Permafrost investigations in Northern Manitoba and Quebec-Labrador: 1955
Brown, R. J. E.
PERMAFROST INVESTIGATIONS IN NORTHERN MANITOBA AND QUEBEC-LABRADOR : 1955

by

R.J.E. Brown

ANALYZED

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PREFACE

The author is a research officer in the Permafrost Section of the Division of Building Research, National Research Council where he is doing research on the distribution of permafrost in Canada.

One of the main projects under this general research program is the mapping of the southern boundary of permafrost in Canada. Data are being obtained by reviewing available literature, circulation of a permafrost questionnaire throughout the North, studying aerial photographs and conducting field investigations.

This report records the results of permafrost field investigations by the author at four locations in northern Manitoba and two locations in Quebec-Labrador during the summer of 1955. Because transportation facilities were critical in these northern areas, it was possible to spend only a few days at each place. It is the Division's hope that more detailed investigations will be possible in subsequent summers.

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July 1956

Robert F. Legget
Director
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In July 1955 permafrost investigations were conducted in several locations in northern Manitoba. Visits were made to Cranberry Portage and Flin Flon, 54 and 100 miles northwest of The Pas respectively. Several days were spent in the new mining town of Lynn Lake, 180 miles north of Cranberry Portage. A journey was made on the Hudson Bay Railway from The Pas to Churchill. Permafrost investigations were conducted along the railway at Bird, 150 miles south of Churchill.

In August 1955 permafrost investigations were conducted in several locations in Quebec-Labrador. Visits were made to the iron ore mining development at Knob Lake in the interior of Ungava, two locations 90 and 150 miles west of Knob Lake respectively, and Great Whale River on the east coast of Hudson Bay.

1. Permafrost and Related Features at Cranberry Portage, Manitoba.

1.1 Location and Site

Cranberry Portage is situated in northwestern Manitoba at 54° 35' N., 101° 23' W., on the C.N.R. line between The Pas and Flin Flon. It is 54 miles north of The Pas and 39 miles southeast of Flin Flon. It is on the East Arm of Lake Athapapuskow on the portage route between this lake and First Cranberry Lake, which is 11 feet higher than Lake Athapapuskow and about three-quarters of a mile to the east (Fig. 2). Lake Athapapuskow has an elevation of 956 feet above sea level.

The town lies just north of the southern boundary of the Precambrian Shield. To the south are broad expanses of flat muskeg with many lakes. To the north are rock hills and knolls with many lakes, deposits of muskeg and thin patches of soil. The site of the town is in the middle of a mile-long terrace of granular material which rises from Lake Athapapuskow to a height of 30 to 40 feet. The material is predominantly sand but there are angular stones and boulders up to 1 foot in diameter. This land form offers the best building site in the area.

1.2 Frost Conditions in Granular Townsite Terrace

According to local inhabitants, winter frost penetrates to a depth of 6 to 8 feet in the granular terrace. The ground does not remain frozen through the summer in this land form. The Manitoba Government is erecting a new house for the Department of Mines and Natural Resources on the side of the terrace near Lake Athapapuskow. The excavation is 8 feet deep at the back of the house and 6 feet deep at the front and no frozen ground was encountered.
Several borings were made in the granular terrace on July 21, 1955, with a Hoffer soil probe and screw-type hand soil auger. Two holes were advanced in the school yard. The vegetation consisted of grass up to 2 feet high and scattered patches of moss. The soil was an unfrozen moist-brown silt with fine sand and random angular stones. Large stones below a depth of 5 feet prevented further penetration.

A local inhabitant dug a pit 2 feet 6 inches deep in his parking lot at the beginning of July and claimed that frozen ground encountered at that depth prevented further penetration. On July 21, 1955 a hole was advanced from the bottom of the pit with the hand auger to a depth of 9 feet 6 inches below the surface. The vegetation was spruce and birch up to 30 feet high and willow up to 10 feet high with low shrubs and grass up to 2 feet high and scattered patches of moss. To a depth of 5 feet 6 inches the soil was an unfrozen moist-brown silt with some fine sand and clay. From 5 feet 6 inches to 9 feet 6 inches the soil was an unfrozen moist-brown medium sand with some silt.

1.3 Permafrost in the Muskeg

In the muskeg-filled depressions in the Precambrian Shield and in the muskeg expanses to the south, permafrost is widespread and was encountered just below the surface cover. A local inhabitant reported that frozen ground was encountered in the muskeg in post holes along the railway south to Simonhouse (10 miles south of Cranberry Portage) but that none was found south of that settlement. At Simonhouse frozen ground is 4 feet below the surface in July.

On July 20, 1955 permafrost investigations were conducted in a muskeg area in a depression in the bedrock 200 yards east of Ma. itoba Highway Number 10, 2 miles north of Cranberry Portage.

The vegetation on the knolls and ridges of bedrock consists of dense stands of spruce and poplar up to 25 feet high, scattered alder up to 10 feet high, shrubs up to 5 feet high, and a ground cover of moss. On the muskeg, the vegetation consists of scattered spruce and poplar up to 15 feet high with some tamarack and low-woody shrubs (Fig. 14). The ground cover is moss and grass under 2 feet high.

The surface of the muskeg consists of moss hummocks 6 inches high. Frozen ground was encountered 6 inches below the surface in the hummocks and 12 inches below the surface in the depressions between hummocks indicating the flat nature of the permafrost table.

Small pools of surface water, each a few feet square, are scattered throughout the muskeg area. The soil under these areas was unfrozen to a depth below 9 feet. From the surface to a depth of 1 foot the material is living yellowish-green moss. From a depth of 1 foot to 7 feet 6 inches the material is unfrozen wet amorphous granular and fine fibrous non-woody organic material. Below 7 feet 6 inches the
soil is an unfrozen wet plastic grey-blue clay.

On July 21, 1955 permafrost investigations were conducted in a muskeg area 100 yards west of the railway track, one mile south of Cranberry Portage. The topography is flat to slightly rolling with scattered rock outcrops.

The vegetation consists of white spruce up to 20 feet high, tamarack 15 feet high, alder 2 to 6 feet high and ground cover of moss, Labrador Tea and pitcher plants. There are scattered open tracts of grass 2 feet high (Fig. 15).

In the wooded muskeg, the ground is covered with moss hummocks 12 inches high. The depth to frozen ground is 18 inches from the tops of the hummocks and varies from 18 inches to below 3 feet in the depressions between hummocks.

In the wetter grass-covered open areas the material is unfrozen to a depth below 9 feet. From the surface to a depth of 6 inches the material is living red and yellowish-green non-woody fibrous moss. From a depth of 6 inches to 5 feet 6 inches the material is unfrozen wet amorphous granular and fine fibrous non-woody organic material. From a depth of 5 feet 6 inches to 7 feet 6 inches the soil is unfrozen wet brownish-grey clayey silt. From a depth of 7 feet 6 inches to 10 feet 6 inches the soil is unfrozen wet brownish-grey to blue highly plastic clay. Penetration was not possible below a depth of 10 feet 6 inches because of large stones or bedrock.

2. Permafrost and Related Features at Flin Flon, Manitoba

2.1 Location and Site

Flin Flon is situated in northwestern Manitoba at 54° 46' N., 101° 52' W., at the end of the C.N.R. line from The Pas. The railway station has an elevation of 1098 feet above sea level. The town and mine buildings are in Manitoba just inside the Manitoba-Saskatchewan boundary but the ore bodies are in Saskatchewan (Fig. 3). The site is predominantly bare rock ridges and knolls with patches of muskeg in depressions in the bedrock.

2.2 Permafrost at Flin Flon

When the town was founded in 1929, there was a permafrost condition in the muskeg. This condition has disappeared over the years from the accumulated heat loss from the many buildings. The chief building problems have been concerned with muskeg and bedrock.

Winter frost penetrates to a depth of 6 to 8 feet in road-fill areas but it may be only 3 to 4 feet in areas of shallow soil. Minimum air temperatures reach -30°F. to -40°F. during the coldest part of the winter. Winter frost persists into late June or early July. (R.F. Comstock, town engineer, reported that this was the condition in the surrounding country too.)
2.3 Frost Conditions in the Muskeg Near Flin Flon

Several borings were made with a Hoffer soil probe and screw type hand auger in a muskeg area adjacent to Manitoba Highway Number 10, 9 miles southeast of Flin Flon on July 23, 1955. This highway was built in 1951 during which time a road allowance about 100 yards wide was cleared. One hole was advanced in the undisturbed area just outside the road allowance. Two holes were advanced in the road allowance area. Frozen ground was not encountered in any of the holes.

In the undisturbed area beyond the road allowance the vegetation is black and white spruce up to 50 feet high with alder up to 15 feet high and ground cover of grass 1 foot high with moss and Labrador Tea. In the hole in this area, the material from the surface to a depth of 5 inches is moist living brown non-woody fibrous moss. From a depth of 5 inches to 2 feet the material is moist black granular and non-woody fibrous organic material. From a depth of 2 feet to below 4 feet the soil is moist-brown nodular clayey silt.

One hole in the road allowance was in an area which supported tree growth before the road was constructed (Fig. 16). The present vegetation is spruce up to 6 feet high, tamarack, alder, fireweed and patches of grass up to 3 feet high. From the surface to a depth of 5 inches the material is moist living brown non-woody fibrous moss. From 5 inches to a depth of 5 feet the material is black granular and non-woody fibrous organic material. From 5 feet to an unknown depth, the soil is brownish-grey silty clay which was more plastic than in the previous hole in the undisturbed area.

The second hole in the road allowance is in a boggy area having surface water. The vegetation consists of weeds and grass up to 3 feet high. From the surface to a depth of 7 feet the material is wet black granular and non-woody fibrous organic material. From 7 feet to an unknown depth the soil is plastic brownish-grey silty clay.

3. Permafrost and Related Features at Lynn Lake, Manitoba

3.1 Location and Site

Lynn Lake is situated in northwestern Manitoba at 56° 51' N., 101° 03' W., at the end of the C.N.R. line extending north from Cranberry Portage for 184 miles (Fig. 4). Most of the townsite is located on a granular deposit on the side of a gently sloping ridge of bedrock. The lower part of the town is built on a shallow muskeg deposit, up to 5 feet deep, overlying sand and silty sand. The town is bounded on the east by Lynn Lake and on the west by West Lynn Lake. These lakes are joined by a narrow creek on the northeast edge of the town. The water level of Lynn Lake has an elevation of 1195 ± 25 feet above sea level. The airport, which is about one mile west of the town is built on an esker which can be traced to the north and
south for many miles. The average width of the esker is 40 feet. It fans out near the town to a width of about one-half mile. The airport is built on this wider portion. To the east of the granular deposit on which the townsite is located is exposed bedrock and to the west is muskeg.

3.2 Permafrost in the Sand

When the townsite was first being developed, the shallow muskeg overlying the sand was frozen. It was stripped and the frost receded into the sand. The distribution of permafrost in the Lynn Lake area is sporadic. When excavations were advanced for basements, some encountered permafrost and some did not. Where permafrost was encountered, the excavations were advanced by thawing. There have been no foundation problems because the small amount of water released by thawing drained away quickly and foundations are solid now.

3.3 Permafrost Data of Sherritt-Gordon Mines Limited

Exploratory drill holes advanced by Sherritt-Gordon Mines Limited revealed the sporadic distribution of permafrost. Where permafrost was found its vertical extent averaged 15 feet. In one hole, which was drilled to a depth of 120 feet, water seeped in and froze in the bottom of the hole.

3.4 Permafrost in the Muskeg

On July 28, 1955 the permafrost investigations were conducted in the muskeg area about 300 yards northwest of the Fairview Hotel, which is on the main street. This flat muskeg area extends westward to West Lynn Lake.

The vegetation consists of open stands of spruce up to 40 feet high averaging 20 feet in height. There are also scattered tamarack up to 15 feet high with a few alder and willow up to 6 feet high. There are two types of ground cover: The first consists of moss hummocks up to 18 inches high with Labrador Tea, lichen and berry plants. The second consists of grass up to 2 feet high in open areas.

In the moss covered areas the depth to permafrost varies from 12 to 30 inches. In the tops of the hummocks, the depth to frozen ground is 18 inches. In the depressions between the hummocks the depth is about 30 inches. In some depressions, granular material consisting mostly of unfrozen sand, was encountered at a depth of 30 inches. Any frozen muskeg that was encountered displayed no discernible ice segregation and was well bonded.

A boring was made with a screw-type hand auger in one of the grass covered open tracts (Fig. 17). From the surface to a depth of 4 inches the material is yellowish-green living moss. From a depth of 4 inches to 1 foot the material is moist light-brown dead moss. From a depth of 1 foot to 3 feet 6 inches the material is an unfrozen and wet brown amorphous granular and woody fine fibrous organic material. From a depth of 3 feet 6 inches to 8 feet 6 inches the soil is unfrozen
and wet brownish-grey clayey silt with some fine sand. From a depth of 8 feet 6 inches to 9 feet the soil is an unfrozen and wet fine sand. Below 9 feet, where the auger met refusal, the soil is an unfrozen and wet fine sand with stones.

In these open tracts there are isolated plateaux of moss hummocks in which there was a small island of frozen ground at a depth of 18 inches (Fig. 18). In one such plateau, which is about 2 feet above the general muskeg level, frozen ground varies from 18 inches below the surface on the south side to 6 inches below the surface on the north side.

4. Permafrost and Related Features at Bird, Manitoba

4.1 Location and Site

Bird, Manitoba is a railway siding on the Hudson Bay Railway at Mile 347 north of The Pas. It is situated at 56° 30' N. 94° 14' W. 308 feet above sea level (Fig. 5). The area investigated extends along the Hudson Bay Railway from Mile 347 to Mile 351. The soil is predominantly shallow muskeg overlying sand and fine-grained soils. The deepest muskeg in this area is 3 feet 6 inches. At Mile 349.5 the Limestone River crosses the railway. It has cut a valley about 100 feet deep exposing banks of silt clay and fine sand with random pebbles.

4.2 Permafrost along the Railway

A flat sandy gravel plain about 300 yards wide extends north from the railway for about one-third of a mile at Mile 348.3 (Fig. 19). Adjacent to this deposit to the east is a gravel borrow pit about one-third of a mile long. About one-half mile to the northeast, just north of the Limestone River is another borrow pit about the same size. No permafrost was encountered in these granular areas.

At Mile 348.3 a railway siding was constructed in July, 1955. Several feet of muskeg were stripped and piled up beside the gravel fill which was subsequently laid down (Fig. 20). On August 2, the frost had risen 1 to 2 feet in the bulldozed muskeg. In the undisturbed area adjacent to the siding, the vegetation consists of open stands of spruce up to 15 feet high with ground cover of moss hummocks and scattered lichens. In this area the depth to permafrost varies from 1 foot to 1½ feet. Scattered through this area are small patches of ground saturated with water. The depth to permafrost averages 4 feet. The soil beneath the muskeg is frozen silty sand with small random stones.

At Mile 347.5 the vegetation consists of scattered spruce and alder up to 8 feet high and shrubs up to 2 feet high. In this area there are several peat ridges about 18 inches high having a vegetation cover of very small spruce, lichens, Labrador Tea and grass. In this area the muskeg is black decomposed amorphous granular organic material.
In the peat ridges the depth to permafrost was 18 inches but in the water-filled depressions below the peat ridges the depth to permafrost was 4 feet or more.

At Mile 351 the vegetation is mixed spruce and poplar with low shrubs and grass. The soil is well-drained clayey silt with fine sand and random stones. Frozen ground was encountered below the 3 foot depth.

At Mile 351.3 the vegetation is scattered spruce and alder up to 6 feet high with an undergrowth of grass, lichens and mosses. The organic soil varies in depth from 2 feet 9 inches to 3 feet. The bottom 2 to 3 inches of the muskeg was frozen in scattered patches throughout the area.

At a Manitoba Government Survey camp on the slope of the Limestone Valley at Mile 350 the soil is a fine moist sand with some silt and random angular stones up to 6 inches in diameter. Where there is a ground cover of moss, frozen ground was encountered at a depth of 2 feet.

4.3 Permafrost in the Nelson River Valley

The Limestone River empties into the Nelson River 1½ miles below its intersection with the Hudson Bay Railway at Mile 349.5. A survey party of the Manitoba Government was examining the Nelson River for hydro-electric power potentialities 9 miles downstream from the mouth of the Limestone River just above Limestone Rapids. A northwest-southeast section was taken across the Nelson River from the southeast facing bank to the northwest facing bank. The depths to frozen ground encountered are given in the following table.

It appears from this table that ground cover and soil type were the critical factors in determining the depth to frozen ground along the traverse. The depths to frozen ground under moss cover in organic soil were much less than those in mineral soils with thinner and scattered moss cover.
### DEPTHS TO FROZEN GROUND.

<table>
<thead>
<tr>
<th>Location</th>
<th>Soil</th>
<th>Depth to Frozen Ground on June 29/55</th>
<th>Depth to Frozen Ground on July 26/55</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 feet NW of SE facing bank</td>
<td>Moss and organic</td>
<td>9 inches</td>
<td>18 inches</td>
</tr>
<tr>
<td>1200 feet NW of SE facing bank</td>
<td>Moss and organic</td>
<td>12 inches</td>
<td>1 foot 9 inches</td>
</tr>
<tr>
<td>400 feet NW of SE facing bank</td>
<td>Moss and organic</td>
<td>1 foot 3 inches</td>
<td>1 foot 3 inches</td>
</tr>
<tr>
<td>Top of SE facing bank</td>
<td>Sand and gravel</td>
<td>2 feet 6 inches</td>
<td>-</td>
</tr>
<tr>
<td>35 feet below top of SE facing bank</td>
<td>Clayey sand above yellow silt</td>
<td>1 foot 3 inches</td>
<td>17 feet</td>
</tr>
<tr>
<td>Centre of Island on NW facing bank</td>
<td>Sandy clay</td>
<td>2 feet 3 inches</td>
<td>3 feet</td>
</tr>
<tr>
<td>SE side of island</td>
<td>Sand and gravel</td>
<td>7 feet</td>
<td>-</td>
</tr>
<tr>
<td>NW facing bank 100 feet below top (i.e. 184 feet above bottom)</td>
<td>Clay</td>
<td>1 foot 4 inches</td>
<td>3 feet</td>
</tr>
<tr>
<td>Top of NW facing back</td>
<td>Sand and gravel</td>
<td>3 feet 9 inches</td>
<td>13 feet 3 inches</td>
</tr>
</tbody>
</table>
5. Permafrost and Related Features at Knob Lake, P.Q.

5.1 Location and Site

The town of Schefferville (Knob Lake) is situated in the centre of the Quebec-Labrador Peninsula at 54° 48' N. 66° 49' W. (Fig. 6). Its elevation is approximately 1800 feet above sea level. It is connected to Seven Islands on the Gulf of St. Lawrence by a 360 mile long railway line.

The soil at the townsite consists of a few feet of coarse sand and gravel overlying highly contorted strata of shale and slate. In some areas where bedrock is at the surface it has been broken into fragments to a depth of several feet. No permafrost has been encountered at the townsite, or in the immediate vicinity at the airstrip and the extensive muskeg area adjacent to the airstrip.

5.2 Mining Operations

The mining operations at Knob Lake consist of four phases ending with the shipment of the ore to Seven Islands by rail:

1. Blasting
2. Loading trucks
3. Preliminary crushing
4. Loading ore trains

1. Blasting

Two types of rigs are used for drilling holes for blasting:

(a) churn-type drill. Many of these have been discarded in favour of ....

(b) rotary-type drill which bores a 9-inch hole much more quickly and effectively than the churn drill.

2. Loading Trucks

After the ore is blasted, it is loaded by electric 7 cubic-yard capacity power shovels into 35 ton Euclid trucks which can each carry 35 tons of ore. These trucks carry the ore to a screening and crushing plant.

3. Preliminary Crushing

The screening and crushing plant is located beside the railway. Regulations require the ore to be in chunks less than 4 inches in diameter.

4. Loading Ore Trains

The ore is carried on a conveyor belt and dumped into hopper cars each having a capacity of about 90 tons. Each train consists of 3
diesel locomotives and about 100 ore cars. During 1955 the Iron Ore Company is aiming for an output of 9 million tons. About 10 ore trains are shipped out daily.

5.3 Permafrost in the Iron Mines

The distribution of permafrost in the Knob Lake area appears to be sporadic. Frozen ground has been encountered in many of the ore faces exposed by blasting. Three exposed frozen ore faces were examined on August 14, 1955:

1. Ruth Lake Mine No. 3

The exposed ore face at Ruth Lake Mine No. 3, displaying red and yellow hematite, was 25 feet high above which there had been 2 feet of unfrozen granular overburden consisting of a red sandy gravel with silt. The stones varied in size up to 6 inches in diameter and were both angular and rounded. The original vegetative cover was scattered spruce up to 15 feet high with a ground cover of moss 6 inches deep.

This ore face had been exposed by recent blasting and there were chunks of frozen ore up to 4 feet in size which were being allowed to thaw.

Ore segregation in the ore face consisted mostly of vertical, with a few horizontal and diagonal ice lenses varying in thickness from one-quarter to three-eighths of an inch (DZ ice segregation - U.S. Corps of Engineers Classification). The distance between individual lenses averaged 3 inches. The estimated moisture content was reported to be 10 per cent. (The Iron Ore Company computes moisture content as a percentage of total weight of ore).

2. Gagnon Mine (First Ore Face Examined)

At a frozen ore face examined at this mine there was originally 2 feet of unfrozen granular overburden consisting of a red sandy gravel with silt. The stones varied in size up to 6 inches in diameter and were both angular and rounded. The original vegetative cover was scattered spruce up to 15 feet high with a ground cover of moss 6 inches deep. This ore face, consisting of red, yellow and blue hematite, had been exposed by blasting recently and there were chunks of frozen ore up to 3 feet in diameter.

Ice segregation in this face consisted of vertical horizontal and diagonal lenses varying in thickness from three-eighths to one-half inch (DZ ice segregation - U.S. Corps of Engineers Classification). The distance between individual lenses averaged one inch. The estimated moisture content (moisture over total weight) was estimated to be 15 per cent.
3. Gagnon Mine (Second Ore Face Examined)

Ice segregation occurred here in overburden of red and green shale covering the ore to a depth of 20 feet. The shale had been contorted and tilted.

Ice lenses averaging one-half inch thickness filled one horizontal cleavage and a vertical crack perpendicular to and adjoining the ice-filled cleavage. About 5 feet to the left was a horizontal lens of slightly milky but otherwise clear massive ice extending for a distance of about 5 feet. Both of these ice inclusions were covered with about 8 feet of shale overburden (Fig. 21).

5.4 Problems Presented by Frozen Ore

The frozen ore presents serious problems to the mining operation at several stages. Much of it breaks into very large unmanageable chunks weighing many tons when blasted and these chunks require a very long period of time to thaw. In some instances, the power shovels are able to scrape off small chunks of frozen ore from the ore face but this is laborious and slow. One method is employed which works fairly well. A pear-shaped steel ball called a frost ball weighing several tons is dropped on the ore chunks by a crane. After three or four blows, the ore is usually sufficiently broken up to facilitate loading. However, the frozen ore chunks are usually larger than the 4-inch limit allowed for loading in the ore trains as it is difficult to crush some of the larger chunks.

5.5 Permafrost Investigations at Ferriman's

On August 17, 1955, permafrost investigations were made at Ferriman's, about 5 miles from Burnt Creek where exploratory work has been done and the Iron Ore Company expects to begin mining operations in 1956.

The purpose of the investigations was to examine any surface manifestations of the frozen ground which might indicate its areal extent and thus facilitate the mining operations.

The investigated area is above the treeline, which is quite sharply defined in the Knob Lake area at an altitude of 2,300 feet above sea level. Below this level there are spruce trees in stands up to 15 feet high above which is alpine tundra vegetation consisting of short grass, mosses and lichens up to 6 inches deep (Fig. 22). There are several gullies up to 30 feet deep with scattered scrubby willow and alder growth up to a few feet in height.

There are scattered areas of shallow mineral soil formed in situ on the bedrock. The most marked feature of the bedrock is that it is severely fragmented by frost action (alternate freezing and thawing). In some areas, gullies are partially filled with
rock fragments which have slumped down from higher levels.

No distinctive permafrost features were found. The only features which suggested frost action, apart from the fragmented bedrock, were of two types:

1. Scattered over the surface in many areas were patches, 1 to 2 feet in diameter of shallow mineral soil formed in situ and partially covered with small flat angular rock fragments up to 2 inches in diameter. These patches resembled frost boils in appearance and there was a partial sorting of fragments with most of the larger ones lying toward the perimeter.

2. Two small ponds, less than 50 feet in diameter, had dried up revealing bottoms of fine-grained soil with large rock fragments up to 6 inches in diameter. Many of these fragments were sorted into incomplete stone polygons or rings.

The vertical shaft extended into the bedrock in 1948 revealed frozen ground to a depth of 100 feet. This shaft is now almost filled with water and has been boarded up. However, this shaft and other pits excavated in the area revealed a high quality of blue hematite ore at about 65 per cent grade.

6. Soil Conditions west of Knob Lake, P.Q.

6.1 Location

Visits were made to two locations west of Knob Lake. Location No. 1 is 90 miles west of Knob Lake and Location No. 2 is 150 miles west of Knob Lake (Fig. 1).

6.2 Location No. 1

The depth of muskeg averaged 18 inches and was underlain by bedrock. In some areas the vegetation cover was light-green lichen about 6 inches thick on bedrock. Tree growth was predominantly scattered spruce less than 15 feet high. No frozen ground was encountered here.

6.3 Location No. 2

Vegetation and soil conditions were similar to Location No. 1. No frozen ground was encountered here.

7. Soils at Great Whale River, P.Q.

7.1 Location and Site

The settlement of Great Whale River is situated at 55° 17'N, 77°
46° W. on the east shore of Hudson Bay about 90 miles north of the entrance to James Bay (Fig. 7).

It is situated on the series of beach ridges which form a triangular sand deposit on the north bank of the Great Whale River (Fig. 23). The series of parallel beach ridges run in a northeast-southwest direction parallel to the present shoreline. Each are about 6 feet high and extend for a distance of one to two miles.

The vegetative cover consists of lichens and mosses about 3 inches deep lying on the sand. Polygonal cracks caused by desiccation cover the surface.

On the landward side of this triangular deposition, the Precambrian bedrock outcrops about 75 feet above the present water level of Hudson Bay. The highest beach ridge is located at this elevation. Just below this elevation on the sand deposition are scattered blowouts and a few dunes. The sand area is devoid of tree growth.

Along the south bank of the Great Whale River there is a deposit of sand extending in an east-west direction about one mile wide and five miles long. This deposit is about 50 feet above the present river level. The apparent dip of strata in the sand is about 5 degrees toward the west. Streams from the higher bedrock to the south have cut narrow and steep-sided V-shaped valleys into the sand.

The soil throughout the triangular area on the north side of the Great Whale River is medium to coarse-clean sand with practically no fines. The moisture content of the sand varies from 2 to 3 per cent.

7.2 Frost Conditions

Frost penetration in the winter is about 13 feet. The foremost problem is the compaction of the airstrip which was laid in the autumn of 1954. During the break-up of 1955 the airstrip was unserviceable for about 8 weeks while the sand was thawing out. The thawed sand could not be compacted enough to permit aircraft to take off. Compaction of the strip is continuing but still presents a problem. Eventually it will be paved.

There is no permafrost at Great Whale River. Dr. Courtemanche of the University of Montreal who carried out bog borings in northern Quebec during the summer of 1954 reported that he encountered the most southern occurrence of permafrost just north of Port Harrison which is on the east shore of Hudson Bay about 300 miles north of Great Whale River.
8. Conclusion

General observations on the distribution and occurrences of permafrost encountered in the investigations in northern Manitoba and Quebec-Labrador can be divided into two categories. In the first place, the distribution of permafrost varies throughout the parts of central Canada to which visits were made. In the second place, the distribution of permafrost varies within any particular area and depends upon the local physical features such as soil and vegetation types.

8.1 Regional Distribution of Permafrost

For purposes of this discussion the area of investigation can be divided into the section west of Hudson Bay (Manitoba) and the area east of Hudson Bay (Quebec-Labrador). Frozen ground is more widespread in Manitoba than at the same latitude in Quebec-Labrador.

Reports from the construction of the Quebec North Shore and Labrador Railway indicate that the frozen ground at Knob Lake is approximately at the southern boundary of permafrost in Quebec-Labrador. In the iron workings at Knob Lake, permafrost occurs in sporadic islands and none was encountered in the townsite. No permafrost was encountered at Great Whale River, P.Q., and none has been found at Goose Bay, Labrador, both of which are at approximately the same latitude as Knob Lake.

West of Hudson Bay, permafrost is more widespread at Cranberry Portage than at Knob Lake although both settlements are at the same latitude. Cranberry Portage appears to be near the southern boundary of permafrost because no permafrost was reported south of Simonhouse which is 10 miles south of Cranberry Portage. No permafrost was encountered at Flin Flon which is 40 miles northwest of Cranberry Portage nor in an undisturbed area 9 miles southwest of Flin Flon.

8.2 Local Distribution of Permafrost

Several physical factors influence the distribution of permafrost within the particular areas that were investigated.

The soil type has pronounced influence on the distribution of permafrost and the depth of the thawed layer. In organic and fine-grained soils, the thawed layer is less than three feet where the frozen ground is encountered. In coarse grained soils such as the granular deposits at Bird, the thawed layer is very deep and in some places extends into the clay which underlays it at depths of 15 feet and more. At Cranberry Portage, no permafrost was encountered in the granular terrace on which the settlement was located although it is widespread in the muskeg surrounding it.

The vegetative ground cover has pronounced influence on the depth of the thawed layer in soils where frozen ground was encountered. The
thawed layer is much shallower under a moss cover than under a grass cover. At Lynn Lake, the thawed layer is below three feet in silty sand supporting grass whereas it is less than one foot in silty sand supporting moss cover.

Surface water is another factor which influences the distribution of frozen ground. In several areas, regardless of the type of soil, frozen ground is not encountered beneath a pool of water to a depth of over 9 feet whereas it is found within a few feet or inches of the surface in soil adjacent to the pool.

The direction of exposure is also important in the depth of the thawed layer. At Lynn Lake and Bird, small isolated islands or wedges of frozen ground were encountered in peat plateaux rising 2 to 3 feet above the general level in an area otherwise devoid of frozen ground. In these plateaux, the depth to permafrost on the south side averages 18 inches and on the north side it averages 6 inches.

8.3 Meteorological Data

Meteorological data for some of the investigated areas were obtained from the Meteorological Division, Department of Transport. By using mean monthly temperatures and precipitations, hythergraphs were plotted for these areas (Figs. 8 to 12 inclusive). There are no meteorological data for Bird, Manitoba, but records were available at Gillam which is only twenty miles southwest of Bird on the Hudson Bay Railway. No data are available for Cranberry Portage. The closest station is at Flin Flon.

Of the areas investigated Flin Flon has the highest temperatures in winter and summer. Unfortunately no data are available for Cranberry Portage which is 40 miles southeast of Flin Flon. A comparison of data between these two stations would be of interest because permafrost is widespread in the area around Cranberry Portage but not in Flin Flon.

The air temperatures of the stations examined on the west side of Hudson Bay are more extreme than those on the east side probably because of the moderating effect of Hudson Bay on the Quebec-Labrador side. The west side has higher summer and lower winter temperatures than the east side. However, the stations on the east side receive twice as much precipitation as those on the west side.
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APPENDIX A

Cranberry Portage, Manitoba

A1. Location

Cranberry Portage is situated at 54° 35'N, 101° 22'W. on the East Arm of Lake Athapapuskow on the portage of an old fur trade route between this lake and the Cranberry Lakes. It is on Manitoba Highway 10, 54 miles north of The Pas and 39 miles southeast of Flin Flon. It is also on the main C.N.R. line from The Pas to Flin Flon. Lake Athapapuskow has an elevation of 956 feet above sea level.

A2. Site and General Features

The terrain is bedrock, scattered deposits of glacial material and muskeg, and many lakes. Cranberry Portage is built on a sand ridge running north and south, rising up from Lake Athapapuskow. Lake Athapapuskow has a shoreline of 1,400 miles and is 18 miles across at its widest point. To the northeast of the town is the First Cranberry Lake, the elevation of which is 11 feet higher than Lake Athapapuskow. The Cranberry Lakes are in the Churchill River watershed whereas Lake Athapapuskow is in the Saskatchewan River watershed.

The village of Cranberry Portage has one main street leading from the railway track and intersecting Highway No. 10 at right angles. All the business establishments are on this main street. Several narrow streets run perpendicular to the main street, on which the private residences, churches and school are located. The buildings have no planned layout and tarpaper shacks and log cabins are adjacent to modern-frame buildings. The business establishments include one hotel with beer parlour, two general stores, two cafes, two grocery stores, two garages, shoe repair shop, poolroom, theatre, drug store and railway station. There is also a curling rink, a community hall, two churches (Presbyterian and Roman Catholic), a public school (9 grades) and several tourist lodges. The Department of Mines and Natural Resources of the Manitoba Government maintains a number of buildings on the lake-front. Several instances of differential settlement were noted but these were due to deterioration of foundations made from untreated timber rather than frost action or soil settlement.

A six hundred foot strip of land along the lake front (Lake Athapapuskow) has been set aside as a public park. This is now being developed into picnic and camping grounds. Beach facilities include swimming and boat rentals.

A3. Population and Activities

The population of Cranberry Portage is 350 in an area of about 10 square miles. The Indian population is largely half-breed Cree Indian known as "Metis".
Local industries include railway maintenance, lumbering, pulpwood and some commercial fishing. At one time there were 20 commercial fishing concerns at Cranberry Portage. Since the highway was constructed in 1951, the tourist industry has become an important economic factor. Approximately 6,000 to 7,000 tourists (mostly American) visited this area in 1954 and a record number is expected in 1955.

Without exception, people encountered were very co-operative and friendly. Two men are worthy of special note and are described as follows:

"Caribou" Bill Anger is a man of about sixty years who is a freelance reporter for various newspapers during the winter and operates a parking lot at Cranberry Portage for American tourists during the summer. He lives in a log cabin filled with curios of the north (animal furs, skulls, teeth, claws etc.) and photographs of northern people and animals. He has cycled across Canada and has also put his cabin on wheels and taken it over the same route. In 1942 he appeared on the cover of one of the issues of "The Beaver" which is published monthly by the Hudson's Bay Company.

Mr. Streamer is a man of 70 years and is one of the original pioneers of Cranberry Portage. He came to Cranberry Portage in 1928 and opened a hardware store, poolroom and barber shop while the town was still in its infancy. At that time, the town was on the shore of Lake Athapapuskow and there were some native shacks on the ridge. In 1929 these buildings on the ridge were destroyed in a forest fire but the buildings along the lake-front were spared. The townsite was later moved up on the ridge to its present location. Twenty-five years ago Mr. Streamer recommended that the government set aside a 500 foot strip along the lake-front for a park. Eventually a 600 foot strip was established and is now being developed. Mr. Streamer is the proprietor of one of the general stores and is the postmaster and local magistrate. He also owns the Bayview Playhouse and other property in the area.
APPENDIX B

Flin Flon, Manitoba

B1. Location

Flin Flon is situated on the Manitoba-Saskatchewan boundary at 54° 46' N., 101° 52' W. The town is in Manitoba but the main ore body of the Hudson Bay Mining and Smelting Company is in Saskatchewan. Flin Flon is at the end of Manitoba Highway No. 10, 100 miles northwest of The Pas and at the end of the C.N.R. line from The Pas. The railway station has an elevation of 1098 feet above sea level. There is also access by wheel and float equipped aircraft.

B2. Foundation Conditions

Most of the building foundations are on rock outcrops. There are also clay deposits and some muskeg. Bedrock is by far the most predominant feature of the area (Fig. 24).

B3. Population and General Features

The population of the Flin Flon area is 13,500 which includes Creighton (about 1 mile southwest, in Saskatchewan) and the suburb of Channing. It is the third largest community in Manitoba and is an incorporated town. It was founded in 1928.

The chief industry is the Hudson Bay Mining and Smelting Company Limited, but there is also some commercial fishing, trapping and lumbering as well as the tourist industry. The town has some 175 business establishments, two daily newspapers, The Daily Miner and The Daily Reminder, nine public schools and one high school, a 1000 watt radio station (CFAR), ten garages, four hotels, one motel, three movie theatres, and one hospital. There are numerous churches, representing most of the major denominations. The town is policed by a R.C.M.P. detachment of 10 men. Within the town is the Phantom Park area including a beach, swimming and boating facilities, tennis courts and a 9-hole golf course. About 14 miles southwest of town is Beaver Lake which is the summer resort area for Flin Flon. It has an excellent beach, hotel, cottages, etc.
APPENDIX C

Lynn Lake, Manitoba

C1. Location

Lynn Lake is approximately 184 miles north of Cranberry Portage at 56° 51'N, 101° 03'W. Access is by C.N.R. railway or by wheel and float-equipped aircraft.

C2. Site

The town is located on a granular deposit on the side of a gently sloping ridge of bedrock (Fig. 25). The lower part of town is built on a shallow muskeg deposit overlying sand and silty sand. It is bounded on the east by Lynn Lake and on the west by West Lynn Lake. These lakes are joined by a narrow creek on the northeast edge of town. The water level of Lynn Lake has an elevation of 1195 +25 feet above sea level. About 4 miles to the west of the town, an airport is located on an esker which has fanned out to sufficient width to accommodate a runway.

C3. History

Prior to 1950, Lynn Lake consisted entirely of a mining camp of Sherritt-Gordon Mines Co. Ltd. When it was discovered that ore reserves at Sherridon, Manitoba were depleted, the decision was made to move the town of Sherridon to Lynn Lake. The first six houses were brought in by tractor train on the 167 mile long winter road during the winter of 1949-50. Four houses were brought in during the winter of 1950-51; seventy-two houses were brought in during the winter of 1951-52; and sixty houses, 1 bank, 1 school, 2 churches and 3 stores were brought in during the winter of 1952-53.

Each house was insured for a waiver of $200.00. The buildings stood up very well during the move, and no claims were made. The move was financed by Sherritt-Gordon Mines Co. Ltd., the money being repaid in monthly instalments by individual house owners. Although the company owned the houses in Sherridon, they are all privately owned in Lynn Lake.

The community at Sherridon consisted of approximately 1,350 people which included Sherridon itself and Cold Lake about 1 1/4 miles away. The mine at Sherridon began to produce in 1929, was closed in 1932 during the depression, and reopened in 1937. The ore reserves ran out in the early 1950's just as the Lynn Lake development began. At present there are 400 to 500 people remaining at Sherridon where the only industries are fishing and trapping. The Cambrian Hotel, a structure of 4 storeys, is still open catering mainly to tourists.
C4. Population and Activities

The present population of Lynn Lake is 1,300 and is increasing at the rate of 200 to 300 per year. The town is being planned for an ultimate population of 2,000 people.

The chief industry is the mine which employs 410 people. There is some commercial fishing in the area and Lynn Lake ships out 2,000,000 pounds of fish per year. Present plans are to build a road to Reindeer Lake which is about 80 miles northwest of Lynn Lake. Fifteen miles of this road are already constructed. Since Reindeer Lake is partly in Manitoba and partly in Saskatchewan, the road will be financed jointly by the two provinces.

C5. Administration

The administrative set-up at Lynn Lake is a new experiment by the Manitoba government. A similar experiment is being made at Snow Lake. A resident administrator Mr. C.R. Neely was appointed by charter. He was the town manager at Sherridon and was in charge of the move to Lynn Lake. There is also an agreement between the province, the mine and the administrator outlining the duties of the administrator and duties and responsibilities of the mining company.

Under this agreement the mining company provides all capital development without cost to the town: schools, roads, water supply, sewerage system, and the electrical system. Subsequent maintenance costs will be met by the town through taxation of the inhabitants. In addition, the mining company must pay the town a sum of $120 per year per mining employee resident. In actual practice they pay more.

Under the agreement the people have the right to become a municipality if they wish. An advisory committee of 5 members is appointed by the Manitoba government to assist the resident administrator. The administrator's jurisdiction extends over a total area of 400 square miles. Policing is done by a detachment of two R.C.M. Policemen, one for the town and one for the rest of the district.

C6. The Town

Under the town's zoning laws three residential and two commercial districts have been established. Many private homes and commercial establishments are currently under construction.

The water supply is obtained from West Lynn Lake and is distributed through a circulating system. The water mains are situated 9 feet below the ground surface. At present, sewage is carried to a septic tank situated between the townsite and Lynn Lake. Future plans call for a barrier between Lynn and West Lynn Lakes so that Lynn Lake can be drained for mining operations beneath the lake bottom. At the present time, some of the older houses are not yet connected to the water and sewerage systems.
The houses are mostly single storey and of frame construction. Many of the home owners are only now putting in basements. Although there is little landscaping to date, a few people have begun to build up a lawn and to plant shrubs.

The Fairview Hotel was completed in January 1955. Most of the stores are new and were built during the summer of 1955. Business establishments in the town include a jewellery store, a drug store, a Hudson's Bay store, a general store, 2 dry goods stores, a bank, and a beauty parlour. The theatre is also new and is of quonset construction. It seats 450 people and the acoustics appear to be quite good.

The community has just completed a curling rink and a skating rink both of quonset construction and a community hall is in the planning stage. There are 4 churches. The railway station is about a mile from town near the mill.

7. Sherritt-Gordon Mines Limited

The mining company began exploration in the Lynn Lake area in 1927. Equipment was brought in by tractor train on the winter road and the mill was constructed. Production began in December 1953 upon completion of the railway.

The ore consists chiefly of pentlandite, a nickel bearing mineral, with secondary deposits of chalcopyrite, a copper bearing mineral, and small deposits of cobalt and silver minerals. The reserve of the deposit is estimated at 14,000,000 tons. This reserve is expected to last 20 years.

There are two ore bodies: the "A" body at the town and the "EL" ore body about two miles southeast of the town. The "EL" ore body has higher grade ore. The "A" shaft goes down 1,700 feet with levels every 75 feet. The "A" shaft has two ore cages each with a capacity of 5 tons.

The capacity of the mill is 2,400 tons of ore per day but it is running through only 1,900 tons per day while further development of the mine is being undertaken. Sherritt-Gordon Mines has patented its own leaching process for concentrating the ore and recovery is about 85 per cent.

The ore is crushed down to particles of $\frac{1}{4}$-inch diameter before being fed into the ball mills. Subsequent concentration is by the addition of chemical reagents and the regular process of flotation. Nickel and copper concentrates are shipped out separately. Traces of cobalt and silver are found in these concentrates. Concentrates are dried in an oven before being loaded into the cars. The nickel concentrate is more difficult to dry than the copper.
The daily production of the mill is one car of copper concentrate and six to nine cars of nickel concentrate. Each car has a capacity of 40 tons. Some of the nickel concentrate is loaded into hopper cars and sent to Coniston, Ontario while some is shipped in box-cars to Fort Saskatchewan. All copper concentrate is put into hopper cars and sent to Noranda, Quebec.
MAP OF EASTERN CANADA

DRAWN: RJE B
CHECKED: L' B
APPROVED: L'B
DATE: OCT. 5/55
SCALE: 1"=15 MI.
DRAWING No. BR 936
CRANBERRY PORTAGE
MANITOBA

LEGEND

\[\text{\textbullet} \text{\textbullet} \] Cranberry Portage
\[\text{\textbullet} \text{\textbullet} \] Fines and Granular Material

FIGURE 2

From RCAF Air Photo AI3904-68

MAP OF CRANBERRY PORTAGE, MANITOBA
DBR. RPTS.82 & 95

DRAWN: RJEB
CHECKED: 
APPROVED: 
DATE: OCT. 6/55
SCALE: 1:40,000
DRAWING No. BR 937
FLIN FLON
MANITOBA

LEGEND

Built-up Area

Hudson Bay Mining And Smelting Company Limited

N.B. Terrain is bare rock hills

FIGURE 3

From RCAF Air Photo A13879-50

MAP OF FLIN FLON, MANITOBA
DBR. REPORTS 824.95
DRAWING No. BR 938
LEGEND

- Built-up Area
- Sherritt-Gordon Mines Company Limited
- Sand
- N.B. Terrain is rocky hills and muskeg

FIGURE 4

From RCAF Air Photo A11080-191
MAP OF BIRD, MANITOBA

LEGEND

- Gravel Pit
- Sand and Gravel

FIGURE 5

From RCAF Air Photo A14126-37

DRAWING No. BR 940

TITLE

DRAWN: RJEB
CHECKED: 
APPROVED:
DATE: OCT. 7/55
SCALE: 1:40,000

DBR. REPORTS 82 & 95
KNOB LAKE
PROVINCE OF QUEBEC

LEGEND

- Muskeg
- Quebec North Shore and Labrador Railway
- Road
- McGill Subarctic Research Laboratory

N.B.
Terrain is predominantly northwest-southeast parallel ridges and troughs

FIGURE 6
From RCAF Air Photo A13866-57

From RCAF Air Photo A13866-57
FIGURE 7

From RCAF Air Photo A14157-85
LOCATION: LAT. 54°46' LONG. 101°52' ELEV. 1098'
REMARKS: TEMPERATURE RECORDS FROM 1928-1950
PRECIPITATION: SUMMER-24 YEARS OF RECORDS
WINTER - 4 YEARS OF RECORDS.

FIGURE 8
HYTHERGRAPH FOR FLIN FLON, MANITOBA.
BASED ON RECORDS FROM 1928-1950.
FIGURE 9
HYTHERGRAPH FOR LYNN LAKE, MANITOBA.
BASED ON RECORDS FROM 1952 - 1955.
DBR. REPORT 82.
LOCATION: LAT. 56° 21'  LONG. 94° 42'  ELEV. 453'

FIGURE 10
HYTHERGRAPH FOR GILLAM, MANITOBA.
BASED ON RECORDS FROM 1943 - 1953.

DBR. REPORT 82.
HYTHERGRAPH FOR CHURCHILL, MANITOBA.

LOCATION: LAT. 58° 47' LONG. 94° 10' ELEV. S.L.
REMARKS: RECORDS ARE BROKEN BETWEEN 1926 AND 1950. READINGS WERE TAKEN FOR 20 YEARS.

FIGURE II

BASED ON RECORDS FROM 1926 TO 1950

DBR. REPORT 82
HYTHERGRAPH FOR KNOB LAKE, P.Q.
BASED ON RECORDS FROM 1948-1955.

LOCATION: LAT. 54° 48'  LONG.  66° 49'

FIGURE 12
LOCATION: LAT. 55°17'  LONG. 77°46'  ELEV. S.L.

FIGURE 13

HYTHERGRAPH FOR GREAT WHALE RIVER, P.Q.
BASED ON RECORDS FROM 1925 - 1950.

DBR. REPORT 82.
Fig. 14  Open stand of spruce, poplar and tamarack on muskeg, 2 miles north of Cranberry Portage, Manitoba. Frozen ground was encountered from 6 to 12 inches below the ground surface on July 20, 1955. Note rock ridge in background.

Fig. 15  Open grass covered tract in spruce, tamarack stand on muskeg, one mile south of Cranberry Portage, Manitoba. On July 21, 1955 frozen ground was encountered from 1\(\frac{1}{2}\) to 3 feet below the ground surface in the forested area. In the grass covered area the ground was unfrozen below a depth of 9 feet.
Fig. 16 Muskeg supporting spruce, tamarack and alder growth 9 miles southeast of Flin Flon, Manitoba. No frozen ground was encountered on July 23, 1955 in either the forested or non-forested area.

Fig. 17 Grass covered tract on muskeg at Lynn Lake, Manitoba. On July 28, 1955 the ground was unfrozen to a depth below 9 feet from the surface. Frozen ground was encountered from 1\(\frac{1}{2}\) to 3 feet below the ground surface in the surrounding forested area.
Fig. 18 Peat plateau in muskeg area at Lynn Lake, Manitoba. On July 28, 1955, frozen ground was encountered 1.5 feet below the surface on the south side (view taken facing north) and 6 inches below the surface on the north side.

Fig. 19 Gravel plain at Bird, Manitoba. No frozen ground was encountered here on August 3, 1955.
Fig. 20  Bulldozed muskeg beside a new railway siding at Bird, Manitoba. By August 3, 1955 frost had risen 1 foot to 1½ feet into this disturbed material. The depth to frozen ground in the undisturbed muskeg varies from 1 foot to 1½ feet.

Fig. 21  Massive ice in iron ore deposit at Knob Lake, P.Q. on August 14, 1955.
Fig. 22  Alpine tundra vegetation above the treeline (2,300 feet above sea level) at Knob Lake, P.Q. on August 14, 1955.

Fig. 23  View west to Hudson Bay on August 20, 1955 from the Precambrian Upland toward the settlement of Great Whale River, P.Q. situated on a sand plain at the mouth of the Great Whale River. No permafrost was encountered here.
Fig. 24  Typical view of Flin Flon, Manitoba taken on July 21, 1955. Note the utilidors carrying the service lines on the surface of the bedrock.

Fig. 25  View from the top of the shaft house of Sherritt-Gordon Mines Limited on July 27, 1955 looking northwest over the town of Lynn Lake, Manitoba.