

THE IRON ORE RESOURCES OF NORWAY

Arth. O. Poulsen

The forty years which have passed since the late Professor J.H.L. Vogt wrote on the Norwegian Iron ores for The XI International Geological Congress at Stockholm 1910 have greatly increased our knowledge of the iron-deposits and proved that our ore supplies are much larger than previously computed.

Studies of our iron-ore deposits seem to make a rearrangement of time-old geological classification of certain ore deposits necessary.

New deposits of any importance have not been discovered.

Our mining industry, and specially the iron-ore industry, received a mighty impulse by World-War I. In the years before World-War II the iron-ore production passed the pyrite industry in importance. World-War II and the German occupation meant a general drawback on the mining industry; and, finally, the invasion in Northern Norway resulted in the complete destruction of the plant and housing accommodation at Kirkenes. Our most important iron-ore mine is thus not working, but rebuilding is going on and ordinary production is to start in a year.

Another consequence of the war is the dominating interest obtained by the government in our iron-ore deposits and mines, partly by confiscating the enemy interest in the mining industry, and, also, by the financial aid rendered for the rebuilding and refitting of plants and equipment

destroyed or worn out during the war.

The ore-minerals are magnetite and hematite.

A siderite, rich in manganese, has been proved to be the main ore-bearing mineral in a deposit which is now being explored.

Geologically, the Norwegian iron-ore deposits can be classified in three main groups:

- A. Magmatic deposits
- B. Sedimentary deposits
- C. Metasomatic ( contact metasomatic ) and vein deposits.

To this may be added a fourth group containing recent deposits ( bog-iron inter alia ). This group, is, however, quite unimportant.

A. Magmatic deposits.

I. Non-titaniferous ores:

- a. Rich in phosphorous: Søftestad (51), Lyngrot and Solberg (48).
- b. " " sulphur: Smorten, Kaljord, Matmoderen, Lonkanfjord (26,27) etc. in the Lofoten and Vesterålen islands in Northern Norway, Jernsmauget (44) on the west coast.

II. Titaniferous ores:

- a. Ores containing titano-magnetite:  
Tappeluft (4), Kjerringhau-  
gen (2), Stjernøy (3) deposits.  
Selvåg (24) etc. in the Vester-  
ålen and Lofoten islands.

Rødsand, Meisingset (40),  
Solnørdal, Sjøholt (41),  
Taffjord (42), Sørødal (43),  
Løland, Myrestø, Ståljern (49)  
Brekke etc., Ramsøy (55),  
Trandum.

b. Ilmenite-ores:

Sokndal, and Ekersund (45,46).

B. Sedimentary deposits.

I. Quartz-banded ores in archean rocks:

Sydvaranger (1), Fiskefjord (22)  
etc.

II. Iron-bearing stratas in the micaschist - marble series  
of Northern Norway (Cambro Ordovician):

- a. Tromsøssundet (5), Salangen (7),  
Sjåfjell (16), Nøverhaugen (28),  
Dunderland (29), Seljelid (32),
- b. Eiterådalen (36) etc.
- c. Rubben (8)

III. III. Ore-deposits of supposed sedimentary origin, metamor-  
posed by palingenesis:

Beitstaden - Hitra (38,39).  
Arendalsfjord (47).

C. Metasomatic and Contact deposits, Veins.

I. In the contact-zone of the Oslo-field:

Åserud, Narverud (53).

II. Replacement-deposits in limestone:

Fehn at Ulefoss (52).

III. Brecciated veins in amphibolic schist:

Langø (50).

IV. Veins in granite:

Spetalen (54).

D. Bog-iron.

Deposits in lakes and marshes:

Storsjøen, Hurdalen etc.

Historical and statistical dates.

The history of the Norwegian Iron-ore industry may be divided in three more or less separate periods. From the remotest time in our history, bog-iron has been extracted from the marshes and used for the production of "blæsterjern". This was a home-industry, but the iron was at that time an important article in trade. The last "blæsterjern" was produced as late as about 125 years ago.

With the introduction of the blast furnace about 1530, the mining of iron-ore was started, and in the next 300 to 350 years the Norwegian iron-ore industry played an important part in the economic life of the country. The Norwegian blast furnaces employed charcoal, but the increasing cost of charcoal and the competition of the European iron industry based on use of coke, made the Norwegian iron-industry unprofitable.

Finally, the electric iron-furnace was introduced forty years ago. The total production of electro-iron during this period is about 850,000 tons. The production of the old blast furnaces was according to Professor J.H.L. Vogt about 1½ mill. tons. The production of "blæsterjern" cannot be calculated.

The production of iron-ore mined up to the year 1908 is

calculated by Professor Vogt to about 4½ mill. tons, of which 750,000 tons were exported. In the years 1909 to 1948 about 17½ mill. tons were produced of which about 16 mill. tons were exported. During the last decade (1939/48) the iron-ore production was 3,8 mill. tons of which 0,8 - 0,9 mill. tons were consumed in the country.

There is, however, a very marked difference in the iron-content of the ore. Up to 1903 the mines produced lump-ore with an iron-content of about 40-42 %. Since the exploitation of the sedimentary ore-deposits in the year 1906, and of later years, the production of iron-ore concentrates and briquettes, have dominated the Norwegian iron-industry. During the most recent period (1909/48) about 90 % of the ore shipped was in the form of concentrate or briquettes with an iron-content of 63 - 66 %.

An important role has also been played by the titaniferous iron-ores, a little above 1 mill. ton (lump-ore and magnetite-concentrate) have been produced altogether, of which 0,9 mill. tons in the last period (1909/48).

The vanadium-content of the titaniferous iron-ores is a valuable asset.

Iron-ore production during recent years:

1945	1946	1947	1948	1949	1950 <sup>1)</sup>
Prod. 78,538	59,072	127,798	199,299	274,305	403,575

1) incl. ilmenite-ore.

The different deposits and their ore-supply.

A. Magmatic deposits.

I. Non-titaniferous iron-ores:

Søftestad (51)

situated about 300 m. from the Nisservann i Telemark in Southern Norway. The deposit has been known for more than one hundred years, but owing to an isolated situation with a difficult access to the sea and a high content of phosphorous, was only started in 1914. After a few years the mine was closed down and was idle up to 1939, when the mine was reopened. During the last ten years (1939/48) production amounted to 166,418 tons. Previously, some 8-9000 tons were taken out: the total production thus lies below 200,000 tons.

The ore contains 56 % Fe and 2 % P.

The deposit is only a small one; ore in sight is about 1/4 mill. tons with two or three times that quantity as a probable and possible ore-supply.

Lyngrot and Solberg (48),

are situated in Southern Norway.

The mines were worked up to 1870 and delivered a few hundred thousand tons of ore. The ore is a magnetite, rich in apatite. The ore-reserves are insignificant, but the Lyngrot mine may possibly have a future as a producer of apatite-ore.

The Northern Norway.

has a number of magmatic ore-deposits, the greater part being rich in sulphur. About forty years ago work was star-

ted on some of these deposits and 5-600,000 tons have since been taken out. The deposits at Smerten (27), Matmoderen (26), Lunkan, Kaljord, Kvæfjord (20), and Bjarkøy have only been worked for short periods before being closed down. The mines of Meløy (18) produced 417,000 tons before being exhausted (1930). A deposit at Kasfjord (19) has been explored, but no work started. The ore mineral is a magnetite, containing 50-62 % Fe and some sulphur, which - according to Professor Vogt - may easily be separated. The ore appears as two parallel layers with a width of about 8 m.

The ore reserves are probably small.

## II. Titaniferous iron-ores.

### a. Ilmenitic ores:

The ilmenite-ores from Sokndal and Ekersund (45,46) were used as an iron-ore 80 to 90 years ago and about 100,000 tons were exported. In 1917 the mines were reopened, the ilmenite being utilized for the production of paints. The ore also contains magnetite and the mines thus produce a magnetite concentrate as a by-product.

The crude ore must be classified as an ilmenite-norite containing about 18 %  $TiO_2$  and 20 % Fe.

By processing, 3,5 tons ore give 1 ton ilmenite and 0,22 ton magnetite.

The total production to the end of 19<sup>48</sup>/<sub>8</sub> was a little above 200,000 tons magnetite and 1. mill. ton ilmenite.

The ore-reserves are large, Storgangen - actually being worked - has an ore-area of about 150,000 sq.m.

The ore in sight is computed to be 50 mill. tons down to 60 m. below the main level. The probable and possible ores are very large in quantity.

The Ekersund ilmenite deposits can, according to a report by Dr. Noest, produce about 4 mill. tons iron-ore concentrate.

b. Titanomagneti<sup>tic</sup> ores:

The country has a number of iron-ore deposits containing a small percentage of titanium oxide. These deposits are classified by Professor Vogt as titanomagneti<sup>tic</sup>.

In Northern Norway we have Stjernøy (3), Kjerringhaugen (2), Tappeluft (4) etc. No prospecting has been undertaken; Stjernøy deposits are, however, supposed to contain a large supply of low-grade ore.

The Selvåg (24) deposits are situated close to the sea-shore on the west coast of Langø in Vesterålen. Some prospecting has been carried out, and the ore in sight is computed to be about 20 mill. tons, the probable ores amounting to about 60 mill. tons.

The ore contains 20-33 % Fe, 3-4 % Ti O<sub>2</sub> and 0,3 to 0,4 % V<sub>2</sub>O<sub>5</sub>.

1 ton crude ore will give 0,3 ton concentrate of magnetite.

Similar deposits at Hjellsand, Andopen etc., are smaller and have only a limited interest.

In the western part of Norway the Rødsand-Meisingset (40) deposits are being exploited. Rødsand produced some thousand tons of lump-ore. From 1910 the mine has delivered an iron-ore concentrate containing 62-63 % Fe and 0,5 % V.

Production has lately been about 50,000 tons a year. The total production is 689,000 tons concentrate and 28,000 tons lump-ore (1910/48).

The ore-supply is computed to be three mill. tons ore in sight, with about the same quantity as possible ore.

1 ton of crude ore gives 0,33 ton concentrate of magnetite.)

On the west coast of Southern Norway deposits are situated at Sjøholt, Solnørdal (41), Tafjord (42), Sørørdalen (43), Lindane etc., the most important being Solnørdal-Sjøholt. The area of the horizontal sections of the ore-bodies is calculated to be about 6,500 sq.m. Mining has been tried at several of these deposits, but the ore-supplies have not been computed. Some titaniferous iron-ore deposits in the eastern part of the country are small and of no economic interest. Professor J.H.L. Vogt gives the total ore-area of the smaller deposits to be 50,000 sq.m.

#### B. The sedimentary iron-ores.

##### I. Quartz-banded ores in Archean rocks:

The most important deposit of this kind is that of Sydvaranger (1), where work was started in the year 1910. The total production is about 12 mill. tons concentrate and briquettes, and a few hundred thousand tons lump-ore. Work was stopped in 1944, when the plant was destroyed during the war, and is scheduled to restart in the autumn 1951.

The mines produced a little short of 70 % of the total iron-ore production of the country.

The new plant is based on a production of 800,000 tons concentrate a year.

The crude ore contains on an average 33-36 % Fe. (30-32 % magnetic Fe).

At present a thorough geological and technical investigation of the deposits is being carried out. The ore-reserves are computed to lie in the neighbourhood of 1,000 mill. tons. (crude ore).

X The Fiskefjord-Vestpolltind (21,22) deposits on Hinne (Vesterålen Islands) contain a banded iron-ore of a type somewhat similar to that occurring at Sydvaranger. Fiskefjord, however, contains less quartz, the bands being mainly composed of other minerals. The ore-bearing area - covering many sq.km. - can be traced from Oksfjord in the south-east up to the Lahaugen (23) deposits (on the Langø) in the north-west - a length of about 50 km. The width of the area is 12-15 km. The ore occurs as a large number of more or less isolated deposits.

Magnetite is the predominating ore-mineral in the central and northern part, with hematite in the southern. In the southern part the ore also contains some percentage of manganese. The iron-content varies from 36-37 % Fe in the Vestpolltind deposits.

Prospecting has been carried out in different places. In the Vestpolltind deposits 5,7 mill. tons ore were proved in sight and probable and possible ore-reserves are 15 mill. tons.

In the Fiskefjord deposits the ore-supply was proved to be some mill. tons in two-three of the larger deposits.

The Lahaugen deposit has - according to S. Foslie - an ore area of 3,000 sq.m.

A thorough geological and technical investigation of this ore-bearing district is still wanted - the quantity of the ore-supply available is thus uncertain.

## II. Iron-bearing stratas in the micaschist - marble series of Northern Norway:

The Tromsøundet-Salangen (5-7), Sjøfjell (16)-Dunderland-Eiterådalen deposits (29-36) form parts of the extensive iron-bearing strata in the northern Marble-Micaschist series.

X The iron-ore bearing strata occur as members of the series, and the deposits usually have a great extension along the strike and the dip. The width of the ore-layers varies within large limits.

The total length of the ore-bearing strata is about 550 km. The strata are, however, interrupted by eruptive intrusions or cut by numerous fjords. The ore-mineral is predominately magnetite in the northern part (from the Ofoten-basin) and a mixture of hematite and magnetite in the southern. There is also a marked difference in the iron-content of the northern and the southern part of the stratas. In the northern part the deposits usually have an iron-content of 20-22 %Fe, which in places goes up to 28-30 %. In the southern, the percentage is 30-33 % up to 40-45 %.

In the northern part, there exists a western and eastern branch of the iron-bearing strata owing to a syncline which extends northwards from Håfjell (in Ofoten). There also exist iron-bearing strata in the eastern part of the country: The Sjåfjell-Beisfjord-Fagernes (12-14) deposits.

The northern iron-ore-bearing strata contain very large quantities of ore, but - although the deposits were discovered 50 to 75 years ago and mining started at several of the deposits - the total ore produced does not exceed 1 mill. tons (mainly as concentrate).

Difficulties with the processing of the ore are responsible for the poor result of the exploitation. The separation problems, however, are said to be solved.

The different mines and deposits from north to south:  
The Tromsøundet deposits (5) prospected in the year 1908

and again during the war. J.H.L. Vogt estimated the ore-supply to be several mill. cb. m. of crude-ore. Recent investigations seem to prove that the ore is too poor for exploitation.

The total production is only a few thousand tons.

The Sørreisa (6) deposits situated on the coast about 100 km. south of the Tromsøund. The deposits, assumed to be one of the largest in Norway of its kind, were calculated by Professor J.H.L. Vogt to have an ore-area of 200,000 sq. m. (transversal sections) and an average width of 23 m. A thorough sampling in recent years seems to prove that the deposits are too poor in iron to be exploited.

The Salangen (7) deposits about 40 km south of Sørreisa were worked for a few years (1909/12) and about a hundred thousand tons of briquettes were exported. Work was, however, given up as unremunerative. One of the deposits - Storhaugen - contains 30 mill. tons ore, the iron content being 26 to 29 %.

The Lavangen and Gratangen (10) deposits are a southern continuation of the Salangen. Some prospecting has been carried out, but the ore contains only 18-22 % Fe.

Bogen (11) is situated on the Ofoten fjord some 70 km south (south-west) of Gratangen. Exploitation was started in 1906 and was - with several interruptions - carried on till 1939. The ore was too poor to give a satisfactory result.

The total production was 365,000 tons concentrate.

✕ The western branch includes deposits on Anderja (9) and Rolløy (17). Prospectings have proved an ore-supply of about 15 mill. tons at Anderja and about 5 mill. tons at Rolløy. The iron content is 31-32 % Fe. The Anderja ore contains a high percentage of phosphorous.

South of the Ofoten fjord are the Håfjell (15), and Sjåfjell (16) deposits. The deposits were extensively prospected during the first decade of this century. The ores are, however, poor; The Håfjell contains 23 % and the Sjåfjell 26 % Fe.

The eastern branch, including Skjomen, Beisfjorden (14), Fagernes (13) Storvann (12), etc., is a direct continuation of the Sjåfjell deposits. Fagernes is the best known: extensive prospecting and sampling were carried out in the year 1910. The ore-area is 22,5000 sq.m. (900 x 25 m), and the <sup>iron</sup> ~~ore~~-content 27,76% Fe. The ore-supply is not calculated.

The Neverhaugen (28) deposit belongs to the southern group. The deposit was found 75 years ago, and extensive prospecting has been carried out. The ore-bearing stratum has a length of about 8 km. The ore-area is calculated to be 12,500 sq.m. The ore contains 36 % Fe and 0,19 % P.

The ore-supply is calculated to 3½ mill. tons above Lake Grønli.

The Dunderland and Rana (29) deposits are situated on the northern side of the Dunderland valley. The Dunderland Iron Ore Co. exploited the deposits from the year 1906 up to the last war. The total production was 636,000 tons (concentrate and briquettes), the work being interrupted several times and for years at a time owing to difficulties with the processing of the ore.

The ore minerals are hematite and magnetite. The proportion:  $Fe_{mag.} : Fe_{hem.}$  is 2:1 in the Storvann deposits and varies from 1:3 to 1:10 in the other deposits.

A small percentage of phosphorous increased the difficulties.

The ore contains on an average 33 % Fe and 0,2 % P.

An intensive investigation has lately been carried out in the deposits. The total ore-area is about 500,000 sq.m. and the

pre-supply 1,000 mill. tons. (crude ore).

The Lasken-Grønlifjell-Nevernes (31) deposits are situated south of the foregoing. The ore-minerals are predominately magnetite in the Lasken-Grønlifjell, with the common hematite-magnetite ore in the Nevernes. The ore-areas are computed to 100,000 sq.m for the Lasken deposits. The ore from Lasken contains 30,35 % total Fe, 25-30 % magnetic Fe. The phosphorous content is somewhat higher than in the ordinary ore types ( 1,1 - 1,7 % P ). The ore-area of the Grønlifjell-Nevernes deposits are probably large, but no definite values are known.

X The Ormlid-Fuglevik-Bjørnå (30) deposits are situated about 20 km to the west of the Dunderland. The ore-areas are not known, but Professor J.H.L. Vogt reports that the deposits are important.

From Hennesberget and southward to Vefsen, a distance of about 150 km, several large iron-deposits occur. The best known are Seljelid, Fuglestrand, Elsfjordstrand, Formo, Dolstadsåsen, Herringbotn, Eiterådalen and Rapen (32-37). More or less intensive prospecting has been carried out on these deposits, but ordinary exploitation has not been started, partly to the repeated failures in the beneficiation of the Dunderland ore.

The ore-minerals are hematite and magnetite in varying proportions.

The Seljelid (32) deposit has an ore-area of 200,000 sq.m and an average content of 34,54 % Fe and 0,15 % P.

The Fuglestrand (33) deposit contains partly a rich ore, and production of lump-ore was tried in the nineties. The proportion hematite: Magnetite is 1:1, the iron-content lies between 38 and 52 %. The ore-area is <sup>u</sup> unknown.

The Elsfjordstrand (34) deposit has an ore-area of 60,000 sq.m and an ore with 34,3 % Fe.

The Forsmo and Dolstadåsen deposits both contain partly a richer ore. Production of a lump-ore was tried, but work was abandoned owing to difficulties with transport.

The Herringbotn (35) deposit has an ore-area of 15,000 sq.m (1000 x 15 m) and the Eiterådalen (36), a total ore-area of about 250,000 sq.m. The phosphorous-content is rather high. The ore has 30 % Fe.

The Rapen (37) deposit in Vefsen is a 10 m wide layer with a granular magnetite. The iron-content is about 40 %.

### III. Ore-deposits of uncertain origin:

In this group will be included the Beitstaden (38) and Arendal (47) deposits, which generally have been classified as magmatic (The Beitstaden) or contactmetasomatic, "Skarnberg deposits" (The Arendal deposits). Later studies seem to prove a sedimentary origin for both. By palingenesis and regional metamorphism the ores have arrived at their present state.

The Beitstaden (38) deposit occurs in an ore-bearing zone, which can be traced from the Fosdalen mines over a length of about 150 km towards the southwest. The ore appears in possibly Archean rocks which are gneisified by regional metamorphism.

The Fosdalen (38) mines, the most important, were opened in 1907. To start with, the mines produced a lump-ore containing 55 % Fe and 2-3 % S. From the year 1914 the mines have produced a concentrate containing 65-66 % Fe, and 0,6 % S. The total production is 2,900,000 tons ore (62,000 tons lump-ore). The crude ore contains 40-41 Fe and 2 % S. The ore-mineral is magnetite.

Ore in sight is 2 mill tons, probable and possible ores are 40 mill. tons. The ore-resources of the un-developed deposits run into a few hundred mill. tons.

The Hitra (39) deposits are small: a few thousand tons have been exported.

The Arendal (47) deposits in Southern Norway, played in older times a most important part in the Norwegian iron industry. The total production is 2,7 mill. tons. In recent years only the Klodeberg and the Bråstad mines have been worked and only on a limited scale.

The total ore-area, covering the twenty odd mines in the district, is, according to Professor J.H.L. Vogt, only 8,000 sq.m and the ore in sight about 1,5 mill. tons. The probable and possible ores are 3-4 mill. tons.

C.

C. Metasomatic and contact-deposits. Veins.

I. In the contact-zone of the Oslo-field a lot of small iron-ore deposits are known. In times past these mines delivered ore to the ironworks situated in the eastern part of Norway.

The only mines which may have some interest are the Åserud-Narverud (53) mines. The ore-area is, however, only 1 a 2000 sq.m.

II. Replacement deposits.

The Fehn mines (52) at Ulefoss. The ore - a hematite - occurs as veins in an impure limestone. Mining started in 1760 and the total production is 991,000 tons of which 376,500 tons during the last forty years. (Prod. 1939/48 was 13,1000 tons).

The iron-content of the ore is 47-55 %: the content of phosphorous is 0,4-0,7 %. The ore-area is about 2,500 sq.m. The ore-supply is only a few mill. tons.

### III. Veins:

The Lange (50) deposits on the island Skåtøy occur as veins in a brecciated amphibolitic schist. The ore-mineral is magnetite, sometimes with a small percent of hematite. The iron-content is 45-48 %. The mines were opened three hundred years ago. The total production is 530,000 tons. Work was suspended about 1870. In later years, (1907/21) 68,161 tons were produced.

The ore-area is calculated by Professor J.H.L. Vogt to be about 2,500 sq.m, and the ore-supply to  $\frac{1}{2}$  a 1 mill. tons.

The Spetalen (54) deposits are situated in the eastern part of Norway. The ore is a hematite which occurs as pneumatolytic or hydrothermal deposits on veins in a granite. The ore is rather rich in iron, usually 57-69 % Fe. The mines have been idle for many years. The total production is calculated at 60-80,000 tons. The ore-area is 2,500 sq.m., and the ore-supply computed to about 1. mill. tons about the level of Lake Spetalen.

Arndal

Samlet per

2.7 ~~2-2 1/2~~ mil<sup>+</sup>

Samlet reiser

v 2-2 1/2 -

7 800 km på

noen type gratesfelle

med 1/2 med 7; parvst

3-4 - - sandstyg

Kladrøy feltet prosiding

kap v 15-20000 +

Resumé.

Ore-resources:

	Ore in sight	Probable ore in mill.t.	Possible ore	Total	
<u>A. Magmatid deposits:</u>					
Søftestad (51)	0,25	0,25	?	0,5-1,0	Rich in phosphorous
Sokndal (46)	2,0	?	?	?	Calcul. as a magnetite
Ekersund (45)				4	conc. (titaniferous)
Selvåg (24)	6-7	18-20		25-30	
Rødsand (40)				2	"
Meisingset (40)					
Solnørdal, Sjøholt (41)					
Tafjord etc. (42)					
<u>B. Sedimentary deposits:</u>					
Sydvaranger (1)				400 <sup>2</sup> 600	Calc. as magnetite conc.
Fiskefjord (22)	2-3	?	?	2-3	Crude ores.
Vestpolltind (21)	5-6	15		20	
Tromsøundet (5)	?	?	?		
Sørreisa (6)					
Salangen (7)	7	?	?	7	Conc.
Andørja (9)	15	?	?	15,	Crude ore
Rolløy (17)	5	?	?	5	"
Fagernes (13)	?				
Neverhaugen (28)	3,5	?	?	3,5	"
Dunderland/Rana (29)				300-400	Conc.

Lasken/Grønlfjell (31)

Ormlid/Fuglevik (30)

Seljelid (32)

Fuglestrand (33)

Elsfjordstrand (34)

Herringbotn (35)

Eiterådalen (36)

Rapen (37)

Fosdalen (38)	2	40	42	Conc.
Arendals-field (47)	1,5	3,4	4-6	Lump-ore

C. Metasomatic and contact-deposits. Veins:

Fehn mines (52)			2-3	"
Langø (50)			0,5-1,0	"
Spetalen (54)		1,0	1,0	"

The Norwegian iron-ore supply - computed from the results of prospecting - lies between 1,000 and 1,100 mill. tons (calculated as an iron-ore concentrate).

The iron-bearing strata in Northern Norway have several large ore-deposits, with an iron-content of 28 to 35 % and sometimes a still higher percentage. These are, however, only partly prospected, and their ore-supplies not computed. This group includes Lasken-Grønlfjell, Seljelid, Eiterådalen etc.

The total ore-area is - as far as determined - about 600,000 sq.m. Professor J.H.L. Vogt has calculated the ore-area of the smaller titaniferous iron-ore deposits to be about 50,000 sq.m.

And, finally, the country has large quantities of ore too poor in iron to be worked at the present time. They represent the potential ore-reserves.

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I am much indebted to Mr. Oppegaard of Titania A/S, Dr. Jens A.W. Bugge of Sydvaranger A/S, Messrs. Lowzow and Asak of Christiania Spigerverk (the Rødsand Mines) for information and helpful suggestions, and to Mr. S. Foslie of the Geological Survey.

## THE IRON ORE RESOURCES OF NORWAY

by <sup>1</sup>

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## I. — GENERAL

The forty years which have passed since the late Professor J. H. L. VOGT wrote on the norwegian iron ores for The XI International Geological Congress at Stockholm 1910 have greatly increased our knowledge of the iron-deposits and proved that our ore supplies are much larger than previously computed.

Studies of our iron-ore deposits seem to make a rearrangement of time-old geological classification of certain ore deposits necessary.

New deposits of any importance have not been discovered.

Our mining industry, and specially the iron-ore industry, received a mighty impulse by World-War I. In the years before World-War II the iron-ore production passed the pyrite industry in importance. World-War II and the German occupation meant a general drawback on the mining industry; and, finally, the invasion in Northern Norway resulted in the complete destruction of the plant and housing accomodation at Kirkenes. Our most important iron-ore mine is thus not working, but rebuilding is going on and ordinary production is to start in the near future.

Another consequence of the war is the dominating interest obtained by the government in our iron-ore deposits and mines, partly by confiscating the enemy interest in the mining industry, and, also, by the financial aid rendered for the rebuilding and refitting of plants and equipment destroyed or worn out during the war.

The ore-minerals are *magnetite* and *hematite*.

A *siderite*, rich in *manganese*, has been proved to be the main ore-bearing mineral in a deposit which is now being explored.

Geologically, the norwegian iron-ore deposits can be classified in three main groups :

a) *Magmatic deposits*;

b) *Sedimentary deposits*;

c) *Metasomatic (contact metasomatic) and vein deposits*.

To this may be added a fourth group containing *recent deposits* (bog-iron inter alia). This group is, however, quite unimportant.

## a) MAGMATIC DEPOSITS

1. Non-titaniferous ores :

α) *Rich in phosphorous*: Söftestad (51), Lyngrot and Solberg (48).

β) *Rich in sulphur*: Smorten, Kaljord, Matmoderen, Lonkanfjord (26, 27) etc. in the Lofoten and Vesterålen islands in Northern Norway, Jernsmauget (44) on the west coast.

1. The writer is much indebted to Mr. OPPEGAARD of TITANIA A/S, Dr. JENS A. W. BUGGE of SYDVARANGER A/S, MESSRS. LOWZOW and ASAK of CHRISTIANIA SPIGERVERK (the Rodsand Mines) for information and helpful suggestions, and to Mr. S. FOSLIE of the GEOLOGICAL SURVEY.

(1909-48) about 90 % of the ore shipped was in the form of concentrate of briquettes with an iron-content of 63-66 %.

An important role has also been played by the titaniferous iron-ores, a little above 1 mill. ton (lump-ore and magnetite-concentrate) have been produced altogether, of which 0,9 mill. tons in the last period (1909-48).

The vanadium-content of the titaniferous iron-ores is a valuable asset.

#### IRON-ORE PRODUCTION DURING RECENT YEARS

	1945	1946	1947	1948	1949	1950 <sup>1</sup>
Prod.	78,538	59,072	127,798	199,299	274,305	403,575

### III. — THE DIFFERENT DEPOSITS AND THEIR ORE-SUPPLY

#### a) MAGMATIC DEPOSITS

##### 1. — NON-TITANIFEROUS IRON-ORES

*Søftestad* (51) situated about 300 m. from the Nisservann i Telemark in Southern Norway. The deposit has been known for more than one hundred years, but owing to an isolated situation with a difficult access to the sea and a *high content* of *phosphorous*, was only started in 1914. After a few years the mine was closed down and was idle up to 1939, when the mine was reopened. During the last ten years (1939-48) production amounted to 166,418 tons. Previously, some 8-9000 tons were taken out: the total production thus lies below 200,000 tons.

The ore contains 56 % Fe and 2 % P.

The deposit is only a small one; ore in sight is about 1/4 mill. tons, with two or three times that quantity as a probable and possible ore-supply.

*Lyngrøt and Solberg* (48) are situated in Southern Norway.

The mines were worked up to 1870 and delivered a few hundred thousand tons of ore. The ore is a *magnetite*, rich in *apatite*. The ore-reserves are insignificant, but the Lyngrøt mine may possibly have a future as a producer of apatite-ore.

*The Northern Norway* has a number of magmatic ore-deposits, the greater part being *rich in sulphur*. About forty years ago work was started on some of these deposits and 5-600,000 tons have since been taken out. The deposits at Smorten (27), Matmoderen (26), Lunkan, Kaljord, Kvæfjord (20), and Bjarkøy have only been worked for short periods before being closed down. The mines of Meløy (18) produced 417,000 tons before being exhausted (1930). A deposit at Kasfjord (19) has been explored, but no work started. The ore mineral is a *magnetite*, containing 50-62 % Fe and some sulphur, which—according to Professor VOGT—may easily be separated. The ore appears as two parallel layers with a width of about 8 m.

The ore reserves are probably small.

##### 2. — TITANIFEROUS IRON-ORES

###### α) *Ilmenitic ores* :

The ilmenite-ores from Sokndal and Ekersund (45,46) were used as an iron-ore 80 to 90 years ago and about 100,000 tons were exported. In 1917 the mines were reopened, the ilmenite being utilized for the production of paints. The ore also contains *magnetite* and the mines thus produce a magnetite concentrate as a by-product.

The crude ore must be classified as an *ilmenite-norite* containing about 18 % Ti O<sub>2</sub> and 20 % Fe. By processing, 3,5 tons ore give 1 ton ilmenite and 0,22 ton magnetite.

1. Incl. ilmenite-ore.

less quartz, the bands being mainly composed of other minerals. The ore-bearing area — covering many sq. km. — can be traced from Oksfjord in the South East up to the Lahaugen (23) deposits (on the Langö) in the North West — a length of about 50 km. The width of the area is 12-15 km. The ore occurs as a large number of more or less isolated deposits.

*Magnetite* is the predominating ore-mineral in the central and northern part, with *hematite* in the southern. In the southern part the ore also contains some percentage of *manganese*. The iron-content varies from 36-37 % Fe in the Vestpolltind deposits.

Prospecting has been carried out in different places. In the Vestpolltind deposits 5,7 mill. tons ore were proved *in sight* and probable and possible ore-reserves are 15 mill. tons.

In the *Fiskefjord* deposits the ore-supply was proved to be some mill. tons in two-three of the larger deposits.

The *Lahaugen* deposits has — according to S. FOSLIE — an ore area of 3,000 sq. m.

A thorough geological and technical investigation of this ore-bearing district is still wanted — the quantity of the ore-supply available is thus uncertain.

## 2. — IRON-BEARING STRATAS IN THE MICASCHIST - MARBLE SERIES OF NORTHERN NORWAY

The Tromsundet-Salangen (5-7), Sjøfjell (16) — Dunderland-Eiteradalen deposits (29-36) form parts of the extensive iron-bearing strata in the northern *Marble-Micaschist Series*.

The iron-ore bearing strata occur as members of the series, and the deposits usually have a great extension along the strike and the dip. The width of the ore-layers varies within large limits.

The total length of the ore-bearing strata is about 550 km. The strata are, however, interrupted by eruptive intrusions or cut by numerous fjords. The ore-mineral is predominately *magnetite* in the northern part (from the Ofoten-basin) and a mixture of *hematite* and *magnetite* in the southern. There is also a marked difference in the iron-content of the northern and the southern part of the stratals. In the northern part the deposits usually have an iron-content of 20-22 % Fe, which in places goes up to 28-30 %. In the southern, the percentage is 30-33 % up to 40-45 %.

In the northern part, there exists a western and eastern branch of the iron-bearing strata owing to a synclinal which extends northwards from Håfjell (in Ofoten). There also exist iron-bearing strata in the eastern part of the country : The *Sjøfjell-Beisfjord-Fagernes* (12-14) deposits.

The northern iron-ore-bearing strata contain very large quantities of ore, but — although the deposits were discovered 50 to 75 years ago and mining started at several of the deposits — the total ore produced does not exceed 1 mill. tons (mainly as concentrate.)

Difficulties with the processing of the ore are responsible for the poor result of the exploitation. The separation problems, however, are said to be solved.

The different mines and deposits from North to South : The *Tromsösundetde posits* (5) prospected in the year 1908 and again during the war. J. H. L. VOGT estimated the ore-supply to be several mill. cb. m. of crude-ore. Recent investigations seem to prove that the ore is too poor for exploitation.

The total production is only a few thousand tons.

The *Sörreisa* (6) deposits situated on the coast about 100 km. South of the Tromsundet. The deposits, assumed to be one of the largest in Norway of its kind, were calculated by Professor J. H. L. VOGT to have an ore-area of 200,000 sq. m. (transversal sections) and an average width of 23 m. A thorough sampling in recent years seems to prove that the deposits are too poor in iron to be exploited.

The *Salangen* (7) deposits about 40 km South of Sörreisa were worked for a few years (1909-12) and about a hundred thousand tons of briquettes were exported. Work was, however, given up as unremunerative. One of the deposits — Storhaugen — contains 30 mill. tons ore, the iron content being 26 to 29 %.

The *Lavangen and Gratangen* (10) deposits are a southern continuation of the Salangen. Some prospecting has been carried out, but the ore contains only 18-22 % Fe.

*Bogen* (11) is situated on the Ofoten fjord some 70 km South (South west) of Gratangen. Exploi-

The *Herringbotn* (35) deposit has an ore-area of 15,000 sq. m ( $1000 \times 15$  m) and the *Eiterådalen* (36), a total ore-area of about 250,000 sq. m. The phosphorous-content is rather high. The ore has 30 % Fe.

The *Rapen* (37) deposit in Vefsen is a 10 m wide layer with a granular magnetite. The iron-content is about 40 %.

### 3. — ORE-DEPOSITS OF UNCERTAIN ORIGIN

In this group will be included the Beitstaden (38) and Arendal (47) deposits, which generally have been classified as *magmatic* (the Beitstaden) or *contact-metasomatic*, *Skarnberg deposits* (the Arendal deposits). Later studies seem to prove a *sedimentary origin* for both. By palingenesis and regional metamorphism the ores have arrived at their present state.

The *Beitstaden* (38) deposit occurs in an ore-bearing zone, which can be traced from the Fosdalen mines over a length of about 150 km. towards the Southwest. The ore appears in *possibly archean* rocks which are gneissified by regional metamorphism.

The *Fosdalen* (38) mines, the most important, were opened in 1907. To start with, the mines produced a lump-ore containing 55 % Fe and 2-3 % S. From the year 1914 the mines have produced a concentrate containing 65-66 % Fe, and 0,6 % S. The total production is 2,900,000 tons ore (62,000 tons lump-ore). The crude ore contains 40-41 Fe and 2 % S. The ore-mineral is magnetite.

Ore in sight is 2 mill. tons, probable and possible ores are 40 mill. tons. The ore-resources of the undeveloped deposits run into a few hundred mill. tons.

The *Hitra* (39) deposits are small : a few thousand tons have been exported.

The *Arendal* (47) deposits in Southern Norway, played in older times a most important part in the norwegian iron industry. The total production is 2,7 mill. tons. In recent years only the Klodeberg and the Brastad mines have been worked and only on a limited scale.

The total ore-area, covering the twenty odd mines in the district, is, according to Professor J. H. L. VOGT, only 8,000 sq. m and the ore in sight about 1,5 mill. tons. The probable and possible ores are 3-4 mill. tons.

## c) METASOMATIC AND CONTACT DEPOSITS. VEINS

### 1. — IN THE CONTACT-ZONE OF THE OSLO-FIELD

In the contact-zone of the Oslo-field a lot of small iron-ore deposits are known. In times past these mines delivered ore to the ironworks situated in the eastern part of Norway.

The only mines which may have some interest are the *Aserud-Narverud* (53) mines. The ore-area is, however, only 1 a 2,000 sq. m.

### 2. — REPLACEMENT DEPOSITS

The *Fehn mines* (52) at Ulefoss. The ore — a *hematite* — occurs as veins in an *impure limestone*. Mining started in 1760 and the total production is 991,000 tons of which 376,500 tons during the last forty years. (Prod. 1939-48 was 13,100 tons).

The iron-content of the ore is 47-55 % : the content of phosphorous is 0,4-0,7 %. The ore-area is about 2,500 sq. m. The ore-supply is only a few mill. tons.

### 3. — VEINS

The *Langö* (50) deposits on the island Skatoy occur as veins in a *brecciated amphibolitic schist*. The ore-mineral is *magnetite*, sometimes with a small percent of hematite. The iron-content is 45-48 %. The mines were opened three hundred years ago. The total production is 530,000 tons. Work was suspended about 1870. In later years (1907/21), 68,161 tons were produced.

The norwegian iron-ore supply — computed from the results of prospecting — lies between 1,000 and 1,100 mill. tons (calculated as an iron-ore concentrate).

The iron-bearing strata in Northern Norway have several large ore-deposits, with an iron-content of 28 to 35 % and sometimes a still higher percentage. These are, however, only partly prospected, and their ore-supplies not computed. This group includes Lasken-Grönfjell, Seljelid, Eiteradalen etc.

The total ore-area is — as far as determined — about 600,000 sq. m. Professor J. H. L. VOGT has calculated the ore-area of the smaller titaniferous iron-ore deposits to be about 50,000 sq. m.

And, finally, the country has large quantities of ore too poor in iron to be worked at the present time. They represent the potential ore-reserves.

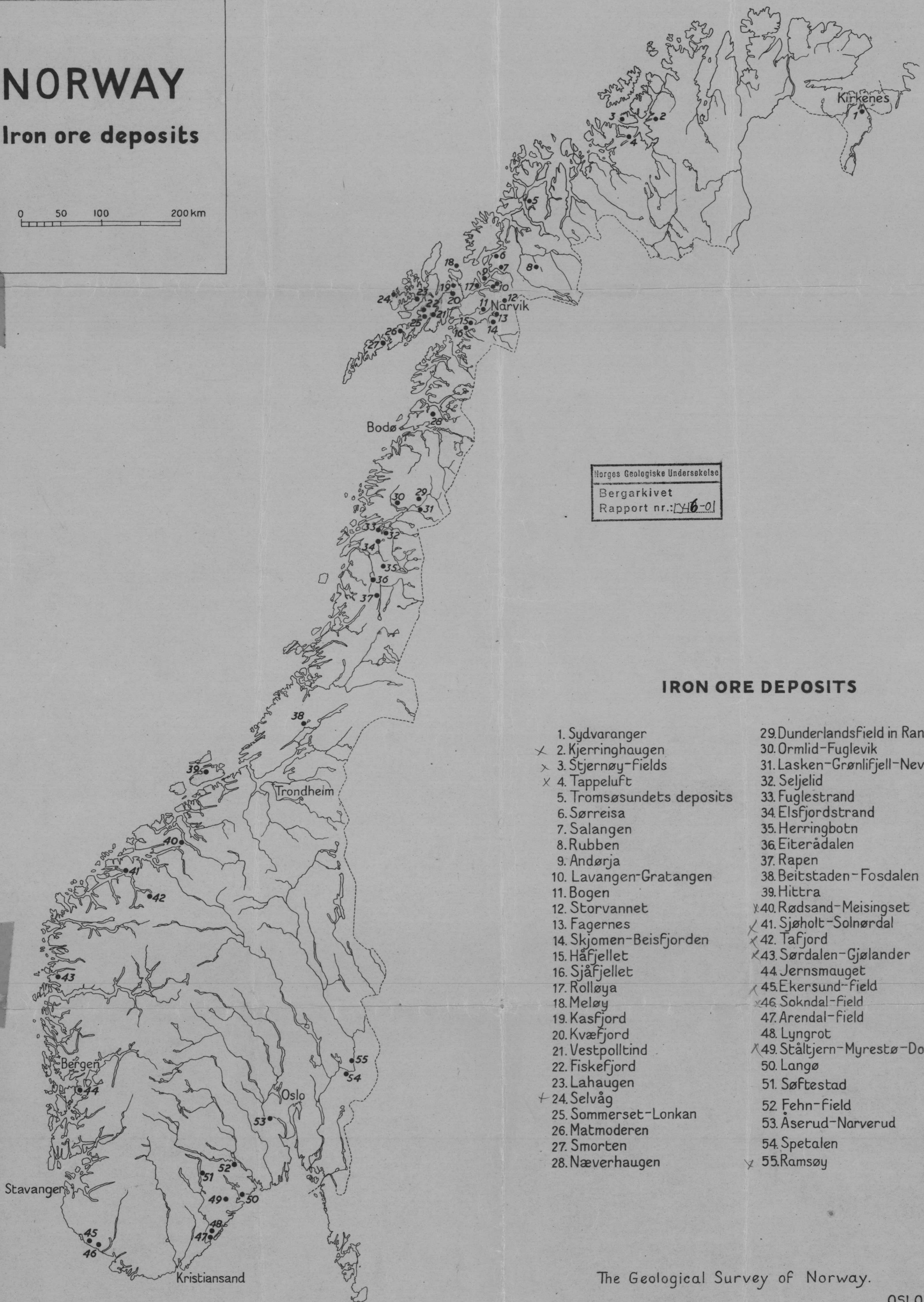
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# NORWAY

## Iron ore deposits

0 50 100 200 km



### IRON ORE DEPOSITS

- |                          |                                 |
|--------------------------|---------------------------------|
| 1. Sydvaranger           | 29. Dunderlandsfield in Rana    |
| × 2. Kjerringhaugen      | 30. Ormlid-Fuglevik             |
| × 3. Stjernøy-fields     | 31. Lasken-Grønlifjell-Nevernes |
| × 4. Tappeluft           | 32. Seljelid                    |
| 5. Tromsøundets deposits | 33. Fuglestrand                 |
| 6. Sørreisa              | 34. Elsfjordstrand              |
| 7. Salangen              | 35. Herringbotn                 |
| 8. Rubben                | 36. Eiterådalen                 |
| 9. Andørja               | 37. Rapen                       |
| 10. Lavangen-Gratangen   | 38. Beitstaden-Fosdalen         |
| 11. Bogen                | 39. Hittra                      |
| 12. Storvannet           | × 40. Rødsand-Meisingset        |
| 13. Fagernes             | × 41. Sjøholt-Solnørdal         |
| 14. Skjomen-Beisfjorden  | × 42. Tafjord                   |
| 15. Håfjellet            | × 43. Sørørdalen-Gjølander      |
| 16. Sjøfjellet           | 44. Jernsmaugt                  |
| 17. Rolløya              | × 45. Ekersund-field            |
| 18. Meløy                | × 46. Sokndal-field             |
| 19. Kasfjord             | 47. Arendal-field               |
| 20. Kvæfjord             | 48. Lyngrot                     |
| 21. Vestpolltind         | × 49. Ståltjern-Myrestø-Dobbe   |
| 22. Fiskefjord           | 50. Langø                       |
| 23. Lahaugen             | 51. Søftestad                   |
| × 24. Selvåg             | 52. Fehn-field                  |
| 25. Sommerset-Lonkan     | 53. Åserud-Narverud             |
| 26. Matmoderen           | 54. Spetalen                    |
| 27. Smorten              | × 55. Ramsøy                    |
| 28. Næverhaugen          |                                 |

The Geological Survey of Norway.

OSLO