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Historikk på engelsk om Løkken Gruber

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Sammendrag

Orkla Grube-Aktiebolag

LÖKKEN VERK - NORWAY

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PRODUCERS OF

FERRO SILICON

AND

CUPREOUS PYRITES

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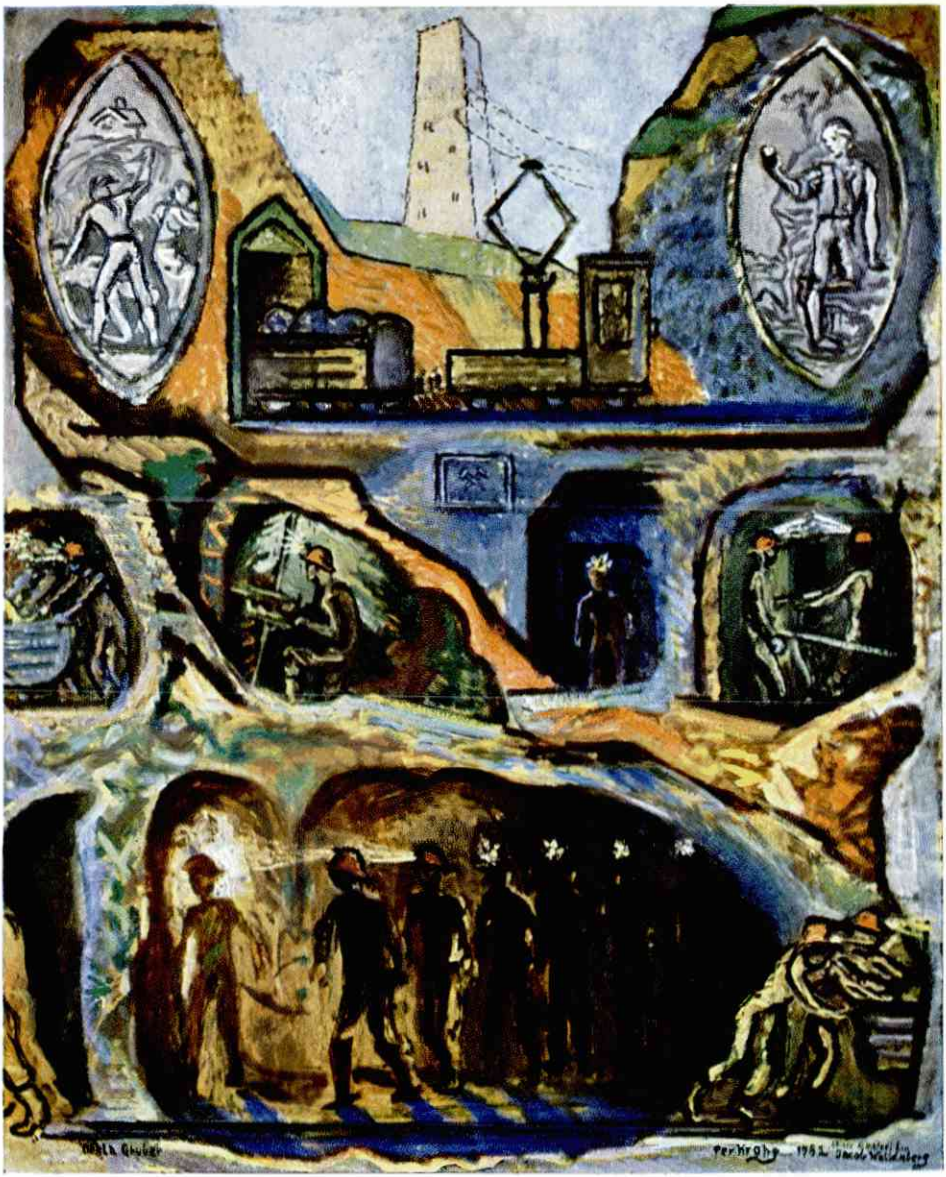
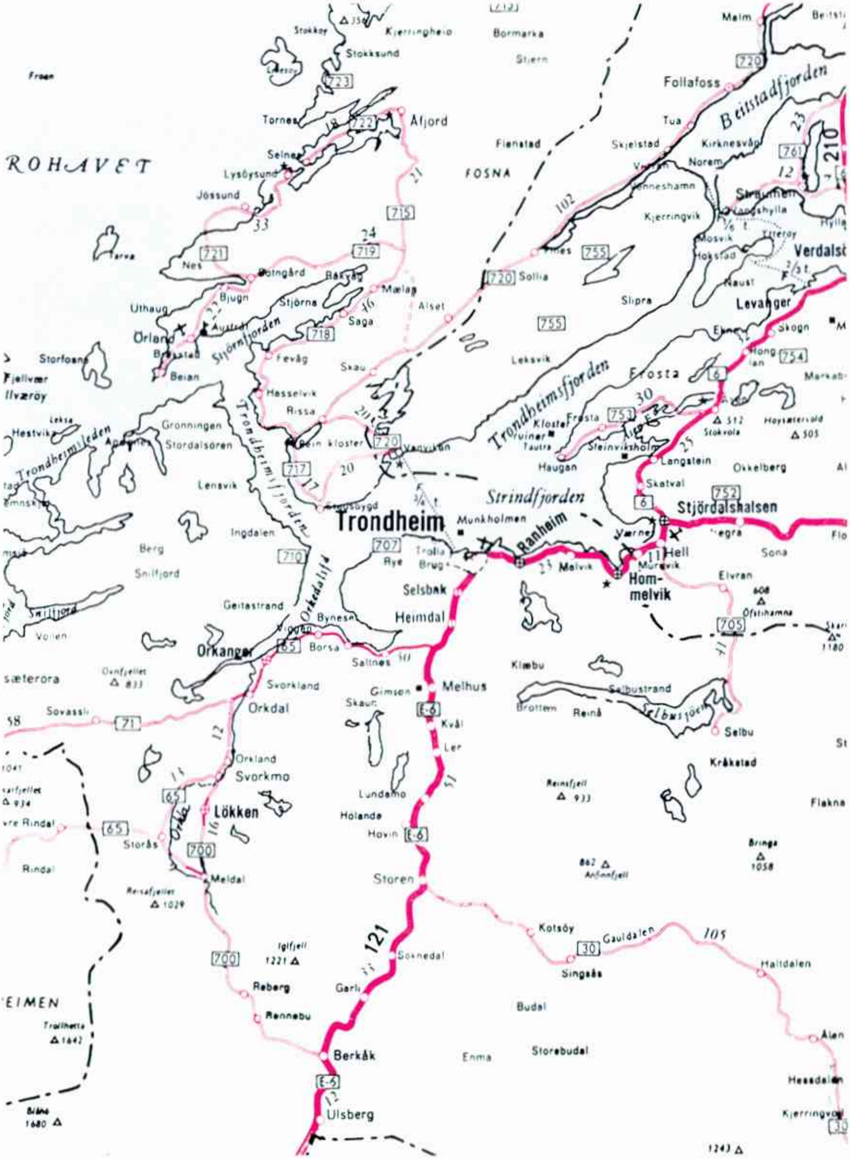


Motives from the Lökken Mine painted by the Norwegian painter Per Krogh in 1952.

Introduction

Orkla Grube-Aktiebolag (Orkla Mining Co. Ltd.) was founded in the year 1904 with the object of operating the pyrites mine at Lökken Verk. The main activity is still the mining and export of pyrites, but the Company is as well running a ferrosilicon plant and is participating in a silicon carbide works. The Company is in addition operating as a holding company with shares in industry, shipping, banking, insurance etc. The Company is also co-owner of ships.



Map showing the position of Lökken Verk and Orkanger, the sites of the mining and industrial activities of the Company.

Location

The mine is situated at Lökken Verk, a community with a population of about 2,500, 25 km up the valley of the river Orkla which falls into the Trondheimsfiord at Orkanger, another village with roughly 3,000 inhabitants. Here, on the eastern side of the river delta, the Company has its port of shipment, and here the ferrosilicon plant was built in 1963—64. On the western side a silicon carbide plant, in which the Company is participating, was erected in 1961—63.

The nearest town is Trondheim with about 120,000 inhabitants, 45 km north-east of Orkanger.

History

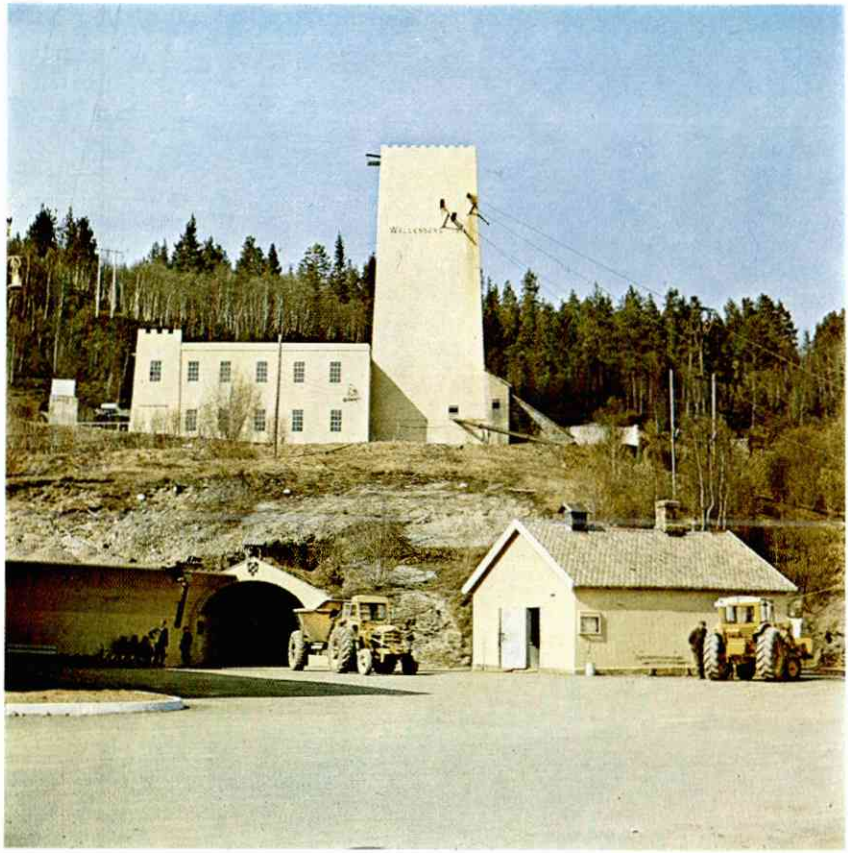
The deposit of cupreous pyrites was first discovered in 1654, and like all other old mines even the mine at Lökken Verk has its romantic legend telling how and where this event took place.

A young taylor, who was performing his tayloring in the different farmhouses, one day had to cross the mountain on his way from one farmer to another. All of a sudden he felt heavy with sleep, and he stopped for a short rest. He fell asleep, and as he woke up he discovered that the stone close to his face radiated a sparkling light, and he found that the surrounding rock was all shining. This was, according to the tradition, how the human eye first met with the cupreous pyrites of Lökken Verk.

The deposit has the shape of a long ruler striking east-west, the axis dipping 11 degrees to the west. The known length of the deposit is about 3.5 km, and the cross section has a more or less lenticular form with a maximum area of 7,000 square meters. The surrounding rock is mostly greenstone which is a basic lava rock.

The minerals are pyrites, chalco-pyrite, zincblende, magnetite and silica. A typical analysis of the pyrites is as follows: 42 % S, 2 % Cu, 38 % Fe, 1.8 % Zn, 0.07 % Co, 0.03 % As, 0.03 % Se, 0.004 % Ni, 18 grams Ag and 0.2 grams Au per ton and 13 % insoluble.

For more than three hundred years this deposit has now been operated. Up to second half of the 19th century copper was the only creative element in the pyrites. The sulphur was during this first period released to the atmosphere as sulphur dioxide. Several small smelters down in the valley smelted the ore and produced rather pure copper which was transported on horse-sledges down to Orkanger and even to Trondheim for export.



The Wallenberg shaft tower.

The copper was at that time won through a roasting and smelting process which was very laborious and highly materialconsuming. The time needed from the arrival of the ore at the smelter until the copper bars were ready for export was in the second half of the seventeenth century 3—4 months. From the notes for one of the smelters we learn that in 1698 14,500 horseloads of raw materials were needed for the production of 58 tons of copper. The price of copper was, however, in relation to costs of labour and raw materials much higher than to-day. One year's pay for a worker was about 15 % of the value of one ton of copper, whereas the same figure to-day would be about 300 %.

In the second half of the nineteenth century the need of sulphur for the production of sulphuric acid changed the valuation of the cupreous pyrites totally as the sulphur from being a nuisance became a most valuable element on a par with the copper. From 1900 to 1950 pyrites in all forms was the main source of sulphur in Europe.

This development had a decisive influence on the operation at Lökken Verk. Soon after Orkla Grube-Aktiebolag had bought the mine a great activity started to modernize the whole set-up, and in 1910 the mining was launched on an industrial scale.

At this time the industry had just started the utilization of the electricity as a source of power. Orkla Grube-Aktiebolag erected a hydroelectric power station in order to supply electric power for all the equipment at the mine, and an electric railway was built between Lökken and Orkanger for transport of the pyrites to the harbour and for passenger traffic. This railway was the first electric railway in Norway.

The increasing demand for sulphur caused opening of several pyrites mines, and in spite of the increasing demand there was about 1920 an overproduction of pyrites in Europe. This was partly due to the competition from the elementary sulphur which was imported from U.S.A. In order to meet this competition Orkla Grube-Aktiebolag, which in the twenties was one of the biggest pyrites-exporters in the world with about 400,000 tons a year, in this decade carried through a research programme and succeeded in developing a process for making elementary sulphur and copper matte from cupreous pyrites.

Based on this process, which is called the Orkla Process, the Company in 1931 started a smelter at Orkanger. The Orkla Process is the only process run for a longer period producing elementary sulphur and copper matte out of pyrites, and it has been licensed to foreign countries.

The Orkla Process can briefly be described as follows:

Lump pyrites is mixed with coke, silica and limestone and smelted in water-jacketed furnaces. Part of the sulphur is as such distilled off in the

The ferrosilicon works.

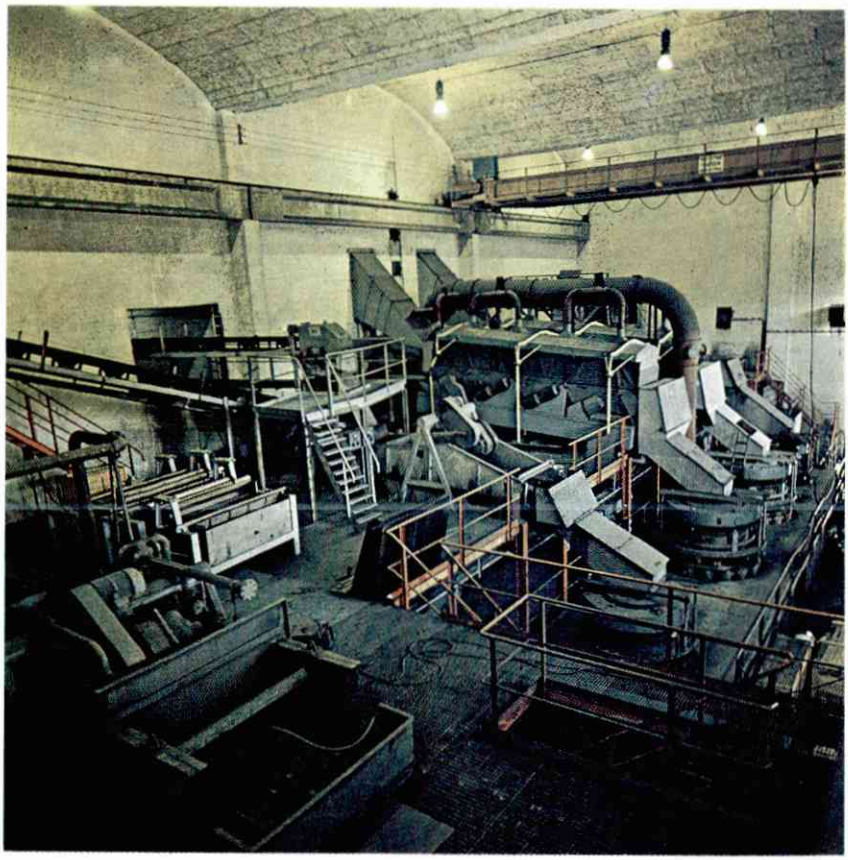
upper part of the furnace, while the iron sulphide is oxidized to form iron oxide and sulphur dioxide in the smelting zone of the furnace. The sulphur dioxide is reduced to elementary sulphur with the aid of coke, which is used mainly as a reducing agent and to a smaller extent as a fuel. The iron oxide reacts with silica and limestone to form a slag. The copper and some iron sulphide form a matte running about 12 % copper. Slag and matte are separated in forehearths, and the matte is remelted to form a matte with about 34 % copper.

The gases leaving the top of the furnace contain about 300 g of elementary sulphur per m^3 plus various sulphur compounds such as SO_2, H_2S, CS_2 and COS. These compounds react over catalyzers to form elementary sulphur.

The recovery of sulphur and copper was 85—86 % and 84—85 % respectively.

The smelter at Orkanger was enlarged to double the capacity in 1937. The capacity of the smelter was then 330,000 tons of pyrites a year which corresponds to a production of 115,000 tons of sulphur and 5,500 tons of copper as copper matte per year. The total production from the mine reached in this period 560,000 tons a year. About 250,000 tons of this quantity were exported as pyrites.

The state of the pyrites market has in the history of Orkla Grube-Aktiebolag changed from prosperity to depression and vice versa. The policy of the Company has been adjusted accordingly. From about 1960 the total pyrites production had to be sold to roasters and refinery works on the Continent as this alternative was the only safe basis for the future operation of the mine. The pyrites smelter was then dismantled and simultaneously Orkla Grube-Aktiebolag planned and participated in the erection of a silicon carbide plant and built a ferrosilicon works at Orkanger.



From the ore dressing plant.

Mining Operations

The deposit is opened by shafts. The first one was sunk about 300 years ago in the eastern part where the orebody outcropped. The main shaft, Wallenberg shaft, was sunk in 1917, and a sub-vertical shaft was sunk in the eastern part of the deposit in 1964. This shaft opens the deepest part hitherto known with the lowest level 930 m below the surface.

The ore is mined in shrinkage stopes in addition to pillar mining, long hole blasting or mining in open stopes. The shrinkage stopes have a width of 19 m and the pillars between the stopes are walls, 8 m thick. The ore is drawn through modified chinaman chutes into 5 tons Granby cars. Formerly a great part of the broken ore was scraped by electric tugger hoists, whereas at present more and more of the raw ore is handled by mechanical loaders.

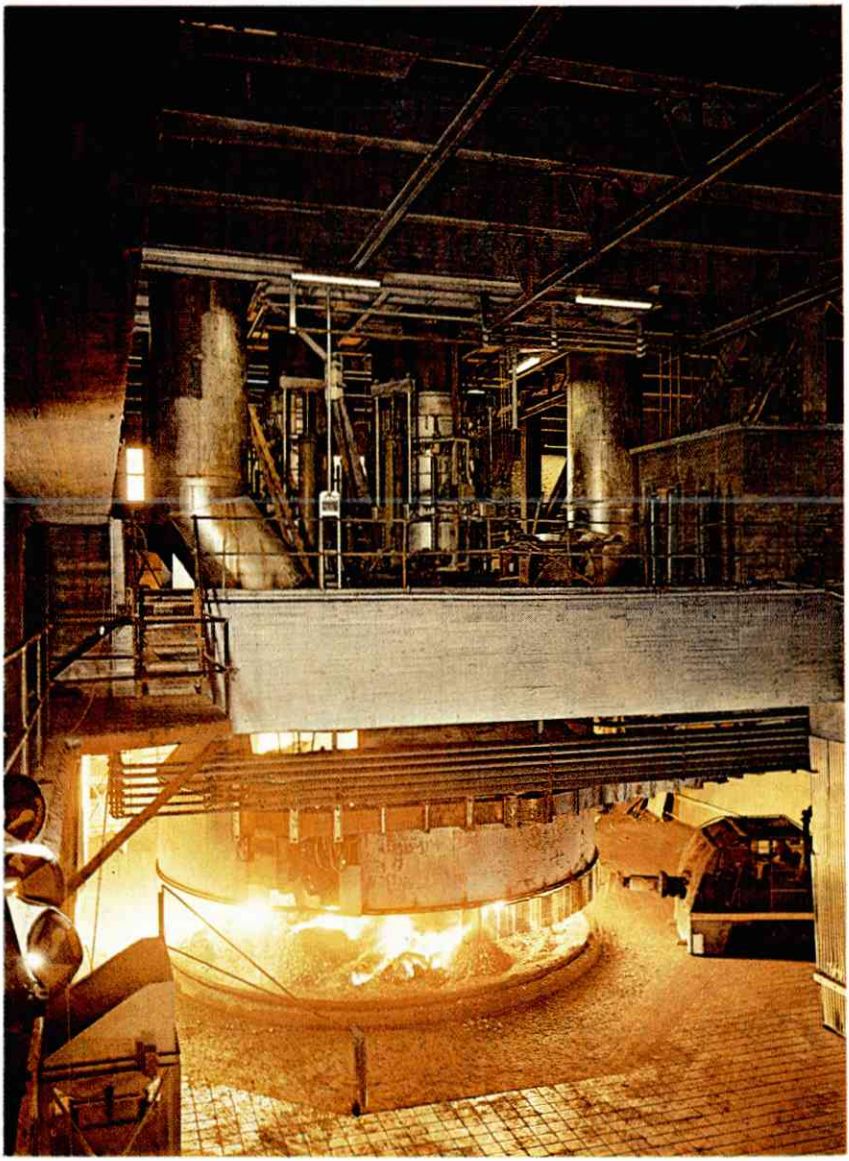
The Lökken pyrites has an extremely fine-grained structure and it contains finely distributed quartz particles. It is supposed to be the hardest ore in the world to drill, and the drill steels are tungsten carbide tipped. During the years more than hundred different types of rockdrills have been tried here, and the mine has thus been a very important testing place for new mine equipment.

The raw ore is passing through a 36″ × 42″ jaw crusher before entering the ore bin at the bottom of the main shaft.

From the main shaft the ore is transported by a small electric railway to the modern ore dressing plant which was rebuilt in 1968. Here the ore is wet screened and crushed to ÷ 40 mm. The + 4 mm raw ore is treated in a sink-float system consisting of a three product Wemco drum. The three products are a concentrate, a middling and a tailing (greenstone). The concentrate is crushed to ÷ 4 mm. The middling is crushed to ÷ 4 mm and washed in a Wemco jig. The finer fractions of the raw ore are dressed separately, and the 0—1 mm is cleaned in a flotation process, while the fraction 1—4 mm is washed in a Wemco jig. The concentrate is mixed with the jig and flotation products to form the export-product, whereas the tailing is returned to the mine as a waste.

By magnetic separation on different stages in the ore dressing process a byproduct of about 5,000 tons a year of high grade magnetite concentrate is won. The magnetite is utilized in the ferrosilicon process at Orkanger in the form of pellets produced at the plant.

The production is now about 250,000 tons cupreous pyrites a year.



The upper part of the electric furnace with equipment.

The Ferrosilicon Plant

When the Company in the early nineteensixties looked for a diversification of its activities, the ferro-alloys production was found to be the industry in which the best possible use could be made of the existing facilities in the industrial area at Orkanger. There were also personnel skilled in metallurgical industry, and electric power and water necessary for such a production were obtainable in sufficient quantities.

The existing furnace was put onstream on the 4th of February 1964 for the production of ferrosilicon. The raw materials are quartz, coke, coal and magnetite pellets or oxide scale. As it is important for the quality of the sales product to use the best possible raw materials, we have made great efforts in selection of both quartz and reducers. We use imported quartz which is purer than the Norwegian quartz and improves the run of the furnace, and we use English reducers of high quality. Some coal «singles» are imported from Spitsbergen. The iron side is mostly covered by magnetite pellets which are produced at the works, the magnetite being an iron ore of excellent quality from the Lökken mine.

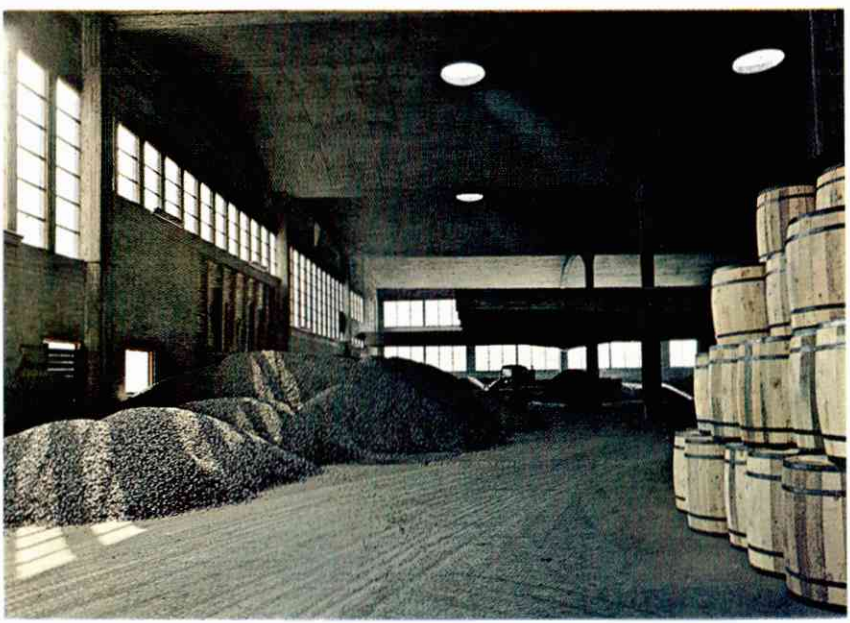
At the quay vessels with up to 20 feet draught can be accomodated, which means cargos of about 3,000 to 4,000 tons. The raw material silos have an effective volume of 11,000 m^3 which is sufficient for the present production. From the silos the raw materials are conveyed to the top of the furnace building by means of conveyor belts, and here smaller silos for the day's demand are located.

The furnace is an open, rotating electro-furnace. The main power transformer lowers the voltage from 130 kV to 22 kV and may be loaded up to 42,000 kVA. The furnace transformer has a capacity of 30,000 kVA and transforms the voltages from 22 kV down to furnace voltage. In series with the furnace transformer on the primary side there are capacitors of 9,000 kVAr. The step changer (18 steps) can be changed on full furnace load (24 MW). The secondary current is at full load about 85,000 A. The capacitors improve the power factor from 0.75 in the furnace circuit to 0.90 in the power supply line.

The furnae is resting on 32 wheels which are running on a ring rail. The rotation speed can be altered from 1 to 1/6 revolution per day.

The furnace is cylindrical, and the shell has an external diameter of 8.5 m. The furnace is lined with fire-proof bricks (chamotte) and rammed with tamping paste. Around the tapping spout the bricks are made of silicon carbide. The internal diameter of the hearth is 6.7 m and the depth of the pot is 2.7 m. There are three tapping spouts. The tapholes

Discharging of the molten ferrosilicon.



From the storage building.

are opened with an electric arc between the furnace bottom (the zero point) and a graphite rod connected with one of the phases.

The electrodes have a diameter of 1.25 m and are continuous, self-baking Söderberg-electrodes. The electrode holders have interlocked contact clamps. The pressure of the cooling water inside the pressure ring is transmitted to the contact clamps by means of rubber membranes. The electrode is lowered through the holder by means of a slipping device, which is operated pneumatically. The electrode is slipped under full furnace load.

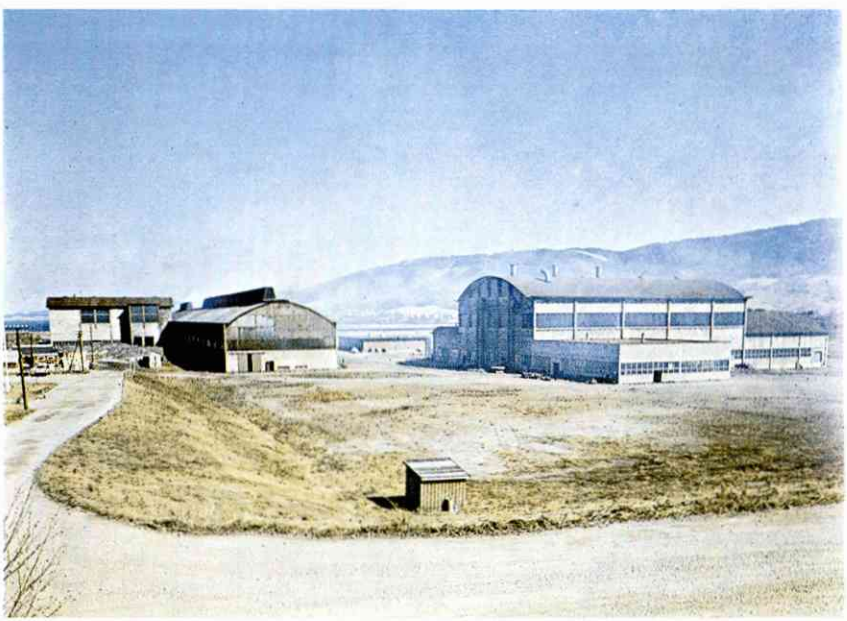
The furnace has three stacks, which provide good ventilation. The metal is tapped into ladles wherein some Al-refining is undertaken. After cooling the metal is crushed either by hand as for the bigger sizes or in a jaw crusher as for the sized material. Different screening systems are in operation to comply with the customers demands. The product is mainly delivered in bulk. Some customers, however, prefer packed material, either in barrels or in pallet boxes.

The ferrosilicon is stored in bulk in the cellar of the furnace building and in a special storingplace under roof. The packed products are stored in a separate building. From the store the products go by lorries to the quay.

The plant now produces about 20,000 tons of material with an average analysis of 77.5 % Si, 1.3 % Al, 20.8 % Fe, 0.02 % P. Plans for fulther expension are presently under consideration.

The predominant use of ferrosilicon is as a deoxidizer in steel works and foundries.

From the process plant at Orkla Exolon.



The Orkla Exolon silicon carbide works.

The Orkla Exolon Silicon Carbide Works

Orkla Grube-Aktiebolag has also sponsored the organization of a silicon carbide manufacturing company called ORKLA EXOLON A/S & CO. K/S. This company is a joint venture, the participants of which are Orkla Grube-Aktiebolag, The Exolon Company, Tonawanda N.Y., and Christiania Spigerverk, Oslo. The company employs about 80 people to-day, and plans are ready for further expansion.

Silicon carbide is a chemical compound which one does not find in nature. It is manufactured in resistance type furnaces from a mixture of silica sand or quartz and petrol coke. Under influence of extreme heat generated in a graphite core connecting the electrodes, silicon carbide crystals build up and form a massive tube around the core. After a cooling period the furnace is emptied, and the silicon carbide goes through a first cleaning and is then precrushed and stored in concrete bins. From there it is taken to the nearby process plant where it is crushed and shaped, chemically treated, magnetically separated and finally graded into the many qualities and varieties required by various industries.

Silicon carbide possesses a number of special physical and chemical properties which explain the widespread usage of this material. Extreme hardness, approaching that of diamond, together with a combination of other properties, make silicon carbide one of the two most used abrasives in the world. Excellent refractory properties explain the second biggest usage area, which is super refractories of every possible kind. The third major usage is in the metallurgical field. Silicon carbide dissociates in molten iron and the silicon and carbon react with metal oxides in the melt, a quality which has established silicon carbide as a deoxidizer. In addition it has become widely used in recent years in order to increase the scrap charge in basic oxygen furnaces. A variety of other usages could also be mentioned.

The silicon carbide produced by Orkla Exolon A/S & Co. K/S is identified under the trade name CARBOREX and marketed all over the world, particularly in highly industrialized areas.

The church at Lökken Verk.

The guesthouse at Lökken Verk.

Electric Power Supply

The building of Orkla's first hydroelectric plant was completed in 1906 with one aggregate of 300 kW. Soon after the planned electric railway made an extention necessary, and in 1912 there were 6 aggregates totalling 3,100 kW on stream.

The electric railway was one of the world's first railways with alternating current.

The steadily growing need for electric power led to building of two smaller power stations in 1917—21 with altogether 1,500 kW, and to rebuilding of the first power station to two bigger aggregates with 5,000 kW in all.

In 1941 a 60 kV-line was built to establish connection with the hydroelectric power stations belonging to the Trondheim area. This was the first step towards a co-ordinated operation with the State Power System.

The power requirements for the ferro-alloys plant necessitated a 130 kV line from the State Power System's nearest transformer. The line was built for 80,000 kW. All power needed for the run of the furnaces at the ferro-alloys and silicon carbide works is now bought from the State Power System whereas the Company's own power stations cover the need of electric power for the mining operations.

Personnel and Welfare

Orkla Grube-Aktiebolag employs 630 in all, the silicon carbide plant personnel not included.

The Company has to a great extent taken care of the social side of the community. In the old days the mine owners provided for a church or a chapel in the small communities built along with the mining installations and smelters. Orkla Grube-Aktiebolag has also in our time honoured this old custom by building a church at Lökken Verk, and it still remains in the possession of the Company.

When Orkla Grube-Aktiebolag at the turn of the century increased the activities at Lökken Verk it had to take care of the housing problems, and even to-day 60 % of the employees at the mine are living in Company houses. Furthermore the Company has houses for the retired people, and a community center with cinema, concert-room and rooms for parties. At Lökken Verk the Company runs a hotel and has a guesthouse for visitors and guests of the Company.

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