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THE COPPER ORE DEPOSITS

ON

ULVERYGGEN MOUNTAIN,

NEAR

RIPPERFJORD, FINMARKEN

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REPORT by OTTO STALMANN.

1913.

THE COPPER ORE DEPOSITS
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ULVERYGGEN MOUNTAIN,
NEAR
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The Mines are situated from $1\frac{1}{4}$ to $3\frac{3}{4}$ miles from the westerly shore of the Ripperfjord, Finmarken, Norway, in about $71^{\circ} 30'$ latitude and between 23° and 24° E. Longitude (see map).

The most expeditious route to reach the property from England is by way of Hull to Christiania by boat, a distance of 660 miles, thence by railway to Trondhjem, 348,5 miles, and from Trondhjem by boat to Hammerfest and Ripperfjord, a distance of 713 and 738 miles respectively. The whole trip requires, in actual travelling, 124 hours, of which 20 hours are spent on the railway and the remainder on boats. Allowing for reasonable time for connections to be made, the trip from London to Ripperfjord requires about six days.

RIPPERFJORD AND ITS CLIMATE.

The Ripperfjord cuts into the mainland, in a S.E. direction at Kvalsund, a distance of 10,5 miles. The fjord is about two miles wide at the Ripperfjord Settlement. The post-office and landing stage of Ripperfjord are about 1,25 miles distant in a N.W. direction from the bottom of the Fjord, where the Ripperfjord river enters it.

The nearest town is Hammerfest, about 25 miles N.W., a place of about 2,500 inhabitants, with which the Ripperfjord Settlement is connected by a post telegraph-telephone office, while mail-boats, running twice weekly in each direction, keep up the communication with the outside world.

From Kvalsund to Ripperfjord numerous small fisherman's settlements and farms are observed, inhabited by about 300 people-Norwegians and Laplanders. A moderate number of sheep, cows, pigs and horses may be seen grazing there in the summer-time, near the shore, while further up the mountains large herds of reindeer find their subsistence. Potatoes, beans, and other vegetables are raised without difficulty.

The climate, considering the high altitude, is not severe, as it is tempered by the proximity of the Gulf Stream. A temperature of -6°C . ($+21^{\circ}\text{F}$.) in winter is reached, while -10°C . ($+14^{\circ}\text{F}$.) may be registered occasionally, a lower temperature than this being an infrequent exception. Snow begins to fall about the beginning of November and usually remains until the middle of May. The midnight sun is on the sky from May 13th to July 21st, while the sun is not on the horizon from November 21st to January 23rd, although there is not darkness during this time by day, but more or less effective dull light, which may be compared to the daylight on an ordinary dull, cloudy day in London.

There is no difficulty in carrying on mining and reduction operations all the year round. In fact, a little over 100 miles E.S.E. from Ripperfjord and only about 25 miles further south at Sydvaranger, large iron mines, connected by a railway 4 to 6 miles long, with a concentrating plant, are operated the whole year, about 800 men being employed, although the climate there is more severe than at Ripperfjord, in the absence of the tempering effect of the Gulf Stream.

HISTORY OF THE MINES.

Some Laplanders discovered copper ore deposits in 1902, which now form part of the property under consideration. The Laplanders disposed of their claims to the present owners, the Nordiska Grufaktiebolaget. These deposits have been developed by them to some extent by shafts and drifts to a depth of over 100 feet. They form a part of the fissure and contact veins which are briefly described below in the remarks on the geology of the district.

Not until 1904 was the cupriferous quartz sandstone lode (as far as known the most important deposit on the Company's concession) discovered by the present owners. Until 1907 the lode was prospected by them in a modest way by running a few cross-cuts on the surface and sinking a few shallow prospecting shafts. Encouraged by the result of their work, they carried on the development work for a few years in a more serious manner, under the able advice of the late Mr. T. Witt, the former manager of the Falun Copper Mines and Works, Sweden, and Professor Vogt, of the University of Christiania, whose plans for the ultimate development and exploitation of the property could only be executed to a limited extent on account of difficulties, which were in no way connected with the pro-

perty or its merits. A considerable amount of work has, however, been done during this period of serious development, the extent and results of which will be found in the following pages.

EXTENT OF PROPERTY.

The property under consideration is comprised in a concession from the Norwegian State, the limits of which are described as follows:

"From the Western Shore of Ripperfjord, about 2 Km. (1.243 miles) from the bottom of Ripperfjord, in a south-western direction, along the highest ridge between Vestra Ariselv and Dyb Elven, a length of 7 Km. (4.35 miles), thence due east to Ripperfjord main river (Stor-Elven), thence N.W. along the river to its mouth, thence north-westerly along the Ripperfjord shore to the point of beginning."

This concession embraces 11.5 square miles. In this concession 77 claims have been taken up. A claim comprises 280 metres (918.4 ft.) of the lode in the direction of its strike and includes perpendicularly to this direction the whole width of the lode and somewhat beyond each of its walls.

These 77 claims are "udmaal" claims, corresponding as to title and rights to the patented mining claims in the United States of America, subject only to such taxes as may be imposed by the law of the land.

In addition to the 77 "udmaal" claims, the Nordiska Grufaktiebolaget own also 34 claims, of which 16 are "udmaalslagde," which means that they have been officially measured and applied for "udmaal", corresponding to the official survey and application for patent in the United States.

These 34 claims stand now in the name of a Company called the "Nordiske Grube Compagni," in Trondhjem, but they are included in the option, The Nordiska Grufaktiebolaget being in the relationship of a parent company to the Nordiske Grube Compagni.

All documents regarding ownership and title have been examined and reported upon by qualified and reliable Scandinavian lawyers, and found to be in good order.

GEOLOGY.

From the western shore of Ripperfjord and a considerable dis-

tance S.E., appear immense beds of quartz sandstone. Adjoined near their S.W. limit by schist and greenstone, these beds are believed to belong to the Devonian Age. N.W. and West from the Ripperfjord, near Naverfjorden, Altenfjorden and Kvalsund, extend large deposits of Dolomite. S.E. from Ulveryggen (the local name of the mountain range in which the cupriferous quartz-sandstone occurs), Serpentine occurs and Gabbro and Granite form a considerable part of the formation from the Ripperfjord Valley east to the Altenfjord West.

The mineral-bearing so-called quartz sandstone division of the formation, the subject of the writer's investigation, is believed to be really a metamorphosed granite (or quartz-porphyry) similar in character to the cupriferous monzonite occurrence in Utah, U.S.A., which in reality, however, is also by many believed to be a metamorphosed granite. The width of this so-called quartz sandstone division is at least 750 ft., and probably more. It extends from the Ripperfjord in a S.W. direction for a length of 2.6 miles. The strike is very regular about N. 40°E., and it dips N.W. at a steep angle (78° to 85° from the horizontal).

ORE DEPOSITS.

At Ulveryggen a number of copper ore deposits of various geological character are found, typical fissure veins traversing the schist and greenstone formation, contact veins consisting of impregnations in slaty rock or zones between greenstone (schist) and sandstone and the mineral-bearing so-called quartz-sandstone formation, the object of the writer's investigation.

Some of the various fissure and contact veins have been developed to an extent proving the existence of some of these veins for a considerable distance in the direction of their strike, and to a depth of about 100 feet. These veins are from 3 to 8 feet thick. Their character is entirely different, however, from that of the large quartz-sandstone lode, the gangue of the former containing a large amount of lime, as a rule much in excess of the silica contents, while in the gangue of the latter lime is entirely absent. And again, while in the fissure and contact veins cupriferous mineral is almost exclusively chalcopryite, in the quartz-sandstone lode the richer copper sulphide minerals, bornite and chalcocite, predominate.

The following analytical results, obtained from typical samples

of each of these ore occurrences, may serve to illustrate this: -

	<i>gang-spar</i> Fissure Vein.	Contact Vein	Quartz-Sandstone Lode
Silicia	8,80 %	15,68 %	75,81 %
Lime	25,49 %	35,20 %	Nil
Copper	6,26 %	3,00 %	1,95 %
Gold	0,106 oz.	0,064 oz.	0,032 oz.
Silver	2,18 oz.	1,18 oz.	1,28 oz.

The paramount object of the writer's visit to the property being an examination of the large cupriferous quartz-sandstone lode, a description of the various smaller fissures and contact veins has been omitted in the following pages.

ULVERTGGEN LODE.

A close observation of the physical characteristics of the quartz-sandstone lode suggests that the sections of richer impregnation in the lode owe their increased mineral contents to a secondary infiltration, which occurred after the lode was in place. Numerous fine streaks of ore intersecting each other all over the sections of richer mineral contents seem to support this suggestion.

The quartz-sandstone lode is impregnated with mineral nearly all over. The predominant mineral is Bornite, frequently accompanied by Chalcocite and occasionally by Chalcopyrite. The impregnation is often poor, but there are large sections containing richer impregnations, and these only, of course, have an economic value.

As far as the present development shows, rich and poor sections alternate in comparatively large blocks, a condition which will contribute to the economy of the exploitation of the mines, as the poorer sections may be left standing in the mine to prevent caving. Again, as far as the present development shows, in a broad sense, the richer blocks contain comparatively high grade mineral for considerable distances in the centre, decreasing gradually in value, while the poorer blocks are poorest in the centre for some distance, increasing gradually in value in the direction where they approach the richer blocks. It will, therefore, be possible to extract only such grade of ore at a given time as will under the fluctuating conditions of the copper market or for local reasons, be the most profitable for reduction.

The vein matter, as well as the footwall, are firm and stand well (the hanging wall has not been reached in any ~~fo~~ the workings). In none of the workings timber or any other material has been used to support the roofs or sides.

The mineral impregnations in this quartz-sandstone lode (of various degrees of richness) at Ulveryggen have been proved, by prospecting and development work, to extend from the lode's S.W. limit for a length of about 7,000 feet on the strike and for a width (perpendicular to the strike) of 350 feet or more. Beyond this point the lode extends N.E. over 7,000 feet in length to the fjord. This latter part of the lode has so far not been prospected.

At a distance of about 5,000 feet almost due east from the mouth of the Erik's tunnel the same mineral impregnation appears in the Hans Mine, which is characteristic of the quartz-sandstone lode. The Hans Mine is developed by a tunnel only, which has passed through a zone of richer impregnations. Otherwise this mine has been little prospected. It is reasonable to assume that the mineral impregnations here belong to a separate ore lode, similar in character to the quartz-sandstone lode. To determine this and the extent of the lode, further prospecting work, is required.

The attached detailed description of the development work at the mines shows that of a total of 7,500 feet, representing drifts, shafts, upraises, bore-holes, and cross-cuts underground, and at the surface, 2,536 feet represents underground work, 3,150 feet (42 %) of this work have exposed pay ore containing from 1.44 to 1.87 % copper.

The work has exposed an ore area of over 190,475 square feet (about 5 acres), containing 1.72 % copper (this is the average result of over 1,400 determinations for copper and over 1,100 samples), which will furnish to each foot in depth over 13,000 tons of ore, or over 1,800,000 tons of ore, if we assume that the ore continues in depth without change to the lowest present ore exposures in the present mine.

The ore areas can be easily prospected and followed on the surface for a greater distance between the Erik's Mine and the end of the lode S.W., a distance of over one mile. The lode crops out boldly at the surface, and is only occasionally thinly covered with small, loose rocks, and sometimes with rocks of large dimensions, foreign to the local formation, which furnish unmistakeable evidence that glaciers are responsible for the presence.

Additional ore bodies will undoubtedly be found in the large areas between the Erik's Mine and the S.W. end of the lode, which have so far not been prospected at all.

Although the limit at depth has so far not been reached by any tunnel, shaft, or borehole in existence now, it is possible that the limits of the present ore bodies at depth may not extend much farther than their lateral limits, but as these ore-bodies re-occur without fail in both lateral directions, they will in a similar manner re-occur at greater depth.

There are unmistakeable signs that in the early period of its existence the Ulveryggen Mountain has been several thousand feet higher than it is now, having been worn away by glaciers and the elements to its present level. The present surface, therefore, was in that period many thousand feet below the original outcrop of the lode. It would be difficult, then, to suggest a plausible reason for the sudden disappearance at depth of the physical characteristics of the lode as we find them at present, and as they must have been throughout the ages required for the reduction of the original surface to its present level.

Again, the lode has been sufficiently explored in its S.W. half for over a mile in length to demonstrate a certain regularity in the recurrence of ore deposits, which owe their richer mineral contents to secondary infiltration. All ore deposits known and samples in this S.W. half of the lode show the same characteristics. Their lateral extensions vary from 100 to 300 feet and more in length and thickness.

The lowest ore exposure in the S.W. half of the lode is in the Erik's Mine, 310 feet lower than the tunnel level at the Vestra Feltet E., which is 150 feet lower than the surface. We may therefore assume with safety that the characteristic ore occurrences of the lode will be found to a depth of at least 500 feet below the outcrop of the lode at the Vestra Feltet.

At the N.E. half of the lode from Erik's tunnel to the Ripperfjord, a distance of 1 1/2 miles, the lode crops out, and can be followed the whole distance, although it is more frequently covered by small debris and rocks of large dimensions than in the S.W. half. No prospecting work of any description has been done here.

The characteristic occurrence of the ore bodies suggests their exploitation by open cut mining. A shaft or shafts should be sunk at convenient places in the ore body to an existing tunnel level, or one

to be driven into the mountain side for the purpose. At the junction of shafts and tunnel (or drift leading to the tunnel) a loading chute should be constructed. The ore is quarried out around the shafts conveniently at different levels and is dumped into the shaft, whence it is automatically loaded through the chutes into cars for transportation to the reduction plant.

This comparatively inexpensive method of mining, which, when the faces extend too far from the shaft for automatic dumping, permits the employment of loading machinery (steam shovels) can be employed for some years to come, at any rate to the level of the lowest present ore exposure.

Taking into consideration the high degree of concentration, 34 tons of ore into one ton of concentrates (by a former test), it is evident that particular stress must be laid on the economy of mining, transportation and concentration, of the ore. In comparison with the amount of ore to be handled, the amount of products will be small and consequently the cost of their reduction, distributed over the amount of ore required for their production, will only represent a comparatively small amount per ton of ore mined. With this in view, it seems advisable that the location of the reduction plant, at least the concentrating plant, be selected with a view to reduce the cost of handling and transportation of the ore as much as possible.

For several years to come the S.W. half of the lode, beginning with Erik's Mine, will undoubtedly furnish all the ore required. A location immediately below the Erik's tunnel appears, therefore, most suitable. The contour of the ground on the side of a hill permits the construction of the plant in a manner that very little, if any, transportation machinery will be required. To begin with, the ore from the mines S.W., above the Erik's Mine, may be transported to the proposed mill site by gravity tramway. Eventually, therefore, the S.W. drift (D 1 in sketch) in Erik's Mine should be extended in that direction, through all the mines situated S.W. from the Erik's tunnel, gaining depth below the outcrop of the lode until it will be about 500 feet below the surface of the Vestra Feltet Mine.

A new tunnel may conveniently be driven 200 feet below the present tunnel and drift for the double purpose of exploration and transportation of the ore to the mill.

An ample water supply for concentration is assured, as several

large lakes are at a moderate distance from the Erik's tunnel and the Vestra Aris river passes the proposed mill site.

WATER POWER.

The Vestra Ariselv river, running through the property in the immediate vicinity of the tunnels and the proposed mill site, was measured on September 27th, 1912; 1.2 cubic metres per second were found to be available. The available fall is at least 300 metres. The season when the water was measured was understood to be the low water season locally. At that rate, this river alone would furnish over 4,000 horse power, ample for all purposes.

About quarter-mile distant West is the Ostra Ariselv river, which if this should become desirable, could be utilised. This river will furnish over 3,000 horse power. Various other and larger water power may be obtained within 10 miles from the property.

The local conditions at Ripperfjord offer advantages for economical mining and reduction operations, which will contribute materially to render the proposition attractive.

Among these are: -

1. - The absence of barren overburden on the lode, all surface exploration will take place in ore.
2. - There is sufficient water power on the property to provide all power required for the daily mining and reduction of any quantity of ore that the results of future development may justify.
3. - The close proximity to a deep harbour, ice free all the year renders transportation of products and supplies economical.
4. - The products can be delivered on the European market within five days from their production.
5. - Labour is cheaply and plentifully obtained in the locality.
6. - The fact that large iron mines are operating all the year round within easy distance from Ripperfjord proves the comparative clemency of the climate in that part of the Continent.
7. - The Ripperfjord ore contains the rich minerals Chalcocite and Bornite. Chalcopyrite is found only very sparingly. A high degree of concentration is, therefore, assured, and the cost of treatment per ton of ore rendered comparative-

ly cheap.

8.- The Ripperfjord ore carries a considerable amount of silver and gold, the value of which will enhance the profits to be derived from the operation.

In conclusion, the writer desires to state that in his opinion the ore occurrences in the Ulveryggen Mountain deserve the attention of Capital. Intelligently explored and developed, and economically exploited, they cannot fail to furnish copper at a cost of production low enough to permit the producer to view with comparative equanimity the lowest price occasionally reached in latter years in violent fluctuations of the market.

(Signed) OTTO STALMANN.

London, January 12th, 1913.

ESTIMATE OF COST AND PROFITS.

The cost for mining has been taken at 2/- per ton at Ripperfjord, based, in addition to local estimates, on the cost of underground mining of similar ore deposits abroad.

The cost of concentration at Ripperfjord by the process of the Minerals Separation Ltd., is based on the actual cost as furnished to the writer by this Company, adding 20 % as a margin of safety.

The amount of royalty required by the Minerals Separation Ltd. (as furnished by this Company) is 2 1/2 % of the metal value of the concentrates.

The percentage of extraction at Ripperfjord has been taken at 83 % for concentration and 90 % for reduction, based on a test made on this ore by the Minerals Separation Ltd.

	Ripperfjord		
	£	s	d
Cost of mining one ton of ore	0	2	0
Freight to Mill on one ton of ore	0	0	10
Concentrating one ton of ore	0	3	0
Smelting Concentrates and Converting Matte ..	0	0	9,36
Freight on product and refining	0	0	8,08
Administration, general expenses, etc. ..	0	0	8,42
Royalty (2 1/2 % on value of Concentrates) ..	0	0	4,41
Total Cost per ton of ore	0	8	4,27

The product per ton of ore will consist of 28,9 lbs. Copper and 1s. 4d. value of Gold and Silver. Taking the price of copper at £60 per ton (silver has been taken at 2/- per ounce), the value of the product per ton of ore would be 16/9, leaving a profit of 8/4 per ton of ore treated.