



Photo LKAB: For more than 60 years, Kiirunavaara was mined in open pits. The last pit mining shift was in September 1962

LKAB – A ferric world leader



Today, LKAB consists of about 30 companies in 15 countries. This includes iron ore mines, processing plants and ore harbours. It has become a world leader, particularly in underground mass mining. **Daniel Gleeson** begins the LKAB series with the history of the company and its mines

Geologists cannot agree on how the ores of Kiruna and Gällivare originated. One theory is that they were a result of several periods of volcanic activity accompanied by massive lava flows. The iron ore that is worked by LKAB is, however, all of the same age and origin, with magnetite being the dominating ore species.

The earliest report of the existence of iron ore in Kiruna was made by Samuel Olsson Mört, bookkeeper at the Kengis works, a nearby smelting facility. In 1696 Mört made an adventurous journey into the wilderness, his purpose being to investigate a copper deposit in far-off Sjangeli that was of interest to his company. During his expedition, he learned of iron-bearing mountains near Lake Luossajärvi. For some reason he did not report this discovery to the mining society, Bergskollegium, for about ten years.

His report was roughly translated as: "In 1696, I was again near Jukkasjärvi for ten days with three men. To the west of Jukkasjärvi, near the river, lie two iron mountains the Lapps call Luossavaara, where the ore is inexhaustible and can be taken for many years without the need of wood. It is unlikely that the forest on either side of the river can ever be exhausted."

These words, written over 300 years ago, are fitting today. 120 years after the first train carrying 1,000 t of Kiruna ore arrived in Luleå, production is still going strong.

Of Mört, little else is known. He received no reward for his discovery, though a street has been named after him in Kiruna. His report was eventually dusted off and Gabriel Gyllengrip, Governor of Västerbotten, set up an expedition to investigate the viability of these deposits. Accompanying him on his journey were, among others, Abraham Steinholtz of the Kengis works and a young officer by the name of Jonas Melderkreutz, who, together with Steinholtz, started the mining operation at Malmberget some years later.

When Gabriel Gyllengrip finally made it to Jukkasjärvi, an elderly Sami man named Anund Anundsson Mangi showed Gyllengrip and his party the way. For his troubles, he was awarded tax exemption and 100 riksdaler in silver. Thoroughly impressed by what one day would be Kiruna, Gyllengrip said, "Regardless of how many blast furnaces we might wish to build here, we will not empty these mountains."

Steinholtz was unable to ignore the two awe-inspiring mountains. He acquired claims on both Luossavaara and Haukivaara in 1747 and advanced plans for exploiting these deposits. He would process the ore in a blast furnace at Vuolusjoki, near the village of Kurravaara, where copper had been smelted.

Steinholtz's plans for his iron works progressed no further than the drawing board. He, and the Kengis works, faced serious economic difficulties. 50 years

later, another iron maker from Kengis became interested in the dormant wealth of the Kiruna mountains. In 1825, Jonas Ekström applied to the King of Sweden for a concession to export ore from the area, via a harbour on the Norwegian coast, for a period of 50 years. However, officials deemed the enterprise unworkable.

Gällivare deposits

The date of the discovery of the Gällivare deposits is still not certain. The Momma-Reenstierna brothers may have known in the mid-1600s of the existence of iron ore in the area, but the man credited with the discovery was a farmer named Per Andersson of Orrbyn.

Andersson had died by the time his ore samples were given to a priest in Råneå in 1735. Samuel Blix was the priest given Andersson's ore samples. At the time his son-in-law, Lieutenant Carl Thingwall, happened to be visiting. Thingwall wasted no time in filing claims on the Gällivare deposits and soon arranged blast furnace privileges. His only problem was he lacked funds. In Kengis, he approached Abraham Steinholtz, who agreed to a joint venture.

As mentioned earlier, an officer named Jonas Melderkreutz was part of Governor Gabriel Gyllengrip's 1736 expedition in search of the Kiruna ore mountains. Melderkreutz understood that enormous riches were there for the taking in the Lapland wilderness. In 1744, he purchased Abraham



Steinholtz's interest in the Gällivare orefields for 30,000 riksdaler in copper. Together, Meldercreutz and Steinholtz built a mill which, by combining the initial syllables of their surnames, they named Melderstein. Pig iron for the mill was brought from a blast furnace built at the same time at Strömsund, near Råneå.

When Melderstein began his career in Norrbotten he was incredibly wealthy, but his riches quickly dwindled. Ore transport posed a problem, and the farmers and Sami were unwilling to provide horses and reindeer to haul ore from the mines. The situation was no better when it became apparent that the rich Malmberget ore was not easily processed in the blast furnaces. In order to produce pig iron of reasonable quality it was necessary to mix the Malmberget ore with 'poorer' ores from the mines of central Sweden, which was not economically viable – an early example of blending different quality iron ores.

Norrbotten County (Norrbottens län) is the northernmost county or län of Sweden and many of its mining pioneers went bankrupt. Meldercreutz escaped such bad fortune, but by the time of his death, the ironworks he had built were badly run down. A man by the name of Jean Bédouire bought everything for 15,000 riksdaler. He in turn sold his enormous land holdings to Samuel Gustaf Hermelin, who became one of Norrbotten's leading 19th-century industrialists. Hermelin purchased mines, ironworks and huge tracts of farmland for 84,000 riksdaler in 1799. He had great plans and procured a number of licences to produce iron. The most important of the new facilities was the Selet mill, which employed 50 people when it began producing pig iron in 1800.

Two English chemists, Thomas and Gilchrist, solved the problem of how to produce steel of good quality from high-phosphorus iron ore in 1878. This was a discovery of great importance, not least to the ore deposits of Lapland, all of which had high phosphorus content. Almost over night, the potential value of the gigantic ore reserves of Kiruna and Gällivare increased enormously, thanks to the advent of the Thomas process.

Malmberget

In Malmberget most mining was at Kaptensgruvan, though new mines were opened by Hermelin. To secure ownership of the land, Hermelin established three freeholds on the mine mountain. In the winter, only small quantities of ore were hauled from the



Map of Lapland in Sweden showing Malmberget, Gällivare, Svappavaara and Narvik. Luleå (pictured inset) is located further south

mines to the blast furnaces on the coast. During Hermelin's time, annual production of pig iron was at most 200 t at Selet and even less at Strömsund. In comparison, the Österby mill in Uppland was able to produce as much as 1,800 t/y.

Hermelin's luck began to ebb. Russian soldiers levelled a couple of his mills, others were destroyed by fire, ore ships were lost at sea and the price of bar iron hit rock bottom during a lengthy recession. His immense fortune shrank quickly, and by 1812 he had no other choice but to declare bankruptcy. Attempts to auction off the properties failed. However, in 1818, help came from an unexpected quarter. The newly proclaimed King, Karl XIV Johan, began buying mills, mines and farmland in Norrbotten. By the time he was finished, he owned 202,500 ha. The first Bernadotte King invested a total of 360,000 riksdaler in his northern province, the Principality of Gällivare. From a business point of view, it was not a good investment. Mines and mills posted only losses, and the King's attempts to liquidate these assets failed. They were inherited by his son, Oscar I, who managed to sell the entire legacy for one million riksdaler.

Malmberget's orebodies are well distributed. Originally there were about 20 deposits of varying size spread out over a 2 x 5 km area, with ten of the orebodies currently mined. Initially, the ore was pit-mined, but since the mid-1920s, all production has been underground.

It was soon apparent that much of the main deposit, Kaptensmalmen, extended under the town. This discovery was to split the community of Malmberget in two, being separated by an

enormous pit known as Gropen. Since there was an impending risk that a rather large section of the town would slide into the mine it was necessary to demolish several houses and service buildings. An indoor pool, a school and the community centre had to be replaced. Over the years, mining has progressed deeper and deeper into the ground. The present main haulage level, at a depth of 1,000 m, has been operated since 2000. Malmberget's first pelletising plant came online in 1955.

Kiruna

The site of Kiruna, as is known today, was desolate in 1890 when LKAB erected the first log cabin – a structure which stands to this day and is known as B1. In 1875, Kiirunavaara was mapped by the Swedish Geological Survey. The work was supervised by engineer Otto Gummaelius, who named the 11 peaks of the mountain Vaktmästaren, Gruvingenjören, Geologen, Statsrådet, Bergmästaren, Direktören, Pojken, Kaptenen, Landshövdingen, Professorn and Jägmästaren. All are long since gone, except for Gruvingenjören. The highest peak was Statsrådet which, when it was blasted in 1910, stood 247.7 m above the level of Lake Luossajärvi. The mine levels are measured from a zero point just beneath this peak.

The Kiruna orebody resembles a large, upended slice. It is 4 km long, averages 80 m in width and has a depth of at least 2 km. Test drilling also indicates that the quality of the deposit is increasingly better at depth. Thus far, production and haulage have been established on successively deeper levels six times. Preparations for mining began in 1898 at the



Statsrådet peak. For the next 60 years it was an open-pit mine. However, from the outset, plans were laid to go underground – LKAB's management did not believe open-pit mining would be possible in Kiruna's bitter winter climate. These fears were unwarranted. Ore was pit-mined year-round until 1962. By then, 209 Mt of ore had been mined and 140 Mt of waste rock blasted and hauled away from the cut that splits the mountain in two.

Since the transition, Kiirunavaara has long been the world's biggest underground iron ore mine. There are some 500 km of drifts and tunnels. There are underground offices, cafeterias, workshops, crusher stations, control rooms and personnel facilities. Skips hoist the ore up from the production areas to mineral processing plants behind the mountain. Kiruna's other mine mountain, Luossavaara, was not worked for a couple of decades, with mining beginning in 1920 and continuing until the late-1980s.

Of the world's large iron ore producers, only LKAB mines underground. The major competitors in Brazil, Australia and Canada all mine ore in open pits. For LKAB, large-scale mining methods compensate for the disadvantages of underground mining, as do the high iron content of its ores, the high degree of upgrading and, not least, the close proximity of the large European market.

All the ore that is delivered to customers is upgraded in some form, mainly as pellets. Thanks to its successful research and development efforts, LKAB has long been one of the world's leading pellet producers. The company has six full-scale pelletising plants in Kiruna, Malmberget and Svappavaara.

The quest for transport

For well over a century, the problem of finding a viable means of ore transport across the Norrbotten wilderness was difficult. Ore hauled from the mines by reindeer and horses cost more than finished pig iron from the mills of central Sweden. The idea of building a railway from the mines to suitable harbours was first discussed in the 1830s.

The first to embrace this idea was a baron named Nils Barck. In 1847, Barck was granted a licence to build a railroad from Gällivare to Töre. He tried to interest English businessmen in the idea, but to no avail. Several years later, the idea was taken up once again by Victor Kjellberg, the man who had purchased the Principality of Gällivare from Oscar I for one million riksdaler. Backed by English capital, Kjellberg started The Gellivare Company.

His plan was to build an 80-km long railway that would carry ore to the Lule River, where it could be transferred to barges. To make the idea work, it would be necessary to build canals to bypass the larger rapids. Work began in 1865. Many people were employed, and after two years and much digging and blasting, the money ran out. By then, the English Canal, which can still be seen at Boden

and Edefors, was only half completed.

Since the Swedish state had invested money in the project, the fiasco had repercussions throughout the country. Victor Kjellberg made his exit, but the English investors held out. They began buying mines and mills; and eventually, their vision of a railway would be realised.

When the hunt for Lapland's dormant wealth began in earnest, English businessmen entered. They were quick to assume major holdings in the ore mountain of Gällivare and they realised that if mining were to be profitable, it would be necessary to build a railway. In 1882 the English company, The Northern of Europe Railway Co., was granted a concession to build a coast-to-coast railway from Luleå to the northern Norwegian fishing village of Victoriahavn. Construction began two years later. The Englishmen, employing a workforce of thousands, managed to build a provisional railway from the mines of Malmberget to the newly built harbour at Svartön in Luleå in the space of four years. The first ore train, 40 cars long and carrying 1,000 t of ore, arrived in Luleå on March 12, 1888. It is believed to have been the heaviest railway train that had ever been hauled anywhere in the world.

The Englishmen's joy after the successful start was short lived. By summer, when the ground had thawed, the railway that the men had toiled so hard to lay was no longer stable, particularly where it crossed marsh and wetlands. At the same time, the company's capital was dwindling. The more than 4,000 men who had laboured on the Kiruna extension could no longer be paid. The bankrupt railway company was forced to abandon its bold venture. In an effort to salvage what could be saved, the Swedish Government purchased the railway for SEK6 million: a bargain considering English investors had poured four times as much into the project.

Repairing the poorly built railway was a costly and time-consuming undertaking. The Luleå-Gällivare section of the line could not be approved for traffic until 1892. By then, two new mining companies with high hopes had been formed – Luossavaara-Kiirunavaara Aktiebolag (LKAB) in 1890 and Aktiebolaget Gellivare Malmfält (AGM) the following year.

Major Robert Schoug, who headed the National Works Administration's northern district, was the driving force behind the formation of LKAB. He had participated in the disastrous English Canal project on the Lule River, and was well acquainted with Norrbotten from his earlier work. Having prospected many of the claims in the 1870s, he was aware that the mountains on either side of Lake Luossajärvi held prodigious wealth.

Schoug took the initiative when LKAB emerged at a meeting in Stockholm, on December 18, 1890. He also stood for half the share capital of SEK3 million. As the company's major shareholder, he was elected Chairman of the Board. Carl Johan Ljunggren was

the Managing Director, brother of the late Alrik Ljunggren, who had been involved for several years in a legal dispute with Schoug over claims to the Kiruna ore reserves. Upon the formation of LKAB, the Ljunggren family owned a quarter of the shares in the company. With the inception of LKAB, Schoug was well on his way to realising his dreams.

However, complications ensued. During his first year as chairman he was forced to sell half of his claims in Kiruna. The buyer was banker K. A. Wallenberg, who had, until then, preferred to maintain a low profile in the scramble for Lapland's iron ore riches. From his office in Enskilda Banken, he was quite happy to lend support to the men whose mission in life was to open the wilderness and begin large-scale mining. For LKAB, as its name implies, the Kiruna reserves were the prime concern. But opening a mine in a land with no roads was out of the question. LKAB's urgent concern, therefore, was to extend the railway westward from Gällivare as soon as possible.

In Malmberget, the newly-formed AGM took control of the mines in 1891. The company was led by the dynamic colonel, parliamentarian and industrialist Carl Otto Bergman, referred to as the King of Norrbotten, and by Consul Gustav Emil Broms. They were well aware of the competition they would face the day mining began in Kiruna. Both men were rich, and were therefore able to grasp controlling interest in LKAB in a boardroom coup in 1893. Schoug and Ljunggren were forced to step down. Broms managed both new companies as well as several others with energy and enthusiasm. Two of them were Norrbotten's Malmförädling, which produced artificial fertiliser from apatite, and the shipping company Rederiaktiebolaget Luleå-Ofoten, which had acquired three vessels for shipping ore.

Eventually, AGM's financial security deteriorated under the weight of unsound business dealings and the long wait for railway construction to continue. Broms searched high and low for willing investors both in Sweden and abroad, but was finally forced, in 1901, to step down as director of the company, though he himself left the scene financially unscathed. When LKAB was suddenly acquired by Trafikaktiebolaget Gränges-Oxelösund (TGO) in 1903, Broms was able to negotiate a royalty payment of ten öre for each tonne of ore sold over the next 50 years. The entry of TGO had come as a surprise, but it was a strategic investment. Naturally, the company's management regarded the mining operations in Kiruna and Malmberget as a serious threat to the mining industry of central Sweden, much of which was controlled by TGO. The strategic move in the north was well timed. The new owners took over just as construction of the railway had been completed.

While Broms had been fighting to save his company with the help of foreign investors, banker



Wallenberg and Arvid Lindman, the latter first as a Director of LKAB and then as Prime Minister, worked hard to encourage the state to take over responsibility for the Lapland orefields. In 1907 their wishes were at least in part fulfilled when the state acquired half of LKAB's preferred shares and retained the right to subsequently purchase the remainder of Grängesbolslagets shares. That right was first exercised in 1957, when LKAB very nearly became a wholly owned state corporation. The deal netted Gränges about SEK1 billion, much of which was invested in the Liberian American Swedish Mining Co (LAMCO), which mined for iron ore in the Nimba range in Liberia, as well as in the construction of the steel mill in Oxelösund.

With the intervention of the Swedish state, the days of AGM were numbered. LKAB also took control of mining operations in Gällivare. Even if things were tough at the start, LKAB eventually became the largest employer in Norrbotten and the hub around which almost everything in the ore fields communities revolved. At most, LKAB had 8,297 employees. That was in 1961. Since then, the workforce has been more than halved, and by 2005, there were about 3,500 employees in the LKAB Group. Much of this reduction has been achieved by very productive, mechanised mining.

From mine to port

The provisional railway project from Luleå to Malmberget was completed by the Swedish state. For LKAB, with its ore base in Kiruna, this railway was, as yet, of little consequence and the state at the time was certainly doing nothing to hasten its extension. There was no consensus as to the appropriateness of building a railway to export Swedish ore. Furthermore, some in high places voiced fears that a railway might open the country to the Russians. It would be better, they argued, to build fortifications to fend them off. Opposition to the construction of the railway was quelled when the prime minister, E.G. Boström, forced the issue by threatening to resign if parliament did not approve the project. Parliament voted in favour of the railway, but only by a slim majority. In 1898 construction began with LKAB having to accept the government's tough terms regarding the operation and maintenance of the railway. LKAB director G. E. Broms was compelled to turn to bankers.

The line from Gällivare to Kiruna was finished by the autumn of 1899, but the extension would prove to be considerably more difficult. Few railroads have been built under such tough conditions as the one between Kiruna and Narvik. Thousands of construction workers endured violent blizzards, bitterly cold winters, severe spring floods and treacherous avalanches, as well as the threat of death from starvation or freezing in their shelters. Tornehamn was the base of operations for the rail gangs working in the mountain area. Here, there

were houses, a store, a small hospital, a brewery and a church.

Their greatest feat was the 840-m tunnel through the mountain Nuolja. It was driven almost entirely by hand, since the power station that had been built at Abiskojokk could not be used during the winter due to the stream freezing. The tunnel was eventually replaced by another and is now sealed. Despite many difficulties, railway construction progressed surprisingly quickly. By October 1899, track had been laid to Kiruna, and in November 1902 the first train hauled an ore load from Kiruna to Narvik. The line was inaugurated under great ceremony, on July 14, 1903 by King Oscar II.

But the railway project was heavily criticised, mainly because of the huge expense it incurred. Costs continued to escalate. The final price tag – SEK40 million – was nearly double the original estimate. Nonetheless, this was a wise investment. Since its start-up, an estimated 1,400 Mt of iron ore has been hauled to the harbours at Luleå and Narvik.

Traffic on the ore railway has been managed by LKAB since the mid-1990s. For many years prior to this, high rail-freight rates had been a major problem. Freight agreements with SJ, the Swedish national railways, were a constant source of irritation for LKAB. Since agreements were based on maximum mileage, SJ received full remuneration, even when ore delivery volumes were lower than normal due to downturns in the market. High rail-freight costs were a major contributor to LKAB's heavy losses during the recessions of the 1970s and 1980s. This eventually led to state intervention. The former Finance Minister, Gunnar Sträng, was appointed mediator, and his efforts resulted in a six year freight agreement that would lead to a drastic reduction in SJ's excessive profit taking. Though this was a great step forward, it was not enough to appease LKAB management. Despite a reduction in freight rates, LKAB's per-tonne rail transport cost was still three times that of its competitors.

Therefore, in the early-1990s, LKAB demanded that it be given full control over ore traffic, and in 1992 it was granted trafficking rights on the ore railway, and four years later, Malmtrafik AB and its Norwegian counterpart Malmtrafik AS assumed control over rail traffic. LKAB has invested in a whole new generation of rolling stock, in efforts to improve rail efficiency further even more. The new locomotives exert a tractive force of 1,200 kN and are the world's most powerful railway engines. Both locomotives and ore cars are designed for a 30-t axle load.

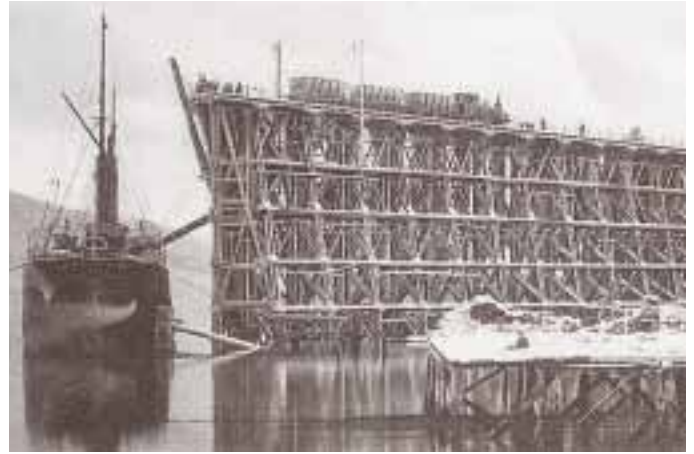


Photo LKAB: It took four years to build the railway from the Malmberget mines to Svartön in Luleå. In January 1903, the first vessel, Upland, was loaded, in the as yet provisional harbour at Narvik

The English company that started building the ore railway in 1884 also saw to it that a suitable ore harbour was established in Luleå. It was built on the peninsula of Svartön, where a farming family were the sole inhabitants.

The first ore vessel left the new harbour in 1887. Its cargo had been hauled by reindeer and horses from the mine in Gällivare.

In the early-1960s the harbour was entirely rebuilt. LKAB invested SEK240 million in the renovation – the largest single investment ever made in a Swedish harbour. Officially reopened in 1964, it was, at the time, one of the world's most modern ore ports.

In 1991 LKAB's management faced a difficult decision. The company was ordered by environmental protection authorities to erect buildings over its stockpiles at Svartön. It was decided that the Svartön facility would be closed and replaced by a completely new ore harbour on the Sandskär peninsula.

The new harbour was operational in 1996. With it, LKAB gained an efficient ore handling facility that was considerably more environmentally friendly than Svartön. The problem of airborne dust was practically eliminated, since ore was now stored in three silos. The discharging station and conveyors are also covered. The new ore harbour is extremely compact, however, in terms of tonnage it is one of Sweden's largest.

Over the years about 300 Mt of ore has been loaded to ships and barges from Svartön and Sandskär. The record year for ore handling in Luleå was 1974, when 8.4 Mt was handled. Today, a significantly lower proportion is shipped out of Luleå since about a third of the ore destined for Luleå goes directly to LKAB's main customer SSAB, which has nearby premises. **IM**

This is the first in the series of articles on LKAB. An article on aspects of the operations will be published every month into late 2010.