THE ORIGIN OF THE CREE LAKE "INTRUSIVES" AND BASIC GNEISSES OF THE KISSEYNEW SERIES, SHERRIDON AREA, MANITOBA.

A Thesis

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THE ORIGIN OF THE CREE LAKE "INTRUSIVES" AND BASIC GNEISSES OF THE KISSEYNEW SERIES, SHERRIDON AREA, MANITOBA.

I. INTRODUCTION

The writer was employed by the Geological Survey of Canada, during the summer of 1947, in mapping an area of Kisseynew gneisses north and west of Sherridon, Manitoba. This work was conducted under the supervision of Dr. J.M. Harrison of the Geological Survey. From him the writer learned about some of the unsolved problems concerning the origin of certain rocks in the Kisseynew series in the immediate vicinity of Sherridon. The Sherridon area had been mapped by Dr. J.D. Bateman in 1943, and using his map as a guide the writer spent a week in the autumn going over a small area in detail and collecting specimens for later examination. The results of this investigation are presented here.

II. ACKNOWLEDGMENTS

The writer is greatly indebted to Dr. Harrison for inspiring the investigation and for many helpful suggestions. Several field photographs were obtained from him and due acknowledgment is made for them where they appear.

The writer is also grateful for the many helpful suggestions and criticisms offered by members of the Geology Department at the University of Manitoba, especially Drs. G.M. Brownell and H.B.D. Wilson.

III. GENERAL GEOLOGIC CONSIDERATIONS

The rocks of the Sherridon area form a small part of the great expanse of metamorphosed quartzose sedimentary rocks which extends over a large part of northeastern Saskatchewan and northwestern Manitoba. Locally numerous bands of basic hornblende-plagioclase gneiss occur interbanded with the quartzose gneisses. Such basic rocks are found in abundance around Sherridon. Much of the Kisseynew gneiss has been intruded by granite and granitized by injection and impregnation of granitic material.

These rocks, around Kisseynew Lake, were first named Kisseynew gneisses by E.L. Bruce (1918). Wright's mapping of the Kississing Lake area (1928) extended the boundary of the Kisseynew gneisses northward.

On the south the Kisseynew gneisses are bounded by the Amisk volcanics. The contact between the Amisk and Kisseynew is not well defined but gradational over a width of one-half to one mile. However, the gneisses are believed to lie conformably with the volcanics, though this has never been definitely established.

Up until 1943 the quartzose gneisses were mapped as one unit and the hornblende-plagioclase gneiss as another, no attempt having been made to map separately individual lithologic types within these broad units. This however, was done on Geological Survey of Canada map 862A, by Bateman and Harrison, published in 1943. The writer feels that, apart from the Sherridon quartzite, lithologic differences are not sufficiently distinct to allow of such separation. This is especially true of the hornblende-plagioclase gneisses, for there is actually as much variation within each of the new units as between them. Consequently, the separation of the hornblende-plagioclase gneisses into different groups must be considered as having been done on stratigraphic and structural grounds only.

Both Bruce (1929) and Wright (1928) considered the hornblende-plagioclase gneisses as metamorphosed basic sediments. Bateman, on the other hand called them altered basic lava flows (1945).

In the vicinity of Cree Lake Wright (1930) found bands of impure crystalline limestone. The crystalline limestone contains many bands of highly felspathic rock.

Bateman (1945) considers this to be carbonatized anorthosite, a unit of the Cree Lake intrusives, "......... that form a related sequence from ultrabasic to granitic types".

The identity of the ultrabasic type pyroxenite is certain. However, the writer believes that one of the other intrusives, "hornblende metagabbro", should be classified with the hornblende plagioclase gneisses.

Bateman states that there is some doubt as to whether the pre-Sherridon group properly belongs to the Kisseynew gneisses or whether they represent older pre-Cambrian formations. On the basis of structure he suggests that there may be an unconformity between the Sherridon and pre-Sherridon groups.

Summary of Problems.

The writer has attempted to provide answers to the following questions:

1. Is the limy rock around Cree Lake carbonatized anorthosite or impure crystalline limestone?

2. Is the hornblende metagabbro actually an intrusive, or is it a hornblende-plagioclase gneiss of the same origin as the other basic gneisses in the area?

3. Is there an unconformity at the base of the Sherridon group, and do the pre-Sherridon rocks belong to the Kisseynew gneisses proper or not?

4. Are the pre-Sherridon, Sherridon, and post-Sherridon hornblende-plagioclase gneisses metamorphosed basic lavas or sediments?

IV. THE MAPS

The results of this investigation have made it necessary to alter the names and positions in the legend of some of the rock units in the area. Consequently, two maps are included, one showing the original interpretation by Bateman (map 1), the second being modified to conform with the writer's opinions (map 2).

Both have been copied from preliminary map 44-4, Sherritt-Gordon Mine Area, Manitoba, published by the Geological Survey of Canada on a scale of 1" = 1000', with geology by J.D. Bateman. This preliminary map has been included without change as part of the final colored map 862A, published by the Geological Survey on a scale of one inch per mile, geology by J.D. Bateman and J.M. Harrison.

Since this investigation has been confined to a determination of the origin of certain rocks and has not gone into structure, a large amount of structural detail shown on map 44-4 has been omitted from the writer's copies.

V. SEDIMENTARY QUARTZOSE GNEISSES

By far the greater bulk of the Kisseynew series is composed of bedded quartzose gneisses of variable composition. These rocks are medium grained, grey to brownish in color, and show excellent bedding in places. The essential feature of these rocks is their richness in quartz.

Bateman has divided the quartzose gneisses into three groups:

1. Post-Sherridon quartz-feldspar-biotite-garnet gneiss.
2. Sherridon quartzite.
3. Pre-Sherridon quartz-oligoclase-biotite gneiss.

Even within each of these units there is considerable variation. Corresponding to the quartzose gneisses are the post-Sherridon, Sherridon, and pre-Sherridon hornblende-plagioclase gneisses.

Besides quartz, feldspar is always present in variable quantities. In places the gneisses are definitely arkosic; the quartzites, on the other hand, contain only minor feldspar. The potash feldspar is microcline for the most part, the plagioclase being an acid to intermediate type. Biotite, and sometimes muscovite, is present as small to large flakes aligned parallel to their long axes, imparting a definite foliation to the rock. Pink garnet is present in most of the quartzose gneisses.

The Sherridon quartzite is the most distinctive of the sedimentary gneisses. It is characterized by a low feldspar and biotite content. This rock is whitish grey in color, medium grained and decidedly gneissic. Under the microscope it is seen to be composed of bands of interlocking, strained quartz grains separated by bands composed of a granoblastic mixture of quartz and microcline with lesser plagioclase and biotite. Large pink garnets are crowded with inclusions of quartz and feldspar. The purer quartz bands, about one-fifth of an inch wide, stand out in relief on the weathered surface, imparting a characteristic ribbed appearance to the rock.

Not far outside the area under consideration, conglomerate beds are found in the Kisseynew gneisses. These are well exposed east of Thunderhill Lake to the south-west[1]. In the same area sillimanite gneiss is present locally. This testifies to the presence of argillaceous as well as quartzose material.

These sedimentary gneisses must have been sandstones and arkoses containing a certain amount of argillaceous impurities.

Some of the gneisses have suffered granitization so that "granitized" and granitoid gneisses are recognized. The granitoid gneiss is similar to granite except that a faint stratiform structure is recognizable in it.

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1. See map 862A (Sherridon) published by the Geological Survey of Canada.

Fig. 1. Sherridon quartzite showing characteristic ribbed appearance on weathered surface.

(Photo by J.F. Wright. 1930)

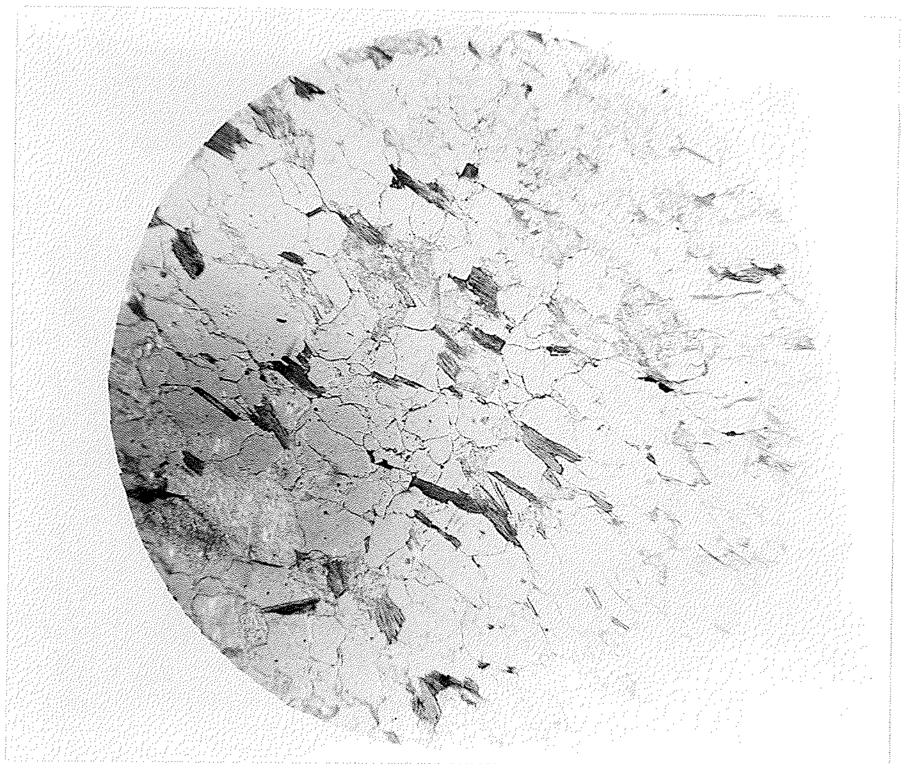

Fig. 2. Photomicrograph of Sherridon quartzite. Small grey flakes are biotite. x 40.

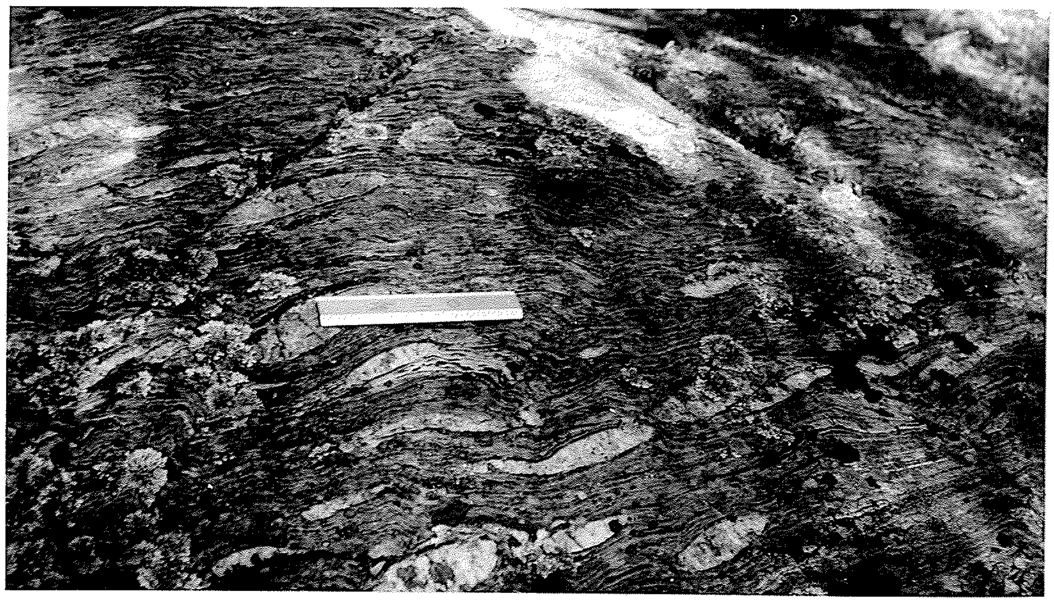

Fig. 3. Conglomerate showing large flattened quartz pebbles, near Thunderhill Lake.

(Photo by J.M. Harrison. 1943.)

Fig. 4. Knotted sillimanite schist near Thunderhill Lake.

(Photo by J.M. Harrison. 1943.)

VI. THE CREE LAKE "INTRUSIVES"

The Cree Lake "Intrusives", around Cree and Found Lakes, include pyroxenite, "metagabbro", "anorthosite", and oligoclase granite, which, according to Bateman, form a related sequence from ultrabasic to acidic types. Apart from the granite, which is of little interest here, these rocks will be discussed in more detail below.

A. Pyroxenite

On the northeast shore of Cree Lake a small sill-like body of a coarse, brown-weathering basic rock occurs. Both Bateman and Wright have briefly described this rock and agree that it is a basic intrusive of the pyroxenite or peridotite family. A limited examination by the writer has shown that this is so.

The original minerals, pyroxene and olivine, are now largely represented by the assemblage antigorite, tremolite, and chlorite, with lesser talc, carbonate, magnetite, and the green spinel picotite.

Olivine occurs as small irregular and angular residual grains imbedded in a groundmass of serpentine, and to a lesser degree as large fractured grains traversed by a mesh of antigorite and magnetite.

The pyroxene, augite, is present as large patchy grains, altered in part to serpentine, tremolite, and talc, and also as remnants in masses of these. Pyroxene and olivine together now comprise only a small part of the total mineral assemblage of the rock.

The serpentine minerals are present in two forms, antigorite and chrysotile. Antigorite occurs in large felted yellow-green masses containing considerable diss-eminated magnetite, and as a network of veins travers-ing fractured olivine grains. The felted aggregates con-tain many grains pseudomorphic after angular olivine remnants. Colorless fibers of chrysotile occur in small seams cutt-ing across the green antigorite. Many of these seams have a central magnetite parting.

Large colorless grains of chlorite with well defined cleavage are present. Some of the chlorite cuts into masses of antigorite.

Colorless tremolite occurs as long bladed grains, some showing good amphibole cross-sections. Residual grains of augite are often enclosed by tremolite.

Talc is common though not abundant, occurring typically as felted masses of fine plates often enclosing ragged patches of antigorite which it appears to replace.

Magnetite is disseminated throughout the whole of the rock. It also occurs as a central parting in seams of chrysotile.

A few large grains of carbonate are present. The carbonate is one rich in magnesium, with refractive index, N_o 1.82. According to Kennedy (1947) this corresponds to a mineral in the magnesite-siderite series, containing about 70% magnesite. Carbonate also occurs as interstitial disseminations throughout the rock.

Abundant small roundish grains of an olive-green isotropic mineral of fairly high relief were found in one section. This is probably the green spinel, picotite.

Considering the minerals present and the notable absence of any feldspar, there can be little doubt that the rock is a peridotite or pyroxenite, the original minerals of which have been altered by deuteric or hydrothermal action to antigorite, tremolite, and talc.

B. "Anorthosite"

Bateman has mapped and described interbanded calcareous and felspathic rocks around Cree Lake as carbonatized anorthosite and anorthositic gabbro, and has included them as a unit in the Cree Lake "Intrusives". He states:

> " Between Cree and Found Lakes are found bodies of anorthosite and anorthositic gabbro that consist principally of plagioclase feldspar with more or less pyroxene, hornblende, carbonate, titanite, and scapolite .... Narrow lenses of calcite and rusty weathering carbonate may be found in these rocks and are believed to be the result of widespread carbonatization........... the pyroxenite and anorthosite have a decayed appearance...... The anorthosites, in particular, are foliated." (1)

Wright (1930) referred to these same rocks as impure crystalline limestone.

Apparently Bateman was aware of this possibility for he makes the following statement in a footnote:

> " C.H. Stockwell of the Geological Survey has examined this section and regards the anorthositic rocks as altered limy sediments. Actually the present mineral assemblage of these rocks might be derived from the metamorphism of either impure limy quartzites or anorthositic intrusive rocks; and it is possible that either one or both types are present." (2)

Although these particular rocks comprise only a small portion of the entire rocks of the area, the correct

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(1) Bateman, J.D. : (1945), p. 3.

(2) Bateman, J.D. : ibid.

interpretation of their origin has an important bearing on the origin of the hornblende-plagioclase gneisses.

It seems rather gratuitous to suggest that both an impure crystalline limestone and an anorthositic intrusive rock might be present unless possibly a more alkaline intrusive were converted to a basic felspathic rock by incorporation of limy material. There is nothing to suggest that Bateman means this. On the contrary, the anorthosite is supposed to represent a unit of a related series from ultrabasic to granitic types.

The writer was impressed by the remarkably straight even contacts between the limy and felspathic bands, along which the rocks separated in a clean-cut manner. Along the east shore of Found Lake an eight inch band of hornblende-plagioclase gneiss was found interbanded with the limy rocks, this band likewise showing the property of breaking smoothly from the enclosing limy rocks.

Elsewhere within this unit outcrops of a coarse dark rock of the same mineral composition as the hornblende-plagioclase gneiss are found. Admittedly these rocks do have an igneous-looking texture. However, since they so closely resemble hornblende-plagioclase gneiss, especially the pseudodiorite of the Sherridon and post-Sherridon groups, it is likely that these rocks in the limy beds are recrystallized hornblende-plagioclase gneisses too.

The condition of alternating calcareous and felspathic bands with straight,even, parallel contacts persists throughout the whole thickness of the rock unit and is certainly more reminiscent of bedding than anything else. Excellent drag folding is found in places.

It is unlikely that widespread carbonatization, after folding, would be so selective as to result in the conditions described above; and, assuming carbonatization to have taken place prior to regional metamorphism, it is even less likely that segregation of felspathic and calcareous elements into separate bands would be so perfect as to impart to the bands such straight contacts, along which, and only along which, the rocks separate with ease.

Further, evidence of interbedding is found in the pre-Sherridon hornblende-plagioclase gneiss immediately east of Found Lake. The presence of a band of this gneiss in the limy series has already been mentioned . The limy rocks themselves contain variable amounts of hornblende. A reciprocal relationship of both limy and felspathic bands within the pre-Sherridon hornblende-plagioclase gneiss is also found.

Field evidence alone, then, is strongly suggestive of a sedimentary origin for these rocks. However, the types of alteration as revealed in thin section tend to strengthen this belief even more.

On the whole, the alternating limy and felspathic bands occur in about equal amounts, although the felspathic portion may appear to be dominant, as it stands out, on account of its greater resistance to weathering, as compared with the limy bands. It is this difference in susceptibility to weathering which accounts for the decayed appearance to which Bateman refers. The widths of the various bands may range from an inch to over a foot, but in general they are only a few inches wide.

Petrography

(a) General:

The normal lime rock, in hand specimen, is soft, white to grey, and coarsely crystalline, with a variable amount of hornblende and green pyroxene in the form of aligned needles which impart a finely foliated appearance to the rock.

The felspathic bands, on the other hand, are hard, dense, and generally fine to medium grained with a texture like that of quartzite. In fact, on first appearance the rock may easily be mistaken for quartzite, although it is composed dominantly of feldspar. These bands also contain some hornblende, pyroxene, or biotite, usually quite subordinate to the feldspar, although in places larger hornblende crystals are so abundant as to nearly equal the feldspar, and the rock approaches hornblende-plagioclase gneiss.

On the point at the northwest side of Found Lake a very coarse, white to grey weathering, feathery textured rock composed of large bladed diopside and tremolite crystals occurs within the limy series.

(b) Limy Bands:

Under the microscope the impure lime rock is seen to consist mainly of large interlocking carbonate grains or else scapolite obviously derived from the carbonate. Either one or both of these minerals compose over 50% of the total mineral content. The remainder of the rock consists of green diopside, hornblende, plagioclase, potash feldspar, and sometimes biotite, titanite, magnetite, apatite, quartz, and graphite. By refractive index the carbonate was determined to be practically pure calcite (Kennedy). Gliding lamellae are common in the calcite.

In certain specimens which appear to be limy bands, but under the microscope are seen to contain only a few percent calcite, scapolite becomes the dominant mineral. These rocks are still characterized by their moderate or subordinate feldspar content so do not properly belong to the felspathic type. The characteristic occurrence of the scapolite is as large interlocking grains similar to the occurrence of calcite.

It is interesting to observe that the large scapolite grains in many cases have inherited the rhombic twinning lamellae of the calcite. It also seems significant that the composition of the scapolite as determined by refractive index places it in the calcic end of the series, containing 70% meionite molecule. (Larsen and Berman).

These observations appear to indicate that the abundant scapolite was derived from the calcite, and not directly from the feldspar.

The ferromagnesian mineral here is largely a pale green diopside which occurs as large irregular, xenoblastic grains showing elongation and alignement. The diopside content of the lime rock may reach as high as 40% but on the average is less than 25%.

Hornblende may occur as dark green patchy grains, similar in occurrence to diopside. However, the majority of hornblende is in the form of ragged masses around the edges of diopside grains, or as small irregular grains enclosed in larger diopside crystals. In most sections hornblende is less than half as abundant as diopside, although in a few it forms about 25% of the rock and diopside is entirely absent.

The plagioclase content of the lime rock is generally quite moderate, but in instances might reach as high as 25% in those rocks still composed dominantly of calcite or scapolite. The plagioclase is an andesine with composition $Ab_{60}An_{40}$, occurring as anhedral grains of moderate size, which may or may not exhibit albite twinning. Potash feldspar is represented by microcline, but it is not at all abundant.

Titanite, in small, rounded and irregular grains occurs in all the sections examined. The majority of this mineral is strongly pleochroic, giving deep pink colors on rotation, almost suggestive of rutile. However, it was positively identified by its strong dispersion and biaxial positive character.

A few small grains of apatite were found in some sections. Minor magnetite, epidote, quartz, and graphite may also be present.

Table I contains four Rosiwal analyses of sections of typical calcareous bands.

TABLE I

ROSIWAL ANALYSES OF LIMY ROCK

Mineral	1.	2.	3.	4.
Calcite	6	17	44	54
Scapolite	41	21	4	--
Diopside	31	37	15	--
Hornblende	11	7	5	24
Plagioclase	8	14	22	19
Microcline	--	--	8	--
Titanite	2	2	2	1
Apatite	1	1	--	--
Epidote	--	tr.	--	--
Magnetite	--	--	--	--
Biotite	--	--	--	2

An examination of Table I shows:

(1). That the calcite content is inversely proportional to the scapolite content. This is in keeping with the observations cited previously regarding the nature of the scapolite and its relation to the calcite.

(2). Similarly, there seems to be an approximate inverse relationship between the amounts of scapolite and andesine in the rock.

(c) Diopside-Tremolite Rock:

This rock is characterized by a white color and peculiar feathery texture caused by the random orientation of coarse, bladed, colorless diopside and tremolite crystals.

Under the microscope the rock is seen to consist of large diopside and tremolite blades, the former being the more abundant, and a considerable amount of plagioclase, which is mostly in moderate sized grains. Lesser scapolite and minor titanite and calcite are present.

Table II shows Rosiwal analyses of three specimens of this diopside rock.

TABLE II

ROSIWAL ANALYSES OF DIOPSIDE ROCK

Mineral	1.	2.	3.
Diopside	60	54	60
Tremolite	--	15	10
Plagioclase	28	30	28
Scapolite	8	--	--
Calcite	2	tr.	1
Titanite	2	tr.	1
Magnetite	tr.	tr.	--

The most significant features of this rock are:

(1). The high content of diopside and tremolite, which means a high calcium and magnesium content. It may be noted again that the diopside in this rock is colorless and differs in this repect from that in the limy and felspathic rocks where it is pale green

(2). The typical decussate structure of the rock. This is characteristic of diopside rocks formed by contact metamorphism of limestones.

(3). The diopside rock occurs where the limy bands are almost completely surrounded by granite. Narrow felsitic and quartz intrusions also occur in the limy beds here.

(d) Felspathic Bands:

The most felspathic specimens of this rock type contain up to 75% feldspar with minor amounts of ferr-magnesian and carbonate minerals. The presence of variable increasing amounts of carbonate, ferromagnesians, and quartz mark gradations towards the limy bands, hornblende-plagioclase gneiss, and quartzose gneiss respectively.

However, most of the specimens are dominantly felspathic, containing plagioclase ranging from andesine to labradorite with considerable microcline and orthoclase. The feldspars form granoblastic aggregates of medium sized grains, thus imparting to the rock a quartzitic texture. Apart from the feldspars the remaining mineral constituents are of some significance.

Pale green diopside and hornblende, generally not much more than 15%, occur as medium to large patchy grains.

Small roundish grains of deeply pleochroic titanite are abundant, even in sections containing minor ferromagnesian minerals. One exceptional specimen containing only 5% ferromagnesians also contained 5% titanite.

Other sections contain notable quantities of biotite and sericite partly recrystallized to platy muscovite. The biotite occurs as flaky grains with associated muscovite. Sericite occurs as felted masses with numerous small grains of kyanite in one section.

These sections containing biotite and muscovite are almost entirely devoid of hornblende or pyroxene; and instead of titanite, rutile is present here, occurring as numerous small slender needles and irregular grains.

This association is suggestive of metamorphosed argillaceous or partly argillaceous sediments, for rutile with biotite and muscovite is an index of moderate grade metamorphism of argillaceous rocks. At increasing grades rutile is made over to titanite while the biotite becomes hornblende and the muscovite forms potash feldspar.

Numerous small rounded and sub-angular grains of apatite are present in all the sections examined. In some sections the apatite grains are exceptionally well concentrated along certain parallel zones.

Most sections contain only minor amounts of quartz. However, as mentioned previously gradations towards the quartzose gneisses are found. One specimen was composed of equal quantities of quartz and plagioclase with smaller amounts of hornblende, titanite, apatite, and magnetite. Texturally and mineralogically this specimen closely resembles much of the pre-Sherridon quartz-oligoclase gneiss.

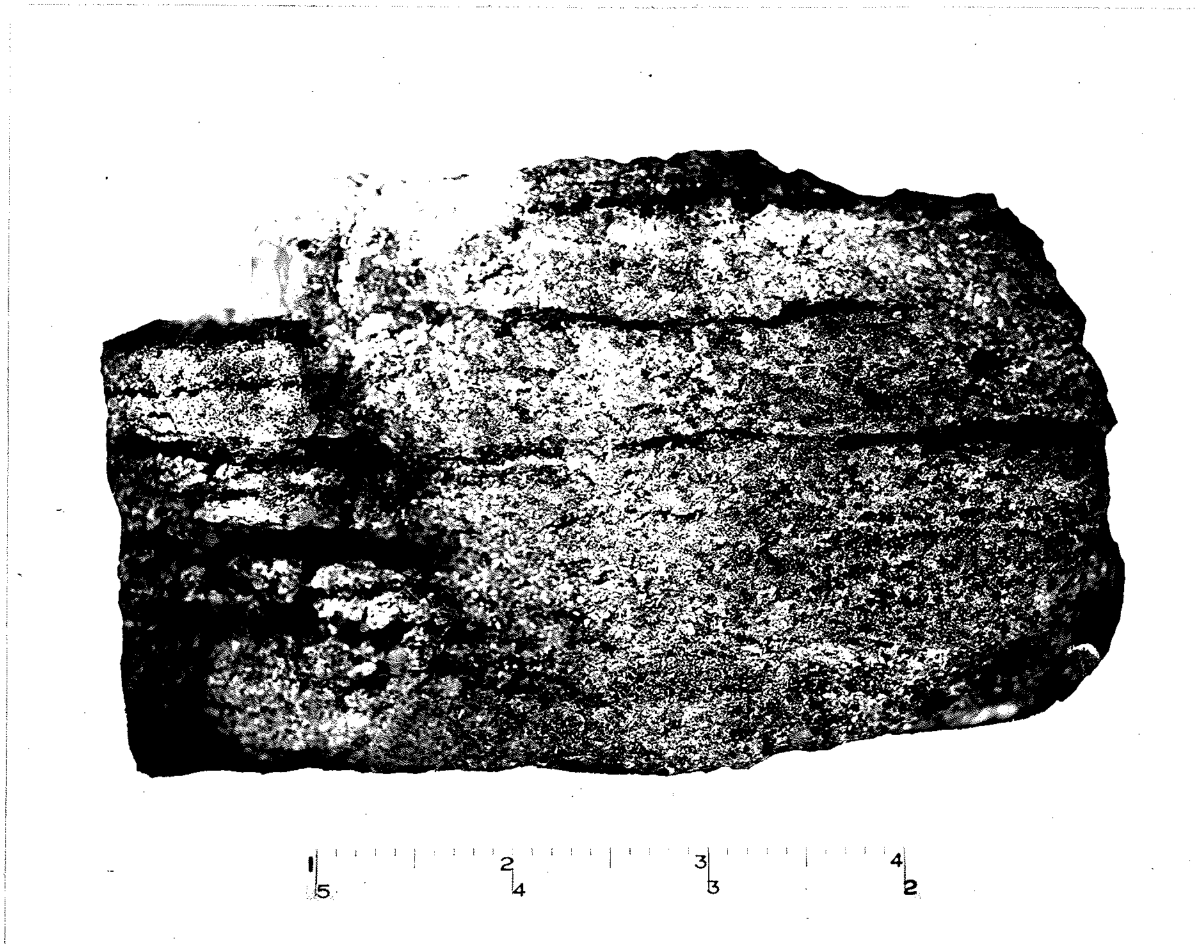
Even the most felspathic specimens contain interstitial calcite. Increasing calcite content represents gradation towards the limy bands.

In summary the following factors are presented as evidence of a sedimentary origin for the rock unit that Bateman called "carbonatized anorthosite:

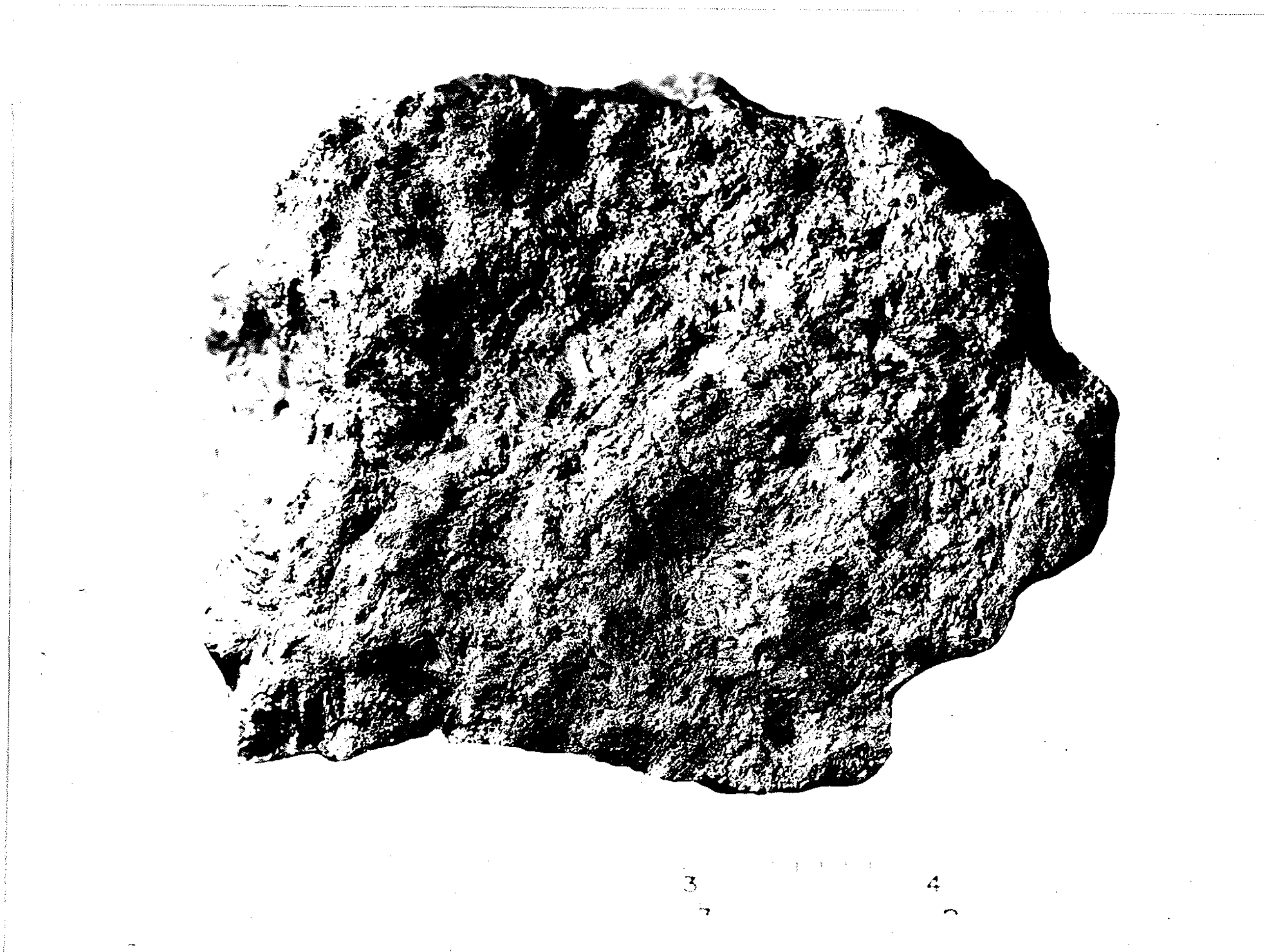
1. Indications of bedding
   - (a) Clearly defined stratiform structure.
   - (b) Interbedding of limy and felspathic rocks.
   - (c) Interbedding of both limy and felspathic types with the pre-Sherridon hornblende-plagioclase gneiss and the presence of a band of this

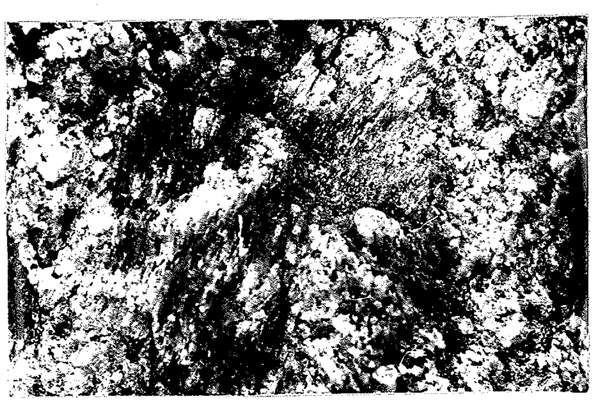
gneiss in the limy rocks.

2. High carbonate content of the limy rocks, the calcite being entirely recrystallized.
3. High scapolite content of certain bands, the scapolite being a highly calcic variety most characteristically developed in crystalline limestones.
4. Developement of diopside-tremolite rock near granite contact, the rock being typical of contact metamorphic limestones.
5. High alumina content of the material in felspathic bands.
6. Identity of certain felspathic bands with the pre-Sherridon quartz-oligoclase gneiss.



<u>Fig. 5.</u> Photograph of hand specimen of felspathic rock. Note the pronounced stratiform structure.





x 5

Fig. 6. Photograph of diopside rock showing feathery texture on weathered surface.

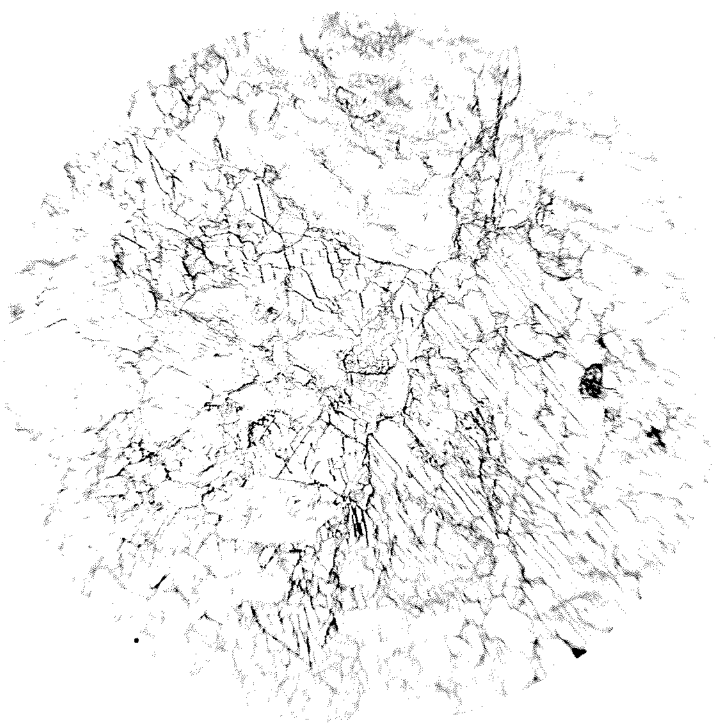


Fig. 7. Photomicrograph of diopside rock. Note random orientation of colorless diopside.

x 40

Fig. 8. Photomicrograph of impure limestone. The two large dark grains are green diopside.

x 40

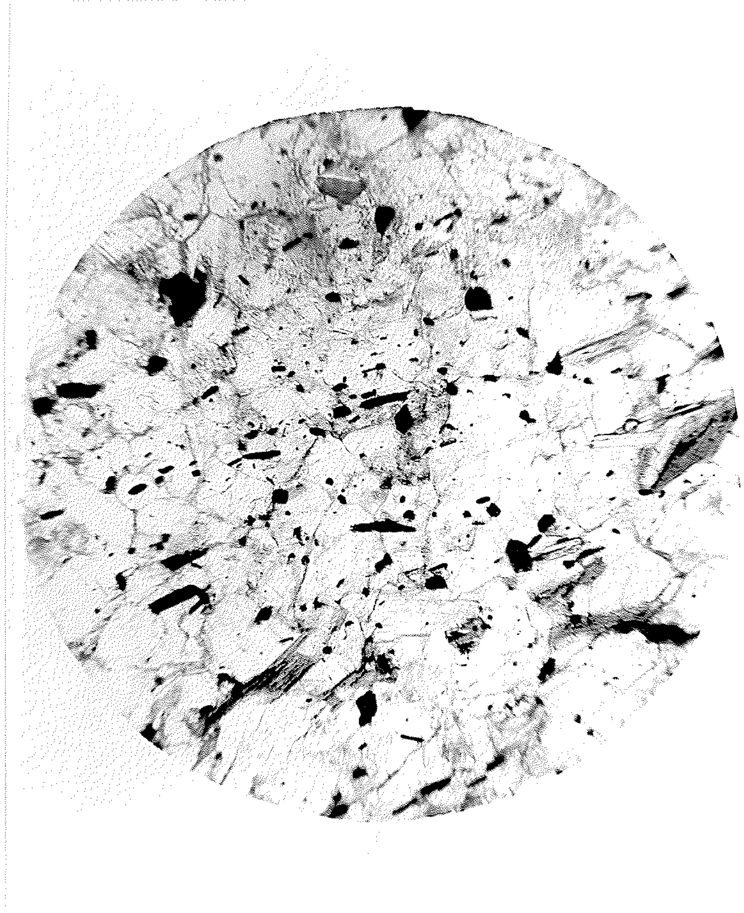


Fig. 9. Photomicrograph of felspathic rock showing abundant rutile needles and irregular grains (black).

x 40

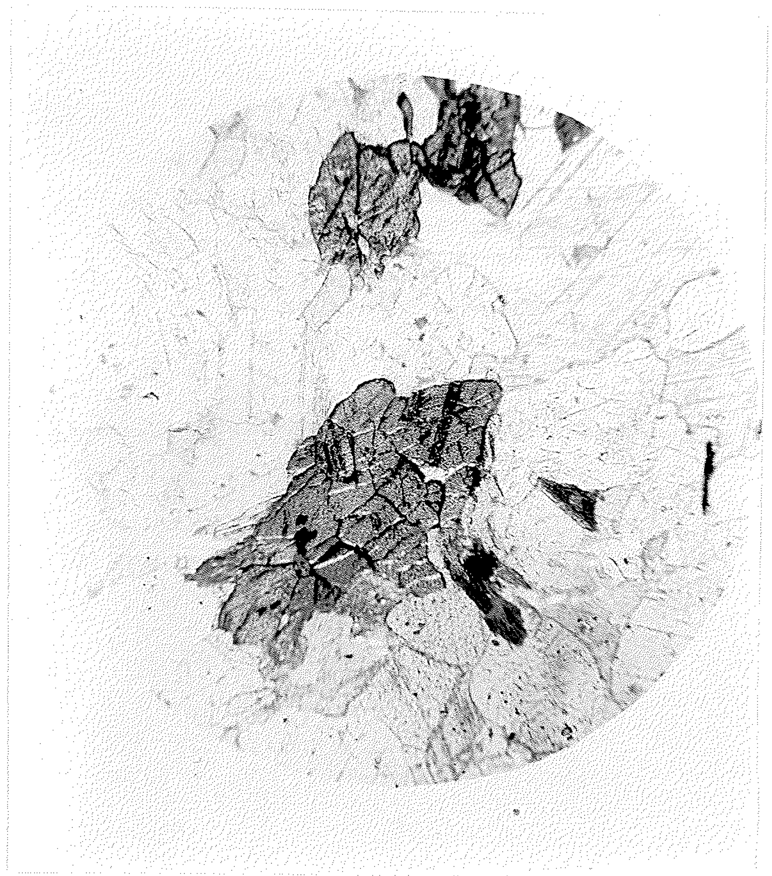


Fig. 10. Photomicrograph of felspathic rock containing large irregular grains of titanite (dark grey).
x 40

Constitution of Original Sedimentary Material

The development of abundant diopside and tremolite near the granite intrusion indicates that the carbonate must have been magnesian in part at least. On the other hand, the abundance of calcic scapolite in certain of the limy bands indicates a preponderance of calcium over magnesium. It seems then that the original limestone was only partly magnesian.

An admixture of aluminous and chloritic material must have been present with the carbonate to form diopside, hornblende, and plagioclase in the crystalline limestone.

If this is the case then it is not difficult to see how the felspathic bands come to be interbedded with the limestones. If these bands originally contained large amounts of both clayey and limy material, then the development of plagioclase would take place according to the following reaction:

$$\underset{}{CaCO_3} + \underset{\text{(Kaolin)}}{Al_2O_3.SiO_2.H_2O} = \underset{\text{(Anorthite)}}{CaAl_2Si_2O_8} + H_2O + CO_2$$

Finely divided albite or other sodic material which is generally present in clayey material would tend to make the resulting feldspar more sodic than anorthite.

It seems most likely, then, that the rock which Bateman called "carbonatized anorthosite" was actually an impure limestone with certain bands containing much larger amounts of aluminous material than others, these giving rise to the interbanded felspathic rocks.

C. "Hornblende Metagabbro"

Apart from its apparent association with pyroxenite and the fact that it is supposed to represent one of the units of "....... intrusive rocks that form a related sequence from ultrabasic to granitic types" (Bateman 1945), the writer is at a loss to know why this particular rock has been named "metagabbro". One of these related intrusives, the anorthosite, has already been discredited. No matter what the origin of the "metagabbro", it exhibits such striking lithologic and microscopic similarities to the hornblende-plagioclase gneisses of the area, that the mere suggestion of its association with basic intrusive rocks is insufficient evidence for naming the rock "metagabbro".

On Bateman's map of the area (map 1), at the northeast side of Cree Lake, the lower contact of the pyroxenite is shown to be in contact with the pre-Sherridon quartz-oligoclase gneiss. In an examination of this area the writer found that a band of "metagabbro", about 150' wide separated the quartz-oligoclase gneiss from the pyroxenite.

This is shown on the enlarged plan (Fig. 11) of this location. It would appear that the basic pyroxenite is a younger intrusive than the less basic "metagabbro", a condition not in keeping with "..... a related sequence from ultrabasic to granitic types." At the same time it is obvious that differentiation in place cannot apply here.

In the field the "metagabbro" is uniformly medium grained, dark green to black, and fairly, though not entirely massive looking. It generally shows a finely gneissic structure caused by alignment of elongated hornblende needles. Lithologically it looks identical with much of the hornblende-plagioclase gneiss of the area.

Microscopically, the normal "metagabbro" is seen to be composed almost entirely of green hornblende and plagioclase. Hornblende, comprising between 50% and 65% of the rock, occurs in irregular grains, in part crystallized around feldspar. The plagioclase, $Ab_{50}An_{50}$, is in medium sized sub-angular grains. Most of the plagioclase is untwinned.

Pale green diopside may be present and form up to 10% of the rock. Apart from specimens collected across the "metagabbro"-quartzose gneiss contact biotite was found only in small quantities. Here it occurred as euhedral plates around which both hornblende and plagioclase had crystallized.

A number of specimens was collected across the contact between the "metagabbro" and pre-Sherridon quartz-oligoclase gneiss. Thin sections of these were examined and Rosiwal analyses made of them.

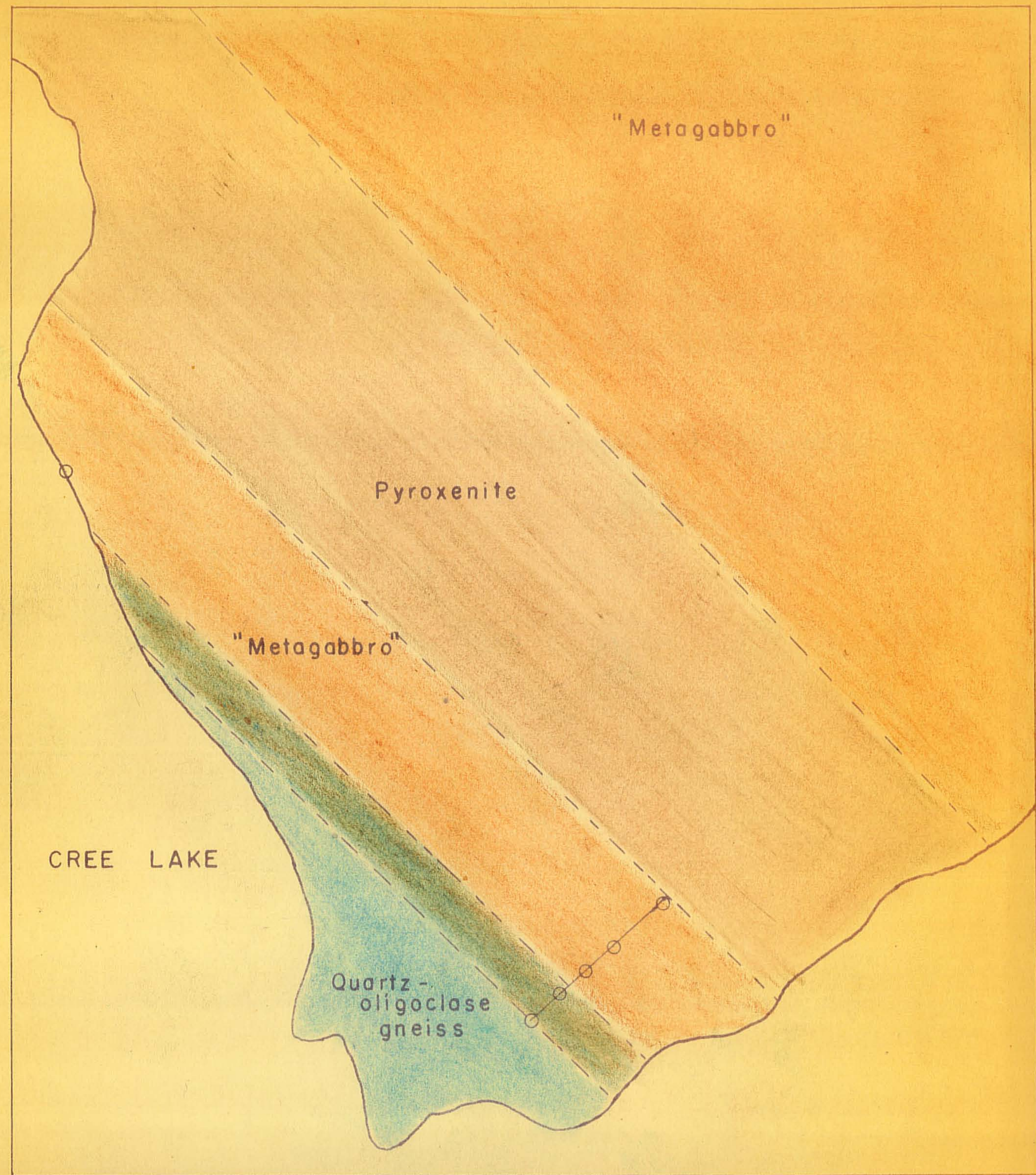
The intention had been to collect specimens across the contact between the sedimentary gneiss and the pyroxenite but, as mentioned previously, a 150' width of "metagabbro" was found to separate the two rocks at this place. Five hundred feet or more north along the shore from the end of the point " metagabbro" was also found.

Figure 11 shows this band of previously unmapped "metagabbro" and from the "metagabbro" towards the sedimentary gneiss the following gradations are found:

(1). Increase in combined feldspar and quartz content.

(2). Increase in biotite content.

(3). Corresponding decrease in pyroxene and hornblende.



GRADATIONAL CONTACT OF "METAGABBRO"

Scale 1" = 200' ○ Location of specimens

Figure 11

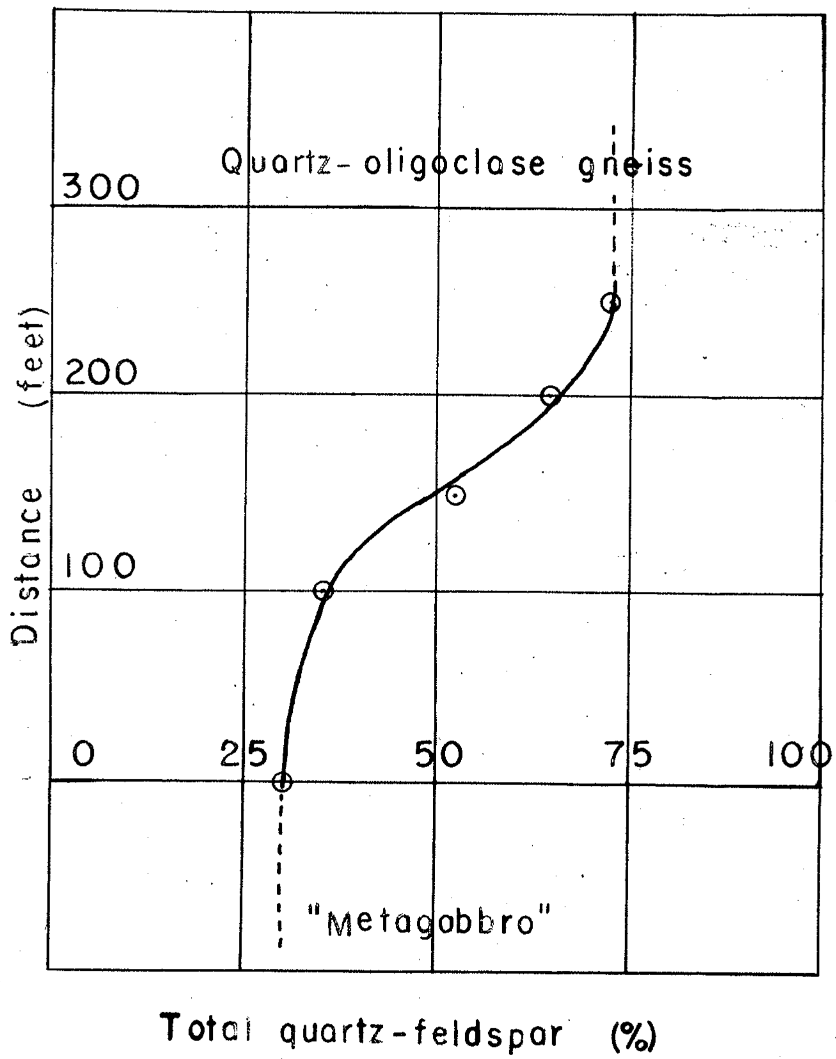

Quartz-oligoclase gneiss
300
200
100
Distance (feet)
0
25
50
75
100
"Metagabbro"
Total quartz-feldspar (%)

Figure 12.

(4). Decrease in combined ferromagnesians, hornblende, pyroxene, and biotite.

In sections containing small amounts of biotite, and still much hornblende, the biotite occurs as small irregular foils and flakes interstitial to the feldspars, especially in portions of the slide where feldspar is more abundant and hornblende less.

Likewise, in sections containing less hornblende and more biotite, both these minerals occur as small patchy interstitial grains. In one such section the biotite was an olive green variety, different from the usual dark brown. The interstitial nature of small biotite and hornblende grains becomes more obvious as the sedimentary gneiss is approached, and is in itself more suggestive of recrystallized finely divided material rather than coarse grains as would be expected in a gabbro.

Texturally and mineralogically, then, there appears to be a gradation from basic "metagabbro" to the quartzose-felspathic gneiss. A plot of the total feldspar and quartz content of five thin sections (Fig. 12) shows this gradational increase.

It may seem that this particular contact, with the pyroxenite in such close proximity may be rather an unreliable place to choose specimens for mineral analyses. However, for the following reasons, it seems unlikely that the pyroxenite has effected any change in the wall rock:

(1). Considering the least felspathic specimen, (closest to the pyroxenite, where the contact action, if any, would be greatest) it contains about the normal amount of feldspar. At least three other specimens collected far from the pyroxenite contained about the same amount.

(2). There are no olivine, serpentine, or other minerals characteristic of the pyroxenite in this section.

(3). There has been no textural deviation from the normal "metagabbro".

(4). It seems unlikely that a body of pyroxenite less than 400' wide and "dry" could effect any addition of material to the wall rock over a width of 150'.

If, then, the effect of the pyroxenite intrusion on the country rock can be disregarded, it appears that the gradational nature of the contact between the "metagabbro" and sedimentary gneiss is indicative of a mutually sedimentary contact. At least the "metagabbro" can hardly be regarded as a basic lava flow.

As pointed out previously, the conception of the "metagabbro" as an intrusive related to the pyroxenite is incongrous.

For these reasons and the fact that it so closely resembles the other hornblende-plagioclase gneisses in the area, which, as will be shown later, are probably all of sedimentary origin, it seems most likely that this "metagabbro" should be regarded as another sedimentary hornblende-plagioclase gneiss.

VII. THE BASIC HORNBLENDE-PLAGIOCLASE GNEISSES

A. The Pre-Sherridon Hornblende-plagioclase Gneiss

The pre-Sherridon hornblende-plagioclase gneiss outcrops around Found and Cree Lakes, overlying the pre-Sherridon quartz-oligoclase-biotite gneiss of sedimentary origin, and is in turn overlain by the Sherridon quartzite.

Regarding the rock Bateman states:

> " The hornblende gneiss may be thinly foliated, but is generally without visible structure. Part of it contains light colored lenticular fragments, and was probably a volcanic breccia. There is some doubt as to whether the pre-Sherridon rocks belong to the Kisseynew group or whether they represent metamorphosed equivalents of older Archean formations............" (1)

Unfortunately the "light colored lenticular fragments" indicative of a volcanic breccia were not described more completely, for examination by the writer failed to reveal anything that could possibly be taken for this.

Bateman J.D.: (1945), p.1.

On the contrary any light colored rocks found within the hornblende-plagioclase gneiss were bands or lenses of altered crystalline limestone, felspathic and quartzo-felspathic gneisses.

Further, east of Found Lake and south of Bay Lake a gradational contact of hornblende-plagioclase gneiss with the Sherridon quartzite is found.

On the whole the pre-Sherridon hornblende-plagioclase gneiss shows considerable variation in mineral composition, grading towards felspathic gneiss as found in the crystalline limestone, towards highly calcareous types, and highly quartzose varieties.

Some of the more significant outcrops and specimens will be described in more detail below.

In the field and hand specimen the hornblende gneiss generally shows no pronounced banding, but is characterized by a definite alignment of elongated hornblende needles. Hornblende may comprise from 20% to 50% of the rock.

Under the microscope the hornblende needles are seen to be very irregular but elongate grains containing abundant grains of feldspar and quartz, when present.

The hornblende, although approaching the skeletal condition shows optical continuity, whereas the enclosed quartz and feldspar are optically discontinuous. Harker refers to this type of structure as "poeciloblastic".(1) The hornblende is the aluminous variety, pargasite.

In some sections green pyroxene is also present, occurring in a manner similar to the hornblende. Pyroxene occurs mostly in those rocks somewhat lower in total ferromagnesians.

Plagioclase generally is in the form of medium sized sub-angular grains, often untwinned. In sections containing considerable quartz the two minerals form a granoblastic groundmass. The plagioclase is mostly $Ab_{50}An_{50}$ but in several specimens it is $Ab_{70}An_{30}$. Like the hornblende the plagioclase content is quite variable, ranging from 30% to 50%.

A few small blades of biotite are present in some slides, generally completely surrounded by hornblende.

Harker (1932) states that poeciloblastic structure of metamorphic rocks may be considered analagous to poikelitic texture of igneous rocks. However, it is to be understood that the two do not have the same genetic significance.

Pink garnet is present in some of the sections examined. It is invariably crowded with abundant small inclusions of quartz and feldspar. Small amounts of magnetite, titanite, and apatite are also present.

The abundance of quartz in certain specimens of the pre-Sherridon hornblende-plagioclase gneiss requires special consideration. Twelve hundred feet east of Found Lake and thirteen hundred feet south of Bay Lake, the hornblende gneiss thins out along its strike. The outcrops of hornblende gneiss examined here exhibited a decidedly ribbed structure caused by the weathering out of hornblende and plagioclase, leaving narrow ridges of quartz standing out in relief. These ridges measure about 1/10" in width, 1/5" in height, and are spaced about 1/5" apart. This type of structure is characteristic of the Sherridon quartzite. Reference to the map shows that the hornblende gneiss pinches out into the quartzite here. There can be little doubt that the condition described is that of interbedding of hornblende gneiss and Sherridon quartzite on a small scale at this gradational contact.

Microscopic examination of specimens from here reveals that quartz occurs in significant quantities throughout the whole rock, but is especially concentrated in alternating bands with lesser plagioclase, the two forming a mosaic of medium sized grains. These alternating bands comprise about a third of the entire section with quartz forming about 20% of the total mineral constituents of the rock.

A somewhat similar relationship is found at the contact between the hornblende gneiss and quartzite between Found and Fox Lakes. A transition zone, fifty to a hundred feet wide is present here, in which the rock is characterized by the same ridge-like weathering. Specimens of this rock are composed of about 40% quartz, 20% feldspar, both plagioclase and microcline, 25% hornblende and pyroxene, and up to 15% scapolite. The rock also contains a small amount of titanite,

Another specimen of dark green hornblende gneiss, collected from the center of the wide band between Found and Bay Lakes contained 47% hornblende, 32% plagioclase ($Ab_{50}An_{50}$), 18% quartz, and about 2% pink garnet. In the field and hand specimen this rock appears to be the normal hornblende-plagioclase gneiss, although it generally contains only minor quartz.

The presence of bands of limy and scapolitic rocks, and also of garnetiferous quartz-biotite gneisses in the hornblende-plagioclase gneiss has already been mentioned. It is needless to describe these rocks again but suffice it to say that their identities have been verified by microscopic examination.

In view of its relation to the sedimentary rocks mentioned it seems certain that the pre-Sherridon hornblende-plagioclase gneiss represents a basic sediment.

Referring to the contact between the Sherridon and pre-Sherridon groups Bateman states:

> " The Sherridon group lies in places upon pre-Sherridon basic gneiss, but elsewhere upon still older sedimentary gneiss. This may be due to thinning out of the hornblende gneiss along its strike, or it may represent an erosional unconformity at the base of the Sherridon.......... The Sherridon group probably represents the lower part of the Kisseynew gneisses." (1)

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(1) Bateman J.D. : (1945), p. 2.

Since the pre-Sherridon hornblende gneiss contains interbedded Sherridon quartzite, and since the contact between the two is gradational it is obvious that there can be no erosional unconformity between them, and that the pre-Sherridon group does properly belong to the Kisseynew series rather than represent "..... metamorphosed equivalents of older Archean formations ...."

B. Hornblende-plagioclase Gneiss of the Sherridon Group

The Sherridon hornblende-plagioclase gneiss bears every possible resemblance to the pre-Sherridon and post-Sherridon as well as to the so-called "metagabbro".

As in these other rocks, this black or dark green hornblende gneiss is finely foliated to massive, in places recrystallized to such a degree as to resemble diorite; this has been called pseudodiorite. Aluminous green hornblende, pargasite and plagioclase, $Ab_{50}An_{50}$, in about equal proportions constitute the bulk of the rock. The hornblende exhibits poeciloblastic structure similar to the other hornblende gneisses. Most of the rock is only medium grained.

In one occurrence of very coarse, knotty-weathering brown gneiss hornblende is rare, its place being taken by large poeciloblastic grains of diopside, much of it showing lamellar twinning. This same rock contains abundant large pink garnets, giving rise to the knotted appearance. Under the microscope the garnets are seen to contain abundant inclusions of plagioclase and some quartz.

Quartz occurred in only one other specimen examined, several large interlocking grains being present; numerous rounded inclusions of quartz were also contained in garnet and plagioclase.

Wright (1930) reported the presence of interbedded crystalline limestone 300' east of the west shaft of the Sherritt-Gordon Mine. This is east of Camp Lake in the hornblende gneiss. The location is now covered with mill tailings and was not open to examination. However, since Wright correctly identified crystalline limestone near Cree Lake, it is likely that limestone ocuurs east of Camp Lake too. A specimen of remarkably pure crystalline limestone with narrow bands of hornblende gneiss, collected by Dr. G.M. Brownell, and now in the petrology collection at the University of Manitoba, is reported to have come from a band of hornblende gneiss near the mine. The exact location is not known but it is certain that, being near the mine, it is not the limestone from Cree Lake, and is probably from the spot east of Camp Lake reported by Wright.

The presence of interbedded crystalline limestone in the Sherridon hornblende gneiss may be taken as good evidence for a sedimentary origin of the latter rock.

Opposed to this view Bateman (1945) reported the presence of remnant pillow structures in the Sherridon hornblende gneiss. An examination of these supposed pillows left the writer unconvinced as to their identity. They appear as indefinite dark lenticular patches and streaks an inch or more wide and several feet long, which are elongated parallel to the foliation of the gneiss. They might indeed represent anything, and there appears no good reason for calling them pillows.

A photograph of the same structure from the post-Sherridon rocks is included in this report (Fig. 15), and with it, one of actual pillows from recrystallized lavas near Star Lake, about three miles east of Sherridon. (See Wright's map, 1928).

C. Post-Sherridon Hornblende-plagioclase Gneiss

Little direct evidence can be presented in favor of either a sedimentary or volcanic origin for the post-Sherridon hornblende-plagioclase gneiss. For the most part the rock is essentially the same as the previously described basic gneisses, consisting of approximately equal quantities of aluminous hornblende and andesine plagioclase. Fairly large interlocking quartz grains are common. In some specimens quartz is present in narrow bands about a tenth of an inch wide, in which plagioclase and quartz form a mosaic of small grains. This is apparent only under the microscope and is not visible in hand specimen. Unlike the pre-Sherridon basic gneiss the Sherridon rarely contains more than 5%or 10% quartz.

Sub-angular grains of apatite, small irregular pink garnets and magnetite, and interstitial calcite are also present, the total amount averaging about 5%.

Structures similar to those which Bateman believed to be pillow remnants are also found in the post-Sherridon.

One outcrop of the hornblende-plagioclase gneiss about 1000' southeast of the extreme south end of Camp Lake, showed excellent banding, probably original bedding. This banded structure consisted of alternating grey and blacker bands, 2" to 3" wide. These layers are remarkably straight and uniform, and considering also their width, persistence, and composition, it seems more logical to interpret this as bedding rather than secondary foliation.

Under the microscope the dark bands are found to have the same mineral composition as the normal hornblende-plagioclase gneiss, being composed almost entirely of hornblende and plagioclase.

The lighter bands, however are characterized by the presence of large irregular grains of light green diopside, with only a small quantity of hornblende, and andesine plagioclase. Numerous anhedral grains of deeply pleochroic titanite, which is almost entirely absent in the darker bands, are scattered throughout the lighter. Interstitial grains of calcite are also present. No magnetite, which does occur in the darker layers, is present in the lighter ones. The plagioclase content of both light and dark is about the same.

In metamorphic rocks, aluminous hornblende, pargasite, is characteristically developed in those rocks which contain alumina in excess of that required to satisfy the formation of plagioclase. On the other hand, in rocks with insufficient alumina to form hornblende, diopside is characteristically developed.

It is obvious that the color banding is not a result of segregation of felspathic and ferromagnesian minerals into separate bands.

It seems most likely, then, that this banding represents original bedding of layers with originally different alumina and calcium contents. It will be recalled that a somewhat similar condition was mentioned in the Sherridon basic gneiss, although the lighter colored, knotted diopside-plagioclase rock there also contained numerous garnets, and was not definitely banded.

D. Origin of the Hornblende-plagioclase Gneisses

A definite threefold relationship between the pre-Sherridon hornblende-plagioclase gneiss, the impure crystalline limestone, and the felspathic bands within the limestone has been noted. Briefly, this relationship consists of a mutual gradation in composition between the three types, and a mutual interbedding between them.

It has been shown that the impure crystalline limestone originally contained notable amounts of clayey and chloritic material, and that the felspathic bands contained major amounts of both limy and clayey matter.

Consequently, since the hornblende-plagioclase gneiss is closely related to the limestone and the felspathic rock, it would be natural to assume that the original sedimentary material of the pre-Sherridon hornblende-plagioclase gneiss contained both calcareous and argillaceous, as well as chloritic elements. This is quite a logical assumption, for there are certain partly calcareous rocks which will change to hornblende-plagioclase gneiss, similar in many respects to the product of metamorphism of a basic igneous rock. It is this similarity in both composition and structure between altered basic sediments and lava flows which makes it difficult to determine the origin of a rock like the hornblende-plagioclase gneiss.

Harker (p.270) has stated the problem well:

> " As a rule, the bulk analysis of any crystalline schist enables us to assign it with some confidence to either an igneous or sedimentary origin .... the high alumina content of argillaceous and the high silica of arenaceous rocks (relative to the alkalies) are very significant .... The calcareous sediments are characteristically rich and the non-calcareous poor in lime. It is easy to see, however, that for partly (italics in the original) calcareous rocks these several criteria may fail, and it is here that ambiguous cases present themselves."

However, in the case of the hornblende-plagioclase gneisses of the Sherridon area, there can be little doubt that these were all partly calcareous sediments. The calcareous nature of the pre-Sherridon and Sherridon hornblende gneisses is obvious from their relation with the limestone bands, and the fact that they both contain variable, in cases large, amounts of calcite themselves. The original nature of the post-Sherridon gneiss is not so obvious, but it too contains some interstitial calcite and is almost certainly bedded, so by comparison with the pre-Sherridon and Sherridon it is safe to assume that the post-Sherridon hornblende gneiss represents the same original sediment as these.

Regional metamorphism of the " Green Beds" of the Dalradian Series in Scotland has produced hornblende-plagioclase gneiss similar to those of the Sherridon area. The metamorphism of these can be followed through every stage. The unaltered sediment is highly chloritic and more or less calcareous, and the hornblende-plagioclase gneiss represents a high grade of metamorphism.

The source of the basic sediment in the Sherridon area is unknown. However, the writer feels that further inquiry into the relationship between the Amisk volcanics, to the south, and the Kisseynew gneisses might be worthwhile. The relationship of the Missi sediments and the Amisk volcanics with the Kisseynew gneisses has not been satisfactorily determined. However, if there should be an unconformity between the Amisk volcanics and the Kisseynew gneisses, the basic gneisses might well represent sedimentary material derived from the first-mentioned rocks.

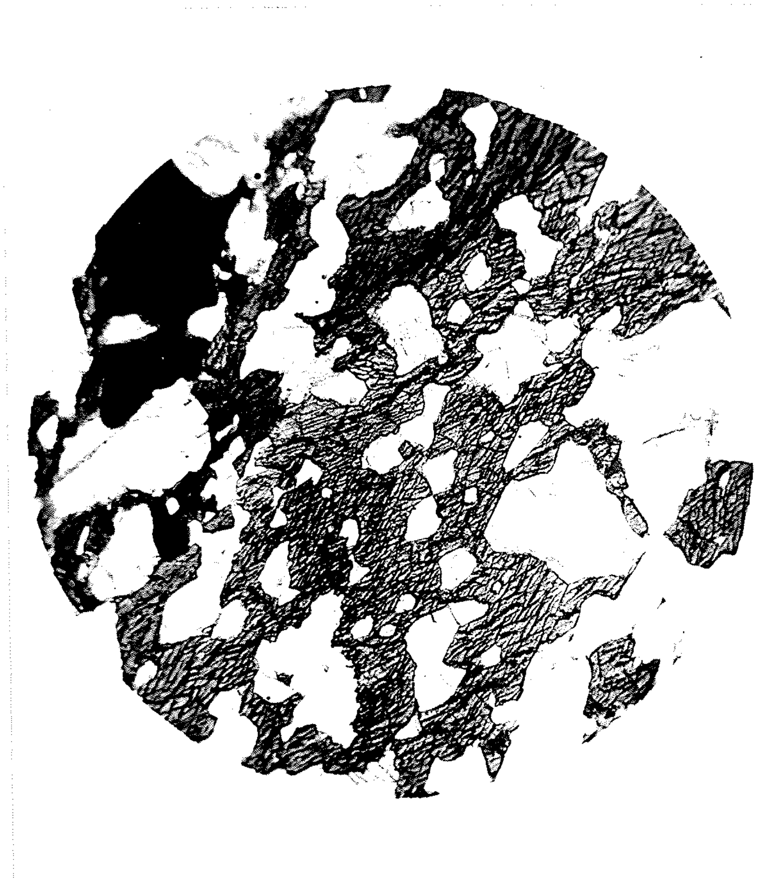

Fig. 13. Poeciloblastic hornblende in hornblende-plagioclase gneiss. The hornblende is optically continuous.

x 40

Fig. 14. Lenticular foliation in hornblende gneiss. Unlike bedded structures foliation is fine and lenticular instead of fairly wide and persistent.

(Photo by J.M. Harrison)

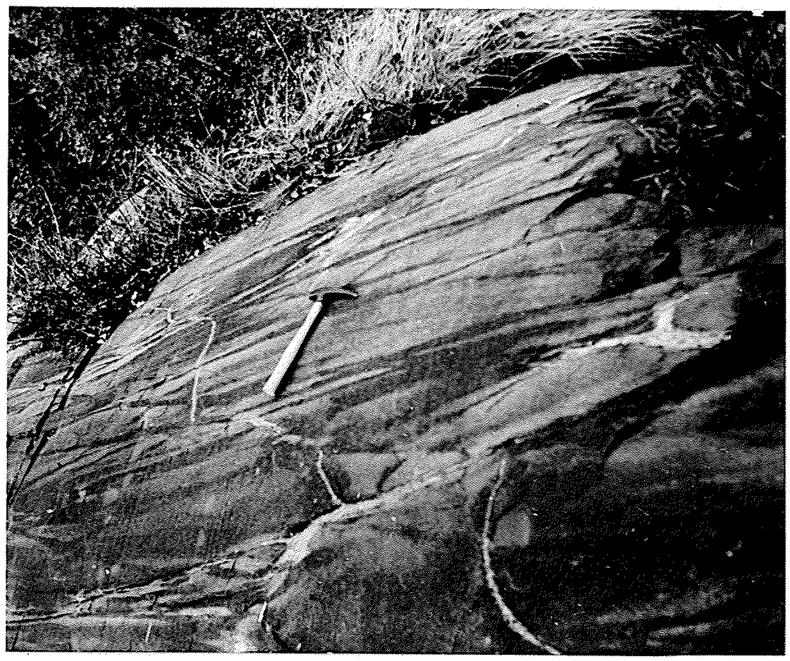

Fig. 15. Supposed pillow remnants (Bateman) in hornblende gneiss.

(Photo by J.M. Harrison)

Fig. 16. Pillow structures in coarsely recrystallized lava - now hornblende-plagioclase rock - east of Sherridon. Compare this with Fig. 15.

(Photo by J.M. Harrison)

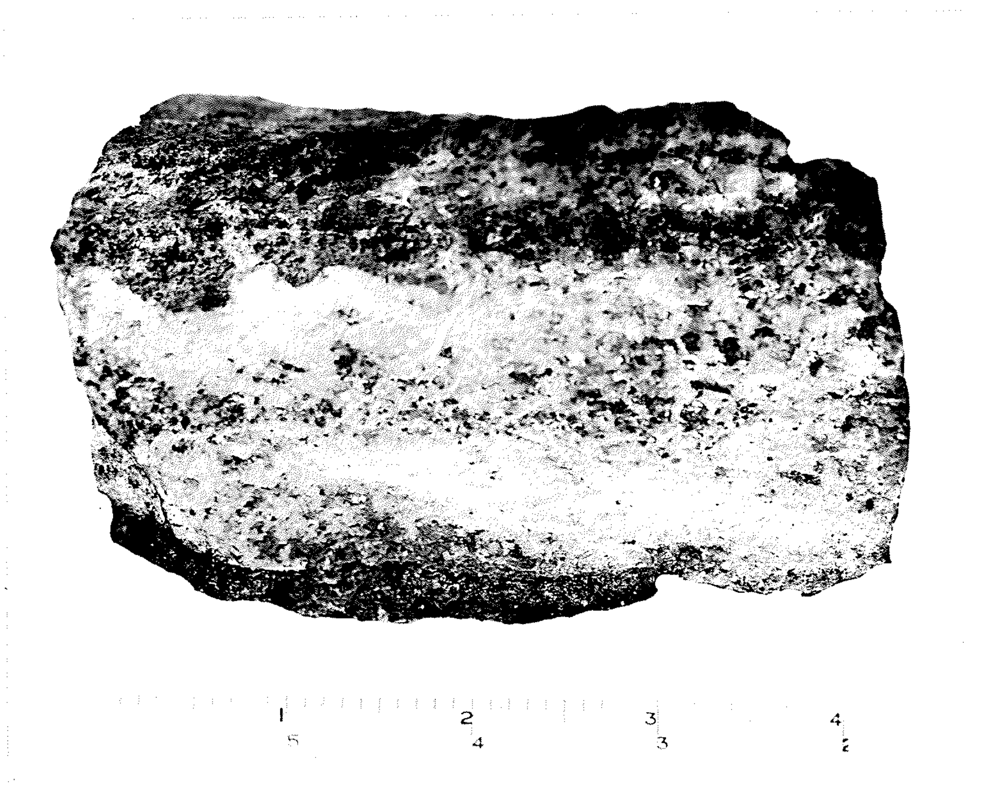

Fig. 17. Crystalline Limestone with narrow bands of hornblende-plagioclase gneiss. Specimen in petrology collection, University of Manitoba. See pages 52, 53 of text.

VIII. SUMMARY

By means of field and laboratory study it has been shown that the basic hornblende gneisses of the Kisseynew series in the Sherridon area are a part of a thick series of interbedded metamorphosed quartzose and basic sediments, rather than interbanded sediments and basic lava flows as postulated by Bateman.

No anorthositic intrusives are present, these rocks actually being altered calcareous sediments. A rock unit previously mapped as metagabbro is almost certainly another sedimentary hornblende-plagioclase gneiss. A pyroxenite intrusion is present on the shore of Cree Lake. However, its presence does not justify the concept of a related series of intrusives, the Cree Lake "Intrusives", since the anorthosite and metagabbro are no longer recognized.

The problem of whether the pre-Sherridon rocks belong to the Kisseynew gneisses proper or whether they represent older formations has been solved. There appears to be no unconformity at the base of the Sherridon group. On the contrary, a gradational contact between the Sherridon quartzites and the pre-Sherridon hornblende-plagioclase gneiss is found. Hence, the pre-Sherridon rocks do belong to the Kisseynew gneisses. They are not "......metamorphosed equivalents of older Archean formations." Rather, they are merely an early phase of the Kisseynew series.

By virtue of the findings mentioned above the original map (map 1 by Bateman) has been altered, so that map 2 by the writer contains the following changes:

1. Bateman's anorthosite is placed in the pre-Sherridon as impure crystalline limestone.
2. The "metagabbro" is placed in the pre-Sherridon as hornblende-plagioclase gneiss.
3. The oligoclase granite is placed at the top of the legend with the younger granite. The former has never been shown to be older.
4. As a result of the above changes no Cree Lake "Intrusives" are present in the legend, although the pyroxenite is retained.
5. The pre-Sherridon rocks are included in the Kisseynew gneisses.

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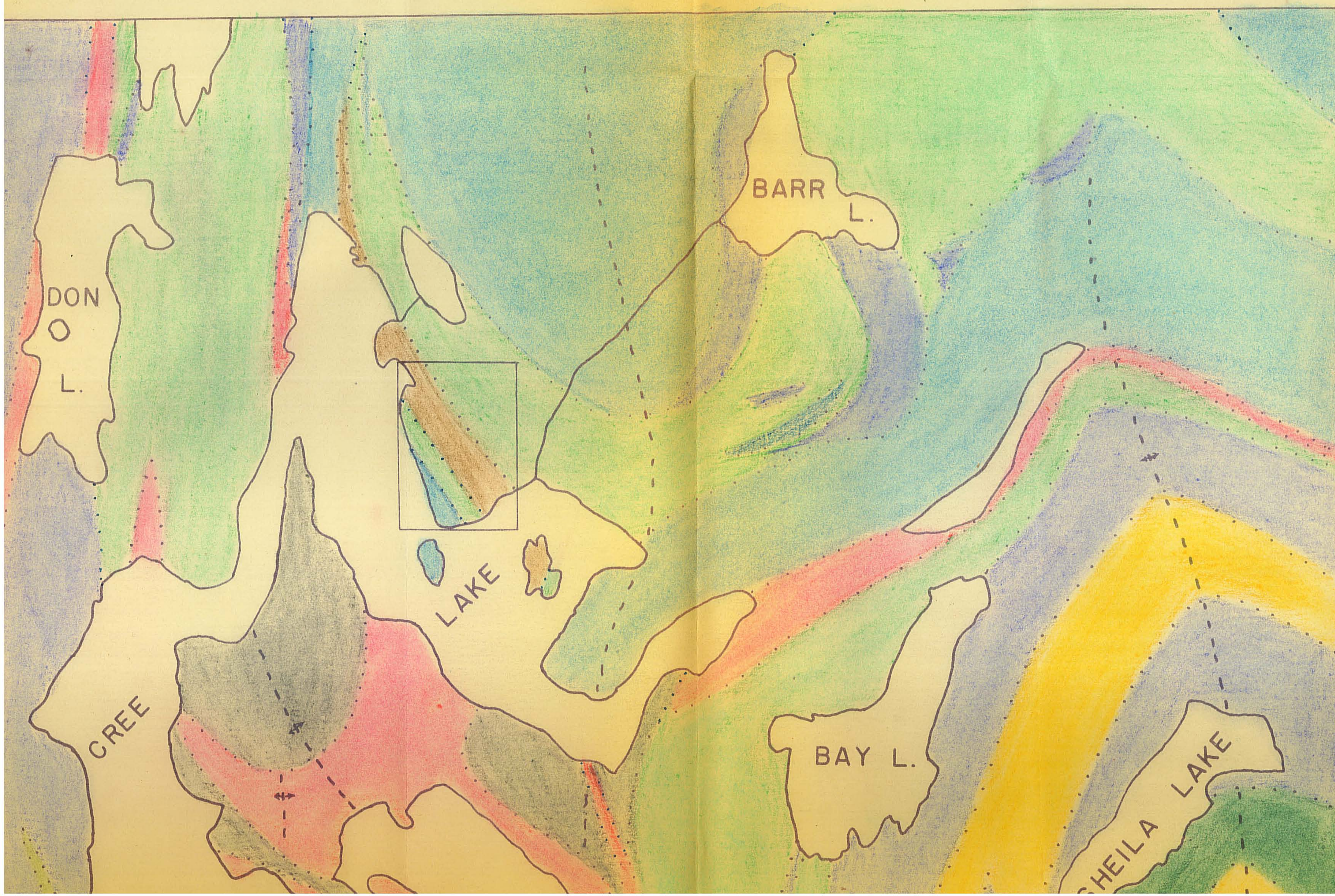
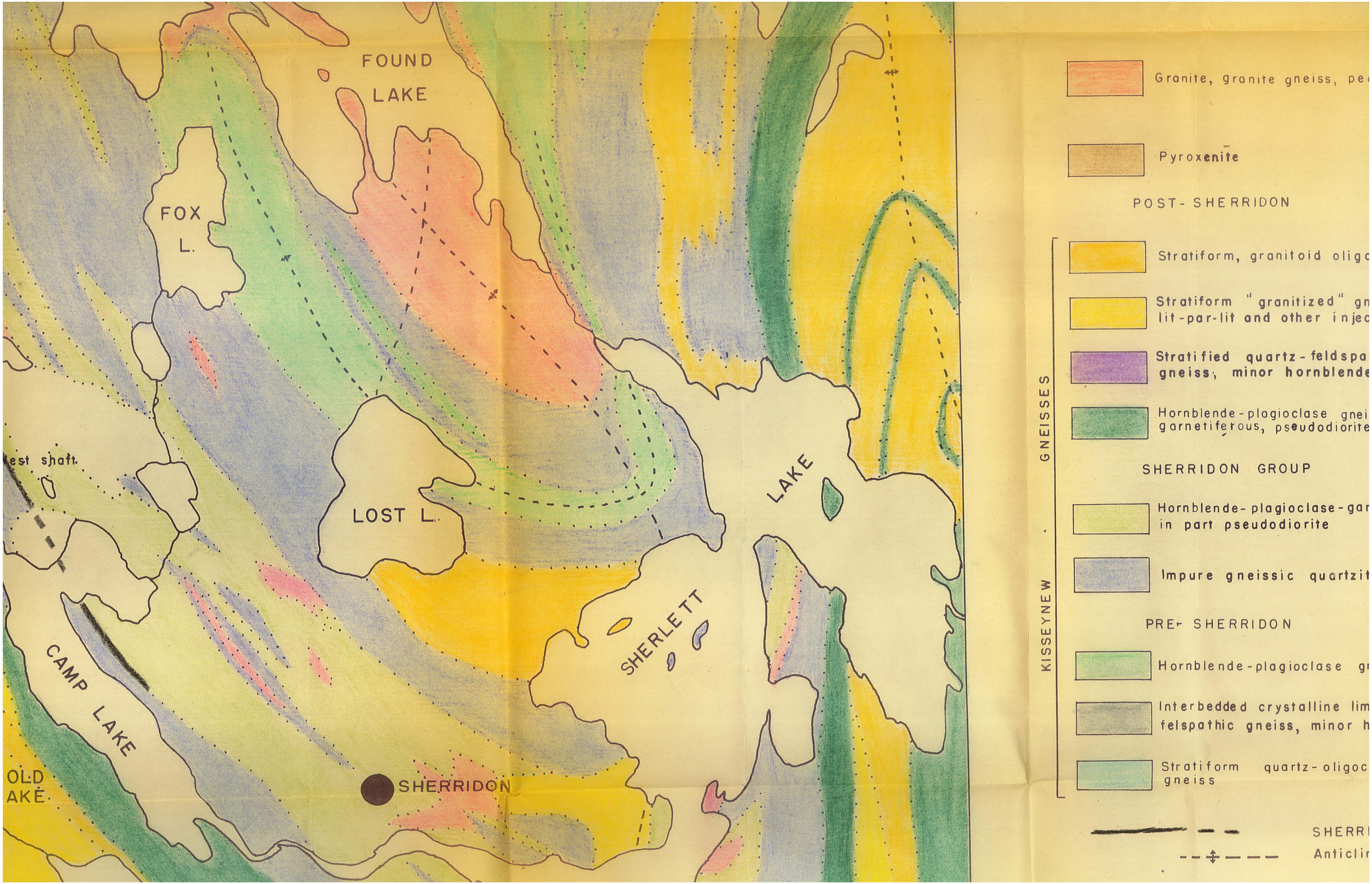


LEGEND


FOUND LAKE
FOX L.
LOST L.
SHERLETT LAKE
CAMP LAKE
OLD AKE
SHERRIDON
est shaft.
Granite, granite gneiss, pe
Pyroxenite
POST-SHERRIDON
Stratiform, granitoid olig
Stratiform "granitized" gn
lit-par-lit and other injec
Stratified quartz-feldspa
gneiss, minor hornblende
Hornblende-plagioclase gnei
garnetiferous, pseudodiorite
SHERRIDON GROUP
Hornblende-plagioclase-gar
in part pseudodiorite
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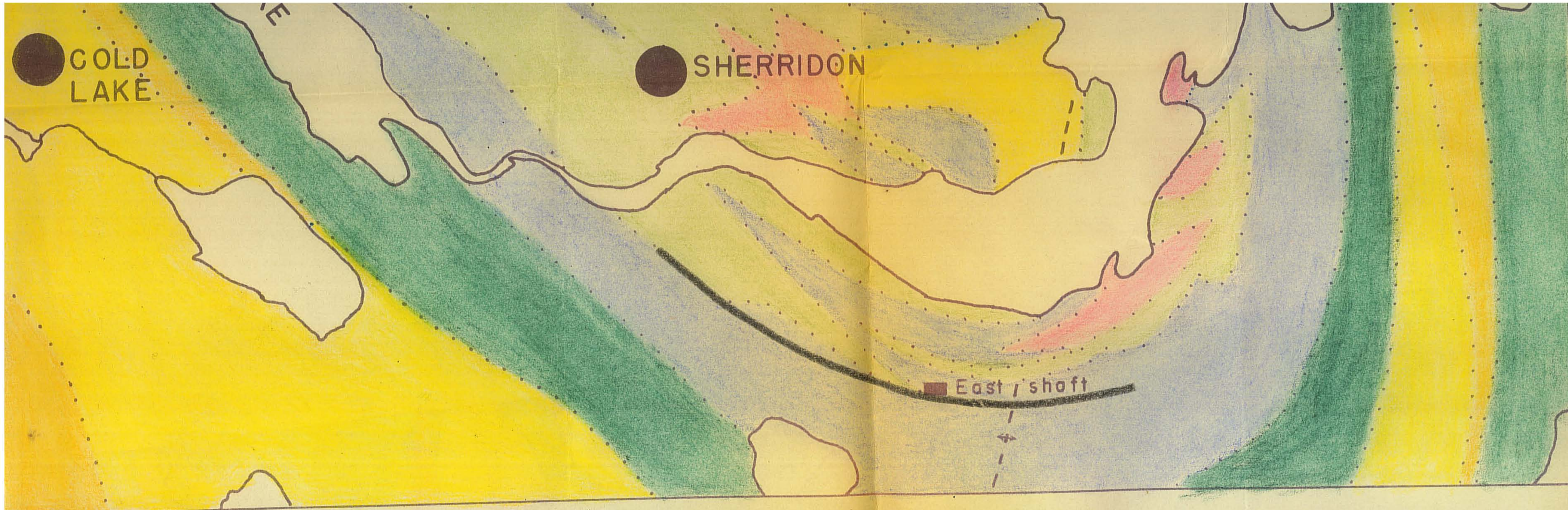

Stratiform quartz-gneiss

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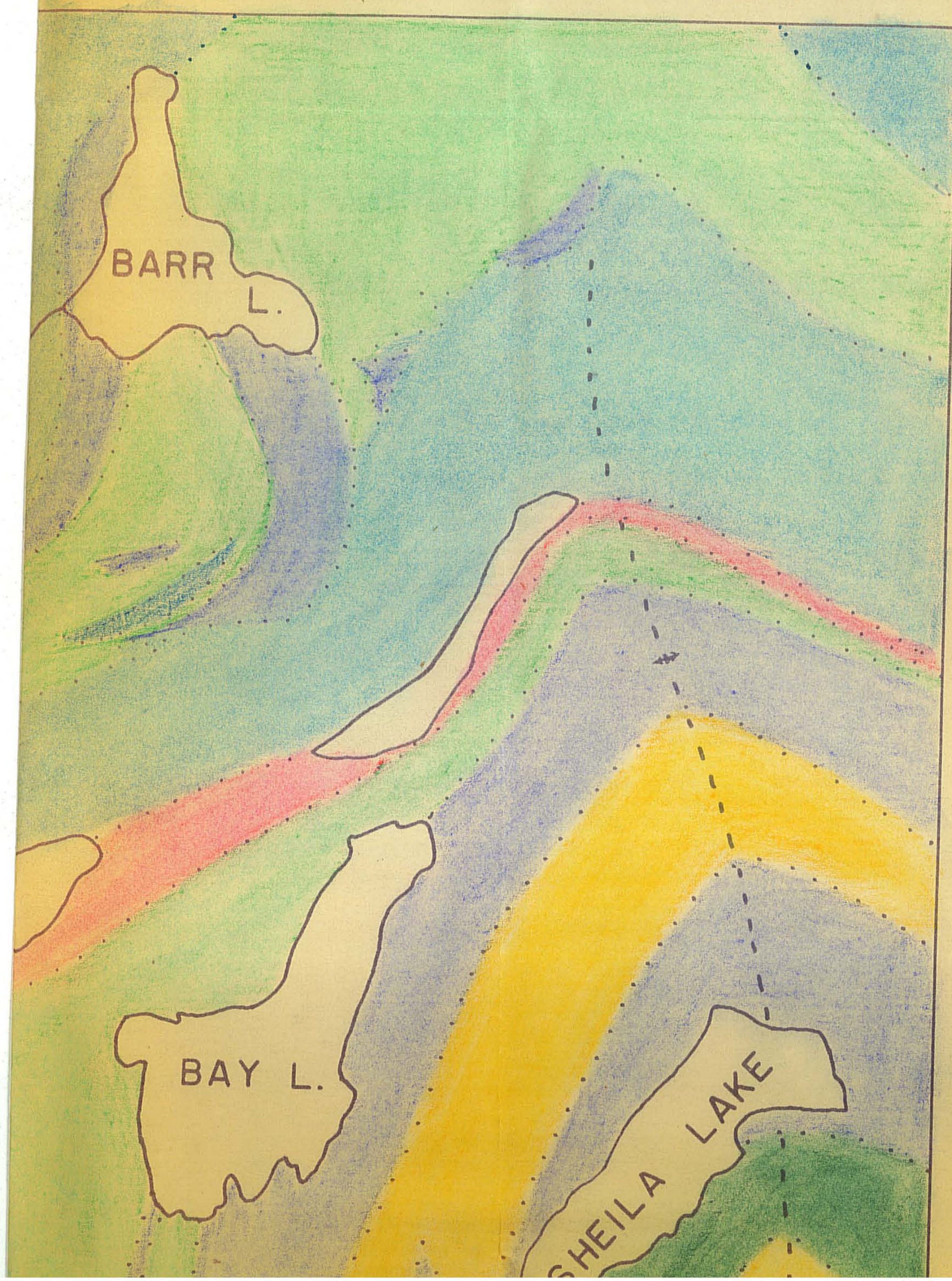
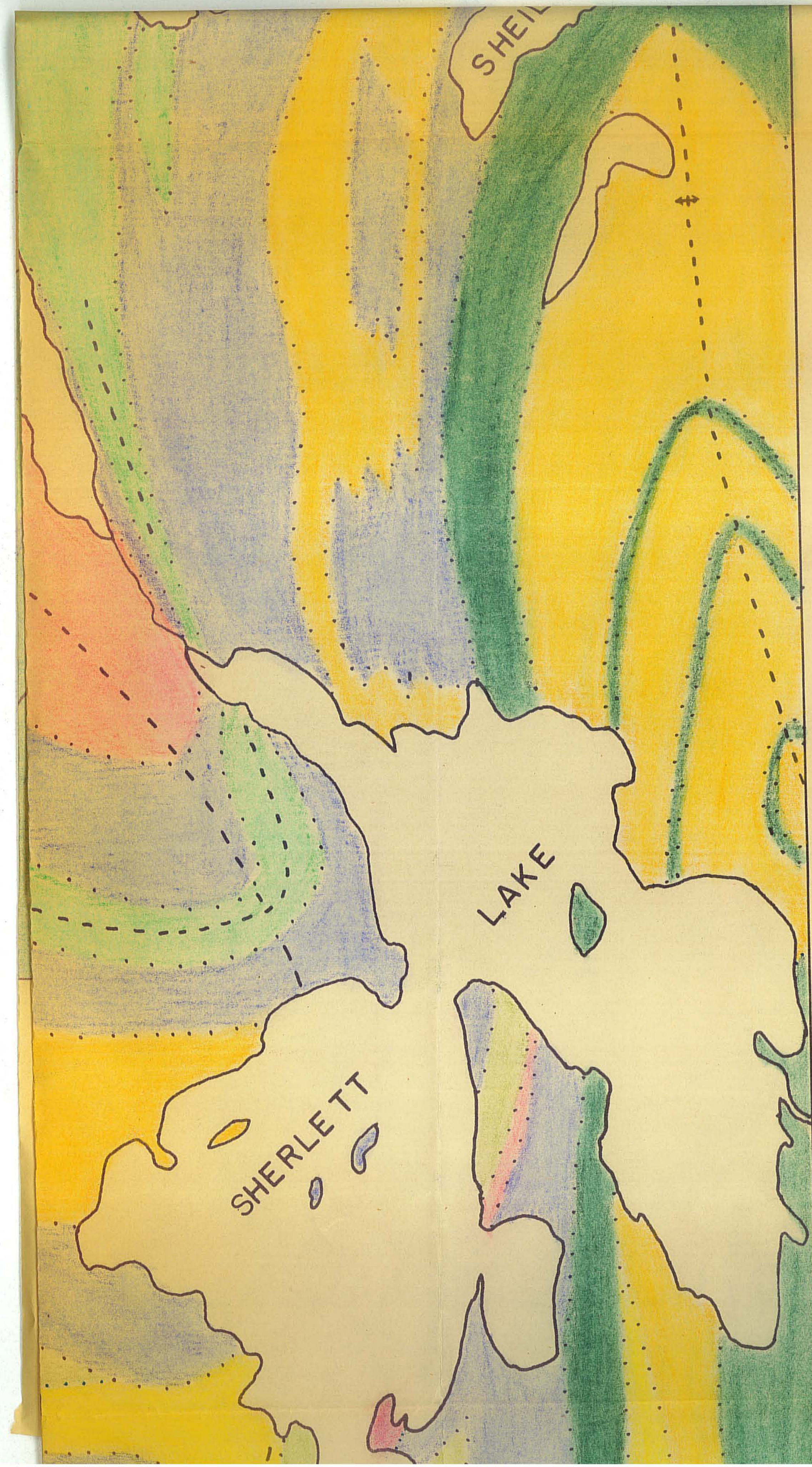
J.F. DAVIES SO THAT B
AND METAGABBRO ARE
SHERRIDON AS CRYSTAL
HORNBLENDE-PLAGIOCL

GEOLOGY SHERRIDON AREA

MAP 2.

Scale 1" = 1000'


BARR L.
BAY L.
SHEILA LAKE



LEGEND

Granite, granite gneiss, pegmatite

Pyroxenite

POST- SHERRIDON

KISSEYNEW GNEISSES

Stratiform, granitoid oligoclase - quartz gneiss

Stratiform "granitized" gneiss including lit-par-lit and other injection gneisses

Stratified quartz - feldspar - biotite - garnet gneiss, minor hornblende gneiss

Hornblende - plagioclase gneiss, in part garnetiferous, pseudodiorite

SHERRIDON GROUP

Hornblende - plagioclase - garnet gneiss, in part pseudodiorite

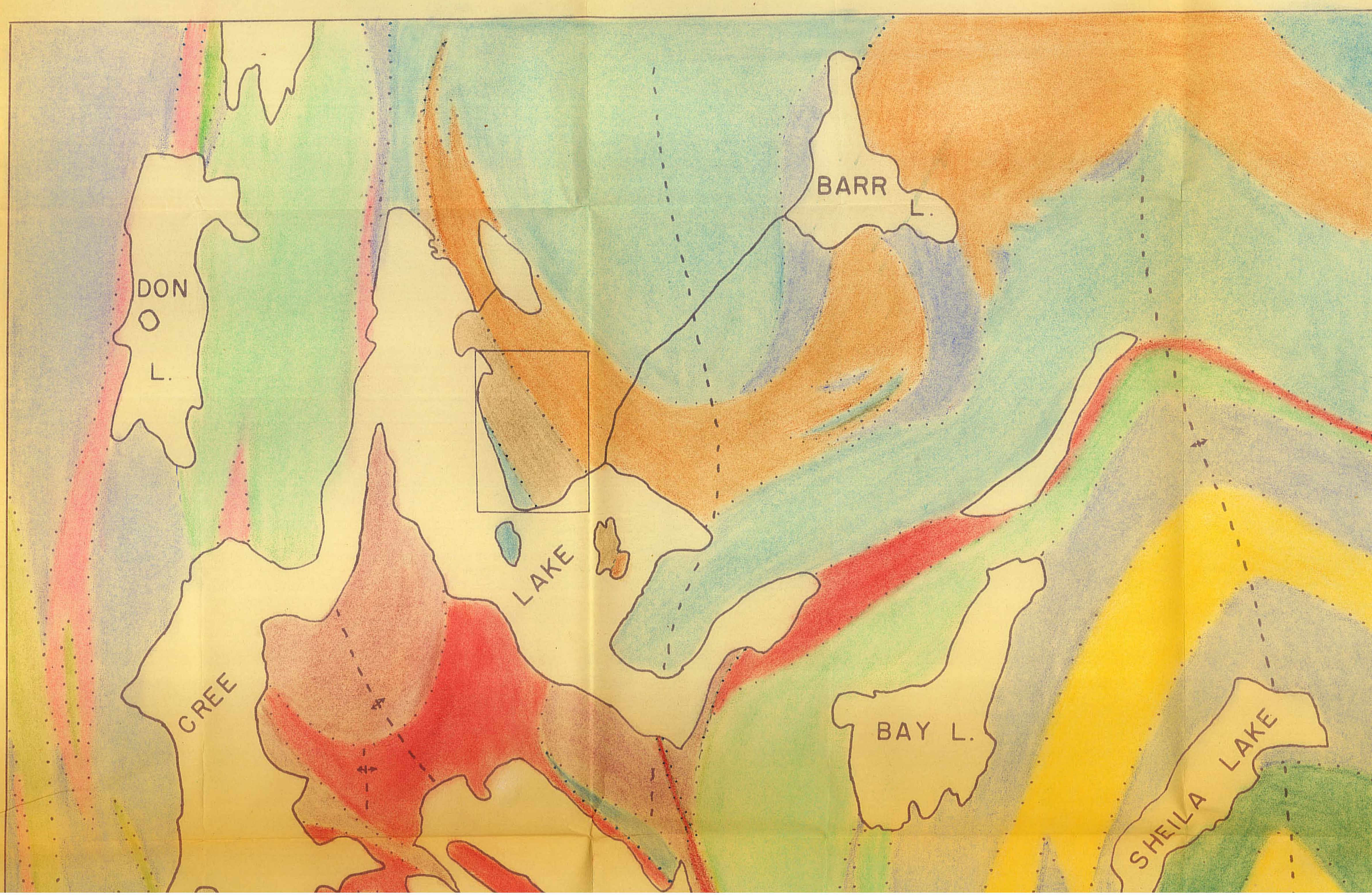
Impure gneissic quartzites

PRE- SHERRIDON

Hornblende - plagioclase gneiss, in part limy

Interbedded crystalline limestone (impure) and felspathic gneiss, minor hornblende gneiss

Stratiform quartz - oligoclase - garnet gneiss



eiss, Pegmatite

USIVE ROCKS

orthositic gabbro

metagabbro

DON

anitoid oligoclase- quartz gneiss

ranitized" gneiss including
d other injection gneisses

tz- feldspar- biotite - garnet
hornblende gneiss

plagioclase gneiss, in part
, pseudodiorite

GROUP

agioclase-garnet gneiss,
dodiorite

tzite, felspathic quartzite, biotite and
arinig quartzites, granitized equi-
hornblende gneiss and granite

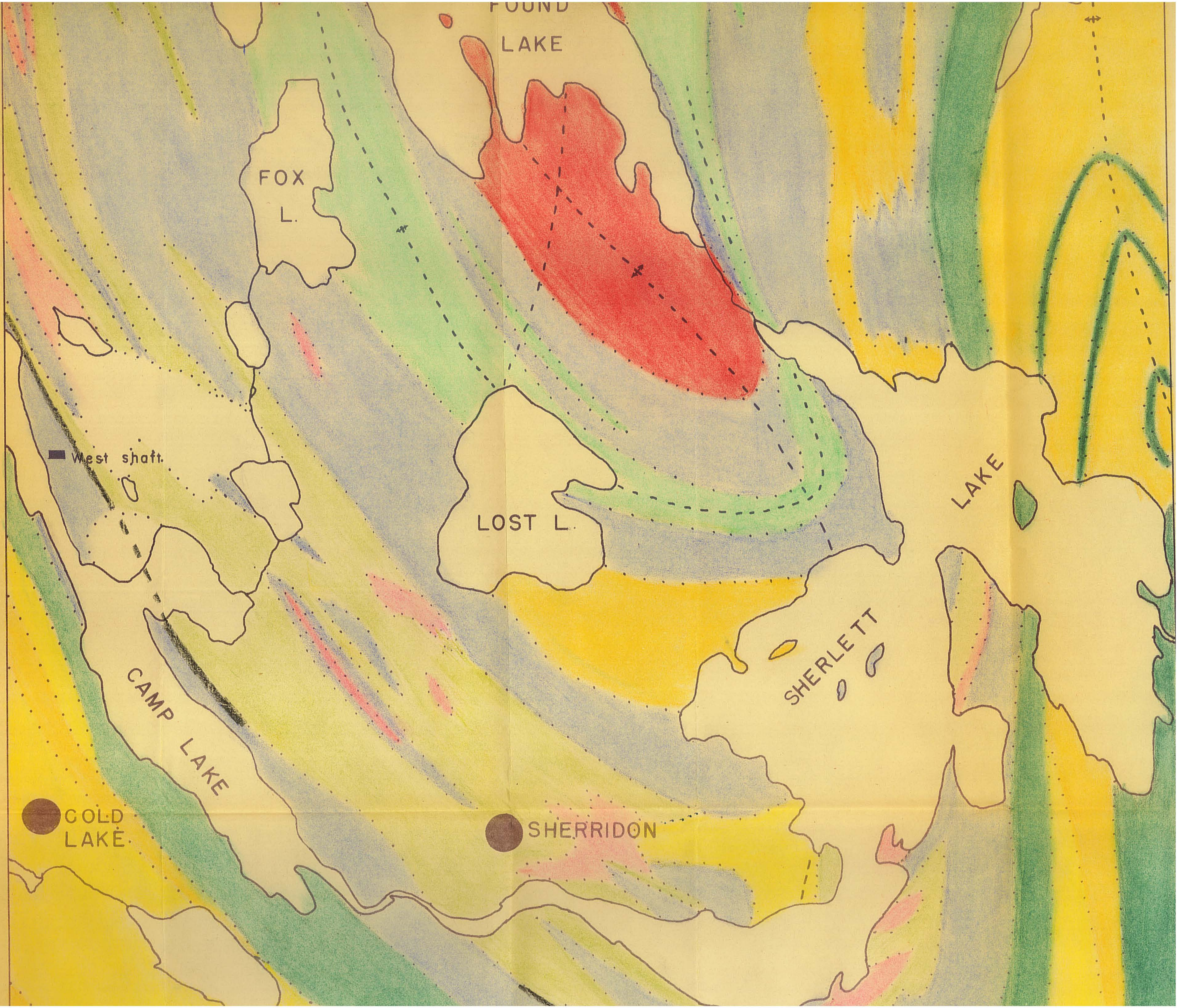
DON

lagioclase gneiss, pyroclastic
may be intrusive

artz-oligoclase-biotite-garnet

Sherritt-Gordon orebody

— Anticlinal axis



ase gneiss, pyroclastic
e intrusive

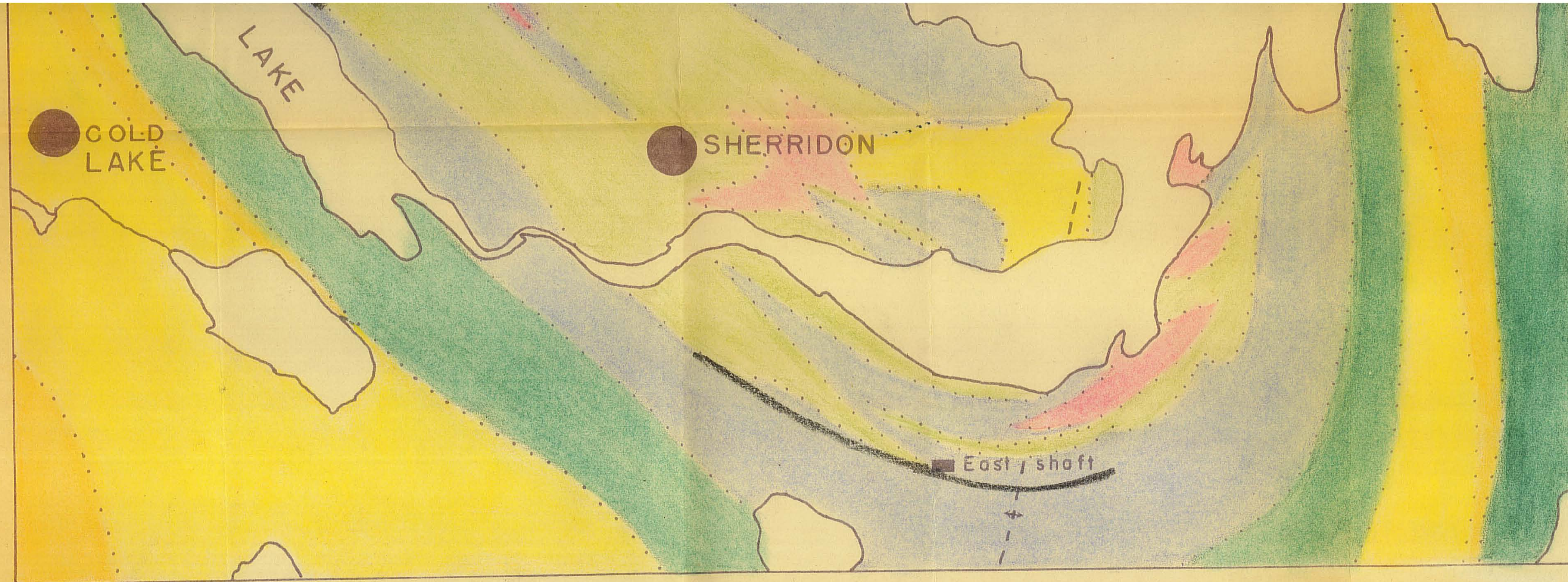
goclase-biotite- garnet

rritt-Gordon orebody

iclinal axis

ND ACCORDING TO

EMAN



MAP 1.

GEOLOGY SHERRIDON AREA

Scale 1" = 1000'

LEGEND

Granite, Granite gneiss, Pegmatite

Granite, Granite gneiss, Pegmatite

CREE LAKE INTRUSIVE ROCKS

Oligoclase granite

Anorthosite, Anorthositic gabbro

Garnetiferous metagabbro

Pyroxenite

KISSEYNEW GNEISSES

POST- SHERRIDON

Stratiform, granitoid oligoclase- quartz gneiss

Stratiform "granitized" gneiss including lit-par-lit and other injection gneisses

Stratified quartz- feldspar- biotite - garnet gneiss, minor hornblende gneiss

Hornblende - plagioclase gneiss, in part garnetiferous, pseudodiorite

SHERRIDON GROUP

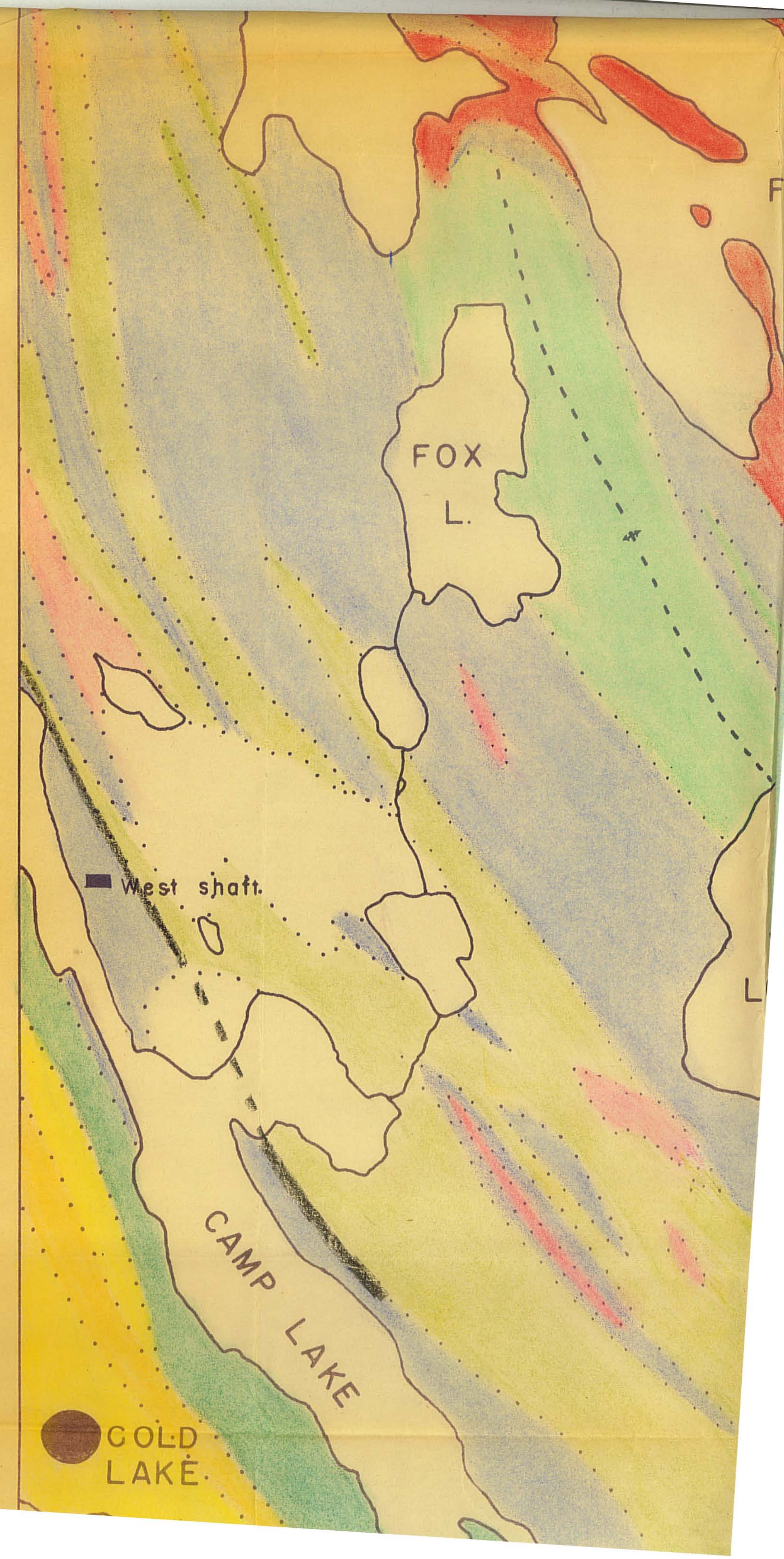
Hornblende - plagioclase - garnet gneiss, in part pseudodiorite

Gneissic quartzite, felspathic quartzite, biotite and hornblende bearinig quartzites, granitized equivalents, minor hornblende gneiss and granite

PRE- SHERRIDON

Hornblende- plagioclase gneiss, pyroclastic breccia; part may be intrusive

Stratiform quartz- oligoclase-biotite - garnet



Sherritt-Gordon orebody

Anticlinal axis

LITHOLOGY AND LEGEND ACCORDING TO

J. D. BATEMAN

MAP 1.

GEOLOGY

LEGEND