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ON THE OCCURENCE OF GOLD IN FINNISH LAPLAND

BY

CURT FIRCKS, M. E.

HELSINGFORS
1906

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WITH 15 FIGURES AND FRONTISPIECE

HELSINGFORS
FRENCKELLSKA TRYCKERI-AKTIEBOLAGET
1906

LOWER COURSE OF THE IVALOJOKI

seen from Iso Palsitunturi, looking east

Ljustryck G. Arvidsson

PREFACE.

The following short description of the Lappish gold veins is made after a sojourn of three months in Lapland. Anyone not personally acquainted with the geology of these parts needs advice and help in many cases. All the members of the Geological Survey of Finland have kindly provided me with ample information, for which I beg to be allowed to express my sincerest thanks.

Most of all am I obliged to Dr. J. J. Sederholm for many valuable hints as to the local geology, and to Mr. V. Tanner, whose knowledge of the country and its inhabitants was a great help to me during the first fortnight of my sojourn in Lapland.

CURT FIRCKS.

Helsingfors, autumn 1906.

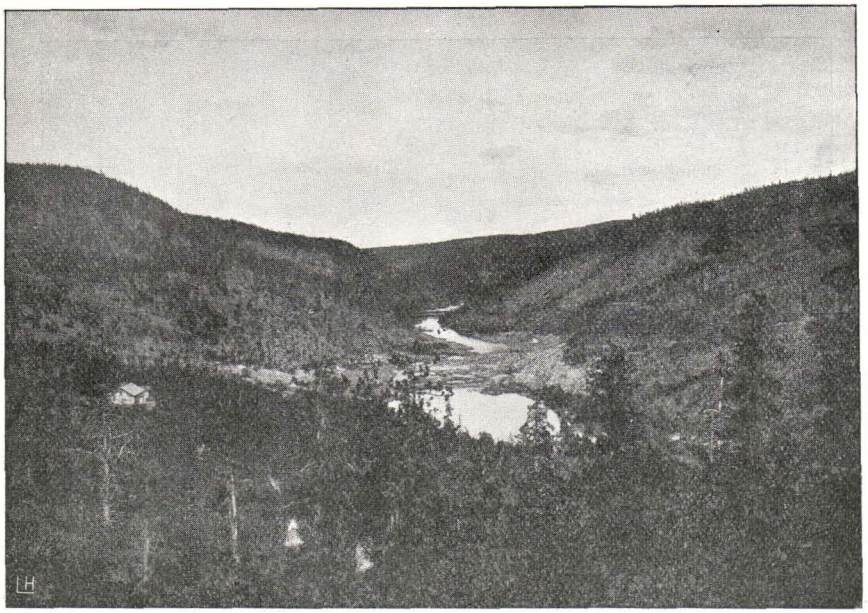


Fig. 1. Kultala, station of the finnish Crown at the Ivalojoki, seen from the west.

The first gold in Finland was found in 1836 at the mouth of the Kemi river in the form of two pieces of dolomite containing native gold. During the years of 1837, 1839, 1840, 1844, 1847, 1849, 1850 much prospecting for the motherload was done in the neighbourhood of the rivers of Kemi and Torneo and in the districts of Kuusamo and Hyrynsalmi, but with no success.

After the discovery made by Thellef Dahll of alluvial gold in the river Tana and its tributaries in the Norwegian province of Finmarken, and also on the Finnish side of the frontier, a new Finnish prospecting expedition was sent out to the Utsjoki Lapmark in 1868.

An examination of the alluvions of the Tana river and its tributaries on the Finnish side nearly always showed the presence of gold, but nowhere was it of economical value.

Returning from Utsjoki the expedition passed the village of Törmänen on the Ivalojoki, whence the leader J. C. Lihr made

Fig. 2. Communications in Lapland. Travelling by canoe.

an excursion up the river to the Ritakoski-Falls. A pan washed here gave the best results of the whole summer.

The government did not prepare for any expedition the following summer, but three Finnish sailors, who had won some experience in goldwashing in America and Australia, undertook the task of exploring the new goldland. For a few weeks they

Fig. 3. Communications in Lapland. Passing the watershed.

washed at the shores of the Ivalojoki in the neighbourhood of the present station of Kultala and found about 2,000 grams. Owing to this unexpected wealth the number of visitors to the shores of the Ivalojoki in the summer of 1870 was rather high and reached the number of 500 the following year.

The difficulty of communication and the shortness of the work ing hours being unfavorable to a quick development and the placers moreover soon turning out to be of a very limited extension, the

Fig. 4. Prospecting trench E. from Laanila.

number of workmen rapidly decreased and only in certain years reached one hundred. Besides the alluvions of the Ivalojoki, those of the Sotajoki, the Palsinoja, the Tolosjoki with their respective tributaries and the Luttojoki were worked.

During a period of 30 years the average production was 14,396.7 grams.

In the course of time numerous expeditions investigated the valleys of the Lappish rivers and very often found them to be auriferous, but scarcely ever of economical value. Recently the company Ivalo made an attempt at goldwashing in the bed of the Ivalo-

joki below the rapids, erecting for this purpose big dams, which stopped up a part of the river at Kultala. The supposition that richer accumulations of gold would be found at such places proved right, though the ultimate result from an financial point of view still seems rather dubious. The principal work below the second, new dam, only completed in the summer of 1905, had to be postponed until the following year.

Goldwashing was also carried on last summer at all the smaller rivers above mentioned, mostly however by a couple of men only.

The prospecting for the motherload of the placers was without any result till 1900, when Henry Kerkelä succeeded in discovering the first gold-vein. Investigations on a larger scale, undertaken in 1902 by the Prospector company, lead to the discovery of a great many veins. Similar veins have been found by several smaller investigators. No doubt these veins are to be regarded as the motherloads of the Lappish placers.

Unfortunately so far no financial success has been obtained. This great enterprise, which was impeded by so many difficulties, has only proved the hopelessness of prospecting for similar veins, which no doubt are of common occurrence in these parts.

A description of the Lappish gold alluvions and placers has been given by E. Sarlin in the „Meddelanden från Industristyrelsen i Finland 1902", but the veins so far have not been described at all. The following sketch of the alluvions is based on the description of E. Sarlin.

The adjoining map shows the auriferous territory.

Its boundaries are in the north and west the Ivalojoki, in the east a line running from N. to S. in the upper part of the valley of the Luttojoki, and it comprises in the south the district of the right hand tributaries of the corresponding part of the Ivalojoki.

On the whole this district is rather mountainous, while the rivers are bordered with bogs sometimes of considerable extent.

The moraine, covering the surface nearly everywhere, reaches a thickness of ten metres and more. The underlying rock is often weathered to a considerable depth. The more important streams of the territory such as the Ivalojoki and the Sotajoki and even some of the smaller rivers (for instance the Palsinoja and the Laanilauttanen) have formed a typical kind of valley, shallow and wide in their upper part, where they intersect only the moraine, but cutting deep into the rock in the middle part of the

Fig. 5. Valley of the Ivalojoki below Kultala, seen from the east.

main river and the lower courses of the tributaries, forming a sort of canyon (cf. fig. 1, 5 and 6). The shores of the Ivalojoki sometimes rise to a height of more than one hundred meters, most characteristically showing the type above mentioned.

The Lappish gold digger discerns three different kinds of gold, „terrace gold", „bottom gold" (swedish: bottenguld) and „bank gold" according to its occurrence:

1. in the gravel, which covers the slopes and bottoms of the valleys.

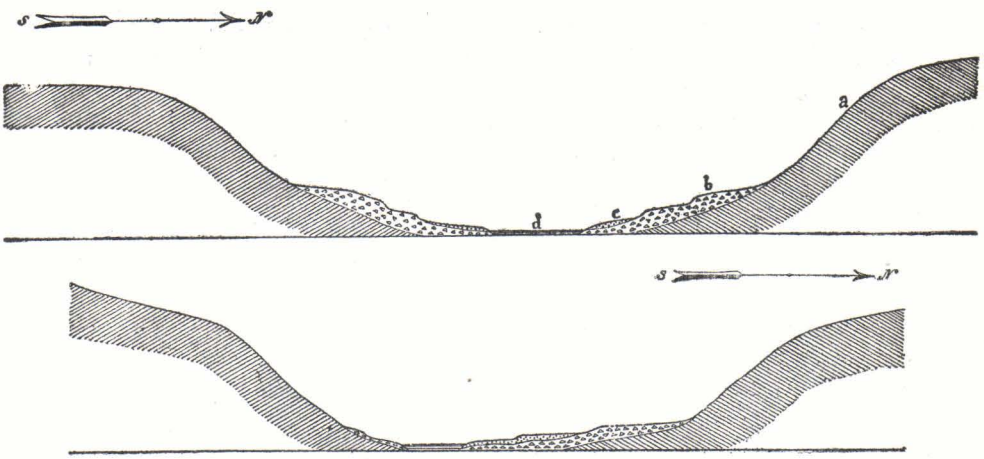


Fig. 6. Diagrams of the valley of the Ivalojoki, the upper 400 m below, the lower 200 m above Kultala.

Scale 1 : 4,000.

d = the river.
c = gravel.
e = moraine.
a = rock.

Fig. 7. Gold diggers at the Sotajoki.

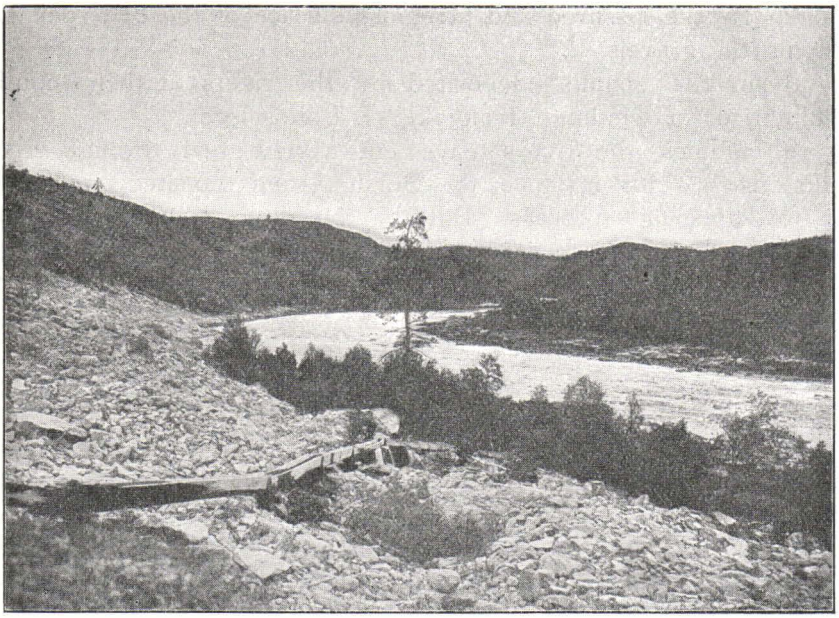


Fig. 8. Placers at the Porttikoski, between Ruikka and Kultala.

Fig. 9. Placer at the Moberginoja, near to its source.

2. on the fissured and irregular surface of the bed rock underlying the gravels.

3. in the „banks“ deposited by the rivers at their mouths (Sotajoki) or at windings (Ivalojoki, cf. frontispiece).

Sometimes the rivers have cut a new bed through these banks, as has for instance the Sotajoki, and repeated once more the „ore-dressing“ process. But the auriferous material of morainic origin of the terraces has been „dressed“ and redeposited by

Fig. 10. Old placers at the Palsinoja.

the rivers, and lies either on the bedrock or on a typical undisturbed moraine. The auriferous beds are often distinguished from their substratum by a „rusty“ color, caused by a varying quantity of ironhydroxyde.

Both the „terrace gold“ and the „bottom gold“ are more coarse-grained and less water-worn than the so called „bank gold“.

The largest quantity of all washed gold belongs to the first class — the „terrace gold“ —; „bottom gold“ is of course best found in such places where the erosion has been the most effec-

tive, at the Ivalojoki, the Sotajoki, the Palsinoja and the Laanilauttanen.

The deposits are generally of a very little thickness, about 50 cm, but may reach 2 metres and more. At the Ivalojoki the overlying dead strata were on an average 1 metre, varying from 0 to 3 metres. The average thickness of the other auriferous alluvions is considerably smaller. The width of the placers is generally only a couple of metres, but can sometimes go up to 10—15 metres.

According to G. Svedelius, to whom we owe the minutest and most authentic statements from the time when the production of the Lappish gold was at its height, the highest point of the placers above the level of the river was 19.6 metres. He estimates the average amount of gold of all the washed sand of the placers at the Ivalojoki during the years 1870—1875 at 7.56 grams per ton, the yield of the gold-deposits themselves at 13 grams per ton, or at 0.00065 %, resp. 0.000378 % for all the washed sand at the river above mentioned.

According to the official statistics for the period of 1870—1899 the yield of all the worked sand amounted to 1.93 grams per m^3, or 0.000093 %. Critical reference to these figures will be made later on.

The tailings consist chiefly of magnetic or unmagnetic iron ore and garnet, at some places also partly of monazite and a little zircon. The biggest nugget of gold (not pure) weighed 89 grams. The remarkable fact, that in several of the placers (during the summer of 1905, for instance at Hangasoja and Luttojoki) traces of platinum were found, will be referred to in the description of the veins. In one case some small pieces of bismuthum were found at the Ivalojoki.

As to the exterior form of the gold this varies of course according to the longer or shorter transport it has undergone.

The ingenious investigations G. Svedelius carried out at the Ivalojoki, in order to obtain a clue to the enigmatical origin of the alluvial gold, are reproduced in the following sketch by E. Sarlin. The supposition of Svedelius, that the motherloads would be found above such places, where the gold occurs most abundantly and is most coarsegrained and on the highest point over the level of the river, afterwards proved perfectly right. Moreover, he observed that traces of platinum were found only on the places above mentioned, lying next to the supposed situation of the vein.

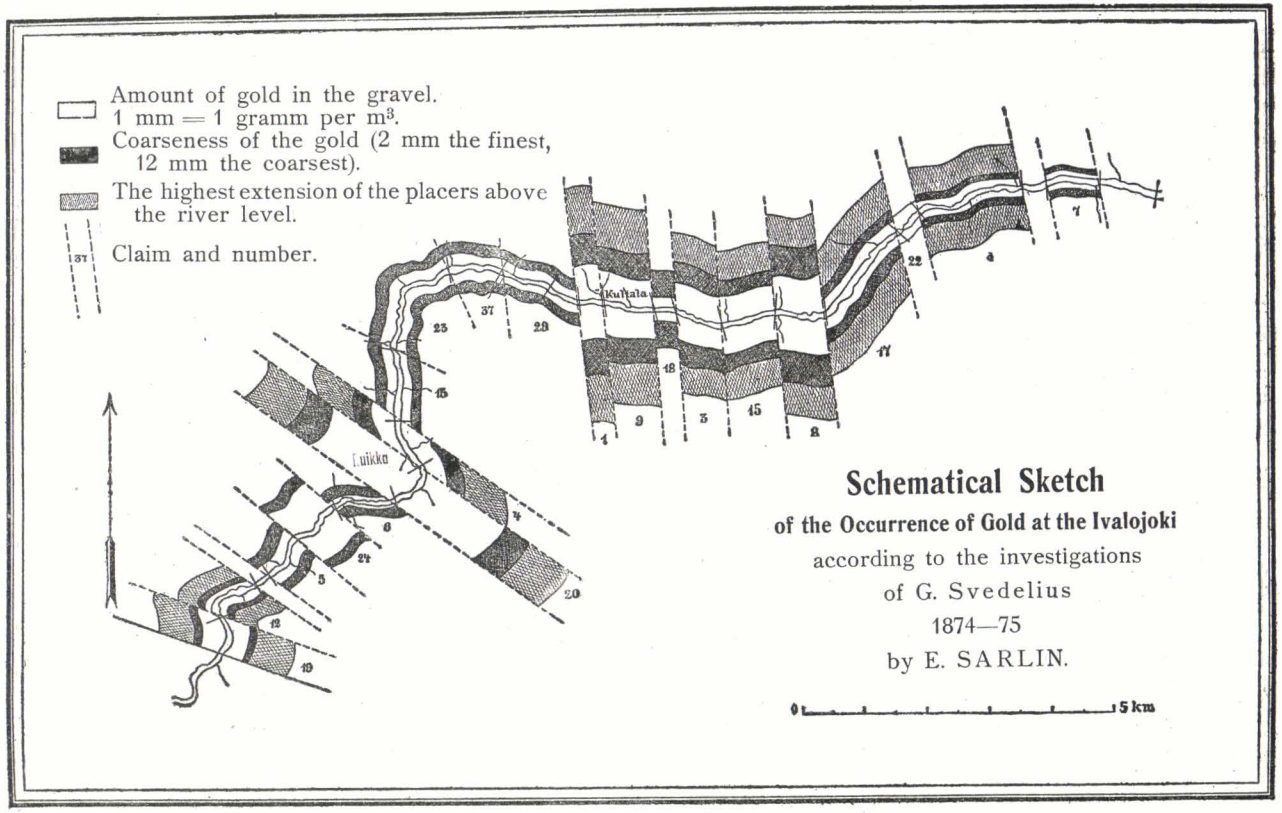

Amount of gold in the gravel.
1 mm = 1 gramm per m³.
Coarseness of the gold (2 mm the finest, 12 mm the coarsest).
The highest extension of the placers above the river level.
Claim and number.
37
Kuttala
Luikka
Schematical Sketch
of the Occurrence of Gold at the Ivalojoki
according to the investigations
of G. Svedelius
1874—75
by E. SARLIN.
0
5 km

Fig. 11.

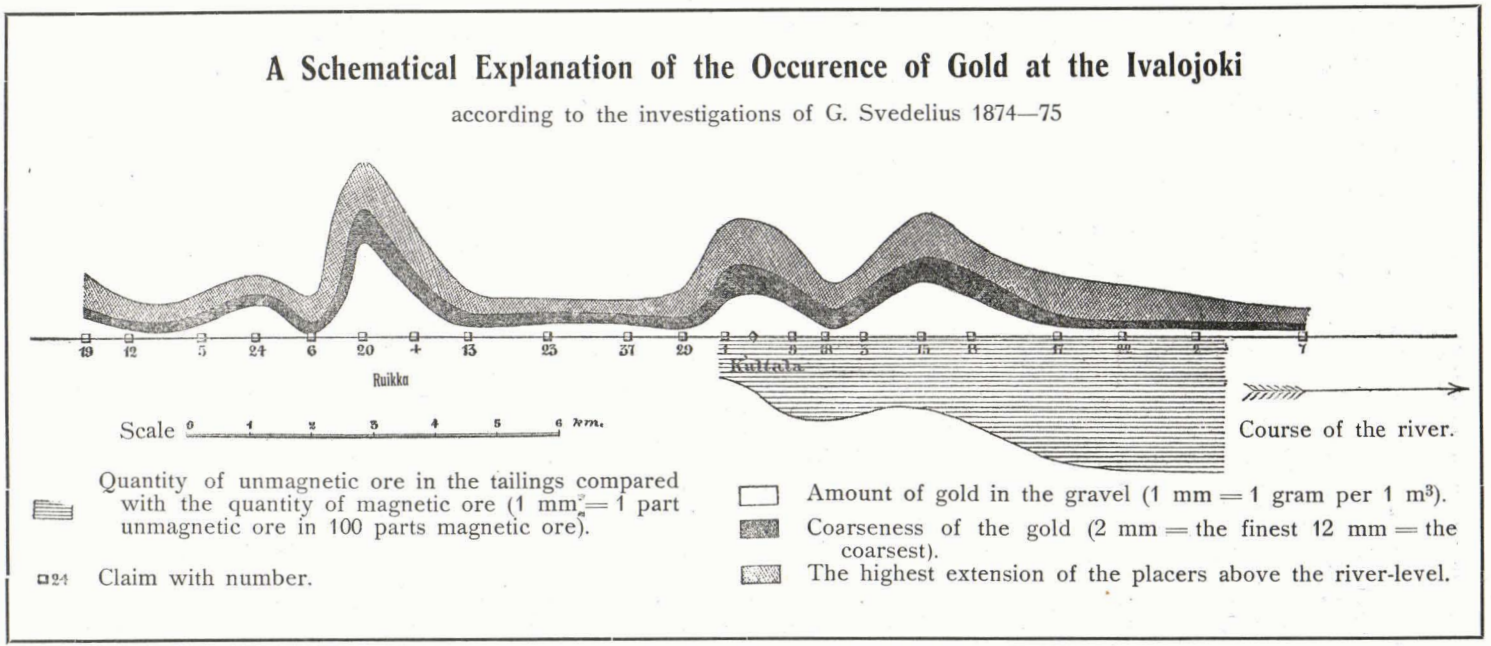

A Schematical Explanation of the Occurence of Gold at the Ivalojoki
according to the investigations of G. Svedelius 1874—75
Ruikka
Kultala
Scale 0 1 2 3 4 5 6 km.
Course of the river.
Quantity of unmagnetic ore in the tailings compared with the quantity of magnetic ore (1 mm² = 1 part unmagnetic ore in 100 parts magnetic ore).
24 Claim with number.
Amount of gold in the gravel (1 mm = 1 gram per 1 m³).
Coarseness of the gold (2 mm = the finest 12 mm = the coarsest).
The highest extension of the placers above the river-level.

Fig. 12.

The countryrock of the Lappish goldveins can provisionally be designated by the common name of granulite, though it shows a different type in different parts. Most closely related to the Saxon prototype of the granulite is the rock of Vahtamaapää: a scaly shistose, white rock, free from mica, composed of quartz and feldspar, and interspersed with small garnets. Frequently the rock takes after the type of a micaceous granulite or a gneissic granulite. The size of the composing minerals and their reciprocal relation vary considerably. The diameter of the garnets reaches an inch and more, showing abundantly the enclosures of feldspar characteristic of the granulite. Mica (biotite), which at certain places occurs in abundance, gives to the rock an appearance of granitic gneiss, while the garnets become more minute or disappear entirely. The feldspar seems to be mostly orthoclase and plagioclase, sometimes microcline.

Of the accessory minerals sillimannite is the most important and often even microscopically visible. It is, like the rutile, commonly idiomorphic and shows the characteristic prismatic form. Of rarer occurrence are monazite and zircon. Finally, the sporadically occuring graphite deserves to be mentioned. It is observed for instance in the rock of the Tolosjoki district.

Altogether it can only be stated at present that the rock is very closely related to the granulite-group. It shows generally very distinct signs of orogenetic pressure and has also been subjected to other metamorphic alterations, not yet investigated in detail.

This „granulite" is intersected by different dikes. Among these frequently occurs a kind of coarsegrained pegmatite which has still taken part in the orogenetic movement of the region and passes by gradations into masses of pure white quartz, and a fine grained diabasic or basaltic rock. As true fissure dikes, which can often be followed for several kilometres running straight through the country rock, occurs a red fine grained porphyry which should, according to its macroscopic character be designated as an orthoclase-porphyry, but whose high amount of silica (70.39 % $Si\,0_2$) refers it to the quartzporphyries, and this rock seems to stand in a genetic connection with the formation of the fissures and veins of the district, with which it has the same strike.

The rare openings do not allow any conclusions concerning the question whether, and in what way, the mineralisation of the ore veins has been directly caused by the „trap".

At some places, as for instance at the confluence of the little river Koijarinjoki and the Ivalojoki, above Ruikka, and especially at Härkäselkä, where it occurs in great masses, the pegmatite-quartz contains pyrite and has therefore attracted prospecting enterprises. However, it is certainly of different origin from the ore-veins here described and cannot be regarded as the motherload of the Lappish alluvial gold.

Preliminary to a description of the auriferous veins of Finnish Lapland there must needs be stated what difficulties investigators in this country have to battle with. The traveller has to struggle with many hardships involved in the local circumstances of this more or less deserted northern wilderness. On account of the frequent rains in summer and snowfalls in winter, as well as the melting of the snow in spring, the openings are quickly filled up by gravel and sand and the shafts often drowned. The first hinders and lengthens the work, the second limits it and often makes it impossible.

This was also the case during the summer of 1905, and therefore the following statements concerning the ores of the lowest levels of several shafts are founded only on the examination of specimens belonging to the collections of the Prospector company in Laanila, of the Geological Survey in Helsingfors and of the miners, who worked the last shifts.

In order to make the map as clear as possible the veins have been marked only by numbers. Names which have been used for some of them are written in parenthesis in the text. All the veins shown on the map have been visited, and investigated as far as possible, by the author.

Before giving a general survey of the Lappish gold-veins a short description of the principal loads will be necessary.

N:o 1. (Hartikainens v.) is a vein which traverses the valley of the Laanilauttanen and has only been investigated by trenches, chiefly in the form of a long opening running along the vein itself, up the rather precipitous wall of the valley.

Strike: N.—S.

Dip: 85° E.

Thickness: 5—30 cm (average: 25 cm).

Character: The gangue is white quartz, irregularly mixed with limonite, which often shows distinctly the cleavage of siderite. Stalactitic limonite occurs in cavities.

N:o 2. (Laanila v.) is in the neighbourhood of N:o 1, W., and is investigated to a distance of about 1 kilometre, by 50 trenches and two shafts 24 and 26 metres deep.

Strike: N.—S.

Dip: 85° E.

Thickness: 20—75 cm (average: 40).

Character: The load consisting in its southern part of one vein only, is divided in its northern part into a great quantity of smaller branches. Quartz and ironhydroxyde, the latter mostly in the form of siderite showing its distinct cleavage, or as a typical „glasskopf" in druses, sometimes forming stalactites, or pseudomorphoses covering crystals of quartz more rarely in the form of weathered crystals of pyrite (in one such case the form $\frac{3\ O\frac{2}{3}}{2}$ being observed) make up the monotonous picture of the vein according to the trenches. The prevalence of one or the other mineral varies, and so does also the character of the quartz, which occurs sometimes in quite well developed crystals, sometimes massive with a glassy lustre, sometimes more like quarzite. The colour is mostly white, seldom gray. The structure of the vein is generally banded, the quartz occupying the walls, while the decomposed carbonates fill the centre. In such cases the granulite often shows a more coarsegrained development with bigger pieces of quartz, the other composing minerals being weathered (cf. „the influence of the veins on the country rock and vice versa"). The banded structure however is neither regular nor constant, the quartz occurring also in the middle of the vein and then often being compact. A breccia in which the fragments of the country rock are imbedded in the veinfilling is of rarer occurrency.

In the „upper" shaft the vein showed nothing out of the common, in the „lower" it offered more diversity *).

*) Here as later on the statements about inaccessible shafts are founded on the notes of Mr. J. H. Saarinen, on personal information, and on the collections above mentioned.

On the 12-metre level the quartz increased and unweathered pyrite appeared. At sixteen metres the quantity of limonite decreased and the vein assumed more the character of a breccia, interspersed with fragments of the country rock. At 17 metres, at the head of a gallery 12 metres long, the ore showed itself comparatively rich in pyrite and quartz.

Fig. 13. Limonite and quartz, incrustating the vein wall. Laanila vein.

Concerning the amount of gold of this vein, the analyses of the Prospector company give the following results. The first column shows the depth in metres, the second the result of the analyses executed at the place itself, the third the corresponding assay in London in grams per ton.

Outcrop	0.0
6 analyses of the outcrop	trace

10	trace		0.38
14	„		
15	„		
17	1.66		
17 gallery	0.83		
17 gallery	0.83		
17 gallery (12 metres from the shaft)	1.0		
17.6	1.66		
18	1.66		
19 (bottom of the shaft)	1.66		
19 (W.-wall „ „ „)	3.33		0.78
19 (E.-wall „ „ „)	0.83		
19 (S.W.-angle of the shaft)	0.83		
19 (1 piece containing pyrite)	3.33		
19 (N.-angle of the shaft)	0.83		
19 (S.-wall „ „ „)	1.0		1.03
19.5	2.0		
19—20	0.5		
20 (N.W.-angel of the shaft)	0.83		
20 (S.-wall „ „ „)	1.0		
10	2.0		
20.5 (W.-branch)	0.5		
20.5 (E. „)	3.0		
20.5 („ „)	1.0		
21	1.0		
21	1.0		
21	1.5		
21.5	1.0		
22.5	1.0		
23	0.5		
23	1.5		
23.25	1.0		
24	2.5		
24.5	1.0		
24.5	1.0		
24.5	1.0		
24.5	1.0		
25.3	1.5		

Of the figures from 17 and upwards one — 3.33 — is of no use for determining the general yield of the vein, being an analysis of only one piece containing pyrite; the other of the same amount seems at least to be very dubious on account of the great difference between the local assays and those made in London.

Up to 17 metres the vein showed only traces of gold and from 17 to 26 metres an amount of 0.5 to 3.0 grams per ton. On the supposition that all these assays are average assays, the average amount would be 1.16. A general assay of each hauled ton was not made. The great difference between the two analyses of the same sample — which repeatedly took place — may be explained by the occurrence of small pieces of native gold which cannot be crushed and are irregularly distributed in the sample, a fact which in consideration of the small samples taken by the Prospector company (30 grams and 50 grams) is of no small importance.

N:o 3 (Kerkelä's v.) was not only the first discovered vein, but also that which produced most.

In the granulite, of a rather gneissoide type, a very coarse-grained pegmatite quartz occurs on the northern side of the river Hangasoja, as well as a vein of the light red porphyry above mentioned. This latter traverses the pegmatite. The thickness of the porphyry varies from 7 to 10 metres; in the south of the river it strikes N.—S., in the north about 20° W. There occurs also in two trenches a vein of fine grained diabase or basalt whose black and compact masses are weathered into parallelepipedic pieces. It strikes N. 15° E. The dip is 64° to E.

For want of sufficient openings unfortunately nothing can be said about its relation to the ore veins or to the porphyry. The following description of the ore veins is based on observations made in several trenches and the mine of Kerkelä.

In the mine itself two chief branches can be clearly distinguished. The chief vein strikes about N. 20° W. having a dip of 70° E. The filling of the vein consists of limonite with scarcely any quartz. Its thickness varies from 25 to 100 centimeters, increasing southwards and decreasing northwards. The other branch strikes about N. 15—20° W., having a dip of 70° to W. The conditions in the mine (a strongly weathered and ferruginous country rock, covered with clay and ice) made the determinations difficult and allowed but an approximate statement. The last mentioned branch consists of a complex of numerous small fissures forming a kind of

network in the crumbling rock, giving to the whole the appearance of a pseudo-breccia. The filling of these fissures — there is a larger vein of a thickness of 4—5 centimetres among them — mostly consists of crystallised quartz and limonite, the former prevailing. The fragments of gneissic granulite between the separate branches are extremely weathered and brittle. Weathering has taken place to a still greater extent in the pegmatite which partly forms the country rock of the chief branch first mentioned. Here the feldspars and partly also the mica are changed to crumbling kaolin and sericite; less frequently an epidotic product of the alteration can be observed.

In this chief branch — 4 metres from the shaft — Kerkelä found the first gold. This occurrence and likewise another one found later in the second branch (consisting of a complex of fissures) he believed to be a so-called „pocket".

In the author's opinion there is no pocket in either case, but we have to do with the very common fact of improvement at the junction of two branches or at a cross-course rather than a junction, though it was impossible to state with accuracy in the mine the faulting of one of the veins.

According to English assays the amount of gold in these improved points varied from 67.75 grams to 289.6 grams per ton, on an average 164 grams. Mr. H. Kerkelä declared that the samples did not consist of „selected" pieces but they were nevertheless taken exclusively from the „pocket". The author was told by miners, who had worked for a considerable time at Kerkelä's, that the richest goldbearing parts occured b e t w e e n the quartz and limonite, though both of them were yielding. Moreover, wiresilver is said to have been found at a depth of 13 metres. These statements are not confirmed. The same miners assured the author that the second „pocket" was at a point where a smaller fissure branched off from the chief vein.

The average yield of Kerkelä's vein besides these „pockets" has not been determined by regular sampling. Samples taken at several places proved the first vein to be very poor, the second a trifle better, but still not workable except at the improved points.

The question whether these two improved points were „pockets" or cross-courses is of no small importance, since the fact that they were pockets would confirm a theory to which we will refer

later on. For a certain time the Lappish veins were supposed to possess this peculiarity, which would have been of a far-reaching influence for the prospecting. If however we have to do with cross-courses here, which is the author's opinion, the Kerkelä mine does not support this theory. But a further extension of the crosscourse may be assumed. It is worth mentioning that a rumour is current among the Finnish colonists in these parts, which would place this extension beyond the regon of doubt; but the workmen are said to have covered the point in question by timbering the shaft, out of enmity to the owner.

In all the trenches so far as they were accessible the Kerkelä vein does not differ from the common type.

N:o 4 (Öfverstens v.). Following the course of the Hangasoja downwards from the Kerkelä mine, we come to the chief placers of the river – which have furnished satisfactory profits up to the present time — and to the trenches of vein N:o 4 not far from the confluence of the rivers Hangasoja and Tolosjoki.

Strike: N.—S.

Dip: 80°—85° E.

Thickness: 20—150 centimetres (on an average: 50 cm).

Character: The vein has been investigated by several trenches and a prospecting shaft 15 metres deep with short galleries, now only partly accessible.

The filling of the vein chiefly consists of limonite. The form of „glasskopf" predominates, the variety showing the cleavage of siderite being rarer. In large druses the „glasskopf" occurs either in concentric laminated nodules or in close-standing thin stalactites, sometimes associated with goethite. Crystallised quartz occurs but rarely. The fact that the secondary products of weathering here occur on a larger scale than in most of the other veins may be, at least partly, explained by the circumstance that the quartz, which is less easily penetrated by water, is scanty or wanting. In most of the other veins, where the mineral is found more abundantly, its presence, especially at the walls, created conditions less favorable for the circulation of water than on the vein N:o 4. The assays of this vein gave as the highest yield at the 12 metre level 5.5 grams per ton, the sample however not having been taken over the width of the whole vein. An assay of the same sample in London gave only 0.78 grams.

Taking the inexactitude of several such assays into consideration, the average yield of the vein at a depth of 12—14.5 metres, its best part, is to be rated at less than three grams per ton.

N:o 5 (Harald v.) is situated in the north of the vein last described on the high wall of the valley of the Tolosjoki. It has been investigated for a distance of some hundred meters by trenches and by a prospecting shaft 7 metres deep.

Strike: N. 10°—12° E.

Dip: 75°—80° to E.

Thickness: 20—400 centimetres (on an average 40 cm).

Character: The very much weathered country rock is here threaded by numerous small fissures often only a few millimetres in thickness. One of these veins reaches in the shaft a thickness of over a metre, and the whole system of these threads occasionally attains a thickness of four metres and more. Weathered siderite of a blackish brown or reddish colour is the strongly prevailing veinfilling, besides compact limonite. Crystalline quartz is found only in a subordinate quantity. Traces only of gold have been found.

N:o 6 (Movitz v.). Farther northwards on the northern shore of the Laanilauttanen, near its confluence with the Tolosjoki, is situated the Movitz vein, which has only been investigated by trenches.

Srike: N. 5° E. (in the southern part of the vein).
N. 5° W. („ „ northern „ „ „ „).

Dip: 70° E.

Thickness: 10—100 centimetres (on an average: 30 cm).

Character: The content of this vein which is also considerably branched consists mostly of weathered siderite and limonite, while the quartz comes only third. The crystals of quartz are often pseudomorphic incrustated by limonite. Sometimes small stringers of iron hydroxyde cross the range of scrins. At several points the weathered country rock was strongly impregnated by (secondary) pyrite, which has only been altered to limonite, when it was accumulated in small scrins. The same ferruginous rock was also irregularly interspersed with graphite in small laminae.

N:o 7 (Carl-Gustaf v.). This vein, the most southern of the district — if we omit some quite unimportant ones (claim of Suopankis) — was investigated by several trenches and a prospecting

shaft 50 metres deep. Its exploration has furnished us with the best information we possess of the Lappish veins.

In the trenches, and to a depth of 20 metres in the shaft, the contents of the vein differed from those of the other veins only so far as the quartz occurred more abundantly, and was often of a peculiar blue or greyish blue colour. Apart from this the veinfilling resembled the other veins.

The weathering of the vein and the country rock, which, according to engineer Saarinen, was very remarkable down to a depth of 28 metres, gradually grew less conspicuous till it reached 40 meters, where more solid country rock appeared. According to its composition the latter comes next to the type of a garnetiferous gneiss. The mica (mostly biotite — rarer muscovite) occurs frequently in bands. The garnets not rarely form „eyes" giving to the rock the appearence of an „Augengneiss". Accessory minerals are sillimanite (rather common) and sometimes magnetite.

„At 43 metres the first unweathered ore was visible and at 50 metres it was almost entirely unweathered".

This unweathered ore of the Carl-Gustaf vein is to be considered as typical of the Lappish gold veins, except for the peculiar color of the quartz.

It consisted chiefly of siderite, calcite and quartz — specularite, magnetite, magnesite, pyrite and a little chalcopyrite occurring less often.

In the fresh ore of this vein the siderite and quartz were equally mixed, and sometimes all the ingredients were rather fine grained. The pyrite occurs partly as an impregnation interspersed between the other components, partly on the fine fissures in the siderite, partly in the country rock itself and then sometimes abundantly. In the last mentioned case it was considerably finer grained than in the vein.

The laminae of specularite are scattered among the siderite. This mineral is partly transformed into magnetite, a peculiar fact which however after a careful investigation cannot be denied. In the middle and fine grained mixture of siderite and quartz crystallised calcite occurs in small druses.

A transition of the calcite into siderite can often be distinctly observed.

The peculiar blue and greyish blue colour of the quartz seems to have been caused only by an extraordinary number of minute

cavities filled with air or any other gas which even when strongly magnified are still very small. There are other inclosures, which are also very small, sometimes indistinguishable, but they occur in such a minority that they cannot be of any influence.

The same structure of a breccia, found in other veins of the district, occurs here too.

The yield in the higher levels to a depth of seven meters varies from 0.5 to 2.0 grams gold per ton. In the lower levels most of the assays only gave traces of gold. Some however gave as much as 4 grams.

According to the assays of the engineers of the Prospector company the unweathered ore yielded 0 to 4 grams silver per ton.

As an interesting and remarkable observation must be mentioned the fact that the gold grains of the assays contained platinum, in some cases even in greater quantity than gold. This fact seems to prove that the grains of platinum found in the placers have the same origin as the gold.

As far as the author knows no similar occurrence of platinum has been observed until now.

N:o 8 (Lutto v.) is investigated by a couple of trenches and by a shaft about 51 metres deep. The vein-filling does not differ from the common type — weathered siderite, quartz, limonite. Also in structure (partly brecciated and often branched) the vein conforms with many others of the district. The dip is not quite so steep as in most of the other veins — 65° E. The thickness reaches 150 cm and is on an average 40 cm. The country rock and its fragments in the vein show a peculiar kind of weathering. The granulite is altered to a greyish green substance consisting chiefly of chlorite and sericite and being sometimes so crumbling, that it can be crushed with the hand, and sometimes quite solid, but of the same color. In this rock the garnets, which reach the size of a pea, are comparatively fresh and of a light red colour. In addition an impregnation of pyrite can often be observed (occasionelly of graphite).

The amount of gold of the ore in the outcrop, and to a depth af 10 metres was infinitesimal. From 10—24 metres the yield was 0.83—4.98 grams per ton, on an average 2—3 grams, in the deeper levels still lower, mostly less than 1 gram per ton.

N:o 9 (Anna v.) has the same structure and contains the same minerals as the other veins. The only remarkable peculiarity is the occurrence of malachite on and in the limonite. The chalco-

pyrite here and there occurring in the veins (in the Carl-Gustaf vein) has been the primary mineral for the carbonate. The strongly weathered country rock is ferruginous and sometimes impregnated by pyrite. The vein is investigated only by trenches and the analyses showed only traces of gold. We omit some more unimportant veins situated in the north and northwest of the vein last mentioned, which do not differ from the general type.

N:o 10 (Cygnæus v.). The chief vein of a thickness of 120 centimetres is accompanied by numerous small scrins and contains much quartz and a weathered crumbling siderite of a red colour. Even here the country rock is abundantly impregnated by pyrite. Yield: only traces of gold.

N:o 11 (Wille v.). In the south-west of the confluence of the Hangasoja and the Tolosjoki, on the western side of the latter, is situated the Wille vein, which differs a little from the the common type.

Strike: (N.-branch) N.—S.
(S.-branch) N. 30° W.
Dip: (N.-branch) 60° to E.
(S.-branch) 90°.
Thickness: (chief-load) 20—40 centimetres).

Character: In the prospecting shaft — a couple of meters deep — the chief load is accompanied by a swarm of small scrins crossing each other in all directions. Besides much limonite and a little quartz it contains even specularite. The whole range of scrins belonging to the load is about 2—3 metres thick. Within this zone the veinfilling is of a brecciated structure. The weathering of the fragments of the country rock is of a character, resembling the country rock of the Carl-Gustav vein, consisting principally of chlorite and quartz, occasionally impregnated by pyrite. The vein is less branched in its southern part. Gold is only found in traces.

N:o 12 (Ramsay v.). Some hundred metres to the west of the vein last mentioned we come to the Ramsay vein which is investigated by numerous trenches and a shaft 16 metres deep with some galleries. Chief load:

Strike: N. 20° W.
Dip: 75° to W. and SW.
Thickness: 10—100 centimetres (on an average: 50 cm).

Character: It is rather difficult in this case to state with the help of the existing trenches which of the numerous scrins and bran-

ches crossing the rock belong to the Ramsay vein and which do not. For an extent of 120 metres many veins occur in which either quartz or limonite prevails. Their thickness varies from one millimetre to 10 centimetres (except the chief load) but is mostly 3—5 centimetres. Most likely we have here to do with a big range of veins, which, probably connected, have to be considered as one load.

The chief vein is distinguished from the other Lappish veins by its abundance of quartz, of which one branch almost entirely consists. In the shaft the more or less weathered siderite with

Fig. 14. Gangue from the Ramsay vein (to the left) and from the Palsi vein (to the right), the latter containing cavities left by the weathering of crystals of siderite.

which we are acquainted in the other veins, was found, forming a breccia with quartz and those dark greyish-green fragments of weathered country rock, described in the vein last mentioned. An impregnation of pyrite sometimes penetrates both the siderite and the fragments.

The yield in the trenches was hardly worth mentioning, nor did it to a depth of 12 metres increase much in the shaft. However from 12 to 15 metres deep only two assays gave less than 2 grams, while the best result was 5.82 grams per ton; the average yield being 3.25 grams per ton.

Several other veins in the district (to N.) are unimportant and do not differ from the general type.

N:o 13 (Moberg v.). In the north of the river Moberginoja we come to a vein which is investigated by some trenches and a little shaft. This less important vein is composed of numerous and mostly thin branches, containing besides the minerals already often mentioned iron hydroxyde even in the form of stilpnosiderite (eisenpecherz), and as a mineral of recent genesis cacoxen. The very drusy and cavernuous quartz often occurs here quite irregularly, mixed with the other ingredients of the veinfilling, and is ferruginous especially between the scrins.

The yield was rather low — less than 1 gram per ton — all over the vein.

N:o 14 (Palsi vein). On the southern riverside of the Ivalojoki, where the mountain of Iso Palsitunturi rises steeply, is a vein investigated by trenches and a prospecting gallery 12 metres long.

Strike: N. 20° W.

Dip: 85° to W.S.W.

Thickness: 40—60 centimetres.

Character: In most of the trenches the vein shows the usual type, brecciated structure etc. Two kinds of quartz of different ages can sometimes be clearly distinguished, one of which is younger, the other older than the siderite. The latter contains negative pseudomorphoses of siderite (cf. fig. 14).

In the gallery the load is accompanied by a dike of compact greenish black trap, which seems to be older than the ore vein. However this cannot be stated with certainty, the greater part of the gallery having collapsed.

The yield in the gallery was 4.16—4.99 grams per ton. The fact deserves mentioning that the country rock here contained 1.66—3.00 grams per ton, and the trap 1.66 grams.

Other veins occurring in the south of this load are rather similar to N:o 14. The gangue is the same, the structure partly brecciated, partly very branched, so that the thickness of the whole zone belonging to the vein reaches 5 and 6 metres.

All of them contained merely traces of gold.

N:o 15 (Kultala v.). Following the course of the Ivalojoki upwards from Palsi we come to the government station of Kultala — marked on the map by a square round the name of Kultala — where the dams mentioned above have been recently erected. Just above the station a vein crosses the river striking N.—S. The investigation (by trenches only) proved the vein to contain a little

more quartz than the other veins do on an average, but in other respects not differing from them. It must be considered as one of the mother loads for the placers at Kultala. The very slightly weathered country rock here must be described as a granitic gneiss.

According to the claimholder an „average sample" of one trench, assayed in London, gave 15 dwt gold. The existence of

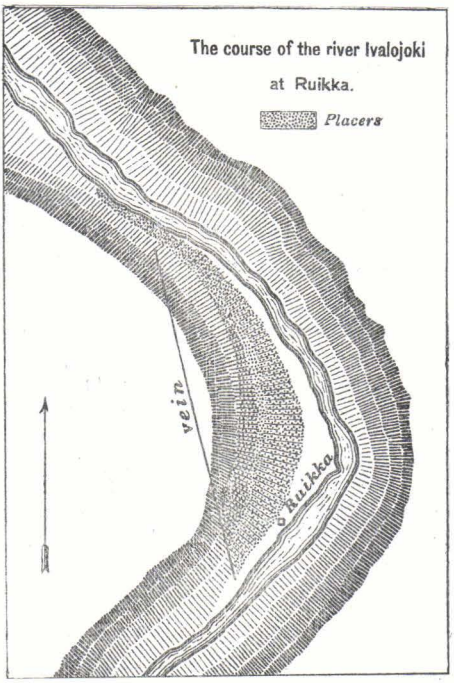


Fig. 15. Relation of placers and vein at Ruikka. Middle course of the Ivalojoki, seen from Iso Palsitunturi, looking west.

tellurides of gold was said to to have been ascertained at the same laboratory.

But according to the engineers of the Prospector company the vein „is as poor as the others". This is no doubt true. A sample from the same wall of the trench, taken and assayed by the author gave only imponderable traces of gold and no tellurides.

N:o 16 (Ruikka v.). On the left riverside of the Ivalojoki about 5 kilometres above Kultala, near the rich placers of Ruikka, the

vein N:o 16 has been investigated by trenches and a shaft 14 metres deep. The rather unimportant vein offers nothing new and its yield — 0.5—4.16 grams — was on the same low level with the others. The place is only interesting on account of the rich occurrence of gold in the placers very high (18—19 metres) above the level of the Ivalojoki. It has occasioned many conjectures as to the origin of such rich placers from so poor a vein, as the motherload at Ruikka evidently is.

The following sketch gives a general view of the situation at Ruikka. With regard to it, one may mention that the upper limit of the placers often almost coincides with the highest point of the slope. The southern outcrop of the vein lies half way up the hill. The riverside opposite to the winding is very precipitous, sometimes rising almost perpendicularly. Several circumstances, favorable to the formation of an exceptionally rich placer have met together here. First the situation of the vein itself rendered a preglacial „oredressing" and concentration in the valley of the Ivalojoki possible, secondly the winding of the river at this place created favourable conditions. Thirdly the inland ice has moved in these parts to N.E. and therefore was able to transport the products of a preglacial gossan to a place most favourable for a postglacial „ore-dressing".

The influence of the veins on the country rock in the upper levels has been a very important one. The rock in the neighbourhood of the veins is nearly always extremely weathered, the feldspar and mica is decomposed into kaoline and sericite, and somemes epidotisation has taken place. The rock is always very ferruginous and a secondary impregnation by pyrite is seen near the vein. However these transformations are more or less confined to the weathered part of the vein, and in deeper levels the country rock seems not to differ from the usual Lappish granulite with the exception of an impregnation (of pyrite) occurring occasionally. So, as far as we have been able to make our respective observations, the veins in their primary condition seem to have had a very little influence on the surrounding country rock.

As to the influence of the latter on the veins, no transmigration of these from the granulite into an other rock having been observed, nothing certain can be said concerning this matter, except that the origin of the secondary quartz by lateral secretion is very probable.

Summing up the foregoing observations, we get the following picture of the Lappish gold veins:

The following are to be considered as primary minerals:

quartz,
siderite,
calcite,
(magnesite),
specularite — a part of it, which should be regarded as a product of a higher oxydation of the siderite. A still higher oxydation has created the
magnetite,
pyrite,
(chalcopyrite).

The minerals in brackets are of rarer occurrence. The pyrites are the youngest minerals of the veins. The gold should be considered as connected with the pyrite. In what form the platinum occurs is not clear. The native bismuth has only been observed in the placers.

The following must be regarded as minerals of the gossan:

limonite (in form of weathered siderite or kidney ore),
siderite (a part of it, which can be considered as a metamorphosis of the calcite by ferruginous solutions — ferruginous partly by the weathering of the pyrite — filtering through the higher levels, a fact known from other mining districts),
malachite (a rare occurrence in the Anna vein)

and rarer minerals as cacoxene. Even the native gold, which has been sometimes found in the veins must be named in connection with this group.

The veins are mostly branched.

The structure is often brecciated, less often banded, showing in order the different age of the minerals.

The thickness is on an average (the chief loads only being taken in consideration) 40—50 centimetres,

the strike is uniformly N.—S. with very small deviations to W. and E.,

the dip is always very steep (the flattest 65°) mostly 75°—85° to E. or W.

The yield is very low, and will be on an average less than 2 grams per ton.

The Lappish veins are, as we have seen, a new type of gold veins, not yet observed in other parts of the world, and this fact explains, may be, the difference in the opinions of eminent geologists concerning the probable motherload of the alluvial gold, before the investigations of the last few years rendered the work easy.

The question how such poor veins could be the motherloads of such comparatively „rich" placers, has been a rather difficult one, and the different opinions concerning this problem will now be discussed.

As to the figures indicating the amount of gold of the placers, given on page 13, attention must be paid to the fact that on account of a number of difficult circumstances (the short working time, the high wages etc.) only the richest placers can be worked with profit. Consequently the figures showing the amount of gold cannot be compared to such from many other gold producing territories, which are worked under considerably more favourable conditions.

But even if we admit that these figures, may be, do not give an exact idea of the average yield of all the placers, the latter are at all events rich, compared to the veins, which no doubt are their motherloads.

Two possibilities are conceivable as to the origin of such comparatively rich placers as the Lappish, the circumstances involved by the arctic situation of the country being taken in consideration: either a very long period of erosion and extraction from poor veins, or a shorter, and more recent one of rich veins, the erosion after the glacial period in these parts being considered unimportant generally.

The moraine in the neighbourhood of the veins always showed a very small amount of gold, and it was therefore assumed that the gold of the placers was of a postglacial origin, and, in consequence, the veins might be expected to be rich.

The improved points of Kerkelä's vein moreover induced the prospectors to assume „pockets" in the veins formed by a process of secondary enrichment, and because the placers were always most yielding below the points where a vein traversed a valley, the pockets might be expected to lie very close to each other, the vein with the exception of the supposed pockets being very poor.

This theory however seems to be a wrong one.

It is quite impossible that the investigations made should not have lead to a discovery of these pockets, did they exist in such series as the theory in this case requires with regard, first, to the fact above mentioned, that the placers are especially yielding below a vein crossing a valley, and further, to the opinion assuming only a postglacial erosion. It cannot be assumed that pockets always existed just on the points in question, and thus formed the source for the gold of the placers, but on the other hand they were so rare except at these places, that none were discovered during a long period of investigation.

So the first of the possibilities above mentioned failed: as we have seen, the veins were neither on the whole so rich as the supposition of an extraction only postglacial would have required, nor should they on the other hand, at least according to the author's opinion, be expected to possess this quality in a degree worth mentioning.

The second possible explanation of a formation of the Lappish placers out of the veins above described is by assuming a very long period of extraction, that is to say a preglacial erosion.

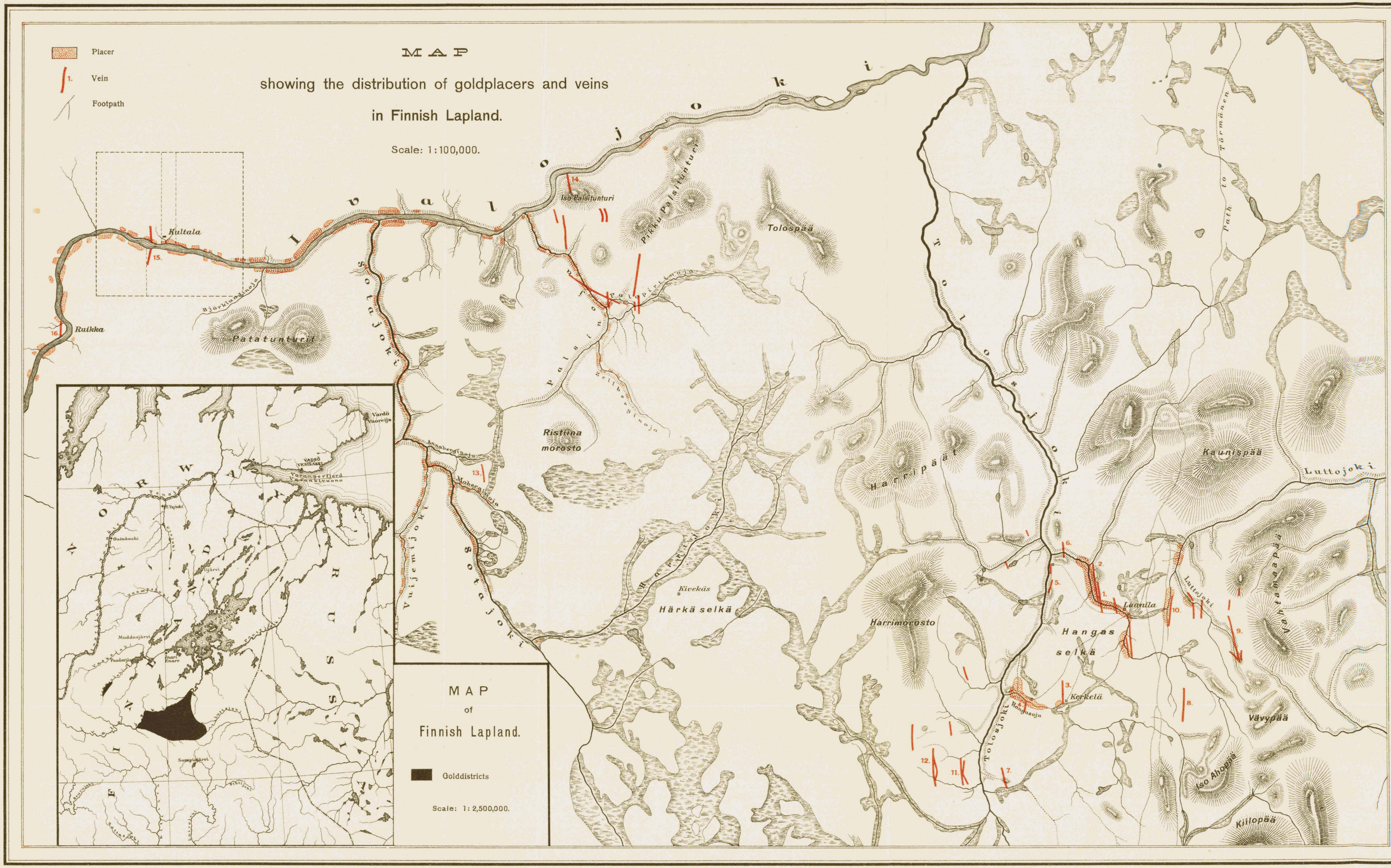
To support this theory a number of valleys must necessarily be considered of preglacial origin.

According to the author's opinion this is the case with many of them; the following rivers especially have to be considered as having valleys partly preglacial: the Ivalojoki, the Sotajoki and part of its tributaries, as for example the lower part of the Moberginoja and the Vuijemijoki, the Palsinoja with the tributaries Zellberginoja and Palopirtinoja, the Tolosjoki and many of its tributaries, especially the Laanilauttanen and finally also the Luttojoki.

These rivers have more or less washed out and extracted the veins, which process lasted for an extremely long period. The rivers performed themselves the most perfect „ore-dressing" operations, separating the gold and concentrating it on certain places.

The character of the veins was favourable to a quick formation of a gossan, and the zone of decomposed minerals in preglacial time must have been of a considerable depth. The greatest part of this gossan was destroyed by the inland ice during the glacial period, and its gold was often spread over a wide area by the moraine, which therefore contains a certain although not very high amount of gold, and pieces of limonite and quartz. But at places where the conditions were favorable, near to the valley of a river, especially when the vein had such a situation as at Ruikka, the fragments of the gossan were transported to a point where in the postglacial period the renewed „ore-dressing" began and so contributed to the formation of the placers.

This is the relation according to the author's opinion between the veins and the placers in Lapland.



Lith. by F. Liewendal, Helsingfors, 1906.

Fascicules parus du Bulletin de la Commission géologique de Finlande (en vente dans les librairies d'Helsingfors et chez MAX WEG, Leplaystrasse 1, Leipzic).

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