

THE RAINY DAY MINERAL PROSPECT.

by

R. C. Emmons.

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INTRODUCTION.

The West Coast of Vancouver Island is thickly wooded and rather mountainous, though to a much less degree than its interior. Numerous prospects have been located on Barkley Sound and of these the Rainy Day has been chosen as representative of the contact metamorphic type, both with respect to geologic relations and estimated dimensions of the ore body.

LOCATION.

The property is situated on the east shore of Henderson Lake about one and a half miles above the outlet (Fig: 1.). The prospect adits are less than fifty feet above the level of the lake on a steep hillside. The outlet of the lake is a broad stream emptying into Uchucklesit Harbour an arm of Barkley Sound and falls only a few feet in a distance of half a mile. Dredging operations have been carried on by the government making possible the commercial transportation of ore.

TOPOGRAPHY.

The general trend of the mountain ranges of Vancouver Island is N 65° W, this direction conforming roughly with the axes of folding and planes of faulting of the district. Glaciation has gouged out the valleys giving them the typical U- shape and removing a great quantity of material. Several large valleys have developed transversely to the trend of the rocks, namely N.E. and S.W.. Examples are Alberni Canal, Henderson Lake, Pipestem and Effingham Inlets. It is probable that their relative size is due to glaciation which would be from the centre of the Island outward. These have been

converted into Fiords with the exception of Henderson Lake which is a few feet above high water level. Other valleys equally important have formed subsequent to the trend of the rocks and folding; as examples of these may be cited Sproat Lake, Mahmint Lake and the northern portion of Henderson Lake. An area of lowlands borders the west coast of the Island; in the vicinity of Barkley Sound it consists of folded sedimentary and plutonic rocks. Clapp states⁽¹⁾

(1). C. H. Clapp: Mem: 13. page 23. Geo: Surv: Can:

that the Tertiary sediments were deposited in small embayments off a mountainous coast with bold promontories. This process can be seen still going on in Effingham Inlet where recent uplift has brought several marine deposits above sea level and they are now suffering erosion by young streams.

GENERAL GEOLOGY.

REGIONAL. The major portion of the rocks exposed on Vancouver Island consists of sediments, and volcanic rocks - the Vancouver Group of Dawson - which are lower Mesozoic in age. They are considerably folded and are intruded by both acidic and basic granitic rocks. Other rock types are found on the Island that do not enter into the geology of the Rainy Day prospect. During Pleistocene times Vancouver Island was covered with ice which eroded deeply sending out valley glaciers to the lower levels and modifying the topography as already mentioned.

LOCAL. Altered Andesite predominates in the crystalline rocks of the district. The volcanics are thought to have accumulated under the sea, on the evidence that structure, thought to be pillow structure

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was observed, and that beds of Limestone in which Clapp found marine fossils are intercalated in the volcanics. The Limestone is generally in thin lenses though occasional beds of considerable thickness were found. Where intruded by granitic rocks it is metamorphosed into such minerals as garnet, epidote, amphibole and pyroxene.

All the Vancouver Group have been greatly folded and faulted causing the limestone beds to have various dips. The strike conforms roughly to that of the axes of folding, namely, N. 65° W. Following the deformation and probably during it there were intrusions of granitic rocks which, in general, followed a north-west, south-east trend, evidently the lines of weakness caused in the overlying beds by the regional folding. These intrusives have been classified as late Jurassic⁽²⁾

(2). C.H. Clapp: Mem: 13: page 112. Geo: Surv: Can:

Deposits of glacial drift cover areas in the district but do not enter into the geology of the Rainy Day prospect.

Vancouver Group. These rocks have been subdivided by Clapp in Southern Vancouver Island, chiefly on the basis of lithological differences. The nomenclature employed by him will be applied to the rocks encountered, where correlation is possible.

Volcanics. The preponderant rocks exposed in the district are the Vancouver volcanics, which apparently form a belt with a trend parallel to that of the Island. Henderson Lake is situated in this belt. The volcanics are principally flow type and are represented

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by amygdaloids, porphyries and tuffs. No fragmental types were found, however, in the immediate vicinity of the Rainy Day prospect. Alteration has taken place in all the rocks, being more pronounced near the intrusions.

Meta-andesite is the most common ^{rock,} Megascopically it appears as a dark green rock, usually porphyritic, the phenocrysts being feldspar and hornblende. Veinlets of epidote cut the andesite, and occasionally fill the vesicles. Small cubes of pyrite could often be detected in the hand specimen.

Microscopically the Andesites were seen to be much altered in all the slides examined. In places the original character of the ground mass was completely obliterated, the phenocrysts ^{only} serving to indicate the relative basicity of the unaltered material. The ground mass consists of felspar laths intergrown and being replaced by Sericite, chlorite and calcite. The phenocrysts consist of felspar altering to Sericite and hornblende considerably replaced by calcite and chlorite; the felspar phenocrysts are of the andesine variety. The Iron leached from the ferro-magnesian minerals is concentrated in patches about the slide. - - - - -
Some of the meta-andesites showed under the microscope a greater degree of metamorphism. The hornblende phenocrysts were almost completely altered to chlorite, the original crystal boundaries usually being retained and also some of the structure; chlorite was abundantly present in all the field.

Near solution channels the volcanics are silicified making the ground mass a fine aggregate of quartz grains usually associated with pyrite. There were small areas of granular epidote and veinlets

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of calcite and epidote cut the rock.

Dacite occurred as a light green or almost white fine grained rock, in which no quartz is visible to the unaided eye; it is found with the andesite but is quite easily distinguished by its colour.

Microscopically the normal Dacite is seen to have porphyritic texture, the phenocrysts being hornblende, felspar and quartz. The felspar is of the oligoclase-andesine variety, the hornblende is altering to chlorite and epidote while ^{the} anhedral phenocrysts of quartz crystals enclose small felspar microlites. The ground mass is felted consisting of felspar laths simple or once twinned. The altered Dacite differs by having chlorite replacing the hornblende and kaolin and ^Serisite replacing the felspar.

Apatite was found as a minor accessory in all the volcanics, and magnetite in the andesite.

A thin section was made of a rock impregnated with pyrite, selected from the face of a tunnel in which the ore lead had failed. The hand specimen was dark green in appearance with a flinty lustre, pyrite cubes being quite abundant. Under the microscope the gangue was seen to consist wholly of quartz in small grains.

The type of alteration undergone by the volcanics is known as propylitic alteration and is thought to be due ^{to} ascending hydro-thermal solutions. (3)

(3). W. H. Emmons. Prin: Economic Geology: page 249.

W. Lindgren. Ore Deposits: page 478.

Sutton Formation. Limestone lenses which occur interbedded in the Vancouver volcanics have been determined by Clapp as Lower Jurassic

they also occur thinly interbedded with tuff, in which case the limestone appears to be more impure. Thin sections were not made of the limestone, but it is apparently finely crystalline with coarser veinlets of calcite running through it. It is highly probable that the limestone and volcanics are contemporaneous in age since they are folded and faulted together, both formed under the sea and generally closely associated. The presence of fragmental types in other parts of the district similarly associated with the limestone, also supports this view.

Plutonies; There are several intrusions of dyke and batholithic rocks in Barkley Sound and it is with one of these in particular that the Rainy Day prospect is concerned. They have metamorphosed and in places mineralized the overlying volcanics and limestone giving rise to several ore deposits.

A quartz-diorite dyke occurs just north of the Rainy Day prospect adits; it is about two hundred yards in width and has a general strike of S 65⁰ E. The superior resistance to erosion of the diorite has resulted in the formation of a mountain on both sides of the lake, marking its location. It is a medium coloured, coarse grained rock quite rich in hornblende; in the hand specimen it appeared quite fresh.

Microscopically the normal diorite is holocrystalline, consisting essentially of subhedral crystals of hornblende altering to chlorite, and andesine feldspar slightly altered to sericite; Quartz is present interstitially in small quantities; Apatite, Magnetite, and Titanite appear as accessory minerals. The rock

therefore, is classified as a quartz-diorite.

The altered diorite is chloritized to a much greater extent and the feldspars are thickly clouded with sericite. The ^{oxide,} Iron, leached from the ferro-magnesian ^{minerals,} is segregated in patches in the slide. Quartz, apparently secondary, is present in the altered rock; this alteration is produced near the borders of the dyke and is evidently due to the solutions from the still warm interior.

Structure: Aside from the major structures referred to under topography, the structure in the vicinity of the prospect is connected with ~~the~~ igneous activity. The intrusion of the diorite dyke resulted in folding, faulting, and fracturing. The folding and faulting followed almost the strike of the dyke, while the fracturing served to obliterate most of the traces of original structure.

Strikes and dips of limestone lenses measured on the shore,, where a continuous exposure could be found, were quite irregular. (Sketches made of this in the field are shown in Fig 2.) There was no evidence of deformation ~~xxx evident~~ in the dyke rock.

The northern adit has been driven into an anticlinal fold that presents some very interesting geological features. (Fig.3.) On the south side a fault cuts off the anticline and is thought to be genetically related to it; the fault wall has been followed for a hundred feet by the tunnel. A layer of gouge lies between the fold and the silicified andesite on the south side of the fault plane. The innermost of the concentric layers forming the fold consists of

a pyroxene,
separated from the next layer of the same mineral by a band of garnet. There is distinct parting in the garnet at angles of about 90° , probably dodecahedral; these parting lines bear a fixed relation to the plane of the garnet band. Incipient crystallization has developed in the garnet, the dodecahedron and trapezohedron having been recognized (Fig; 4.). Between the second and third layers of pyroxene were some large fragments of limestone with open spaces between them; the surfaces of the fragments were weathered and gave no information concerning their position. It is important to note that the fragments were not wholly recrystallized. All three bands of pyroxene showed a tendency towards comb structure, the crystals standing out in better relief near their bases than toward the center. Another band consisting of a fine grained aggregate of vesicular epidote lay outside of the pyroxene. Neither the epidote nor the pyroxene was fractured.

The typical mixture of country rock, namely, limestone and andesite was found bounding this formation where exposed. In the extreme center of the fold was some leached material, quite porous and black. The contact of the garnet and pyroxene was frozen but well defined, that of the layers of pyroxene was not so solid, nor was that dividing the epidote and pyroxene; these latter were marked by a very thin ^{surface} line of material, presumably gouge.

Very slight metallization has taken place in the pyroxene, there being merely a few traces of the persistent mineral pyrite in thin sheets parallel to the longitudinal axes of the crystals. This association of sulphide and pyroxene was noticed elsewhere.

Lithology of the Anticline: The garnet is brown in colour and very brittle, separating easily along the two sets of parting ~~planes~~ ^{planes}; these ~~planes~~ were noticed to cross and run parallel to the plane of the band. Under the microscope one set of parting lines was more numerous than the other, suggesting slight stress; a few crystal borders were noticed. Veinlets of Quartz ~~grains~~ cut the Garnet usually parallel to the parting. Qualitative tests were run for Aluminium, Iron, and Calcium, proving the absence of Aluminium and the presence of Iron and Calcium. It is concluded that the garnet is of the andradite variety.

The epidotized rock is rather light green, finely granular and with many vesicles of small size; there were no fractures evident. Microscopically the rock consists almost wholly of epidote in small euhedral crystals and grains. Considerable leucoxene is present lining the vesicles and scattered over the slide. Chlorite and Quartz are found between the Epidote crystals many of which show wavy extinction.

The Pyroxene is a dark green mineral consisting of elongated crystals in a sub-parallel arrangement. Small veinlets of Calcite run parallel to the other crystals and a little Pyrite is scattered through the rock. Microscopically the Pyroxene has a high maximum extinction angle $42^{\circ} - 43^{\circ}$. The index of refraction was determined, by immersion, to be over 1.70, which limits the mineral to Augite or Hedenbergite. A qualitative test for Aluminium gave a negative result; it is concluded, therefore, that the mineral is Hedenbergite. The calcite contains numerous grains of Pyroxene many of which show typically the square cross section with truncated corners.

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The Garnet-Pyroxene contact shows crystals of Garnet intergrown with Pyroxene which ^{here,} is in short crystals, extinction angle 40° - 44° , in sections showing one set of parallel cleavage lines; Quartz grains are also present.

Origin: The study of the origin of the anticline has proved interesting as throwing light on the order of events in contact metamorphism. The intrusion was preceded by a period of folding and faulting which affected the country rock for some distance ~~and~~ around; it will be remembered that the intrusion ^{was} undeformed. The result was the obliteration locally of all traces of original structure and the formation of channels which would facilitate the free movement of solutions. In one small area may be represented, in various sized fragments, limestone beds which were laid down under widely different conditions. There are fragments, therefore, in juxtaposition some of which may have been, under certain conditions, easily penetrable by solutions and others comparatively unaffected. Selective assimilation of materials from the solutions may give rise to similar results in different parts of the same bed and the products may even be divided by a sharp ^{plane (4)} ~~line~~. The relatively

(4) W. H. Emmons: Principles of Economic Geology: page 226:

small quantity of Iron in the epidote rock, estimated from its mineral composition, would seem to preclude the possibility of its having ^{been} formed from the andesite which ^{is} high in Iron. Assuming the epidote to be metamorphosed limestone, the vesicles are easily accounted for by the escape of carbon dioxide. Similarly the andradite garnet, which is high in lime, relatively to the andesite,

is more easily explained as a metamorphosed limestone than altered andesite. The Pyroxene, however, may possibly have resulted from either by addition of material from the solutions. If the veinlets of Calcite, parallel to the Pyroxene crystals, are considered residual, the rock is metamorphosed limestone; if regarded as introduced either possibility remains. The solid contact of the pyroxene and Garnet is one such as would be expected if a thin limestone bed between two bands of andesite were folded together, the high pressure produced locally by the folding, having caused flowage in the limestone, mineralization following and finding no obstructions such as gouge. ^{The impure nature of} The contacts of the Pyroxene ^{bands}, on the other hand, may have originated by two beds of andesite slipping slightly during the process of folding and ^{by} subsequent metamorphism giving rise to the pyroxene, but failing to sufficiently alter the gouge. No residual minerals, such as apatite, characteristic of the volcanics, were found in the pyroxene.

Propylitization of the andesite probably commenced with the development of fractures, which acted as solution channels, and was evidently accompanied and followed by silicification nearer the intrusive, or ^{nearer} channels more directly connected with it. The Iron bearing minerals were in such cases altered to chlorite and Pyrite. No silicification was noticed away from well defined channels.

The fault and its accompanying fold were formed by the advance of the intrusive, as evidenced, first, by the fact that the solutions exuded by it followed the structure mineralizing the adjacent rocks, and secondly, by the absence of fractures and the negligible development of cataclastic effects in the metamorphosed rocks.

The fold and its fault are considered as genetically connected, as revealed by the ^{drag}relations brought out in the diagram. The garnet, epidote, and pyroxene must, therefore, have been formed between the time of formation of the fold and the crystallization of the diorite. Quartz is among the latest of the gangue minerals, ~~probably~~ a product, therefore, of a more advanced stage of mineralization.

The presence of pyrite as a probable alteration product in the volcanics would suggest that some of the pyrite associated with the pyroxene is due to the alteration of the iron bearing minerals, and preceded the expulsion of the materials from the intrusive giving rise to the metalliferous deposits.

In the alteration of the rocks forming the anticlinal fold there are two possible courses that may have been followed by the solutions. First, they may have travelled along the axial plane of the fold and permeated the beds outward, or secondly, they may have followed the fault plane, each bed tapping this source. In the first case the process would be one of selective absorption due to chemical affinity rather than the alteration of beds of different composition; whereas in the second case, the latter explanation would seem to be more plausible. The first theory is a possible explanation but does not appear to lend itself as readily to the available evidence as does the second. It is doubtful that solutions from the fold would penetrate the fault gouge and mineralize the rock beyond since gouge is so often found to be impermeable to solutions. The silicification of the hanging wall of the fault may then be considered as an indication that the fault was a solution channel. The hypothesis which most easily explains the alteration of the foot wall postulates a genetic connection with these solutions.

It seems inadvisable ,therefore, to place a great deal of emphasis upon the influence on the surrounding rocks of the solutions which travelled along the axial zone of the fold, On the other hand, the leached nature of the central member of the fold,now merely a black porous residue,indicates that some solutions actually have made use of that channel, but the absence of siliceous matter suggests that the solutions were posterior to the formation of the minerals of the fold.

Considering then,that the fault and the folding took place prior to the advance of the intrusive to its present position relative to the deposit, and therefore, prior also to the contact metamorphic minerals of the fold, the conclusion follows that the formation of the pyroxene did not take place in the zone of rock flowage, since the limestone which had not flowed would certainly have done so at such a depth. It is interesting to know that Keyes believes⁽⁵⁾

(5)- - Keyes: Economic Geology : Vol IV: page 365. Garnet Contact Deposits.

that the heavy anhydrous minerals formed well above the zone of rock flowage at the "San Pedro " copper deposits and neighbouring localities.

ECONOMIC GEOLOGY.

Workings.

The workings consist of

two prospect adits, one driven on the ore lead and the other parallel to it. The former divides immediately inside the portal, one branch striking S.5° E., for a distance of forty five feet,the latter strike N.75° E., for a distance of thirty feet; a winze is sunk near the end of this but was filled with water.The second adit is about 50 feet north of the first and runs parallel to the apparent strike of the ore lead.

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It follows the fault, strike due E., for a distance of one hundred feet, then crosscuts and picks up the ore following it for some 25 feet. A winze was sunk here also, but yielded nothing upon examination. An ore dump of a few tons of almost solid sulphide gave an idea of the material extracted.

MINERALOGY: The ore consists of massive pyrrhotite and pyrite mixed with some chalcopyrite and gangue; veins consisting of Chalcopyrite and pyrite and veins of pure pyrite cut the pyrrhotite. The gangue consists almost wholly of metamorphosed country rock - pyroxene - altering to chlorite, associated with quartz and a little calcite; epidote was not found in the ore although associated with it. The sulphides form over 75% of the mass.

Pyrrhotite is the most abundant sulphide; it occurs in massive form replacing the contact rock and is itself cut and replaced by the other sulphides.

Pyrite is found in considerable quantities usually mixed with some chalcopyrite; it is both massive and granular often associated with quartz as a gangue; in such cases it commonly forms small cubes.

is the chief
Chalcopyrite, *is the chief* ore mineral of the district, but is not found in large quantities on the Rainy Day prospect. It occurs in small veins associated with pyrite irregularly cutting the pyrrhotite. Assay results ~~furnished~~ (by the owner) are stated to have occasionally run quite high in copper, but to have averaged about 1%; the sulphur content ran about 30%.

Except for a surface coating of limonite and a little copper carbonate the ores are unoxidized. It is possible that they were at one time enriched by supergene action but the immense amount of erosion which has taken place subsequent to mineralization has removed all trace of it. In any case the extent of secondary enrichment would have been small as is usual in ores so abundant in pyrrhotite.

PARAGENESIS: Specimens of the ore were polished and studied under the metallographic microscope; it was found that the earliest of the ore minerals introduced was pyrrhotite, which replaced most of the contact rock that it penetrated leaving small irregular masses of gangue as inclusions. Pyrite followed the pyrrhotite ^{and cuts it} replacing the gangue inclusions from the margins inward. This process can be seen in various stages (Figs: 6 & 7). No evidence was found to indicate that up to this time any chalcopyrite had been introduced, but following the impregnation by pyrite and, perhaps, during it some of the ore ^{minerals} were subjected to stresses. These stresses caused the pyrrhotite to flow (Fig: 8) and the pyrite ^{veinlets} to fracture, resulting in the pyrrhotite flowing between and around the pyrite grains as though introduced later (Fig: 8 & 9). The gangue displays, with the pyrrhotite, typical flow structure apparently being of approximately the same hardness. Accompanying the stresses there was an introduction of chalcopyrite, which was forced to follow the direction of minimum resistance, namely, the courses occupied by the fractured pyrite; accordingly chalcopyrite was invariably associated with pyrite. No persistent veins of chalcopyrite were noticed and none was found associated

with unfractured pyrite, which goes to prove that the chalcopyrite was, for the most part, later than the pyrite and also later than the commencement of the period of stress which fractured the pyrite.

CLASSIFICATION AND CONCLUSIONS: Deposits of this nature have been classified elsewhere as contact metamorphic deposits and are of common occurrence. The Rainy Day may be considered as a typical example and inference relating to it may be governed, to some extent, by the observations made on similar deposits in other districts. The extreme irregularity of the boundaries of the mineralized areas is an outstanding feature of the deposit. It is difficult therefore, if not impossible, to estimate the size with any degree of accuracy, but available information indicates that it is similar in dimensions to other deposits in the district, none of which have justified operations on a large scale under present conditions.

Kemp states ⁽⁶⁾ that the emissions from the inner part of an outwardly

(6) J.F.Kemp: Economic Geology: Vol : VIII : 1913: page 597.

chilled intrusive, favour local channels rather than the general emergence. It may be assumed, therefore, that the Rainy Day and a few other prospects located along the same dyke form only a portion of the mineralized area. With this principle in mind it is quite possible that if the deposits of the district were exploited as a whole in order to bring the cost of operation down to a minimum, that they might be worked to yield a suitable return. The owner expresses the intention of utilising the sulphides as an ore of sulphur, but it is doubtful that ores so high in pyrrhotite could compete for this purpose with the higher grade products of pure pyrite now on the market.

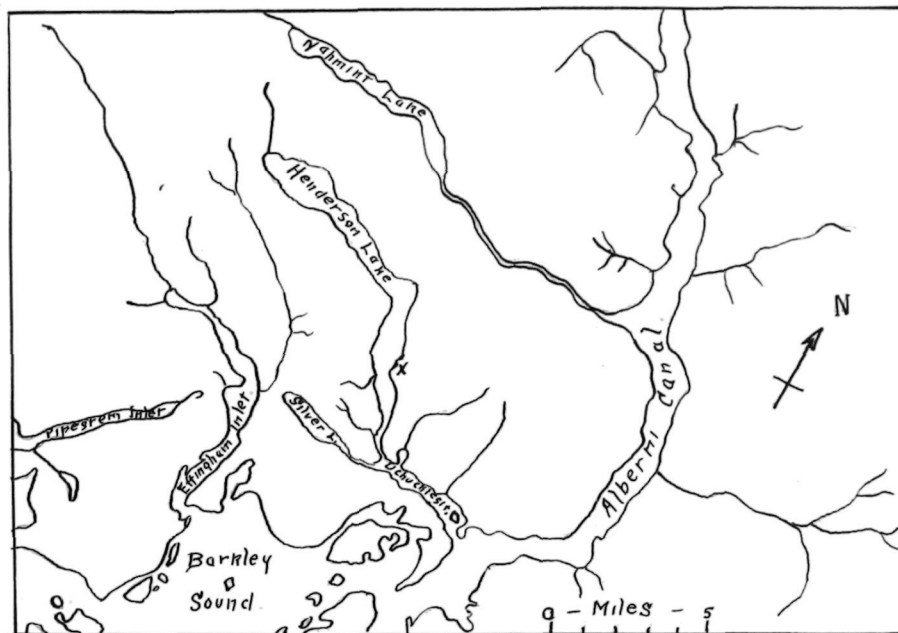


Fig: 1. Regional map of Henderson Lake.

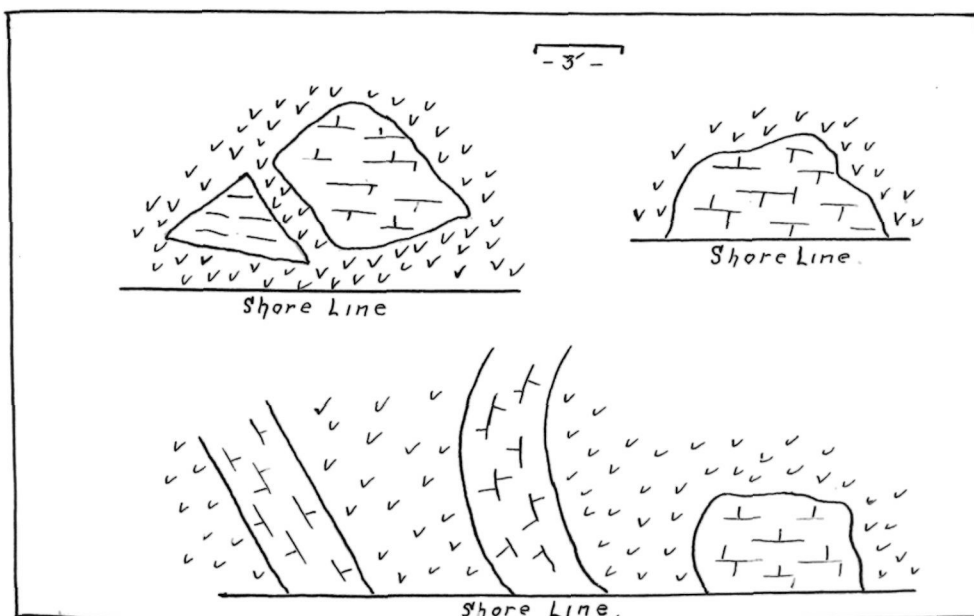


Fig:2. Showing the structure of the limestone and andesite as exposed on the shores of Henderson Lake near the diorite intrusive.

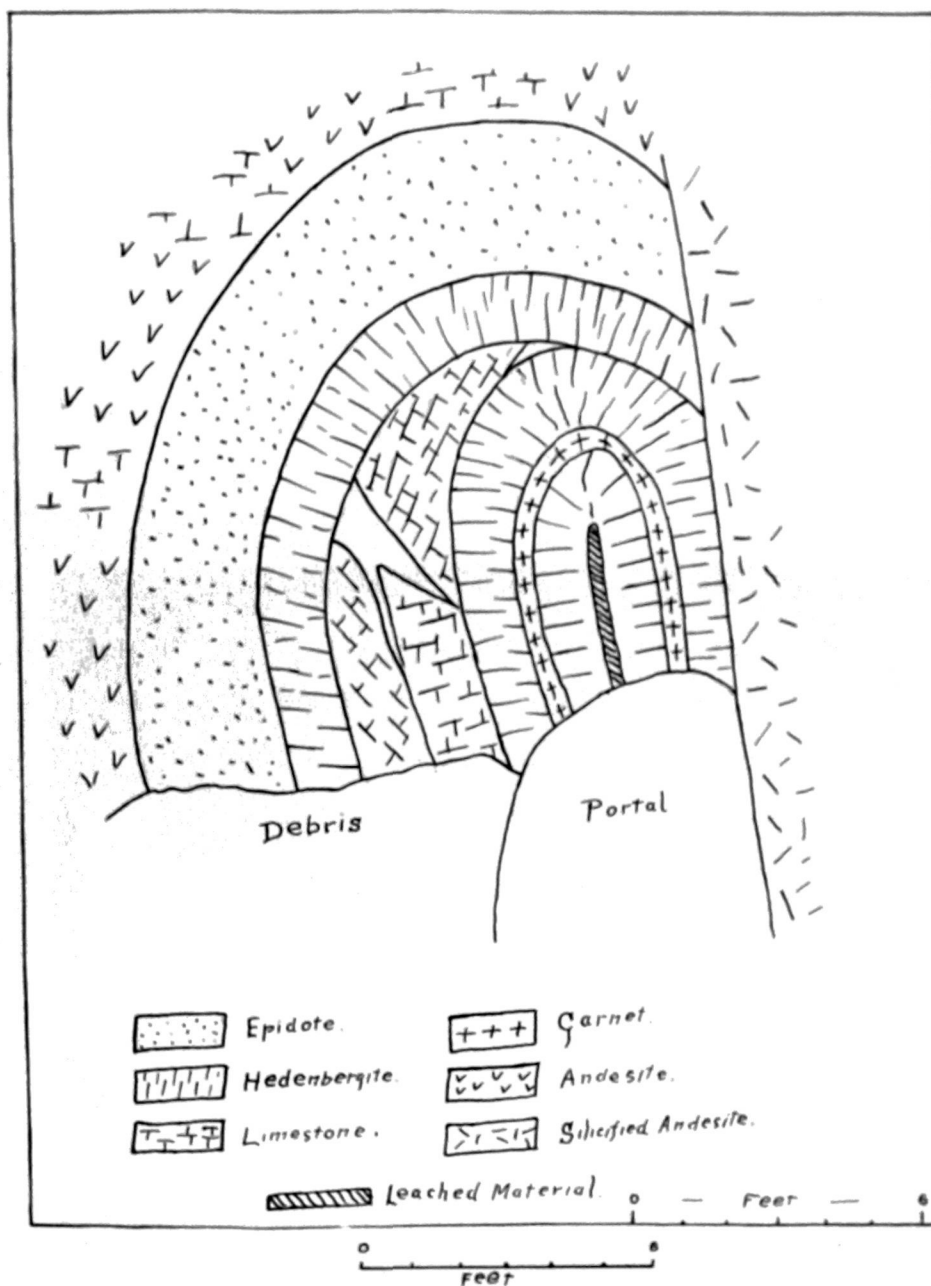


Fig: 3. Anticlinal Fold. (Elevation)

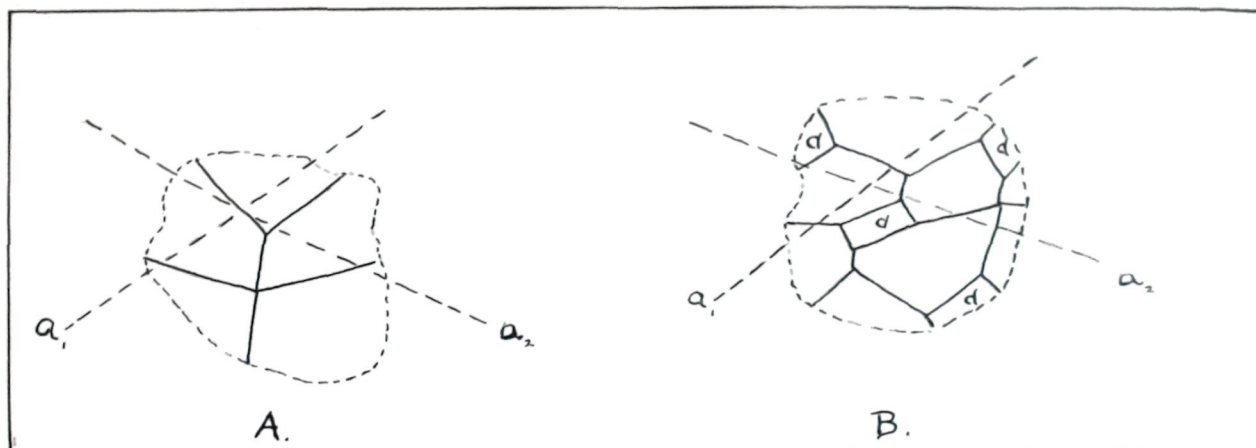


Fig : 4. Crystallization in the garnet. A. Trapezohedron.
B. Trapezohedron and Dodecahedron.

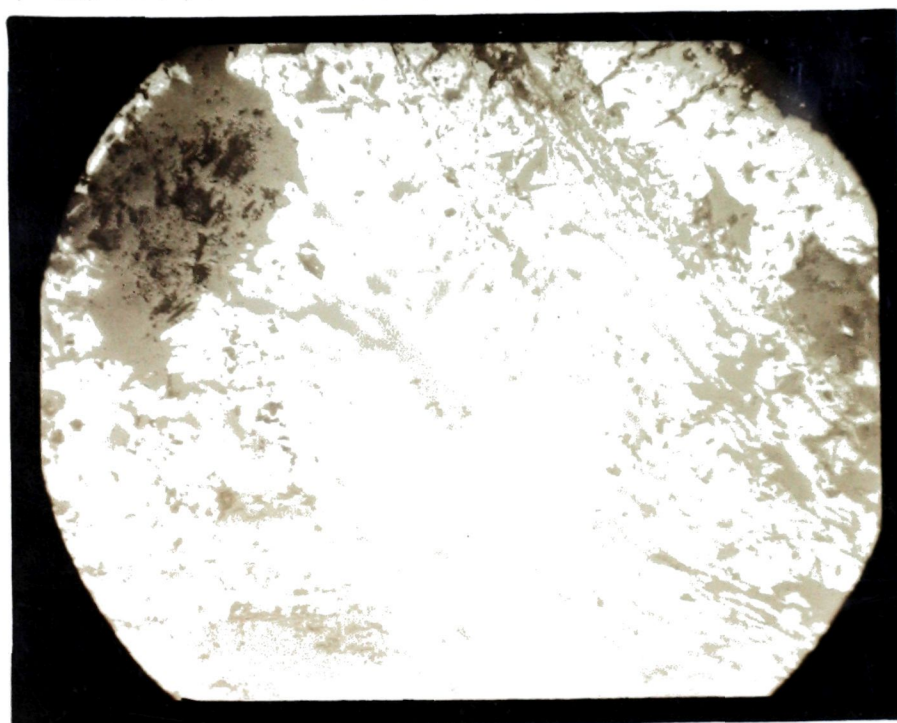


Fig : 5 ; Flow structure in the pyrrhotite. X 100

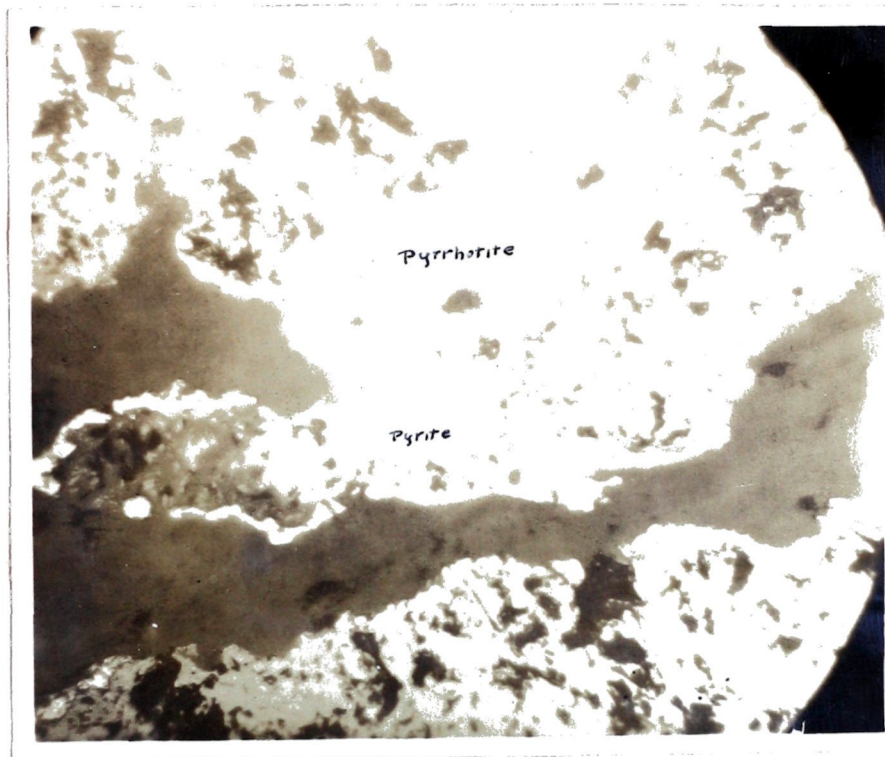


Fig 6 : Pyrite replacing gangue along the contact with pyrrhotite. The initial stage. X 60

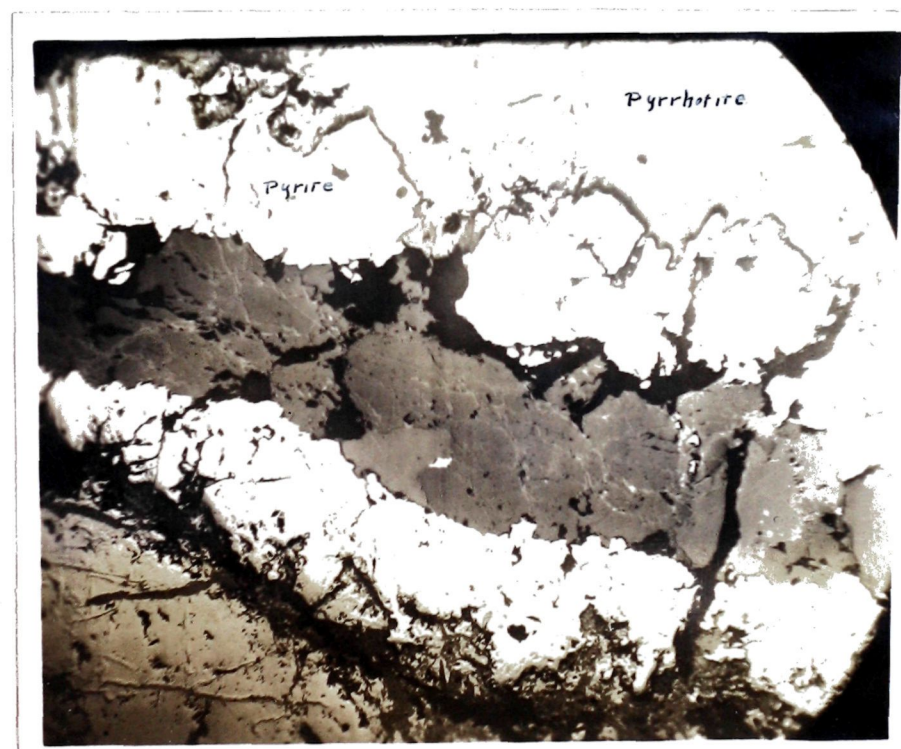


Fig 7 : The same process shown in Fig 5, more advanced. X 100

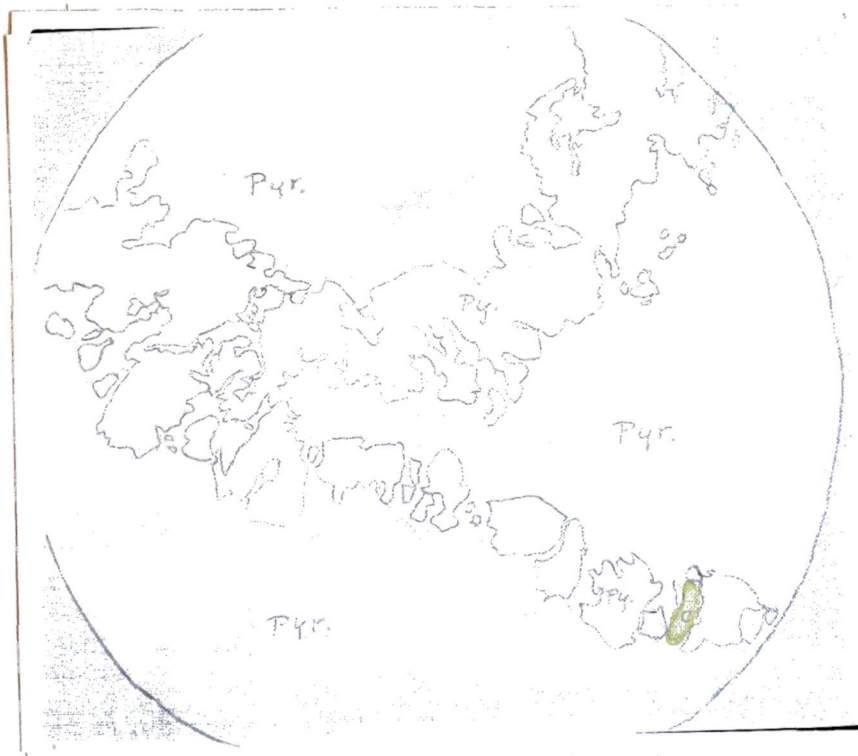


Fig 8: Photomicrograph showing pyrrhotite (earlier) flowing around fractured pyrite. Chalcopyrite is colored yellow. x100



Fig 9 : Another occurrence of the same phenomena shown in Fig 7 after the introduction of chalcopyrite (yellow). (Figs. 5 to 8 form a suite.) x100

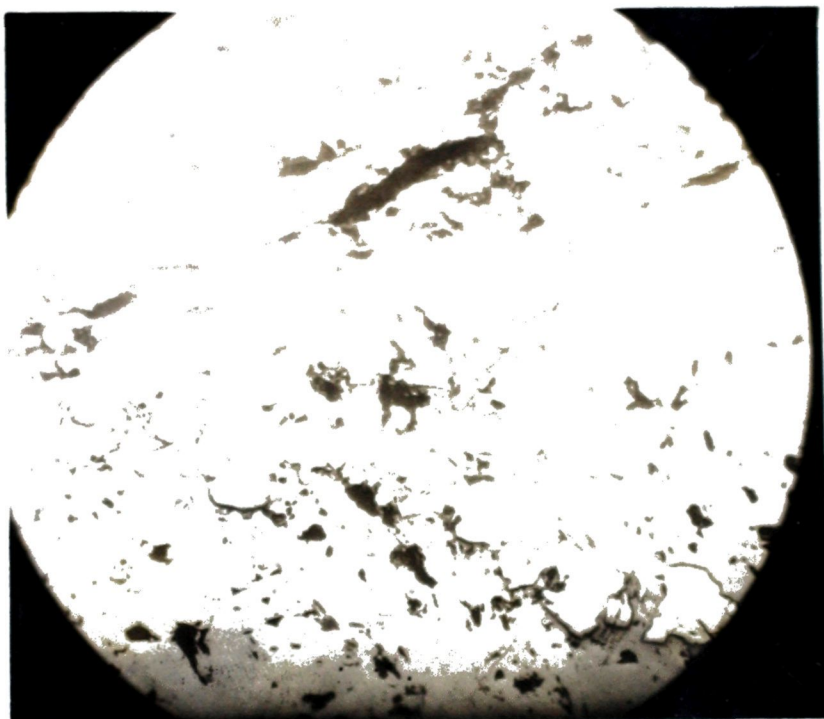


Fig. 8: Photomicrograph showing pyrrhotite (earlier) flowing around fractured pyrite. Chalcocite is colored yellow. X100

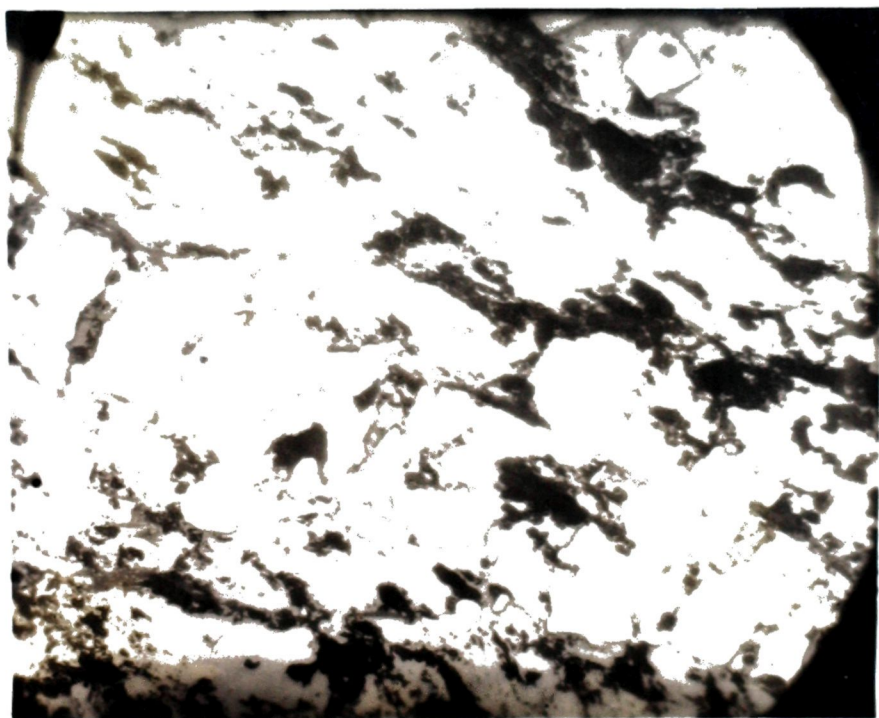


Fig 9 : Another occurrence of the same phenomena shown in Fig 7 after the introduction of chalcocite (yellow). (Figs. 5 to 3 form a suite.) X100