THE GEOLOGY OF LAKE FORTUNE MINE

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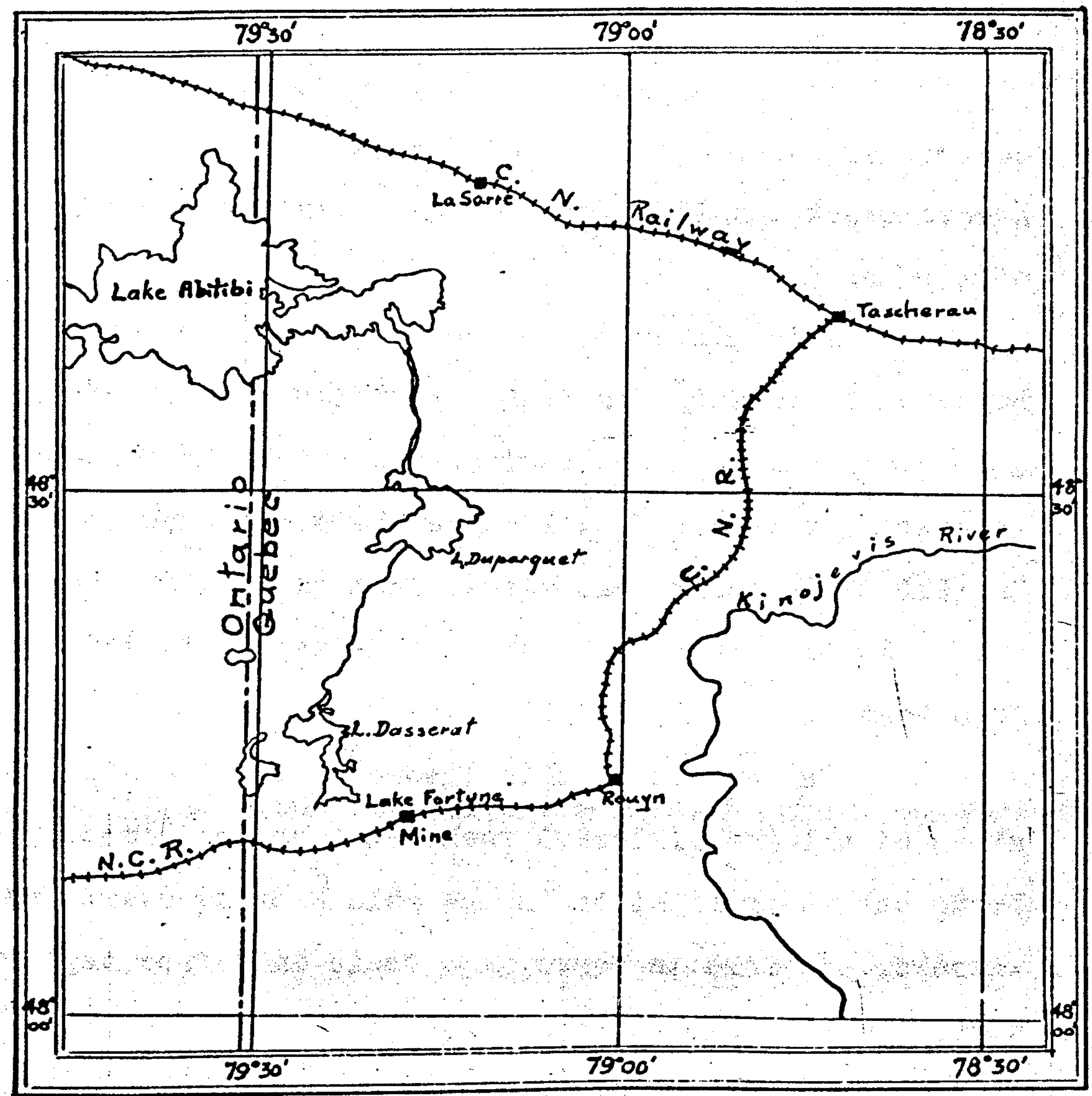
INTRODUCTION

The Lake Fortune Mine is situated in the southwest quarter of Boischatel township in the Province of Quebec. A more exact location is given by a key map shown on the next page.

This property was the first to be located in Boischatel township for mining purposes as early as 1907. Three years later a small steam-electric plant was installed to drive a four-stamp mill and a shaft was sunk to 150 feet. In 1911 the property was closed down until 1923 when another shaft was sunk on a small high-grade vein. In 1927 about 5000 feet of diamond drilling was done.

The object of this thesis is to make a petrographic study of all the different rock types on the property and to bring out their relation to the gold bearing quartz veins wherever possible to serve as a basis in future exploration work.

The writer wishes to express his appreciation to Messrs. Alderson and MacKay for the permission to use all available data on the property such as maps, drill core records, etc., and also to Dr. Winchell for his suggestions and advice in the preparation of this thesis.



Plan showing location of

Lake Fortune Mine.

GENERAL GEOLOGY

The geological sequence of events given in the table below is not based entirely on information obtained within the small area under investigation, but the structural relations of the district as a whole have been taken into consideration.

Table of Formations

Quaternary	(Post-glacial clays and gravel)
Upper Huronian	(Cobalt sediments)
	Unconformity
Pre-Cobalt	(Olivine lamprophyre ? (Quartz veins (Tourmaliniferous, quartz-feldspar porphyry (Feldspar porphyry (Titanite feldspar porphyry (Quartz diorite
	Folding -- Unconformity
Keewatin	(Volcanic agglomerate (Andesite (Auganite

STRUCTURE

The Keewatin lavas which are represented here as volcanic agglomerate, auganite, and andesite are highly folded and dip steeply to the north. The exact dip could not be determined definitely since the area has been subjected to intense regional metamorphism which has almost completely obliterated the flow contacts. According to the "Summary Report of 1922, Part D"[1] of the Canadian Geological Survey, which describes the general structure of the region, these flows form a part of the south limb of an overturned syncline. There was not sufficient evidence within the small area under investigation to confirm this conclusion.

The folding has set up great stresses which produced large faults. They are quite conspicuous on the surface since the movements along such planes of weakness have produced shear zones which attain 200 feet in width in some cases. The direction of the horizontal movement is indicated by numerous minor drag folds within the shear zones. The north side of the different faults has moved eastward relative to the south side. The direction of the vertical movement as indicated by its relation to folding is such that the north side of the different faults has moved upward relative to the south side.

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1. Cooke, H.C., Opasatika Map-Area, Timiskaming County, Quebec, pp. 19-74.

The strike of these faults varies from due west to N. 60° W. and the dip ranges from 40° to 80° N. No evidence could be found on the surface or by diamond drilling by which the actual amount of displacement could be determined.

This period of folding and faulting was followed by a series of intrusive dykes of quartzdiorite, porphyries, and lamprophyre. Some of these dykes, which intersect the faulted and sheared zones, are equally sheared and highly altered; yet it has not been possible to determine any noticeable displacement. The conclusion reached here is that the major fault movements had almost ceased at the time of the intrusion, but that minor adjustments continued throughout that time, and even after the intrusion of the dykes, which produced shearing, but not any appreciable displacement. Also, much of the alteration of the dykes within the shear zone may be attributed to the action of hydrothermal solutions, so that very little shearing movement was necessary to produce this mineralogical change.

The quartz veins and quartz-carbonate veins, which were formed as a later phase of the porphyry intrusions, occur within the shear zones or in fractured zones. These veins have been subjected to a later movement which produced fractures and provided openings for the infiltration of the gold-bearing solutions. The amount of fracturing produced in the veins has to some extent a direct bearing on the gold content of the veins. They vary in width from mere stringers a fraction of an inch to ten feet wide. Drilling has indicated that the veins rake to the east.

After this period of intrusion there followed a long period of denudation and then a period of submergence during which the Cobalt sediments were laid down. Later the area was again uplifted, and the sediments are now exposed on the surface. A conspicuous unconformity exists where the nearly horizontal almost unaltered sediments rest on highly altered, steeply inclined lava flows. This unconformity is exposed at the foot of Swinging Hills, about three miles west of this area.

A block diagram of the entire property is shown on the following page. It is intended to represent the structure as nearly as possible from the data obtained by diamond drilling.

PETROGRAPHY

The following chapter contains a petrographic description of the different rock types. Some of the rocks show a considerable amount of alteration when examined in thin sections, but in most cases they contain enough of their original mineral constituents to classify them. They are described in their order of formation beginning with the Keewatin volcanics.

Auganite

Slide No. 28 - Station 49 + 100' + 100' W

Slide No. 46 - Station 61 + 100'

A hand specimen of this rock does not differ materially from one described below as andesite. Microscopically it differs a gread deal. The rock consists of small lath-like crystals of partly altered feldspar which give the rock an ophitic appearance. The feldspar was found to be more basic than that in andesite. Its composition, as obtained by measuring equal extinction angles and comparing its index with that of quartz, was found to be intermediate between andesine and labradorite or $Ab_{50}An_{50}$. The groundmass consists of chlorite, calcite, and epidote with a small amount of secondary quartz. The rock has been slightly fractured and the fractures filled with carbonate.

Andesite

Slide No. 12 - Station 2 + 20'

This rock consists of small subhedral crystals of feldspar embedded in a hypocrystalline to glassy ground mass. Some of the larger feldspar grains are orthoclase and are characterized by Baveno twinning. Most of the feldspar is acid plagioclase and approaches the properties of andesine, $Ab_{55}An_{45}$. The extinction angle measured from the optic plane to 001 cleavage in a section ⊥ to Z is 14°. Much of the feldspar is altered. Any ferric minerals originally present in the rock have been completely altered to chlorite. There is also a large amount of carbonate present, mostly calcite. The amount of carbonate present appears to be considerably more than what could possible result from the breaking down of lime-bearing minerals. It seems therefore logical to conclude that a large part of the calcite has been introduced. There is also some fine granular quartz present which is possibly residual. Pyrite is irregularly and sparcely disseminated throughout the rock.

Slide No. 25 - Station 32 - 100' + 70' E.

This sample is similar to No. 12, but considerably more altered. It was obtained from about the centre of the shear zone. The constituent minerals are quartz, calcite, chlorite, sericite, and pyrite. The feldspars are almost completely destroyed.

Slide No. 26 - Station 31 - 165' + 10' W.

Sample No. 26 was obtained from Keewatin flows near the quartzdiorite contact. It is altered even more than sample No. 25. The feldspars are altered beyond recognition. The main constituents are chlorite and calcite with minor amounts of epidote, zoisite, quartz and small clusters of nearly opaque material possibly produced by the separation of iron from some of the basic constituents.

The last two slides illustrate the futility in attempting to classify a rock when hardly any of the original constituents remain. In sample No. 12 there are sufficient remnants of the original minerals to determine the rock with some degree of certainty. However, in the two latter samples it is only a faint outline of the original texture that in some respects resembles slide No. 12.

Volcanic Agglomerate

Slides No. 49 and 50. Station 63 + 100'.

An outcrop of this type of rock occurs near the northwest shore of Renault Lake. A narrow strip about 75 feet wide and exposed for 300 feet in length may be seen on the side of a hill.

The included fragments are rounded and angular. They consist of quartz, granite and lavas ranging in size from minute fragments to pebbles three inches in diameter. They give the rock the general appearance of a conglomerate, yet the pebbles are not assorted in any way to determine top or bottom. Furthermore this agglomerate lenses out sharply to the east between two lava flows.

Examination of the groundmass in thin sections shows considerable alteration. The resulting minerals are chlorite, epidote, sericite, calcite, and quartz. The texture and general appearance of the groundmass under the microscope very strongly suggests a volcanic origin of the material.

Quartz Diorite

Slide No. 17 - Station 14 + 10' + 40' W.

Slide No. 44 - Drill Hole No. 12 at 100'

This rock is considerably altered near the surface and along the contact with the Keewatin lavas. Samples were taken from a drill core 100 feet below the surface and about 100 feet from the contact which show still some remnants of the original mineral constituents.

The texture of the rock is granitic. The mineral particles are holocrystalline and medium grained. They show a slight amount of interpenetration.

The chief constituents are feldspar and hornblende with a small amount of quartz.

The feldspar is almost completely altered into a mass of saussurite consisting mainly of epidote and zoisite. A few of the grains are comparatively unaltered so that the twinning bands can still be recognized. As nearly as could be determined by means of measuring equal extinction angles and comparing the index of refraction with that of quartz, the feldspar was found to be andesine, $Ab_{55}An_{45}$. There was also a small amount of orthoclase noted. The amount of quartz present is estimated to be about 5 to 10%.

The amphibole in this rock consists of a pale green, strongly pleochroic variety of hornblende. The maximum extinction angle was found to be 23°. The hornblende is partly altered to chlorite.

In slide No. 17 a mineral was noted which consists of an intergrowth of vermicular quartz and plagioclase feldspar which was determined to be oligoclase. It was first described by Sederholm[1] several years ago, who called this peculiar intergrowth of the two minerals myrmekite. Sederholm found this to be a product of recrystallization from potash feldspar, and it is generally believed to be secondary. Some of the other alteration products noted are small amounts of calcite and sericite.

The accessory minerals are ilmenite, magnetite, and pyrrhotite. Ilmenite has been partly altered to leucoxene.

Porphyries

There are three distinctly different kinds of porphyry on this property. They are possibly derived from the same

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1. Sederholm, J.J., On Synantetic Minerals and Related Phenomena, Bulletin No. 48, De La Commission Geologique De Finlande, 1916.

reservoir but have been brought into their present position at different time intervals. It has not been possible to disclose any structural evidence in the field which would prove their relative age; however, it was possible to reach some conclusion by means of texture, acidity, and accessory minerals as to the possible order in which they have been intruded. Wherever these dykes cut across the main shear zone they are very much altered and sheared, even the youngest of the three, but there is no apparent displacement of the dykes. Nevertheless the shearing of the dykes would indicate that they were intruded before or during the period of shearing. They are described below in the order in which they are believed to have formed.

Slides No. 52 - Station 42 + 100' + 100' E.

1. <u>Titanite Feldspar Porphyry</u> occurs at 100 feet NE of Station 42. Here a dyke 30' wide striking N 86° E cuts across quartz diorite. A similar smaller dyke has also been cut in drill hole No. 12 at 286 feet below the surface.

Microscopically this porphyry consists chiefly of euhedral albite phenocrysts having an average diameter of 1/8 inch. Scattered throughout the rock are larger phenocrysts of microcline which have an average diameter of 1/2 inch. The feldspar phenocrysts are comparatively unaltered except for the development of minute specks of sericite. The groundmass consists of fine grained albite and biotite with a very small amount of quartz.

Some of the large feldspar crystals have been broken and fractured, and the minute seams have been sealed up by later quartz. There are also isolated clusters of small grains of quartz throughout the ground mass which form a mosaic pattern; this also appears to be later quartz. Some of the biotite has been altered to chlorite. The optic angle of biotite is very near 0°, and the birefringence is extremely high. It is therefore high in iron and possibly contains some titanium.

The accessory minerals consist of a considerable amount of titanite which occurs as inclusions in albite phenocrysts and is still more plentiful in microcline; it constitutes also part of the groundmass. There are also minute needles in the groundmass which have very high relief and resemble rutile.

Pyrite is also a common constituent of the groundmass but has been introduced later.

Slide No. 51 - Station 58 + 75' W

2. Feldspar Porphyry occurs as two large dykes up to 40 feet wide which cut across the main shear zone. They are very much altered where they intersect this zone, even for a considerable distance away from it. Several smaller dykes of similar porphyry have also been intersected by drill holes. They are possibly apophyses from the larger dykes.

Microscopically the rock is composed chiefly of euhedral albite phenocrysts, $Ab_{100}An_{0}$, which are quite uniform in size and average about 1/8 inch in diameter. They are only slightly altered and show the development of minute shreds of sericite. The groundmass consists of fine grained albite, quartz, chlorite, sericite, and calcite. Some of the quartz is secondary. The rock also shows fracturing. Some of the minute fractures have been filled by later quartz and calcite while others are filled by sericite.

Slide No. 6 - Station 78 + 80' + 20' E.

3. <u>Tourmaliniferous Quartz-Feldspar Porphyry</u> occurs along the south shore of Lake Fortune; there are several small dykes which have an average width of five feet. The texture is much finer than in the other two types. It also contains considerably more primary quartz.

Microscopically the rock consists of subhedral phenocrysts of albite, anorthoclase (Ab,Or), and quartz. The albite crystals average about 1/16 inch in diameter but occasionally they are up to 1/4 inch in size. The anorthoclase crystals are about 1/4 inch in diameter and contain inclusions of much smaller crystals of albite oriented in all positions; in some grains the smaller albite crystals are oriented at right angles to each other producing an interwoven texture within the large phenocryst. The quartz phenocrysts average about 1/16 inch in diameter. Frequently they contain small inclusions of albite.

The groundmass consists of very fine grained feldspar and quartz with considerable calcite, sericite, and a small amount of chlorite. Sericite is particularly well developed around the anorthoclase partly digesting the edges of the crystals.

In addition to the above mentioned minerals, there is an appreciable amount of a blueish-black variety of tourmaline present. The tourmaline crystals are a little larger than the average grains of the groundmass so that they stand out quite prominently. They are scattered throughout the entire groundmass, but are concentrated more around phenocrysts and along minute fractures, which have served as channels for the hydrothermal solutions. It appears as if tourmaline has been an original constituent of the dykes as it was found to be present in four different dykes as much as 1000 feet apart. Since it was one of the last constituents to crystallize, it was deposited in any openings and fractures it could find in the dykes. Some of the vapours and solutions may have continued to emanate from the magma even after the dykes had solidified, so that any slight fracturing in the dykes would have provided additional space for these solutions. Consequently we find some dykes to contain considerably more tourmaline than others.

Slide No. 8 - Station 67 - 120' + 80' W.

This dyke is identically the same as described in No. 6 except that the development of sericite is much more marked, and tourmaline is also present but in smaller amounts.

Slide No. 43 - Station 79 + 80' W.

This sample is from another dyke of the same type. It is very similar to 6 and 8 in texture, mineral composition, and degree of alteration, but the amount of tourmaline present is even less than in the dykes described above.

Slide No. 45 - Station 66 + 60'.

This dyke occurs at the southeast shore of Lake Fortune and forms the hanging wall of a narrow, high-grade, gold bearing quartz-carbonate vein. It is identically the same type of porphyry as described under 6, 8, and 43, except that it is much more altered.

The feldspars in this dyke are almost completely altered to sericite. There is also a small amount of chlorite present. Even the tourmaline shows signs of alteration, its pleochroism is not as strong as the tourmaline in the less altered dykes. This would indicate that the tourmaline was present in the dyke before the hydrothermal vein solutions started the process of altering the wall rocks. Or, if tourmaline is considered a precipitate from the vein solutions, it must have been precipitated at a very early stage.

Quartz is practically the only unaltered constituent, and it is by means of the quartz and the general faint outline of the original texture that this rock could be recognized as being of the same type as 6, 8, and 43, since the quartz grains are of the same size, shape, and distribution. They also have the same characteristic inclusions as the quartz grains in the other dykes.

Olivine Lamprophyre

Slide No. 20 - Station 63 - 50' + 20' W.

Slide No. 20a - Drill Hole No. 2.

These dykes are only a few inches wide but persist for a considerable distance along the strike. One dyke follows the main shear zone on the surface but it intersects this zone along the dip. This dyke has a dip of 70°N. Within the shearing the dyke is altered almost beyond recognition, but below the shearing some of the original minerals can still be recognized. A similar dyke strikes almost at right angles to the one just described and has a vertical dip. It cuts across the Keewatin lavas, agglomerate, and also across the feldspar porphyry. This dyke is only about four inches wide. It has not been possible to determine whether these dykes are later than the quartz veins, but since similar dykes have been found to cut gold-bearing quartz veins elsewhere in this mineral belt, it is assumed that the same age relation exists here.[1]

Microscopically the rock consists of skeletons of olivine crystals which constitute about half of the rock. These crystals, although they are completely altered to Ca - Mg carbonate and magnetite, still retain their original shape; they still show the fractured surface characteristic of olivine. The magnetite forms a cluster of minute crystals around the border of each olivine crystal; it also fills the fractures within the crystals. There is also considerable magnetite throughout the groundmass. The groundmass itself is composed of a large amount of small flakes of biotite mica which have been partly altered to chlorite. There is also a small amount of carbonate present in the groundmass and a few grains of quartz.

Where this dyke intersects the shear zone, it is completely altered to chlorite, carbonates and quartz. Scattered throughout the altered mass are clusters of minute needles of rutile which are not present in the less altered rock. The olivine skeletons are completely destroyed. Most of the magnetite has also been removed.

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1. Spurr, J. E., Basic Dyke Injections in Magmatic Vein Sequences, Bulletin of the Geological Society of America, Vol 36, 1924, pp 545 - 582.

Cobalt Conglomerate

Slide No. 48 - Sample from southwest corner of property.

This rock consists of a matrix of quartz, feldspar, and chlorite. The grains vary in size from the average size of sand grains to minute almost isotropic material. The feldspar grains are considerably larger than the quartz grains and are of many varieties. They show practically no alteration.

Macroscopically the size of the inclusions vary enormously from small pebbles to large boulders. Some are well rounded and water worn while others are angular, brecciated fragments. The pebbles and boulders consist of almost every variety of rocks known to exist in the district.

Alterations of Wall Rock

The walls of the veins and fissures have been subjected to intense hydrothermal alteration. This alteration is definitely later than the tourmaliniferous porphyry intrusion as is shown by the large amount of alteration suffered by one of these dykes, which forms the hanging wall of a high-grade vein about 50 feet north of station 66. The amount of alteration is much more intense immediately adjoining the veins than it is 10 or 20 feet away from them, indicating that the vein fissures have served as channels for the solutions which produced the alteration of the wall rock.

These solutions were high in lime, magnesia, potash, and carbon dioxide, since the chief minerals of the resulting rock are calcite, magnesiodolomite, and white mica or sericite. Some of the mica has a peculiar green color which is best noted in a hand specimen. The maximum index of refraction of this mica was found to be 1.60; it is probably the variety known as fuchsite, a chromium mica. There has been also a slight amount of silicification or addition of silica. This may be observed by borders of quartz around original quartz grains which have different extinction, also by a fine granular quartz filling minute fractures in the wall rock. There is also a mineral present with high relief and extremely high birefringence. It is uniaxial and negative; it is usually accompanied by some limonite, which appears to result from its alteration. These properties correspond very closely with those of siderite, although siderite is not common here and has not been observed in any other section. The sample containing this mineral was obtained from the foot wall of the high-grade vein near station 66.

From the above description it is evident that the chief processes active in the alteration of the wall rocks have been scricitization and carbonation with a minor amount of silicification.

ECONOMIC GEOLOGY

The only mineral of economic importance found on this property at the present time is gold. It occurs in the free state in quartz-carbonate veins; it is found to be associated with pyrite and it occurs also in chemical combination with tellurium as gold-silver tellurides.

In the following pages an attempt will be made to determine something about the history of the gold-bearing veins. Their relation to the igneous intrusives and the structural conditions favourable for the formation of the gold-bearing veins; also the paragenesis will be discussed in detail in the following pages.

Relation of Porphyry Dykes and Quartz Veins

As mentioned previously, there have been three distinctly separate periods of intrusion of porphyry dykes. The first and oldest of the three is the titanite - feldspar porphyry. The next intrusion was a slightly more acid type of feldspar porphyry which is not characterized by any typical accessory minerals as the other two types are. The third type of intrusion is a fine-grained, tourmaliniferous, quartz-feldspar porphyry. Each successive type of porphyry increases in acidity as observed in thin sections. This was confirmed by a Rosiwal analysis which shows the first type of porphyry to contain 5.2%, the next type 18.5%, and the quartz-feldspar porphyry contains 33% of free quartz by volume. Thus the magma residue has become extremely high in silica. This siliceous residue is now expelled into any opening that it may find, such as fractures, joints, fissures, and faulted or sheared zones. The filling of these openings constitutes the main vein forming period. These veins are found to cut across all of the porphyries. Some of these openings or planes of weakness existed since the time of folding and faulting. Along these planes of weakness we find the largest and commercial veins; they are up to ten feet in width, while the fractures and openings produced during the intrusive period usually contain short and narrow veins; often such fractures are confined to the porphyry dykes themselves and cut across them at all angles. The veins thus produced consist of comparatively barren, white quartz. Some of these veins were fractured later by further movements and the fractures filled by carbonates, quartz, and ore-bearing solutions. This process will be described in more detail in the following chapter.

Vein Types and Their Formation

The veins on this property may be divided into three classes:

1. Non-commercial veins.
2. Commercial veins.
3. Veins of later formation.

1. The non-commercial type of veins occurs usually in joints and fractures along which no other movement has taken place except that which produced the opening originally. Veins of this type are usually short and narrow. A few of these veins are also found along fault planes or shear zones. After their consolidation the walls of these veins have been subjected to slight movements which have produced a small amount of fracturing in the veins. These fractures have become filled with carbonates, tourmaline, sericite, and a small amount of sulphides of iron and copper. The constituents forming these minerals were carried into the fractures as highly aqueous solutions and vapours issuing from the magma reservoir below. That the solutions were extremely fluid is shown by the minute fractures which they penetrated; also by the fact that the tourmaline crystals have grown quite large and are unusually well developed. Since the amount of fracturing in this type of veins has been rather limited, the fractures were sealed up with the higher temperature minerals before the gold-bearing solutions could contribute much of their valuable metallic constituents. Consequently these veins contain low gold values and are not of a commercial type. As an example of one of these veins is the vein on which the No. 1 or the inclined shaft was sunk.

2. The commercial type of veins occurs along fault planes or shear zones. Since the movements along fault planes

are not uniform, but are much more intense at some points than at others, we find some veins much more fractured than others; some could even be described as crushed. These openings require considerably more time to become sealed up than the veins which are only slightly fractured. Also the movement may continue for a greater period of time at such points, continuously producing new openings. The minerals filling the openings in the veins are chiefly carbonates, sericite, quartz, and pyrite with minor amounts of tourmaline, chalcopyrite, tellurides, and gold. The tourmaline crystals in these veins are much smaller than they are in the veins described above, indicating a decrease of the tourmaline constituents in the solution or less fluidity or possibly also a reduction in temperature and pressure. This process of filling and cementing of the fractures in such veins extended over a considerable period of time, allowing for sufficient reduction in temperature to permit the precipitation of gold and the gold-bearing minerals; hence such veins carry gold values sufficiently high to make them commercially valuable. An example of this type of vein is the high grade vein on which No. 2 or the vertical shaft has been sunk.

3. The third type consists of veins which are seldom more than one half of an inch wide. Nevertheless this type contains a distinctly later phase of quartz, veinlets of which cut across commercial veins at all angles and also extend into

the wall rocks. The quartz is a barren, glassy-looking type, but frequently specks of free gold may be found in it. These veinlets are in themselves of no commercial value, but their occurrence in older veins is quite desirable as they help to contribute some of the gold values.

Source of the Gold-Bearing Solutions

The close and intimate association of tourmaline, sericite, pyrite, tellurides, and gold, as shown by a number of thin sections would indicate that they have a common source. It may be recalled that the youngest porphyry contains a considerable amount of tourmaline, and that tourmaline has been found in every section of this type of porphyry. Some of these samples have been taken from entirely separate dykes as much as 1000 feet apart. Considering the widespread occurrence and close association of tourmaline with this type of porphyry it seems logical to conclude that the tourmaline solutions have come up along the same channels and from the same magma from which these younger dykes have been derived. Or the tourmaline may have been an original constituent of the dykes which remained in solution until the dykes solidified and then crystallized out into any openings remaining in the dykes. Similarly the gold-bearing, tourmaliniferous quartz veins, which were formed shortly after these dykes, also contain a conspicuous amount of tourmaline in minute fractures in association with pyrite, sericite, gold, and tellurides.

The presence of tourmaline in these veins would indicate that magmatic emanations continued from the time of intrusion of the younger porphyry until the end of the period of vein formation. It seems logical to conclude that the tourmaline in the porphyry and that found in the veins has had a common source. Similarly, the close association of tourmaline and the auriferous sulphides, tellurides, and gold in minute fractures would indicate that the gold-bearing solutions have travelled along the same channels as the tourmaline and may be considered as of the same magmatic source.

The fact that none of the auriferous minerals was deposited in the porphyry along with the tourmaline and sericite may be explained on the basis of temperature, which was too high at that time for such minerals to precipitate. Later when the temperature was sufficiently low for their precipitation the openings in the porphyries had become sealed up, and since the dykes have not been subjected to as much fracturing as the quartz veins, the gold bearing solutions followed the path of least resistance into the veins. A more definite relation between the different minerals will be brought out in the next chapter on the paragenesis.

Vein Minerals and Paragenesis

The two main constituents of the gold-bearing veins are quartz and carbonates. The carbonates consist chiefly of calcite with a smaller amount of magnesiodolomite. The

The maximum index of refraction for this magnesiodolomite as determined by index liquids is 1.684. Plotting this result on a graph prepared by N. Sundius[1], which is shown on the next page, the molecular composition of this carbonate is found to be 92% $CaMg(CO_3)_2$ and 8% $CaFe(CO_3)_2$. Its specific gravity can also be obtained from this graph and was found to be 2.89.

The next most abundant minerals of the veins are sericite and possibly some fuchsite, also pyrite, and tourmaline. The indices of refraction for tourmaline were found to be N_o=1.6575 and N_e=1.6275. The birefringence is 0.030. These results are represented graphically by red lines on a triangular diagram on which the indices of refraction and the birefringence of pure dravite, elbaite, and schorlite[2], believed to be the common molecular constituents of tourmaline, are plotted. Since the red lines which represent optical properties of the tourmaline occurring in the veins, do not intersect within the triangle, the exact molecular proportions cannot be determined. However, the results do show that the lithium molecule elbaite is absent or at least not abundant, and that the proportion of the magnesian molecule dravite, $(H_5NaMg_2Mg_2Al_8B_4Si_8O_{41})$ to the iron molecule schorlite, $(H_5NaFe_2Fe_2Al_8B_4Si_8O_{41})$ is approximately 2:1. Pyrite appears to be later than tourmaline as it was found to be crystallized

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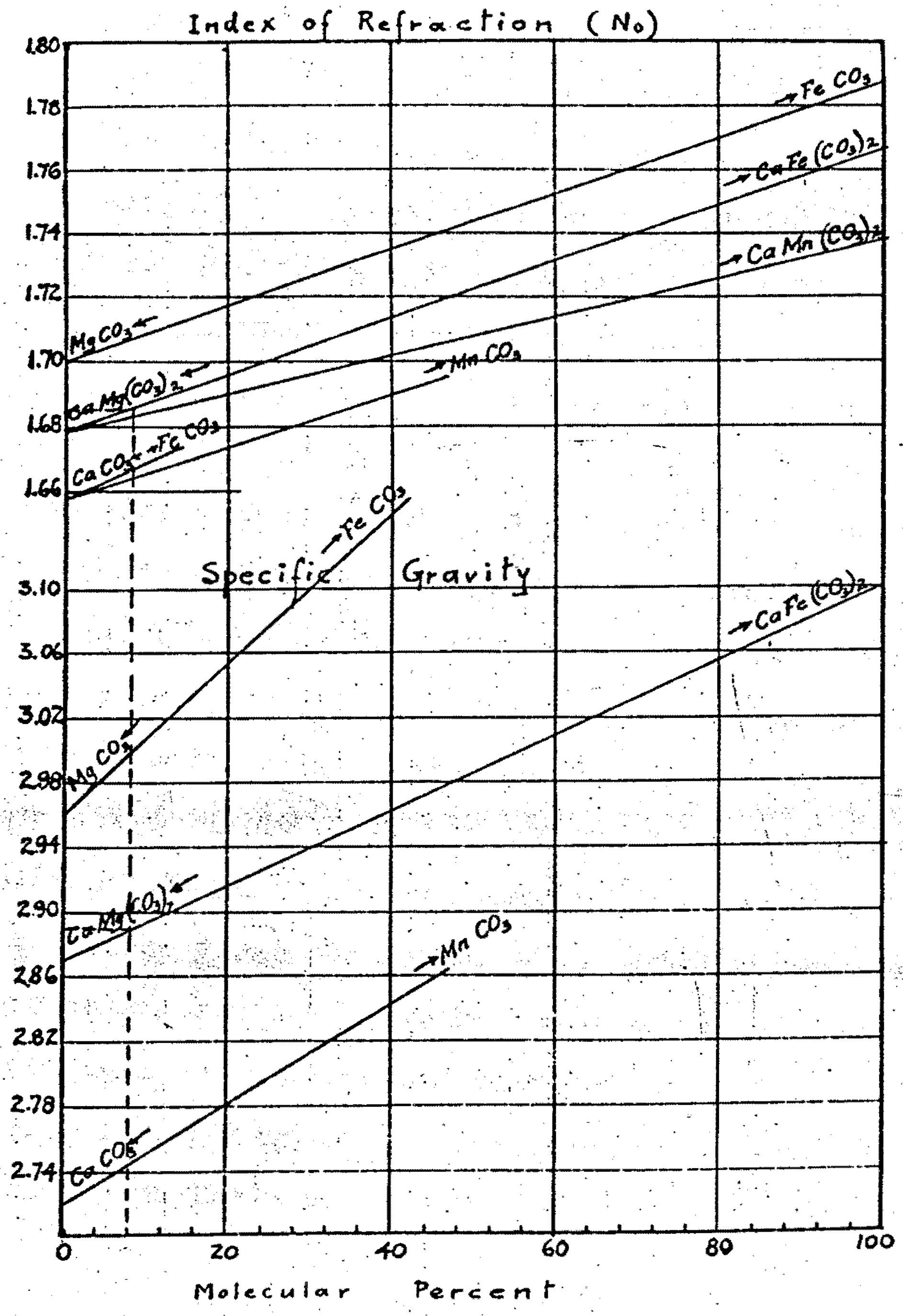
1. Sundius, N., Ueber die Karbonate der Mittelschwedischen Manganreichen Skarn - Karbonaterze., Tschermaks Mineralogische und Petrographische Mitteilungen, Band 38, 1925, p. 189
2. Winchell, A.N., Elements of Optical Mineralogy, Part II, p.246.



Composition Diagram for Carbonates

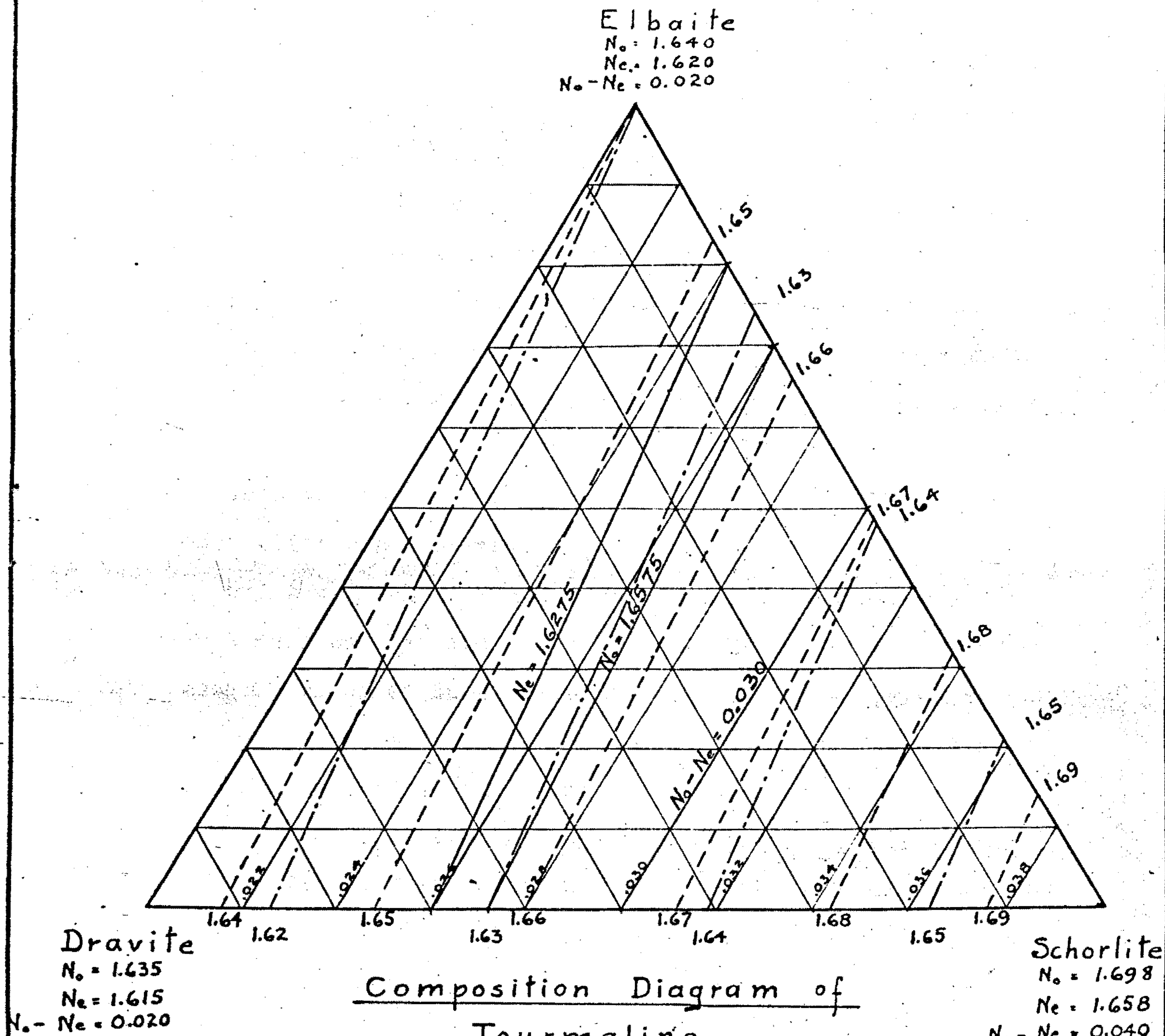
around tourmaline in several thin sections.

There is also a black, opaque mineral present which is closely associated with tourmaline and pyrite. A chemical analysis might possibly reveal the nature of this mineral, but it was not possible to determine it optically.

Another group of minerals has been determined by a study of polished sections by means of the reflecting microscope. These minerals are chalcopyrite, petzite, sylvanite, and gold. They appear to be the last minerals to crystallize. Several camera lucida drawings are given on the following page to show the relation of these minerals to each other.

They occur in minute fractures in quartz. The fractures have first been filled by carbonates which are later replaced by chalcopyrite, tellurides, and gold. The chalcopyrite occurs only in very small amounts, and its relation to the other minerals could not be established very definitely, but it is nearly always found to be in company with the telluride minerals.

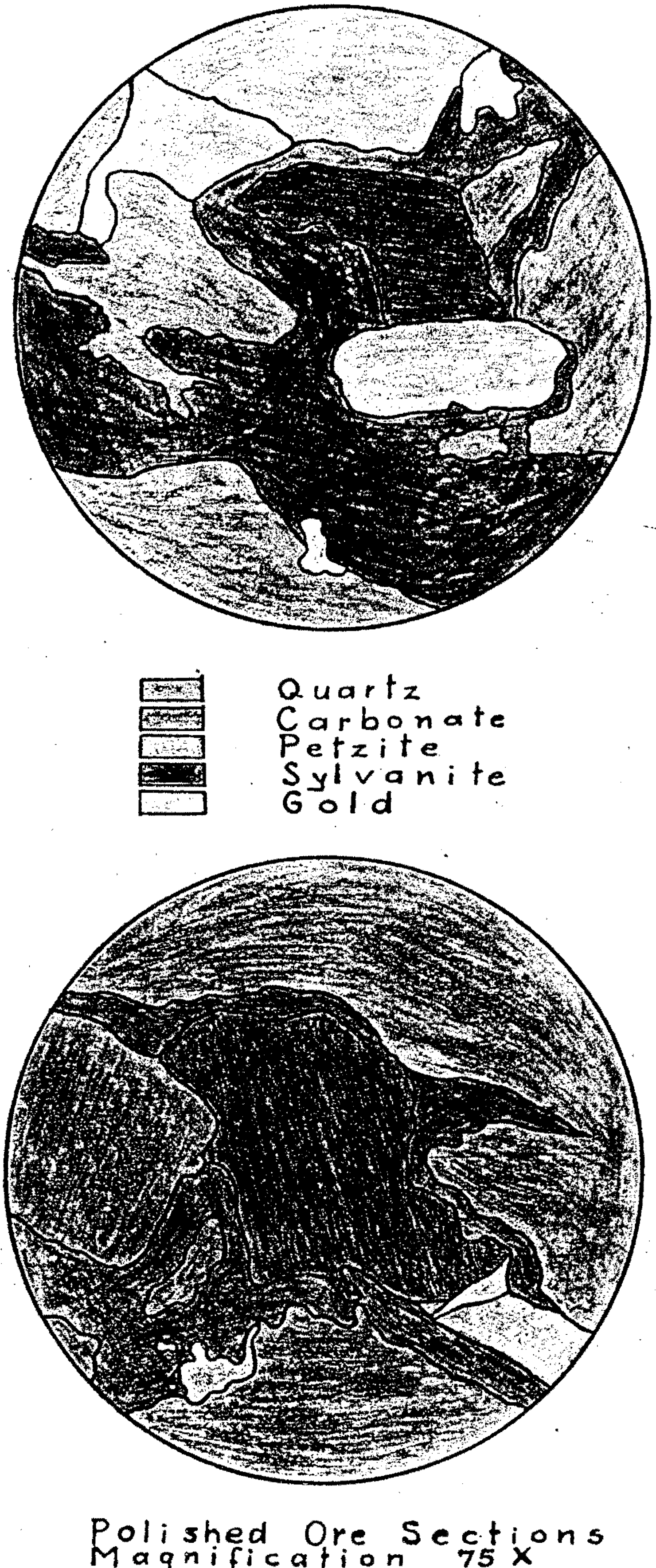
From the sections examined it could be concluded that petzite is present in larger amounts than sylvanite, and that petzite has crystallized a little earlier. The gold appears to be later than either one of the tellurides. In one of the drawings a minute veinlet of gold may be seen cutting across both tellurides, but more frequently the gold has crystallized within the carbonate or around the outside



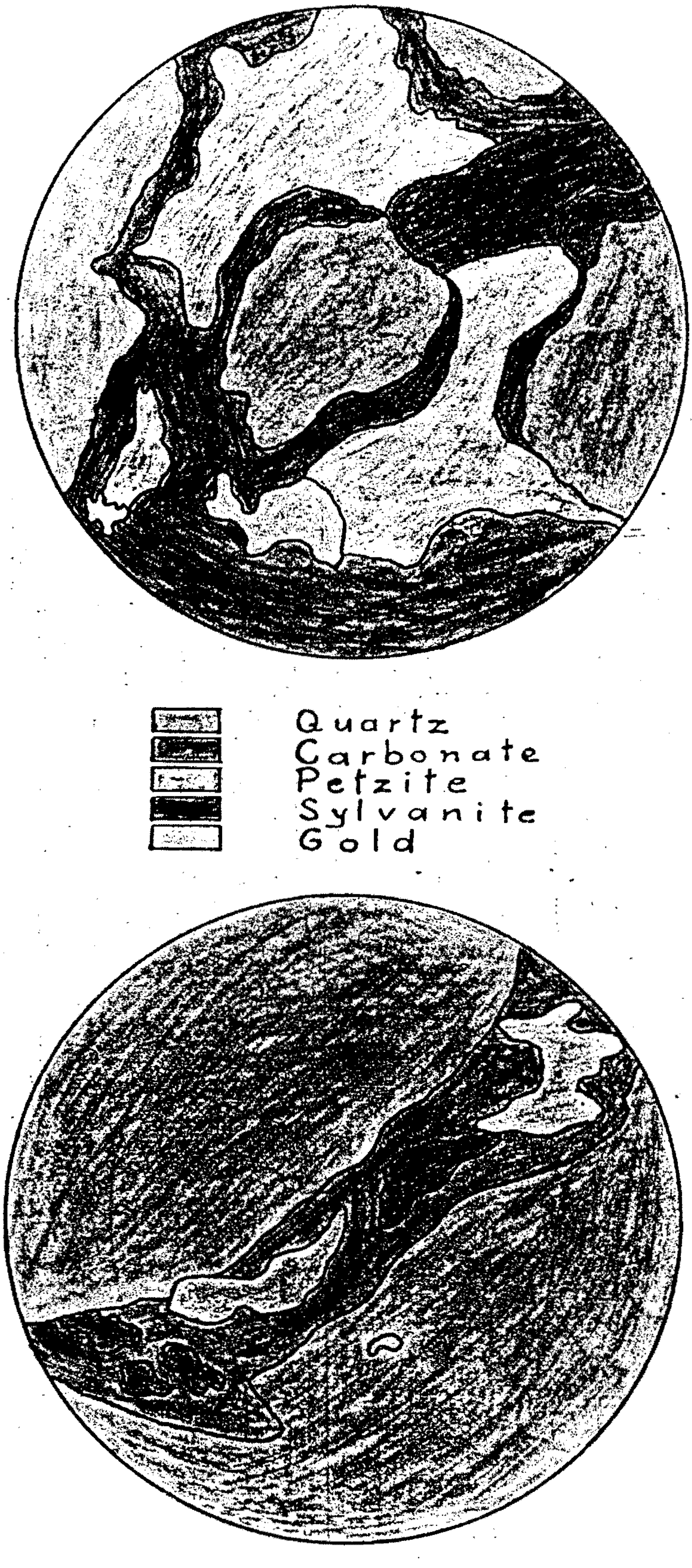
Composition Diagram of Tourmaline

No = — — — — —

Ne = —·—·—·—



Polished Ore Sections
Magnification 75 X



Polished Ore Sections
Magnification 75 X

of the tellurides. In the sections examined, nearly all the gold was found to occur in carbonate, although a few specks were noted in quartz.

Another mineral occurring in the high grade vein near station 66 is graphite. It occurs as thin films on sheared surfaces. Since it occurs within the quartz vein, its origin is possibly igneous.

A somewhat similar occurrence of graphite in veins was studied by Dr. Winchell[1] several years ago in an area near Dillon, Montana. Dr. Winchell suggests that oxides of carbon may exist in magmas and in vein forming solutions and that graphite can be produced by their decomposition according to the formula $2\ CO = CO_2 + C$. It has been shown experimentally by Boudouard that CO when cooled from 1000° to 500° C breaks up almost entirely into CO_2 and graphite.

The graphite found to occur in the quartz veins on the Lake Fortune property is believed to have had a similar origin. The original form of the graphite deposited here is believed to be cryptocrystalline. Its temperature of formation as indicated above would suggest that graphite was deposited at about the same time as tourmaline and before the deposition of gold. Later shearing movements changed some of the graphite into macrocrystalline form which is believed to have taken place after the main deposition of gold.

1. Winchell, A.A., A Theory for the Origin of Graphite As Exemplified in the Graphite Deposits Near Dillon, Montana. Economic Geology Vol. 6, 1911, pp 218-230.

Some of the macrocrystalline graphite is coated with a very thin film of gold. This has been observed only at the surface and may therefore be considered only as a surface phenomena. Since graphite is known to be a strong reducing agent, it seems logical to assume that the gold has been deposited on the graphite from surface solutions.

Finally, the order of formation of the different minerals found in the gold bearing veins is given below, beginning with those first formed:

Quartz
Carbonates
Sericite
Fuchsite
Cryptocrystalline Graphite ?
Tourmaline
Pyrite
Chalcopyrite ?
Petzite
Sylvanite
Gold
Macrocrystalline Graphite
Quartz

Temperature Conditions of Vein Formation

The presence in the veins of such minerals as sericite, tourmaline, carbonates, and possibly carbon would indicate a high temperature of formation. The decomposition of oxides of carbon as described by Dr. Winchell[1] begins at 1000° C and is complete at 500° C. The temperature of formation of tourmaline

1. Winchell, A.N., A Theory for the Origin of Graphite As Exemplified in the Graphite Deposits Near Dillon, Montana. Economic Geology Vol. 6, 1911, pp 218 - 230.

is generally accepted as between 550° and 650°C. Sericite and carbonates are in most instances known to have formed under conditions of fairly high temperatures. There are many variable factors to be considered in attempting to reach a conclusion on the temperature of formation of an ore deposit. However, when there are minerals present such as tourmaline which serve as thermometers, it may be concluded that the temperature of formation of these veins has been between 500° and 700° C. This would place the veins in a high temperature class.

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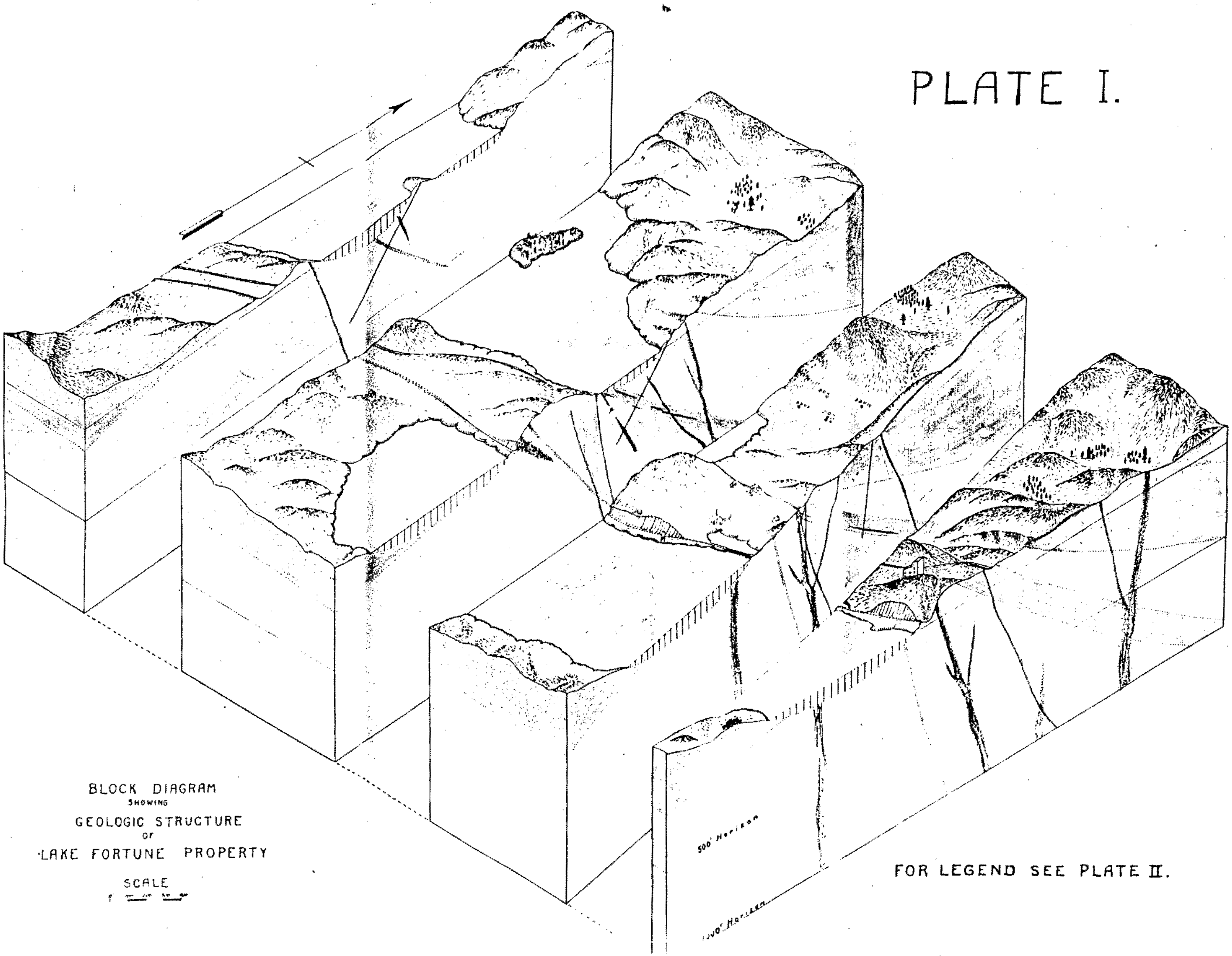
Winchell, A.N., A Theory for the Origin of Graphite as Exemplified in the Graphite Deposits Near Dillon, Montana, Economic Geology, Vol. 6, 1911, pp. 218-230.

Winchell, A.N., Elements of Optical Mineralogy, Part II, p. 246.

PLATE I.

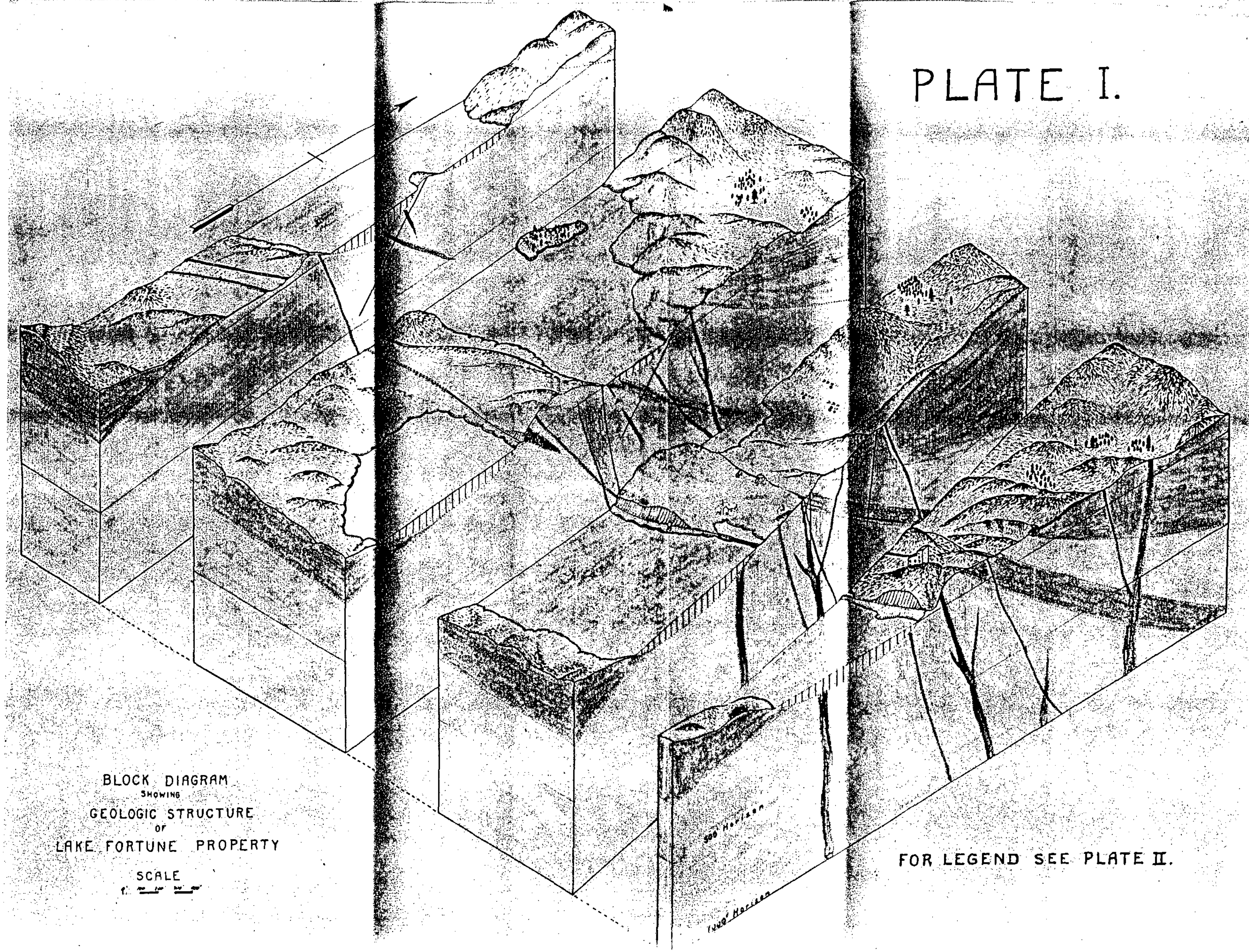


BLOCK DIAGRAM
SHOWING
GEOLOGIC STRUCTURE
OF
LAKE FORTUNE PROPERTY

SCALE

FOR LEGEND SEE PLATE II.

PLATE I.

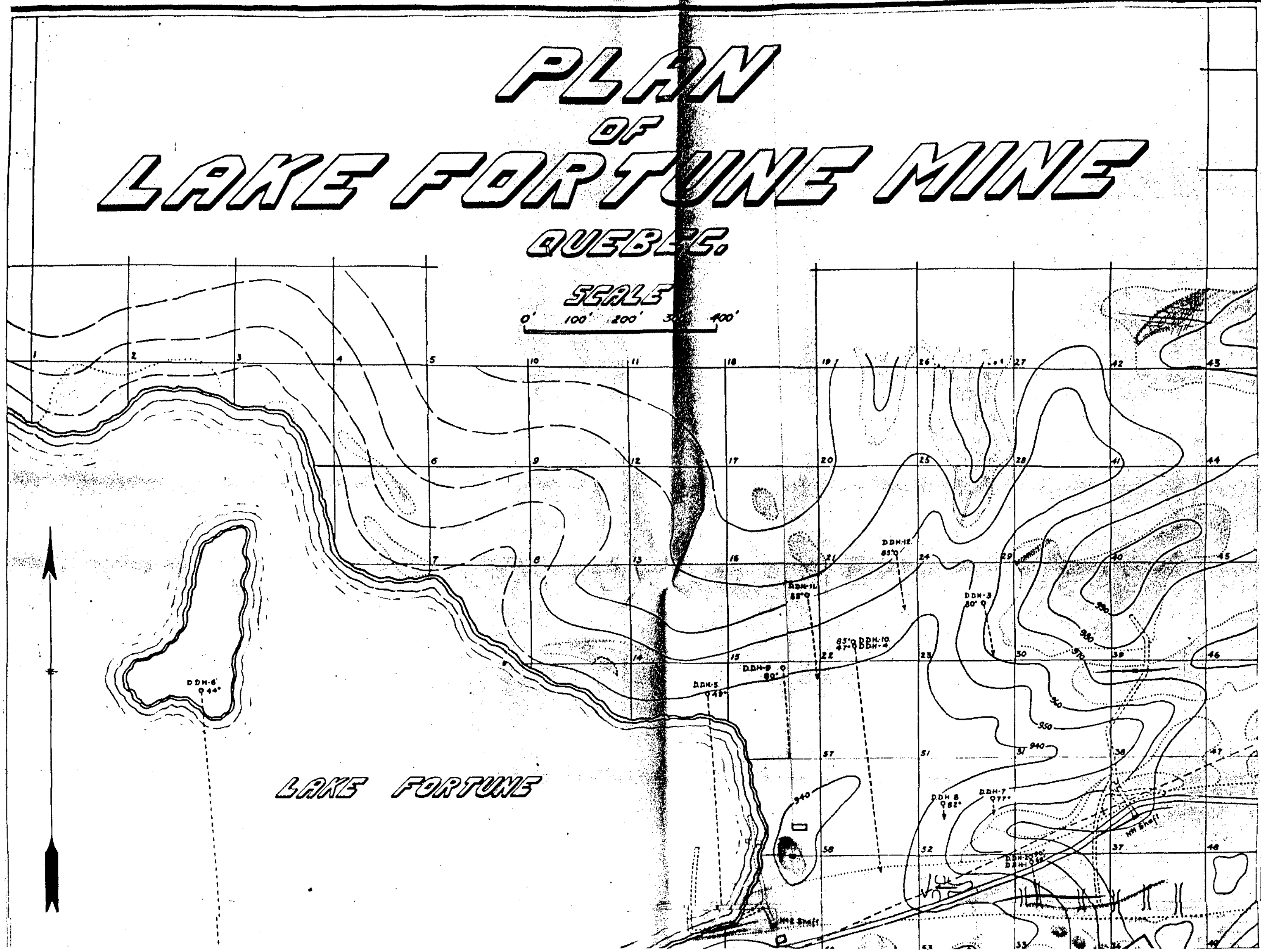


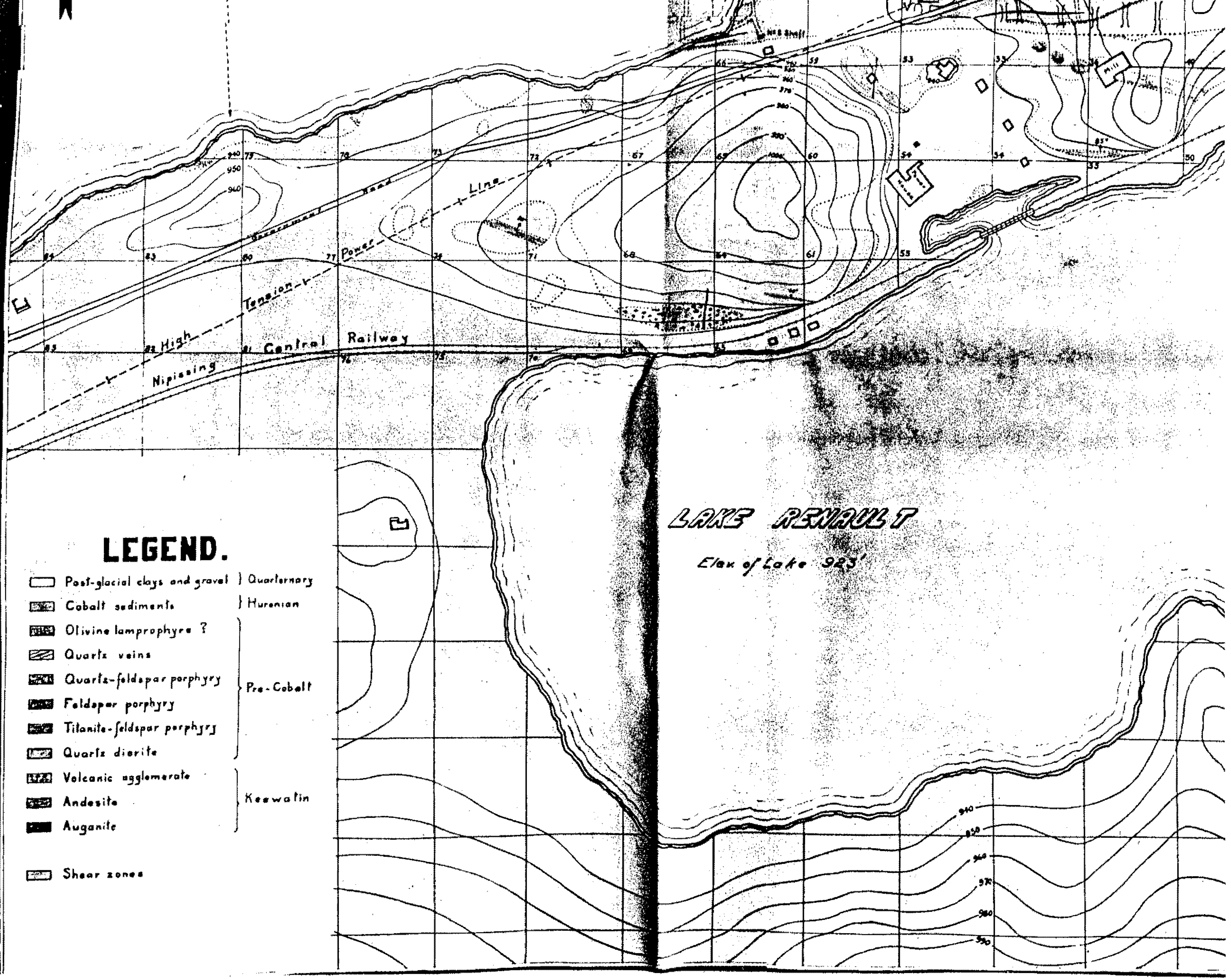
BLOCK DIAGRAM
SHOWING
GEOLOGIC STRUCTURE
OF
LAKE FORTUNE PROPERTY

SCALE

FOR LEGEND SEE PLATE II.

PLATE II.


PLAN
OF
LAKE FORTUNE MINE
QUEBEC.
SCALE
0' 100' 200' 300' 400'
LAKE FORTUNE
DDH-12 85°
DDH-11 85°
DDH-3 80°
85° DDH-10
47° DDH-4
DDH-9 80°
DDH-5 45°
DDH-6 44°
DDH 8 82°
DDH-7 77°
No 1 Shaft
No 2 Shaft
990
980
970
960
950
940
940



LAKE RENAULT
Elev of Lake 923'
Nipissing Central Railway
High Tension Power Line
Government Road
Mill
LEGEND.
Post-glacial clays and gravel
Quarternary
Cobalt sediments
Huronian
Olivine lamprophyre ?
Quartz veins
Quartz-feldspar porphyry
Feldspar porphyry
Titanite-feldspar porphyry
Quartz diorite
Pre-Cobalt
Volcanic agglomerate
Andesite
Auganite
Keewatin
Shear zones