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THE QUEBEC-LABRADOR IRON BELT, QUEBEC AND NEWFOUNDLAND
(Preliminary Report)

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INTRODUCTION

A belt of Proterozoic rocks, commonly referred to as the 'Labrador trough', extends northward from the southwest corner of Labrador to Cape Hopes Advance at the northwest tip of Ungava Bay, a distance of some 600 miles (Figure 1A). The 'trough' is about 60 miles wide in the central part, but tapers to a width of about 12 miles, as exposed on the northern extremity, and 'fishtails' to nothing at the southern extremity. Iron formations are known to occur throughout most of the length of this belt, and this report is a brief summary of the geology in the part where developments of iron deposits are under way. Some 400 million tons of high-grade iron ore are now known in forty-three orebodies that lie near the height of land marking the boundary between the territory of New Quebec and Newfoundland's Labrador. Burnt Creek is the present centre of operations and lies in Quebec, just north of the height of land. It is served by the Knob Lake airstrip, equipped with modern navigational aids, that lies about 10 miles by road east of Burnt Creek, and local seaplane traffic operates out of Knob Lake, about 3 miles southeast of the settlement. At present the region is accessible only by air, but the Quebec North Shore and Labrador Railway is scheduled for completion by 1954. It will connect Sept Iles (Seven Islands), on the north shore of the St. Lawrence River, with Knob Lake, where the townsite for operations is to be built (See Figure 1A).

HISTORY OF EXPLORATION

The first geologist to record iron deposits in this region was A. P. Low of the Geological Survey of Canada, who made a remarkable trek through Ungava Peninsula between the spring of 1893 and the autumn of 1895 (12)[1]. Although he referred to iron ore, it is now known that this term applied to what is now called iron formation. The first iron ore was discovered in the summer of 1929 by an exploration party under the direction of W. F. James and J. E. Gill, at what is now called the Ruth Lake No. 1 orebody in Labrador. In 1937, J. A. Retty was shown the Sawyer Lake hard-ore deposit by Mathieu Andre, and in 1938 Dr. Retty discovered iron ore in New Quebec. These discoveries stimulated interest in the possibilities of mining iron ore, and for several years Dr. Retty directed a program of detailed geological mapping and prospecting on two concessions that cover the iron belt centred near Burnt Creek. The Labrador Mining and Exploration Company Limited (L.M.E.) acquired the concession in Labrador and the Hollinger North Shore Exploration Company Limited, the adjoining concession in Quebec. Both concessions were operated by L.M.E. In 1950 the Iron Ore Company of Canada (I.O.C.) was formed with rights to mine certain amounts of iron ore on parts of the two concessions, and is an incorporation of several iron and steel companies from the United States and Hollinger Consolidated Gold Mines Limited of Canada. Since that time development of the project has gone ahead rapidly, and it is expected that iron ore will be shipped from Knob Lake in 1954. Within 2 or 3 years thereafter, production is scheduled for 10 million tons a year, and eventually shipments of 20 million tons a year may be made. Detailed

[1] Numbers in parentheses are those of references in the Bibliography at the end of this report.

accounts of the history, organization, and financing of current operations, as well as general accounts of the geology, have been given by Retty (13, 14), and some general accounts of operations are included in the Bibliography. Other operations are being undertaken by various exploration companies, especially in the northward extension of the Proterozoic 'trough'.

SCOPE OF REPORT

The present study is being made on a strip from 2 to 3 miles wide that extends northeastwards from the southwest margin of the 'Labrador trough' (Figure 1B). Detailed mapping on a scale of 1 inch to 500 feet was begun in 1950, following a general reconnaissance of the area in 1949, and it is planned to carry this study at least 25 to 30 miles northeastward to join with the work that was completed by Fahrig (6) and Frarey (7) on the northeastern half of the 'trough' (See Figure 1B). The total length of the belt will be about 60 miles, but only about 12 miles of it has been completed so far. Hence, the information, even on this strip (to be termed the Burnt Creek strip) is incomplete. General comments are based largely on 'spot' observations, and interpretation of Company maps and reports.

ACKNOWLEDGMENTS

This study could not be made without the active co-operation and assistance of officials of the Labrador Mining and Exploration Company and the Iron Ore Company of Canada. In addition, their geological staffs have supplied maps, reports, air photographs, specimens, and ideas that are the results of several years' study. The writer has benefited from numerous discussions with Dr. J. A. Retty, formerly Consulting Geologist for I.O.C., and with Dr. A. E. Moss, now Chief Geologist for I.O.C. Many other geologists have contributed information and ideas, of whom C. Dufresne, R. Geren, R. W. Kirkland, H. A. Neal, J. A. Stubbins, and J. L. Usher have been most closely associated with the writer. Thus, the present study is based on a background of material obtained by Company geologists. Some interpretations of structure, lithology, age relations, and stratigraphy are modified from those accepted in Company reports, but for the most part the suggestions made here were earlier made by Company geologists.

PHYSIOGRAPHY

Bedrock structures of Proterozoic rocks in the region about Burnt Creek trend northwest, and elongate hills of resistant rock rise more than 1,500 feet above the levels of the lowest lakes. Local relief is rarely more than 500 feet but intervals between higher ridges are closely spaced. Knob Lake, which is practically on the height of land at an elevation of 1,620 feet, drains northward via Swampy Bay River to Kaniapiskau and Koksoak Rivers and thence to Ungava Bay. Lakes south of Knob Lake drain southwards through Ashuanipi and Hamilton Rivers to the Atlantic Ocean. The valley in which Knob Lake lies extends northward for 100 miles or more and southward for several miles to where it is lost in a maze of large lakes. A dissected plateau rises southwest of this valley to form a range of hills parallel with the valley. All but a few of the currently known deposits of iron ore are in rocks of this range; except for the Sawyer Lake deposit, which is unique, so far as known, the others occur in the range of hills that lies northeast of the valley.

The northwesterly trending 'grain' of the country has been accentuated by Pleistocene glaciation, which scoured the valleys deeper but had comparatively little effect on the more resistant ridges. For the most part, ice-movement was essentially parallel with the regional rock ridges, although three directions of movement have so far been recognized within a few miles of Knob Lake. Probably the earliest glacial currents moved southeast, as deduced from the shapes of hills, but later they moved northwest, as shown by plucking on the northwest ends of ridges. Finally, the ice moved northeast, distorting the tails of some earlier 'crag and tail' structures. Good evidence for all three directions of movement may be found within a radius of half a mile. In spite of such diversified glaciation, several V-shaped valleys remain in the area about Burnt Creek, a feature that is difficult to explain. In some localities, part of a single valley is V-shaped, but another part is U-shaped. The V-shape may be due partly to slumping of the valley walls after glaciation, partly to post-glacial stream erosion or to streams that carried meltwater from glacial remnants at higher altitudes, and partly to post-glacial movement along faults. All the V-shaped valleys are less than 100 feet in depth, and most are less than 50 feet.

Most of the glacial debris is moderately to well sorted; crossbeds are common, and stratified sands and gravels were observed in all the thicker exposed sections. The mantle of glacial material is usually quite thin, and bedrock commonly lies no more than 2 or 3 feet beneath the surface in fairly large areas where no rock is exposed. Here and there, however, deposits 40 feet or more thick are known.

Timber does not grow above an altitude of about 2,200 to 2,300 feet and all hilltops are bare except for the ubiquitous caribou moss. Black spruce and tamarack are the common trees in the valleys, some as much as 32 inches at the butt, and balsam fir and birch grow locally. Numerous shrubs occur in the valleys and on the hill slopes.

GENERAL GEOLOGY

Proterozoic rocks occupy a broad belt that trends northwest and lies with great unconformity on Archaean gneisses. The rock units of the belt are tightly folded, and most folds are overturned to the southwest at moderate to steep angles. The rocks are cut into numerous slices by thrust faults that dip northeast, and small cross-faults are common.

In a strip through Burnt Creek, these Proterozoic rocks underlie a belt about 60 miles wide from southwest to northeast. The southwestern 30 miles is composed mainly of sedimentary rocks, including iron formations, but interbeds of volcanic rocks are common southeast of the section line, and in the northeastern part of this half of the belt. Company geologists have given the name of Kaniapiskau[1] System to this

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[1]Pronounced "kan-ee-ap-iss-cow", with no accented syllable; means "Rocky Point".

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assemblage, but the writer prefers to designate these rocks as the Knob Lake group, pending more detailed information. The northeastern 30 miles of the strip consists mainly of volcanic rocks of the Murdock and Doublet groups, and the relatively narrow sedimentary members of the Howse group. Clastic sedimentary rocks occur at several horizons within the Murdock and Doublet groups, but according to Frarey (7) comprise less than 25 per cent of them.

The relations between the rocks of the Knob Lake group and those of the Howse, Murdock, and Doublet groups, are not clear, but the weight of field evidence at this point in the study indicates that the Knob Lake group is older and lies conformably beneath the others (7). A similar relation was suggested as a possibility by Company geologists, but the Howse, Murdock, and Doublet were not included in their Kaniapiskau System.

The total thickness of the Proterozoic succession is difficult, if not impossible, to estimate, because the rock units vary greatly in thickness from place to place. A rough average, with an unknown amount of the youngest rocks lost by erosion, is probably in the order of 20,000 feet.

The northeast contact of the Proterozoic 'trough' is marked by a broad zone of heavily sheared rocks that must mark a major fault. Structural trends of rocks on each side of the fault indicate thrusting from the northeast (6). The southwest contact, on the other hand, is only faulted locally, and the regional unconformity at this contact was observed at several places.

It should be emphasized that the following table of formations does not apply to the whole belt of Proterozoic rocks, but only to a strip taken through Burnt Creek. Lithological associations vary greatly both northwest and southeast of the line of this section, and Company geologists report that they are preparing an overall account of the regional stratigraphy.

Table of Formations[1]

ERA	GROUP[2]	FORMATION	LITHOLOGY
Cenozoic			Unconsolidated till, outwash, stream deposits
		Unconformity	
Proterozoic			Diorite, gabbro, serpentine; diabase; syenite
	Doublet		Basic flows and pyroclastic rocks; quartzite, argillite, carbonaceous slates
	Murdock		Basic agglomerate, breccia, tuff; minor basic flows; conglomerate, quartzite, argillite
		Unconformity (?)	

	Howse		Thin bands of argillite, quartzite, and slate separated by thick sills of diorite and gabbro; possibly some basic flows. May be part of Menihek formation
	Knob Lake[3]	Menihek	Creamy grey to jet-black carbonaceous slates; varying amounts of impure dolomite; greywacke; pyritiferous slate; minor chert
		Unconformity (?)	
		Sokoman	Iron formations: banded silicate; thin-banded jasper; banded cherty; thick-banded jasper; cherty metallic; cherty iron carbonate; massive cherty; lean chert; and slaty members
		Ruth	Black to greenish black, ferruginous, carbonaceous slate; some chert interbeds, locally abundant; base is black, massive chert
		Wishart	Quartzite, arkose; minor slaty and calcareous beds near base; minor cherty beds at top
		Fleming	Massive chert, chert-breccia, quartzite with chert cement; chertified slate; conglomerate of chert pebbles in matrix of chert-cemented quartzite
		Disconformity (?)	
		Denault	Buff to grey weathering, dense dolomite; arenaceous dolomite; dolomite breccia cemented by dolomite and/or chert; cherty dolomite; minor slaty and quartzitic interbeds
		Attikamagen	Varicoloured slates; local interbeds of dolomite; porous, granular chert in lowest exposures
		Unconformity	
Archaean	Laporte		Biotite and hornblende schists. May be of same age as Ashuanipi, or may be equivalent to Doublet

	Ashuanipi		Biotitic, hornblendic, garnetiferous, and granitic gneisses; amphibolites; granitic intrusions

[1]Except for the Knob Lake group, names of all rock units have been taken from Company reports and maps. However, included strata and unit classifications differ somewhat from Company usage.

[2]'Group' is here used as a general term, and probably includes units of formational and series rank.

[3]Volcanic flows and tuffs occur at several levels in the Knob Lake group, but their stratigraphic limits have not yet been determined.

ARCHAEAN

Granitized gneisses and associated intrusions apparently form most of the bedrock of Ungava Peninsula, and they are the basement on which the Proterozoic rocks lie. Very little work has been done on these rocks near the region covered by this report, but reconnaissance studies were made by Low (12) throughout the peninsula, by Company geologists near Michikamau[1] Lake, about 125 miles east-southeast of Burnt Creek, and by Eade (4), about 125 miles southeast of Burnt Creek.

[1]Pronounced "mih-shik-a-mow", with slight accent on second syllable; means "a large body of water".

Ashuanipi Complex

The Ashuanipi[2] complex is the name given by Company geologists to the mixture of granitic, volcanic (?), and sedimentary gneisses that lie along the border of the Labrador 'trough'. They are much like the gneisses of the Grenville Series in southeastern Ontario and southern Quebec, and the Kisseynew complex in Manitoba and Saskatchewan. In the area about Michikamau Lake, similar gneisses are intruded by anorthosite(12), and gabbro intrusions have been mapped by Company geologists. However, most of the rocks are highly metamorphosed, and granitized sedimentary and volcanic (?) gneisses are intruded by masses of granitic material.

[2]Pronounced "ash-wah-nih-pee", with slight accent on second syllable; means "lake with two outlets".

Laporte Group

These rocks have been mapped only as a narrow strip along the northeast side of the 'Labrador trough' at about latitude 55°10'. They are highly crumpled and contorted biotite and hornblende schists that grade eastward into garnetiferous rocks. They are separated from the Doublet rocks on the west by a major shear zone, and from the Ashuanipi complex on the west by another, but less well marked, zone of schist. Company geologists thought they might be intermediate in age between the Ashuanipi and Proterozoic rocks (11), but the writer, in 1949, considered them to be a less altered facies of the Ashuanipi rocks. Fahrig, who studied them in much more detail in 1950, suggests that they may be altered sedimentary strata of the Doublet group (6).

PROTEROZOIC

The rocks included in the Burnt Creek strip are all part of the Labrador 'trough', and all are believed to be of Proterozoic age. However, Company geologists have suggested that some of the rocks in the northeastern, essentially volcanic, half of the strip, may be Archaean.

Proterozoic-Archaean Relations

The northeast side of the Labrador 'trough' is separated from the Archaean rocks by a major fault, at least in the area so far mapped (6), so that age relations cannot be determined directly. However, direct observations can be made at the contact on the southwest side.

About 3 miles southwest of Stakit Lake (See Figure 1B), basal, pebbly Proterozoic quartzite rests on Archaean granitic gneisses. The decomposed, crumbly nature of the gneisses is in marked contrast to the well-bedded quartzite, which dips from 5 to 10 degrees northeast. Bedding in the quartzite truncates foliation in the gneisses, and there can be no doubt that this contact marks a major unconformity.

Knob Lake Group

This name has been applied by the writer to the predominantly sedimentary succession that contains the iron formations. This succession has been divided into three units of series rank by Company geologists, but, in the strip so far mapped by the writer (See Figure 1B), evidence for such a division has not been obtained. Hence, the "Knob Lake group" is a name given as a convenience for this report, and will be abandoned as soon as the evidence warrants it.

Some of the formations in the Knob Lake group extend for many miles along strike, are repeated in nearly every thrust slice, and are remarkably constant in thickness; others vary greatly in thickness and may only occur locally. Figure 1C represents the writer's interpretation of the stratigraphic arrangement in the southwest part of the 'trough' before folding and faulting took place.

Attikamagen Formation

The Attikamagen[1] formation occurs in many thrust slices across

[1] Pronounced "Ah-tik-ah-mah-gen", with a hard "g", and with the second syllable slightly accented; probably a distortion of the Indian word meaning "white fish".

the Burnt Creek strip, but not at the southwest contact of the 'trough', where quartzite rests directly on the Ashuanipi gneisses. Probably this formation lensed out shoreward, and was not deposited in this part of the depositional basin, as illustrated in Figure 1C. Its base has not been observed, for its lowest exposed limits are marked by faults or anticlinal crests. Exposures seen by the writer range in thickness from about 100 feet, near Stakit Lake, to 1,200 feet in the ridge northeast of Knob Lake.

The formation consists mainly of yellowish to greenish grey slates, but red, violet, green, buff, and brown varieties are locally abundant. Bedding is commonly obscured by cleavage but, where it can be seen, the strata are thinly laminated and their tops can be ascertained here and there by graded bedding. Angular grains of quartz, averaging 0.02 to 0.05 mm. in length, are set in a matrix of fine micaceous and clayey material, and much chert is present locally. Interbeds of carbonate rock are common, and in some specimens carbonate forms the matrix for the quartz grains. Some specimens from the lowest exposed beds consist of oolitic ferruginous chert stained by hematite 'dust'; others are composed of dark grey, granular chert, and one consists of well-rounded grains of quartz that average 0.5 mm. in diameter, in a matrix of fine micaceous and cherty material.

Beds of carbonate rock vary in thickness from a fraction of an inch to more than a foot and are especially common near the top of the formation. In a few places, dolomite occurs in lenses as much as 100 feet thick, but it is not certain whether these are interbedded with the slates or are infolds of the succeeding Denault formation.

Denault Formation

On the Burnt Creek line of section, the Denault formation, which is mainly dolomite, is restricted to the southwest and northeast parts of the Knob Lake group, and appears to extend only a few miles northwest of Burnt Creek. It is not certain that the dolomites to the northeast are of the same age, but some of these seem to occur at the same stratigraphic level. Northeastward from the southwest margin of the 'trough', no dolomite appears for 3 or 4 miles. The first occurrence is less than 100 feet thick, but the formation thickens abruptly in succeeding thrust slices to the northeast, reaching a maximum of about 600 feet near Burnt Creek.

Near the base of the formation, dolomite is interbedded with slate and rare quartzitic beds, but most of the outcrops consist of dense, massive to well-bedded dolomite that weathers in shades of brown. Much of it contains small seams of chert, but locally the chert forms seams 2 or 3 inches thick or occurs as nodules 2 or 3 inches long. Here and there the dolomite is brecciated and cemented by dolomite, or chert, or by both. Where the dolomite is well bedded, tops can be determined by crossbedding and, less commonly, by grain gradation. Some excellent examples of arenaceous dolomites are displayed in the strip, and clastic grains of quartz and chert are common in some beds. Where the Denault formation is overlain by the Fleming formation, the uppermost beds are invariably slate; where overlain by the Wishart formation, the upper part is interbedded with quartzite.

Fleming Formation

The Fleming formation occurs only where underlain by Denault dolomite, but the Denault may be succeeded by Wishart quartzite without intervening Fleming strata. Fleming rocks were first observed on the line of the Burnt Creek strip about 5 miles northeast of the southwest contact of the 'trough', where they are about 50 feet thick. Northeastward, the formation becomes irregularly, but progressively, thicker, reaching a maximum of 250 to 300 feet about 2 miles southwest of Burnt Creek; from there its thickness decreases again to zero, just southeast of Burnt Creek. A similar rock was seen on the northeast side of the Knob Lake group at Marion Lake (See Figure 1B), also lying above dolomite.

At its most southwesterly occurrence, the Fleming consists of rounded pebbles of chert in a matrix of quartzite cemented by chert. Northeastward, the exposures consist of massive chert, chert-cemented quartzite, and angular fragments of chert in a matrix of chert or cherty quartzite. The colour varies from creamy white to grey, pink, brown, red, or green. A chert-pebble conglomerate is commonly present at the top of the formation and in sharp contact with the Wishart formation. At a few places in the thicker sections, but especially near the base of the formation, chertified slate is common.

The main exposures consist of angular fragments of massive, bedded, or concentrically banded chert of various sizes in a matrix of chert or cherty quartzite. In places, what appear to be cracks in otherwise massive chert are filled with well-rounded grains of quartz cemented by chert. This material grades into cherty quartzite containing few or no fragments of chert. One exposure near Burnt Creek shows what appear to be mud-cracks on a bedding plane (?) in chert, but here the chert appears to have replaced an originally argillaceous sediment.

The Fleming formation is unusual and its origin is puzzling. Company geologists have suggested that it marks an erosion surface (11), probably including the debris of the cherty Denault dolomite, but the extreme angularity of the chert fragments in the breccia is difficult to explain by a cycle of weathering. Also, a band of slate from 1 foot to 4 feet thick separates dolomite from chert-breccia in every locality where the writer has seen the contact exposed, and where the Denault is in direct contact with the Wishart formation the two are interbedded. The remnants of chertified slate suggest that chertification of argillaceous muds under near-surface conditions, with contemporaneous washing-in of rounded quartz grains, may account for at least part of the formation. However, Jones reported (10) that there is good evidence for an unconformity, at approximately this horizon in the Proterozoic succession, about 130 miles northwest of Burnt Creek.

Wishart Formation

The Wishart formation occurs as a stratigraphic unit across the whole of the Knob Lake group. Northeast from the southwest contact of the 'trough' it lies successively on the Ashuanipi gneisses, Attikamagen formation, Denault dolomite, and Fleming chert. Northeast from Knob Lake it lies successively on Denault and Attikamagen rocks. It is remarkably constant in thickness, at least across that part of the Burnt Creek strip so far mapped. Where it rests directly on the gneisses it is 80 to 100 feet thick, and it increases gradually in successive thrust slices to a maximum of 160 feet about 3 miles northeast of Knob Lake. Thicknesses northeast of that point are not known accurately, but appear to be about the same.

Most of the Wishart formation consists of well-rounded to spherical grains of quartz cemented by quartz. A little feldspar, and minor amounts of tourmaline, zircon, and other silicate minerals are usually present. Lenses of grey to bluish grey, coarse arkose pinch out along strike; some of these are 40 to 50 feet long and up to 2 feet thick, but most of them are much smaller. The quartzite is pale buff to grey or white. Some of it is massive, but the basal part is usually well bedded and, locally, bedding is clearly displayed to the top of the formation. Crossbedding is a common feature, and ripple-marked beds are abundant in some places. Where the Wishart rocks are underlain by Fleming, the contact is sharp and, at three localities, thin interbeds of dolomite and slate were observed between the base of the quartzite and the chert-pebble conglomerate of the Fleming formation. When the Wishart rests directly on the gneisses, pebbles of chert are common in a feldspathic quartzite cemented by chert. Where it rests on Attikamagen or Denault rocks, it is interbedded with the older rocks. However, according to the schematic reconstruction shown in Figure 1C, there may be an unconformity at the base of the Wishart formation.

Ruth Formation

The Ruth formation is exposed nearly everywhere that the Wishart formation appears. In the Burnt Creek strip, it is thinnest near the southwest margin of the 'trough' where it is only about 10 feet thick. Northeastward, it thickens gradually in succeeding thrust slices, but the beds are so highly contorted that an estimate of their aggregate thickness is difficult to obtain. Probably it does not exceed 60 or 70 feet in any of the exposures examined. In spite of its thinness, the formation extends at least 70 miles to the northwest, where it has been mapped by Company geologists.

The formation is mainly a carbonaceous, ferruginous slate, with interbeds of dark grey to green chert, and is bottomed by black, massive chert from 4 to 10 feet thick. Current laboratory studies indicate a high percentage of organic carbon. Bedding is commonly obscured by crumpling, but local cherty beds provide useful markers for determining attitudes of bedding and drag-folds. Here and there graded beds can be distinguished in argillaceous members. The rock consists mainly of minute fragments of quartz in a black, semi-opaque matrix in which iron oxides, chert, and graphitic material are evident. Locally, minnesotaite (ferriferous talc) is abundant, and fragments of feldspar have been noted in several thin sections. The lateral extent and thinness of the formation, together with the extreme angularity of the fragments in the rock, are features characteristic of tuffaceous rocks, but the high content of organic carbon and the presence of argillaceous members indicate a more typical sedimentary origin.

Relations to the Wishart quartzite are not clear. In some places, rounded 'cobbles' and 'pebbles' of quartzite are embedded in the basal chert, but they are cut by stringers of chert. Near one such locality the chert appears to cut evenly across the bedding of the quartzite at an angle of about 10 degrees for 200 or more feet. It is not certain whether this represents a small disconformity or whether the quartzite has been partly replaced by chert associated with the Ruth formation. If a disconformity, it must be small because the Wishart formation is of such uniform thickness.

Sokoman Formation

Except for the underlying Ruth formation, the Sokoman[1] includes

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[1]Pronounced "Saw-koh-man", with first syllable slightly accented; Indian word meaning 'iron'.

all the iron formations of the Burnt Creek strip, and occurs throughout the Knob Lake group. It is about 200 feet thick at the southwest margin of the 'trough' and reaches a maximum of about 550 feet near Burnt Creek. Northeastward it appears to decrease in thickness, but has not yet been mapped in the same detail as the bands near Burnt Creek.

The lithology of the Sokoman formation varies along strike and from thrust slice to thrust slice, but a general stratigraphic sequence is apparent and has been set up by Company geologists. In general, the same terms are used in this report, but some modifications have been made to accord better with the exposures seen along the Burnt Creek strip, as interpreted by the writer. According to Company geologists, the Sokoman formation contains about 30 per cent iron (15).

Although the iron formations differ greatly in lithology, they all have some characteristics in common. All are composed of chert and iron compounds in varying proportions; characteristic clastic textures are comparatively rare; most individual bands occur as elongate lenses rather than in parallel arrangement; detrital silicate minerals are exceedingly rare; all contacts between different members are gradational; and all members are characterized by an oolitic arrangement of some of the constituent minerals. These oolites are composed of chert, iron oxide, siderite, or iron silicate, or any combination of these minerals. The principal minerals of the iron formations in the Burnt Creek strip are chert, goethite, hematite, magnetite, lepidocrocite (?), minnesotaite, and, locally, quartz.

<u>Banded Silicate Member.</u> Wherever the complete sequence was seen by the writer, this member occurs at the base of the Sokoman iron formations and is interbedded with the Ruth formation. It averages 30 to 40 feet in thickness, but is no more than 3 or 4 feet thick in some places and is more than 60 feet thick in others. It has a distinct granular appearance, weathers in shades of brown, contains much magnetite and minnesotaite, and commonly contains some siderite. Bedding is clearly defined, and tops have been determined by cross-bedding at several localities. A clastic structure is apparent on many weathered surfaces and, near Stakit Lake, pebbly beds have been seen. What appear to be ripple-marks are common, and structures resembling mud-cracks occur here and there.

<u>Thin-banded Jasper Member.</u> This member commonly lies above, and grades into, the Banded Silicate member. It varies in thickness from a few feet to 50 or 60 feet, and consists of alternating, elongate lenses of bright red jasper and black hematitic material, which pinch and swell but are rarely more than an inch or so in maximum thickness. Locally magnetite is the predominant iron oxide.

<u>Banded Cherty Member.</u> This member commonly succeeds the Thin-banded Jasper, but also occurs at other stratigraphic levels, especially near the top. In some thrust slices it forms the bulk of the Sokoman formation; in others it is probably no more than 10 or 20 feet thick. It grades into banded jasper both across and along the strike and, as the distinction between banded chert and banded jasper lies solely in the colour, boundaries between the two are purely arbitrary.

<u>Thick-banded Jasper Member.</u> This member is much like the Thin-banded Jasper except that its colour is not so intense and the lenses are as much as 6 inches thick. It is not represented in all thrust slices, and grades into other members. Its thickness is variable, but generally less than 50 or 60 feet. In a few places, structures resembling mud-cracks were seen in the dark, iron-rich layers.

Cherty Metallic Member. This is the name applied to a massive, steely blue variety of iron formation that has a superficial resemblance to iron ore. However, its iron oxide content is probably less than 30 per cent, and the colour is due to finely and evenly disseminated hematite. The member varies greatly in thickness; it is missing in some thrust slices and as much as 100 feet thick in others. In some places the iron oxides are rusty, and the rock is brown to purplish brown; in others, small fragments of jasper occur in sufficient numbers to impart a reddish purple tint. Brownish, pitted patches here and there are probably due to the weathering of carbonate. The member grades into Banded Cherty, Thick-banded Jasper, and Massive Cherty varieties of iron formation.

Cherty Iron Carbonate Member. This member is relatively rare in the strip mapped by the writer, and was seen mainly near the southwest contact of the 'trough' in layers a few feet thick. Company geologists report that it commonly occurs in the upper part of the Sokoman formation. Where seen by the writer, it consists of alternating beds of siderite and grey chert, and minnesotaite is commonly developed along the bedding planes. A chocolate-brown weathered surface is characteristic.

Massive Cherty Member. This name has been applied by the writer to a group of massive cherts pocked with rusty pits, or speckled with iron oxides. The member occurs in nearly all bands of the Sokoman formation, especially in the upper part, and may be as much as 100 feet thick. The pocked variety weathers brown or buff, and the individual pits contain soft, brown goethite. The pits may be $\frac{1}{2}$ inch or more in diameter, but are commonly less than $\frac{1}{4}$ inch, and appear to be due to the weathering of siderite. The speckled variety is a more glassy, milky or grey chert in which small clots of iron oxide are sparsely to thickly disseminated. The base of this member is fairly sharply defined and in contact with Banded Cherty or Cherty Metallic members.

Lean Chert Member. 'Lean cherts' are so called because they contain very little iron oxide. They lie at, or very near, the top of the Sokoman formation, and may be as much as 200 feet thick, although much less in most occurrences. Most exposures are a pale apple-green, but near Ruth Lake, where they are best displayed and thickest in the Burnt Creek section, they are grey, blue, brown, rose, and milky white. Locally they form breccias similar to those of the Fleming formation, but most of them are massive and porous. Rarely, they appear bedded. They grade downward and laterally into the Massive Cherty member, and near Ruth Lake, grade into quartzite that appears to be derived from sandstone that includes grains of chert.

Slaty Member. This member is distinct from the Ruth formation, but is highly ferruginous. Where seen by the writer it forms the uppermost part of the Sokoman iron formation, and is interbedded with lean chert in bands varying in thickness from 20 to 150 feet. In some outcrops it is highly magnetic and granular; in others it is a jet-black, carbonaceous slate; and in still others it is high in iron carbonate. Apparently this member marks the close of the cycle when deposition of iron formations was in full sway.

In one locality, near Ruth Lake, are outcrops of a unique iron formation that, apparently, is interbedded with lean chert. The formation consists of coarse, rounded clastic grains of chert in a matrix of chert and iron silicate. It is olive-brown on weathered surfaces, and appears to lens out to finer material of similar composition; the whole series of exposures is about $\frac{1}{2}$ mile long.

Menihek Formation

The predominantly slaty Menihek[1] is the youngest formation in the Knob Lake group. Its total thickness is not known; within the area mapped in the Burnt Creek strip, it reaches an exposed maximum of about 1,000 feet, but farther northeast, in the valley of the Knob Lake airstrip, it may be much thicker. If the Howse group is equivalent to the Menihek formation their aggregate thickness probably exceeds 5,000 feet.

[1] Pronounced "men-i-heck", with slight accent on the first syllable.

The Menihek formation is least altered southwest of Stakit Lake, where it is a jet-black slate that weathers ashy to dark grey, and contains interbeds of pyritiferous slate and cherty material. Near Knob and Ruth Lakes, it weathers a brownish grey, apparently due to contained iron oxides, and northeast of Knob Lake some outcrops contain interbeds of cream weathering dolomite. In the valley of the Knob Lake airstrip, the formation contains much greywacke. Differential thermal analyses suggest a considerable amount of organic material in the outcrops near Burnt Creek. Northwest of the Burnt Creek section, the formation contains much dolomite and, near the contact with the Howse group, dolomite constitutes a large proportion of Menihek(?) rocks (7).

The contact of the Menihek with the Sokoman formation seems to be completely conformable in the Burnt Creek section. Slaty iron formation passes into an argillaceous rock that marks the base of the Menihek, and it is difficult to locate the actual contact. In places, typical Menihek slate appears interbedded with Sokoman chert. However, about 75 miles to the northwest, Company geologists have recently found that the Menihek overlies Sokoman, Ruth, and Wishart formations and even appears to extend onto Ashuanipi gneisses. It is possible that this feature is due to progressive overlap by the younger formation, especially in view of the conformable relations near Burnt Creek. Nevertheless, still farther north, at about latitude 57°20' and longitude 69°50', iron formation is overlain by a slaty formation that contains a jasper conglomerate at the base. However, the stratigraphic succession there is not the same as that near Burnt Creek (2, 10) so it is not yet possible to make exact correlations; but it is clear that, in some parts of the 'trough', an unconformity separates a formation similar to the Sokoman from a formation similar to the Menihek.

Volcanic Rocks

Volcanic rocks have been mapped by Company geologists at several horizons in the Knob Lake group, especially to the east and southeast of Knob Lake. They have not yet been mapped in any detail by the writer, but traverses were made at a few such localities in 1949. Some tuffaceous rocks occur interbedded with Attikamagen(?) slates near Knob Lake, and flows and breccias have been seen with the Wishart and Sokoman strata a few miles farther southeast. In the region near Sawyer Lake, about 30 miles southeast of Burnt Creek, the Sokoman formation has been split into two formations by basic volcanic rocks, according to Company maps. Near Point Lake, about 3 miles west of Sawyer Lake, an excellent example of a volcanic conglomerate is displayed. Pebbles and boulders of igneous and sedimentary rocks are set in a matrix of basalt, as if the lava had flowed onto a boulder beach. Jaspery pebbles and fragments are common in some other flows, and chert selvedges mark pillowed structures in some other flows near Hollinger Lake.

Howse Group

Only a small part of the Howse group has been seen by the writer, and most of the information is taken from Frarey (7). In the northeast part of the 'trough', bands of interbedded slate, argillite, fine quartzite, and basic flows(?) are separated by thick sills of diorite and gabbro and the sedimentary members comprise only about 20 per cent of the terrain. Their total thickness is difficult to estimate because crumpling is evident in the few exposures, the bands are discontinuous, and there is nothing to indicate the amount of repetition due to faulting and folding. Frarey suggests that 4,000 feet is a reasonable estimate of the thickness of the group in the area mapped by him. The rocks are much the same, in general appearance, as those of the Menihek formation, but lack of outcrops in critical localities precludes positive correlation, although all data obtained indicate a conformable relation. To the southeast, near Marion Lake (See Figure 1B), the writer examined some exposures that are part of the belt mapped as the Howse group. Nearby are some Menihek rocks, and so far as could be determined the two are identical. Structures appeared to be continuous throughout, and no evidence of unconformity, or more than minor faulting, was obtained. If subsequent study proves a conformable relationship and lithological similarity, the name "Howse group" should be dropped, a possibility suggested by Company geologists at least as early as 1949 (11).

Murdock Group

The Murdock group forms a narrow belt on the northeast flank of the Howse group. A strip about 20 miles long has been mapped in some detail by Frarey (7), who found a maximum width to the exposures of about 1 mile. The aggregate true thickness of the group could not be estimated, for the rocks are highly schistose, crumpled, and altered, and top determinations are rarely possible. The group consists of basic pyroclastic rocks, with possibly some flows, interbedded with clastic sedimentary material, including conglomerate. All are converted to green schists, so that details of stratigraphy posed a problem.

The relations between Howse and Murdock rocks are obscured by a major fault that follows their contact. On the basis of metamorphism, Company geologists suggested that the Murdock is an upthrust block of older, Keewatin-type material (11). However, an outcrop of roundstone conglomerate on the northeast shore of Walsh Lake, at the base of the Murdock group, contains pebbles of several different rock types, including some that appear to be of jaspery iron formation. The only such iron formation known in the region is that in the Sokoman formation, and pebbles of it here are strongly indicative of an unconformity at the base of the Murdock group. On theoretical grounds, the intimately mixed assemblage of clastic sedimentary and pyroclastic members suggests the beginnings of volcanism. Further, the high degree of shearing may be due to the fact that this mixed assemblage occurs on the sole of a major thrust fault, where the greatest degree of shearing would be expected.

Doublet Group

The Doublet rocks are mainly basic volcanic flows containing some interbedded breccias and clastic sedimentary rocks; they comprise the northeastern part of the Proterozoic succession. They are closely folded and faulted, but the volcanic members are thought to be at least

10,000 feet or more thick, and the sedimentary members about 2,500 feet (6, 7). Most of the flows are well pillowed and many are separated by a few feet of black, graphitic slate. The more coarsely clastic sedimentary rocks occur in well-defined bands as much as 1,000 feet or more thick, and one such band forms the base of the group (7). These sedimentary rocks are commonly crossbedded.

Relations with the Murdock group are obscured by faults, but the succession appears to be conformable and the Doublet rocks probably represent the culmination of volcanic activity that began when the Murdock rocks were formed. The upper part of the Doublet group has been eroded.

Intrusive Rocks

Intrusive rocks in the areas so far investigated by Geological Survey field parties are all basic, except for some syenite that cuts the Howse and Murdock groups. The basic intrusions that cut the Howse, Murdock, and Doublet groups vary in composition from diorite to serpentine (6, 7), and some are splotchy with light-coloured clinozoisite. Diabase dykes are the only intrusions noted in the Knob Lake group of the Burnt Creek strip; they cut across all structures in the older rocks and trend nearly north.

In the southern part of the 'trough', about 150 miles south of Burnt Creek, large intrusions of granitic and basic material cut the iron formations and associated rocks. About 150 miles north of Burnt Creek, other geologists have suggested that similar relations obtain, but the evidence appears to be questionable.

STRUCTURE

Nearly all the Proterozoic rocks have been intensely faulted and folded. Here and there, some of the rocks on the southwest side of the 'trough' are virtually undisturbed and dip gently northeast, but details of most structures are difficult to determine. Company geologists have long known that at least most structural data point to the operation of pressures from the northeast. The numerous thrust faults dip northeast, and axial planes of overturned folds also dip northeast. Exception to these attitudes have been noted near Sawyer Lake, where the beds dip steeply west; near the southwestern extremity of Labrador, where attitudes are variable; and west and southwest of Ungava Bay, where the rocks have a zigzag trend within the confines of the 'trough'.

The following comments will be restricted mainly to the Knob Lake group in the Burnt Creek strip. Details of structures in the Howse, Murdock, and Doublet groups can be obtained from maps by Fahrig (6) and Frarey (7).

The characteristic structure in the Burnt Creek strip is the overturned anticline, with a large part of the overturned limb truncated along a thrust fault (Figure 1D). The northeast limb of the fold dips irregularly northeast at low to moderate angles, and the southwest limb dips moderately to steeply northeast. The under limb characteristically rides on a northeast-dipping thrust fault that probably dips at an angle less than that of the bedding. The synclinal complements of these anticlines are much sharper and are commonly V-shaped. Top determinations are comparatively rare, and drag-folds have been formed that are not related to the major fold. Hence, the stratigraphic succession must be followed closely to determine detailed structure. The shapes of most folds indicate that they were formed at the same time as the thrust faults, probably as a result of the thrusting. Plunges of folds are commonly less than 25 degrees but, locally, may be as much as 50 degrees, and reversals in direction of plunge may occur in a strike length of a few feet. The northeast slopes of hills are mainly at angles corresponding closely with the dips of formations so that a false impression of the thickness of these formations may be obtained. The southwest slopes, on the other hand, are commonly steep, and may even be undercut, so that apparent thicknesses in plan are less than the true thicknesses. In several places the noses of hills slope at nearly the same angle as the plunge of folds, to produce the illusion of extreme sharpness to the folds as seen on a map. In one place the slope of the ground is steeper than the plunge of a syncline, which appears to close down the plunge.

Fault planes are rarely exposed in the area, so the attitudes of faults are commonly considered the same as those of the schistosity in the rocks where sheared by the faults. However, the schistosity dips at moderate to high angles and is probably due to slippage tangential to the fault plane. One fault, where exposed by a bulldozer, dips at 40 to 45 degrees, but the schistosity of the beds in the overlying fault plate dips 60 to 65 degrees in the same direction, flattening as the fault plane is approached. In other places, the surface trace of the schistosity strikes at angles as much as 30 degrees to the trace of the fault. It is probable that most of these faults, if not all, flatten with depth, for the cover of Proterozoic rocks is comparatively thin and the basement rocks are nowhere exposed.

Many thrust faults follow stratigraphic contacts for long distances, and can only be recognized where they cut obliquely across formations.

Cross faults of small displacement are common and, where exposed, all were seen to dip vertically to steeply northwest or southeast. Slickensides and crenulations indicate that the main component of movement was horizontal, and both right- and left-hand offsets occur. As seen in plan, many of these faults curve into the thrust faults; others cut across the thrusts. Diabase dykes may fill some cross faults that trend nearly north, for the rocks on opposite sides of some dykes at least do not match. Probably more than one age of cross faulting occurred. At least one cross fault shows a displacement measurable in hundreds of feet, but most of them indicate offsets of only a few feet.

In an area where so much thrusting has occurred, normal faulting would be expected after the compressive stresses were dispersed, but evidence for such movement is exceedingly rare and has been seen by the writer at only one locality. However, in the construction of the section shown in Figure 1D, it appears that normal faults may occur near two of the orebodies.

One of the features of all faults, where the adjacent rocks are exposed, is the narrow zone in which shearing has occurred. One fault, with at least 1,500 feet displacement, is marked by sheared and brecciated slates for only a foot on either side; other faults show only an inch or so of clay gouge; still others show only minor brecciation.

In the Burnt Creek strip so far mapped, a maximum thickness of 3,000 feet of moderately to steeply dipping rocks occupies a belt at least 20 miles across. Judging from the attitudes of the formations (See Figure 1D), the present width of exposures is no more than one-fifth of the original width of the belt when the beds were deposited. If it be assumed that the same degree of shortening applies to all the Proterozoic strata in the Burnt Creek strip, the present width of about 60 miles represents a basin that was at least 300 miles across at the time the rocks were laid down. This strip represents one of the widest parts of the 'trough', but it is clear that the present width, as shown on the maps, is only a fraction of the original.

The term 'trough' is, geometrically, not applicable to this belt of strata, for the opposite sides do not match and the dips are mainly northeastward. However, from the information at hand, it can be inferred that the site of deposition was originally a broad geosyncline, or trough, and that the contained rocks have been folded and faulted to their present position. The thickness of the Murdock and Doublet groups suggests that the trough was probably deeper on the northeast side. If the Murdock lies unconformably above the Howse group, the basin probably developed progressively from southwest to northeast.

METAMORPHISM

The rocks in the Burnt Creek strip show only a low grade of metamorphism in spite of the structural complexity. A hundred or more miles to the south, where intrusive rocks are abundant, the iron formations have been converted to magnetite-specularite quartzites, and to grunerite, cummingtonite, and stilpnomelane schists; the dolomite has become a marble, and the slates have been converted to biotite schists. To the north, near Larch River, metamorphism is said to increase in grade, but not to the same degree as in the rocks to the south. The following comments apply only to the Knob Lake group of rocks between the southwest contact of the 'trough' and the Knob Lake airstrip (See Figure 1B).

Degree of alteration increases from the margin towards the interior of the 'trough', but only at faults and near orebodies is it great enough to obscure the character of the rocks. Secondary enlargement of detrital quartz grains is clear in thin sections of the Wishart formation, and primary features, such as crossbedding, ripple-marks, and lensing of beds, are distinct. The Denault and Menihek dolomites are dense, fine-grained rocks that locally exhibit crossbedding and grain-gradation in well-preserved arenaceous beds of dolomite. The slaty rocks are clearly bedded and grain-graded, and the coarser fractions are clear under the microscope.

Details of metamorphism are more clearly shown in the iron formations than in any other units of the Knob Lake group. All specimens examined from the unfolded part of the iron formations southwest of Stakit Lake contain siderite as disseminated grains or as discrete bands. Minnesotaite (ferriferous talc) occurs as finely disseminated plates, as sheaves and rosettes, and as lamellar growths, but it is especially concentrated along the contacts between chert and carbonate layers. Ovoids, some of which are oolites, consist mainly of chert, with local carbonate, silicate, and iron oxides, and most of them are distinct from the matrix either in grain size or composition. Those that consist mainly of silicate mineral are distinctly green and too fine grained to determine accurately, but are probably minnesotaite and may be of primary origin. The iron oxide is chiefly hematite, but magnetite is common and goethite is rare. In the folded iron formation northeast of Stakit Lake, siderite is much less common, and minnesotaite and magnetite are more abundant, especially in the Banded Silicate member. This minnesotaite is colourless to pale green, and is clearly metamorphic, for crystals grow across veinlets of secondary quartz. Ovoids are distinct in plane light, when examined in thin section, but can rarely be distinguished with crossed nicols because of recrystallization. Goethite is common and in many slides is obviously pseudomorphic after minnesotaite and siderite. Some of the lean cherts are recrystallized so that they appear as granular quartzite in hand specimens, but the ovoid character of the material can be seen with the microscope in plane light.

Here and there, the rocks along faults have been more or less altered, and minerals such as chlorite, sericite, and secondary carbonate can be distinguished.

IRON DEPOSITS

No special effort has been made by the writer to study the deposits of iron ore, and the following comments are of a general nature. They have been derived from discussions with Company geologists, or from visits to selected localities under their guidance, and from the mapping of five orebodies and several occurrences in the Burnt Creek strip. Numerous sulphide deposits, none of which is known to be commercial, occur in the northeastern, predominantly igneous, half of the 'trough', and several are described by Fahrig (6) and Frarey (7).

As pointed out by Company geologists (11, 15), all known orebodies are exposed at the present erosion surface; all are comparatively shallow (300 feet is the common depth); most of them appear to be in structural troughs; all are confined wholly or mainly to iron formation; and, except for the unique Sawyer Lake deposit of hard ore, all are composed mainly of soft ore. These characteristics fit the orebodies perfectly for the classic explanation of the origin of iron ore of Lake Superior type — surface waters leaching silica from iron formations and leaving a residually enriched deposit of iron ore. However, some of these features, as indicated below, may be more apparent than real.

(1) Connection with Present Erosion Surface. The exploration of this belt of iron-bearing rocks has virtually just begun, and it is only reasonable to expect that the first discoveries will be exposed at the surface. So far as known, no evidence indicates that unexposed orebodies do not occur (11).

(2) Orebodies Are Shallow. The fact that all the known orebodies are shallow may be due to the relation between the controlling structural features of an orebody and the erosion surface. In an area where the rocks are as complexly folded as in this belt, it would be most unusual for any local fold to persist more than a few hundred feet in depth (See Figure 1D). According to Company geologists (11), most orebodies are known to be closely associated with faults or shallow folds, or with both, so the intersection of a folded structure with a fault could be the significant relation here, as it is in so many other mining camps in the Canadian Shield.

(3) Ore Occurs in Structural Troughs. Information obtained by drilling indicates that this is a definite feature (11), but it may be due to the type of folding. Anticlines are commonly broader and their crests more gently rounded than the complementary synclines. As a result, the tightly compressed rocks in the synclines are more likely to be brecciated, especially where associated with faults, and hence provide easy channelways for whatever solutions accomplished the alteration to or emplacement of iron ore (15).

(4) Orebodies Are Confined to Iron Formations. Most, or all, of any one orebody lies within the iron formation member of the Sokoman formation, but by no means all material of ore grade is confined to iron formation. The Ruth slate, although an iron formation, is highly aluminous and yet is commonly converted to ore near the margins of orebodies. In one or two places, alteration to ore has continued beyond the Ruth slate so that Wishart quartzite has been partly replaced by iron oxides. In fact, where this quartzite is exposed near an orebody it has commonly been altered by iron-bearing solutions to produce a red, sandy rock that is an excellent guide for prospecting. One comparatively small pod of iron oxides occurs in Fleming chert breccia, and elsewhere in the same formation iron oxides comprise 50 per cent or more of the rocks. Although these occurrences are small, stratigraphic and structural relations indicate that iron formation lies no nearer than several scores of feet from them. Further, the outlines of breccia fragments are clearly preserved in some of the iron oxide, showing that the iron oxide formed by replacement and not by leaching silica from a formation that contained an original, local, concentration of iron oxides. The writer has seen several places where lean cherts at the top of the Sokoman formation have been brecciated by faults and the breccia cemented by iron oxides. All these features indicate that iron moved in solution on a broad scale, and that some at least of the enrichment is due to metasomatic replacement of silica by iron oxides.

(5) Soft Ores Are Weathered Products. Except for the Sawyer Lake deposit, all the known orebodies consist of soft ore with streaks and bands of hard material that appear to follow particular beds. These soft ores are usually considered to result from surface waters leaching silica and leaving a residual, porous ore. However, in every place the writer has seen Burnt Creek ores naturally exposed, they are covered by a hard capping that grades downward in a few feet to soft, friable ore, but where excavations have uncovered the ore beneath glacial debris it is soft. It seems that weathering, at least under present conditions, results in an indurated rock, not a friable material.

Hard ore, such as that at several mines in the Lake Superior district, is commonly regarded as a result of folding and heat on previously formed and buried soft ore. The Sawyer Lake deposit consists of such hard ore, is in an area of intense folding, and was thought by Company geologists and the writer to represent just such an occurrence. However, one of the Company field parties, mapping near the southwest contact of the 'trough' in 1951, discovered bands of hard, blue hematite about 6 inches thick in gently dipping iron formation that has never been folded. The iron formation in this part of the 'trough' is among the least altered of any seen and, although angular boulders of diabase occur in drift nearby, it would be difficult to postulate thermal metamorphism sufficient to change soft ore to hard ore without simultaneous alteration of the iron formation. At the only locality where the writer has seen diabase cutting iron formations, thin sections of iron formation from the contact showed no discernible effects from the intrusion.

Many ore deposits contain considerable amounts of manganese (14, 15, 18). This manganese must have been introduced into the orebodies at their present sites because the iron formations themselves are deficient in it. The manner in which the manganese occurs in orebodies is not known to the writer, but numerous small deposits of manganese oxides are found here and there as fracture fillings and veinlets in a wide variety of host rocks.

In summary, the general relations of iron ore show most of the features commonly attributed to enrichment by surface waters acting to disolve the silica and residually enrich the iron formations. However, at the present stage of knowledge, the writer feels that all these features can be explained just as readily by appealing to hydrothermal solutions or to Gruner's modification of hydrothermal activity (9), as was done by Stubbins (17), and also feels that many features can only be explained by such a process.

BIBLIOGRAPHY

1. Aubert de LaRue, E. (1948): Geological Survey Through the Ungava Peninsula; Jour. Arctic Inst. North America; vol. 1, No. 2, pp. 135-136.

2. Bergeron, Robt. (1951): Geology of Forbes Lake Area, Ungava; Columbia Univ., unpublished M.A. thesis.

3. Bonham, W. M. (1949): Labrador Iron Range; Can. Min. Jour., vol. 70, No. 7, pp. 57-61.

4. Eade, K. E. (1952): Unknown River, Labrador, Newfoundland; Geol. Surv., Canada, Paper 52-9.

5. Faessler, C. (1950): The Labrador Peninsula; Can. Min. Jour., vol. 71, No. 6, pp. 47-50.

6. Fahrig, W. F. (1951): Griffis Lake, Quebec; Geol. Surv., Canada, Paper 51-23.

7. Frarey, M. J. (1952): Willbob Lake, Labrador-Quebec; Geol. Surv., Canada, Paper 52-16.

8. Gill, J. E., Bannerman, H. M., and Tolman, C. (1937): Wapussakatoo Mountains, Labrador; Bull. Geol. Soc. America, vol. 48, pp. 567-586.

9. Gruner, J. W. (1937): Hydrothermal Leaching of Iron Ores of Lake Superior Type: A Modified Theory; Econ. Geol., vol. 32, pp. 121-130.

10. Jones, R. H. B. (1948): private report.

11. Labrador Mining and Exploration Company (1949): private report.

12. Low, A. P. (1896): Report on Explorations in the Labrador Peninsula; Geol. Surv., Canada, Ann. Rept. 1895, vol. 8, pt. L, 387 pp.

13. Retty, J. A. (1945): Surface Work Indicates Possibility of a Major Iron Ore Field in Central Labrador; Min. and Met., vol. 26, pp. 255-256.

14. Retty, J. A. (1951): Iron Ore Galore; Can. Geog. Jour., vol. 42, pp. 2-21.

15. Retty, J. A. and Moss, A. E. (1951): Iron Ore Deposits of New Quebec and Labrador (abstract); Econ. Geol. vol. 46, pp. 799-800.

16. Rice, H. R. (1949): Grand Scale Prospecting in Labrador and Quebec; Can. Min. Jour., vol. 70, No. 9, pp. 65-77.

17. Stubbins, J. S. (1950): The Goodwood Iron Deposits; private report.

18. Tanton, T. L. (1949): Observations on Concentrations of Manganese Ore Minerals in Ungava and Keonjhar; Trans. Roy. Soc., Canada, 3rd ser., sec. 4, vol. 43, pp. 113-117.