

MAP-AREA
WEST OF TIMMINS BAY, LAKE ATTIKAMAGEN,
LABRADOR.

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INTRODUCTION

The area to be described is situated in Labrador (latitude 54° 52' N., longitude 66° 30' W.) on the concession of Labrador Mining and Exploration Company. It lies just west of Timmins Bay, Attikamagen Lake, and covers an approximately rectangular area of a little less than $2\frac{1}{2}$ square miles. (See map, page 4).

The area is accessible from Knob Lake using the company's seaplanes, the distance being approximately 12 miles eastward.

The work consisted of detailed mapping at the scale of two hundred feet to an inch with the help of a plane table. Iron-bearing formation was traced out, particular attention being paid to the iron ore showings that had been discovered and staked around 1943.

The writer was assisted in the mapping by John Stubbins from Queen's University and by G. Lilly from Nova Scotia Technical College who handled the plane table.

The writer is also greatly indebted to Dr. J. E. Gill for his valuable criticisms and corrections of the present writing.

HISTORY

Iron-bearing formations have been known to exist in Ungava since the explorations of A. P. Low in 1895. Low predicted the possibility of occurrence of iron ore out of the vast amount of iron formations present in the Labrador Trough.

In 1929, important explorations were conducted by J. E. Gill on the iron formations of the Trough. Geological parties were distributed in the field where promising ground had been located from a quick aerial survey. As a result of this work a few deposits of high grade iron ore were discovered along with several enrichments especially in the Ruth Lake area but as far north as Irony Mountain.

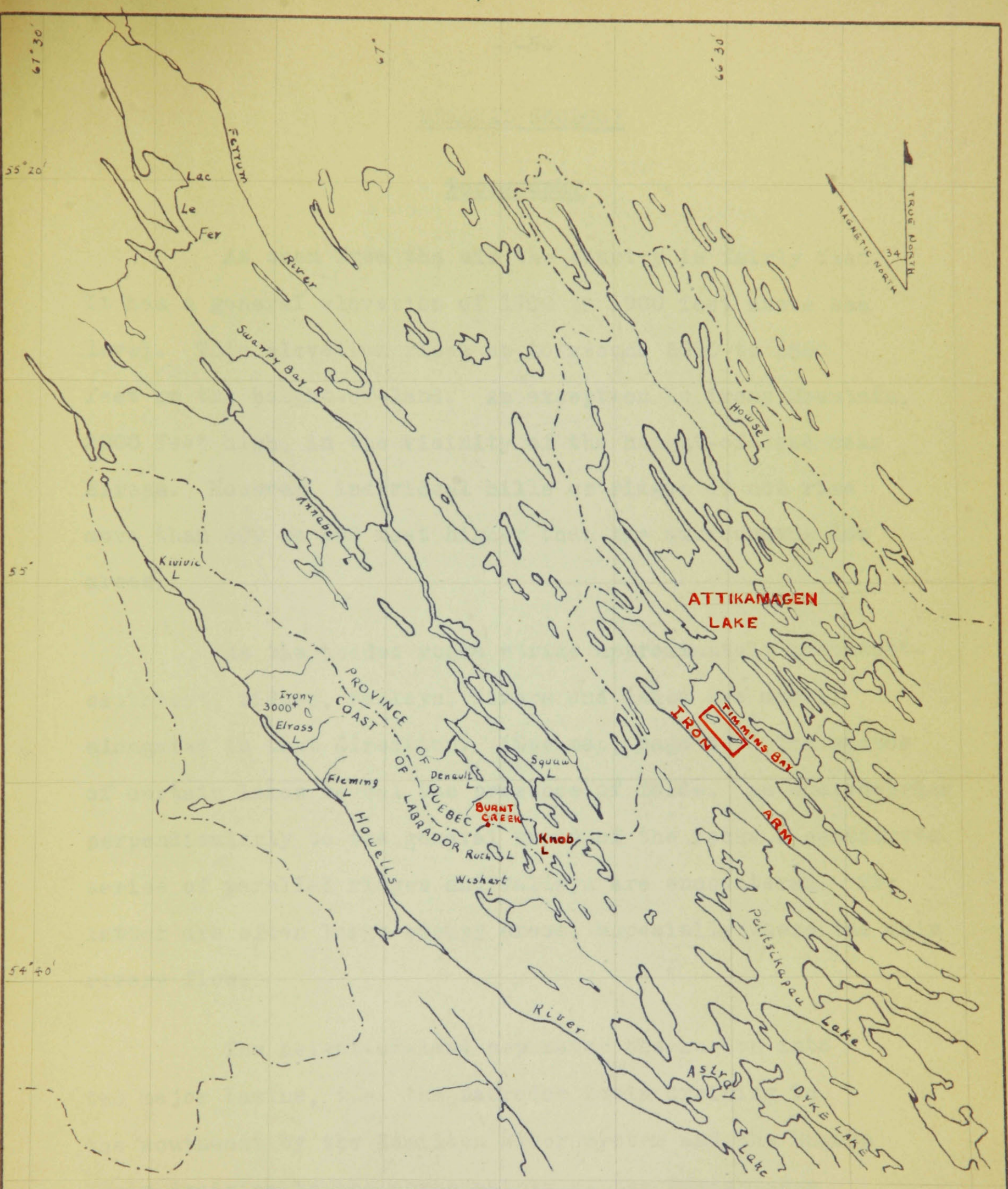
In 1942, other explorations were performed by Dr. Retty. These were financed by Hollinger Gold Mines. The previous discoveries around Ruth Lake were re-examined and because of the numerous enrichments of the iron formations in that area and in the vicinity, further work was considered worthwhile.

Because the region contained the Quebec-Labrador boundary which is determined by the height-of-land, two companies were incorporated: the Hollinger North Shore Exploration Company in Quebec holding a concession of 3900

square miles and the Labrador Mining and Exploration Company in Labrador with a concession covering 20,000 square miles. The M. A. Hanna Company of Cleveland took a minority interest in both.

Extensive development and progress have been achieved since that time. An air strip was built (11 miles east of Burnt Creek) along with a seaplane base at Knob Lake. All kinds of modern equipment and machinery were flown in from Mont Joli. Several roads were constructed. Buildings were erected at the camp site, Burnt Creek. Exploration and drilling have resulted in the proving up of over 550 million tons of iron ore. A railroad is now being planned in order to provide transportation from Burnt Creek to Seven Islands, a distance of about 350 miles.

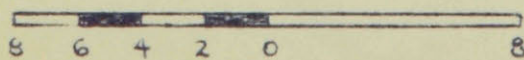
Regarding the history of the deposit to be discussed, called the Timmins Bay deposit, very little work was done after the prospector's discovery except for a few traverses by Dr. Retty and Dr. Moss who did exploration mapping. There was neither trenching nor pitting done in order to investigate the size of the deposit as was the case for most of the important showings of the "main ore zone". The main reasons being probably its distance from the camp site, the presence of the Iron Arm (a bay of Attikamagen Lake extending for about 15 miles southwest) requiring transportation by air and the limited amount of ore exposed.



PART OF DYKE LAKE SHEET —

QUEBEC - COAST OF LABRADOR

Scale: 8 miles to 1 inch



GENERAL GEOLOGY

Topography

As seen from the air the country is fairly flat. It has a general elevation of 1700 to 1900 feet above sea level. This elevation rises up to around 2600 to 2800 feet on the height-of-land. An exception is Irony Mountain, 3000 feet high, in the vicinity of the height-of-land near Elross. However, individual hills or ridges do not rise more than 600 to 800 feet higher than the surrounding low areas.

As the bedded rocks strike approximately northwest-southeast, ridges, valleys, rivers and lakes are mostly elongated in that direction. (See map, page 4). The shapes of certain lakes reveal the presence of folds. As one traverses perpendicularly to the general trend of the rocks a continuous series of parallel ridges and valleys are encountered. The latter are often large swampy areas, especially where the main rivers flow.

The height-of-land separates the region into two major basins, i.e. the Labrador basin draining to the southeast by the Hamilton River system and the Ungava basin draining to the north mainly by the Kaniapiskau River with important tributaries such as the Swampy

Bay River and the Goodwood River. Outside the Trough, which is about 50 miles wide, the drainage pattern becomes irregular and very typical of the Canadian Shield.

The whole country has all the characteristic features of a glaciated land. It has a disorganized drainage system exemplified everywhere by innumerable lakes, swamps and marshes. The rivers are very youthful with numerous rapids and falls along with lakes throughout their courses. Ground moraine contains boulders, gravel and sand material irregularly scattered, but often assuming definite shape such as eskers.

The vegetation in general is poor varying from unusually rich conifer forests close to the major streams to completely barren areas on the higher lands. Rock exposures are numerous along the higher parts of the ridges, these often showing nothing but bare rock on top. On the other hand, valleys are usually covered up with much glacial drift.

The general topography of the Labrador Trough has a low relief, generally less than a thousand feet. The Trough is only a small part of the Canadian Shield. As in other parts of the Shield the even sky-line is a striking feature. When considered in relation to the complex structure it shows clearly that peneplanation

occurred at some earlier date. In Labrador and especially along the borders of the Shield facing the Atlantic and the St. Lawrence Gulf, uplift has caused rejuvenation as shown by the main rivers which behaved like antecedent streams. Actually there may have been several uplifts, each followed by peneplanation as in the case of the evolution of the Appalachian rivers described by D. Johnson.¹ However, the present youthful character shows that peneplanation from the last uplift has not yet taken place. Superposed on this land surface were the effects of glaciation in remodeling the superficial topography. The present river system is parallel to the structure of the rocks although the apparent movement of the ice seems to have been transverse to this structure as seen from glacial striae. Thus, it seems that the general action of the ice on the land surface was not sufficient to change the pre-glacial northwest-southeast direction of drainage.

Rock Series

The "Labrador Trough" is marked by a belt of folded and faulted conglomerates, quartzites, dolomites, slates, iron-bearing formations and lavas. These are lenticular and therefore give rise to variable thicknesses. Their composition may vary locally but on a broad scale it remains essentially the same. The sediments

observed the previous summer along the Kaniapiskau River between the Swampy Bay and the Larch Rivers are similar to those around the Burnt Creek area. They are all made up of the different types mentioned previously with some additional and unusual horizon markers as in the case of the Chert Breccia around Burnt Creek. This latter region has a total lack of intrusives cutting across the sediments while there has been much igneous activity near the Koksoak River.

In the Burnt Creek area itself the series is as follows:

	(	Diabase dykes
	(	
	(	Menihek Upper Shales and Slates
	(	
	(	Sokoman Iron-bearing Formation
	(	
	(	Ruth Slates
Late Pre-Cambrian	-(	
	(	Wishart Quartzite
	(	
	(	Fleming Chert Breccia
	(	
	(	Denault Dolomite
	(	
	(	Attikamagen Lower Shales

- unconformity -

Early Pre-Cambrian -(Gneisses and Granites

The sediments rest unconformably on the old gneissic and granitic rocks outcropping just west of

Howells River. The series is also cut by infrequent diabase dykes such as the one present north of Astray Lake (southeast of Burnt Creek). There are local minor variations in the series, such as the appearance of a band of chert about 15 feet thick above the Wishart quartzite at Elross and an unusually well-developed dolomitic breccia at the base of the Denault dolomite at Slimy Lake.

Structure

As already mentioned the sediments of the "Trough" are folded with axes generally striking north-west.

In the Burnt Creek area there is a predominant eastward dip. The normal sequence of the formations and criteria for determining top and bottom such as cross-bedding in quartzite show that many west limbs of anticlines or east limbs of synclines have been overturned with resulting eastward steep dips. Thus, open folds are rather rare but not completely absent. Entire sections tilted toward the east are repeated across the strike of the rock, showing that the beds have been bent into overturned folds and, in some instances, cut by thrust faults.

The major strike faults are rarely seen in the field, as the surface outcropping of the resulting planes of weakness are represented today by depressions or deep valleys. Excavations that have reached below the overburden have, however, revealed the presence of gouge and breccias in places where faulting had been assumed. Cross-faults are also present but on a much smaller scale. These have produced strike separations of 100 feet or so.

The Chert Breccia, the quartzite and the jaspery phase of the iron-bearing formation stand up fairly well to erosion and usually form the most prominent ridges.

The Ruth slates along with the lower and upper shales and slates are the most folded formations. They show numerous drag folds that are often useful in working out the structure.

Ore Deposits

The area containing the important commercial deposits has been called the "Main Ore Zone". It extends from Astray Lake to Eclipse Lake, a distance of 70 miles in a north-west direction and has an average width of about 15 miles. The Sawyer Lake orebody about 40 miles further south is outside this zone.

This zone is characterized by numerous enrichments in the iron-bearing formation, especially in the Ruth slates and Sokoman chert. Locally, this enrichment has formed ore. Prospecting is rather difficult and deceiving, as small outcrops of ore may reveal the presence of deposits of variable size especially where overburden assumes importance.

The ore is genetically related to the iron-bearing formation proper i.e. it is not encountered in any other formations. It is often very irregular in shape and does not appear to be controlled wholly by definite structure of the rocks such as bedding and folding. Beds highly enriched in one particular place may be completely barren farther away along the strike. Leaching, replacement and migration processes must have been important.

The ore is either hematite or goethite with an average iron content of about 59%. It may range from an extremely hard and compact hematite as in the case of Sawyer Lake deposit (about 68% Fe) to a porous goethite or hematite. Manganese is very often associated with the iron. It then forms manganiferous iron ore (about 7.5% Mn) and rarely very small manganese deposits.

Drilling with churn drills and diamond drills has been conducted on a large scale in order to determine

the size and depth of ore discoveries. Bulldozers, electric shovel and hand pitting have also helped in determining their extent. Since 1946 about 350 million tons of ore have thus been proved.

In both Quebec and Labrador the main deposits so far discovered are, namely: Eclipse, Sunny, Goodwood, Kivivic, Elross, Fleming, Star Creek, Ferriman, Ruth Lake, Wishart, Burnt Creek, Denault, Knob and Sawyer.

GEOLOGY OF THE AREA

Topography

The area presents a maximum relief of about 290 feet, the lowest level being Lake Pterodactyl (elevation: 1770 feet) and the highest ground (elevation: 2060 feet) the hill just northwest of Lake Joyce. Varying in height between these two levels are fairly continuous ridges following the structure of the rocks and elongated in a northwest-southeast direction. There are two principal hills or knobs standing out 40 to 60 feet from their adjacent lower grounds as for example the one near the central part of Lake Pterodactyl. Unusually steep slopes mostly covered by talus, as on the west shore of this same lake, rise to a height of 170 feet in a horizontal distance of about 400 feet (a gradient of 2244 feet to a mile).

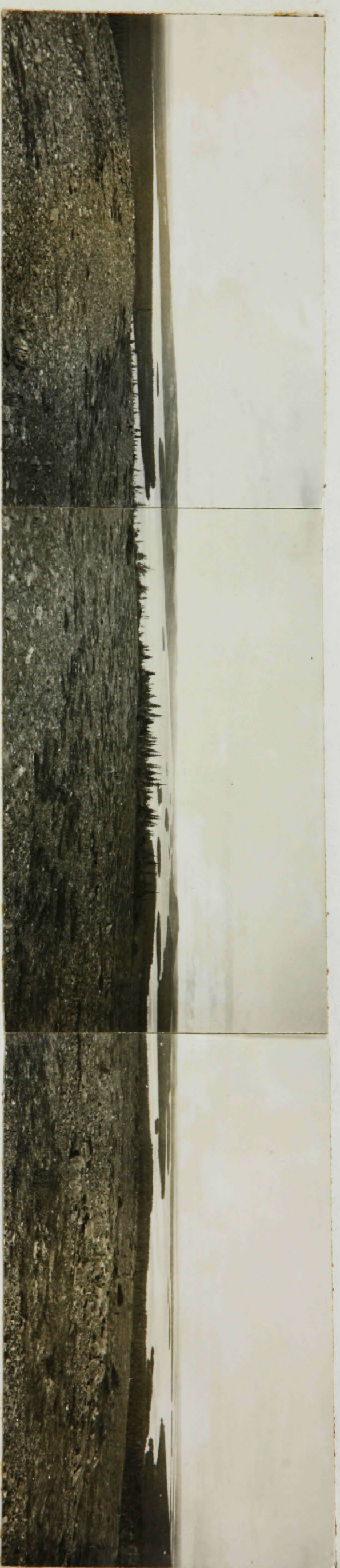
Lake Pterodactyl and Lake Joyce constitute the main bodies of water within the area. There are also a few small swamps. Outside the area and surrounding it, except for the southeast part, is Lake Attikamagen (Timmins Bay to the N.E., the Iron Arm to the S.W. and the main body of the lake to the N.W.). Lake Joyce has no outlet except early in spring when it overflows southeastward. Many of the small ponds become dry by August. At the bottom of one in particular (500 feet by

200 feet in surface area and about 10 feet in depth at high level) glacial drift was found to be fairly well cemented. The cementation is most likely the result of residual salts from evaporated water.

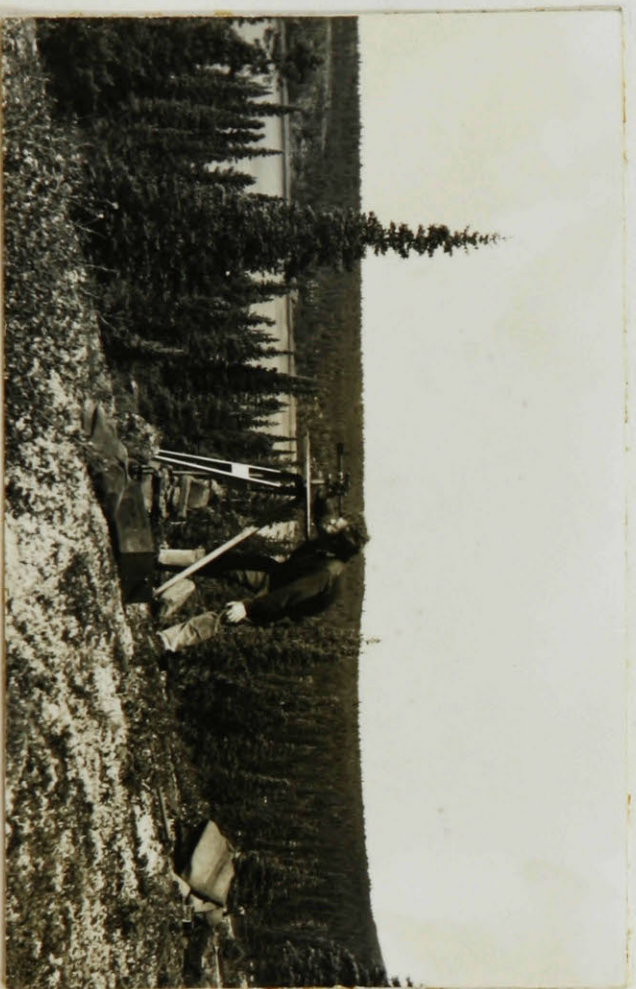
Widespread till deposits and numerous eskers indicate that the whole area has been glaciated. Till has filled in many depressions and covered several slopes and flat upper ground. Also, scouring action of the glaciers on rock surfaces has left glacial striae. These are best exposed on argillite outcrops. Two or three sets of striae can usually be distinguished, though the one that is best developed strikes about northeast, i.e. nearly perpendicularly to the orientation of the topography. As a few boulders of the Chert Breccia formation typical of the Burnt Creek area (15 miles to the west) have been noticed it is probable that the movement was northeastward.

Concerning the vegetation, the ground is mostly covered by cariboo moss. Spruce, tamarack and alder grow best near lakes and gradually die out as the upper barren ground is reached.

Lake Attikamagen - the Iron Arm at the extreme left.
Looking northwest from the highest hill of the area.



In the left foreground: argillite outcrop, to the right: lower quartzite.



Lake Joyce (looking west).
Mapping by plane table and
telescopic alidade.

Geomorphology

The land and lake forms are closely related to the underlying structure of the rocks and also to the varying degree of resistance to weathering of these same rocks.

Lake Joyce has its basin in a closed syncline plunging at about 35 degrees southward near its nose. The northwest-southeast elongation of the lake is only at about 15 degrees to the axes of the fold. Lake Pterodactyl has its peculiar shape because it is the site of both an anticline and a syncline and also because of the different hardnesses and solubilities of the formations making up this local structure. As for Lake Joyce, the northwest bay of Lake Pterodactyl occupies the northern part of a syncline plunging 20 to 25 degrees southward. Similarly, the northeast bay faces the nose of the anticline beautifully displayed by the resistant argillite formation rising in a hill a hundred feet high. The bay itself, however, is most likely underlain by less resistant rocks such as the slaty and the thin-banded iron formation. On the other hand, where the less vulnerable jaspery and magnetite silicate iron formations outcrop along the same axis, a hill, advancing into the lake, stands out.

Both ridges and valleys correspond roughly to anticlinal and synclinal axes. An exception, however, is to be found in the southeastern part of the area where the upper slates form a hill even though they are synclinally folded. Generally, then, we may say that the relief was not inverted, i.e. synclinal ridges and anticlinal valleys are uncommon.

As to the physiographic history, the area is much too small to draw any general conclusion. The present low relief indicates intense erosion and the recent glaciation has brought slight modifications to the topographic forms.

Petrology

The rocks found in the area are of types indicated in the following table, which also shows their age relations.

Table of Formations

Quaternary -(Pleistocene Glaciation

-unconformity-

		Thickness in feet
Late Pre-Cambrian	(Upper Slates.....	180 - 200
	(	
	(Sokoman Chert...	70 - 80
	(Jaspery Iron	
	(Formation....	230 - 230
	(Iron-bearing (Magnetite-sili-	
	(Formation -(cate Iron Form..	65 - 70
	(Thin-banded	
	(Iron Formation..	290 - 290
	(Slaty Iron Form.	25 - 30
	(	
	(Upper Quartzite.....	100 - 120
	(	
	(Argillite.....	80 - 100
	(	
	(Lower Quartzite.....	60 - 80
Total thickness.....		1100 -1200
Iron-bearing Formation.....		680 - 700

Description of the Formations

Lower Quartzite

Fresh surfaces of this quartzite are light grey, brown or pink - pink being the most widespread colour. The weathered surface is greyish to reddish.

The rock is rather massive and bedding is often hard to distinguish. The grain size ranges from a fraction of a millimeter to two millimeters.

A thin-section revealed quartz grains cemented together by secondary silica having crystallized in optical continuity. In the available interstices, between these cemented quartz grains, hematite and limonite have been introduced. Associated with the quartz are feldspar fragments making up about 25% of the rock. Cracks in those feldspars have also been filled with hematite and limonite. Alteration of the feldspars to sericite has occurred locally. (See Plate 1).

This lower quartzite, solely on evidence of its composition and appearance, could not be differentiated from the upper quartzite on top of the argillite though its definite feldspar content and its usual pink colour are fairly constant. What

complicates the situation is the fact that these last mentioned characteristics are also to be found in some beds of the other quartzite. The separation was made mainly on structural grounds and the sequence of rock layers.

Only the upper beds of this lower quartzite are observable in the field as erosion has not yet eroded deep enough to uncover its base. The average thickness of that portion as deduced from the few exposed sections is around 60 to 80 feet.

Argillite

This formation can be separated into two distinct units in the field: the lower banded facies and the upper massive argillite proper. The lower facies 30 to 35 feet thick has well-defined bands assuming different colours from greenish, yellowish, light and dark grey to different shades of red. These color variations take place over rather small thicknesses of beds, i.e. a fraction of a millimeter to a few millimeters. The weathered surface has less brilliant contrasting colours.

The upper facies of the argillite proper (the remaining 50 to 65 feet) has a more uniform composition and texture. Its grey or greyish green

interior colour is transformed outwardly to a darker or brownish green on the weathered surface. It is extremely fine grained. Being quite massive, the bedding is not particularly apparent unless it is looked for very carefully.

Under the microscope these rocks are seen to be made up chiefly of fragmental quartz and feldspar with occasional biotite and muscovite, the whole embedded in a light green matrix. This matrix is extremely fine and it was identified as being most probably chlorite. (See Plate IV). From this composition (especially the presence of quartz) and the grain size averaging 1/16 to 1/10 of a millimeter, it appears that the rock is not a true argillite but rather a siltstone. There are also iron oxides (hematite and limonite) of mostly secondary origin as deduced especially from the examination of the more quartzitic beds in the lower facies. These, in hand specimen, show a reddish stain not restricted to bedding planes but cutting across.

In the lower facies some slightly folded beds (4 or 5 mm. thick) were observed to be in contact with adjacent unfolded laminae of much the same composition. This structure is probably the result of

deformation in an unconsolidated state (such as mud slipping on a gentle slope because of gravity).

This whole formation stands up amazingly well to erosion as it now constitutes the most prominent hills. The outcrops have been smoothed out by the action of the moving ice and abundant glacial striae have been observed on such outcrops.

Upper Quartzite

This quartzite is definitely less arkosic than the lower one and usually finer in grain (1 millimeter or less).

The lower greenish beds, some 15 to 20 feet in thickness are more like a graywacke with a grain size slightly coarser than that of the underlying argillite. One thin-section has revealed the following characteristics. The rock is composed mainly of quartz and feldspar fragments (and biotite) in a fibrous or platy chloritic groundmass. The chlorite shows a tendency to assume the shape of the fragments it surrounds (while being mostly elongated parallel to the bedding) and to penetrate into cracks. This gives a fringy boundary to the fragments. (See Plate III). Secondary iron solutions have infiltrated between beds as seen by extremely fine limonite

(a gradation between limonite and goethite) with similar optical orientation and extinction in the same direction as bedding. This preferred orientation parallel to the bedding of both chlorite and limonite would seem to suggest a rearrangement or regrowth in the direction of least resistance. Some chert (finely crystalline quartz) fragments are also present as well as a few unusually large detrital quartz grains with well-rounded shape (4 or 5 times the surrounding average grain size). These most probably have been transported from a much more distant source.

The remaining 85 to 100 feet of the formation constitute the upper quartzite proper. The colour cannot serve as a guide for indicating definite horizons as it varies through different shades of grey, brown and red.

The study of two thin-sections has revealed a cherty cement between the quartz grains. Part of this cherty cement has recrystallized around the quartz grains with optical continuity. A very thin film of remaining chert now indicates the former outline of the grains. (See Plate II). In arkosic beds the feldspars are partly decomposed (with traces of sericite in the case of potash-rich feldspars)

and much cracked. Chert grains are not uncommon. Biotite is also present in small quantity and seems to be associated with some fine chlorite. Of particular interest is the secondary iron that has been introduced, now represented by hematite and limonite. The secondary origin is obvious from hand specimens as the brown or reddish stain has no definite orientation and shape. It has no relation with the bedding as it cuts this latter irregularly. Furthermore, microscopically the iron is seen to have been infiltrated in the available space at the contact between interlocking cemented quartz grains. This stain is very widespread in the youngest beds of the formation.

Cross-bedding has been occasionally observed in this quartzite. Its use for determining top and bottom was considered to be reliable in a few places.

Iron-bearing Formation

Slaty Iron Formation

These ferruginous slates have been observed in the field at only seven different places. Being very soft and friable they outcrop rarely. They may vary in thickness from 25 to 30 feet. From the few possible observations the slates showed most commonly a parting parallel to bedding. The thickness between successive parting planes ranges from a

fraction to one centimeter. Resulting slabs lie irregularly scattered over the surface. Correct attitude of the beds is therefore difficult to find. The beds are extremely fine and are made visible from changes in hematite content. The colours alternate from pale reddish grey to darker red. The weathered surface is brown or more generally hematite red.

At one particular place a small outcrop (a few square feet) of these slates revealed dark greenish grey pyritic beds. The pyrite seems to be distributed along bedding planes only and is more coarsely crystallized than ^{the} argillaceous matrix. This may suggest a secondary origin. The weathered surface of the rock has a rusty colour. These beds (only a few feet) are most likely the bottom of these slates. At no place, however, could a whole section be observed so that only on scattered information can ~~the~~ the succession be reconstructed. This slaty iron formation has been markedly enriched locally. The rock is then much heavier because of the greater concentration of hematite. This was observed in the little syncline in the northern extremity of the area. There were no natural outcrops so this enrichment was seen only where the overburden had been stripped off.

The ferruginous slates are in the same stratigraphic position as the Ruth slates of Burnt Creek area. The very small thickness would be accounted for by the fact that all these sediments are quite lenticular over relatively large areas.

Thin-banded Iron Formation

This facies of the iron formation is the most important economically speaking as it is the one containing numerous enrichments locally reaching ore grade. It is also a very prominent member as its thickness is around 290 feet. It outcrops fairly persistently along its strike.

Its most outstanding characteristic is its colour bands varying through white, yellow, brown, blue and red. The colour bands mark groups of beds generally from two to five millimeters thick. (See Plate XVIII). The white bands are made up of chert; the yellow, chert with finely disseminated iron oxide most probably in the form of limonite; the brown, chert with limonite and crystalline goethite in variable proportions (See Plate XII); the blue, crystalline hematite in rather large concentration in comparison with the chert groundmass; and finally, the red bands made up of granular or earthy hematite.

The brown bands often have no other contrasting colours but different shades of brown so that the banding character is not so apparent. In such bands, parting planes result in layers $\frac{1}{2}$ a centimeter or less in thickness. These layers break down in slabs as does the underlying slaty iron formation. On the other hand, some adjacent bands may have widely spaced parting (10 to 15 cm.). Beds occasionally present structures which most probably have originated from deformation in an unconsolidated state. Laminae 2 or 3 mm. thick are displaced with resulting miniature grabens (about 5 sq. mm. in cross-section). Slipping and folding, also in millimeters, are present.

All of the thin-banded iron formation has an extremely fine grained texture. If it were not for the different contrasting colours and the limited number of constituents, namely silica and iron oxides, the identification of minerals would be rather difficult. Coarser textures are represented by recrystallized iron oxides associated with high enrichment, e.g. fibrous radiating goethite with external botryoidal shape, or specular hematite often arranged in "rosettes" when filling cavities.

Of eleven polished sections from this type of iron formation not one revealed the granule texture so common in the jaspery beds.

Magnetite Silicate Iron Formation

These beds outcrop most extensively east and west of Lake Pterodactyl. They may have a total thickness of 65 to 70 feet. This estimate, however, is approximate since the formation generally shows several minor folds or drag folds.

The oldest beds are dark green and weather brownish green while the youngest beds are more bluish. A dark bluish stain is always present on the walls of fractures. The rock is fine grained and bedding is often more apparent on the weathered surface.

The composition as seen in 2 thin-sections is chiefly fine light brown needles (irregularly oriented or in radiating clusters) showing strong pleochroism and parallel extinction and identified as stilpnomelane or perhaps minnesotaite. Euhedral magnetite is quite common and is concentrated mostly along bedding planes. The hand specimens are strongly magnetic. Minor quantities of chert constitutes the groundmass, some arrangements suggesting a granule texture. (See Plate VIII). The youngest

beds contain needles about a millimeter in length of the amphibole, riebeckite. Chert and magnetite are more abundant here than in the underlying strata. (See Plate VII).

It is quite surprising that these beds do not outcrop in the northern and central part of the area. On reaching the right stratigraphic position, as indicated in a few places by the beginning of the jaspery formation, it was found that the beds resemble more the upper part of the thin-banded strata.

Jaspery Iron Formation

This most resistant member of the iron formation is about 250 feet thick. The weathered surface is either brown or red. The beds on the fresh surface have colours varying from greyish blue to reddish according to the predominance of hematite, magnetite and jasper respectively. The formation has a characteristic granule texture well-defined in some beds, but in others very faint and rather hard to decipher especially where there is a greater concentration or enrichment in hematite. The grain size corresponds to the size of granules, usually $\frac{1}{2}$ to 2 mm. but much finer where hematite is in abundance.

Six polished sections and three thin-sections revealed the microscopic details of the granule texture. The groundmass is made up of chert either transparent or reddish (then containing fine hematite and called jasper). The granules are also composed of chert with a variable quantity of hematite either uniformly or most commonly irregularly distributed. The granules, however, are aggregates of these minerals and possess an external rounded outline resulting from their mode of origin. This outline is often very clear, as when there is a segregation of hematite around the margin or when the composition between matrix and granule gives sharp contrasting colours normally red and white (or colourless). (See Plates V, VI and XIII). The boundaries may also be discontinuous because of tension cracks developed during dehydration and crystallization. The cracks are filled with chert coarser than the matrix. Several different patterns may be seen in the granules such as flocculent arrangement of jaspers² and polygonal or circular masses of reddish chert with darker nuclei near the center³.

Magnetite is also quite common. It is euhedral with octahedral crystal faces. It is easily recognized in reflected polarized light by its grey colour, its octahedral outline and isotropism. Hematite

possesses a brilliant white colour and is anisotropic. The streak, magnetism and natural colour along with etching reactions also help in the identification. The magnetite appears to have originated after the formation of both granules and matrix as crystals have grown across both and often contain inclusions of adjacent minerals. (See Plates XIII, XIV and XVI). The same seems to be true of very fine transparent needles, most probably an iron silicate like colourless minnesotaite, observed mostly in the matrix but also in the granules or projecting from one into the other. Needles of brown goethite and red hematite were also noticed, most likely oxidation products of the iron silicate. (See Plate V). Magnetite is much oxidized to hematite and this latter is often distributed along octahedral planes especially near the outside crystal boundaries⁴. (See Plates XV and XVI). The hematite also assumes other irregular patterns within the crystals. (See Plate XIV).

Oolites have also been observed. These are constituted of a granule core made up of chert or jasper with surrounding concentric cherty layers of variable hematite content. One oolite composed of two individual smaller ones has even been noticed from a study of a polished section. Another polished section and the corresponding hand specimen have the appearance

of an intraformational conglomerate. Many of the spherites and granules are angular and partly broken. Both may also be contained in much larger sub-angular cherty fragments up to two centimeters across. This intraformational conglomerate is about ten feet or less in thickness and is situated stratigraphically near the base of the jaspery formation.

Quartz veins up to two inches thick have been noticed in the field at various outcrops of the jaspery formation. These nearly always contain specular hematite in platy crystals averaging one millimeter in size. One vein in particular had bluish fibers (5 cm. long) with an outside appearance like asbestos. The study of a thin-section proved the fibers to be riebeckite (or crocidolite, the blue asbestos variety) i.e. the same iron silicate as the needles present in the magnetite-silicate beds. Also, euhedral magnetite and the quartz groundmass. Some strain in the quartz crystals has probably occurred as they now possess a small 2V angle instead of the normal uniaxial character. The quartz veins usually strike approximately perpendicular to the bedding and are vertical.

Cross-bedding in jaspery beds was observed in one particular instance on a cross-section about a square foot in area.

Sokoman Chert

The 75 to 80 feet of this section of the iron formation is mostly chert. The rock is reddish white when hematite is present either in a very disseminated way or in aggregates. The weathered surface may be pitted because of this irregular distribution. Otherwise, in massive chert, the color has multiple shades of red, pink, brown, grey and white.

Bedding is extremely hard to detect especially in the upper strata which are nearly all massive chert. Granules are still to be found in these beds. Their outlines are not always conspicuous as a slight content of fine iron oxide particles is necessary in order to make the appearance different from adjacent cherty ground-mass.

A redistribution or concentration of hematite seems to have taken place locally as slight enrichments have often been noticed in the field.

One particular outcrop very close to the top of the formation revealed a breccia-like texture with fragments around a centimeter in size. A polished section showed cherty fragments with rather uniform composition and granule texture. These were embedded in a fine

hematite-limonite matrix and their outline, partly wavy, seems to suggest some replacement of the chert by the iron. The present rock may be a result of both fracturing and replacement.

This part of the iron formation has been called the Sokoman Chert in correlation with similar chert lying on top of the jaspery iron formation in the Burnt Creek area. There, however, it assumes a much greater thickness.

Upper Slates

These slates vary in colour from black, through grey to pink. Adjacent beds often have contrasting colours. The black variety is slightly graphitic. Thickness between parting surfaces may be very fine, a millimeter or so, resulting in delicate slabs easily broken. This is especially true for the youngest beds. The oldest ones are more coherent and thickness between parting surfaces is about a centimeter.

The thickness of these slates may be around 180 to 200 feet but these figures are approximate because of the presence of many minor folds or drag folds throughout the formation. Furthermore erosion has removed the top beds so that the actual thickness is unknown.

On account of the sharp contrast in the resistance to weathering between these slates and the underlying Sokoman Chert and the usual steep dip of the strata, a wall 3 to 4 feet high made up by the chert is usually present at the contact. Slaty debris lie at the foot of the wall.

Pleistocene Glacial Deposits

Till made up of boulders, gravel, sand and clay constitutes the ground moraine present everywhere except where the rock outcrops. Clay, however, is not in abundance as may be seen directly in the sandy character of the soil and from the lack of sediments transported in the extremely clear water in the streams.

The deposition has been very irregular. The bottom of valleys often contains hills 10 to 15 feet high. These hills seem to be made up entirely of till as they never disclosed any rock exposure. At other places, conical depressions 10 feet or more in depth and less than 100 feet in diameter at the surface are found in the till. These may be the result of blocks of ice having been buried in the ground moraine and on later melting caused the surface to collapse.

The thickness of the till is generally greatest at the bottom of valleys and gradually diminishes on reaching higher ground where bare rock often shows glacial striae.

Structure

The synclinal and anticlinal axes all trend northwest-southeast. All the folds, except for the extreme northern part of the area, plunge southward at angles varying from 20 to 35 degrees. All the drag folds or minor folds observed in the iron formation, the argillite and the upper slates agree with this southward plunge. The limbs of the major folds have steep dips, very often vertical but never any lower than 20 degrees, as near the nose of the folds. The axial planes are either vertical or dip westward at 75 to 80 degrees.

Three major folds cover most of the area, namely the syncline containing the basin of Lake Joyce, the Lake Pterodactyl syncline and the anticline exposing the lower quartzite in the center of the area. In all of these folds, beds have been overturned. The west limbs of the two synclines and the east limb of the anticline are dipping steeply (generally around 80 degrees westward.) This steep overturning would explain the average 680 feet of horizontal outcropping of the iron formation in the west limb of Lake Joyce syncline as compared with the average 1200 feet of that same formation in the normally dipping east limb (dipping westward with

angles as low as 55 degrees). Even in this east limb, slight overturning has taken place just north of the main deposit. The Lake Joyce syncline gradually opens as the upper slates occupy more horizontal surface (measured across the strike) near the south-eastern part of the area and as the west limb itself becomes folded to form the central major anticline. It is interesting to note the small wrinkle on the highest hill of the area (north-western extremity) where lower quartzite, argillite and upper quartzite outcrop. Of similar structure but on a bigger scale is the anticlinally folded argillite between the north-western end of the Lake Pterodactyl syncline and the major central anticline.

This major central anticline discloses the lower quartzite all along its axis. If we consider, along this axis, the horizontal distance across the strike of the quartzite, it is seen that it changes rather suddenly from about 100 feet to 350 feet. This may be due partly to the change in topography as shown by the contours on the map and to less pronounced dips. The lower quartzite is very massive and correct attitudes of the beds are difficult to find.

In the Lake Pterodactyl syncline the overturned beds of the west limb show west dips as low as 50 degrees. These may be slightly exaggerated on account of the steep hill where gravity may bend the outcropping beds downward.

In the northern part of the area, there is a small syncline of iron formation plunging northward and either overturned or vertical. One outcrop has revealed a thickness of about 30 feet of upper quartzite (usually around 100 feet thick) in contact with iron formation on the east side and argillite on the west side. About 3 feet of this quartzite is highly sheared. Schistosity was also noticed a few hundred feet farther southeast outside the syncline. Anticlinally folded argillite and lower quartzite just west of the small syncline of iron formation seem to be in structural disagreement with the east limb of the Lake Joyce syncline. It seems necessary to assume faulting along a zone dipping steeply to the west with the schistosity. An upward movement of the hanging wall would best explain the different structures.

Slickensides were observed on bedding planes at a few places in the iron formation. The direction of plunge of these slickensides is approximately perpendicular to the strike of the beds. Being on

bedding planes, such slickensides may have been produced from slipping of beds past one another during folding.

Secondary cleavage was observed in the lower argillite beds outcropping near the highest hill of the area. These beds are anticlinally folded (as seen from their changing attitudes throughout almost continuous outcrops) and the angle between bedding and cleavage seems to vary with the position from the fold axis. The cleavage is restricted to incompetent beds (1 to 2 cm. in thickness).

Secondary cleavage is markedly developed in the upper slates. These, beside being folded in a syncline as a major structure, show several minor folds or drag folds. In one in particular the cleavage surfaces proved to be at a slight angle with the axial plane.

Joints striking about perpendicularly to the bedding and dipping 50 degrees southward were amazingly well-developed at one particular place (over a distance of about 700 feet) in the west limb of the Lake Joyce syncline. This jointing in the jaspery iron formation has produced steps 2 to 3 feet in height as seen in profile on a slope. Such joints, because of their perpendicular orientation

with the axes of the folds, are most probably tension joints resulting from slight elongation parallel to the axes.

Related to jointing are quartz veins generally one inch thick. These are mostly perpendicular to bedding. They have been found chiefly in the two quartzites and in the iron formation.

The tectonic force which has produced the major folding of the strata caused overturning toward the northeast. A force from a northwest direction might have effected such a deformation. The folding may also have been the result of several stages of deformation and of more complex forces.

It is worthy of note that the overturning to the northeast in this area is contrary to the general attitude of the overturned beds of the Burnt Creek area. Overturning toward the southwest is most common in the western part of the "Trough".

Ore Deposits

Description

The main iron ore deposit of the area lies northeast of Lake Joyce. It is exposed at the surface in one major outcrop 200 feet long (measured along the strike) by 30 feet wide and of several smaller ones (less than 100 sq. feet) scattered to the northwest, the whole deposit covering at the most an area 600 feet by 170 feet.

The ore is contained in the thin-banded iron formation with the uppermost exposure within the base of the jaspery facies. There is a complete absence of the magnetite silicate beds. The ore is massive bluish hematite occasionally coarsely crystalline (specularite) but most commonly very fine grained. The weathered surface is also bluish but it locally shows hues of yellow and green. The ore is extremely heavy and has a tendency to break along parallel parting surfaces which may correspond to the original bedding. No free silica is to be seen with the naked eye. This bluish massive hematite has been compared with the high grade ore of the Sawyer Lake deposit.

The adjacent thin-banded iron formation has been partially enriched along bedding planes as hematite-enriched beds are found to lie next to cherty beds. (See Plate XVIII). Where the boundary between the orebody and this partial enrichment could be observed it was found that the enriched beds, when examined along the strike, were continuous into the orebody (gradually attaining ore grade) while on the other hand the cherty beds thinned out on approaching it. (See Plate XVII).

As seen on the map, several outcrops of iron formation surround the deposit, thus allowing little chance for possible extension. Several quartz veins, around an inch thick and cutting across bedding, were observed in the iron formation surrounding the deposit.

Another ore showing of much smaller dimension was found in the central part of the area 30 or 40 feet up from the base of the iron formation. It extends for about 350 feet along the strike but outcrops are at the most 40 feet thick. Again, the ore is similar to the preceding deposit except for the irregular presence of goethite. As there is a lack of outcrop southward and northward along the strike for about 550 and 250 feet respectively, and also eastward across the strike for

about 100 feet, areal extension of this small deposit is possible.

There is an interesting exposure of iron ore about 100 feet from the northwestern extremity of Lake Joyce. The ore there is slightly different because of its porous character and the presence of both hematite and goethite (this latter, in greater concentration). The ore occurs close to the top of the jaspery iron formation and very near the axis of the Lake Joyce syncline. The exposure consists in a major outcrop 80 feet by 20 feet and a very much smaller one (10 feet by 10 feet) about 20 feet away across the strike. From the map, it is seen that there is little chance for extension of this enrichment except perhaps southward.

A discovery that may prove to be interesting is the little syncline containing iron formation in the northern part of the area. The east limb contains high enrichment along with ore over a distance of 500 feet (along the strike) and in a zone 60 feet wide. In the east limb, digging uncovered enriched slaty iron formation at two different places at the most 20 feet from the top of the upper quartzite. Because of the heavy overburden and the relatively small outcrops (50 square feet or so) of ore, it is rather difficult to predict any extension to these exposures, but synclinal structure

and the general high enrichment may disclose further ore upon trenching. Yet it must be mentioned that the largest outcrop (60 feet by 25 feet) in the vicinity of the enrichment still showed bands of silica (less than 1 inch thick) adjacent to bands of ore.

Enrichment, with little real ore, has also been found at about 150 feet from the south-eastern end of Lake Joyce. The ore as shown in a small outcrop (50 square feet) consists mainly of fibrous goethite (crystals being several inches long). Irregular quartz veins up to a foot thick have been observed close to the enrichment. The whole, however, as ore, is unimportant because of the great amount of silica.

Origin of the Ore

Primary Textures and Associated Secondary Features

Several interesting observations were made from the study of 25 polished sections of the iron formation. Textures and relations between primary and secondary features resulting from the iron enrichment are quite variable.

Some of the textures that are considered to be primary are granules. These are undoubtedly the result

of coagulation of colloids composed partly of silica gel and granular iron oxides collecting into globular form. Upon dehydration and crystallization these circular or elliptical shapes are preserved. Oolites consist of these granules as a core with several concentric layers of either silica or iron oxide.

Among secondary features related to granules is the presence of magnetite crystals and iron silicate needles. As already mentioned in the description of the jaspery iron formation, both magnetite and iron silicates crystallized after the formation of granules. Later, oxidation to hematite took place. In the case of the major deposit, the uppermost part revealed hematite ore with a texture closely resembling granules. A polished section of this ore showed fine crystalline hematite replacing earlier granules. The outlines of the granules are still visible because of the contrast offered by coarser hematite occupying the former groundmass. Magnetite is completely absent. It is quite possible therefore that if magnetite had ^{been} present, as is usually the case in jaspery beds, a change to hematite occurred. Upon nearly complete removal of silica and enrichment in hematite, the former crystal boundaries of magnetite were obliterated.

Evidence for Replacement

The nature of the contact between the main orebody and the adjacent partially enriched iron formation has already been described. The lensing out of cherty beds and the continuity of hematite-enriched beds on approaching the orebody suggest replacement. (See Plate XVII).

Polished sections of enriched iron formation show fissures filled with hematite. The filling of such openings has been accompanied by replacement as proved by a gradual decrease of hematite away from the walls into chert beds (i.e. the absence of sharp walls) and by the non-parallel arrangement of corresponding walls (if no displacement occurred parallel to fissures). (See Plate XVIII). Intricate patterns assumed by hematite such as shown by Plates IX and X again would suggest replacement (considering that such patterns are contained in a plane perpendicular to the stratification)..

General Discussion of Solutions

Circulation of solutions through a rock could result in replacement if minerals of the walls of channel-ways became unstable in the presence of the solutions.

To produce iron ore from iron formation, silica has to be removed. The iron, originally present may remain stationary or it may migrate. Iron may also be added from outside. Actually, a combination of these processes probably occurred. Certainly some iron was added. If replacement does not take place volume for volume, leaching of the silica might increase the porosity (in proportion to the depth at which the process occurs), thus facilitating further migration of the solutions. If replacement does occur volume for volume, then exchange of atom for atom would most likely be the process. (As suggested by F. W. Barth⁵, metasomatic replacement may consist in exchange of metal and silicon ions within crystal lattices, the oxygen ions remaining stationary. The oxygen ions occupy about 92% of any rock volume).

The important channel-ways of the solutions seem to have been fractures and bedding planes. The fractures are filled with coarsely crystalline hematite and show signs of replacement along walls, some however are filled with fine-grained quartz. The general orientation of zones of enrichment, aside from fractures, is parallel to bedding planes, suggesting that these influence the solutions in their migration. Thus the fractures may have served as main channel-ways through which the solutions migrated. Any available porosity between

adjacent bedding planes then provided other openings for their circulation. The replacement here results in a finer grained texture than for minerals filling fractures.

As seen microscopically the replacement by hematite along bedding planes seems to be located where silica already contained extremely fine iron oxides (probably of primary origin as for much of the iron oxides of granules and oolites). Thus, such fine iron in chert may have served as nuclei in initiating or facilitating the process of enrichment when iron-bearing solutions penetrated the rock. Plates IX, X and XI show some of the gradations from only scattered hematite in chert to stages where the chert gradually disappears to give place to the hematite. The ultimate end as in the case of ore is a nearly complete removal of silica. (It should be remembered that when looking at such plates one sees only two dimensions and that actually the secondary concentrations of iron oxide appearing to be discontinuous because of surrounding chert are most likely continuous if looked at in three dimensions, the continuity probably being more or less parallel to bedding planes, the polished sections being cut perpendicular to beds.)

While circulating solutions were active along a certain bedding plane, the already present fine iron

(mentioned before as nuclei) close to this active zone may have participated in the reaction by migrating toward this active zone of replacement, leaving behind rather pure silica. As no pores are observed where the iron has left, it may be assumed that the replaced silica has migrated and filled the cavities. Thus, highly enriched beds (a millimeter or so in thickness) with irregular outline are in sharp contact with chert containing practically no iron at all. Clusters of crystalline hematite are similarly in contact with barren silica. Yet, this same iron-free silica grades away from the clusters to silica with the normal content of fine iron of the siliceous bed.

The source of the circulating solutions may have been hydrothermal or meteoric or both. A hydrothermal origin is suggested from the oxidation of magnetite to hematite. Magnetite under surface weathering is one of the most stable minerals and downward-circulating waters would probably not produce the oxidation in comparison to oxygen-bearing hydrothermal solutions. The secondary iron introduced in the lower and upper quartzites may have been transported by solutions downward and upward respectively from the iron-bearing formation. The source of these solutions may be either hydrothermal or meteoric or both.

No igneous rocks were seen in the area and the only sign of igneous activity is represented by quartz veins if those are considered to be of such origin. These quartz veins (usually 1 to 2 inches thick, rarely attaining 1 foot) were observed especially in the quartzites and the iron formation. Riebeckite, goethite and specularite were occasionally noticed when the veins were in contact with iron formation. The iron necessary for the formation of such minerals may have been derived from the adjacent walls. When cutting enriched beds of the thin-banded formation, the walls of these quartz veins proved in a few instances to be sharp with resulting discontinuity of the enrichment. This would suggest fractures younger than those which permitted solutions to permeate and enrich the rock. However, not enough investigating was done to be able to draw general conclusions as to the relation of these quartz veins to the enrichment.

Metamorphism of the Iron Formation

According to Van Hise and Leith⁶ chert, siderite and greenalite with minor quantity of hematite and magnetite are the chief constituents of primary and unmetamorphosed iron formation in the Lake Superior area. Today, it is recognized that secondary iron silicates such as minnesotaite, stilpnomelane and

greenalite may be developed from the combination of primary silica and iron through metamorphism such as deep burial with associated high temperature and pressure or contact metamorphism.

Thus, the absence of siderite and greenalite (greenalite has not been seen anywhere within the "Trough" so far) in the iron formation of the area, the presence of stratigraphic horizons rich in minnesotaite or stilpnomelane such as the magnetite silicate beds, and the high degree of oxidation (as shown by hematite, goethite and martite) of all other members of the formation would indicate a certain stage of metamorphism.

According to S. A. Tyler⁷ "oxidation of either the original siderite or greenalite iron formation or a facies composed of secondary iron silicates and chert produces the ordinary red or yellow cherty iron formation. The soft ores, both limonite and hematite, result from the oxidation and leaching of that facies in which the chert has been largely or completely combined with iron to form iron silicates". According to this idea, the apparent absence of the magnetite silicate formation at the main ore deposit (which has its main body in the thin-banded iron formation but

its upper part within the jaspery beds) would have been caused by the oxidation of the iron silicates and magnetite of that same formation, the silica having been leached completely in the case of the ore but only partially for the adjacent enriched beds now referred to as thin-banded iron formation. However, the processes of enrichment leading to ore seems to be more complicated than straight oxidation and leaching.

Conclusion

The ore seems to be a result of replacement through solutions. The nature of these solutions, i.e. whether hydrothermal or meteoric, is not known at present. The paths of the solutions through the iron formation seems to have been controlled by fissures and bedding planes, the amount of fracturing along with original content of iron, determining enrichments or orebodies.

To what extent the metamorphic grade attained by the iron formation has influenced the formation of ore is difficult to establish but field evidences would tend to favor a certain influence.

Thin-sections



Plate I. Lower Quartzite.
Quartz grains cemented together by secondary silica having crystallized in optical continuity. A thin film of secondary iron oxide between interstices (at the left especially). Two feldspar fragments with vague twinning. Crossed nicols, x 70.

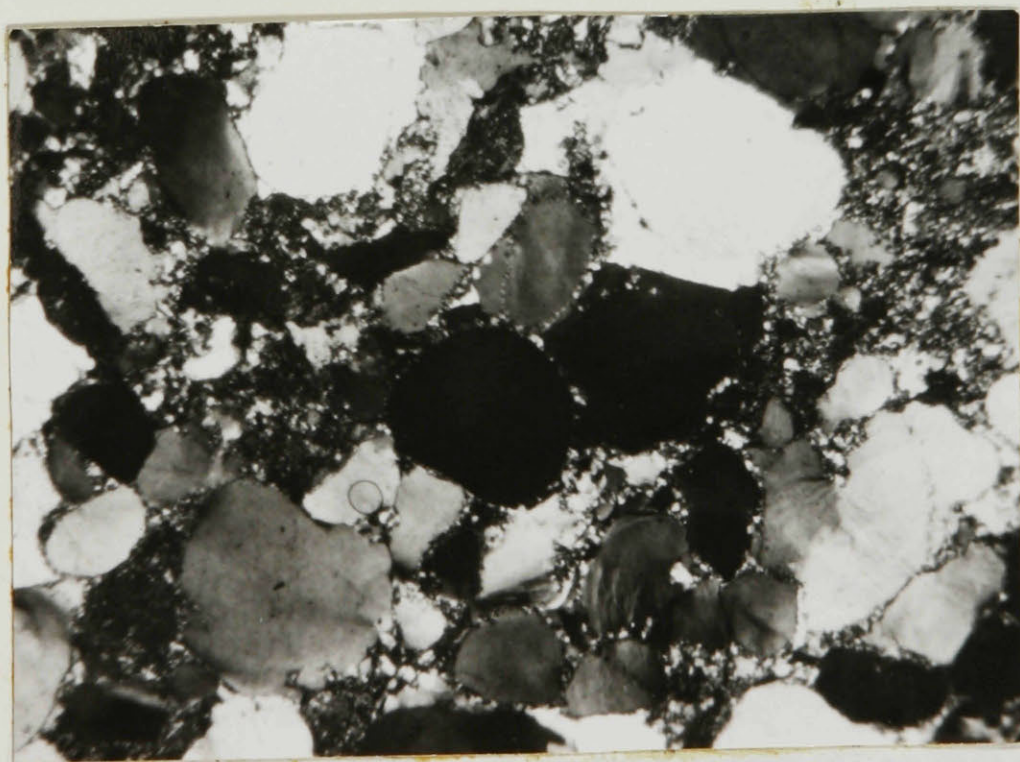


Plate II. Upper Quartzite.
Quartz grains cemented by chert. Former boundary still visible because of thin film of chert. The cherty groundmass (where darker colored) contains a light green mineral, probably chlorite. Crossed nicols, x 70.



Plate III. Upper Quartzite
(lower graywacke beds).
Quartz and feldspar fragments in a chloritic matrix. Replacement by chlorite of both quartz and feldspar may be seen in the "fringed" margins of the fragments. Plain light, x 150.



Plate IV. Argillite (lower facies).
Same composition as above (with little mica). Bedding prominent because of variation in grain size and composition. Plain light, x 30.



Plate V. Jaspery Iron Formation.
Granules composed of chert (light grey) with variable quantity of fine hematite (dark grey). Coarser hematite associated with magnetite appear as black. Note the very fine needles of iron silicates partly altered to goethite and hematite and distributed throughout both granules and groundmass. Plain light, x 40.



Plate VI. Jaspery Iron Formation.
Same type of granules as above as seen between crossed nicols. The chert of the groundmass is coarser grained than the chert of the granules. x 70.



Plate VII. Magnetite Silicate Iron Formation. Intergrowth of the amphibole; riebeckite, (lath-shaped crystals) in a groundmass of chert (white) and fine iron silicate either minnesotaite or stilpnomelane (grey). Also euhedral magnetite (black). Plain light, x 150.



Plate VIII. Magnetite Silicate Iron Formation. Faint granule texture. Fine iron silicate needles either minnesotaite or stilpnomelane (grey) and chert (white). Euhedral magnetite (black) distributed irregularly along bedding planes. Plain light, x 150.

Polished sections

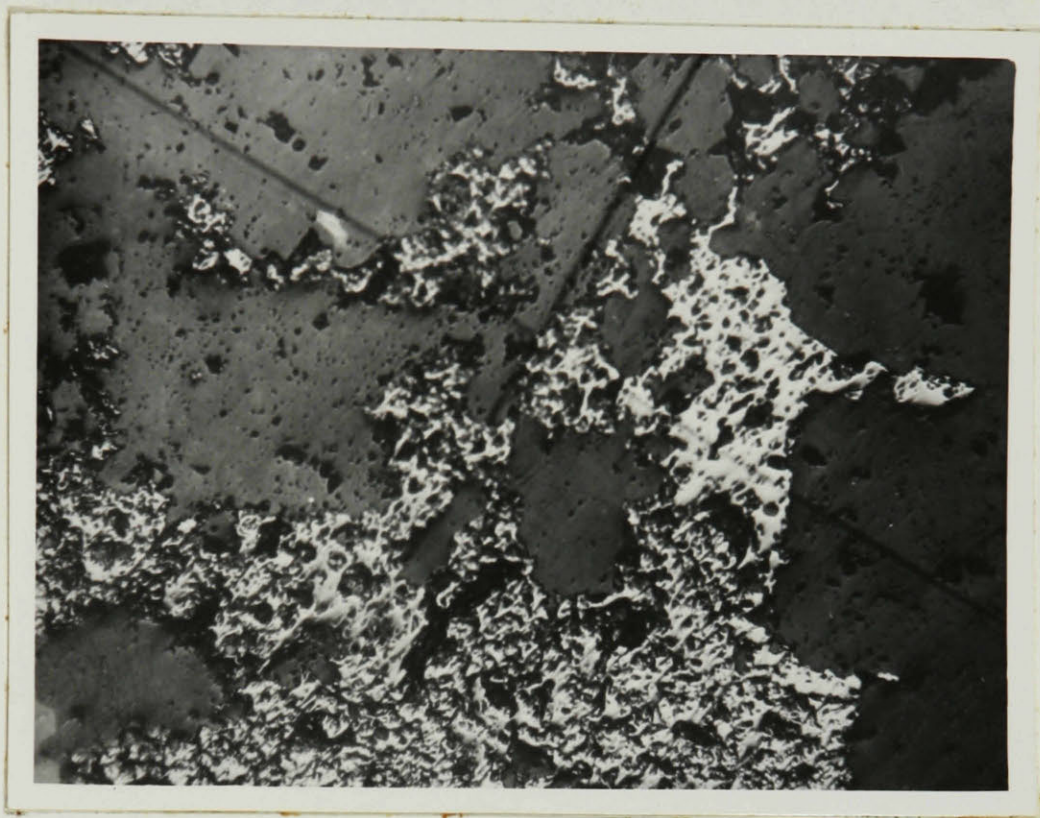


Plate IX. Thin-banded Iron Formation.
Replacement of chert (grey) by hematite
(white). The crystalline hematite has
replaced chert containing very fine iron
oxide (not visible here). x 70.



Plate X. Thin-banded Iron Formation.
Replacement of chert by hematite.
(Same as above). x 280.

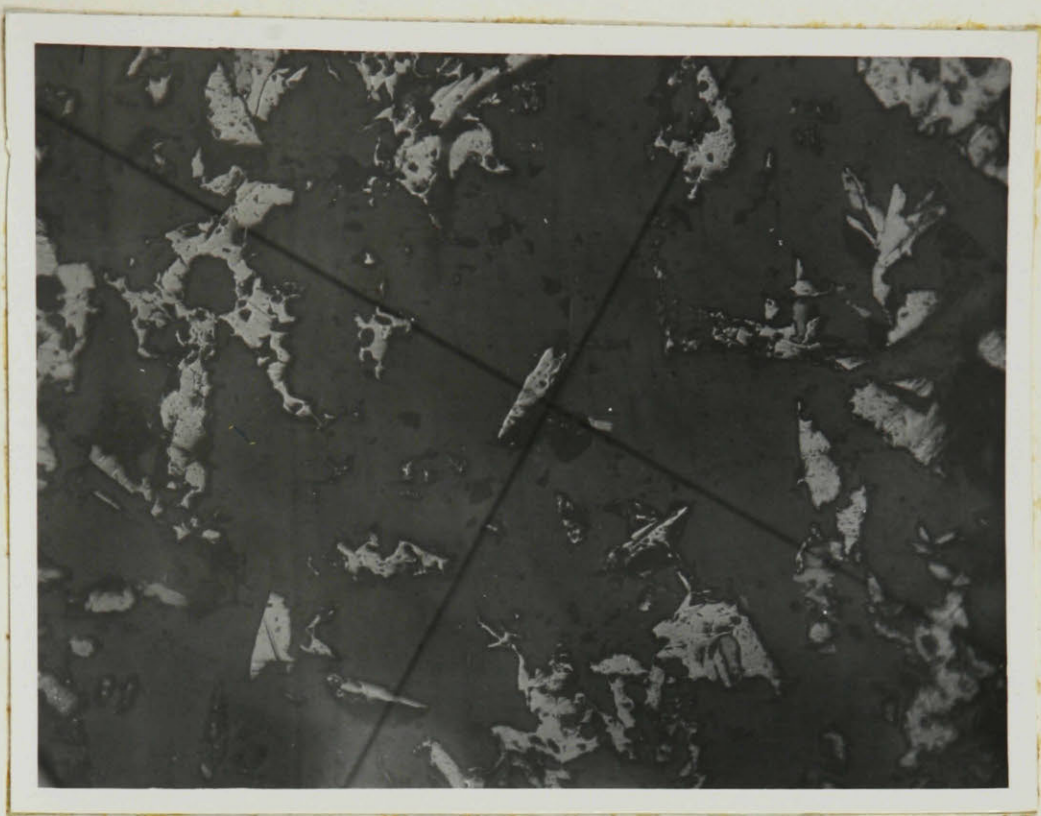


Plate XI. Jaspery Iron Formation.
Coarsely crystalline hematite (light
grey) in chert (grey-black) containing
fine reddish iron oxide (not visible
here). Slight remnants of magnetite
(dark grey). x 70.

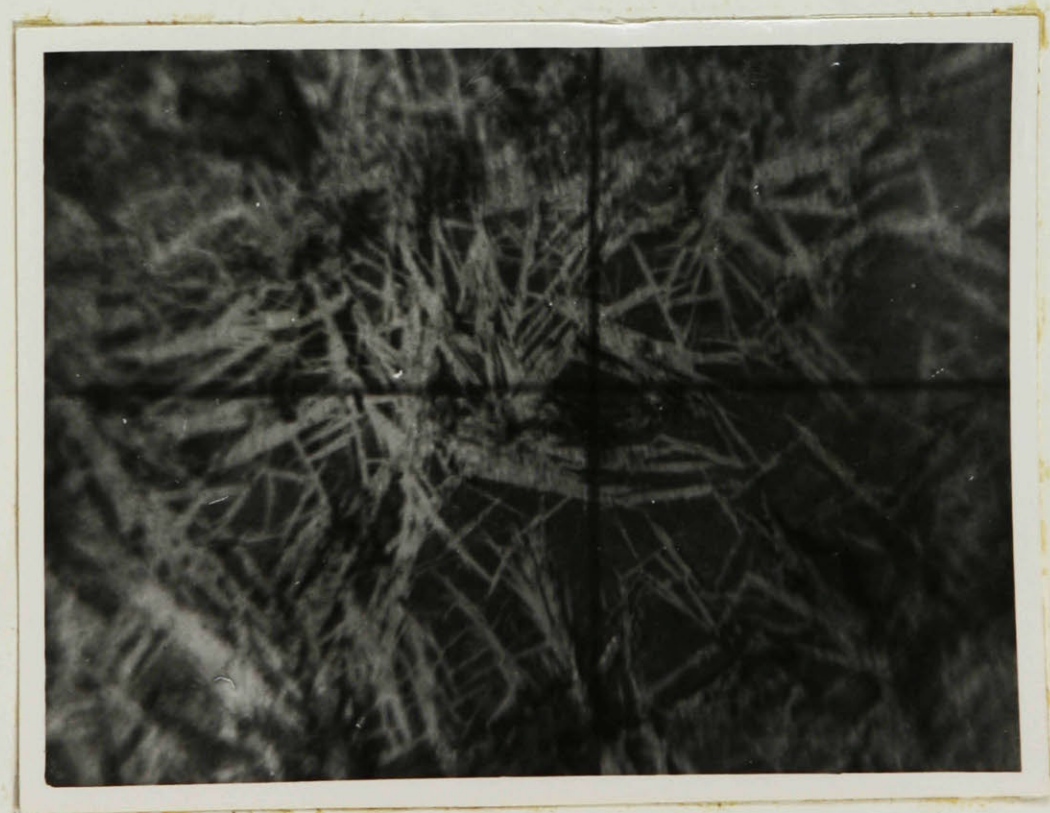


Plate XII. Thin-banded Iron Formation.
Intergrowth of goethite crystals in
brown chert (containing fine limonite).
x 280.



Plate XIII. Jaspery Iron Formation.
Chert granules containing irregularly
distributed hematite (when fine grained;
white). The groundmass is chert (dark grey).
Euhedral magnetite present in both granules
and groundmass. x 65.



Plate XIV. Jaspery Iron Formation.
Part of a granule showing euhedral magne-
tite having grown partly in the chert
groundmass and in the granule. Some
oxidation of the magnetite (light grey)
to hematite (white). x 280.



Plate XV. Jaspersy Iron Formation.
Chert granule containing hematite (white)
and magnetite (light grey). The largest
magnetite crystal shows oxidation along
octahedral planes. x 280.



Plate XVI. Jaspersy Iron Formation.
Same as above. The upper right magne-
tite crystal has grown across the two
adjacent granules (upper granule poorly
outlined). x 280.

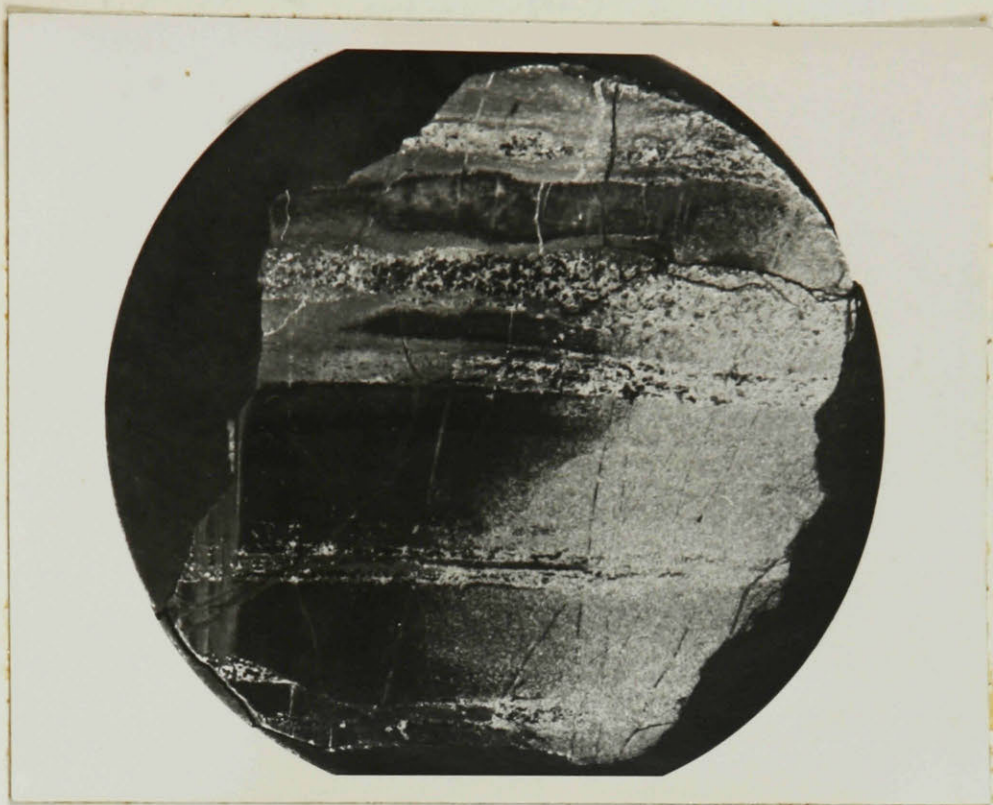


Plate XVII. Thin-banded Iron Formation. Cherty beds (grey black) in gradational contact with hard blue hematite ore (light grey). The gradational enrichment suggests replacement. (Polished section mounted in bakelite). x 3.

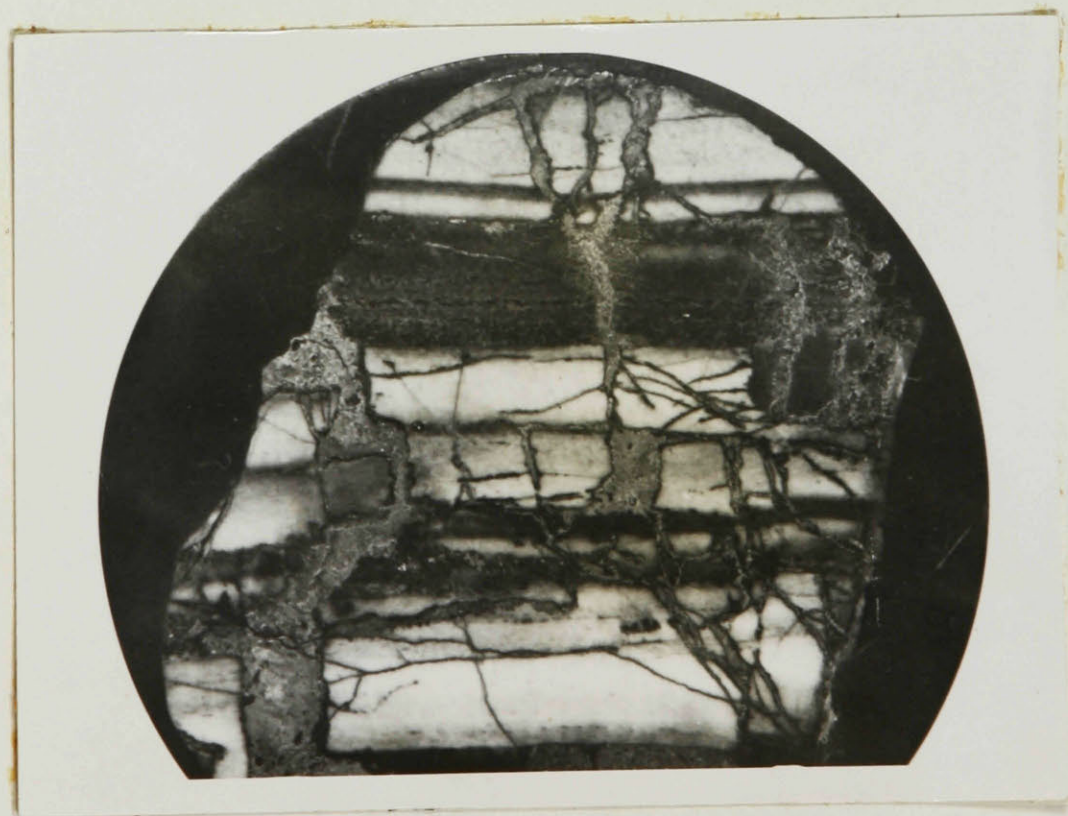
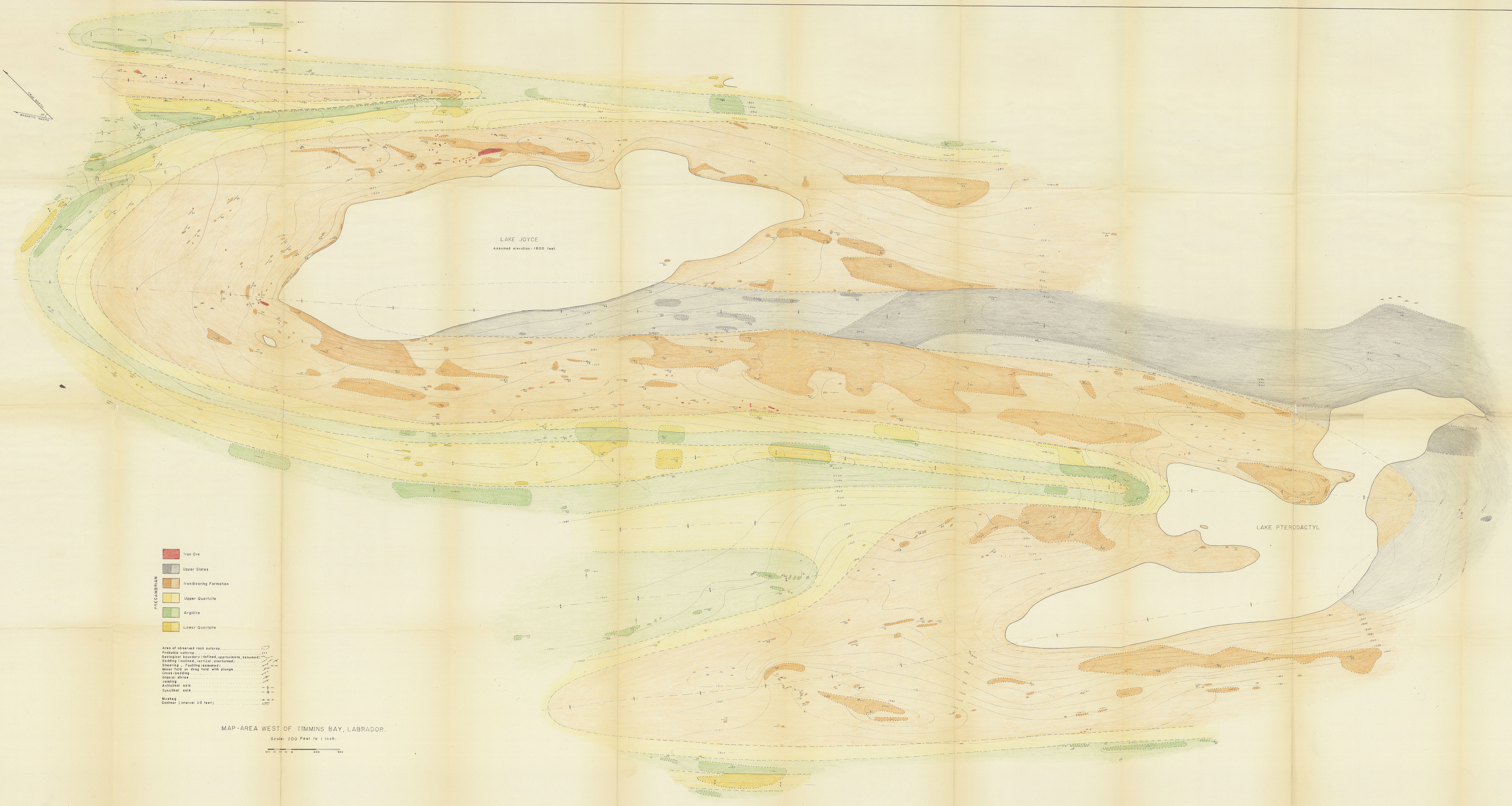
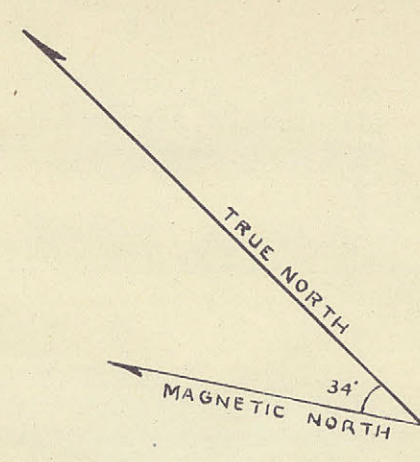


Plate XVIII. Thin-banded Iron Formation. White chert and hematite-enriched beds. Fractures filled with coarse hematite. gradational contact making up walls of fractures and non-parallel arrangement of corresponding walls would suggest replacement. x $3\frac{1}{2}$.

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- 7) Tyler, S.A., Development of Lake Superior Soft Iron Ores from Metamorphosed Iron Formation, Bull. G.S.A., Vol. 60, July 1949. p. 1102.



- PRECAMBRIAN
- Iron Ore
 - Upper Slates
 - Iron-bearing Formation
 - Upper Quartzite
 - Argillite
 - Lower Quartzite

- Area of observed rock outcrop
Probable outcrop
Geological boundary (defined, approximate, assumed)
Bedding (inclined, vertical, overturned)
Shearing, Faulting (assumed)
Major fold or drag fold with plunge
Cross-bedding
Dip-slip strike
Jointing
Anticlinal axis
Synclinal axis
Muskeg
Contour (interval 20 feet)

MAP-AREA WEST OF TIMMINS BAY, LABRADOR.

Scale: 200 Feet to 1 inch.



