No. ____

CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 124

A REPORT ON STUDY AND EXAMINATION OF IRON DEPOSITS IN SWEDEN

July 6 to 14, 1966

G. A. GROSS

OTTAWA
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INTRODUCTION

One week, July 6 to 14, was spent in Sweden following a scientific exchange visit in the U.S.S.R. The main purpose of the stop-over in Sweden was to discuss current research and exploration of iron ore deposits by the Geological Survey of Sweden and to examine a number of iron deposits and mines. Two full days were spent in discussions and study of geological records at the Geological Survey headquarters in Stockholm, three full days examining iron ore deposits and mines in Lapland, one day in travelling to and from the mine areas in the Arctic and one full day, Saturday, for personal interests in Stockholm.

The following brief account of the visit is intended to give some of the significant impressions gained in the course of this work and does not provide descriptive detail of observations or conclusions. Copies of the most significant scientific publications on the iron deposits of Sweden were obtained in the course of the visit. Discussions with geologists currently studying iron deposits in Sweden and limited field and mine observation provided first-hand knowledge of the geology and a good basis for critical appreciation of the excellent literature available on iron ore in Sweden.

ACKNOWLEDGMENTS

The interest shown in this visit, assistance and kind hospitality extended to the writer by Members of the Geological Survey of Sweden and the Luossavaara-Kiirunavaara AB company staff are gratefully acknowledged.

Geological Survey of Sweden staff who made special contribution of their time and facilities to the success of the visit are:

The Director, Mr. K.A. Lindbergson,
Dr. Rudyard Frietsch,
Dr. Otto Brotzen,
of Stockholm, and

Mr. Bo Eriksson,
Mr. Ulf Hallgren,
of the Geological Survey office in Kiruna.

Mr. Gunnar Sundén of the LKAB company gave special assistance in arranging a travel itinerary, personal contacts and accommodation at the company guest houses during the visit to mines in Lapland. Mr. Mats. I. Haglund and Mr. Kauno Kangas, Engineers at Malmberget, provided an excellent briefing and tour of the mine area and production facilities in this area.

Mr. Yarlvon Feilitzen and Mr. Tibor Parák of the Geological staff at Kiruna discussed the geology and accompanied the writer on a very informative tour of the Kiruna and Svappavaara Mines.

The writer is indebted to these people for their kindness and personal interest in arranging a very efficient and useful study tour of the geology of iron deposits in Sweden.

GEOLOGICAL SURVEY OF SWEDEN - STOCKHOLM

During the course of the visit the Director General of the Geological Survey, K.A. Lindbergson, interviewed the writer, extended their hospitality and discussed their interest in the study of iron deposits. He spoke briefly about the organization and objectives of his Survey and asked about Economic Geology studies in our Canadian Survey. Copies of an organization chart and a paper on exploration policy for the Geological Survey of Sweden are appended to this report which cover the information discussed in the interview.

I concluded from this discussion and from contact with the Survey staff that the Geological Survey program is oriented mainly toward the study of mineral deposits and Economic Geology and their scientific studies are all closely related to mineral exploration and development and to the needs of the mineral industry. A lot of the Geological Survey budget in Sweden is used for exploration drilling and for applied aspects of geology, whereas in Canada this work is done almost entirely by private industry.

Norrbotten County Project:

Dr. Rudyard Frietsch, a senior geologist in charge of geological studies and exploration in Norrbotten county in northern Sweden spent one day with the writer discussing their current program and iron deposits in this classical area. Norrbotten county has been withdrawn from staking or exploration by private interests, and the Government through the Geological Survey is now responsible for all geological and mineral exploration and investigation. The iron mines are operated by a number of companies which are almost entirely owned or controlled by the Government of Sweden.

The Geological Survey is involved in a long range project aimed at evaluation of the mineral potential, principally iron ore, in Norrbotten county, and approximately one million dollars per year is being spent. This is one of the major, if not the largest single project in the Geological Survey program and is obviously expected to provide basic

information for formulating a long term national policy for developing the iron ore resources. The program integrates results from geological mapping, geophysical surveys, both gravity and magnetic methods are used, geochemical studies, surface prospecting and drilling of ore prospects, definition of ore deposits by drilling, and special studies involving laboratory methods which will help to define the composition and physical character of iron ore and provide an appreciation of its genesis.

Dr. Frietsch discussed a number of case histories in their exploration for iron deposits which illustrated the sequence in which different types of surveys and different levels of geological information are used in the exploration and appraisal of mineral prospects. Sweden has been a pioneer in combining magnetic and gravity survey methods in the study of iron deposits. The very detailed geological maps of surface geology on deposits at Svappavaara, prepared after stripping or before mining started, are of a high standard that is rarely achieved and are classical examples of their type. A volume with maps on the Geology and Ores of the Svappavaara Area of Northern Sweden by Dr. Frietsch was published this year which provides excellent detailed geological information.

One important point was appreciated during the course of this visit namely that comprehensive study of Kiruna and the literature on it alone would be misleading if it were accepted as typical of iron deposits in the region. Much has been written about the nature and origin of the Kiruna iron deposit which has many unique features and is the largest in the area. It has been recognized as a special type and is generally regarded outside of Sweden as typical of the iron deposits of the area. The Kiruna deposit and others in the area may have many common factors in their origin and history but similarities are not so obvious in the geological settings, internal features, mineralogy, shape, size, or composition of the various iron deposits in Norrbotten county.

Iron Formations of Central Sweden

Dr. Otto Brotzen is in charge of research work on the metamorphosed iron-formations in Central Sweden and took time from his annual leave to spend one day with the writer. He was very anxious to compare methods and objectives in the study of siliceous iron sediments and seemed to look at our situation in Canada as a worthy guide for developing their research. We discussed problems in the sedimentation, composition and geochemistry of iron-formations in detail. It was reassuring that he proposed a program in Sweden with objectives and study approach that were very similar to those set forth by the writer in Canada in 1962 for a long term research program on iron sediments (Project 62-47). I understand that at least $100,000 has been allocated to Dr. Brotzen's project for study of the composition and internal features of the iron

sediments as well as a sizeable field staff for collecting sample material and data. Although we did not have time to explore the logistics of his program in detail he obviously commands considerable facility for both field and analytical work. A tour through their laboratory building suggested that they operate a highly efficient laboratory establishment with advanced methods that might well be studied as a model.

Earlier work on the minor element content of iron ores in Sweden by Landergren (1948) which has been a classical guide for many iron ore geologists has not been followed up. Dr. Brotzen plans in the course of his project on iron sediments to provide systematic data covering some of the principles set forth by Landergren and of course to interpret these data with reference to chemical sedimentation of iron and silica, and to later magnesian metasomatism which is a characteristic feature of many iron-formations in Sweden. He made it clear that they are looking forward to work in Canada as a guide because of the variety of iron-formations here that have a minimum of chemical alteration, and which represent many different depositional environments. It was regrettable that time did not permit a visit to the field for examination of their iron-formations.

VISITS TO MINE AREAS IN LAPLAND

The LKAB Company, Luossavaara-Kiirunavaara AB was interested in the visit and was most hospitable. Their office in Stockholm was visited briefly and Mr. Sunden of their Public Relations Department provided an itinerary for visiting the mines, looked after all travel arrangements, flights and railway reservations, provided living accommodations at their guest houses at Malmberget and Kiruna, as well as automobile transportation. The efficiency, courtesy and hospitality of this company was deeply appreciated and was especially noteworthy after the previous seven weeks of intensive work and travel in the Soviet Union by the writer. The field work in Sweden provided "a capsule" of scientific observation, discussion of applied geology, and orientation to a very large and significant iron ore area, and the writer was exposed to an incredible amount of geology in three days. Without the support of good publication one would have been overpowered by the great amount of data and descriptive information.

Malmberget:

The town of Malmberget and Gallivare are located about 90 kilometres southeast of Kiruna and 65 kilometres north of the Arctic Circle. The principal iron ore deposits are located immediately north of the town of Malmberget and form a sinuous complex zone that extends from west to east for about 4 miles. The ore zone is up to 330 feet wide and dips steeply. The iron ore forms a series of 'lenses' that are more or less

continuous and conformable with the foliation in the granitoid gneisses or leptite rocks of the area. Magnetite is the principal ore mineral. It is associated with minor hematite and occurs in massive lenses or disseminated in the leptite. Apatite is a prominent gangue mineral. The iron content in the ore from the mine varies but usually exceeds 40 per cent and the ore is concentrated to give 7 different categories of ore in which the iron content varies from 59 to 71 per cent. Much of the ore concentrate is pelletized and this product contains about 68 per cent iron, 0.010 per cent phosphorous and 0.7 per cent silica. About 1 million tons of pellets and 4 million tons of concentrate are produced annually in this area.

All mining is now underground and the operation was closed at the time of the visit during the company's annual vacation period and it was not possible to examine the larger ore zones. Smaller ore deposits and geological relationships were examined in a number of surface mine workings that are no longer operated.

Some of the ore zones are composed predominantly of hematite but the bulk of the ore mined is magnetite. The general distribution of the ore deposits suggests that they may be stratiform or formed by replacement of a favourable stratiform host rock or sedimentary bed. In most cases the iron oxide appears to have replaced granitoid rock or in some instances may even be injected into the host rocks. The expected associations of skarn or calcium silicate mineral aureoles are conspicuous by their absence. The ore is cut in many places by granite or pegmatite dykes.

The genesis of these deposits is not well established and in spite of the general appearance of stratiform distribution stratigraphic control is not an essential factor in predicting ore distribution. Many individual ore lenses occur in geological settings that are comparable to that of the great Kiruna orebody but the geology of the Malmberget ore zone as a whole seems to be much more complex.

Kiruna Orebody and Mine:

A brief visit to the Kiruna underground mine provided a unique experience as the writer was taken for a tour of one level in a taxi and mine personnel are transported underground in buses. Much has been written about the highly efficient engineering and operation of this mine which is all most impressive and does not require further description here. Very good detailed geological description of the orebody is maintained at the mine and is accepted as a routine part of mine development and operation. The impression, however, was gained that emphasis has been given mainly to improving engineering methods and that geological work, especially that on ore genesis, has not been advanced in a comparable degree in recent years.

The Kiruna mine is the largest underground iron ore mine in the world and produces more than 15 million tons of high grade ore and ore concentrate annually. About 2 million tons of pelletized ore is now produced annually. The tabular orebody strikes north-south, dips 40 to 75 degrees east, is about 2½ miles long and averages 300 feet wide with a maximum width of 650 feet and iron content ranges from 60 to 65 per cent. Ore has been proven by drilling to depths exceeding 3,000 feet and the ore masses continue to much greater depth. Most of the apatite gangue ranging from 15 per cent to negligible in the ore is removed in the milling and concentration. The composition of pellets produced is 67 per cent iron, 0.06 per cent phosphorous, 1.9 per cent silica and 0.4 per cent CaO.

Typical geological features were examined in detail along one cross-section through the Kiruna orebody. The boundaries between massive magnetite ore and syenite wallrock are abrupt and well defined and reveal very little obvious information about the origin of this orebody.

The great size and the sharp demarcation between ore and host rock are impressive features of this orebody. The ore consists of massive magnetite with only very small quantities of hematite. The phosphorous or apatite content in the ore varies and the phosphorous rich zones are irregular in shape and are reliably defined by analyses data. They can however be distinguished megascopically as much of the apatite is relatively coarse grained and ore textures in the apatite rich material are distinctive.

The essential difference between the Kiruna ore zone and that at Malmberget or other zones in the region is that Kiruna appears to be one large single continuous massive magnetite lens but other ore zones are complex and consist of numerous small lenses of magnetite and hematite and disseminated magnetite bodies. The genetic history of these orebodies may be similar but there is conspicuous difference in the form and physical habit of the various occurrences.

Svappavaara Mine
Leveaniemi Orebody:

This mine located about 25 miles southwest of Kiruna has been opened recently and when production of about 3 million tons of ore per year is achieved this year it will be the third largest iron ore mine in Sweden.

The mine consists of surface pits and workings in relatively low and flat ground where the depth of overburden on the ore is usually less than a few tens of feet. The geological setting and distribution of ore lenses is similar to that at Malmberget. Grey hematite lenses are more conspicuous and abundant than at Malmberget and more of the ore is composed of mixtures of grey hematite and magnetite. Oxidized zones in the surface and upper parts of many magnetite lenses are interesting features in this ore zone where magnetite is altered to martite and red and brown hydrous hematite or goethite. The depth of martitization and oxidation does not exceed 100 feet in most ore lenses. This oxidation and alteration took place prior to glaciation and its effect on the ore as well as kaolinization of other associated rocks is of considerable geological interest.

The geology at Svappavaara is complicated and study of this ore zone may prove to be the most revealing concerning the origin of the iron deposits in Norrbotten county and those commonly referred to as Kiruna type.

Gruvberget Orebody:

This orebody near Svappavaara was visited briefly with members of a field party of the Geological Survey of Sweden. The excellent exposure of the iron ore lenses provided a good opportunity for study of geological features. The chalcopyrite and sulphide rich zones along the west side of the magnetite and hematite body were of special interest. The open pits and crude mine workings in the sulphide zone were examined where the Laplanders mined copper ore about 300 years ago. The sulphide minerals are disseminated and distributed in irregular patchy zones in scapolitized leptite along the border of the well defined hematite and magnetite of the iron orebody. The sulphide and iron oxide bodies are believed to be closely related genetically but mineral paragenesis is not well defined.

Other Sulphide Occurrences:

A few pyrrhotite - pyrite occurrences were examined in the region with members of the Geological Survey. The sulphide minerals are disseminated in biotite and amphibolite lenses in the leptite and graphite is associated with some of the sulphides. These are believed to be stratiform deposits that are analogous to sulphide facies of iron-formations. None of the zones examined contained significant amounts of base metals but these zones are being prospected and further south in Central Sweden similar types of occurrences contain base metals.

SUMMARY

One week proved to be a very brief and limited period for gaining an appreciation of the extensive geological program being carried out in Sweden on the iron-formations and on the well known iron deposits at Kiruna, Malmberget and throughout Norrbotten county.

Liaison and discussion of common interest and study of iron-formations proved very useful and it was reassuring for the writer to find a similar approach being followed in the research in Sweden to that in progress in Canada.

Field observation in this classical area provided background for a better understanding of the available literature and brought insight and awareness of the complex geological conditions in which the Kiruna type of deposits occur. The information and background will have long range value in the studies of the metallogenesis of iron.

Discussion of specific problems such as difficulties encountered in the pelletizing of this type of ore concentrate were very informative and are of direct value in appraisal of some Canadian deposits.

Considerable modern literature and reference material was obtained in the course of the visit which would not have been easily acquired without direct contact with geologists in Sweden.

Fig 1

MINISTRY OF COMMERCE

GEOLOGICAL SURVEY OF SWEDEN.

DIRECTOR GENERAL K. A. LINDBERGSON. .

Department of research and applied geology
F. BROTZEN.

57 employees

Geological Research

- Stratigraphy and Paleontology incl. Micropaleontology. Rocks and non-metallic minerals.
- Hydro-geology and Soil science

Consulting activity

- Oil and gas prospecting Hydro-geology. Non-metallic minerals resources Rock mechanics

Data processing

- Museum and stores
- Records of wells and drill holes

Mapping department
P. H. LUNDEGÅRDH

25 employees

- Maps and descriptions of bedrock and Quaternary deposits
- Stratigraphic investigations in the pre-Cambrian and the Quaternary.
- Special petrological and petrographical investigations.

- Publication office

Ore investigation department.
G. KAUTSKY

92 employees
114 workers

Geology

- Geological mapping and reconnaisance for ore. Field exploration of ore bodies. Geochemical prospecting.

Drilling

- Diamond drilling Transport Field accomodations. Workshops

Geophysics

- Geophysical surveying on the ground by electromagnetic-magnetic methods. Constructions of geophysical instruments.

- Kiruna office
- Malåtråsk offi. Workshops

Geophysical department
S. WERNER

31 employees

- Airborne geophysical measurements.
- Development of methods, instruments and interpretation technics for ore prospecting and general geological purposes.
- Electronic computing and its application to geophysical, chemical and geological problems.

Analytical laboratories
A. DANIELSON

19 employees

Analytical lab.

- Wet chemistry. Emission spectroscopy. X-ray fluorescens

Mineral chem. lab.

- Mineral separation. X-ray diffraction. Microprobe analysis.

Methods development

Administration
G. NÆSMAN

23 employees

- Secretary offices
- Economy
- Staff
- Documentation

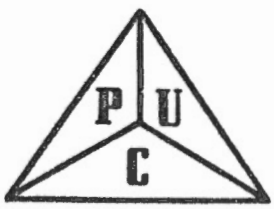
- Library

THE ROLE OF NATIONAL GOVERNMENTS

in

EXPLORATION FOR MINERAL RESOURCES

Edited by
WILLIAM E. BONINI
HOLLIS D. HEDBERG
JORMA KALLIOKOSKI



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CHAPTER 9

Mineral Exploration by the Geological Survey of Sweden

by

K. A. LINDBERGSON

The Geological Survey of Sweden is at the present time very actively engaged in mineral exploration. For the 1963-1964 financial year, $1,250,000 have been proposed by the Swedish Government for mineral exploration out of a total budget for the Geological Survey of 2 million dollars. This sum of money is large by Swedish standards and by the standards of other countries in western Europe. It indicates a favourable attitude to mineral exploration on the part of the Government. Our exploration includes not only geological and geophysical investigations but also an extensive program of diamond drilling in order to estimate tonnage and grade. Of course, we register our discoveries in the name of the Crown. The general conditions for our exploration work will be described below under three headings.

1. The development of the Survey and especially the ore investigation department.
2. The formulation and development of the mining laws of the country.
3. The policy of the government.

The Survey itself is more than 100 years old. It is directly responsible to the Ministry of Commerce. According to its statutes the Survey's job is to gather information on the geology of the country, to carry out the necessary scientific investigations and pay special attention to economic aspects of rocks and soils, to prospect and examine ores and other deposits of economic interest and to study ground water and other geotechnical problems. Both scientific

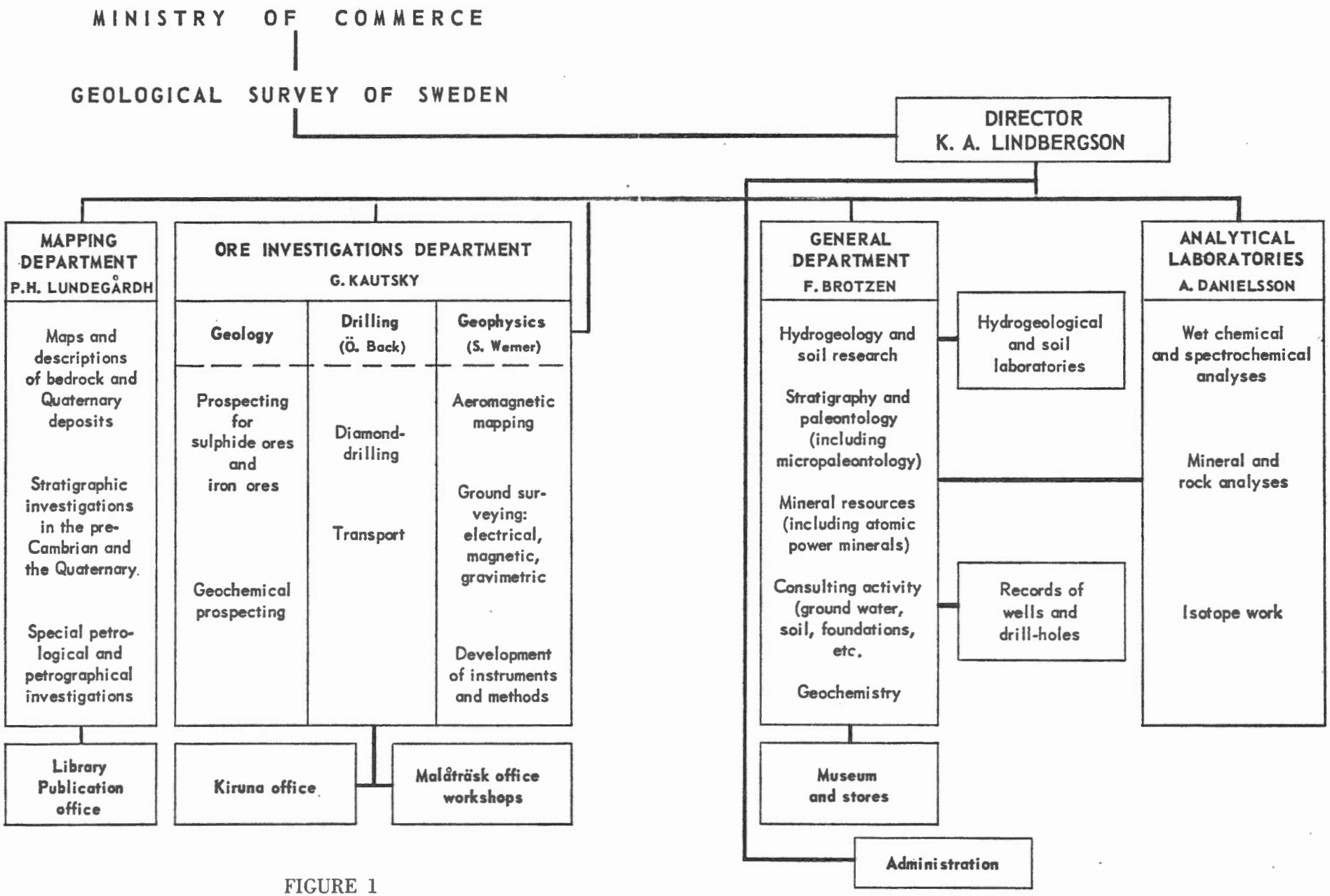
MINISTRY OF COMMERCE
GEOLOGICAL SURVEY OF SWEDEN
DIRECTOR
K. A. LINDBERGSON
MAPPING DEPARTMENT
P.H. LUNDEGÅRDH
Maps and descriptions of bedrock and Quaternary deposits
Stratigraphic investigations in the pre-Cambrian and the Quaternary.
Special petrological and petrographical investigations
ORE INVESTIGATIONS DEPARTMENT
G. KAUTSKY
Geology
Drilling (Ö. Back)
Geophysics (S. Werner)
Prospecting for sulphide ores and iron ores
Geochemical prospecting
Diamond-drilling
Transport
Aeromagnetic mapping
Ground surveying: electrical, magnetic, gravimetric
Development of instruments and methods
GENERAL DEPARTMENT
F. BROTZEN
Hydrogeology and soil research
Stratigraphy and paleontology (including micropaleontology)
Mineral resources (including atomic power minerals)
Consulting activity (ground water, soil, foundations, etc.
Geochemistry
Hydrogeological and soil laboratories
Records of wells and drill-holes
ANALYTICAL LABORATORIES
A. DANIELSSON
Wet chemical and spectrochemical analyses
Mineral and rock analyses
Isotope work
Library Publication office
Kiruna office
Malåträsk office workshops
Museum and stores
Administration

FIGURE 1

and practical aspects are studied and attention is constantly paid to industrial and other needs.

The Survey consists of three departments (See Figure 1).

1. The *Mapping Department* responsible for all mapping of rocks and soils.

2. A *General Department* responsible for stratigraphy and palaeontology of fossil-bearing formations, hydrology and geotechnical matters. The department also undertakes work for public authorities and other clients. During the past five years typical projects undertaken by this department have included a survey of landslides in the Göta River valley, exploration of uranium deposits for the Atomic Energy Company and extensive investigations for several water power projects.

3. The *Ore Investigation Department* includes the Geophysical Section.

The activities of this department is the subject which I want to inform you about today. Besides the departments mentioned we also have separate *Chemical* and *Geochemical laboratories*, and an *Administrative section.*

The Survey as a whole employs 300 persons and of these 200 belong to the Ore Investigation Department. As I said in my opening remarks we expect to spend about 2 million dollars in the coming financial year and our revenues from commissions amount to $300,000. In 1953 our budget was only $500,000.

I should like to say a few words about the development and organization of the Ore Investigation Department.

Originally, prospecting for ores was not a task of the Survey. Toward the end of the 19th Century the Government actually turned down a proposal by the Survey that when an employee found an ore deposit a claim should be made on behalf of the Crown. The shortage of metals (other than iron) and of sulphur during the First World War caused the Government to change its mind. A systematic prospecting was started in Västerbotten County, south of the large iron ore district of northernmost Sweden. Its aim was essentially to locate, by electrical prospecting, the mother lodes of pyrite and copper ore boulders found in the glacial drift that covers most of the bedrock in this part of Sweden.

The outcome of the prospecting of Västerbotten and adjacent parts of Norrbotten County by the Government and the private

Boliden Company in keen competition was the discovery and opening up of one of the most important sulphide ore districts in Europe.

The worldwide search for iron ores after the Second World War caused the Survey to start investigations of the iron ore fields in Norrbotten. In 1958 exploration for iron ores was begun in the Kiruna region (where the world's largest known deposit of high-grade iron ore is situated) on behalf of the state-owned mining company operating the Kiruna mine (LKAB). This brought about a great expansion of the Survey's prospecting department. Ten years ago 50 persons were employed, five years ago 100 persons, and at the present time more than 200 are engaged in this venture. This gives some idea of the development over recent years. The exploitation of the various ore deposits and the part played by the government will be outlined later.

As regards the organization of the Ore Investigation Department, three sections exist; one for drilling, one for geology and one for geophysics. The geological section includes about 15 geologists and 25 other persons. The mining engineer in charge of the diamond-drilling has a staff of 70 persons. He is responsible for 12 machines which drill approximately 25,000 metres per year. The geophysical staff numbers about 90 persons and includes five with academic training, as well as instrument makers and field crews. Last year 6,000 square kilometres were surveyed magnetically from the air, and approximately 350 square kilometres surveyed on the ground, where magnetic, electrical and gravimetric methods were used. In all our operations great emphasis is placed on close cooperation between geologists and geophysicists. Discussions are almost daily, and each program is thoroughly discussed by the respective heads of the geological and geophysical sections before the work begins. At intervals the progress of the work is reviewed. We also recognize the need for employing geophysical methods as regards other aspects of the Survey's work, such as mapping. At the moment, however, our resources are not sufficient.

Mining has very old traditions in Sweden. Our first mining laws date back to the fifteenth century. I do not intend to give you a complete summary of the laws but a few points may be mentioned in order to clarify the situation.

First, I must mention a special law in Sweden dating from 1916 which states that no foreign citizen or company may obtain

or work a mine or deposit in the country without permission from the government. Nor may they take out a mining claim.

Today the right of exploring and exploiting mineral deposits in Sweden is governed by three laws:

1. The Mining Act of 1938.
2. The Coalfields Act of 1886 relating to coal, salt, gas and oil.
3. The Uranium Act of 1960.

In the Coalfields and Uranium Acts, the concession system is applied. I am not going to plunge deeply into these two laws. I just want to say that, presently, our Government is considering alterations to the Coalfields Act, so that this law will be better suited to modern prospecting, especially concerning oil and gas. In this connection I should add that the Survey carried out a prospecting program for oil and gas about ten years ago, paid for by the Government. Traces of oil and gas brines were discovered, which could be of economic interest. We have also prospected for uranium since 1939, lately at the request of the partly state-owned Atomic Energy Company.

The Mining Act is based on the claim-staking system and is deeply engrained in Swedish jurisdiction. This act applies to mineral deposits containing such metals as copper, lead, zinc, and iron and also to minerals like iron pyrites, pyrrhotite, apatite, and magnesite. Graphite is also included. According to the law, the first person to take out a claim at the Mining Inspector's office has the right to investigate and exploit the deposit claimed. The claim covers a circular area with a maximum radius of 200 metres or 660 feet and is valid for three years. It can be extended when special circumstances are at hand. The Crown also takes out claims, a task which therefore also belongs to the Survey, as a result of its prospecting activities.

In some areas, however, claims may not be taken out. Of special interest in this connection are certain state-mining reservations in the northern part of the country, sixteen in all, where only the Crown has the right to take out claims. The extension of these fields is determined by Parliament. They are only to be found on land belonging to the Crown. Seven of the sixteen fields are more than 50 years old.

Earlier there were also restrictions on taking out claims on land owned by the Crown but which did not fall within the reservation area in the northern parts of the country.

A person with a claim who wants to retain his rights must apply for exploitation rights before the expiration of the claim. This

application is handled by the Mining Inspector and if it can be shown that a deposit of value exists he receives what in Swedish is called "utmal." This corresponds to a patented claim in American terminology and has a maximum area of 65 acres.

By the Mining Act of 1938 the State is entitled to 50% interest in a mining venture. But in this case the State must invest capital in proportion to its interest. Prior to this the landowner held this half share. Since the Mining Act did not alter existing legal arrangements the landowner's share is still a feature of all mines on claims, made before this law was enacted. These mines constitute by far the greater proportion of the Swedish mining industry.

Compensation is paid to the landowner for loss of his share. This is a royalty equal to 1% of the value of the minerals up to a maximum of 10,000 Sw.Cr. per patented claim.

Formerly a certain amount of assessment work had to be done to preserve mining rights but this rule is no longer in force. There is instead a retention fee of 20 Sw. Cr. per hectare payable annually by the mine owner. This is divided equally between the State and the landowner.

Matters relating to mineral exploration and mining are dealt with by the Ministry of Commerce (Handelsdepartementet) on the advice of the Board of Trade (Kommerskollegium) and the Geological Survey. The claims are taken out by the Survey in the name of the Crown. Exploitation rights for the land in question are delivered in the name of the Crown, but at the request of the Board of Trade, which manages state mining properties. Active and intimate cooperation between the Board of Trade and the Survey is therefore of great importance. I am pleased to say that this teamwork functions very well indeed.

As I have mentioned earlier the Government was not at all interested in ore prospecting, as late as the 1890's. Dr. Hjalmar Lundbohm, later a famous director of the Luossavaara-Kiirunavaara Company, located the Tuolluvaara iron ore body near Kiruna when employed by the Survey. He took out claims and reported his find to the Government, but the latter was not interested. He was permitted to treat it as his property and sold it afterwards to a private company for about $170,000, which was a lot of money at that time. At the beginning of the 20th Century the policy of the Government changed. In 1907 an agreement with Trafikaktiebolaget Grangesberg-Oxelösund was reached. The State became an equal partner of the

important iron fields at Kiruna. The State also got the option to buy the rest of it at stated intervals. In 1956 Parliament decided to make use of the option and now the State is the sole owner.

After the First World War our prospecting work was centred on the Skellefteä area in the north of Sweden. Several mineral deposits containing copper, zinc and iron sulphides were found and these were—and some of them still are—mined by the privately owned Boliden Mining Company, after agreement with the Government. For most of the ores the company pays the State a certain amount per ton varying with the grade, as well as the prices on the international market.

In the case of the special deposits of the Adak field there is a different sort of agreement. For these mines, producing copper in particular, the State has made all investments and has paid the working expenses. The Boliden Company has operated the mines and receives a certain part of the profits. The balance has been handed over to the State.

As the development of our Ore Investigation Department shows, the interest of the Government in searching for mineral deposits has grown steadily. As we are short of copper in Sweden almost all our resources, before 1957, were concentrated on sulphidic ores. One recent result of this is a new, 12 million ton ore body in the mountains at Stekenjokk with 1.5% copper and 3% zinc. It is situated in the mountains of Västerbotten County near the Norwegian border. The opening of a mine is being considered and the Government is building an access road. Planning in order to find the best way of exploiting the ore is also well under way.

Shortly after the State became the sole shareholder in the giant Luossavaara-Kiirunavaara Company, the company found it necessary to investigate other iron deposits belonging to the Crown in the Kiruna area. With the agreement of the Board of Trade it got an option on the Svappavaara region southeast of Kiruna. The the problem of the company was whether it should carry out its own prospecting, etc., or hand over the job to another organization. The Survey got the job in 1957 and its expenses were paid by the company. The work will probably be finished this year. Our investigations have been mainly concentrated on the Leveäniemi ore body. At first Leveäniemi was thought to consist of some 30 million tons, but later on it was discovered that the real figure was about seven times as high. The company has recently decided to open a new iron ore mine here.

In January, this year, a Government committee, of which I was a member, recommended to the Government that a general investigation of all iron ores in Norbotten should be undertaken. The intention is that the Survey shall carry out this work over a period of 10 years at a cost of about 8 million dollars.

Sweden has a long tradition in mining and in the treatment of iron ores. The centre of this activity was for many centuries Middle Sweden, where several mines still have good ore left.

Today the hardening international competition in most fields results in rationalization and changes of the industrial structure. It is likely that some of the mines of Central Sweden will have to close, because of their relatively small size. If Sweden is to retain her share of the world market regarding iron ore, it will have to rely on the northern parts of the country where the larger ore bodies are to be found. Most of these are owned by the State. When planning for the future, the State must have the best possible knowledge of the ores. This helps to explain the Government's strong support for the prospecting activities of the Survey. We realize of course that in certain cases no visible return may be seen for many years on which money has been spent on this work. But the Survey's expenses are very small compared with the potential value of the ores. They will be more than repaid to say the least, if—by providing a sound basis for future planning—they prevent hazardous investments. Our results up to now have convinced the Government of the wisdom of investing in our ore investigations. We hope the Government, later on, will also regard favourably our requests for increased financial support for mapping and purely scientific work.

Our interest in the ore resources of our country prompted many years ago an official Spanish publication to characterize Sweden as the most forward thinking nation in Europe. Even if this is a polite exaggeration, our present activities in the field of ore prospecting are based on consideration for the future.