing silicon product is located to Ljungaverk west of Sundsvall. It belongs to the ***Nobel Industries*** group.
- Ferro alloys are produced in two plants, ***Vargön Alloy, Ferrolegeringar*** and a third is under construction, ***Swed Chrome.***
- ***Sandvik*** and ***Seco Rock*** produce tungsten carbide from the ores mined by Statsgruvor.

In addition to these plants based on domestic or imported ores there are a few scrapbased smelters and refineries. ***Boliden Bergsöe*** in Helsingborg is the most important one producing non-ferrous metals.

Boliden has a monopoly position in the Swedish non-ferrous metals industry. However, the structure of the international industry crosses the national borders. The concentrates not treated at Rönnskär are sent abroad to plants in the Federal Republic of Germany, Preussag Boliden Blei and to Norway, Norzink. These plants are only 50 per cent owned by Boliden; the rest is owned by Preussag and BP Minerals respectively.

Mining equipment industry

In addition to the mining and metals industry as such Sweden has a large and growing mining equipment industry. The sales value of the mining equipment industry exceeds that of the mining industry. See Figure 3. Internationally well known companies in this branch are: Atlas Copco, Sandvik, Skega, Trelleborg, NitroNobel, Morgårdshammar (crushers), ASEA (lifts, transport equipment, furnaces), Kockum, Mining Transportation, Volvo BM (dumpers), Hägglunds (drills), Lindén Alimak (lifts), Svedala, Sala International (ore treatment equipment). The last two companies are owned by the US Allis-Chalmers group.

Consulting

Boliden has a consulting subsidiary, ***Boliden WP Contech***, which is active around the world in the fields of exploration, mining and metallurgy.

LKAB used to have a similar subsidiary, LKAB International, but this was divested in 1985 and taken over by ***Scandiaconsult***.

SWECO, Swedish consulting group, is a group of general consulting companies which has been involved in several large international constructing projects including mines and metallurgical plants.

SGAB, Swedish Geological, is a state owned exploration organization, which is engaged both in domestic exploration but also in the international market.

Employment

In 1984 the Swedish non-ferrous metals industry had 4 995 employees accounting for 0.9 per cent of industrial employment. Out of these app. 80 per cent were workers and 20 per cent salaried staff. Since 1977 there has been a substantial rise in employment in this branch of industry and the corresponding figures in that year were 3 884 and 0.4 per cent. The non-ferrous metals smelting and refining industry employed 3 973 persons in 1984.

However, in the local mining communities the importance of Boliden and Vieille Montagne to the overall rate of employment is much bigger. Many of the mines are located in remote areas with only limited industrial activities except mining. See Table EPL.

During 1986 the crisis in the international non-ferrous metals industry has also reached Sweden and lay offs are now suggested by Boliden. Three mines with a total of 400 employees (Stekenjokk, Saxberget and Garpenberg) will probably be closed down. Also the Rönnskär smelter is in crisis and lay offs of 500 persons, one fifth of the total staff, are planned by the company.

Sales value

The total sales value of the Swedish non-ferrous metals production at the mining stage was 2 135 MSEK, which is approximately 0.5 per cent of the total sales value of all industrial production. In 1977 the figure was 664 MSEK and per cent.

The sales value of the non-ferrous metals industry as compared to total sales value of the mining industry (including ferrous metals) has risen from 30 per cent in 1977 to 47 per cent in 1983. These figures reflect the growing importance of the non-ferrous metals industry both compared to the mining industry as a whole and to all industry.

The sales value of the non-ferrous metals smelters and refineries in 1984 was 4 899 MSEK.

Productivity

Productivity has increased by 50 per cent in the underground mines between 1970 and 1985. See Table PTB. Between 1982-85 the mining branch in Sweden has been operating at high levels of theoretical capacity, between 95 and 99 per cent.

The productivity at the Rönnskär works has developed favourably in the early 1980s, from 1980 to 1985 it rose by more than 50 per cent (measured as tons of copper produced per man hour). In 1984 and 1985 the production level at Rönnskär was close to maximum capacity.

Research

Expenditure on research by mining companies is estimated at 50 MSEK in 1983. This is equal to approximately 10 per cent of the investment volume of the mining companies and the level is roughly the same as other branches of Swedish industry excluding the most research intensive branches such as pharmaceuticals. In addition to this, research is carried out by some organizations jointly financed by industry and by the state. Research by universities is concentrated to the University of Luleå.

The most important areas for research in the late 1980s are:

- Computer aid in general
- Mechanized scaling and rock bolting
- Shaft sinking
- Grovhålsbrytning
- Stigortsbrytning

Consumption

The Swedish consumption pattern is similar to the pattern found in other industrialized countries such as e g the US. Compare Table CST. The consumption of alloying metals is among the highest in the world due to the highly developed special steel industry.

A forecast about metals consumption in 1985 and 2000 was made in the end of the 1970s. See Table FCST.

Some specific charachteristics of Swedish non-ferrous metals consumption should be noted.

Lead

Production of batteries accounts for 70 per cent and a growing part of the lead consumption. The comparable international figure is 55 %. The Swedish consumption of lead for cables is higher than the international 7 % (in 1975 the Swedish figure was 28 %).

Zinc

A larger part than the international average consumption(50 % 1975) goes into anti-rust treatment of steel. This is due primarily to wide spread use of galvanized steel in the construction industry. Brass accounted for 40 % of the consumption in 1975.

Copper

The consumption pattern is fairly similar to the international one. A slightly higher part is used for cables.

Tungsten

No tungsten produced from ores is used in the steel industry. The hard metal industry accounts for all consumption.

Trade

Minerals and metals account for app. 15 % of Swedish foreign trade. The share is declining slowly. Most of the trade consists of semifinished products of various types.Zinc, lead and copper concentrates with some precious metals content are exported to Norway, Finland, GFR and Belgium.

Imports of ores and concentrates are dominated by chromium, molybdenum and tungsten in terms of value. Most important countries of origin are USSR, USA, The Netherlands, Norway, Turkey, Brazil, Canada and China.

It is difficult to find correct figures, in available official statistics, cn trade balances for ores and concentrates. Tables FTE and FTI give some figures from 1975, 1980 and 1985. In spite of these difficulties it is clear that the total trade with non-ferrous metals in ores and concentrates shows a deficit in 1975 and a surplus in 1985. This is due primarily to growing zinc and copper exports.

The import dependence for certain metals in 1975 and some of the companies supplying these metals are given in Table ID.

BOLIDEN

History

During the first world war an important part of the mineral supplies to the European countries from overseas colonies were cut off because of the sub marine war. This resulted in a severe shortage of several strategic metals, among them copper. The Swedish industry, which at this time imported most of the copper it consumed was badly hurt. The copper prices skyrocketed because of the war.

These were the two main reasons for Centralgruppens Emissions AB to start the first systematically organized exploration campaign in the county of Västerbotten in 1918. Centralgruppen was a predecessor of todays Boliden group, and was backed financially by capital from a Swedish banking consortium which was later to become one of the leading Swedish bank, the SE-Banken. The Centralgruppen used novel electrical exploration techniques which were later proven to be very successful in locating sulphide orebodies.

In December 1924 a gold/copper orebody was found at Boliden, a place which would later give its name to the company itself. The orebody was rich in gold (average 15 g/t) but also had high arsenic content.

The complexity of the Boliden ore made it difficult and not very profitable to sell the ore to existing smelters in Europe. It soon became evident that it was necessary to construct a smelter using novel technology which could operate efficiently in spite of the high levels of arsenic and other contaminants. The Rönnskär works started production of blister copper in 1930. An electrolytic refinery was added the year after and a plant for refining precious metals was completed in 1933. Boliden grew quickly during the 1930s. It was actively supported by the state to secure the supply of non-ferrous metals and was of great importance during the second world war.

The Boliden mine was in operation between 1925 and 1968. In 1934 the gold production reached its peak, close to 8 t. Over the years the mine would give its owners huge profits and become the cornerstone of the whole Boliden group.

Today Boliden is one of the few vertically integrated copper producers in Europe. It has a monopoly position in Sweden as the only non-ferrous metals producer. In an international perspective Boliden is a medium sized mining group.

Besides its mining and metals divisions Boliden has a chemical subsidiary since 1963. It is based on the sulphur contents of the ores mined producing mainly sulphuric and phosphoric acid. To complement the Rönnskär works with a zinc refinery a 50 per cent interest in the Norwegian company ***Norzink*** was aquired in 1964. In 1972 the West German metals producer Preussag sold half of its lead smelter at Nordenham to Boliden and a 50/50 per cent joint venture called ***Preussag Boliden Blei*** was formed. In 1979 a secondary lead refinery, ***Paul Bergsöe*** in Landskrona in southern Sweden, was bought by Boliden.

In the late 1970s Boliden had severe economic problems and to avoid the dependency on the cyclical fluctuations of the international metal markets an internationalization programme with a stronger orientation towards the final markets for Boliden's traditional products was initiated. There were no substantial results from this thrust until 1986 when the ***Ahlsell group*** was taken over by Boliden. It is a Swedish conglomerate controlling mainly whole sale dealers in building supplies and instrument manufacturers. The synergistic effects of the merger have been questioned in Swedish press.

Some general economic indicators for Boliden's two main divisions, Boliden Mineral and Boliden Metall, are to be found in Tables GAG, GAM.

Marketing of mining and metallurgical know-how of Boliden was coordinated within a consulting group, WP-System, which was acquired in 1979. In 1983 the remnants of the once important Grānges mining group was added to what is now called ***Boliden WP Contech***. The international mining projects of Boliden will be discussed separately below. Boliden has also entered into the field of "new metals" and produces gallium arsenide and selenium and has been exploring for silicon in Spain.

Ownership

Boliden was traditionally a part of the Wallenberg sphere and had a stable ownership situation. However, the latest 8 years have been extremely turbulent with 6 different main owners. In April 1986 Boliden was taken over by the Swedish rubber manufacturer ***Trelleborg***, which has 3.8 million shares or 44 per cent of the votes. Trelleborg is controlled by a system of foundations, built by the founder Henry Dunker in the early 20th century, and several of its people are on the newly elected board of directors.

MINES AND CONCENTRATORS

Boliden Mineral carries out exploration work both inside and outside of Sweden, it operates mines and concentrators in Sweden producing concentrates containing primarily copper, lead, zinc, silver and gold.

Since the 1930s Boliden has had its major activities in the county of Västerbotten. In 1957 Boliden bought a group of existing zinc mines called AB Zinkgruvor in central Sweden. These mines formed the core of the second of Boliden's mining areas. The third area is in the far north of Sweden and covers the Aitik mine only. It was opened in 1968.

The first two areas consist of a number of small satellite mines, delivering their ores to central concentrators. See Figure 3. Some of the mines are formally owned by the Swedish state but operated by Boliden. Stekenjokk, Rävliden and Homträsk are wholly state owned, Aitik, Enåsen, Garpenberg, Laisvall, Saxberget, Udeen are partially state owned, partially owned by Boliden.

Aitik is by far the most important operation giving 60 per cent of the total copper production of Boliden and 35 per cent of the gold. 80 per cent of the lead production is mined at Laisvall. The total metal content of the 1986 production from all Boliden mined is estimated to reach 60 kt copper, 70 kt lead, 130 kt zinc, 200 t silver and 4 t gold. The lead and zinc content exceeds the annual Swedish consumption of these metals. The copper content is equal to half the Swedish consumption and the silver app. 2/3.

From the ores mined also 400 kt of pyrite is also produced. It is used for sulphuric acid production at Boliden's chemical division in Helsingborg in southern Sweden.

For details of production see Table PBG1 and PBG2.

SMELTERS AND REFINERIES

The Boliden group has four metal smelters. The wholly owned Rönnskärsverken (***Boliden Metall***) and the jointly owned Preussag Boliden Blei and Norzink are all based on ores. Boliden Bergsöe, the fourth smelter, is based on scrap.

Boliden Metall

The Rönnskär works is an integrated smelter and refinery. It specializes in treating complex sulphide ores. It produces approximately 100 kt of copper per annum, 60 kt lead, 6 t gold and 200 t of silver. A number of byproducts are also recovered and Boliden is a leading world producer of arsenic and selenium. Arsenic is used as a wood preservative, as a highly purified metal in the electronics industry and in the glass industry. Selenium is used in photo copying, as a feed supplement and in the glass industry.

For details on production see Table PBM1 and Table PBM2. A short description of the processes used is attached.

Copper

The copper refinery capacity will be expanded by more than 50 per cent through a 90 MSEK investment in autumn 1986 and reach 94 kt per annum The blister copper not processed inhouse is exported to various refinieries in Western Europe.

The amount of copper originating from ores mined and concentrated by Boliden Mineral has decreased since the late 1970s from 60 per cent to 50 per cent. Most probably this figure will continue to decline due to increasing difficulties for Boliden Mineral to supply the smelter with the ore needed.

The bulk of the refined copper is sold in Sweden but around 40 per cent is exported, mainly to the UK. The biggest customer in Sweden is the wire manufacturer Elektrokoppar buying 40 per cent of the total production. Boliden tried to aquire Elektrokoppar in 1981 from ASEA but without success. Other important customers in Sweden are the metal manufacturers Gränges Metallverken (now owned by the Finnish Outokumpu group) and Gusum.

The value of the blister copper export has risen rapidly during the 1980s, due to the sharply increased production, from 16 MSEK in 1980 to 840 MSEK in 1984. In 1984 around 40 kt of blister copper was exported. Refineries in Belgium imported 30 kt. West German refineries were the second most important group of customers. Smaller quantities were also exported to Finland and North America.

Lead

The Boliden group produced app. 125 kt lead in 1985. Boliden Metall produced 65 kt (50 kt refined and 15 kt crude), Preussag Boliden Blei (of which production Boliden controls 50 %) produced 100 kt and Boliden Bergsöe 25 kt from secondary sources.

Ores and concentrates from Boliden Mineral accounted for 55 per cent of the raw materials (70 kt) and foreign concentrates and scrap accounted for equal parts of the rest. The percentage of ores from Boliden's own mines will probably grow in future primarily due to output from mines in Canada and Greenland purchased by Boliden recently.

The production of concentrates from Laisvall and other mines in northern Sweden is shipped to Rönnskär but the ores from Saxberget and Garpenberg are transported to Nordenham and the Preussag Boliden Blei plant. The zinc concentrates imported are from all around the world, e g Australia, Greenland and Canada.

Half of the Rönnskär production of refined lead (25 kt) is sold to the battery and wire industry in Scandinavia. A third of the production is exported to customers in Great Britain (40 MSEK, 1984), 15 kt crude lead containing between 96 and 98.8 per cent lead and some silver is sold to Preussag Boliden Blei (PBB). The production figures of PBB is given in Table PPBB. Out of the total supply of crude and concentrates to PBB 30 per cent (30 kt) is produced by Boliden in Sweden.

Boliden Bergsöe produces 25 kt lead from secondary sources, mainly car batteries, every year. Most of the production is sold in Sweden. For production details see Table PBB.

Zinc

The smelter at Rönnskär does not produce refined zinc. However, a zinc rich product (70 % Zn) called zinc clinker is obtained as a byproduct. The entire clinker production is exported to the Norzink refinery in Norway. Norzink was founded in 1924 by the Belgian ***Compagnie Royale Asturienne des Mines***. Boliden bought half the company in 1964 in exchange for Boliden shares. The company was located to Odda, Norway because of abundant and cheap electricity. BP Minerals bought the other 50 per cent in 1981. Table PNZ gives some details about Norzink.

A third of the 245 kt zinc concentrates (metal content 138 kt) produced by Boliden Mineral in 1985 is exported to Norzink. This is about 55 per cent of the Norzink supply or 50 kt zinc (metal content) which equals 35 per cent of Boliden Mineral's production. Boliden Mineral also exports zinc concentrates to Outokumpu in Finland and has a five years contract to deliver 30 kt (metals content) of zinc every year since 1981. The rest of the zinc concentrate production is sold to West Germany and Eastern Europe.

Gold, silver

The main part of the gold and silver production of Boliden Metall comes from concentrates produced by Boliden Mineral. In 1985 the gold production was 6 t and the metal content in Boliden's ores was 4 t. The corresponding figures for silver were 200 t and 190 t.

The production capacity for precious metals will be expanded when the new copper electrolysis capacity is completed in 1986. All of Sweden's gold consumption, 1.5 t, is covered by Boliden. The rest of gold production and most of the silver produced is exported to West Germany.

International activities

The exploration activities of Boliden were extended to Norway and Finland already before the second world war. However, it was only after the war that the international exploration made some substantial progress.

In 1955 ***Nordisk Mineselskab*** managed by Boliden and owned by a group of Swedish and Danish companies including Boliden opened a lead/zinc mine on the east coast of Greenland. The mine was in operation 8 years until the most high grade ore was depleted. Beside this successful project Boliden was doing some exploration in the Portugese colonies Angola and Mocambique in the 1950s. In 1961 Boliden signed an agreement with the Imam of Jemen concerning a minerals survey of the whole country. This was the start of an intense period of exploration together with local or international partners such as for example Rio Tinto Zinc and Amax in Canada, Morocco and Colombia. However, all projects were discontinued before any mining activities could be started.

In the middle of the 1970s the plans to secure the supply of cheap raw materials to the Rönnskär smelter were revived. A Philippine exploration project on the island of Catanduanes was started together with Swedish and local participants. In Canada a deposit called Atlantic Nickel Mines was bought and later sold off.

All through the years Boliden has given three main reasons for exploration abroad:

- The Swedish mines are charachterized by low grades and high costs. The reserves have never been large.
- The smelter at Rönnskär must have a stable and cheap supply of ores.
- Boliden has know-how and experiencefrom exploration particularly in areas similar to Canada and also in smelting of complex sulphide ores.

In 1986 when the close down of several mines in Sweden is probable, exploration and other international activities to secure the supply or ores are back in focus. Boliden is sending its exploration teams and other experts to USA, Canada, Saudi Arabia and to the Iberian peninsula.

USA

In 1982 Boliden aquired the ***Pinos Altos*** copper/zinc deposit from ***Exxon***. So far only test drilling has been made and no decision about production has been made yet. So far Boliden has spent 5 MUSD on the project. At present Boliden plans to open a much smaller mine than originally was envisioned by Exxon. The size which is most probable would produce perhaps 8 kt copper, 7-8 kt zinc and 17 t of silver per annum.

Canada

Since 1976 Boliden owns a dominant part (29 per cent) of the ***Great Lakes Nickel*** deposit at Thunder Bay, Ontario, Canada. The cost for this project is estimated to have reached around 5 MUSD.

In 1985 Boliden made an agreement to buy two gold mines in Val d'Or, Quebec, Canada from Continental Illinois Bank, Chicago. The gold production in the two mines is around 1.5 t/year. The price has not been disclosed.

In November 1985 Boliden was appointed the main agent for the ***Faro*** lead/zinc mine and also bought a minority share from the majority owner ***Curragh Resources Corp.*** It is planned to start production again in 1986 after the mine has been rehabilitated. The production level is believed to reach 350 kt zinc concentrates and 170 kt lead concentrates.

Greenland

In June 1986 it was disclosed that Boliden is negotiating with the Canadian group ***Cominco*** to buy the ***Black Angel*** lead/zinc mine in Greenland. Boliden has earlier been recruiting staff for the operations. The price is said to be 25-30 MSEK for the bankrupt mine, which is the biggest industrial operation in Greenland. If this deal comes through, which it most likely will, Boliden will literally be back in the same place where it started its international search for minerals, Greenland.

With the Black Angel and Faro capacities for zinc and lead added Boliden will become one of the western world's leading traders in zinc concentrates.

Saudi Arabia

Boliden is one of the few international mining companies which have been allowed to explore for metals in Saudi Arabia. It has an agreement with ***Petromin***, the Saudi Arabian authority responsible for oil and metals, to share exploration and development costs. In the case of any exploitation Boliden has a 50 per cent part of production. This agreement was originally negotiated by Gränges but transferred to Boliden after the merger of the two groups' international activities.

At present a very promising gold deposit called ***East mine*** located at Sukhaybarat about 350 km south east of Medina is studied in detail.

Spain

Boliden opened an office in Madrid in 1984. The exploration activities are concentrated to northern Spain where the potential for polymetallic sulphide ores has been demonstrated.

VIEILLE MONTAGNE

The Belgian company ***Société des Mines et Fonderies de Zinc de la Vieille Montagne***, which was founded in 1837 has been called "the creator of the zinc industry in Europe". Already in the 1870s it produced 70 kt zinc annually. The mines in Åmmeberg (Zinkgruvan) in southern Sweden have been known since the 16th century and producing at least since the middle of the 18th century. They were bought by Vieille Montagne in 1857. The Belgian company paid 2.5 million francs, a fortune in those days, to a private Swedish owner.

In spite of later changes in Swedish mining laws, prohibiting foreign ownership of Swedish mines and land, the mines at Zinkgruvan have stayed under Belgian control. Vieille Montagne is part of the Union Miniere group. Today zinc and lead concentrates containing 65 kt zinc and 10 kt lead are produced annually. For details see Table . The total production is exported to Belgium and smelted at the Balen works owned by Vieille Montagne. The company used to have several mines supplying concentrates to the Belgian smelters. Since a few years Zinkgruvan is the only fully controlled source of supply. The operation in Sweden is organized as a Swedish division of the mother company. This has meant that the usual economic statistics available for most mining companies have been difficult to find in the case of Vieille Montagne.

The number of employees has risen in the last few years from 438 in 1980 to 535 in 1985. This is mainly due to the opening of a new production level in the early 1980s. Total investment in this new level is 40-50 MSEK in the years 1981-1985. Replacement investments in machinery and equipment amounts to 20 MSEK annually. Sales amounted to a little less than 300 MSEK in 1984 and profits before appropriations were 55 MSEK the same year.

LKAB VISCARIA

The Viscaria orebody was located in 1972 when a LKAB geologist found an abundant habitat of the plant Viscaria alpina. This plant tolerates high copper concentrations and a copper orebody was soon proven. Ten years later mining started in the Viscaria mine named after the plant. The mine is situated only 3 km from the iron ore mine in Kiruna. The deposit contains mainly copper pyrites. Reserves are in excess of 50 Mt of which 20-25 Mt are considered technically and economically minable.

The mine is planned to have a life time of 15 years at an annual production level of 1.3 Mt ore with an average copper content of 1.9 per cent. The annual production of concentrates is estimated to 125 kt with an average copper content of 25 per cent.

Investment in the mine and plant could be limited because of the existing LKAB facilities in Kiruna but nevertheless total investment was 380 MSEK. Government subsidies and long turn loans amountad to 150 MSEK of this. This was in part motivated by the difficult situation experienced by Kiruna during the crisis in the iron ore industry. Construction started in 1981 and the first production came through in 1983. For production and economic details see Table .

The business idea is to cover the high demand for smelter feed in Europe. According to early calculations the operation needed copper prices above 13 SEK/kg to reach break even; this level has not been reached in the first years of producion. The copper price, as is well known, has not developed favourably and the economic results of Viscaria have been poor, in spite of good production results and high capacity utilization (100 per cent in 1985). In 1986 LKAB has negotiated to sell the company to the Finnish group *Outokumpu*. This deal will most probably be finalized in summer 1986 and is only pending on approval of the miners' union.

The output is sold on five year long term contracts to four customers. The Swedish *Johnson group*, metals and ores traders (35 kt annually), Outokumpu (50 kt), Boliden (20 kt) and the GDR company *Intrac* (20 kt).

STORA KOPPARBERGET

Stora Kopparberget is owned by the Swedish pulp and paper group *STORA*, one of the leading European pulp and paper producers. Its Falu mine is the oldest and smallest non-ferrous mine in Sweden. The deposit contains complex sulphide ores. The reserves are estimated at a total level of 11 Mt ore with 0.5 per cent copper, 1.5 per cent lead, 4.5 per cent zinc and 30 per cent sulphur. The mine was initially an underground mine but disastrous cave ins in the 17th century turned it into an open pit mine. In the last decade a gradual change to underground mining has taken place once again and today all production takes place underground. The company has a concession to mine and concentrate 200 kt of ore per annum.

The present yearly output is around 30 kt of concentrates. Details are given in Table . The ores are sold directly to refineries inside and outside of Sweden but the pyrite is used for production of sulphuric acid and sulphur dioxide mainly for use in the Stora group's pulp and paper industries. The mine and concentrator employs 120 persons and the total plant 250 persons. Annual sales are app. 100 MSEK of which 50 per cent is exported. The economic result is satisfactory according to company sources.

STATSGRUVOR

The second LKAB subsidiary mining non-ferrous ores is ***AB Statsgruvor***. The company which has specialized in mining tungsten ores has been operated by LKAB since 1965 and became a subsidiary in 1975. In the end of the 1970s and the early 1980s the company operated two small concentrators close to two mines (scheelite from the Yxsjöberg mine and sulphide ores from the Stollberg mine). Three additional small mines were operated to supplement the concentrator feed (Wigström scheelite mine 1978-81, Fredriksson zinc mine 1979-81 and the Ullhyttan lead/zinc mine in 1978 only). The annual production of lead and zinc concentrates reached app. 10 kt (5 and 5 respectively) in the middle of the 1970s and declined gradually until mining was discontinued in 1982. The concentrates were sold to the Federal Republic of Germany. Since 1982 only the Yxsjöberg mine producing scheelite has been in operation. The bulk of the production is delivered to the Swedish hard metal producers, the rest has been exported to GDR.

In the late 1970s the company also had some plans for production of vanadium pentoxide in Sweden and molybdenum in Norway. However, these projects never materialized. The production of scheelite and some general economic indicators are given in Table PGS.

The very existence of the company was threatened early in 1986 because of the poor tungsten market and also by the limited ore reserves in the existing mine. However, the Swedish tungsten consumer, Sandvik, was given certain investment advantages by the Swedish government and has agreed to buy the production at prices high enough to continue the mining operation. In this way the domestic supply of this strategic resource is guaranteed.

BOLIDEN METALL - PROCESSES AND PRODUCTS

Lead is produced in three qualities, i e Kaldo lead containing 96-98 % of lead together with some silver and gold, refined lead and crude lead with 99.7-99.9 % of lead and some silver. Kaldo lead and crude lead are delivered as ingots weighing about 2500 kg. Refined lead has a lead content of 99.99 % and is delivered as 42 kg ingots.

The gold produced is 999.95 fine and is delivered as 1 kg and 12.5 kg ingots.

Copper is produced in two qualities, i e crude copper, known as blister copper, and electrolytic copper. Blister copper contains about 98.5 % of copper and some precious metals. It is delivered in the form of anodes in bundles weighing around 2800 kg or as ingots weighing about 1100 kg. Electrolytic copper has a copper content of at least 99.995 % and is delivered in the form of cathodes, in bundles weighing an average of 2200 kg.

The palladium produced has a purity of 99.95 %. It is delivered as a powder or in the form of ingots.

Platinum metal slime is delivered as a powder in a fibre drum weighing app. 10 kg.

Silver has a purity of 999.5 fine and is delivered as granules or as ingots weighing 1 kg or 30 kg.

Silver nitrate with a purity of at least 99.999 % is delivered as a powder in a hard plastic drum with an inner plastic bag. The net weight is 25 kg.

Arsenic trioxide contains more than 99 % of arsenic trioxide. It is delivered as a powder in steel drums weighing about 210 kg.

Arsenic metal contains 99 % of arsenic. The metal is delivered as lumps in steel drums weighing about 100 kg.

Arsenic acid contains 61-66 % by weight of arsenic pentoxide in a water solution. The acid is transported in special tanks.

Sodium-selenium salts - sodium selenite with a selenium content of about 41 % and sodium selenate containing around 45-46 % of selenium. The salts are delivered as solutions or in the form of powder in a fibre drum, with two PVC bags as the inner packaging. The net weight is 75 kg.

Nickel sulphate contains at least 99.5 % of $NiSO_4$ $6H_2O$. The product includes more than 22 % of nickel. It is delivered in units of twenty 50 kg plastic bags on a one-way pallet.

Selenium. In addition to standard and special selenium, alloyed and doped selenium as well as selenium compounds are also available. The purity of standard selenium is 99 %, whereas that of special selenium is 99.999 %. Selenium is delivered as a powder or granules in fibre drums with inner plastic bags. The net weight is 50 kg.

Zinc clinker contains about 70 % zinc, 6-7 % of lead and traces of tin and silver. The clinker is in the form of a powder and is shipped by sea to Norzink AS, where zinc and other metals contained in the clinker are extracted.

Boliden iron silicate (crude slag and expendable abrasive) contains 45-48 % of iron oxide and 35-39 % of bound silica. The crude slag is delivered as a powder and is shipped in bulk. The expendable abrasive is delivered in units of twenty 50 kg paper bags on a one-way pallet.

Liquid sulphur dioxide contains 99.98 % of SO_2. It is delivered in special rail tankers.

Sulphuric acid contains 94-98 % of H_2SO_4. The acid is delivered in special rail tankers or by sea.

LAISVALL

In operation: 1943, discovered at the end of the 1930s.
Ore: Lead ore with zinc and silver.
Annual production: 1.50 Mt.

Concentrator
1.50 Mt will be milled this year. Annual production 70,700 t of lead concentrate and 23,100 t of zinc concentrate.
Metal contents in the concentrates: 54,100 t of lead, 13,200 t of zinc and 11,000 kg of silver.

THE GARPENBERG DISTRICT

Garpenberg
In operation: Bought by Boliden 1957, discovered in the 14th century.
Ore: Complex ore with copper, lead, zinc and precious metals.
Annual production: 200,000 t.

Garpenberg North
In operation: 1972, discovered in the beginning of the 20th century.
Ore: Silver ore with zinc and lead.
Annual production: 350,000 t.

Central concentrator at Garpenberg
557,000 t will be milled this year. Production of 1,800 t of copper concentrate, 12,800 t of lead concentrate and 25,300 t of zinc concentrate.
Metal contents in the concentrates: 330 t of copper, 7,050 t of lead, 13,750 t of zinc, 52,000 kg of silver and 147 kg of gold.

THE SAXBERGET DISTRICT

Saxberget
In operation: Bought by Boliden in 1957. Discovered in the 19th century. In production in 1880.
Ore: Complex ore with copper, lead, zinc and precious metals.
Annual production: 137,000 t.

Concentrator at Saxberget
137,000 t will be milled this year. Annual production 4,200 t of copper concentrate, 4,100 t of lead concentrate and 16,000 t of zinc concentrate.
Metal contents in the concentrates: 950 t of copper, 2,600 t of lead, 8,500 t of zinc, 4,650 kg of silver and 28 kg of gold.

Statsgruvor has severe problems with an almost depleted orebody. Present reserves will only last 6 years. Exploration around the concentrator is intense.

LKAB is also cooperating with Svenska BP Mineral primarily in prospecting for tungsten in the vicinity of the Statsgruvor dressing plant.

NSG stands for exploration activities of the same order of magnitude as Boliden and PAB. NSG has the only project for industiral minerals, 15 % of its total budget. The part of NSG's efforts going into alloying metals has dropped from 45 per cent in 1983 to only 1 per cent in 1985. In 1985 some minor tungsten efforts is what remains of earlier alloying metals projects. A nickel and a chromium project were finished without success. A vanadium deposit (Sumåsjön) has been localized and is offered to mining companies to exploit.

Foreign prospectors

Svenska BP Mineral spends 20 MSEK in three years on base metals and tungsten in central and northern Sweden. It is interesting to note the many direct and indirect links of BP with Swedish mining, exploration with LKAB, zinc production with Boliden and with Norsk Hydro in Norway.

Terra Swede recently acquired by Norsk Hydro is specialized in gold exploration. The non-fuel mineral exploration department of Norsk Hydro was merged with Terra Swede. It is at present a small company and it is difficult to judge what plans Norsk Hydro has for the future. One important project will be gold exploration in Brōndal in Norway.

EXPLORATION

General

There are three main exploration organizations in Sweden: ***Boliden Mineral***, ***LKAB Prospektering*** (PAB) and ***Nämnden för Statens Gruvegendom*** (NSG). The two former ones have full exploration capabilities. The third, NSG, is a government authority, which supports exploration in general and also has exploration projects of its own carried out by consultants.

State activity in exploration has traditionally been extensive. There is a political consensus that the high risks involved in exploration, particularly considering the high demands for environmental protection in later mining stages, makes it necessary for a state support. Otherwise there would not be sufficient capital invested by private enterprises. In four years the state share of total exploration activities in Sweden has risen from 38 per cent to 50 per cent in 1985.

The total cost for exploration in 1985 is given in Table EXT.

The state budget for exploration is divided into two main parts:

- Regular funds (43 MSEK, 1985) for NSG's own exploration projects, most often carried out by the stateowned exploration company ***SGAB*** (Swedish Geological).
- Extraordinary exploration subsidies, totalling 300 MSEK to be distributed in 5 years starting 1983.

Exploration for non-ferrous metals is primarily carried out close to existing concentrators. See Table EXP. Green field exploration accounts for 37 per cent of total activities. Government policy has been and is to encourage exploration for base metals, certain alloying metals and industrial minerals. Base metals and precious metals dominate the present projects. See Table EXP. In spite of the big per capita consumption of alloying metals tungsten is the only alloying metal on the list.

The recent changes in Swedish mineral laws has made it possible for foreign prospectors to operate in Sweden. So far only two foreign groups are engaged in Sweden, ***BP*** and the Norwegian oil, fertilizer and metals group ***Norsk Hydro***, but several others are interested in starting. Both of the foreign companies receive Swedish state support.

Exploration organizations

Boliden Mineral explores for base metals and gold. The long term goal for Boliden is to have reserves which equal 15 years of todays mining rate. The present reserves total 500 Mt of ore, or 10-12 years of production. Aitik has reserves for 30 years of mining but in the Skellefteå fields the ore in certain mines will be depleted in the early 1990s. Special deep penetrating air borne and ground surveys below depths of 200 m have been carried out in this area to find new deposits for the existing dressing plants.

Green field prospecting is made in the Junsele and Gävle-Sandviken areas.

Vieille Montagne has increased its prospecting activities lately probably due to the growing importance of the Zinkgruvan mine, at present the only fully controlled source of concentrates for the Vieille Montagne smelter in Belgium. All efforts are made in the existing mining area.

PAB is a wholly owned LKAB subsidiary. It has its own program concentrated towards base metals, precious metals and tungsten. PAB is the only Swedish prospector with a developed green field activity, to a large extent as joint ventures with ***Volvo***, ***Svenska BP Mineral*** and ***Studsvik Analytica*** as partners.

PAB also carries out most of the exploration efforts by the two LKAB subsidiaries Viscaria and Statsgruvor.

Besides the water pollution the most serious problem to the mining industry is damage to the landscape caused by open pit mining methods and by large waste rock heaps. Draining of lakes and rivers to exploit underwater deposits has recently been discussed. In two cases, the new silver deposit by lake Dammsjön, close to the Garpenberg mines and the Laisvall lead mine which extends under the Laisan lake, Boliden has claimed that draining of a lake is necessary for an economic and safe exploitation of the ore.

In the case of Dammsjön the whole procedure of environmental inquiry lasted four years. Permission to start mining was finally granted by the government provided that the lake was restored afterwards and that 500 000 m^2 of old waste rock heaps at the Garpenberg mines were covered. Boliden has estimated the cost for only the covering of the waste rock heaps to be 50 MSEK. The company claims that the environmental demands set makes it impossible to start mining the deposit. However, a very important factor contributing to this decision is also the low silver prices.

The Rönnskär works have been and still are the worst polluters in Sweden. In the early 1930s the emission of sulphur dioxide was 180 kt annually, in 1985 it has been reduced to 10 kt but Rönnskär is still the biggest sulphur dioxide polluter accounting for 14 per cent of all sulphur dioxide from the Swedish industry. In 1985 Boliden at Rönnskär also emits 20 per cent (700 kg) of all mercury to air in Sweden.

The results from this long time pollution are evident in the area around the smelter. Acidified lakes and parts of the Baltic around the works, water plants exterminated due to arsenic and copper emissions, fish poisoned by cadmium, copper and mercury in the water. Doubled mortality rates in cancer of the lung in persons living close to the smelter due to arsenic emissions. High levels of miscarriages among women living close to the plant. The damages could have been even worse had the smelter not been localized on a peninsula with prevailing winds blowing from the west towards the Baltic away from inhabitated areas.

The emissions from Rönnskär since the 1930s are shown in Table RUT. The reduction in the 1970s of water emissions by 90 per cent and athmospheric emissions by 60 per cent were due to a large investment programme totalling 250 MSEK. The SNV has demanded that the emissions should be further reduced considering the continuing harmful influence on the environment by the emissions. Boliden has estimated the cost to fulfil these demands to reach 350 MSEK. The company claims that if the demands will be pushed through lay offs will become necessary. Boliden has even hinted at the possibility of a total close down of the Rönnskär works. The final decision will be taken by the government in 1987.

MINING LEGISLATION

The present Swedish mining legislation was adopted in 1974 (SFS 1973:342) but has its roots in different periods of the history of Swedish mining industry. Three different systems are used:

- A ***mining claim*** covers most metals, gold, silver, copper, lead, zinc, iron, nickel etc. Anyone who finds an ore deposit has the right to develop and exploit it. The right is granted for a period of three years within which a development must take place. The system was originally introduced in the 18th century to support and encourage investments in the mining industry. Today there are examples of how this system, which does not make any difference between for example a mining company and a private person trying to make a mineral find, makes it difficult to organize a cost effective large scale mining operation.
- A ***concession*** is given only after special consideration by the state. This system covers all energy minerals, oil, coal, uranium, natural gas, peat and oil shales. It was introduced in the early 20th century to protect Swedish energy reserves from foreign ownership.
- The ***land owner system***. This system gives the right to the landowner to mine all minerals which are not covered by the two other systems, mainly the industrial minerals. The system is a remnant from medieval times when most Swedish mining was carried out by landowning peasants mainly in winter time.

In all mining claims the state has the option to participate in the operation on a 50/50 basis. The state also has the possibility to start mining even on privately held claims. This system of state participation was introduced in 1938 and was part of a series of laws aiming to protect Swedish minerals from foreign ownership. This process was started in the early 20th century when the important iron ore mines in Kiruna and Gällivare were about to be sold to foreign investors. The series of laws was completed only after the second world war. In the early 1980s, however, the economic integration of the Western World and the subsequent demand for reciprocity in investment codes forced the Swedish government to allow foreign ownership to Swedish mineral resources. The new law (SFS 1982:617) gives the government the right to allow foreign ownership of Swedish mineral deposits and land. This is a very important change in policy considering that it comes closely after a 50 years struggle to enforce a system of laws necessary to guarantee national control of the subsoil. In particular the Miners' Union have opposed the new law. At present a committee, set up by the Parliament, is working to review the mineral law from 1974. One of the main problems is the old mining claim system as mentioned above. There are suggestions that a single concession system should replace all three earlier systems. A report from the committee is expected in late 1986.

In practice the Swedish state has not actively exercised the possibilities which the existing laws give to direct and influence the activities of the mining industry. The state today leases its mineral rights to public companies such as Boliden. Three of the mines operated by Boliden are wholly state owned (Stekenjokk, Rävliden and Horntråskvliken) and others, in principle all new mines such as Aitik, Enåsen, Garpenberg, Laisvall, Saxberget, Udden and Släppen, are jointly owned on a 50/50 basis. In the case of LKAB and its subsidiaries Viscaria and Statsgruvor the company itself is stateowned but that does not change the working of the system.

Organization

The Ministry of Industry controls both official authorities, such as ***Nämnden för Statens Gruvegendom (NSG)*** which is the authority responsible for all state owned deposits, for state exploration and for state support to exploration, and the ***Swedish Geological Survey (SGU)*** and for state owned business organizations such as LKAB and its subsidiaries

Statsgruvor and Viscaria. 13 of the Swedish non-ferrous metals mines are wholly or partially owned by the state through NSG. For all these mining rights Boliden and LKAB paid 27 MSEK in 1984. Aitik alone was accounting for 14 MSEK.

WORKERS' HEALTH AND SAFETY

The mining industry in Sweden, as elsewhere, has severe problems both concerning accidents and injuries due to long term exposure to mineral dust, diesel fumes, radioactive emissions (radon), noise and draught. The accident rate in the mining industry is the highest compared to all other branches of industry in Sweden. The rate of accidents in the mining industry is twice the average rate for all industrial branches which is app. 20 accidents in 1 million work hours. See Table WHS1. The rate of accidents is not declining in spite of considerable efforts. This is due to the fact that all new safety measures are counterbalanced by demands for higher productivity and higher efficiency. The accident rate in underground work is about twice the level in surface work. See Table WHS2.

In the period 1975-1984 a total of 38 fatalitites were reported. The year 1984 was the first ever without any fatal accidents at all in the history of Swedish mining industry. Types of work with fatalities in the 1975-84 period are given in Table WHS3. Working days lost because of injuries has been constant and was in 1985 22 days per injury for underground work and 18 days for surface work.

A study made in 1977 gave the following rank of the most severe problems in the miners' work environment:
Underground work: Noise, diesel fumes, dust and draught.
Surface work: Noise, dust, heavy work.

After 1977 the radon problem has been highlighted and a higher than normal mortality due to cancer of the lung has been demonstrated in miners. It is also proven that this is due to the radon and the radiation it causes.

The present main demands from the unions concerning the work environment are: further improvements of mine ventilation, electrical vehicles in the mines instead of diesel vehicles, better blasting techniques and rock bolting to diminish the risk for falling rocks.

No case of silicosis have been found in workers employed after 1949 in all mines of Boliden. In the last few years, however, measurements of the dust levels have shown that the risk for silicosis is not yet totally eliminated.

Recent development trends show that new, large scale technology does not necessarily improve the work environment. Mechanization has undoubtedly eliminated many of the traditional physically very demanding jobs from the mining industry. At the same time, however, the new dumpers and drills are often diesel driven and the exhaust gases are harmful. Pneumatically powered equipment such as drills creates oil mist and harmful noise. Better ventilation to avoid high concentrations of dust gives draught problems.

This does not mean that important improvements have not been made but rather that the efforts to create a better work environment must continue even when mines are operating at the relatively high standards of the Swedish mining industry.

BOLIDEN MINERAL - MINES AND CONCENTRATORS 1986

AITIK

In operation: 1968, discovered in the 1930s.
Ore: Low grade copper ore with precious metals.
Annual production: 11.4 Mt of ore and 12.8 Mt of rock in an open pit.

Concentrator
11.4 Mt will be milled this year. Production of 143,900 t of copper concentrate, containing 39,600 t of copper, 37,550 kg of silver and 1,309 kg of gold.

THE BOLIDEN DISTRICT

Långdal
In operation: 1967, discovered in the middle of the 1930s.
Ore: Complex ore with copper, lead, zinc and precious metals.
Annual production: 145,000 t.

Långsele
In operation: 1956, discovered in the middle of the 1920s.
Ore: Complex ore with copper, zinc, precious metals and sulphur.
Annual production: 450,000 t.

Udden
In operation: 1971, discovered in the middle of the 1950s.
Ore: Complex ore with coppper, zinc, sulphur and precious metals.
Annual production: 330,000 t.

Renström
In operation: 1952, discivered in the middle of the 1920s.
Ore: Complex ore with copper, lead, zinc and precious metals.
Annual production: 215,000 t.

Central concentrator at Boliden
1.19 Mt will be milled this year. Production of 22,300 t of copper concentrate, 6,500 t of lead concentrate, 83,600 t of zinc concentrate and 284,700 t of pyrite concentrate.
Metal contents in the concentrates: 4,500 t of copper, 3,000 to of lead, 45,900 t of zinc, 41,800 kg of silver and 739 kg of gold.

ENÅSEN

In operation: 1984, discovered in the 1950s.
Ore: Complex ore with gold, copper and silver.
Annual production: 200,000 t of ore and 580,000 t of waste rock in an open pit.

Concentrator
200,000 t will be milled this year. Production of 5,400 t of copper concentrate.
Metal contencts in concentrates: 509 kg of gold, 570 t of copper and 600 kg of silver.

ENVIRONMENT

Background

The present system of laws, regulations and authorities set up to protect the environment in Sweden was introduced in the end of the 1960s. However, laws regulating emissions to water have been in force since 1941. The law to protect the environment (SFS 1969:387) deals primarily with emissions to water, to the athmosphere and noise from industrial, agricultural and other activities as e g waste water treatment and energy production. Important areas such as emissions from vehicles are not regulated by this law.

Laws

The law for protection of the environment defines a number of industries for which an advance permission is mandatory. The authorities granting these permissions are organized at three levels: local, regional and national. At the national level there is a ***Board of concession*** which checks all industrial activities that have an influence on the environment at a national scale. Mining and metallurgy are examples of industries scrutinized by this Board. There is also a central authority, the ***Swedish National Environment Protection Board (SNV)*** which primarily sets the long term goals and controls the activities of the local, regional and national authorities giving permissions for environmentally dangerous emissions.

In case of very important and large industries the government has the responsibility to scrutinize the pollution problems. According to the paragraph 136 a localization or introduction of industrial activities which are of crucial importance to the economizing on energy, wood fibres and the Swedish land and water resources requires government permission. When the government has given its principal permission the case should be tried by the appropriate authoity as described above. According to this law the local communities have the right of veto to all applications.

A case of interest to the mining industry was the veto of the Skövde community, which stopped a project to utilize uranium containing shales in the early 1980s.

Present situation

In the 1970s 8 billion SEK were invested in measures to protect the environment in Sweden. The annual costs, both investment costs and operating costs, in the 1980s have been estimated around 2.5 billion SEK.

The Swedish mining industry has invested heavily in pollution control during the last decade. By international standards the situation in the Swedish industry as far as the environment is concerned is quite good. However, the mining and in particular the metals refining industry are still among the heaviest polluters.

In the mining industry the main problem is water pollution. Leaching processes caused by acid waste water release heavy metals, which are poisoning the surroundings of both existing mines and ancient waste rock heaps. SNV has demanded Boliden and Stora Kopparberget to take measures to stop leaching of heavy metals from waste rock heaps at the Falu and the Garpenberg mine. These heaps are from the beginning of mining of the mines, i e at least from the15th century. The companies claim that this is not their responsibility. In the case of Garpenberg an area of 900 000 m^2 has to be covered with a 3 m thick layer of earth. Final decision is expected during 1986 in this case.

Pollution of the athmosphere is in general not a problem to the mining industry. The Viscaria copper mine is an exception. Its oil fueled driers emits sulphur which causes acid rain.