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Norges Geologiske Undersøelse
Bergarkivet
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Norges Geologiske
Undersøelse

On the mines of Kaafjord, Raipas, and Kvænangen
and the Alten Copperworks in the departments of Finmarken and
Tromsø, Norway.

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The situation of the several mines, which will be described here, shall be determined when treating the different mining fields, having first reported on the

History

of the works.

Already as long ago as the year 1740-50 traces of discoveries of copper ore in the Kaafjord in Alten had been found. Some shallow workings are traced not far from the church near to the shore of the fjord, but as no working has been made there, after that actual mining began here, the vein has probably been considered too insignificant to deserve being worked.

Of more importance was the discovery of copper pyrites on the little peninsula of Sakko Banja between the Kaafjord and Kvænavig. The ore was found in pockets and lumps of the size of one cub. feet, and even more was found. This deposit was worked for some time after the beginning of actual working at the Kaafjord, and some very rich copper ore was mined out. In the year 1826 the English Consul Crowe was shown a piece of copper pyrites from the Kaafjord, and this induced him and Mr. Woodfall to begin prospecting and mining at this place. Until the year 1833 the ore was shipped to England, but after that time a company with a capital of £ 75 000 was formed. The building of smelting furnaces began, but these were first taken in use in the year 1833.

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The Raipas mines in the Raipas mountain were worked from the year 1845 to 1865, and the ore was sent to Bosekop and shipped to the smelting establishment at the Kaafjord.

At Kvænangen a company was formed to work the occurrences of copper ore in the year 1840; the ore was sold to the Kaafjord copper works until the year 1858, when the two companies were associated. The English company continued working with more or less profit until the year 1878, when operations were suspended.

After that Consul Persson of Helsingborg partly by claiming the mines, and partly by buying had acquired all the mining titles, the estates, waterfalls, forests etc. belonging to the company, operations were resumed 1895, and are now steadily proceeding.

Situation.

The mining field of the Kaafjord district is situated on the northwestern side of the fjord, which is an inner continuation of the Altenfjord on $69^{\circ}57'$ Lat. and 23° East of Greenwich, and between Tromsø and Hammerfest 110 miles from Tromsø and 44 miles from Hammerfest. All the mines are situated near to good harbour in the Kaafjord.

The Raipas mines are situated about 275 meter above the sea-level in the little Raipas mountain between the Altenelv and the Tverelv 1,6 miles from the Raipas estate and 3 miles in southeasterly direction from the little trading place of Bosekop. The ore is conveyed by road to Bosekop and from this place is shipped one mile to the Kaafjord.

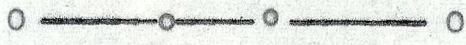
The mining field of Kvænangen in the department of Tromsø is situated on the eastern side of the Kvænangen fjord 30 miles in length and about 25 miles to the west-south-west of

the Kaafjord, from which place one can go to Kvænangen by passing the beautiful and fertile Mathis valley. To get to the mines of this district, the journey from Kaafjord may also be taken by the Langfjord and over the Alteid, 6 miles in length, to the Kvæangfjord, and from that place to Baddern and Kjækan. The situation of the many mines, which are lying spread, will be treated of on reporting on the different mines.

Geological description.

Although the mines of Kaafjord and the other mines and works have been visited and examined by many experts, surveyors of mines and other scientific men, still the literature on this subject is very scarce; the following treatises and reports will be referred to, viz:

- H.C. Strøm. Mag.f.Naturv. Anden Rækkes 1ste Bind 1833.
- Russegger. Archiv f. Mineralogie, Geognosie etc.
- G.A. Netto. Geschworner. Freiberg.
- Dr. Tellef Dahll. Beskrivelse af Altens Kobberverk 1868.
- Bergmester Ellefsen. Bemærkninger om Altens Kobberverk.
- Dr. H.Reusch. Iagttagelser fra en reise i Finmarken 1890.
- Mr. Trelease. Of Ytterøen. Manuscript.
- Director S. P^{son} Henning. Manuscript.
- Overdirector A.S.Bachke. Manuscript 1826.
- Fr. Schütz. Managing director of the Altens Kobberverk at present. Several manuscripts and reports.



On the geological map of Northern Norway, executed by Dr. Tellef Dahll, the formation environing the Kaafjord is indicated as belonging to his Raipas system or the devonian formation. The rocks in this system, which occurs on several places within Finmarken, although with relatively inconsiderable extent, consist of yellow and green sandstones, hard clay-slates,

yellow and brown dolomite, and sometimes of conglomerates.

Dr. Reusch, however, considers this system to be much older, probably belonging to the cambrian formation. Bergmaster Strøm in his before mentioned treatise has adjoined a little geological map, upon which the following rocks are indicated, viz: mica-quartz schists, diallage rock, limestone, clay-alum slates, and chloritic schist. The higher mountains surrounding the Kaafjord consist of mica- and quartz-schists belonging to the Gaisa system of Dr. Dahll or the cambrian formation according to Dr. Reusch. The so called Raipas system has been broken through by amphibolic rocks, being the orebearing rocks, with which the copper ore occurrences are connected. This amphibolic rock on both sides of the Kaafjord is greenstone or a massive dioritic rock, middle to finely granular, composed of feldspar, green hornblende, and sometimes some chlorite; and within the boundaries of this eruptive masses all the many mines and workings of Kaafjord are situated. These dioritic eruptives generally appear as ranges of rounded hills and between them violet to greenish schists are met with. The copper ore occurs within the diorite in lodes or veins of a coarsely granular quartz and coarsely granular, often somewhat reddish dolomite-spar into irregular masses mixed without order. Thus these occurrences are of a quite different character than the deposits of iron- and copperpyrites occurring in schists, probably belonging to the cambrian-silurian formation, and generally found in the vicinity of eruptive rocks, and with a striking direction often parallel to the stratification of the surrounding schists; deposits of this kind are represented for instance by the occurrences of Røros, Undal, Ytterøen, Vigsnes, Sulitelma, etc.

Besides the above mentioned rocks gray clay-slates and black alum-slate are met with at several places. As yet fossils

have not been found. By this occasion it will be noticed, what Russegger remarks concerning this matter: "In the schists no organic matter or rests generally are observed; however Director Thomas showed me pieces containing substances that I consider to be trilobites, but which I could not determine."

Dr. Reusch has observed some prominences in the dolomite, which he considers possibly might be corals, very much altered. Besides, gray and black limestone (black marble) is met with, as also a finely granular to amorphous dolomite of an impure white or somewhat reddish colour penetrated by veins of quartz. It is on the surface of this dolomite that the above mentioned prominent substances are found. In the Mathisdal to the south-west from the Kaafjord sandstone and quartzite is met with. On the southern side of the fjord at the mouth of the river Ongajokka there is to be seen a small landscape with terraces, and a similar one with the same height, when the Kaafjord river discharges into the fjord. Dr. Reusch has found the height of these terraces to be 61 meter.

The Raipas mining field.

The geological formation here is the following, viz: undermost stratified sandstone dipping 30° - 40° to the south-west, and upon this clay-slate with the same dipping is found. Above this the ore-bearing rock, being two beds of a reddish dolomite dipping 50° - 60° and separated by an indurated gray-brown clay-slate, is met with. In both of the beds of dolomite (the lower being 24 meter, the upper 20 meter and the separating bed of clay-slate 10 meter in thickness) several veins and fissures, forming a network, filled principally with peacock copper ore, some copper pyrites and copper-glance, occur.

The mining field of Kvænangen.

On going from the Kaafjord to Kvænangen through the Mathis valley, quartzite and mica-schist with slight dipping is at first met with. Nearer to the Kvænangen thick beds of dolomite similar to the corresponding rock from Kaafjord and Raipas occur and within these an extensive greenstone or dioritic rock has broken through, to which a widely spread system of copper ore-bearing veins of calc-spar is connected. Thus the formation is on the whole analogical with that of Kaafjord and Dr. Dahll on his geological map also indicates it as belonging to his Raipas system.

Mineralogical composition of the lodes.

Generally these veins carry but few different specimens of minerals. In Kaafjord copper pyrites in larger or smaller lumps, nodules or nuggets; iron pyrites sometimes in big lumps; coarsely *granular quartz,* granular somewhat reddish dolomite spar; calc spar sometimes crystallized in scalenohedrons, pretty abundant magnetic iron ore, aggregates of epidote, apatite, and the constituents of the diorite-feldspar (plagioklas) with green hornblende and chlorite occur. In a breccia of sandstone above the old smelting house copper pyrites, green mica, rutile, and brown turmaline are found.

Raipas.

The principal ore here is peacock copper ore; besides some copper pyrites and copperglance; further occur quartz, large crystalline dolomite, calcspar and twins of scalenohedrons. In the upper bed of dolomite one of the veins carries heavy spar.

The principal ore in the Kvænangen district is copper pyrites further some peacock copper ore, iron pyrites, magnetic pyrites, some magnetic iron ore, and specular iron, calcspar, dolomite and quartz

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are found. Native sulphur has been found drusy in cavities in a vein of quartz. Arsenic (except inconsiderable in Edward's mine), antimonium- and bismuth-minerals have not been found.

Description of mines.

The mining field of Kaafjord.

The many mines belonging to this district are all situated within the boundaries of a mass of greenstone extended on both sides of the fjord. It seems to occur here four different systems of ore-bearing veins or zones, on which the following mines and workings, on a range from the Mathisvalley to the south to the Langfjord in northerly direction to a length of about 125 miles, have been driven, viz:

- 1.- Thomas' mine;
- 2.- Ward's or the little mine;
- 3.- The old mine with the north and south workings;
- 4.- Woodfall's mine, to the north Bachke's lode;
- 5.- Carl Johan's workings;
- 6.- Mitchell's mine;
- 7.- Mancur's mine;
- 8.- Rypers mine.

Besides should be mentioned:

Colletts workings;

Ditlews mine;

Wilson's mine;

Hoskin's mine;

New lode;

West & Cate's lodes;

Kvænvig mine and

Melvig mine.

The veins, occurring pretty regularly within the diorite, generally have a striking direction North-South and generally a westernly dip. They are principally composed of calcspar and quartz, in which the copper ore sometimes with a little iron pyrites occur in larger or smaller masses, nodules and nuggets, and sometimes is disseminated in the vein-stone. They have a variable thickness amounting to 4-5 meter and even more. Sometimes it occurs that a vein forks eventually that veins from a junction, and in that case considerable ore bodies are to be found at the places of the junction. More seldom faults are observed.

We will now more closely treat the different mines as far as they are at the present accessible for examination.

- 1.- The Thomas' mine is considered to be situated on the lowest system of veins and the vein seems to begin not far from the present concentrating works. It has been followed to a length of about 2000 meter. The mine is lying in the utmost northern part of this vein as far as it is known. It is opened up with a sinking 14 meter deep, from where stopes have been driven to both sides 12-24 meter, and which has yielded rich copper ore. One adit level for the present driven 24 meter, when continued 120 meter probably will reach the vein 32 meter below the bottom of the sinking. Some shallow workings are driven in the continuation of the vein to the south.
- 2.- The Ward's mine or the Little mine is situated on the second system of veins. This is the deepest of all the mines in the Kaafjord and in level with the fjord about 32 met. below Ward's deep adit or the crosscut, now called the Nils' stoll. Mr. Trelease states, that from the Ward's mine the output was good, and that there has also been done a good deal of work. Although not demonstrated by actual exploration, there seems no doubt but that both this and the old mine workings are on the same

vein. Ward's adit was before driven to a length of about 200 met., and it is now decided to continue the driving to the South workings of the old mine a length of about 250 met., of which some 100 met. are completed. A winze shall also be driven between Carr's adit now called the Sture's adit from the southern workings in the old mine to the Nils' adit about 80 met. in the dipping direction or 45 met. perpendicular height. Mr. Trelease remarks, that as the ground between and above Ward's mine and the old mine's south workings is quite unexplored to a length of more than 400 met., the intersection of ore bodies at this depth from the surface would give immense quantities of mineral, which could be worked very cheaply.

The Old mine with the South and North workings. Concerning this lode Mr. Trelease remarks that it is of a large and masterly character varying from 4 to 15 feet in width and in places still much larger; its chief composition is a mixture of quartz and calcspar, through which the ore is disseminated in more and less quantities, yielding from 4 to 5,5 tons of ore per fathom cubic of about 5 % of copper.

The South workings are opened up by the Sture's adit, which reaches the vein on a length of 329 met. Here a large ore-body is traversed on a length of 12 met., and its continuation is proved 20 met. to the South and 50 met. to the North. According to Mr. Trelease these workings alone in 7 years contributed over 15500 tons of ore. After that time ore was worked out below the Sture's adit, and from these workings most part of the output in the years 1875-76-77 & 78 was derived. In the southern continuation the vein has been abandoned at the length of 90 met., and a crosscut 30 met. in length has been driven in the foot-wall. ~~On a level 35 met. above this~~

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the vein is opened up in the said direction, and the ore is mined out to a length of 250 met. The continuation and prospective value of this vein thus being satisfactorily proved, a continued working between this place and Ward's mine may strongly be recommended. The workings below the Sturés adit being full of water, no close examinations can be made, but no doubt also here the vein continues. Bergmaster Dahll observes on this occasion: "The vein continues in both mines (Ward's and Old mine) in the deepest levels, and there is no reason whatever to think that it will cease in the depth.

The North workings is connected with the Sture's adit in the South workings through a winze, by which the conveyance of the ore takes place. This winze has a dipping of 65° thus not following the vein. The lowest adit in the North workings, the Northern adit level, is situated 22 met. above the Sture's adit. From the winze the ore is followed about 200 met., and a good deal thereof is also mined out. The ore, however, continues in the level, and its thickness is larger than the height of the adit. Thus the continuation of this adit level will enhance the prospects of a large output from this mine.

The innermost northern part above this Northern adit level is not developed on a length of about 100 met.; thus also here explorations can begin. However, it will be remarked that a winze is driven here, in which there is rich ore, the thickness of the vein being 4 met.; still the hanging wall is not reached. Through another winze the North and South workings are also connected towards the south. The North workings are in connection with the surface by means of two winzes called the Shallow and Railroad levels. The thickness of the vein may be estimated to be about 4 met., the known length being about 400 met. Further to the north one deposit has recently been discovered which is probably in connection with the Woodfall's

mine. In the dipping of the vein a sinking (Bachke's sinking) has commenced, from which place a winze shall be driven to the North workings.

The Woodfalls mine west of the Ward's mine is driven on the third zone. In its northern continuation Backe's mine is with all probability situated, the vein-stone being of the same character in both mines. The mine is on the 80 fathoms level in connection with the Ward's mine by means of a crosscut 80 met. in length from the Nils' adit. Below this level 3 sinkings have been driven; the middle being 32 met. deep has yielded rich ore. The mine is opened from the surface by means of the South- and 40 fathoms adit levels, and both are connected with the surface by 2 shafts driven on the vein. Below these adits the 50 and 80 fathoms levels are situated. In the Woodfalls mine the vein has a dip of 70° - 80° to the West and that of the Ward's and the Old mine 25° - 30° also to the west, the striking direction being north-southerly; thus these mines will form a junction in the depth, and with all probability large ore-bodies will be formed at the junction points.

Mitchell's mine is situated within the fourth system of veins, and in the continuation to the south the Carl Johans workings, and to the north some other occurrences as for instance Mancurs, Rypers and several more mines are lying.

- 5.- The Carl Johans workings are situated on a hill to the northwest from the directors building. The output from here has been good, the thickness of the vein amounting to 2-4 met.; the length of the occurrence is with certainty known to be 400 met. On this stretch only shallow workings have been made.
- 6.- The Mitchell's mine is in connection with Woodfalls by means of Mitchell's deep adit. Here 2 veins seem to occur. Estimated by

the workings on the surface and the old waste heaps, the mine seems to have been worked some hundred meters. The thickness of the vein may be estimated to be 1-1.5 met.

- 7.- Mancurs mine is situated further to the north, and is only worked to a length of 50 met.; being full of water no observations can be made for the present.
- 8.- Rypers mine is the last mine on this main. It is opened by a deep adit level. The thickness of the vein may be estimated to be 1-1.5 met., and the output from this mine is reported to have been good.

The mining field of Raipas.

The Raipas mine is situated about 275 met. above the sea-level on the summit of a mountain range of the same name. Here several veins have been worked, the principal among these being Labouchire's vein. There are 4 large and some smaller veins, which have been opened by 4 shafts and adit levels and crosscuts and followed to a depth of about 160 met. from the surface, having for these distances yielded fair returns. The walls are regular and well defined. The lodes are composed of limestone (heavy spar is found in one of the veins) and friable gossan, in which as also immediately in the dolomite itself peacock- and yellow copper ore, copper glance, blue and green copper carbonates are met with. Sometimes the mineral is so finely disseminated, as to be invisible to the eye. These lodes or mineral veins are of a very peculiar character, subject to great and sudden fluctuations both in size and value, yielding from 2 to 40 % of copper. Generally one cubic meter of the vein yields 2/3 ton of ore with 6% - 7% of copper. Large quantities of ore containing between 30 % and 40 % of copper have been produced, and the indication continued very promising in the bottom part of the mine, when operations were suspended in 1866 on account of

the water, as the natural drainage point had been reached.

The Kvanangen mining field.

is situated 400-600 met. above the sea-level. The number of mines and workings, which are spread in this extended district are numerous, and the deposits are upon the whole analogical with those in the Kaafjord district, in as far as they occur in veins of calcspar 0.5-2 met. in thickness in an extended eruptive rock, greenstone or diorite. The following mines and workings have been driven, viz:

- 1.- Edward's mine;
- 2.- Saxes mines Nos. 2 & 3;
- 3.- Kjækan mine;
- 4.- E, D & F mines or the Old mine;
- 5.- The A mine;
- 6.- The G lode;
- 7.- The C mine, upper & lower;
- 8.- The Badder river workings;
- 9.- Magnus mine;
- 10.- Malla mine;
- 11.- Cedars mine;
- 12.- The "H" or Pyrites lode.

- 1.- The Edward's mine is situated 350 met. above the sea level at a distance of 3300 met. in southern direction from the estate of Kjækan at the Kvanangen fjord. The vein composed of calcspar and quartz and some chlorite, striking north-south with a dip of about 60° towards the east does not occur immediately in the diorite, but in a bed of graphite schist about 12 met. in thickness. The ore being copper pyrites occurs in this schist in the form of larger and smaller masses and nodules and sometimes

disseminated in association with some peacock copper ore. The thickness of the vein is variable being from 0.5 to 1.3 met. The mining workings of elder times was reduced to a sinking about 16 met. deep, by which the vein was followed 18 met. in its striking direction. At the present 3 adit levels have been driven, by which plenty of rich ore is met with in all the workings. The produce yields 4,08 %, 6,18% & 8,02 % of copper. Thus this mine, having a very favourable situation, may be considered to be of great prospective value.

- 2.- The Saxes mines N^{OS} 2 & 3 are situated at a distance of about 40 met in northern direction from the Edward's mine, and its vein is probably parallel to that, on which the Edward's mine is worked.

The N^O 2 mine is an open quarry about 20 met. in length and 4 met. deep; the ore is copper pyrites in a vein of calcspar about 2 met. in thickness. In the N^O 3 mine the indication is similar to that in N^O 2, but less working has been done here.

- 3.- The Kjækan mine is situated close to the vein of the Edward's mine, and has been worked for peacock copper ore, occurring on fissures. Almost all of the workings are accessible.

- 4.- The E, D & F mines, also called the Old mine, are situated 2600 met. in easterly direction from the Edward's mine. They are the mines most worked in this district, and according to old reports, the output of copper ore has been large and rich. Some of the workings here are not accessible on account of water.

In the continuation of the old mines vein towards the east

- 5.- the "A" mine is situated. This is reported to be the oldest of all the mines in the district of Kvænangen. Here a shaft 20 met. deep has been driven and in connection with an adit level reaching the vein. On both sides of the shaft there are left about 0,5 m. thick masses of very rich copper ore. The mine is for the present only partly accessible.

6.- The G lode or vein is striking parallel to that of the Old mine at a distance of 200 met. towards the east. The vein can be followed to a length of about 600 met., and the ore consists of yellow copper ore associated with magnetic pyrites. Besides some small stopes a sinking about 15 met. in length and 12 met. deep has been driven. The thickness of the vein, as far as can be observed at present, is 0,75 met. On a depth of about 40 met. perpendicular from the surface an adit level about 50 met. in length has been driven. This adit, however, is not as yet driven so as to reach the vein, but on continuing the same, the extension ore field will be reached, and no doubt much ore might be worked out. Possibly the vein of the old mine may also be reached by the same adit level.

7.- The C mines, upper & lower, situated to the south from the A mine, are not much worked and seem to be of less importance; but the vein, composed of calcspar and quartz, carries nodules of copper ore of more or less size.

8.- Baddern river workings. On the northern side of the Baddern river there are some small mines as the Bergmarks mine, the Saxes mine N^o 1 and some other workings of less importance. The vein of the Bergmarks mine carries 0,5 met. of iron pyrites, however, it is not as yet so much worked, that the solid rock has been reached.

The Saxes mine N^o 1 is situated in north-westerly direction from the before named. The vein strikes on a slope, which for the present is inaccessible. According to old reports the prospects shall have been very promising.

9.- The Magnus' mine, situated to the north-west of the Saxes mine N^o 1, has been worked but very little.

10.- The Mallas mine is situated in north-westerly direction from the Magnus' mine; only surface workings have taken place. The copper

ore occurs in nodules in a vein of calcspar 0,5-1,5 met. in thickness. The vein can be followed on the surface to a length of 125 met. It is probable that the Magnus' and Malla mines are situated on the same vein.

11.- The Cedars mine is situated to the north-west of Mallas mine and about 520 meter above the sea-level, 5,6 miles from the estate of Kjækan and 5,3 miles from the Baddern both at the Kvænangen fjord, and is the mine latest worked in this district in the times of the old work. Concerning this mine it should be noticed that its vein is of another character than the other occurrences in this district. Its striking direction is north-south and the dipping is perpendicular or strongly to the west. Its known thickness is more than 8 met., but the checks are not yet reached. The output has been large and rich from comparatively small workings. Eight years subsequent working has proved, that the lode continues both in the striking direction and in the hanging and foot wall as also in the bottom part of the mine, and in no part dead rock has been met with. The vein-stone is a yellowish white, reddish or greenish gray amorphous quartz with conchoidal fracture resembling flint. The copper ore occurs in this vein-stone more or less richly disseminated. Analyses of the richly disseminated ore from the Cedars mine have given the following results:

1.- 5,53 % copper; 7,81 % sulphur; 70,34 % insoluble.

2.- 8,02 " " ; 8,22 " " ; 40,62 " "
26,14 % lime (CaO); 16 grams silver pr. ton; large traces of gold.

3.- 9,18 % copper, 13,01 % sulphur, 0,55 % lime, 54,78 % insoluble

4.- 9,35 " " , 17,02 " " , 50,83 % quartz.

The three first analyses are made at the laboratory of the copperworks of Helsingborg; the last is made at the laboratory of the Sulitelma mines.

In northern direction from the Cedars mine, where the whole field is covered with loose glacial masses, sand, and erratic stones, the characteristic quartz-vein has been found, as also to a length of full 1500 met. a mass of large stones of the peculiar flinty quartz with copper ore disseminated into it has been met with. Thus undoubtedly the vein has the striking direction indicated by the loose stones and carries rich copper ore in many places.

Report of the working that takes place at the present,
and approximate calculation of the produce of the mines,
according to Dir. Fr. Schütz.

The first working place is the Nils' adit level. As before said, this adit level will open up the field of the Old mine 45 met. below the Sture's adit level. Before reaching the occurrence still 150 met. more must be driven. One sinking from the Sture's to the Nils' adit level is already in work. The entire length of the South and North workings being 500 met., the thickness of the vein 5 met. and the width (= the dipping stretch) about 80 met., the dip being 35° , the output should be $500 \times 5 \times 80 = 2000000$ cubic met. According to experience from previous working and the output of the recent driftings one cubic met. yields 0,5 ton of ore with a copper content of 8 % - 10 %; thus the output from this place would be equal to 100.000 tons.

Further, as the second place working may be considered
The continuation of the Sture's adit.

Here the vein of the North workings may at any time be reached, the adit at present being nearly right across the sinking, driven to meet the adit level with a length only considered to be 200 met., a thickness of the vein of 3 met., and a width of 30 met., the returns would be $200 \times 3 \times 30 = 18000$ cubic met., corresponding to about 9000 tons.

The third working place is

The winze in the North workings.

The length of this winze to the surface is 100 met.; according to recent reports the thickness of the vein is 3 met. and the length in the stretching direction 200 met. Thus this will give an output of $100 \times 3 \times 200 = 60\ 000\ m^3$ or 30 000 tons of ore.

The fourth working place is

The Backke's sinking. In the beginning of the previous year the driving of a crosscut between the Backke's sinking and the winze from the North workings began. After having worked for a while, it was evident that the occurrences are running on parallell veins. Considering this sinking, which is at present 40 met. deep, when continued on the vein to the Nils' adit level to be say 250 met., and having a corresponding length to that of the North workings say 200 met., the thickness being estimated to 1,5 met., the output would be $200 \times 15 \times 250 = 75\ 000$ cubic met. corresponding to 37 500 tons of ore.

These figures give the approximate quantities of ore opened up by the working of the previous year.

Thus the returns would be the following, viz:

between the Nils' and the Sture's adits	-	100 000	tons
" " Sture's and the Northern "	-	9 000	"
" " Northern and the surface	-	30 000	"
" " Nils' adit and Bachke's sinking		37 500	"

Total - 176 500 tons

According to reports from elder times one cubic met., as before said, yields 0,5 tons of ore, besides, there always results some smalls, which might be contracted by washing; thus the foregoing figure may be rounded to 180 000 tons.

Besides the quantities of ore, which may be opened up by the before named working, there exist, as will be seen on the map, large areas to be mined above the adit levels of the South workings as also in the North workings.

As the first subsequent work should be recommended:

Trial borings with diamond drills to develop the Nils' adit in the hanging wall, in order to ascertain in what manner the vein is lying on level with the Woodfalls and Mitchell's mines. There is also occasion to explore the hanging of the North workings, in order to ascertain with what thickness the vein in the Bachke's sinking is occurring, to be in the position to drive with safety proper preparatory work. A valley runs on the back side of the office building by the Carl Johans workings and along the Mitchell's mines, from whence short and convenient trial holes might be bored, in order to prove and develop the veins.

Succeeding work.

At the same time as the drifting already in operation is continued, the crosscut from the Ward's to the Woodfall's mine should be reached, in order to be acquainted with the manner in which this has been worked. The same operation should also be undertaken concerning the Mitchell's mine. As soon as the vein of the South workings is reached by the Nils' adit, there should also be made preparatory work for mining on a lower level by means of a deep adit on equal height with the fjord. This adit level must be situated in a manner facilitating the subsequent mining. The said adit level will be about 400 met. in length before reaching the veins, the perpendicular height between the Nils' adit and the surface of the fjord being 32 met.

It is worth noticing that Mr. Trelease remarks on this occasion: "This question Adits must have the first consideration of whoever will undertake the further developement of this mineral field, and when such have been carried out at the 3 above named places, I have not the least doubt, but that immense deposits of mineral will be laid open, and in looking at these concern, collecting the Alten mining field as a whole, offers chances not met with every day, and I

have not the least hesitation in saying that there remains many valuable pieces of ground to be opened up."

Approximate calculation of the quantities of ore to be mined above the proposed deep adit level.

The Ward's mine. Supposing a width of 40 met. and a length of 400 met. with a thickness of the vein of 2 met. the output would be $40 \times 400 \times 2 = 32000$ cubic met. or 16000 tons of ore.

The Woodfalls mine. The width in the dipping direction to the deep adit being estimated to 35 met., the length to 500 met. and the thickness of the vein to 1,5 met., the returns would be $35 \times 500 \times 1,5 = 26250$ cubic meter or 13125 tons of ore.

The Mitchell's mine. The width to the deep adit may be estimated here to be 100 met. (this mine only being worked 80 met. above the Woodfalls mine), the thickness of the vein to 1 met. and the length to 700 met.; thus the output would be $100 \times 1 \times 700 = 70\ 000$ cubic meter or 35 000 tons of ore.

The Old mine (South & North workings). With a supposed breadth of 40 met., a length of 500 met. and a thickness of the vein of 4 met. the output from this place would be $40 \times 500 \times 4 = 80\ 000$ cubic meter or 40 000 tons of ore.

The Mancurs mine. The breadth is estimated to be 300 met.; the thickness of the vein to 1 met. and the length to 400 met.; this would give an output of $300 \times 1 \times 400 = 120\ 000$ cubic met. or 60 000 tons of ore.

The Rypers mine. Here also a breadth of 300 met., a length of 400 met. and a thickness of 1 met. is supposed, by which the output would be 120 000 cubic met. or 60 000 tons of ore.

In southern direction from the Ward's mine the Carl Johans workings are situated. Supposing here the breadth of the vein in the

dipping direction to be 100 met., the thickness 2 met., and a length of 400 met., the returns would be $100 \times 2 \times 400 = 80\,000$ cubic met. = 40 000 tons of ore.

The vein, situated lowermost, on which several surface workings and sinkings, and towards the north the Thomas' mine is situated, is not as yet taken into consideration. With a length of 400 met., a thickness of the vein of 1 met. and a breadth of 100 met., the output would be $400 \times 1 \times 100 = 40\,000$ cubic met. or 20 000 tons of ore.

By this calculation the approximate quantities of ore, which might be mined above the deep adit level without great cost for the conveyance of the ore, should be obtained.

Total output.

Quantities of ore, developed by the present workings, were calculated to be 180 000 tons;

1.-	from the	<u>Ward's mine</u>	16 000 tons
2.-	" "	<u>Woodfalls</u> "	13 125 "
3.-	" "	<u>Mitchell's</u> "	35 000 "
4.-	" "	<u>Old</u> "	40 000 "
5.-	" "	<u>Mancurs</u> "	60 000 "
6.-	" "	<u>Rypers</u> "	60 000 "
7.-	" "	<u>Carl Johans workings</u>	40 000 "
8.-	" "	<u>Thomas' lode</u>	20 000 "

Total 464 125 tons

In addition to this the output from the different mines during the period 1843-1877 inclusive is given below, viz:

Name of mine		TONS Total pro- duction of copper ore	TONS Metallic copper	Average % of copper
Kaipas'	worked during 31 years	12475,290	841,080	6,74
Old mine	34 "	49104,576	2341,390	4,77
United	29 "	6585,283	292,898	4,45
Carl Johans	12 "	243,444	18,696	7,68
Mitchell's	19 "	1758,436	105,219	5,98
Rypers	14 "	935,755	59,791	6,39
Wilson's	5 "	1033,188	71,122	6,88
Kvænvig	14 "	607,134	35,034	5,77
Mancurs	9 "	585,257	31,191	5,33
Melvig	3 "	49,009	2,755	5,62
Woodfalls	2 "	256,134	13,660	5,33
Thomas'	5 "	194,709	17,973	9,23
Coles lode	4 "	64,863	2,652	4,09
Kvænangen	19 "	6803,758	503,565	7,40
New lodes	6 "	216,250	14,726	6,81
Concentrating works	5 "	313,372	14,167	4,52
Total production		81226,458	4365,919	5,37

By this table it appears that the output from those mines in the Kaafjord that had been worked during the period 1843-77 amounted to 61291,267 tons of ore or round 60 000 tons, which have yielded 2983,531 tons of metallic copper, corresponding to an average of 4,88 %. If to this is added a smelting loss of say 1 %, which may be considered very low, as analyses on the slag in the old waste heaps have given 1,85 - 2,20 % of copper, the average yield would be 5,88 % of copper.

It may be considered that the output in the period 1843-77 has only amounted to about the half of the total output of the mines

from the beginning of the working; thus the total output would amount to $2 \times 60\ 000 = 120\ 000$ tons, and this added to the above calculated 464125 tons would give a total sum of 584125 tons, representing the contents of ore in these deposits above the sea level.

With all probability it may be supposed that the veins continue below the sea level even so far as above the same, and thus the content of copper ore would amount to $2 \times 584\ 125 = 1,168\ 250$ tons.

By the calculation of the production of the above named mines, only those deposits which have yielded a somewhat considerable output have been taken into consideration, and the smaller and less worked ones are entirely omitted. However, the occurrences in northerly direction towards Melvig, those on the other side of the Kaafjord in the mountain Sakko Banja at Kvænvig and also those in southerly direction towards the Mathis valley deserve to be noticed. In order also to calculate some production from the ^{se}deposits it may be considered, that the output from these places would fill up the above found figure to 1250 000 tons, thus corresponding to a production of 81 700 tons.

There existed at these mines in the elder period no establishment to concentrate all the ore produced. Some of the ore, being finely disseminated in the gangue, was not utilized on account of this lack; the ore could not be milled for want of stone-breaker, rolls etc. Only the smalls, resulting by mining and shooting, was treated by hand-sieves. It would certainly therefore pay to utilize and concentrate the smalls and debris left in the mines and the waste heaps.

Resuming of the working in the year 1895 and its results.

At first it was important to make the adits, partly filled up with ice, accessible and put the inaccessible workings in proper order. As the most convenient place to begin with, the Old mine was

chosen. This mine was in the best order and easiest accessible of all the mines, having downfalls but in few places. After close examination it was decided to make the explorations and preparatory workings at the places before named. The principal importance was laid upon the development of the vein, not so much attention being given to the production of ore; still the output with only a few men amounted to 500 tons, which were screened to yield 10-20 % of copper. One building for dressing the ore has been established. One griddle or inclined grizzly, with 50 millimeter and below this two smaller with 15 millimeter interstices, are adapted to it. Also one little concentration plant, where the fines are treated, is established. The fines is at first sorted in 5 different sized classes on one revolving screen, whereupon it is treated in 4 single-compartment jigs. By this treatment a produce yielding 15-17 % of copper is obtained out of smalls with a copper content of 2-2,25 %.

The concentrating experiments, giving such promising results, it was decided to adapt one complete establishment for dressing the ore with stone-breakers, revolving-screens, crushing-rollers etc. Also two Linkenbachs vanning concentrators to treat the slimes are established. These plants, as will be seen, are calculated only to treat small quantities of say 15-20 tons in 10 hours, and thus may be considered only as trial establishments; by a higher produce larger plants must be established.

Proposed new plants.

From the foregoing it is evident that on establishing one new concentration plant and smelting furnaces, not too small sizes may be chosen, provided that they should be based on a yearly production of say at least 50 000 tons. To attain such a production would be required:

- 1.- One concentration plant capable of producing 40 000 tons of copper ore in smalls, about 10 000 tons to be produced by dressing by hand. This represents a daily output of 133 tons.

Such a plant might cost say about Kr. 300 000 and will require motor-power of about 120 H.P. The difference in specific gravity between the copper ore and the gangue being considerable, a quick and easy concentration can take place.

- 2.- One smelting, bessemerizing or electrolytic plant for treating 50 000 tons of ore; such a plant is calculated to cost Kr. 500 000. 100 H.P. is considered to be required here.
- 3.- Mining buildings, working of adit levels necessary to attain the proposed production: Kr. 200 000
- 4.- Electric plant at the Mathis river " 100 000
- 5.- New buildings for workmen and sundry expenses " 400 000

Foundation capital Kr. 1500 000

The cost of producing

The cost of producing the ore per ton will be as follows:

To every ton of ore there are required 2 cubic met. solid mass of rock å Kr. 5 per cubic met., thus:

<u>Mining expenses</u>	5 x 2	-	Kr.	10
<u>Conveyance of ore</u>	1,25 Kr. pr.m ³ x 2	-	"	2,50
<u>Dressing</u>			"	3
<u>Concentrating</u>			"	4
<u>Managing & sundry expenses</u>			"	2

Total per ton of ore Kr. 21,50

However, it has now been proved by the work already done, that the ore both by hand-dressing and by washing may be concentrated to much larger content of copper.

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By screening by hand and concentrating the following results have been obtained:

No.	Dressed by hand TONS	Copper percent.	Concentrated TONS	Copper percent.
13	12	9,74	1	16,36
20	11,700	8,98	2	15,80
21	11,700	12,06	3	14,10
22	6,600	11,22	4	17,32
23	7,700	8,68	5	13,64
24	8,600	9,90	6	13,28
29	11,500	12,08	7	15,32
30	15,800	11,82	8	14,82
31	15,900	11,10	9	14,80
32	17,450	12,42	10	16,84
33	18,300	11,94	11	13,56
34	13,500	11,30	12	16,36
Total & average 148,750		10,94		15,19

Analyses of some samples of the smalls having passed the fine gridirons

No. 4 contained 3,19 % of copper

- 8 -" - 3,60 % " "

- 16 -" - 1,44 % " "

- 26 -" - 3,14 " "

- 28 -" - 2,82 " "

Average 2,84 % of copper

By the dressing by hand of a produce of 500 tons, 150 tons No.1 copper ore with a yield of copper as in the table above and 350 tons No. 2 copper ore were obtained, which latter on analyzing gave No.25 - 2,12 % & No 27 - 2,16 % of copper. This second class ore after being

crushed and concentrated may evidently yield a similar produce to that of the concentrated smalls.

Smelting expenses.

Considering the ore to contain 7 % of copper, about 15 tons ore are required to 1 ton metallic copper, thus:

Cost of ore to one ton of Copper $21,50 \times 15 =$ Kr. 322,50

Smelting expenses Kr. 300, -

Total cost for one ton of copper Kr. 622,50

The price of copper being say " 800,00

Net profit Kr. 177,50

With an output of for instance 25 000 and 50 000 tons of ore the following results will be obtained respectively:

Cost of producing 25 000 tons of ore yearly:

Mining of 25 000 $\times 2 = 50$ 000 cubic met. $\text{à } 5$ Kr. = Kr. 250 000

Expenses for conveyance of the output $\text{à } 1,25$ kr. = " 62 500

Dressing of 25 000 tons of ore $\text{à } 3, -$ = " 75 000

Concentrating " " " " " " $4, -$ = " 100 000

Management & sundries " " $2, -$ = " 50 000

Total cost of ore = Kr. 537 500

Smelting expenses:

25 000 tons of ore with 7 % of copper will yield about 1660 ton metallic copper; if as before the smelting expenses

are calculated to be Kr. 300 pr. ton, that will give Kr. 498 000

Total cost of 1660 tons
copper - 1035 500

If as before the price of copper is put to

Kr. 800 pr. ton this will give 1660×800 - 1328 000

Net profit Kr. 292 500

The cost of concentrating and smelting plants etc. was calculated to be - - - - - Kr. 1500 000; in a production of say only 25 000 tons, the cost may be reduced with about one third, thus will be round Kr. 1000 000.

The corresponding costs by a production of 50 000 tons of ore will be as follows:

<u>Mining</u> expenses 50 000 x 2 = 100 000 m ³	à Kr. 5 =	Kr. 500 000
<u>Conveyance</u> of output 100000 m ³	" " 1,25 =	" 125 000
<u>Dressing</u> of 50 000 tons of ore	" " 3,00 =	" 150 000
<u>Concentrating</u> " " " "	" " 4,00 =	" 200 000
Managing & sundry expenses	" " 2,00 =	" 100 000
<hr/>		
Total cost of ore		Kr. 1075 000

Smelting expenses:

50 000 tons of 7 % copper ore will yield say 3333 ton metallic copper, and considering the smelting expenses to be Kr. 300 pr. ton, this will give

Kr. 999 900

Total cost of 3333 tons of copper

Kr. 2074 900

Smelting price 3333 x 800

Kr. 2666 400

Net profit

Kr. 591 500

On a distance of about 2500 met. to the south of the Kaafjord there is in the Mathis river a large and splendid waterfall 45 met. in height, which will afford necessary and more than sufficient power to the establishments; the cost of the electrolytic transmitting of say 300 H.P. is calculated to amount to about Kr. 100 000.

The district of Alten is very remarkable for its extraordinary mild climate, considering that it is situated so far to the north, and

this circumstance is evidently owing to the moderating influence of the Gulf-stream. It is of the greatest importance that the Altenfjord never freezes, so that shipping may take place all the year round. The middle-temperature in the Kaafjord according to observations made during 11 years is found to be + 1,2 C°. Barley ripens in Alten.

The local steamers are regularly trading between the Kaafjord and Hammerfest, and the Kaafjord itself will afford safe anchorage for the largest vessels in all states of the weather.

The nearest telegraph-office is in Alten.

A large estate of an area of 3200 hektar or 7900 acres belongs to the works. It is abundantly covered with large forests of firs and birchs. The splendid Mathis valley, through which the Mathis river, abounding in water, is running, might profitably be cultivated, and especially be adapted for pasture and dairy farming.

Approximate calculation of the ore deposits
of the Raipas mine.

The geological condition of the deposits of this mine is treated above. The mine has a depth of 60 met., and has been worked to an extent of 120-130 met. As before said the thickness of the veins is somewhat varying; according to Netto it has been 2,5 - 3,3 meter. According to the statistical table of the output of ore from 1843-78 the Raipas mine has yielded 12,475,290 tons of ore, which have yielded a produce of 841.080 tons of copper corresponding to 6,74 %. As it is not with certainty known how long time the mine has been worked, and as during the years 1843-44-45 & 46 about 1000 tons of ore have been produced yearly, the total output from this mine may be estimated to have been about 20 000 tons. The smelting loss having been at least 1 %, the ore might have yielded 7,75 % of copper.

One proposed deep adit on 120 meter level will develop an area of 60 meter in height to be worked. Considering that the vein will continue in a similar way below the deep adit level as above the same to a depth of say 120 met., and supposing an equal output for this concern, the approximate produce would be $20\ 000 \times 2 = 40\ 000$ tons. Thus the total output to the fixed depth would amount to $20\ 000 + 40\ 000 = 60\ 000$ tons.

In order to get access to the mine it will be necessary to clear the deep adit and from thence pump out the mine in order to reach the deepest level, and from this place sink a shaft in the vein. One steam-boiler, pipes, and two pulsometers might conveniently be used.

The distance from the mine to loading-place at Bugten near Bosekop is about 3 miles. The high road passes close by the mine, and during the previous working period the ore was conveyed on this road by means of horses. The ground being flat down to the harbour the conveyance of the ore may take place at a cost of 2 Kr. pr. ton. At Bugten there is a good harbour with sufficient depth for the vessels.- Thus, to put the mine in proper order to produce ore, is required:

1.- A deep adit about 400 met. in length	kr. 25 000
2.- Boiler, pipes, and 2 pulsometers	" 7 000
3.- Building in the old mine	" 5 000
4.- Sinking of shaft with hoisting and pumping machinery	" 50 000
5.- Building of quay at Bugten	" 3 000
6.- Management & sundry expenses	" 10 000

Total Kr. 100 000

Cost of mining.

According to experience from elder times 2 cub.met. of rock-mass will yield at least 1 ton of ore, and the cost per ton

will amount to kr. 20,00, viz:

<u>Mining</u> á	Kr. 5 per m ³	2 x 5 =	Kr. 10,00
<u>Conveyance</u>	" 1,25 " "	2 x 1,25 =	" 2,50
<u>Screening</u>	" 3,00 " ton		" 3,00
<u>Concentrating of half the produce</u>			" 2,00
<u>Management & sundry expenses</u>			" 2,50
<u>Total</u>			Kr. 20,00

At a price of copper (best selected) of $\text{£} 52$ per ton, the selling price of the ore will be $7/6$ d. per unit, and thus ore containing 7,75 % (loss 1 %) will realize 50/7 d.

<u>Cost of mining</u>	22/3 d.	
<u>Conveyance to the loading place</u>	2/3 d.	
<u>Freight to England or the Continent</u>	8/0 d.	32/6 d.
<u>Profit</u>		18/1 d.

The Tverelv runs close by the mines and at a distance of 1000 met. from the same it forms a waterfall 20 met. in height with the sufficient water to afford at any time motive power, that might be required at the mine.

To the mine belongs a large estate on which 7 large buildings for the workmen and one for the manager are erected.

Report of working during the summer-time 1895 & 96
and approximate calculation of the resources of the ore deposits
of the mines of Kvænangen.

The Edward's mine. The working performed at this mine is already mentioned above. The parcels between the 3 adit levels and upwards to the sinking and further along the sinking direction say 100 met. would yield the following output when only assuming a thickness of the vein of 1 met., viz:

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between adit level I and the sinking	8000 m ³
" " " I and adit level II	15000 "
" " " II and " " III	39500 "

Total cub. met. 62500

Here, it may be estimated that one cub. met. rock-mass will yield 0,4 ton of ore with a content of 8 % of copper; thus, the total produce might be estimated to 25 000 tons. The charges for mining per cub.met. will amount to 10 Kr. á 11 in adits and Kr.3,50 - 4 in stopes.

The Cedar's mine. It is noticed before that the vein of this mine can be followed to a considerable length in the sinking direction, and that also its thickness is very considerable, being more than 8 met. It is proposed to develop the deposit by an adit on 50 meters level, and then, for every hundred meter mined on the vein, the returns might be estimated to be $50 \times 8 \times 100 = 40\,000\text{ m}^3$.

The ore being pretty uniformly disseminated in the matrix, it might be estimated that every cub.met. will yield at least 0,5 ton of ore, and thus, for every hundred met. in the sinking direction of the lode, an output of 20 000 tons of ore might be obtained.

Thus it is evident that this extended mining field will yield a very considerable production. The copper content of the ore is displayed above. The cost of mining will be equal to that at the Edward's mine.

Besides, the two mines named above the E. D & F mines or the Old mines complex have been somewhat examined and worked. An adit on 30 met. level has formerly been driven and is now partly cleared up. These mines have in earlier time yielded most of the produce from the Kvænangen district and with a high percentage of copper, and consequently they should be more actually developed.

Transportation.

As is previously noticed, the Kvænangen mining field is very extensive, and the several mines lie widely spread, wherefore it possibly will be necessary to use two ways for conveyance of the ore, one to Kjækan and one to Badderren, both being loading places at the Kvænangen fjord. The ore from the Edward's mine as also from the Saxes mines 2 & 3, from the A, G, and Old mine might conveniently be conveyed to Kjækan, while the ore from the Cedar's mine will most conveniently be transported to the Badderren loading place, one length of about 5,3 miles. In both cases cable tramways are to be used.

One splendid waterfall, the Baddernfoss in the Badderely with a total perpendicular height of 135 met., will afford motive power for the concentrating of the ore when necessary and for other purposes, when motive power is required. It is situated about 2,5 miles from Badderren. The river also forms another waterfall 20 met. in height further up in the mountain, and which also conveniently might be used for concentrating purposes.

To the mines belongs an extended estate Kjækan, on which 20 buildings for different purposes are erected.

Resumption.

From the facts and estimates previously noticed it results:

that the mines of Kaafjord, Raipas & Kvænangen and the Alten Copper-works have a very favourable situation and a tempered climate, in consequence whereof mining & concentrating work and shipment may take place the whole year round;

that the many different deposits have a large extent and thick-

ness, carrying rich and pure (free of detrimental matters) copper ore, the estimated resources of ore amounting to millions of tons, thus allowing a considerable production for long future periods;

that mining will be easy and cheap on account of a favourable situation of the lodes;

that conveyance of ore etc. to the concentrating works and shipping places for the most part will be easy;

that charges for necessary plants will be comparatively reduced, the present establishments already allowing a considerable production;

that expenses generally may be essentially reduced, the Norwegian State liberally granting fuel & mining timber free of costs, and

that sufficient motive power for purposes, which might be required, may be obtained from the different waterfalls.

Kaafjord & Mo i Ranen
the 28th January 1899

Fr. Schütz (sign.)

Albr. Hasselbom (sign.)

