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Quaternary Geology of the City of Thunder Bay and Vicinity

District of Thunder Bay

By

G.J.Burwasser

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ABSTRACT

Located on the western margin of Lake Superior, the City of Thunder Bay and vicinity was glaciated from the north by the Patrician ice mass and, most recently, by the Superior lobe moving westerly out of the lake basin. Up to 46 m (150 feet) of glacial-related drift, ranging in age from Late Wisconsinan to Holocene, covers the Precambrian basement complex.

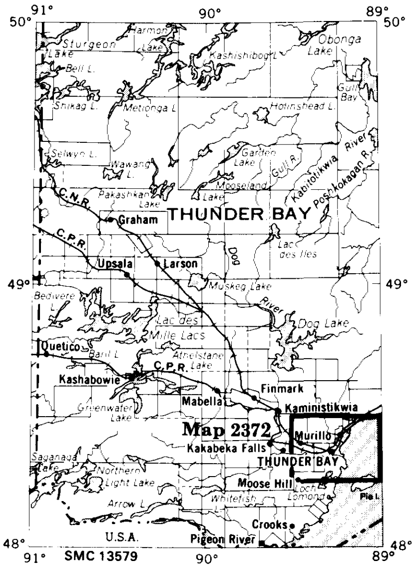

Figure 1–Key map showing location of Thunder Bay and Vicinity map-area. Scale 1:3,168,000 (1 inch to 50 miles).

Pre-Late Wisconsinan glaciation from the north-northeast built the Brûlé Creek Moraine of stoney sand till west of the map-area and dammed Glacial Lake O'Connor southwest of the map-area prior to 11,700 years B.P. Following the melting of this ice mass a westerly readvance of the Superior ice lobe built the Marks Moraine of gritty silt till and clay till (disturbed Glacial Lake O'Connor sediments) northwest of the map-area and moulded the drumlin field northeast of Murillo. Glacial Lake Kaministikwia was dammed in the angle of the Superior and Dog Lake ice lobes while the MacKenzie Interlobate Moraine was built between them prior to 10,200 years B.P. Recession of the Superior ice lobe opened the Kaministikwia River spillway and meltwater channel which drained into the expanding pro-glacial lakes formed in the Superior basin. Pulsations of the ice margin during this general retreat built the Intola Moraine and deposited a silty facies of the gritty silt till. After the Superior basin was cleared of glacial ice approximately 9,500 years B.P. a series of lakes formed with progressively lower water levels until the isostatic uplift of the bedrock sill in the St. Mary's River, Sault Ste. Marie, allowed the water to rise to its present level.

Important sites containing granular resources with some potential for future development are located south of Hazelwood Lake in an outwash delta deposited into glacial Lake Kaministikwia and south of Toimela in the ice-contact deposits of the Marks Moraine. The interlobate deposits of the Mackenzie Moraine and the outwash deposits along the Kaministikwia River from Kakabeka Falls to Pointe de Meuron also contain significant amounts of usable gravel and sand.

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INTRODUCTION

Location and Access

The City of Thunder Bay and Vicinity comprises the Twin Cities topographical sheet (NTS 52 A/6) extending between Latitudes 48°15′N and 48°30′N and Longitudes 89°00′W and 89°30′W covering approximately 1000 km^2 (400 square miles). This includes part or all of the townships of Oliver, McIntyre, MacGregor, Paipoonge, Neebing, and Blake, the City of Thunder Bay and the Fort William Indian Reserve (IR52). The principal city is Thunder Bay (population in 1972; 106,237). Less than 5,000 people live in the area immediately surrounding the city.

Access to the area is via the Trans Canada Highway 11-17 and Provincial Highway 61. Canadian National Railways and Canadian Pacific Railway have rail lines through the area. A modern airport is located in Neebing Township. Within the map-area a system of grid roads 2.4 to 4 km (1½ to 2½ miles) apart provides reasonably good access for the gathering of geological data.

Climate

Climatic data obtained from the Atmospheric Environmental Services Branch of the Canada Department of Environment are given in Table 1.

[1]Field geologist, Ontario Division of Mines, Toronto. Manuscript approved for publication by the Chief, Phanerozoic Geology Section, August 12, 1975.

TABLE 1 Climatic data for city of Thunder Bay based on 30 Years of recorded data.

Average Annual Rainfall	21.97 inches	55.80 cm
Average Annual Snowfall	87.40 inches	222.00 cm
Average Annual Precipitation	29.07 inches	73.84 cm
Highest Average Monthly Rainfall (Aug.)	3.46 inches	8.79 cm
Highest Average Monthly Snowfall (Jan.)	20.30 inches	51.56 cm
Average Annual Maximum Temperature	47.1°F	8.4°C
Average Annual Minimum Temperature	25.5°F	-3.6°C
Average Annual Mean Temperature	36.3°F	2.4°C
Highest Temperature recorded	96.0°F	35.6°C
Lowest Temperature recorded	-42.0°F	-41.1°C

Topography and Physiography

Two physiographic subdivisions of the James Region (Bostock 1970, Map 1254A) of the Precambrian Shield exist within the map-area. The Seven Upland, a vast, broadly rolling surface of crystalline Archean rocks occupying most of northwestern Ontario, has as its southernmost boundary a line running from Whitefish Lake, west-southwest of Thunder Bay, through Kakabeka Falls, Hardwood Lake and eventually to the Black Sturgeon River northwest of Nipigon. South of this line are the Port Arthur Hills, a much smaller unit of south-dipping Proterozoic sills and metasediments which occupies most of the map-area.

Maximum surveyed topographic elevation is 482 m (1,581 feet) above sea level attained on Mount McKay which stands 299 m (980 feet) above the lake. Mount McKay is the northern rampart of The Nor'Westers, a mountain range, extending southwest from Thunder Bay, capped by thick diabase sills and forming the core of the Port Arthur Hills. The elevations of the highest mesas do not vary by more than 30 m (100 feet) along the spine of the range.

Below The Nor'Westers the land surface rises away from the lake, 184 m (603 feet) a.s.l., to levels in excess of 460 m (1,500 feet) west of Mokoman, 32 km (20 miles) inland. Bluffs and steep palisades punctuate the topography along the shore north of the city. The higher levels of ancient lakes have accentuated the protrusions of Precambrian sills and have cut shore cliffs in the metasediments.

Drainage

The area drains to Lake Superior via Kaministikwia River, Neebing River, McIntyre River, McVicar Creek, Current River, Whiskeyjack Creek and Lomond River, as well as several minor creeks and streams northeast of the city.

Loch Lomond, 287 m (942 feet) a.s.l., collects most of the runoff within The Nor'Westers and is in turn drained by Lomond River. A few square miles of mountain slope south of Mount McKay are drained by Whiskeyjack Creek.

The Kaministikwia River with its tributaries forms the major drainage system at the Lakehead. It flows south out of Dog Lake and turns east 4.8 km (three miles) below Kakabeka Falls emerging into Lake Superior at the City of Thunder Bay after traversing the thick deltaic deposits formed in the Kaministikwia River spillway. Major tributaries and most of the minor ones enter the river from the south or west. Within the angle formed by the Kaministikwia River, the other fluvial bodies mentioned above pursue reasonably direct courses to the lake, making shallow cuts into the metasediments. A notable exception is the Neebing River system which also crosses the Kaministikwia River delta.

The course of the Kaministikwia River is controlled throughout most of its length by bedrock features which have been accentuated to some extent by increased volumes of water supplied by the draining of Glacial Lake Kaministikwia and the melting of the ice sheet lying within the Dog Lake Moraine. Drumlins and drumlinized bedrock knobs form some blockages to drainage across the till plain west of Thunder Bay, but the directions of most water courses are determined by pre-existing bedrock features.

Mineral Production

Clay, sand and gravel, and crushed stone are produced within the area. The total value of structural mineral production in 1971 was $3,010,841 with sand and gravel accounting for approximately half. Over three million tons of sand and gravel and one half million tons of crushed rock were used during the 1971 production year.

Previous Work

Considerable geological investigation has taken place in the Lakehead region. A compilation map (Pye and Fenwick 1965) presents the regional picture of the bedrock geology. Earlier investigations were made during the search for and study of specific mineralized localities and as part of organized reconnaissance of unsurveyed areas of the province. Tanton (1931) supplies a bibliography, containing 103 entries, dating back to 1825 which traces the efforts of federal, provincial, municipal and professional bodies as well as those of independent investigators, to collect and interpret data relating to the geology of the Lakehead area. Tanton's report included work on the lithology, structure, history, stratigarphy, economic and archeologic aspects of the Precambrian bedrock and the unconsolidated Quaternary sediments. More recently Moorhouse (1960) mapped the Gunflint Iron Range in the townships of Oliver, McIntyre, Paipoonge, Neebing and parts of Blake and MacGregor.

Quaternary deposits have received varying amounts of attention. Peat bogs (Anrep 1922a,b) were investigated as a possible fuel source. Clay for brick and tile in the Thunder Bay area was the subject of study by government agencies in 1924 (Keele) and again in 1967 (Guillet). Leverett (1929) made an extensive examination of lacustrine and glacial features around Lake Superior. Tanton

(1929) produced a map of surficial deposits outlining glacial and postglacial sediments. He included much of Leverett's work in his memoir (Tanton 1931) dealing with the geology of the Lakehead region. The Ontario Soil Survey carried out reconnaissance investigations in northwestern Ontario (Hills and Morwick 1944) and is now preparing more detailed maps of the entire area (Hoffman 1971). Hough (1958; 1963) detailed the history of the Great Lakes during deglaciation and throughout their postglacial level changes. The Superior basin and this field area were not examined in great detail except as they relate to water levels. Farrand (1960) also developed a history for the Superior basin from his work on ancient strandlines in Ontario, Minesota and Michigan. Zoltai (1963) described the glacial events in the vicinity of the Lakehead and in the surrounding region (Zoltai 1965a). Zoltai's Pleistocene map (1965b) covering more than 100 000 km^2 (40,000 square miles) of the District of Thunder Bay is one of the primary sources of regional Quaternary information for northern Ontario. Saarnisto (1974; 1975) refined the dating of major moraine deposits in northwestern Ontario by correlation of palynologic data.

Present Study

Field work for this report was carried out during part of the summer of 1971. Field data were obtained from natural and man-made exposures including river banks, shore cliffs, road cuts, pipeline trenches, and areas of open pit mineral extraction. Test pitting, soil probing, and hand augering was done where suitable exposures did not exist. Additional subsurface information was obtained from gravel pit descriptions, borehole, test pit, and foundation investigation records made available by various provincial, municipal and private agencies. A preliminary map of part of the work carried out has been published previously (Burwasser 1973).

Acknowledgments

Assistance was provided in the field by J.J. Pinch, G.C. Bulger and J.S. Hancock.

Professor D.W. Hoffman of the Department of Soil Science, University of Guelph provided preliminary soil maps of the area. Water well information was provided by the Ontario Ministry of the Environment with the assistance of Mr. A.J. Tasker and Mr. A.A. Mellary of the Hydrologic Data Branch. Gravel pit locations, foundation investigation sites and additional petrographic information was supplied by Mr. Z.L. Katona and Mr.D. Ryding of the Ontario Ministry of Transportation and Communications, Materials and Testing Branch. Other subsurface data was provided by Dominion Soil Investigation Limited, V.B. Cook Company Limited, Thunder Bay Testing Limited, and Kam Aggregates Limited. Laboratory space during the field season was supplied by the Geology Department of Lakehead University. Dr. E. Mercy, Dr. J. Franklin and Dr. B. Phillips of Lakehead University and Mr. D. McKay of the Lakehead Planning Board provided information and discussions on various topics within the field area. The Lakehead Planning Board and the City of Thunder Bay Departments of Engineering and Public Works kindly supplied survey and subsurface plans within the area of the city. Laboratory analyses were carried out by the Mineral Research Branch of the Ministry of Natural Resources.

To all the above individuals and organizations the author extends his gratitude. Special appreciation is accorded the residents of the area who provided local intelligence and access to private lands.

PRECAMBRIAN GEOLOGY

The bedrock of Thunder Bay and Vicinity is formed entirely of Precambrian rocks. The list of lithologic units given in Table 2 corresponds to the sketch map in Figure 2 (Chart A, back pocket).

Early Precambrian (Archean)

Age relationships within the Early Precambrian rocks are complicated by intrusive contacts, extensive deformation, metamorphism and erosional gaps in the geologic record. The age of the basement complex exceeds 2480 million years (McGlynn 1970). The relationships are most easily explained pictorially. Figure 3 (Chart A, back pocket) is a block diagram illustrating these relationships along with those of the Late Precambrian rocks. Lithologic units correspond to the list in Table 2.

The metavolcanics (1,2) are the oldest rocks in the map-area. They consist of basaltic and andesitic lava flows and fragmental rocks (2) containing various metasediments such as slate and conglomerate (1), and occur in the northern half of the area in Figure 2 (Chart A, back pocket). Associated with these metavolcanics are the metasedimentary iron deposits (3) which are concentrated in Conmee Township. Other metasediments are the greywackes and slates (4) which occur in a band across the northern part of the area in Figure 2. Many of the above rocks have been metamorphosed to schists and gneisses.

Other metasediments (5) occur in disconnected patches in Conmee, Ware and Gorham Townships. These are also altered conglomerates, slates and greywacke. They are of uncertain age and therefore present difficulties in correlation.

Small bodies of mafic and ultramafic igneous rocks (6) have intruded the metavolcanics (2). One body occurs in Conmee Township and another occurs in the southwest corner of Ware Township where it is associated with the later metasediments (5).

Early Precambrian unsubdivided metavolcanics (1) were intruded by metamorphic felsic rocks (7). North and northwest of Thunder Bay they are separated from the metavolcanics by early metasediments (4).

TABLE 2 | Precambrian Lithologic Units in Vicinity of Thunder Bay

PRECAMBRIAN

MIDDLE TO LATE PRECAMBRIAN

KEWEENAWAN

INTRUSIVE IGNEOUS ROCKS

Diabase, porphyritic diabase, gabbro, anorthositic gabbro sills and dikes, "Logan Sills"

INTRUSIVE CONTACT

ANIMIKIE

ROVE FORMATION

Argillite, shale, greywacke, minor volcanics

GUNFLINT FORMATION

Conglomerate, taconite, algal chert, chert, chert-carbonate and carbonate rocks, argillite tuff

UNCONFORMITY

EARLY PRECAMBRIAN

METAMORPHOSED FELSIC INTRUSIVE ROCKS

Granite gneiss, porphyritic granite gneiss, quartz and feldspar porphyries, migmatite, syenite, pegmatite, etc.

INTRUSIVE CONTACT

MAFIC AND ULTRAMAFIC IGNEOUS ROCKS

Peridotite, dunite, serpentinite

INTRUSIVE CONTACT

METASEDIMENTS

Conglomerate, arkose, greywacke, slate, limestone, etc.

Arkose, greywacke, slate, mica schists and gneisses
Iron Formation

METAVOLCANICS

Basic and Intermediate metavolcanics: massive greenstones, hornblende and chlorite schists, pillow lava, pyroclastic rocks

Unsubdivided metavolcanics and some metasediments

after Pye and Fenwick (1965)

Middle and Late Precambrian (Proterozoic)

The Animikie Series was deposited on the essentially planar erosional surface of the Early Precambrian rocks. Radiometric dates from Michigan, Wisconsin, and Minnesota indicate deposition of the series prior to 1100 million years ago (Palmer 1970) and possibly as much as 1700 million years ago (DuBois 1962). The Animikie sediments occupy the central part of the map-area. Moorhouse (1960) described the Animikie Series as containing two formations, the Gunflint (8) and the Rove (9). The extreme complexity of the Gunflint Formation is due to its great variety of rock types. It is divided into lower and upper units by a band of argillite-tuff which persists throughout the extent of the formation but is usually poorly exposed. The Lower Gunflint contains beds of algal chert and ferruginous carbonate as well as thin beds of hematite and magnetite. The Upper Gunflint is predominantly thinly bedded chert and carbonate at the base, succeeded by flaggy beds of taconite and shaly silicate. The Rove Formation is predominantly dark coloured fissile argillite with occasional calcareous interbeds. It contains calcareous concretions up to 2.5 m (8 feet) in diameter. There is apparently no unconformity between the Gunflint and Rove Formations (Moorhouse 1960, p.19).

The most recent event in the Precambrian history of the area is the Keweenawan intrusion of the Logan sills (10). They are olivine diabase, and were implaced approximately 1100 million years ago (Palmer 1970, p.1432). Numerous small dikes are included in this unit and the "sills" themselves actually exhibit a low angle cross cutting relationship with the Animikie sediments (Moorhouse 1960, p.20). The sheets of diabase are up to 60 m (200 feet) thick. They are the caprock to The Nor'Westers and form an impressive palisade along Highway 61. Smaller occurrences are in the townships of McIntyre and Paipoonge (Photo 1), and the City of Thunder Bay.

QUATERNARY GEOLOGY

The sequence of events which occurred during the latest stages of continental glaciation in the vicinity of Thunder Bay is not entirely discernable from deposits and features within the map-area. Comparison with penecontemporaneous events reported elsewhere allows correlation with recognized Quaternary episodes. As far as can be determined the deposits are of Late Wisconsinan age.

The Pleistocene history proposed for the region by Zoltai (1963; 1965a), when compared with the chronology for Lake Agassiz by Elson (1967), suggests a retreating ice margin in the vicinity of Thunder Bay at Latitude 48°26'N, approximately 12,400 years ago. Prest (1970, p.716, 717) indicates a slightly later date for this event. Lacustrine sediments which accumulated south of this margin were incorporated in till by the Superior lobe during a readvance approximately 11,500 years ago (Wright 1971). Following partial dissolution of the Superior and Hudson Bay ice masses lacustrine and deltaic deposition was reestablished approximately 11,000 years ago (Saarnisto 1975), although the Superior basin was not entirely free of ice until sometime after 10,000 years ago (Prest 1970).

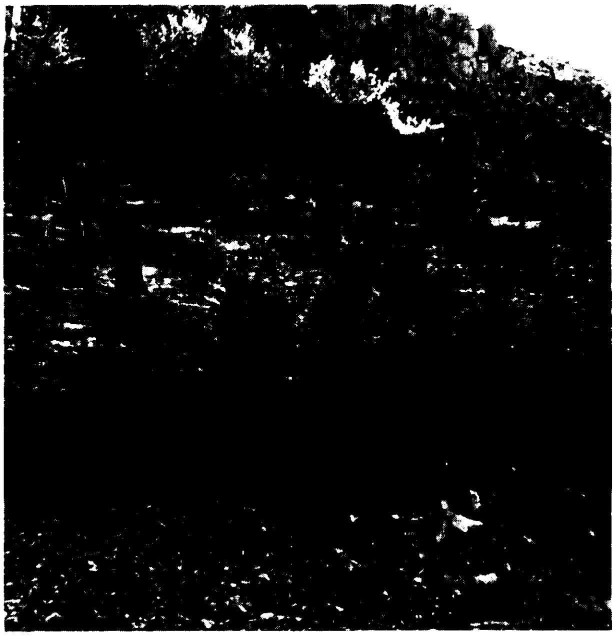

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Photo 1–Intrusive contact between argillite of the Rove Formation and the overlying diabase of the Logan Sills in 17 m (55 feet) high quarry face in Paipoonge Township.

A generalized surficial geology map (Figure 4, Chart A, back pocket) modified after Zoltai's surficial map (1965b) shows the Thunder Bay map-area in relation to the regional setting. Moraines marking significant ice marginal positions in the deglaciation history of the Lakehead region form an arc around the map-area. The Brûlé Creek Moraine (Zoltai 1963) represents a still-stand of the whole Patrician ice mass. The Marks Moraine (Zoltai 1963) and Dog Lake Moraine (Elson 1957) mark the extremities of temporary readvances by individual lobes of this ice mass (Table 3). The MacKenzie Moraine (Zoltai 1965a) is an interlobate deposit related to both ice lobes.

Drift Thickness

With noted exceptions Quaternary deposits are thin throughout the map-area. Bedrock is extensively exposed in The Nor'Westers south of the City of Thunder Bay and along the raised shore-cliffs which extend northeast of the city. North of the Kaministikwia River all water courses contain numerous bedrock cuts. Till and outwash deposits in the northern part of the area and lake

EVENT		ASSOCIATED ACTIVITY AND (OR) DEPOSIT	REPRESENTATIVE MORPHOLOGY
lobal retreat leaving Superior basin ice-free, c. 9.5 ka B.P.	Superior ice lobe retreat	formation of late glacial and post glacial lakes in the Superior basin	shore bluffs, beach ridges, lacustrine and deltaic plains
		opening of Kaministikwia River Spillway from Glacial Lake Kaministikwia	deltaic uplands
		deposition of ice marginal material, overridden outwash and silty facies of gritty silt till	Intola Moraine, hummocky stagnation moraine, crevasse fillings, eskers, and contorted outwash
general retreat of Patrician ice mass accompanied by lobal advances, c. 10.2 ka B.P.	Superior ice lobe advance	formation of Glacial Lake Kaministikwia*	Hazelwood Delta* and glaciolacustrine plains*
		deposition of interlobate material with Hudson Bay ice lobe	MacKenzie Moraine*
		deposition of clay till (remobilized Glacial Lake O'Connor sediments)	clay till ground moraine
		deposition of gritty silt till	Marks Moraine*, fluted ground moraine, Marillo drumlin field, west- and northwest-trending striae
	Hudson Bay ice lobe advance	deposition of stony sand till	Dog Lake Moraine*
general retreat of Patrician ice mass, c. 11.0 ka B.P.		formation of Glacial Lake O'Connor	contorted varves in clay till ground moraine
		deposition of stony sand till	Brûlé Creek Moraine*
general advance of Patrician ice mass prior to 12.0 ka B.P.		deposition of stony sand till	discontinuous sandy ground moraine, south-trending striae

sediments in the southern and eastern parts thin to nothing around innumerable small knobs of bedrock. Were it not so widespread and so evenly divided between outcrop and drift, the bedrock-drift complex (map unit 2) could be shown as bedrock.

Glacial deposits and postglacial lacustrine sediments near the mouth of the Kaministikwia River which have been penetrated by water wells and bore holes have a maximum recorded thickness of 50 m (160 feet) but few borings have been completed to bedrock. Similar depths are reported from the Rosslyn Village vicinity, although 3 km (2 miles) to the west bedrock is exposed in the Kaministikwia River channel. South of the river the drift thins towards The Nor'Westers to less than 22 m (70 feet) but remains fairly thick along the course of the tributary Slate River (greater than 35 m (115 feet) south of Moose Hill).

The next thickest drift within the map-area is found in the outwash gravel (map unit 4) directly north of the City of Thunder Bay where up to 12 m (40 feet) of material is exposed in commercial excavations. Depths of 3 m to 5 m (10 feet to 16 feet) are more common in the outwash gravel (units 4 and 5) and sand (units 6 and 7).

All tills exposed within the map-area appear to be relatively thin deposits but few boreholes have been sunk to bedrock, thus making such statements tentative. The gritty silt till (map unit 3a) has a maximum recorded thickness of 11.6 m (38.0 feet) (Ontario Water Resources Commission test well) but generally is less than 4 m (13 feet) thick. The greatest observed thickness of the clay till (map unit 3b) is 2.6 m (8.5 feet) west of Moose Hill.

Bedrock and drift of various types are nearly equally represented in the bedrock-drift complex (map unit 2). Although the drift cover rarely exceeds 1 m (3 feet) and is commonly confined to systems of clefts between outcrops it cannot be meaningfully represented as a separate unit on Map 2372 (back pocket).

Glacial Deposits and Features

STRIAE AND ASSOCIATED FEATURES

Glacial striae and associated features, caused by material held in the base of a glacier scraping across bedrock surfaces, are the most direct indicators of ice movement although they commonly do not show the sense of such movement. Features such as chattermarks, crescentic and lunate fractures, polished and facetted rock surfaces, and stoss-and-lee topography aid in determining the direction in which the ice moved. Striae occur singly and as intersecting sets throughout the map-area. Cross-cutting relationships indicate two major episodes of glacial movement. The relative ages of intersecting sets of striae can be determined by observations of weathering, stoss-and-lee relationships and multiple facetting of rock surfaces as well as strength and depth of grooves, flutings and the striae themselves. An extensive description of striae as directional indicators has been given by Chamberlin (1888).

Sufficient evidence exists to confirm, with little modification, the two major directions of ice movement given by Zoltai (1963, p.103). The older striae indicate an advance from the northeast. These are the oldest glacial features found within the map-area and probably are related to a general Patrician ice advance. Directional trends vary between 170°E and 215°E with the modal value occurring between 190°E and 195°E. Well developed sets of striae occur in the highlands west of Intola and in The Nor'Westers. The younger striae are stronger and more dominant in the lower bedrock areas bordering Lake Superior and north of the Kaministikwia deltaic plain. These striae, left by the Superior lobe as it advanced to the Marks Moraine, are approximately normal to the shore bluffs from Navilus to McVicar Creek east of Jumbo Gardens. From the Murillo drumlin field, in the northwest of the map-area, west to the Marks Moraine they approximate the trend spread of the drumlins varying between 295°E and 315°E. Along the northern boundary of the area the orientations vary from 320°E to 335°E, approximately normal to the arc of the Marks Moraine to the northwest. Striae left by this advance of the Superior lobe along the flanks of The Nor'Westers vary in orientation from 170°E to 205°E.

TILL

There are two tills containing a total of five recognizable units in the vicinity of Thunder Bay. The older till does not occur within the map-area, but is significant in itself as a source of granular material and as an indicator of ice movements which affected local depositional conditions. The four younger units are facies of the till sheet deposited by the Superior lobe during its advance to the Marks Moraine and subsequent retreat across the map-area.

Stoney Sand Till

The older till lies northwest of the Marks Moraine. It is a stoney sand till which Zoltai (1963) associated with both the Brûlé Creek Moraine and the Dog Lake Moraine first reported by Elson (1957). These features were caused by a halt during the retreat of the Patrician ice mass (Brûlé Creek Moraine) and a subsequent readvance of the Hudson Bay ice lobe (Dog Lake Moraine) over much of the same territory (Zoltai 1965a, p.266). No deposits of this till were found at the surface within the area covered by the Superior lobe when it advanced to the Marks Moraine, but it was observed in sections along the Mac Kenzie Interlobate Moraine where it was exposed as several thin sheets interdigitated with sand and gravel. Extractive operations have exposed more than 16 m (53 feet) of ice-contact material in the MacKenzie Moraine but the actual thickness of the stoney sand till is unknown.

The till is best described as moderately compact, fine sand with up to 40 percent clast content of medium to very coarse pebbles. The matrix is calcareous and contains up to 25 percent silt; clay does not exceed 15 percent and is commonly half that value (Table 4). In colour the till is grey (5YR5/1) oxidizing to pale brown (10YR6/3). Modal clast diameter is in the coarse to very coarse pebble range (24 to 48 mm) with the rare occurrence of boulders up to 1 m in size.

TABLE 4 Analyses of Till Samples in the Vicinity of Thunder Bay

TILL	NUMBER OF SAMPLES	TEXTURE % CLAY	% SILT	% SAND	CARBONATE % TOTAL	CALCITE/DOLOMITE RATIO
stoney sand	4	4-15	11-25	69-84	9.7-21.8	1.79-4.36
gritty silt	10	7-14	45-66	23-45	1.8-2.1	0.24-0.41
silt (phase)	4	17-25	53-69	4-25	2.1-9.1	0.29-0.64
clay	4	40-45	39-56	3-20	2.3-14.1	0.29-1.27

Diabase is the predominant clast lithology with porphyritic diabase and granite each accounting for up to 15 percent of the rock types represented. Sandstone and siltstone clasts occur rarely since they are easily ground into medium sand and smaller sizes.

Gritty Silt Till

The younger till resulted from the advance of the Superior lobe to the Marks Moraine. It is mainly represented by two sub-units; a gritty silt till (map unit 3a) and a clay till (map unit 3b). North and west of Kakabeka Falls these two sub-units are interdigitated, but they do not have this relationship within the map-area.

The gritty silt till is described by Zoltai (1963, p.103) as a stoney silty sand till containing, in the matrix, up to 35 percent silt and 15 percent clay, with clasts having Late Precambrian affinities constituting up to one third of the volume. This unit is the surface till in most of the area south of the Marks Moraine and east of the Kaminiastikwia River, thereby occurring throughout the northern half of the map-area. Readily accessible exposures occur along the Oliver—McIntyre Township line 5.1 km (3.2 miles) north of Baird (Photo 2) and in section in the Kurchina quarry 1.8 km (1.1 miles) north of the intersection of Highway 130 and Central Avenue. It is this till which forms the Murillo drumlin field (Figure 4) west of the City of Thunder Bay. Its greatest observed thickness is 4.5 m (14.8 feet) in the Kurchina quarry section, but a bore hole at the junction of the Lakehead Expressway and Highway 61 south of Thunder Bay penetrated 7 m (23 feet) of this deposit before passing into Rove shale.

The colour of the freshly exposed gritty silt till is brown (7.5YR4/2) drying to light reddish brown (5YR6/3.5). The oxidized surface is yellowish brown (10YR5/6). It is a fissile, compact, stoney, gritty silt till usually with less than 15 percent clay in the matrix. Sand content is up to 45 percent and concentrated in the fine to very fine sand range.

Clast size ranges from fine pebbles (grit) to small cobbles and composes approximately one fifth of the volume. Precambrian metasedimentary rocks of the

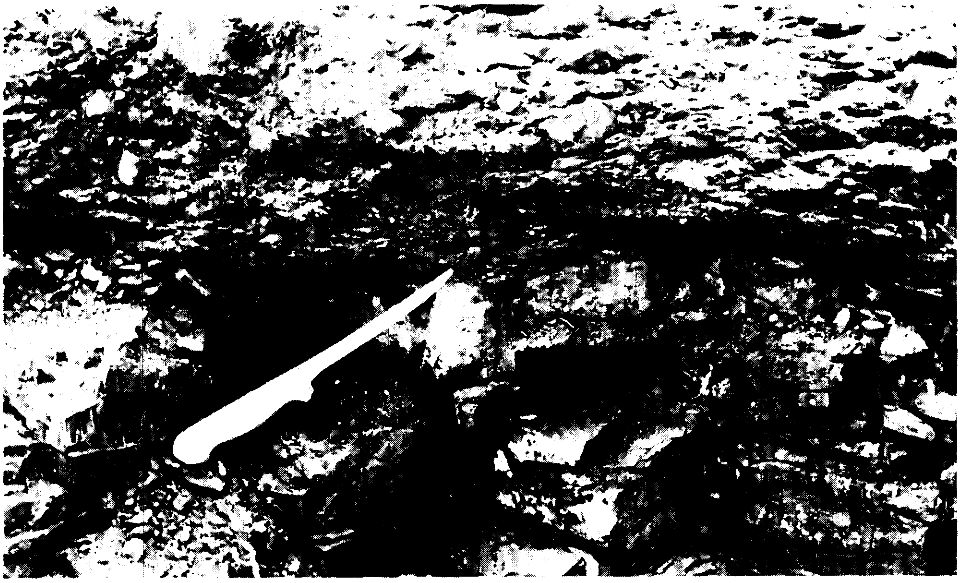

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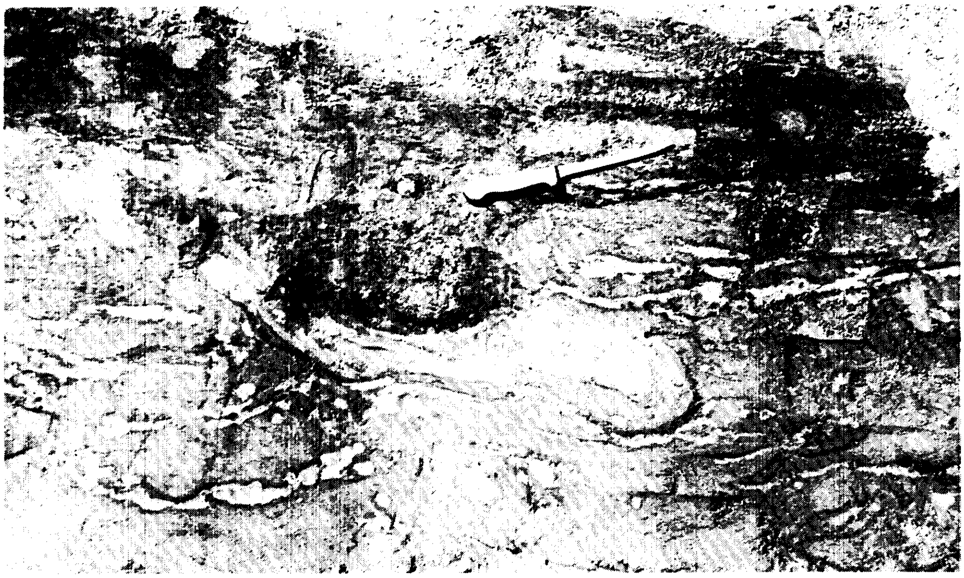
Photo 2–Contact between argillite of the Gunflint Formation and the overlying gritty silt till in McIntyre Township.

Gunflint and Rove Formations account for approximately one third of the clasts. Diabase predominates in the small cobble range. Decayed granite, chlorite schist and sand inclusions up to small cobble size occur.

The grain size, colour, and very low carbonate content of the matrix are due to the inclusion of much material from the readily eroded Rove Formation. These carbonaceous variegated slatey shales are easily comminuted to silt size fragments. Chert and jasper from the Gunflint Formation also add a reddish cast to the till. Reaction of the till to 10 percent HCl is slight. The metavolcanic rocks underlying much of the area covered by the Superior lobe are not easily ground down and add no carbonate to the till. The iron carbonates of the Gunflint produce most of the carbonate content the till possesses.

An area of stagnation moraine (map unit 3c) developed northwest of Thunder Bay during the retreat of the Superior ice lobe. This geomorphic feature consists mainly of gritty silt till which has been deposited by inactive ice rendering it less compact than the ground moraine composed of the same material. In addition to the till, ice-contact stratified deposits, such as crevasse fillings and small kames, are present indicating the existence of stranded blocks of ice. Some of these stagnation features have been at least partially overridden during osscillation of the retreating ice margin in this vicinity. Minor till ridges within the unit are interpreted as corrugated moraine (Prest 1968, p.3).



ODM9514

Photo 3–Contorted lacustrine clays incorporated at the base of the clay till near Moose Hill, Ontario.

Clay Till

The clay till (map unit 3b), which has been described by Zoltai (1963) as a weak red (10R4/3), slightly calcareous, gritty clay till containing approximately 35 percent silt and 20 percent sand in the matrix, occurs west of the Kaministikwia and Slate Rivers. The occurrence of incorporated blocks of varved sediments in this till lead to the inference that an earlier glacial lake (Glacial Lake O'Connor, Zoltai 1963, p.111) occupied the area. This lake was dammed by the Brûlé Creek Moraine and an unidentified ice margin to the east (Zoltai 1963, p.111). Overridden during the advance of the Superior lobe, these lake deposits supplied the clay- and silt-sized material which comprise the till.

Within the map-area the clay till is exposed at the surface along the Slate River near Moose Hill (Photo 3) where it overlies varved clays. Outside the map-area it is exposed southwest of Stanley near the confluence of the Whitefish and Kaministikwia Rivers and 2 km (1.25 mile) east of Mokomon where it is interbedded with glaciolacustrine sand and clay near the top of the Marks Moraine. The observed thickness of this unit ranges from 2 m to 6 m (7 feet to 20 feet). When fresh the clay till is weak red (7.5R5/4) in colour and dries to pinkish grey (5YR7/2). The weathered colour is dark grey (5YR4/1 and 10 YR4/1). It is a stiff, clacareous clay till containing up to 20 percent sand in the matrix. Fine pebbles occur infrequently throughout the unit but small cobbles of fine calcareous sand, varved clay and silt, and varved clay and fine sand are numerous at the base. Boudinage structures and incorporated blocks of clay, both massive and varved with silt, up to 4 m (13 feet) thick have been observed in the Marks Moraine west of the Kaministikwia River. Similar features of smaller scale are common where the overridden lacustrine sediments have not been completely destroyed by advancing ice. The colour of the till is attributed to the underlying lacustrine sediments which were deposited in Glacial Lake O'Connor.

Silt Till

A fourth sub-unit occurs within the till deposited by the Superior lobe. This is a silt till with very low clast content (map unit 3d) and is restricted to a belt of land 1.5 km to 2 km (0.9 to 1.2 miles) wide which extends west-southwest from Jumbo Gardens pinching out midway between Murillo and Jelly. The best exposure is in the Kurchina Quarry 1.8 km (1.1 miles) north of the intersection of Highway 130 and Central Avenue. Here the unit is 3 m (10 feet) thick and overlies 4.5 m (15 feet) of gritty silt till from which it is separated by a decimetre (0.3 feet) of very fine sand.

The colour of the silt till is brown (10YR5/3) to greyish brown (10YR5/2) drying to light reddish brown (5YR6/4). It is a slightly calcareous, compact, fissile, slightly bouldery, silt till containing up to 25 percent sand and up to 25 percent clay in the matrix. Observed clast content is less than 10 percent by volume and consists mainly of cobbles and boulders derived from diabase intrusive rocks, the Rove Formation, or the underlying till. As with the gritty silt till the colour is related to the bedrock over which the ice sheet most lately passed. The till has a very slight reaction to 10 percent HCl.

The flow direction of the Superior ice lobe, when it deposited the silt till, was approximately north. Determinations of direction varying between 350°E and 10°E were inferred from striae, chatter marks, boudinage features and one till fabric. Ice overrode the pre-existing till, as seen at the Kurchina quarry mentioned above, or scoured away the till and some of the underlying bedrock. On Lakeshore Drive, 1050 m (0.7 miles) west of the T-intersection with Highway 800 a ditch cut exposes 0.7 m (2.3 feet) of greyish-brown sandy silt till implaced by north flowing ice directly overlying metaconglomerate of the Gunflint Formation. Lacustrine silt and sand cover the till to a depth of 1.6 m (5.4 feet).

Ground Moraine

Ground moraine consists of till with gently undulating to moderately rolling topography formed by active ice deposition. Linear elements, if any, trend parallel to the direction of ice flow. Bedrock topography may be subdued or totally obscured by thick ground moraine; thinner deposits generally reflect the underlying bedrock topography. Highly resistant bedrock formations, such as diabase or quartzite may protrude as outcrops or act as cores over which till is moulded to produce positive linear forms such as drumlins, rôches moutonées and craig and tail features. Less resistant shales and weathered intrusive rocks are commonly scoured and gouged adding material to the till and forming negative linear forms such as flutings and grooves.

The ground moraine within the map-area is composed of the tills of the Superior ice lobe. North and east of the Kaministikwia River the gritty silt till forms the ground moraine except in the narrow strip occupied by the silt till. The land surface rises toward the northwest from approximately 259 m (850 feet) a.s.l. west of Thunder Bay to 381 m (1,250 feet) a.s.l. at the base of the Marks Moraine near Mokomon beyond the boundaries of the map-area. The average rate of rise increases smoothly from 10 m to 30 m per kilometre (50 to 150 feet per mile). Local relief in the map-area is low, generally less than 3 m (10 feet), throughout most of this district. Exceptions are the drumlins which rise to 5 m (16 feet) and abandoned meltwater channels along the Neebing and McIntyre Rivers where ancient valley walls as high as 7.5 m (25 feet) have been observed. North of Thunder Bay, numerous exposures of striated and moulded diabase protrude through a veneer of till. A recently cut sewer trench north of Boulevard Lake revealed only 0.3 m (1 foot) of gritty silt till deposited by ice flowing northwest atop Gunflint cherty slate. In this part of the map-area the ground moraine-bedrock complex is masked by 1.5 m to 7 m (5 to 23 feet) of outwash sand.

Southwest of Kakabeka Falls, outside the map-area, the ground moraine consists of clay till (map unit 3b). The topography rises to the west and south at approximately one and a half times the rates mentioned above, but the land surface is more highly dissected by modern streams due to the finer grain size of the till. Pockets of disturbed lacustrine sediments, such as the varves near Moose Hill, are common within the till since it was developed by ice overriding lake clays. Diabase sills, forming the uplands west of the map-area, impeded the westerly ice advance sufficiently to allow accumulation of greater than 50 m (164 feet) of clay and clay till in their lee.

The till surface rises rapidly toward the Marks Moraine northwest of the map-area. The local relief is from 8 m to 10 m (26 to 33 feet) through this more rugged terrain. Slope erosion of the gritty silt till has been retarded by the occasional exposures of the more readily removed clay till which occurs along the base of the moraine west of Kakabeka Falls.

The uplands in the southeast and those southwest of the map-area are formed by diabase sills overlying the Rove Formation and partly covered by gritty silt till or a mixture of gritty silt and clay tills. The ground moraine in these areas is discontinuous leaving numerous exposures of bedrock knobs, escarpments, and palisades. Talus slopes produced by postglacial erosion at the bases of the nearly vertical walls of diabase obscure the underlying sediments. Stream channels cut into the uplands expose up to 1.2 m (4 feet) of till, usually buried by several decimetres of alluvial gravel and sand derived from the Rove Formation or the thin till caps above the diabase. Striae observed in these uplands have a southerly trend varying from 170°E to 205°E. This orientation roughly parallels the regional direction of movement for the Patrician ice mass, but is probably related to fanning of the Superior lobe during its advance to the Marks Moraine.

End Moraine

End moraines are linear topographic features composed of till and other ice-contact deposits lying transverse to the direction of glacial movement. Each represents an ice frontal position during a stage when the glacier margin was stationary. Although an end moraine is commonly related to a single ice lobe it may be the result of more than one stage of active construction resulting in complex stratigraphy involving one or more till sheets. Moraine morphology is initially determined by the amount, type, and distribution of material within the glacier and the rate at which it is deposited. Subsequent modification is affected by the quantity of meltwater present during dissolution and finally by the postglacial erosional forces brought to bear on the deposit; see Flint (1971, p.199 to 206) for further discussion of and references on end moraines.

There are four end moraines of particular interest near the City of Thunder Bay. One small moraine actually occurs within the map-area but three end moraines related to major glaciations exist north and west of it (Figure 4, Chart A, back pocket).

END MORAINES OUTSIDE THE MAP-AREA

West of the map-area the Brûlé Creek Moraine is the result of a still-stand of the Patrician ice mass. According to Zoltai (1965a) it is a fragment of the Eagle-Finlayson Moraine which extends nearly 300 km (180 miles) to the northwest and was developed during a halt in the general retreat of the Patrician ice mass that occurred prior to 12,400 years ago (Elson 1957; 1967). Its significance to the Thunder Bay region lies in the fact that it dammed Glacial Lake O'Connor in which were deposited fine-grained sediments that eventually formed the clay till facies of the Superior lobe till.

Northwest of the map-area the Dog Lake Moraine marks one position of the Hudson Bay ice lobe during the readvance between 12,000 and 11,000 years ago. Together with the Marks Moraine, formed by the penecontemporaneous advance of the Superior lobe, the Dog Lake Moraine acted as a dam to form Glacial Lake Kaministikwia into which the economically important Hazelwood Delta gravels and sands were deposited.

The Marks Moraine forms an arc around the west and north sides of the Thunder Bay map-area. It was named by Zoltai (1963) and described as a semicircular, disjunctive belt from 1.6 km to 4.8 km (1.0 to 3.0 miles) wide which indicates the maximum extent of the Superior ice lobe during its last major advance west of the Superior basin. Its lithology, consisting mainly of diabase and shale, distinguishes its source area as being to the east since the moraine generally overlies mafic metavolcanics and intrusive rocks along its north and west limbs. Surface elevations atop the moraine are up to 488 m (1,600 feet) a.s.l. Both the proximal and distal walls have been altered by meltwater erosion. Several minor meltwater channels cross the moraine, and the Kaministikwia River, flowing in a fault controlled major meltwater channel, breaches the moraine at Mokomon Station approximately 14 km (9 miles) northwest of Murillo. Short, narrow eskers and crevasse fillings up to 12 m (40 feet) high are common along the moraine, especially in Marks Township 28 km (17 miles) west of Rosslyn Village. Northeast along the moraine these features become broader and more subdued producing a hummocky knob-and-kettle topography. This gives way to a bedrock controlled ridge which forms the core of the moraine from the Kaministikwia River to Toimela, 5.3 km (3.3 miles) north of the map-area.

END MORAINE WITHIN THE MAP-AREA

A recessional halt of the Superior ice lobe during its retreat from the Marks Moraine resulted in the deposition of an area of stagnation moraine (map unit 3c) between Murillo and Intola. The western margin of this till sub-unit is marked by a ridge indicating an ice-frontal position. The name Intola Moraine is proposed for this feature (Photo 4).

The Intola Moraine transects the Murillo drumlin field from 2.4 km (1.5 miles) east of Murillo to 1 km (0.6 mile) west of Intola. It trends approximately normal to the strike of the drumlins, is 12 km (7.5 miles) long and is accompanied by numerous active and stagnant ice features. The moraine crest stands less than 7 m (23 feet) above the surrounding till surface and is pocked with kettles and small ice-pressed ridges. Forming a slight ridge through otherwise low marshy lands, the moraine crest has been cleared for farming at several locations, thus making it more visible on aerial photographs (Photo 4).

Compact cobbley, gritty silt till (map unit 3a) forms the core of the Intola Moraine. A looser variety of this till occurs at the surface as an ablation facies. Pockets of sand and fine gravel have been incorporated on the flanks and crest of the moraine as short linear ridges which represent filling of crevasses around stagnated ice blocks during the final melting of the Superior lobe at this site. The surface till has a coarser texture than the gritty silt till core due to the inclusion of these ice-contact deposits.

Associated with the Intola Moraine is an area of stagnation moraine which masks the fluted surface of the underlying ground moraine. Crevasse fillings occur up to 650 m (0.4 mile) from the crest on both the proximal (east) and distal sides indicating the existence of stagnated ice. Corrugated moraine topography subparallel to the crest forms a belt up to 1.3 km (0.8 mile) wide on the proximal side. Low, short ridges composed of dense, cobbly, gritty silt till and capped by rudely stratified sand are evidence of glacial activity very shortly before the formation of the stagnant ice features.

A prominent feature adjacent to the moraine is an ice-contact complex west of the Neebing River on the proximal side of the moraine (Photo 5). An esker at the centre of the complex trends toward 280°E. Stranded ice blocks on either side allowed the formation of large scale crevasse fillings at angles of 45° and 90° to the esker ridge. The complex was partially overridden by ice flowing toward 320°E, approximately normal to the crest of the moraine at this location, which deposited about 2 m (6 feet) of cobbly gritty silt till (Photo 6). High-angle thrust structures enter the overlying till from the gravelly sand of the esker. Boudinage features within the creavasse fillings also indicate active ice movement after stagnant deposition.

ODM9515

Photo 4–Air photo mosaic of the Intola Moraine across the Murillo drumlin field.

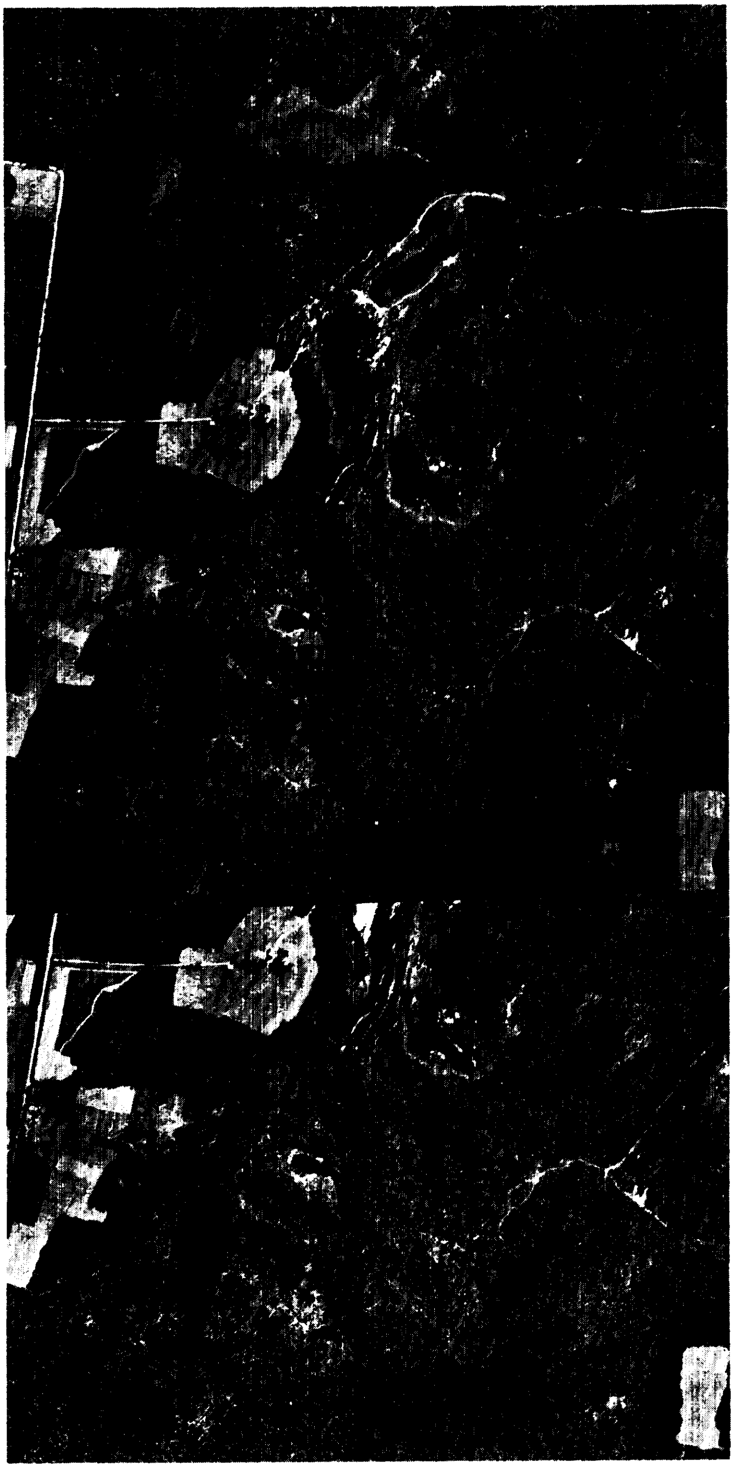


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Photo 5–Ice-contact complex associated with the Intola Moraine near Intola, Ontario (stereoscopic pair)

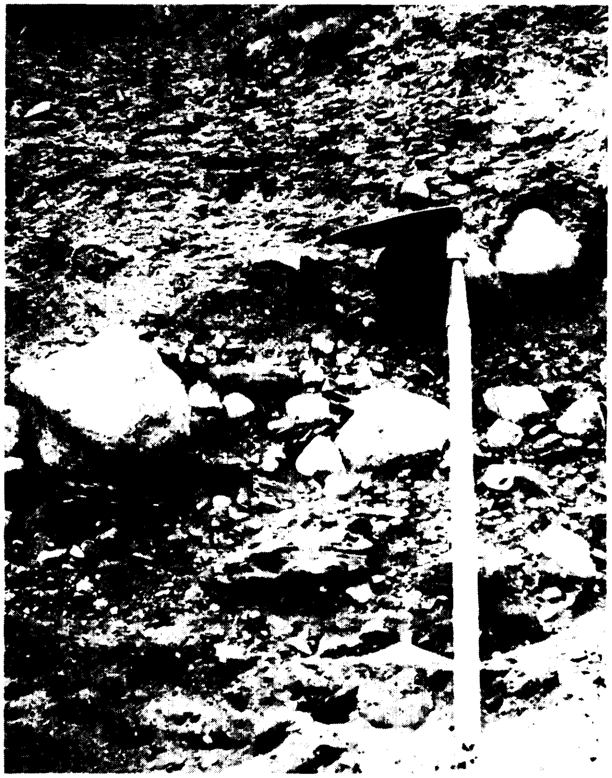

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Photo 6–Gritty silt till overlying ice-contact sand and gravel in the Intola Moraine.

From the preceding discussion it appears that the Intola Moraine and its associated area of stagnation moraine are the result of oscillations of the Superior lobe margin at a very late stage in its recession from the vicinity of Thunder Bay. Corrugated moraine topography was developed by active glaciation followed quickly by a temporary cessation of motion. The ice-block topography of the overridden esker complex was created by the deposition of stratified material among stagnant ice blocks followed by active glaciation. The morainic core was deposited by active ice but the surface features indicate the existence of small stranded ice blocks, i.e. stagnant conditions. The overriding of the esker complex and the existence of the corrugated moraine indicates that in this vicinity there was a period of active glaciation preceded and followed by stagnation conditions.

Drumlins

The Murillo drumlin field occupies western McIntyre and eastern Oliver Townships. Tanton (1931, p.79) briefly mentioned stoss-and-lee type moulding of uplands but did not show the drumlin field on his map. Zoltai (1963, p.105) described and located some of the drumlinoid ridges stating that an irregular thickness of ablation till masked them and made them difficult to find without the aid of vertical air photography (Photo 4).

Roughly fan shaped, the drumlin field spreads outward toward the north and west covering the northwest corner of the map-area and extending to the base of the Marks Moraine. It was formed during the advance of the Superior lobe to the Marks Moraine and is composed of ridges of gritty silt till, commonly moulded over bedrock cores. Striae and stoss-and-lee features on the exposed cores indicate a northwesterly direction of ice movement. Ridge orientation varies across the drumlin field from 270°E in the southern part to 305°E in the northeastern part. Individual ridges are up to 4300 m (14,100 feet) long and as much as 545 m (1,790 feet) wide at the base although they are more commonly 500 m to 1200 m (1,650 feet to 3,900 feet) in length and approximately 85 m (280 feet) wide. Ridge heights do not exceed 9 m (30 feet) and are usually between 3 m and 6 m (10 to 20 feet).

The Intola Moraine, arcing through the Murillo drumlin field, partially masks the pre-existing fluted topography. At the Oliver–McIntyre Township line the moraine is draped over a large drumlinized bedrock knob. Mafic metavolcanics are exposed on the east and south faces of the drumlin. These faces were striated and chatter marked by ice moving toward the northwest (300°E to 310°E). At least 4.3 m (14 feet) of gritty silt till is plastered around the north and west sides of the rock drumlin. The drumlin's axis orientation is 270°E although the southwest face approaches 300°E, approximately normal to the arc of the Intola Moraine at this site. This relationship suggests a shifting ice flow direction from west to northwest. A similar relationship exists within the overridden esker complex.

Glaciofluvial Deposits and Features

OUTWASH DEPOSITS

Outwash deposits (map unit 4, 5, 6, and 7) in the form of channel fills and outwash plains occur in approximately 30 percent of the map-area. The majority of this material was deposited along the course of the ancient Kaministikwia River meltwater channel which emptied into the Superior basin and had its origin northwest of the map-area at the Dog Lake Moraine. The other deposits, mostly in McIntyre Township, are less extensive and shallower.

Kaministikwia River Meltwater Channel and Spillway

The ancient Kaministikwia River was formed as a meltwater channel northwest of the map-area upon withdrawal of the Superior ice lobe from the Marks Moraine. Glacial Lake Kaministikwia, which had occupied the area between the

Marks and Dog Lake Moraines while the ice margins stood at those features, was eventually drained by a spillway which followed this meltwater channel (Zoltai 1963, p.113). With the retreat of the Superior lobe lower land was exposed into which the lake could be drained. The Marks Moraine, which blocked the drainage path, was breached from the village of Kaministikwia to Mokomon Station. This route appears to be influenced by the location of intrusive rock bodies within the metasediments of Oliver and Conmee Townships (Figure 2). From Mokomon to Kakabeka Falls the channel arcs westward. Halfway through the arc a second channel joins the first just north of Hume, along a boundary between metavolcanics and felsic intrusive rocks. A sharp southward turn in the channel coincides with the intersection of two faults, one of which forms the lower boundary of the Gunflint Formation. The eastward bend upstream from Stanley also occurs at a fault-boundary intersection. From Rosslyn Village to Lake Superior the present river course meanders through postglacial deltaic deposits tens of metres thick. Bore hole data suggest that the ancient Kaministikwia River may have entered the lake basin along a course now partly occupied by the lower reaches of the Neebing River (Figure 8).

The coarser material (map unit 4) along the Kaministikwia River was derived mainly from the outflow of meltwater through the proglacial lake bed formed in front of the Dog Lake Moraine. It emptied into the proglacial lakes forming in the Superior basin in front of the retreating Superior lobe. There material was supplied directly by the Superior lobe as well, but since it was, for the most part, disturbed lake clay and silt deposited directly into an actively growing water body little coarse grained material was deposited east of Pointe de Meuron, on the Kaministikwia River. Bore holes in the delta indicate a fine grained till unit directly above the bedrock at approximately 27 m (89 feet) below the surface. This is overlain in several holes by 0.5 to 2.5 m (1.6 to 8.2 feet) of coarse sand and gravel, probably outwash, which is overlain by fine-grained deltaic units to the west and very fine grained lacustrine units to the east. If the gravel unit is outwash it may be related to the retreating Superior lobe, the front of which was submerged in the ice-marginal lakes that preceded the Minong Stage in the Superior basin. Coarse deltaic outwash from the retreating Superior lobe is found at the surface west of Highway 17 in Oliver Township near Kakabeka Falls. The material was deposited toward 255°E to 265°E as poorly sorted medium-bedded sandy gravel. Thrust planes through the deposit trending toward 275°E indicate a vascillating ice margin to the east. Bore holes in the vicinity penetrate up to 10 m (33 feet) of sandy gravel before entering the gritty silt till which was deposited by the advance to the Marks Moraine. Samples 509B and 510D in Figure 5 illustrate the moderately well-sorted grain size distribution of sands from the overridden outwash complex. Samples 509D and 510A show the poor sorting throughout the total range of materials (other sample data are recorded in Appendix C).

At least in its upper reaches, the Kaministikwia River meltwater channel and spillway flowed along the margin of the retreating Superior ice lobe. Sediment moving down the spillway from the Dog Lake Moraine district had a distinctly different character from that deposited directly off the Superior lobe ice margin. Samples 538B, 528D, 518ø and 514C in Figure 6 illustrate the progressive textural change in the terrace deposits downstream from Mokomon Station to Kakabeka Falls. The material becomes finer and better sorted with increased

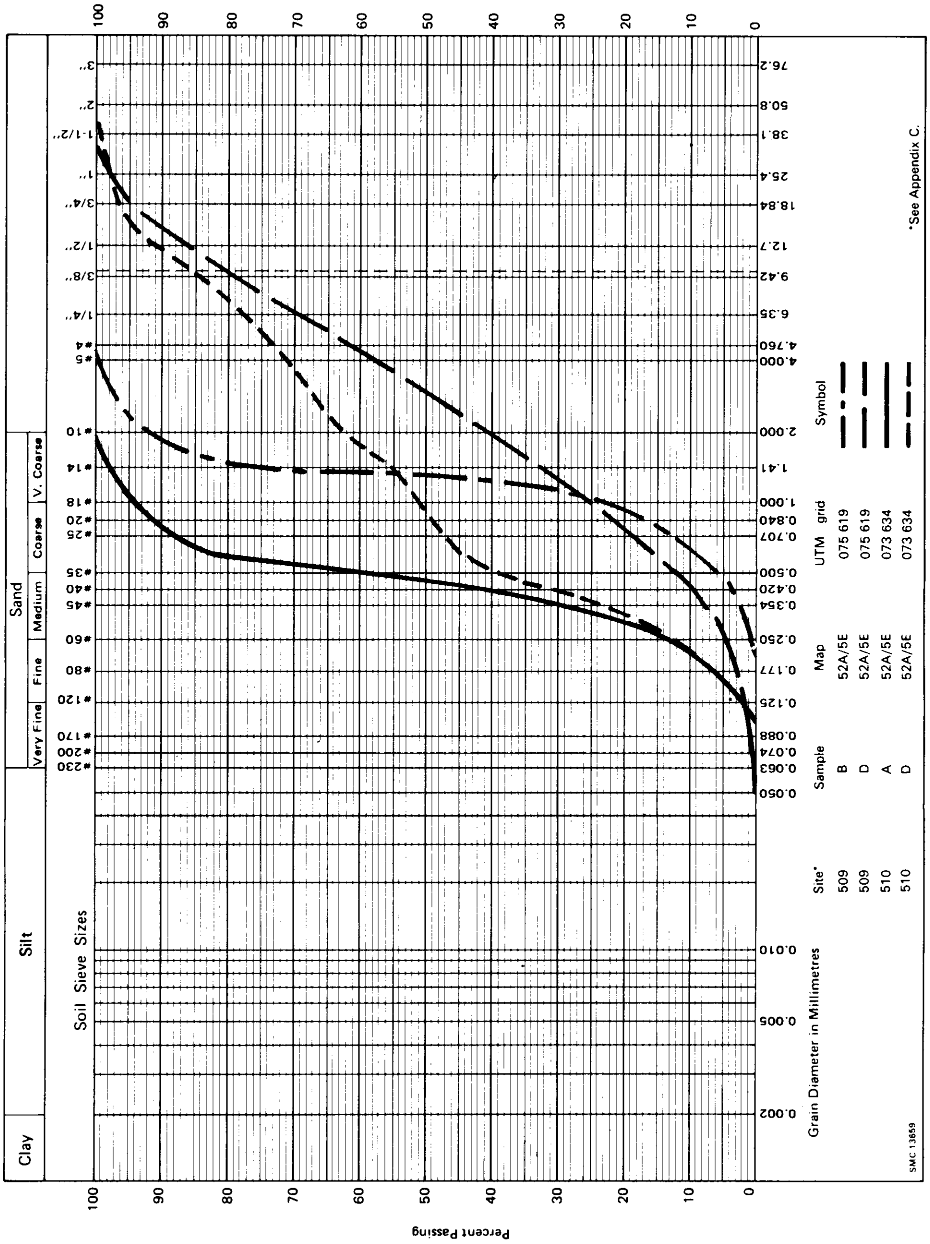


Figure 5–Grain size distribution curves for overridden outwash deposits near Kakabeka Falls.

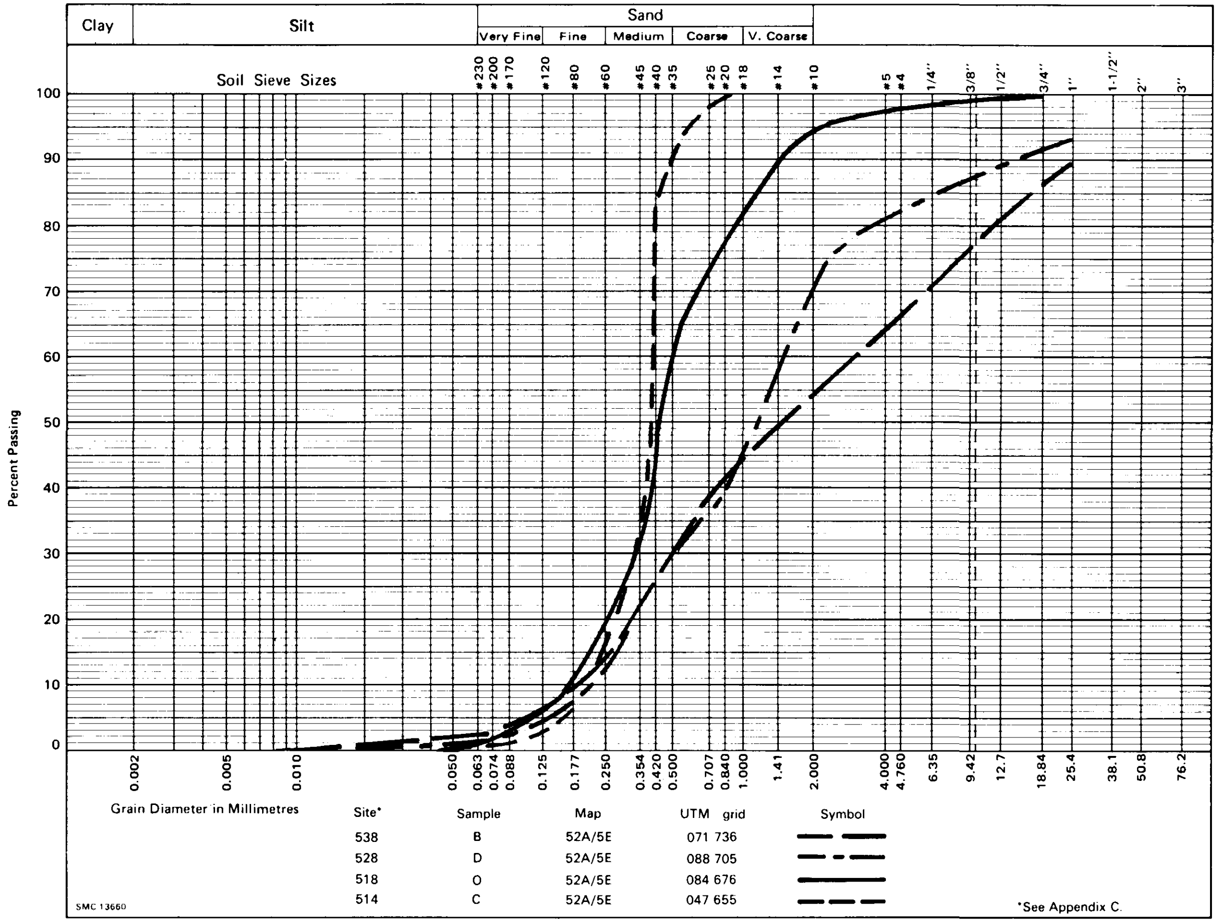
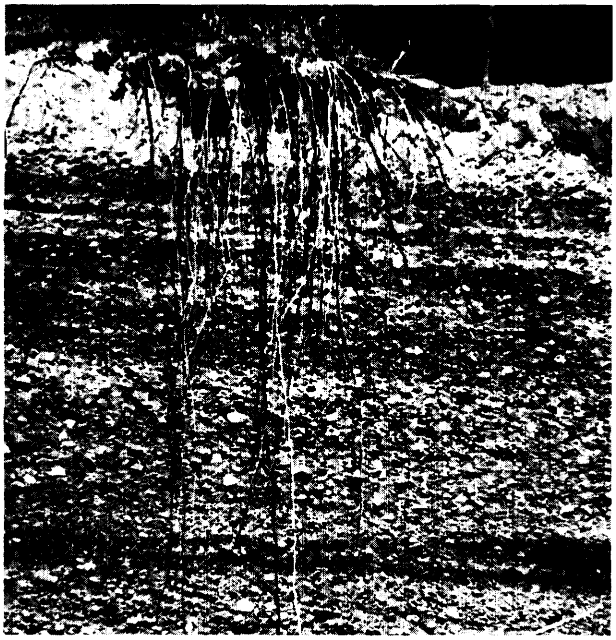


Figure 6–Grain size distribution curves for spillway deposits from Mokomon Station to Kakabeka Falls.



ODM9518

Photo 7–Outwash gravelly sand exposed in a meander of the Kaministikwia River south of Twin City, Ontario.

distance from the Dog Lake Moraine. A notable difference in the petrology of the sands is the lower shale and siltstone content of the spillway terrace deposits compared to sands from the Superior lobe outwash deposits. The former averages 50 percent less than the latter with actual amounts slightly decreasing downstream from the breach through the Marks Moraine. Amounts of free quartz and feldspar are somewhat lower in the outwash sediments from the east while the number of non-comminuted felsic and mafic rock fragments is marginally higher. Although not at a level of statistical significance both of these indicate the direction to source and relatively shorter transport distance of the material (Dreimanis and Vagners 1971, p.242).

Downstream from Rosslyn Village the meandering of the modern Kaministikwia River has exposed buried outwash gravels in the delta. Approximately 10 m (33 feet) of poor to moderately sorted sandy gravel were observed in several pits along the riverbank overlain by less than 2 m (6.5 feet) of lacustrine silty fine sand (Photo 7). The gravel content varies from 20 to 60 percent and consists of angular to subrounded pebbles and cobbles with up to 40 percent shale and siltstone particles in the medium sand range. The angularity of the clasts, relative abundance of local material and lack of sorting all indicate a source nearby, such as the retreating Superior ice lobe, rather than one at any distance.

Other outwash deposits of gravelly sand (map unit 5) and sand (map unit 6 and 7) occur north and northwest of the City of Thunder Bay. Most are thin, discontinuous sand bodies (map unit 6) usually underlain by bedrock or till, occurring in or near the short meltwater channels which abound among the bedrock knobs of the rugged shield terrain. Current directions are strongly controlled by local bedrock topography but indicate, generally, a northwesterly flow. Mineralogy of the sand and fine pebble fractions corroborate the source directions as east or southeast across the Middle Precambrian shales (Figure 7). Deposit depths rarely exceed 3 m (10 feet) and are usually less than 1 m (3 feet). The underlying material is the gritty silt till or the Precambrian bedrock. North of Wild Goose and northeast of North McIntyre the deposits (map unit 7b) are so thin that bedrock is exposed or within 0.5 m (1.6 feet) of the surface in 40 percent of the unit area.

Outwash gravel deposits (map unit 4) are less common in the immediate vicinity of Thunder Bay than are outwash sands. The John Street dump site 3.5 km (2.2. miles) northeast of Baird is in a gravel unit deposited by northwest flowing meltwater and subsequently overridden toward the west by the Superior lobe during the deposition of the gritty silt till (Photo 8). Similar situations exist in the gravel deposits 3 km (1.9 miles) and 4.5 km (2.8 miles) north of Jumbo Gardens with the difference that the overriding ice moved in a more northerly direction. Gravel-bearing units at the above mentioned sites are up to 2.5 m (8 feet) thick. Total deposit depths exceed 8 m (26 feet) and contain up to 45 percent gravel.

Along the northern boundary of the map-area are thin deposits of outwash gravelly sand overlying gritty silt till (map unit 5a) or bedrock (map unit 5b). Current directions are generally toward the northwest. Although some deposits appear to be more than 5 m (16 feet) thick they are banked against the bedrock walls of small meltwater channels to form thin veneers of unconsolidated material. It is reasonable to assume these are late glacial outwash sands since there exists no evidence of overriding but some reworking by lacustrine action occurs up to 60 m (200 feet) above the present level of Lake Superior.

Within Thunder Bay North are extensive but thin deposits of outwash sand (map unit 7c) which have been considerably reworked by subsequent lacustrine action. Although much of the area has been covered by urban development, limited access for sub-surface investigation is afforded by ditch cuts, stream banks and various excavations. The observable deposits range from less than 1 m (3 feet) in thickness, just above the main lacustrine bluff southwest of Boulevard Lake, to 2.5 m (8 feet) thick southeast of the Lakehead Expressway. Gritty silt till underlies the sand and is itself underlain by bedrock at depths of 0.6 m (2 feet) or less. Evidence of lacustrine reworking is visible up to 240 m (800 feet) a.s.l. (present level of Lake Superior is 184 m (603 feet) a.s.l.), approximately coincident with the base of a southwest-trending diabase dike (map unit 1d) north of Boulevard Lake. The surface material has been winnowed by limited longshore drifting and beach ridges have been developed in the vicinity of Boulevard Lake. The entire deposit is bounded on the southeast side by a raised shore bluff at 205 m (675 feet) a.s.l.

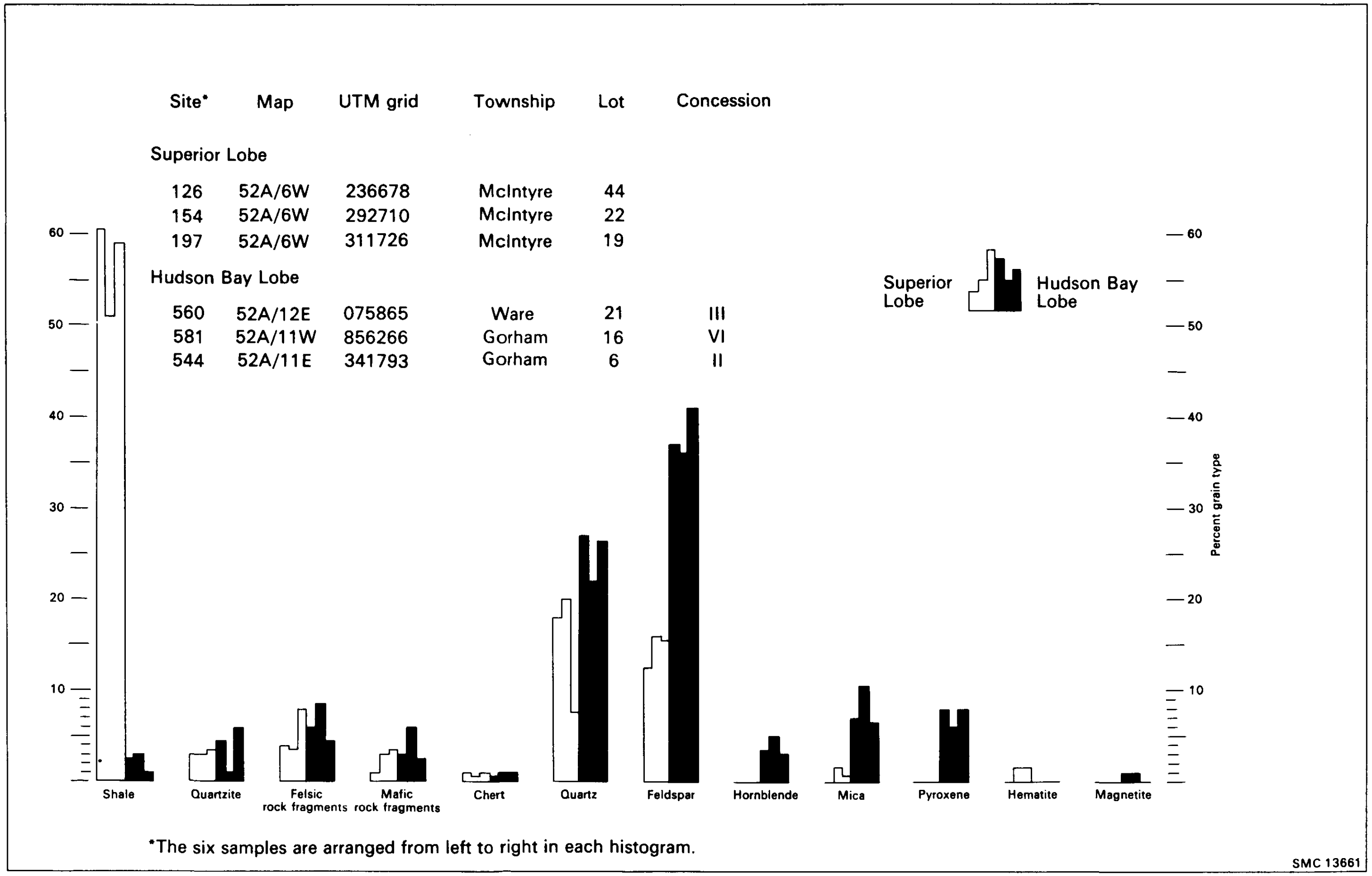


Figure 7–Histogram comparison of mineralogy and lithology for the 0.25 to 4.0 mm fraction of proximal outwash deposits related to the Superior and Hudson Bay ice lobes near Thunder Bay.

ODM9519
Photo 8–Drag features caused by glacial overriding of outwash sand and gravel exposed at the John Street dump near Thunder Bay, Ontario.

Small Meltwater Channels

Meltwater channels presently occupied by underfit streams are common west of the City of Thunder Bay. These abandoned drainage ways were formed by water flowing off the margin of the Superior lobe and eventually finding its way to a major watercourse such as the ancient Kaministikwia River. Bedrock topography has strongly affected the orientation of these small meltwater channels since they had only sufficient erosive power to cut loose, unconsolidated material. Depths of channels range from 2.5 m to 5 m (8 to 16 feet) whether they are cut in till or outwash. Where channels are rock-walled on one side evidence of running water is visible up to 7 m (23 feet) above the present valley floors. Outwash deposits within the channels are generally shallow (up to 1.5 m; 5 feet) compared to the major deposits previously described. These are underlain by 3 m to 5 m (10 to 16 feet) of gritty silt till except in the areas east of the Current River and northeast of North McIntyre where they directly overlie the bedrock.

It is probable that the rock-walled channels have been re-occupied on various occasions during the Quaternary history of the area, but only those cut in till are related to the most recent ice retreat. South of Baird are segments of channels which appear to be related to the final retreat of the Superior lobe. During a recessional halt a partially ice-walled channel was formed southeast of Baird. As the ice margin withdrew farther toward the Superior basin other channels were cut into the silt till. These remnants of channel walls are indistinct fragments of ancient water courses which were not strong topographic features even when they were fully developed. They have since been subjected to the reworking activities of littoral currents and, therefore, do not present a clear picture of their original relationship to the Superior lobe.

ICE-CONTACT DEPOSITS

CREVASSE FILLINGS

Crevasses and fissures are formed in glaciers by tensile stresses which create fractures that are enlarged by melting. Debris carried by meltwater collects in the fissures forming short, relatively straight ridges, often intersecting other similar features to create a cross-hatched pattern.

Crevasse fillings occur along the southern two thirds of the Intola Moraine on both the proximal and distal sides at distances up to 650 m (2,150 feet) from the moraine crest. On the distal (west) side these features are subdued and indistinct due to subsequent fluvial erosion. The drumlinized bedrock, thinly mantled by till in this area, creates a strong topographic fabric normal to the trend of the moraine. Water channeled through the flutings (Photo 4) tends to reduce the height of any transverse features such as the crevasse fillings, which are composed of loosely compacted material deposited between melting ice blocks. East of the moraine the bedrock is more deeply buried and exerts less influence on the topography in the immediate vicinity of the moraine. Crevasse fillings are more prominently developed along the proximal side especially in Concession IV, Lots 1 and 2 of Oliver Township. Here the features reach a height of 1.0 m to 1.5 m (3 to 5 feet) and exhibit the cross-hatched relationship mentioned above.

Other crevasse fillings occur along the proximal side of the moraine as far north as the ice-contact complex which occurs on the proximal side of the Intola Moraine (Photo 5). These are low ridges, usually less than 1 m (3 feet) high, parallel to the moraine with relatively few connecting ridges perpendicular or at angles to them. They have been slightly modified by subsequent meltwater action winnowing finer material from the crests and streamlining their shapes. These features are observable in North McIntyre Road Concession, Lot 32, McIntyre Township, northeast of the large rock drumlin.

Eskers

Eskers are sinuous, narrow, elongated ice-contact ridges composed of stratified materials originally deposited in fractures or sub-glacial tunnels by flowing water. The only esker within the map-area is 2 km (1.2 miles) south of Intola. It bisects the ice-contact complex which occurs on the proximal side of the Intola Moraine (Photo 5). The esker ridge is 1.7 km (1 mile) long and rises to a maximum height of 15 m (49 feet). It is composed of stratified medium to coarse pebbly sand deposited in beds up to 0.3 m (1 foot) thick, dipping toward 280°E. This direction of deposition is subparallel to the nearby drumlins, especially the large rock drumlin 1250 m (0.8 miles) to the southwest, and approximately normal to the general trend of the Intola Moraine.

Surrounding this esker is an area of ice stagnation related topography. Crevasse fillings trend at 45° and 90° to the axis of the esker (Photo 5). These collapsed sediments lay in fractures between melting blocks of glacial ice buried by till of a subsequent advance toward 320°E, perpendicular to the Intola Moraine in this area. Boudinage features in the buried gravels indicate this direction of movement. North and south of the esker steep ice-contact slopes form walls surrounding the entire complex.

Glaciolacustrine Deposits and Features

Lakes ponded by the Superior ice lobe during late glacial events inundated the map-area to at least 260 m (850 feet) a.s.l. Beach bluffs up to 358 m (1,174 feet) a.s.l. are reported outside the map-area west and south of Kakabeka Falls (Farrand 1960, p.32), and at 460 m (1,510 feet) a.s.l. near Horne on the Canadian Pacific line, 45 km (28 miles) west of Thunder Bay (Zoltai 1963, p.109). Lacustrine deposits formed during earlier intervals of glacial retreat are observable in section beyond the map-area up to 366 m (1,200 feet) a.s.l. and were noted in logs of water wells up to 396 m (1,300 feet) a.s.l. northwest of Kakabeka Falls. Lacustrine material exposed within the map-area includes beaches of gravel and gravelly sand (map unit 8), nearshore sand (map unit 9), deep-water deposits of silt and varved clay (map unit 10), and deltaic sand (map unit 11). Prominent shore bluffs and beach ridges which arc northeast from the Kaministikwia River through the City of Thunder Bay and on past Wild Goose Point were produced by late glacial lake stages in the Superior basin.

The sequence of lake levels established in the Superior basin during and following its deglaciation has been studied at various localities for nearly a century. Farrand's (1960) terminology is followed in this report since it is the most complete for the strands represented in the map-area. Table 5 lists the six readily observable levels together with their elevations in the vicinity of Thunder Bay and their approximate ages. The dates given are those of Saarnisto (1975) which represent the latest data available. In the main this chronology, based on palynologic stratigraphy (Saarnisto 1975), confirms previous work based on morphologic models (Farrand 1960; 1962) with the exception of the Nipissing Great Lakes date which corroborates the material cited by Prest (1970).

KAMINISTIKWIA DELTA

Between the diabase sills of The Nor'Westers and the prominent shore bluffs cutting through Thunder Bay North lies the delta of the Kaministikwia River. This body of silt, sand and gravel extends approximately 32 km (20 miles) inland to the vicinity of Kakabeka Falls. It is divided into two distinct physiographic units, the deltaic upland and the lower deltaic plain (Photo 9), by a

TABLE 5 | Late Glacial Lakes of the Superior Basin in the Vicinity of Thunder Bay

STAGE[1]	ELEVATION[2]	APPROXIMATE AGE[3]
Sault (Taylor 1895)[4]	190m (622 ft.)	2,200 B.P.
Algoma (Taylor 1894)	192m (629 ft.)	3,200 B.P.
Nipissing Great Lakes (Taylor 1895)	200m-204m (656 ft.-668 ft.)	5,500 B.P.
Houghton (Farrand 1960)	166m (545 ft.)[5]	8,000 B.P.
Post-Minong (informal, Farrand 1960)	226m-240m (740 ft.-788 ft.)[6]	9,000 B.P.
Dorion Beach (Farrand 1960)	208m-229m (682 ft.-750 ft.)	
Minong (Stanley 1941)[7]	236m-248m (773 ft.-814 ft.)	9,500 B.P.

[1]Authors cited are in the references of this report.
[2]Maximum and minimum elevations are derived from Farrand (1960).
[3]Age in years before present are from Saarnisto (1974).
[4]cf. Farrand (1960) p.60, Saarnisto (1975) p.312, 316.
[5]Elevation derived from Farrand (1960) p.48 and Farrand (1962) p.187.
[6]Elevations refer to highest Post-Minong strand.
[7]cf. Farrand (1960) p.36.

strong bluff representing the lowest Minong Stage shoreline. The Dorion beach, formed during the Post-Minong stage crosses the lower deltaic plain separating the earlier Minong bottom sediments from the later deltaic and near-shore sediments of more recent lake stages. The present disbributaries of the river form two deltaic islands in Lake Superior.

The deltaic upland extends from Rosslyn Village upstream to the vicinity of Kakabeka Falls 15 km (9.3 miles) to the west. Its surface elevation rises from approximately 230 m (750 feet) to over 260 m (850 feet), a level coincident with the present river base above the falls. Farrand (1960, p.41) records 261.2 m (857 feet) as the maximum elevation of delta gravels north of Stanley, midway between the falls and Rosslyn Village. The eastern face of the upland is formed by a wave-cut bluff, 7.6 m (25 feet) high, marking the coincident levels of the lowest Minong and the highest Post-Minong stages in the Superior basin.

Outwash gravel and sand which forms the core of the upland is exposed along the river in several commercial excavations. Up to 3.6 m (12 feet) of material is observable in pits above the Minong bluff south of the river. Waterwell logs from north of the river indicate 10.3 m (34 feet) of gravel and sand underlying at least 3.6 m (12 feet) of outwash sand which forms the surface. A layer of fine sand up to 1.5 m (5 feet) thick thins southward from the gravel as far as Slate River Valley, covering the lacustrine silt and silty clay into which the main outwash channel was incised. Upstream, northwest of Stanley, the gravel-filled channel lies north of the present river. Outwash from the oscillating margin of the Superior lobe entered the channel in this area swelling the volume of water

ODM9520
Photo 9–Mount McRae of The Nor'Westers viewed across 7.5 km (4.7 miles) of the Kaministikwia River's lower deltaic plain southwest of Thunder Bay, Ontario.

and adding coarse material of an eastern provenance to the sediments moving south from the Dog Lake Moraine. This core is flanked by deltaic sand units which are confined south of the Kaministikwia River by clay till. North of the river they are mixed with the coarser outwash materials which border the gritty silt till.

The lower deltaic plain is more extensive than the deltaic upland being 24 km (15 miles) long and varying in width from approximately 6.5 km (4 miles) to more than 21 km (13 miles). The surface elevations from the base of the Minong bluff at Rosslyn Village to Lake Superior drop only 43 m (141 feet) with no major topographic breaks in the general slope. South of the Kaministikwia River diabase sills protrude through the unconsolidated sediments to form bedrock hills up to 61 m (200 feet) high.

Arcing north across the delta from the Neebing rail yards is the Dorion strand line (Figure 9), a series of low beach ridges, 207 m (680 feet) a.s.l., which marks the uppermost limit of deltaic sediments as a mappable surface unit. Between the Minong and Dorion strands the present surface consists of up to 2 m (6.5 feet) of lacustrine reworked silt and silty fine sand. These represent materials deposited during an earlier, higher lake stage and reworked by the waters of the Minong and later stages during erosion of the bluff near Rosslyn Village. Beneath this unit in the area of Twin City is at least 5.5 m (18 feet) of gravel and sand deposited in the steeply dipping, upward fining cyclic sequences associated with outwash deltas (map unit 4). From Twin City east to the vicinity of the Dorion beach this unit becomes increasingly fine grained due to its extension into deeper water and mingling with lacustrine sediments. Meandering of the Kaministikwia River has exposed the gravel southwest of Twin City and several extractive operations have been established. Well logs indicate at least 25 m (82 feet) of gravel to the west and over 12 m (40 feet) to the east but this latter deposit is deeply buried beneath finer deltaic sands and lacustrine silts.

East of the Dorion strand the deep-water fine sediments have been buried or removed by subsequent shallower lake stages. The deltaic and near shore fine sand appears in thin to medium beds up to 20 cm (8 inches) thick which are essentially flat lying. Foresets within the beds are not common near the surface but were observed in a few deeper cuts along the Neebing River.

Low bluffs and beach ridges mark the Nipissing Great Lakes shoreline at 197.5 m (648 feet) above sea level. Neither the Nipissing nor the Dorion lake stages left a topographically prominent strand on the delta, but the Nipissing shore bluff forms the northern boundary between the delta and pre-existing lacustrine deposits. Planation during the Nipissing stage has left the eastern half of the lower deltaic plain a nearly featureless surface sloping to the present shore of Lake Superior.

The present delta front contains three distributaries formed by the modern Kaministikwia River as it enters Lake Superior. That these have not been the only channels, even during the Recent, is easily observed along City Road which borders the Fort William Indian Reserve. An abandoned channel scar, now filled with silty fine sand, extends from the turning basin to Mission Bay. Other less distinct channel scars are visible north of Whiskyjack Creek and entering the cove north of Grand Point. Brûlé Bay was also an outlet for the river at one time. Squaw Bay served as a distributory channel probably during the Dorion stage or at some earlier time.

Although the modern Kaministikwia River outlet appears to be migrating northward there is evidence that the ancestral river had an outlet slightly north of the present distributory system. During the Geotechnical Data Compilation Program carried out in 1972 by the Geological Survey of Canada numerous bedrock depths in the delta area were contoured by Mr. J. Scott in the Mining Recorders Office at Thunder Bay (Figure 8). His results suggest a bedrock channel with a base elevation of approximatey 137 m (450 feet) above sea level which entered the Superior basin in the vicinity of the Neebing River. The sites of Scott's data are too scattered to allow for anything other than speculation on the subject.

DEEP WATER SEDIMENTS

Fine-grained glaciolacustrine sediments consisting of layered or varved clay, silt and silty fine sand were mapped between the Kaministikwia River channel and The Nor'Westers, south of Murillo and along the Superior shore from McVicar Creek to Navilus. Pockets of varved clay were observed along the lower reaches of McIntrye River and in gravel pit excavations from Murillo to Onion Lake Road north of Jumbo Gardens at elevations below 297 m (975 feet). Keele (1924, p.127-129) reported clay deposits used for brick-making near Rosslyn Village and in the former cities of Fort William and Port Arthur. Tanton (1929, map 197A) mapped most of the area between The Nor'Westers and 48°20′N

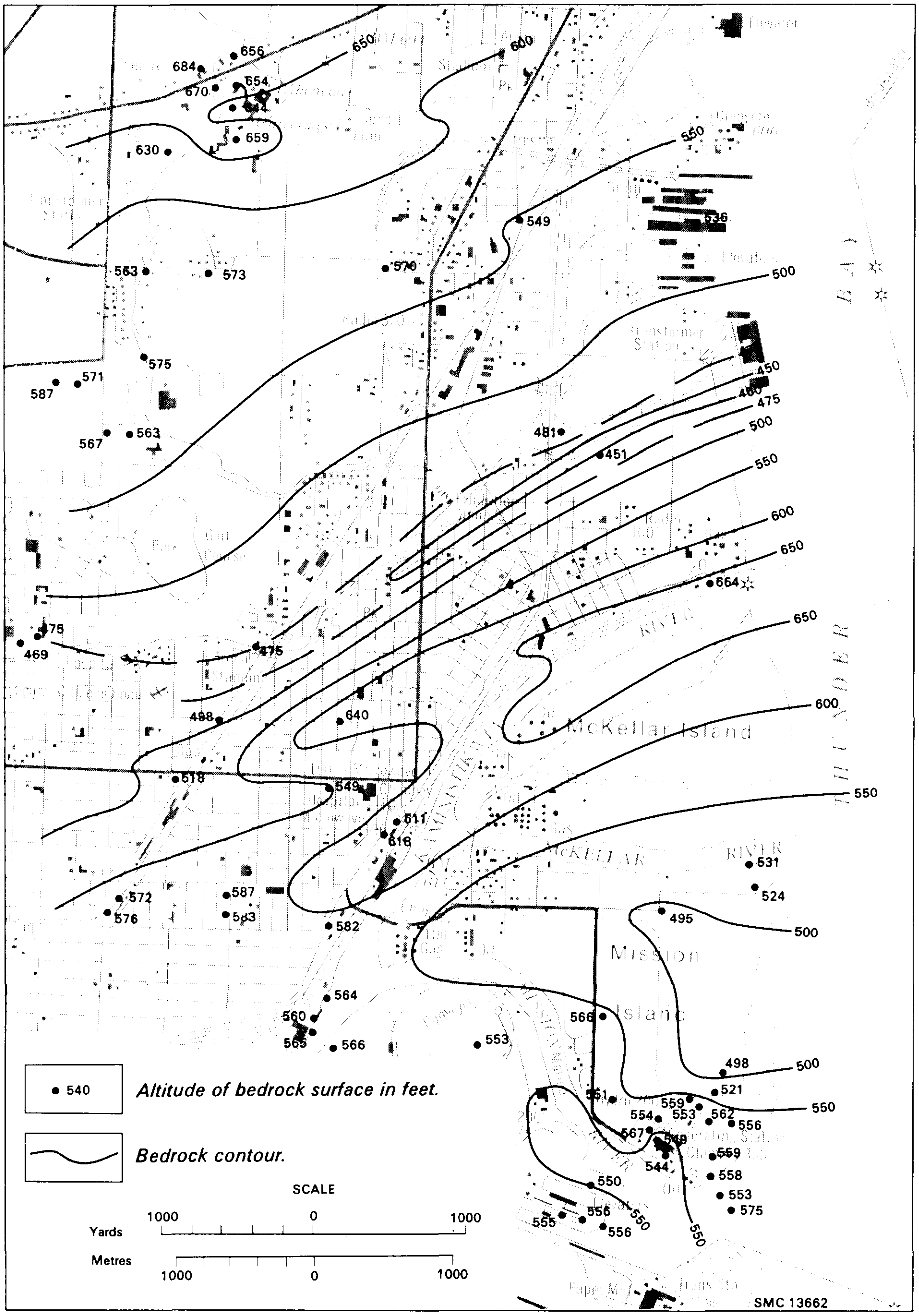


Figure 8–Sketch map of bedrock topography beneath the Kaministikwia Delta.

Latitude as clay deposits of Glacial Lake Algonquin. He showed silt belts bordering the Kaministikwia delta and occupying the areas of swamp. Zoltai (1963, p.106) indicated clay lake sediments along the Superior shore from east of Boulevard Lake to McNab Point and inland along the Slate River past Moose Hill in the southwest corner of the map-area.

In the Slate River—Mosquito Creek basin silt-sized particles are more prominent up to approximately 230 m (750 feet) a.s.l. Waterwell records indicate from 6 m (20 feet) to 22 m (72 feet) of silt or silty clay overlying gravel or gravely clay till.

No definite boundary marks the southward transition of the silt to clay through most of the basin. At elevations above 230 m (750 feet) clay forms the surface unit and is visible in the creek banks and ditch cuts as layered sequences. The clay is reported by Keele (1924, p.127) to be at least 23 m (76 feet) thick in a pit near the Kaministikwia River on the outskirts of Fort William (Thunder Bay South). Up to 17 m (55 feet) of clay, lacustrine sediments, and lacustrines fine over an unidentified till is reported in the few waterwell records available in this part of the basin. Above the Minong bluff (225 m; 740 feet) road cuts expose 1.8 m (6 feet) of laminated and varved clay. Waterwell records are highly inconsistent but indicate a thinning of fine-grained lacustrine sediments from 27 m (90 feet), north of Moose Hill, to 6 m (20 feet), northwest of Carters Corners. Most of the wells do not penetrate bedrock but terminate in an unidentified till unit.

Pockets of varved clay and silty clay were observed in various excavations near Murillo and Baird, along the Neebing and McIntyre Rivers as well as along McVicar Creek north and west of Jumbo Gardens. Dropstones, material deposited out of floating ice, are fairly common in these deposits and consist mainly of fine pebble-size fragments of silty till. Medium pebbles of Sibley siltstone and shale form a small proportion of dropstones, but this increases from North McIntyre to the Current River with proximity to the source area. All the sites contain deformed sediments. Commonly the deformation is simple slumping and collapse, probably penecontemporaneous with deposition. Decollement structures, flame structures and boudinage features, the results of sediment shift under loading conditions, are observable in several exposures off Hillsdale Road north of Jumbo Gardens. In the A. Cooper and Company, Limited gravel pit 1.3 km (0.8 miles) south of McVicar Creek such a section, containing a 38-couplet sequence of contorted varves was overridden by ice depositing sandy silt till toward 35°E. The maximum elevation at which contorted varves, occur is 297 m (976 feet), in the V.D. Rigato Limited gravel pit 2.4 km (1.5 miles) north of McVicar Creek on Hillsdale Road where a 78-couplet sequence is exposed.

All the varved clays observed in the vicinity of Thunder Bay are red to brown in colour. The Slate River clays are pink to weak red oxidizing to stronger shades of red or red-brown. Scattered deposits are darker reddish brown when oxidized, but otherwise, they appear slightly redder than the clays to the south.

The relative age of these varved clays is less than that of the last major advance of the Superior ice lobe and greater than that of the cutting of the lowest Minong bluff. The unidentified subsurface till which underlies them is fine-grained and is occasionally described as clay till in the waterwell records suggesting that it represents the Superior ice lobe advance to the Marks Moraine that overrode pre-existing lacustrine fine-grained sediments to produce the clay till commonly exposed west and south of the map-area.

SHORELINE FEATURES

Prominent strands of three late glacial lake stages are represented in the vicinity of Thunder Bay. Less well defined shoreline indicators of several other lake stages in the Superior basin also occur.

Numerous observations by previous workers form a sizeable, if not consistent, literature dealing with the lacustrine history of the basin and its relationship to stages in the lower Great Lakes. Observations by Leverett (1929, p.59) "made with aneroid barometer on McKay Mountain...indicate lake action up to 1,350 feet [477.5 m] above sea level..."; these observations were interpreted by Leverett to be related to Glacial Lake Algonquin. Tanton (1929) mapped discontinuous lake beaches from Moose Hill around The Nor'Westers to Squaw Bay and from Murillo to Port Arthur (Thunder Bay North). Continuous lake beaches extended from Port Arthur beyond Wild Goose Point. He subsequently stated "...The highest lake beach observed on Mount McKay is 835 feet [254.5 m] above sea level..." (Tanton 1931, p.81) although he also ascribed this shore feature, as well as those measured (772.1, 750.8, 720.4, 697.7 and 691.8 feet a.s.l.) by Lawson in 1891 (Tanton 1931, p.81), to successive stages of Lake Algonquin. He identified three levels of the Nipissing Great Lakes through the main business section of Port Arthur. Hough (1958, p.216-224) used the observations of the above mentioned authors and others to refute the idea that Lake Algonquin's main stage existed in the Superior basin. He stated at the outset of his discussion of this basin that its history was more obscure than any other Great Lakes basin due to the primitive conditions of the area, the lack of pre-existing data in readily usable form and the fact that no horizontal segments of the oldest strandlines had been found, thus making precise measurement of the original water plane elevation impossible (Hough 1958, p.124). Nevertheless, he was able to set forth a comprehensive interpretation of the basin's history which was not altered in subsequent publications where he outlined the direct influence of bedrock structure on the basin (Hough 1962, p.11-19) and updated it's history in light of more recent work (Hough 1963, p.102-105). Hough's outline (1958) included the early stages in the Superior basin, the discussion of Lake Algonquin's maximum extent, the post-Algonquin pre-Nipissing stages, Nipissing, and post-Nipissing levels.

Farrand's (1960) investigations in the Superior basin supplied specific data on present elevations and correlations of strandlines as well as a detailed interpretation of lake history after the late Wisconsinan retreat of the Superior ice lobe. His treatment of the period between the Duluth stage and the Nipissing Great Lakes significantly expanded Hough's outline. Zoltai (1963) touched briefly on the sequence of late glacial lakes but was more concerned with the interstadial water bodies, which are not represented by any strand features in the vicinity of Thunder Bay. Zoltai's (1965a) study of the Quetico—Nipigon Area followed Farrand's outline of lake stages, as does the present report.

The best developed strandline features in the area are erosional bluffs cut into Quaternary sediments or Precambrian bedrock. Constructional features such as beach ridges and bars are commonly less well developed, but are easily recognized on vertical aerial photographs and generally can be located on the ground without great difficulty. Shore gravels (map unit 8) and gravelly sands (map unit 9) also occur in sheet deposits of varying thicknesses with the underlying bedrock or till close to the surface (often at depths less than 1 m; 3 feet). Extremely thin deposits of gravel on reworked till indicate littoral processes but cannot be interpreted as distinctive strandlines.

Shoreline elevations were determined with reference to bench marks and spot elevations on N.T.S. sheets and M.T.C. cross-sectional surveys, which are considered precise to ± 1.5 m (5 feet).

Strand Sequence at Wild Goose

The most complete sequence of shoreline features reaches an elevation of approximately 260 m (850 feet) a.s.l. in the northeast corner of the map-area. This maximum elevation is the base of a strong bluff incised in the bedrock from the vicinity of Wild Goose to west of the Current River above Boulevard Lake. Nearly continuous throughout its extent, the bluff exceeds 8 m (26 feet) in height. Only the Current River has created a major break in the wavecut wall. Once through this breach the river parallels the bluff for a short distance and has accentuated its height by constant erosion. Below the bluff is a sequence of low beach ridges and gravel bars (map unit 9) deposited around bedrock knobs and terminated by a second strong bluff, also cut into bedrock, at approximately 200 m (660 feet) a.s.l. This lower bluff is continuous from the northeast corner of the area to west of Navilus where it is lost in the merging of near-shore and off-shore postglacial lacustrine sediments. From the base of this bluff to the present level of Lake Superior, 184 m (604 ± feet) a.s.l., off-shore sediments of former lake stages are mixed with near-shore sediments of very recent stages in a continuous sequence. Bedrock knobs protruding from the sediments near Navilus, Green Point, Wild Goose and Wild Goose Point exhibit segments of a wave cut bench and bluff at approximately 190 m (620 feet) a.s.l.

This sequence correlates well with Farrand's (1960) observations near the area. Deltas deposited into Lake Minong along MacKenzie Creek with surface elevations of 260 m to 262 m (852 to 860 feet) were terraced by subsequent Minong stages down to 248 m (814 feet). The highest post-Minong strand, a prominent bluff, stands at 231 m (759 feet) in the MacKenzie area, succeeded by the Nipissing bluff measured west of Navilus at 202 m (664 feet) and west of MacKenzie Creek at 200 m (657 feet). A sequence of beaches and bluffs, none strongly developed, represent the Algoma and Sault stages. The Sault bluff occurs at 190 m (622 feet) near Wild Goose Point.

Minong Stage

Much of the sequence at Wild Goose can be traced across the map-area (Figure 9) using Farrand's elevations as a basis for correlation. Strands within the Minong series occur from Jumbo Gardens to Murillo. A 3 m (10 foot) high bluff cut in outwash sand (map unit 7a) crosses the hydro lines west of the Lakehead Expressway at approximatey 235 m (770 feet) a.s.l. It skirts a rock knob north-

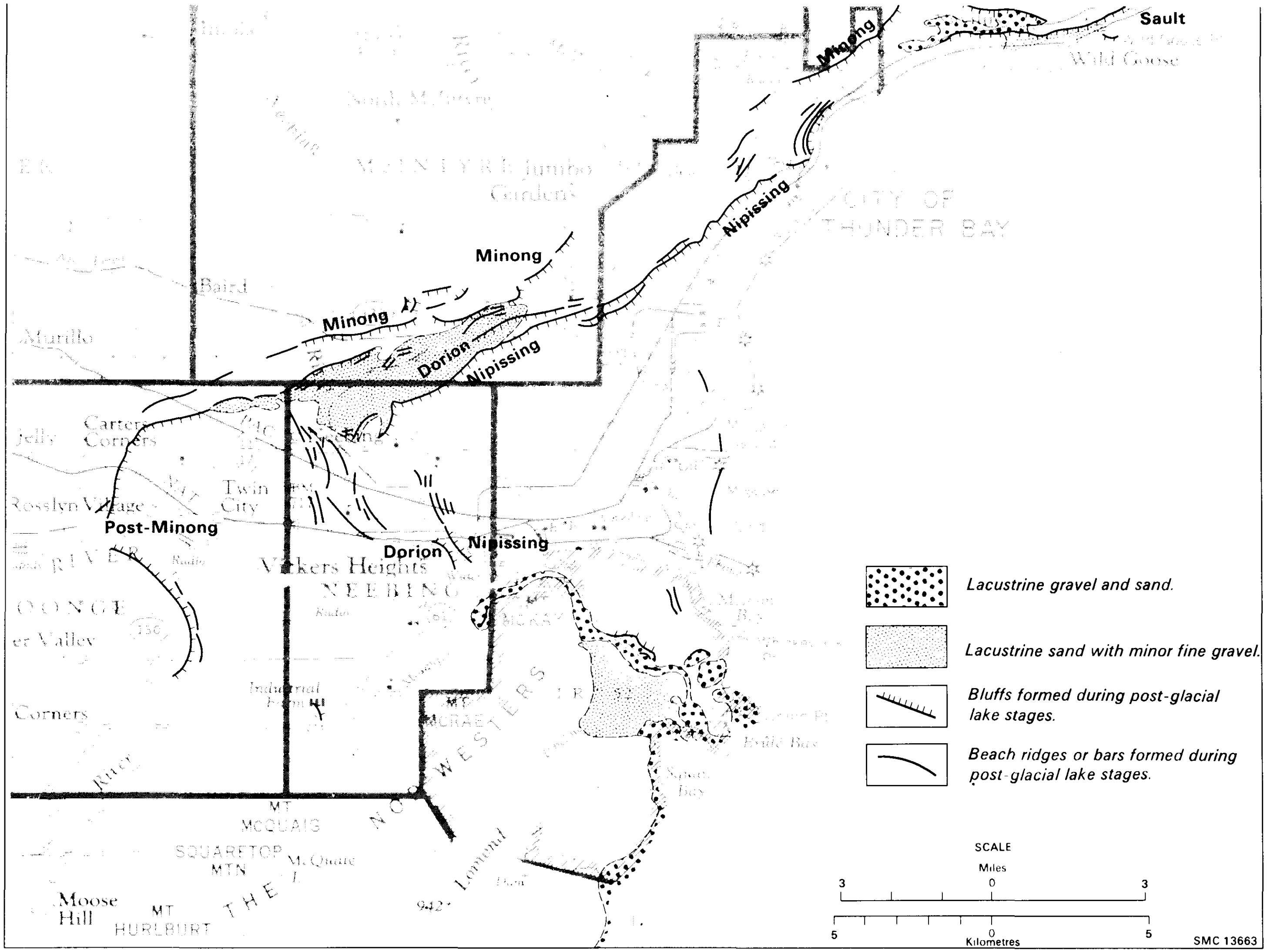


Figure 9–Location of strandlines in the vicinity of Thunder Bay.

west of the intersection of Highway 130 and Central Avenue at 233 m (765 feet) a.s.l. where the strands are marked by numerous shallow gravel pits. Above 259 m (850 feet) the pits have been sunk through 1 m (3 feet) to 3 m (10 feet) of silt till (map unit 3d) to the Gunflint Formation. No beach material was observed above these pits. At a location 2.8 km (1.8 miles) west of the intersection of Highway 130 and Central Avenue a Minong bar at 245 m (805 feet) a.s.l. cuts off a small embayment north of the highway. A bluff, cut in till, continues southwest crossing a sideroad near an abandoned rail line at approximately 245 m (800 feet) a.s.l. A low ridge accumulation of gravelly sand on silt till, beginning approximately 3.2 km (2 miles) farther to the southwest has a surface elevation of 241 m (790 feet) a.s.l. but cannot be physically traced to the aforementioned bluff.

Post-Minong Stages

The highest post-Minong strand measured in the sequence near Navilus by Farrand (1960, p.182) was at 233 m (764 feet) a.s.l. Field observations showed this to be a poorly developed gravelly sand ridge at the base of several bedrock knobs protruding through a sequence of shore deposits representing the Minong and post-Minong stages. West of the city of Thunder Bay this strand is represented by a strong bluff attributed by Farrand (1960) to the convergence of the lowest Minong and highest post-Minong beaches between 226 m and 229 m (740 and 750 feet) a.s.l. in that area. Except where it has been removed by extractive operations this strandline can be traced from Belrose Road, 320 m (0.2 miles) north of the intersection of Highway 130 and Central Avenue, to the Slate River, 4.8 km (3 miles) south of Rosslyn Village. At Highway 130, the 2 m high bluff cut in pre-existing shore gravels has a surface elevation of approximately 225 m (740 feet) a.s.l. At a location 1.6 km (1 mile) northwest of Rosslyn Village a 7.5 m (25 feet) high shore bluff is cut into outwash sand which was deposited in the Kaministikwia River delta to form the deltaic upland. The base is 227 m (745 feet) a.s.l. South of the Kaministikwia River the bluff exposes the outwash gravel along the main river channel and the lacustrine clays deposited during earlier, higher lake stages (see section on "Historical Geology"). The base is approximtely 225 m (740 feet) a.s.l. and is parallel to several low sandy ridges, probably off-shore bars. Gravel beach deposits (map unit 8) around the nose of Mount McKay occur as well-developed ridges up to 227 m (745 feet) a.s.l. and therefore probably represent the coincident Minong and post-Minong strands at this level.

Dorion Beach

Of the lower post-Minong levels the best developed strand is the Dorion, named by Farrand (1960, p.44). It can be traced as fragments of shore bluffs and beach ridges from Highway 102 in Thunder Bay North, where its elevation is approximately 212 m (695 feet) a.s.l. along the south side of Highway 130 to the intersection with Central Avenue where its elevation is approximately 210 m (690 feet) a.s.l. Passing through the area of post-Minong shallow water and shore deposits (map unit 9) it crosses Maple-Ward Road 800 m (0.5 miles) north of Highway 17 as a beach ridge at approximately 209 m (685 feet) a.s.l. Farrand identified as the Dorian strand the well developed beach ridge in Vickers Heights at this same elevation as well as the ridge exposed in an inactive gravel pit on the west flank of Mt. McKay. Dorion beach ridges cross the Kaministikwia delta just west of the Neebing yard at approximately 207 m (680 feet) a.s.l. Other less prominent post-Minong beach ridges occurring above the Dorion strand on the Kaministikwia River delta are at 216 m (710 feet), 212 m (695 feet) and 210 m (690 feet) a.s.l.

Houghton Low Stage

Using evidence from the other lake basins, a low stage in the Superior basin during the existence of Lake Chippewa and Lake Stanley in the Michigan and Huron basins has been postulated by several investigators, notably Leverett and Taylor (1915), Taylor (1931), Stanley (1938), Hough (1958), and Farrand (1960). Farrand named this the Houghton low stage (1960, p.46) from organic deposits near Houghton, Michigan, and estimated its original elevation as 104 m (340 feet) a.s.l. (1962, p.187). It followed the opening of a channel between Lake Nipissing and the Mattawa River which occurred during deglaciation of the North Bay area. None of its shore sequence remains above lake level in the vicinity of Thunder Bay.

Nipissing Great Lakes Stage

The most prominent strandline feature in the map-area is the Nipissing Great Lakes bluff (Photo 10). Work on this lake level in the Superior basin has been continuing since Lawson's (1893) investigations were published. Hough (1958), Farrand (1960) and Saarnisto (1974; 1975) all give excellent bibliographies documenting this research as well as that on other lake levels.

In the vicinity of Thunder Bay the Nipissing strand can be traced with relative ease along the present shore. It is cut into the Gunflint Formation or borders the diabase sills. Lakeshore Drive follows the bluff from the northeast corner of the map-area to the junction with Highway 102 in Thunder Bay North. Elevations of 200 m to 202 m (656 to 664 feet) a.s.l. have been measured along this section at various locations during the past 80 years. Lawson's (1893) measurement of 18.7 m (61.4 feet) above the lake surface taken at the Court House on Algoma Street is the earliest recorded. At Boulevard Lake and near Navilus the base of the bluff is approximately 203 m (665 feet) a.s.l. It crosses the McIntyre River at approximately 200 m (655 feet) a.s.l. and trends southwest forming a border of the William Peat Bog. The bluff swings sharply to the south in concession V, lot 17, Neebing Township, just west of a gravel sideroad where its elevation is 199 m (653 feet) a.s.l.

ODM9521

Photo 10–The main shore bluff of the Nipissing Great Lakes along Algoma Street in Thunder Bay, Ontario.

Accumulations of shore gravels in the Navilus–Wild Goose area are partially relict deposits of the post-Minong lake recession, which were re-distributed during the tenure of the Nipissing Great Lakes. East of Wild Goose and west of Navilus shallow deposits of outwash gravel or sand masking the bedrock have been reworked to form ridges and bars in proximity to the major strand. Depth to bedrock rarely exceeds 3.5 m (11 feet) along the bluff and averages about 1 m (3 feet). Consequently, large amounts of shaley pebbles from the Gunflint Formation have been added to the reworked Quaternary sediments in the vicinity of the strand.

From its southward turn in northeast Neebing Township the Nipissing strand crossed the Kaministikwia delta as a series of sand ridges. The bedrock, buried by the clay of deeper lake stages and the silt and sand of the growing delta and near-shore lacustrine deposits, affects neither morphology nor lithology of the strand.

South of the Kaministikwia River a deposit of shore gravel, in places only thinly masking bedrock, skirts Mount McKay and extends across the Fort William Indian Reserve to McNab Point. The base of this series of beach ridges and minor bluffs is the Nipissing strand and occurs at 196.5 m (645 feet) a.s.l. where it crosses Whiskeyjack Creek. From Squaw Bay south to the edge of the map-area shore deposits are continuous from the present margin up to the base of the

ODM9522
Photo 11–Layer of radiocarbon dated organic material (at tip of knife blade) south of Rosslyn Village, Ontario.

palisades formed by diabase sills throughout the Lakehead region. The highest beach shingle observed along the shoreward side was approximately 230 m (760 feet) a.s.l., possibly a Minong strand. The Nipissing strand is a distinct bluff incising the bedrock but has been obscured in many places by rock falls.

Sault Stage

Of the post-Nipissing lake stages only the Sault bluff is identified within the vicinity of Thunder Bay, this being cut in bedrock at Wild Goose Point at 190 m (625 feet) a.s.l. Wave-cut benches at approximately 189 m (620 feet) existing around small bedrock knobs as far west as Navilus probably represent this stage. Beach ridges on McKellar Island, Mission Island and inland from Mission Bay, all at approximately 186 m (610 feet) a.s.l. may represent a slightly lower substage in the Sault series or may be related to the modern Lake Superior.

ORGANICS

A reported radiocarbon date of wood chips collected in a clay pit south of Rosslyn Village gives an age of 9380 ± 150 years B.P. (GSC-287, Dyck *et al.* 1966) (Photo 11). This was interpreted by Zoltai (1965a) as the age of the highest post-Minong beach in the Lakehead area, and referred to by Saarnisto (1975) as the lowest Minong beach. The site was located and examined during the present investigation but the deposit proved to be of limited extent. The datable material consisted of twigs, cone bracts and segments of fir needles concentrated (apparently locally) at the base of a 30 cm (12 inches) sequence of very thinly interbedded layers of clay and ripple cross-laminated silty fine sand passing upward into 30 cm (12 inches) of thinly bedded ripple cross-laminated very fine sand and finally into 67 cm (26.4 inches) of planar thinly bedded fine sand. The underlying material, at least 3.4 m (11 feet), was thinly interbedded clay and very fine sand, contorted by loading to such an extent that the uppermost metre (3 feet) showed lenticular bedding. The lower 2.4 m (8 feet) contained oxidized trough cross-laminated sand beds up to 5 cm (2 inches) thick separated by layers of pink clay and silty clay up to 3 cm (1.3 inches) thick. This varved sequence below the contorted layers represents at least 150 cycles of deposition but a precise count could not be made.

Recent Deposits

ALLUVIAL DEPOSITS

Alluvium (map unit 12) consists of sediments in fluvial channels laid down under conditions of more or less continuous deposition existing from the recent past to the present. Modern organic material is commonly present, usually as undecayed detritus. The distinction between this material and the underlying sediments from which it is generally formed is fairly arbitrary if the modern river channel has not altered significantly in position or size since the removal of Pleistocene glacial influence over depositional processes. Material was mapped as alluvium if it occurred within a recognizable modern water course (not necessarily active at present) and showed evidence of fluvial deposition distinguishable from sedimentary processes observable in surrounding deposits.

Composition of alluvium within the map-area is controlled by the local underlying material. Where the surface material is sand the alluvium in rivers traversing that area tends to be fine sand with some silt content. In the areas covered by fine-grained glaciolacustrine sediments the alluvium consists of silt with minor amounts of clay. The Kaministikwia River flows from an area of coarse sand and gravel across a zone of fine-grained sediments and into an area of medium-grained sediments. Alluvium found along the banks varies accordingly. Upstream from Rosslyn Village the alluvium consists of coarse sand and some medium to coarse pebbles deposited in channel fills and lateral bars below rapids. From Rosslyn Village to the turning basin the material becomes much finer; no gravel is found and more silt is present in the medium sands. Channel dredging downstream from the basin indicates an increase in silt content.

The Slate River flows only through fine-grained sediments thus producing alluvium of silt-to-mud consistency. Lacking any major flood plain this material tends to be deposited in pockets along the eroded banks and to be continually redistributed by the river resulting in a fairly uniform sediment depth of 50 cm to 75 cm (20 to 30 inches).

The Neebing, McIntyre, McVicar and Current River systems follow the same pattern within the glaciolacustrine and glaciofluvial deposits. Where these water courses cross the gritty silt till they do not form alluvial deposits due to the lack of material from the erosion resistant till.

BOG AND SWAMP DEPOSITS

Three major bogs and several swamps (map unit 13) of varying size occur within the map-area. The bogs have developed on raised lacustrine sediments north of the Kaministikwia River. Two smaller swamps, developed on similar sediments occur on the Fort William Indian Reserve. Two systems of extensive but very shallow swamps occupy the Neebing River tributaries north of Baird. Throughout the area covered by the gritty silt till (map unit 3a) and the bedrock-drift complex (map unit 2) are marshy low-lying pockets where the water table is at or near the surface creating numerous tiny collecting basins for organic detritus. In addition to these are several cut-off meander scars along the Kaministikwia River which have developed into swamps.

The three major bogs were included by the Geological Survey of Canada in a 1921 survey of peat deposits in Ontario (Anrep 1922a) and at that time constituted approximately 3 percent of the area covered by bogs in the province (Anrep 1922b). The Arthur Bog in Paipoonge Township and the William Bog in Neebing and McIntyre Townships each had maximum depths of 2.7 m (9 feet) and average depths of 2.1 m (7 feet) or less. The Twin Cities Bog, most easterly of the three, had a maximum depth of 1.8 m (6 feet) and an average depth of less than 1.2 m (4 feet). The results of the investigation indicated that just over 2 million tons of the lowest possible grade of peat usable for fuel was available in the combined bogs.

SOILS

The reconnaissance soil survey (Hills and Morwick 1944) of the Thunder Bay area produced a generalized classification of soils in five land types;

(a) clay lands
(b) loamy lands
(c) gravelly and sandy plains
(d) thin soils over bedrock
(e) deep peat bogs.

These roughly correspond to;

(a) laminated lacustrine clays or glacial clay tills
(b) deltaic sands and silts and glacial gritty silt till
(c) lacustrine stratified gravel and sand
(d) weathered bedrock
(e) bogs and swamps.

A sketch map (1:253,440; 1 inch to 4 miles) of the area accompanies the report by Hill and Morwick. Detailed study of the area has since been completed (Hoffman 1971) and outline maps, at scale 1:50,000, are available from the Ontario Soil Survey. A report to accompany these maps is to be published in the near future.

HISTORICAL GEOLOGY

The sequence of glacial events occurring in the vicinity of Thunder Bay prior to Late Wisconsinan time is not known since no evidence has been found which can be definitely assigned to an earlier age. Striae trending from 195°E to 205°E observed along Highway 17A and adjacent roads near Intola are the oldest glacial features in the area for which direction of movement has been inferred but there is no way of knowing when they were formed. Zoltai (1965a, p.266) noted that similarly oriented striae were found in northern Minnesota by Sharp (1953) and assigned them to an early area-wide glaciation of undetermined age.

The first clearly discernable event to affect the region is represented by the formation of the Brûlé Creek Moraine, a remnant of which occurs west of the Marks Moraine, west of the map-area. Correlation of the Brûlé Moraine with the Eagle-Finlayson Moraine was suggested by Zoltai (1963, p.113) as part of a general retreat by the Patrician ice mass prior to the Valders maximum (Zoltai 1965a, p.266). At this time glaciolacustrine sediments were deposited in a body of water dammed to the north by the Brûlé Creek Moraine. This body, Glacial Lake O'Connor, defined by Zoltai (1963, p.111), occupied much of the land southwest of the map-area. Its eastern boundary is unknown. Drainage of this lake occurred during withdrawal of the Patrician ice mass to the north of the Thunder Bay area. West of Thunder Bay the Patrician ice retreated to the Hartmann Moraine and remained more or less stable, at least until the initiation of Lake Agassiz II (Elson 1967, p.92; Zoltai 1961, p.80). A maximum date of 11,740 years B.P. (Y-1327; Wright and Ruhe 1965, p.39; no error factor given) has been reported for this event.

Readvances occurred in the ice masses to the north and east of Thunder Bay in the form of two lobes. The Dog Lake lobe of the Hudson Bay mass advancing from the northeast, halted at the Dog Lake Moraine. It formed the Kaiashk Interlobate Moraine with the Patrician ice mass halted at the Hartmann Moraine (Zoltai 1965a, p.255). Ice of the Superior lobe advanced westerly across the map-area to halt at the Marks Moraine forming the MacKenzie Interlobate Moraine with the Dog Lake ice lobe (Zoltai 1965, p.255). Gritty silt till (map unit 3a) deposited during this advance is found throughout most of the map-area and forms most of the Quaternary deposits included in the bedrock-drift complex (map unit 2). The clay till (map unit 3b) west of Moose Hill, which represents the overridden sediments of Glacial Lake O'Connor was also deposited at this time. The drumlin field northeast of Murillo was formed of gritty silt till and several sets of striae with orientations ranging from 270°E to 310°E were cut in the bedrock knobs west of Thunder Bay.

Lake Kaministikwia, first postulated by Taylor (1897), developed in the angle of the Dog Lake and Marks Moraines. It was a contemporary of the expanding Lake Duluth (Farrand 1960) which dates from at least 10,220 ± 500 years B.P. (M-359; Crane 1956, p.669). Withdrawal of the Superior ice lobe opened the spillway and ice marginal channel which drained the lake through a breach in the Marks Moraine and down the ancient Kaministikwia River meltwater channel. Melting of the Dog Lake lobe increased the volume of meltwater causing the channel to erode the lake sediments which supplied much of the fine-grained material presently found in the Kaministikwia delta.

Although retreat of the Superior lobe was fairly rapid it was attended by minor pulsations. The area of recessional moraine (map unit 3c) south of Intola contains such stagnant ice features as crevasse fillings and other ice-contact ridges as well as one esker complex, all indicating a mass of ablating stationary ice. This was subsequently overridden by ice moving toward 320°E but this ice halted within a short distance to form the Intola Moraine which is draped over the pre-existing drumlins.

Other evidence of local readvance is the northward overriding of proglacial lacustrine deposits, developed during ponding at the ice margin, and of sediments in the ancient Kaministikwia River meltwater channel. Deformation structures and the overlying layer of silt till (map unit 3d) are the result of this overriding.

A series of glacial lakes formed in the Superior basin during and following the retreat of the Superior ice lobe. Southwest of the map-area the Epi–Duluth lakes (Farrand 1960, p.115) were formed in the most westerly part of Lake Superior. Discharge was into the Mississippi river system (Farrand 1960; 1969). As the ice margin retreated northward the Epi–Duluth lakes coalesced to form Glacial Lake Duluth, a rapidly expanding water body which occupied the western extremity of the basin possibly as late as 10,200 to 9,600 years ago (Wright *et al.* 1973). With the opening of an outlet through the Huron Mountains along the Upper Peninsula of Michigan more than 10,100 years ago (Saarnisto 1974) the water levels dropped approximately 150 m (500 feet) through a series of Post–Duluth levels (Farrand 1969), becoming stabilized at the Lake Beaver Bay level. The delta in the Kaministikwia meltwater channel began building just below Kakabeka Falls into this lake which drained through the AuTrain–Whitefish outlet into the last high-level post-Algonquin lake in the Michigan basin (Saarnisto 1975).

Rapid retreat of the Superior lobe cleared the basin of glacier ice approximately 9,500 years ago (Saarnisto 1974) allowing the formation of Lake Minong which occupied the entire area of the basin. The highest strand in the map-area is represented by the bluff at 259 m (850 feet) a.s.l. near Wild Goose which is probably the earliest Lake Minong shore. The cutting was initiated during the Lake Beaver Bay stage and Saarnisto (1974, p.323) assigns it to that level.

The highest post-Minong feature coincides topographically with the lowest Minong strandline to form a strong bluff on the Kaministikwia delta. The organic deposit near Rosslyn Village dates this event at 9380 ± 150 years B.P. (GSC-287; Dyck *et al.* 1966). Numerous strandlines of post-Minong age developed at progressively lower elevations until the strong Dorion beach was formed.

About 8500 years ago, the retreat of the Laurentide ice sheet opened a low channel between Lake Nipissing and the Mattawa River allowing the lakes in the upper Great Lakes basins to drop to extremely low levels (Farrand 1960, p.127). In the Superior basin the Houghton low stage existed during this phase but its shores were subsequently submerged by water rising to the Nipissing Great Lakes level in response to isostatic rebound of the glaciated area. Successive lowering of the lake to the Sault level proceeding from the Nipissing Great Lakes maximum about 5500 years ago (Saarnisto 1975, p.372) with the eroding of the Port Huron outlet. Isostatic rise of the bedrock sill in the St. Mary's River initiated the Algoma stage (Taylor 1894) about 3200 years ago which was followed by the Sault stage about 2200 years ago (Saarnisto 1975, p.318) and, by continued differential uplift, has allowed Lake Superior to rise to its present level.

During this development the Kaministikwia delta was extended into the Superior basin spreading fine-grained fluviolacustrine sediments over the till deposited by the Superior ice lobe. Bogs and swamps developed on the poorly drained deltaic flats and several distributary channels were cut in a classic fan shape between Squaw Bay and the present mouth of the river.

Reconnaissance and compilation work by Zoltai (1963; 1965) provided comprehensive maps of the major geomorphic and physiographic units near the Lakehead and, in combination with radiocarbon data from other areas (Zoltai 1965a, p.266-269), postulated a sequence of late glacial events which could be correlated with Elson's work in the Lake Agassiz basin (1957; 1967) and subsequently extended eastward to the vicinity of Hearst, Ontario (Boissonneau 1966). Within the Superior basin itself only the waning phase of the Late Wisconsinan glaciation was recorded in sediment cores recovered by Farrand (1969) from below water depths in excess of 150 m (500 feet). These indicated oscillations of the ice margin but contained no evidence of deposits older than Late Wisconsinan age (Farrand 1969, p.196). Saarnisto (1974) concluded that synchronous ice-marginal zones existed from south of North Bay to northwest of Kakabeka Falls representing continuous though spasmodic retreat of the entire Laurentide ice sheet without significant readvances between the Valders (ca. 11,800 years B.P.) and the Cochrane (ca. 8,000 years B.P.) events.

ECONOMIC GEOLOGY

Quaternary deposits form an important source of construction materials for the expanding urban centre. The need for increased information regarding the distribution and quality of these materials has been known for some time (Hewitt 1962). Such knowledge forms part of the background data from which cogent mineral resource planning is developed. This, in conjunction with a planned approach to site development (Bauer 1970) and resource utilization (Hewitt 1968), leads to an efficient use of non-renewable resources and prevents mineral production areas from being rendered permanently unsuitable for any other future purposes.

Sand and Gravel

Reported values of sand and gravel products for the vicinity of Thunder Bay in 1971 were in excess of $2,300,000. Numerous non-reporting pits were operated on a part-time basis. The majority of this material was used within the City of Thunder Bay but significant quantities were utilized by the surrounding townships and the provincial Ministry of Transportation and Communications for road and highway construction or maintenance.

Figure 10 (Chart A, back pocket) shows the distribution of granular resource deposits near the City of Thunder Bay. Important resource areas lying outside the area covered by Map 2372 (back pocket), especially in Ware, Gorham and MacGregor Townships, have been indicated along with the locations of several extractive sites. Information concerning pebble lithology and mineralogy of selected samples is given in the appendices at the end of this report.

Within the area illustrated in Figure 10 (Chart A, back pocket) the major zone of granular resource extraction lies in or near the outwash delta south of Hazelwood Lake (Photo 12). A second important producing zone south of Toimela is in the ice-contact deposits of the Marks Moraine (Photo 13). Outwash and ice-contact deposits on both sides of the MacKenzie Moraine between Stepstone and Jumbo Gardens have been developed, but much material remains to the east along this interlobate feature.

West of Thunder Bay the Kaministikwia River valley has been extensively developed for granular resources upriver from Twin City to Kakabeka Falls. Most of the material in this region is outwash gravel buried beneath varying depths of deltaic or outwash sand. A few pits have been opened in the Marks Moraine where it was breached by the Kaministikwia spillway but large quantities of ice-contact material remains. Outwash deposits north of the moraine should also be considered as potentially significant producers of gravel and sand.

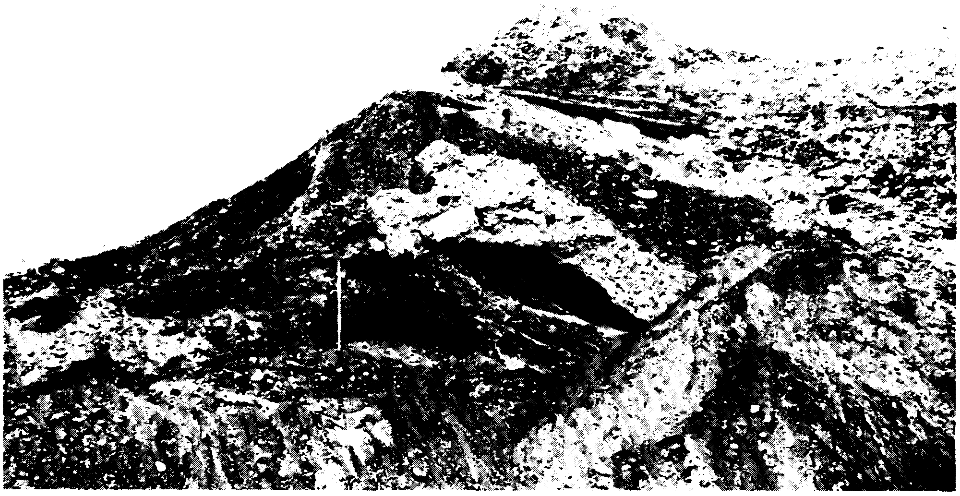
The outwash delta near Hazelwood Lake was deposited into Glacial Lake Kaministikwia during the time when the ice margins stood at the Dog Lake Moraine and the Marks Moraine. It consists of 9 m (30 feet) to over 18 m (60 feet) of sandy gravel, thinning westward and overlain by up to 2 m (6 feet) of deltaic sand. Weathered granite rock in the pebble fraction breaks down readily in the crushing operation and thus does not present a serious difficulty to processing.

The ice-contact deposits of the Marks Moraine south of Toimela present a problem to the developer in terms of the irregularity of the deposits. Thick sheets of sand related to Lake Kaministikwia commonly mask concentrations of coarser granular material. The stoney sand till forms the oldest Quaternary deposit exposed in this vicinity and is itself a source of gravel having a low clay content and up to 50 percent clast content. Oversize material is the major problem encountered when developing the till resources.

Outwash deposits from Stepstone to Jumbo Gardens range up to 8 m (26 feet) in thickness but commonly are closely underlain by gritty silt till south of the MacKenzie Moraine. Siltstone cobbles and boulders encountered in the deposit, as well as the amount of slatey material in the pebble fraction, are of concern to developers and must be taken into consideration during processing. North of the moraine the deposits are sandier containing a smaller pebble fraction and slightly more oversized material. The moraine itself is a source of granular material but development is rendered difficult by the irregularity of the material. Isolated kames contain valuable concentrations of usable gravel but may be interspersed with non-economic material. Stockpiling of sand for fill or future washing operations increases the cost of extraction, but appears inevitable when the nature of the deposit is considered. Even with this limitation the interlobate

ODM9523

Photo 12–Airphoto of the outwash delta (outlined) between the Dog Lake Moraine and the Marks Moraine south of Hazelwood Lake in Gorham Township.



ODM9524

Photo 13–Ice-contact deposit of the Marks Moraine showing a rectangular block of stratified sand incorporated in a boudinage of gritty silt till surrounded by gravel and sand. V.D. Rigato, Limited, pit (No. 75, Figure 10, Chart A) south of Toimela, Ontario.

deposits should be carefully investigated as a possible major source of construction material.

The Kaministikwia delta upstream from the vicinity of Twin City contains deep deposits of outwash gravel. In excess of 10 m (33 feet) of gravel is reported from drill holes along the river margins in the deltaic upland below the 3.6 m (12 feet) of gravel already exposed. Sand overburden is up to 3.6 m (12 feet) thick. The gravel and sandy gravel is generally well sorted, but siltstone and slate content must be taken into consideration.

A breach in the Marks Moraine cut by the Kaministikwia spillway exposes the interlayered till and ice-contact material to a depth in excess of 40 m (130 feet). As with the previously mentioned ice-contact deposits the material is highly variable and, in this location, capped by more than 5 m (16 feet) of till. The Marks Moraine west of Mokomon has a lower potential as a large scale producer of granular resources but should be considered for local supply purposes.

At Kaministikwia, outwash and ice-contact materials are presently being developed. The outwash gravelly sand, in places more than 10 m (33 feet) thick and commonly capped by 3 m (10 feet) of ice-contact sand, is a major source of washed sand products and graded stone.

Beach deposits do not constitute a major source of gravel in the Thunder Bay area. Most of the paleostrandlines are bluffs cut into bedrock or pre-existing sandy materials. The shaley material reworked by the post-Minong lakes south of Highway 130 is nearly exhausted and the remaining material is of uncertain quality.

Clay

The only clay extraction within the map-area is being carried on by the Superior Brick and Tile Company, Limited south of Rosslyn. A description of the geology of the pit as given by Guillet (1967, p.189-192) appears in Appendix B of this report.

Property Descriptions

Numerous properties, principally gravel pits, were visited during the field season. Some of the active operations are described below. Most operations are run on a part-time basis, the pits becoming active upon demand. Brief data on these pits is given in Appendix C of this report.

Four companies maintain full-time gravel operations in the vicinity of Thunder Bay. Kam Aggregates Limited main plant and office is located in the Village of Kaministikwia approximately 31 km (19 miles) northwest of Thunder Bay. Alf Cooper & Company, Limited, Hacquoil Construction Company, Limited, and V.D.Rigato, Limited have offices in the City of Thunder Bay.

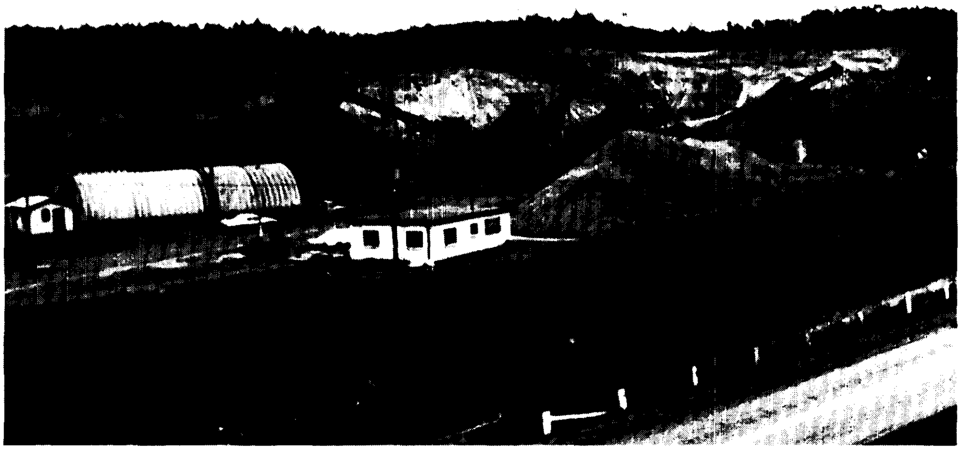
KAM AGGREGATES LIMITED

Terraces of outwash gravelly sand of the Kaministikwia River meltwater channel form the deposit in which the main operation of Kam Aggregates Limited is located. Extraction is from two pits in Ware Township, one located in concession II, lot 14 (18)[1] and the other larger pit, in concesion A and B, lots 13 and 14 of the Dawson Road Lots (Ware) (22) where a processing plant has been built (Photo 14).

The main pit (22) is in excess of 15 m (49 feet) deep with reserves to the east and south. Gravel forms up to 40 percent of the deposit with 40 percent of it exceeding 2.5 cm (1 inch) and 10 percent exceeding 10 cm (4 inches) in size. Boulders up to 0.8 m (2.6 feet) in diameter were observed in a lag deposit along the northwest wall of the pit. Thin-bedded medium to fine sands are interbedded with medium-bedded pebbly to slightly cobbly sand below the boulder lag. The pebbles are subrounded to subangular and commonly occur in southwest dipping, upward fining beds. Above the boulder lag is approximately 5 m (16 feet) of unsorted gravelly sand in which much of the oversized material is concentrated. Another face, 9 m (30 feet) high, in the same pit exposes 3 m (10 feet) of medium-bedded gravelly sand, similar in texture to that describe above, which contains numerous slump features probably caused by the melting of buried ice blocks. The remainder of the face is talus covered.

A large sand classifier is located on this property. It operates in conjunction with a permanently implaced cone crusher and a multiple deck screener.

[1]Numbers in parenthesis refer to property locations on Figure 10.



ODM9525
Photo 14–Outwash gravel and sand exposed in Kam Aggregates, Limited main pit (No. 22, Figure 10, Chart A) near Kaministikwia, Ontario.

Intermittent operations at a pit (54) located in concession A, lot 19 of Paipoonge Township produce a better sorted sand from the upper zones of the Kaministikwia River meltwater channel terraces. The 3 m (10 feet) high east face has an upper 0.8 m (2.6 feet) thick unit of thinly bedded, poorly sorted coarse sand containing less than 10 percent fine pebbles. This overlies more than 2 m (7 feet) of gravelly sand exposed in cut and fill structures comprised of 10 cm (4 inches) thick beds of medium sand with 30 percent fine pebbles and 5 cm to 20 cm (2 inches to 8 inches) beds of silty fine sand. Total gravel content is approximately 20 percent with 5 percent of the gravel exceeding 2.5 cm (1 inch) in diameter.

ALF COOPER AND COMPANY, LIMITED

Several pits are operated by Alf Cooper and Company, Limited in the outwash material west of Twin City. Partially exposed by the meandering of the Kaministikwia River, much of the deposit remains buried by silty fine sand of the post-Minong lake plain.

The main pit (46) is located in concession B, lot 6 of Paipoonge Township. Material to be processed is hauled to a plant situated in a nearly depleted pit (48) in lot 7 directly across the local access road.

Six metres (20 feet) of medium-bedded outwash sand and gravel is exposed

ODM9525

Photo 15–Outwash gravel and sand of the Kaministikwia River meltwater channel exposed in the A. Cooper, Limited, pit (No. 46, Figure 10, Chart A) near Twin City, Ontario.

in the 9 m (30 feet) high face on the south side of this pit (Photo 15). Pebbles and cobbles up to 15 cm (6 inches) comprise nearly 45 percent of the exposed deposit with 40 percent of the gravel exceeding 2.5 cm (1 inch) and 20 percent exceeding 10 cm (4 inches). Pebbles are subrounded to rounded and commonly sorted into eastward dipping beds up to 30 cm (1 foot) thick.

The eastern face of the pit is 8 m (26 feet) high and has exposed a cross-section of the outwash channel deposits. Particles up to 15 cm (6 inches) in diameter were deposited in successive medium crossbeds of a southward migrating channel. Sixty-five percent of the material is gravel. Of this 35 percent exceeds 2.5 cm (1 inch) and 5 percent exceeds 10 cm (4 inches). The pebbles are rounded to subrounded and commonly well sorted in upward fining sequences 15 cm to 30 cm (6 inches to 12 inches) thick with the coarse pebbles forming open, contact framework beds approximately 10 cm (4 inches) thick.

Gravel reserves in this deposit appear extensive. Boreholes indicate at least another 10 m (33 feet) of similar material underlying the exposed part of the deposit, but the sand overburden thickens markedly to the north while the gravel thins to the east.

A second pit (45) operated by Cooper is in concession B, lot 5 of Paipoonge Township. Exposures on the south and west faces are predictably similar to those in the previously described pit (46) since they occupy positions immediately downstream in the same outwash terrace. These faces are approximately 8 m (26 feet) high and contain 40 percent gravel of which 25 percent is larger than 2.5 cm (1 inch) and less than 5 percent is larger than 10 cm (4 inches). Cobbles do not exceed 15 cm (6 inches) in size.

The east face of the pit is operated in two lifts. The upper lift is 4 m (13 feet) high and represents a continuation of the outwash gravel and sand. Thirty percent of the material is stone of which 30 percent is over 2.5 cm (1 inch) and none exceeds 10 cm (4 inches). Rounded to subrounded coarse to fine pebbles occur in a thin-bedded moderately well sorted matrix in which very coarse sand predominates. Approximately 1 m (3 feet) of sand overburden must be removed to reach the gravel. The lower lift is 4.5 m (15 feet) high and consists almost entirely of thick sand beds dipping slightly east of south and containing several northwest dipping sets of thin crossbeds. A cross-cutting erosional break at the south end of the lift marks the sharp transition to coarser material brought down the meltwater channel during the retreat of the Superior ice lobe.

A gravel pit (111) in McIntyre Township, operated by Cooper on lot 16 west of Onion Lake Road, is in a deposit of coarse outwash gravel and sand related to the retreating Superior ice lobe. Eleven metres (35 feet) of material is exposed at this site but the total depth of the deposit is unknown. Local relief above the nearest bedrock outcrop is 23 m (75 feet) indicating large reserves in the undeveloped parts of the deposit.

In the upper 4 m (13 feet) of the southwest face beds up to 50 cm (20 inches) thick of medium sand and fine pebbles containing occasional cobbles to 25 cm (10 inches) are interbedded with 20 cm to 30 cm (8 inches to 13 inches) thick layers of subrounded to rounded coarse to fine pebbles, also containing occasional large cobbles. This overlies at least 1.5 m (5 feet) of medium to coarse sand containing 15 percent fine to medium pebbles deposited at inclined cross-beds in 20 cm (8 inches) thick beds dipping northeast. The remaining 3.5 m (10.5 feet) of the face is talus covered. Total gravel content at this exposure is approximately 40 percent with 40 percent of the gravel exceeding 2.5 cm (1 inch) and 5 percent exceeding 10 cm (4 inches). One very large greenstone boulder, 2.4 m (7.8 feet) in its longest dimension, is lodged near the top of the face but other boulders do not exceed 25 cm (10 inches).

A face cut on the northwest side of this pit is worked in two lifts. The upper lift is 6 m (20 feet) high and contains no more than 10 percent gravel of which 25 percent is larger than 10 cm (4 inches). The remainder of the material is poorly sorted sand deposited in north dipping beds up to 10 cm (4 inches) thick. The lower lift is nearly 8 m (26 feet) high containing 50 percent gravel of which 50 percent exceeds 2.5 cm (1 inch) and 30 percent exceeds 10 cm (4 inches). The maximum boulder size in either lift is 45 cm (18 inches).

HACQUOIL CONSTRUCTION COMPANY, LIMITED

A large pit (7) operated by Hacquoil Construction Company, Limited is located on concession VI, lot C of Conmee Township in the ice contact deposits of the Marks Moraine (Photo 16).

Nearly 40 m (130 feet) of material is exposed in the north face of the pit which has been excavated in the moraine and outwash deposits of the Kaministikwia River meltwater channel. Most of the lower two-thirds of the face has slumped but only the lowest 6 m (20 feet) is so talus covered as to be completely

ODM9526
Photo 16–Outwash gravel and sand sequence 18.5 m (61 ft.) below the top of the Marks Moraine. Hacquoil Construction Limited pit (No. 7, Figure 10, Chart A) near Mokomon, Ontario.

unobservable. At least 3 m (10 feet) of silty clay till overlying 4 m (13 feet) of contorted outwash sand has been stripped at the top of the face to reach the underlying ice-contact and outwash gravel deposits. The 4.5 m (15 feet) of ice-contact material consists of irregularly bedded gravelly sand intercalated with fine to medium sand deposited as sub-parallel laminations in beds up to 1 m (3 feet) thick. The presence of buried ice is indicated by collapse structures observed in this unit. Boudinage features trending northwest indicate the movement direction of the overriding ice sheet. Beneath this unit is up to 6.5 m (21 feet) of outwash deposited in thin, north dipping beds. Gravel content of this unit is 60 percent with 20 percent exceeding 2.5 cm (1 inch) and 5 percent exceeding 10 cm (4 inches). No cobble larger than 25 cm (10 inches) was seen. Another 2 m (6.5 feet) of medium sand underlies the outwash unit.

Gritty silt till caps the moraine in another section of this face. Only 1.5 m (5 feet) was observed but stripping had removed an unknown amount. The till overlies less than 1 m (3 feet) of highly contorted lacustrine silty fine sand which lies disconformably on at least 3.6 m (12 feet) of coarse outwash material. The upper 1.5 m (5 feet) has been winnowed and consists of 80 percent gravel with 10 percent exceeding 2.5 cm (1 inch) and 30 percent exceeding 10 cm (4 inches). Most cobbles are rounded and none is larger than 25 cm (10 inches). The remaining 8 m (26 feet) of this section is talus covered.

The highest section on this face is capped by 6 m (20 feet) of red silty clay overlying 3 m (10 feet) of contorted glaciolacustrine clay which lies unconformably on 3 m (10 feet) of gritty silt till. Five metres (16.5 feet) of north dipping, thin bedded outwash gravelly sand underlie the gritty silt till and are underlain by at least 2 m (6 feet) of clay till (map unit 3b). Below this level the pit face consists of deposits related to the Kaministikwia River meltwater channel. It is mostly slump covered but the sequence consists of at least 5 m (49 feet) of channel sand deposited in 15 cm to 35 cm (6 inches to 14 inches) thick layers, characterized by foreset cross-bedding and cut-and-fill structures, interbedded with three layers of gravelly sand each approximately 1.5 m (5 feet) thick and containing up to 35 percent gravel with 30 percent larger than 2.5 cm (1 inch) and 10 percent larger than 10 cm (4 inches). Six metres (20 feet) at the base is talus covered.

Two other pits operated by Hacquoil are in the outwash gravel and sand deposits of the Kaministikwia River meltwater channel.

The larger pit (32) is located at the south end of concession II, lot 34 (north of the river) of Paipoonge Township. It is 5.5 m (18 feet) deep consisting of 1.8 m (6 feet) of medium-bedded fine sand overlying 0.6 m (2 feet) of 15 percent gravelly medium sand deposited in cut-and-fill structures which overlies another 1.8 m (6 feet) of medium-bedded, fine to medium sand and 1.2 m (4 feet) of coarse sand containing approximately 10 percent medium pebbles. All the units contain cross-beds foreset to the southeast. Total gravel content is less than 5 percent with the largest clast not exceeding 10 cm (4 inches).

The smaller pit (33) is at the north end of the same lot. It is 3.6 m (12 feet) deep and consists entirely of east-dipping, medium-bedded outwash gravelly sand. Forty percent of the unit is gravel with 40 percent larger than 2.5 cm (1 inch) and 10 percent larger than 10 cm (4 inches).

Reserves in this area appear large but excessive quantities of sand are found throughout most of the deposits.

V.D. RIGATO, LIMITED

A large gravel pit (105) on lot 19 of McIntyre Township operated by V.D. Rigato, Limited is located in a shallow deposit of outwash gravel and sand deposited directly over the Lower Gunflint Formation on the east side of the property and over gritty silt till on the west side of the property.

The northeast face of the pit is 4.5 m (15 feet) high with 0.6 m (2 feet) of sand overburden covering at least 2.2 m (7 feet) of outwash fine pebbles and coarse sand. Forty percent of the material is gravel of which 50 percent exceeds 2.5 cm (1 inch) and 10 percent exceeds 10 cm (4 inches). Dipping approximately southwest the material was deposited in beds up to 30 cm (12 inches) thick but most commonly 10 to 15 cm (4 to 6 inches) thick. Although the lower 1.7 m (5.5 feet) of the face is completely slumped it is assumed to be coarser outwash based on the type of material spread about on the pit floor.

On the west side of the property the pit cuts through much sandier outwash. A northwestern face exposes 3.7 m (12 feet) of medium to coarse sand containing 20 percent pebbles and occasional cobbles. Fifteen percent of the gravel is larger than 2.5 cm (1 inch) and less than 1 percent is larger than 10 cm (4 inches) with none exceeding 15 cm (6 inches). The beds are up to 20 cm (8 inches) thick and dip south-southwest.

Where the floor of the pit is not directly on bedrock, boulders up to 1.1 m (3.5 feet) were imbedded in an unsorted sand and gravel matrix. A single pocket of thin bedded red clay 82 cm (2.7 feet) thick was observed overlying the boulders. Collapse features around the clay pocket indicate its possible origin as a kettle pond. Similar clay pockets occur southwest of this site and none are extensive.

Reserves in this area are difficult to assess due to the shallowness of the deposits. Material to the east and north is generally coarser and less well sorted than that to the west or south.

Another pit (69) operated by Rigato in lot 48 of McIntyre Township was begun in the strand deposits of Lake Minong around the base of a bedrock hill. Upper Gunflint shale is now quarried at the base of the hill and diabase from the top. Up to 3 m (10 feet) of reworked outwash sand overlies the shale. A veneer of silt till (map unit 3d) is cut by the diabase intrusive rocks (map unit 1d).

APPENDIX A

DESCRIPTION OF MEASURED SECTIONS

Metres[1]	BT 71009[2] (Photo 3)
0.0-2.1	weathered dark grey (10 YR 4/1) clay till; very compact, calcareous, very slightly gritty, irregular blocky fracture
2.0-3.4	weak red (7.5 R 5/4) clay till; compact, calcareous, gritty, cobbly, sand stringers
3.4-4.6	light red brown (2.5 YR 6/4) clay and brown sand; interbedded, contorted by overriding ice sheet, grades into sandy silt and clay varves at base
	BT 71011
0.0-1.2	grey brown medium to fine sand, thin bedded, very gentle dip 222°
1.2-1.8	weathered light red brown (5 YR 6/3) gritty silt till; moderately compact, pebbly to cobbly
1.8-3.1	diabase; brecciated, quartz veins
	BT 71038
0.0-0.3	yellow brown medium to fine sand; weathered, no internal structures, contains numerous peat flecks
0.3-0.8	brown fine sand, silty, very thinly bedded
0.8-1.2	grey brown (10 YR 5/2) silt till; compact, slightly fissile, clayey
	BT 71039
0.0-0.3	grey brown medium to fine sand
0.3-0.9	brown (10 YR 5/3) silt till; moderately compact, fissile, slightly calcareous
0.9-2.8	brown (7.5 YR 4/2) gritty silt till; compact, cobbly, fissile
2.8-3.7	Gunflint shale
	BT 71052 (Kurchina Quarry)
0.0-0.3	weathered light red brown (5 YR 6/4) silt till; fissile structure
0.3-3.0	grey brown (10 YR 5/2) silt till; fissile, slightly calcareous, bouldery, compact, fabric 353°, thrust planes marked by sand stringers 008°
3.0-3.1	grey brown fine sand; distorted laminations
3.1-7.6	brown (7.5 YR 4/2) gritty silt till; fissile, very compact, slightly calcareous, slightly cobbly
7.6-9.1	diabase; striations 308°
	BT 71126 (Photo 8)
0.0-1.5	brown (7.5 YR 4/2) gritty silt till; moderately compact, pebbly and cobbly, very sandy and pebbly lowest 0.5 m, fissile fracture
1.5-3.1	brown sand and gravel; thin to medium interbedded fine sand and gravelly medium to coarse sand, foreset 321°, thrust faults 189°
	BT 71192
0.0-0.4	grey brown silt; no internal structures
0.4-2.7	medium to coarse sand; pebbly to cobbly, medium bedded
2.7-3.2	brown (7.5 YR 4/2) gritty silt till; compact, cobbly to bouldery, slightly calcareous, fissile

[1]Thickness measured in meters from top to bottom for sections.
[2]Located on Map 2372 (back pocket).

BT 71237

0.0-0.3	brown (7.5 YR 5/2) silt till; fissile, moderately compact, thrust planes marked by sand stringers 033°
0.3-0.7	grey and brown varved clay and silt; 38 couplets
0.7-2.2	medium bedded sandy gravel; foreset cross bedding 030°

BT 71270

0.0-0.6	brown fine sand, weathered, soil developed to 0.2 m, no other internal structures
0.6-0.8	fine to medium sand with 20 percent medium to large cobbles, weathered
0.8-1.7	sand; coarse at base grading upward to fine at top, medium bedded, braided cross-bedding
1.7-2.4	grey (10 YR 5/1) gritty silt till; compact, slightly pebbly to cobbly, fissile, implaced toward 003°
2.4-2.6	Gunflint conglomerate

BT 71292

0.0-0.9	brown medium to fine sand; weathered, medium bedded
0.9-1.4	brown (10 YR 5/3) gritty silt till; compact, pebbly to slightly cobbly, fissile, slightly calcareous
1.4-1.8	Gunflint conglomerate; striated 308°

BT 71306

0.0-2.1	sand and gravel; medium bedded, medium to coarse sand interbedded with medium bedded, medium sand containing 30 percent pebbles and small cobbles, dipping to 301°
2.1-2.6	Gunflint conglomerate

BT 71318

0.0-1.5	weak red clay and fine sand; interbedded laminated clay and thin bedded sand, ripple cross laminated, erosional contacts at top of sand units, clay units are varved with clayey silt, 40 cycles represented above base of unit, erosional contact at base
1.5-3.4	sand and gravel; thin bedded coarse to medium sand with 5 percent medium pebbles, dipping to 220°, erosional contact at base
3.4-4.4	fine sand; thinly to very thinly bedded, horizontal, erosional contact at base
4.4-4.9	very fine sand, ripple cross-laminated, thin bedded

BT 71338

0.0-0.4	grey brown sand and gravel; medium to coarse pebbles, subrounded, imbrecated 110°
0.4-1.4	brown medium to coarse sand; thin bedded
1.4-2.6	light red brown (5 YR 6/4) silt till; weathered, fissile, very friable, clayey, pebbly
2.6-4.7	brown (10 YR 5/3) silt till; fissile, blocky toward base, pebbly

BT 71372

0.0-0.9	light red brown (5 YR 6/3) gritty silt till; moderately compact, very pebbly and cobbly, highly fractured
0.9-1.9	metavolcanic bedrock, striations and chatter marks 308°

BT 71432 (Photo 6)

0.0-0.9	yellow brown (10 YR 5/6) gritty silt till; weathered, friable, fissile, moderately compact, slightly pebbly
0.9-1.0	brown sand and gravel; thinly bedded, silty fine sand, numerous small cobbles, contorted
1.0-2.3	brown (7.5 YR 4/2) gritty silt till; very compact, fissile, cobbly and bouldery, slightly calcareous, sand stringers and boudinages
2.3-2.9	gravel and sand; boulders and cobbles in medium pebble to fine sand matrix, medium bedded, overthrust 320°
2.9-3.8	sand and gravel; thin bedded medium sand to coarse pebbles

BT 71433 (Photo 2)

0.0-1.6	red brown (5 YR 5/3) gritty silt till; compact, pebbly to cobbly, fissile
1.6-3.9	Gunflint cherty shale

BT 71440

0.0-0.7	brown weathered fine sand; no internal structures
0.7-2.4	coarse sand and fine to medium pebbles; dips to 300° (steeper at base of unit) thin bedded, moderately well sorted
2.4-2.8	grey clayey silt; grades upward into fine sand at top of unit
2.8-3.3	sand and gravel; similar to upper unit
3.3-5.0	slump

BT 71447 (Photo 11)

0.0-0.7	brown fine sand; weathered, thinly bedded, horizontally laminated
0.7-1.0	brown fine sand, weathered, thinly bedded, ripple cross laminated
1.0-1.3	brown fine sand; weathered silty thinly bedded, ripple cross-laminated, interbedded with weak red clay, horizontally laminated, erosional contacts between interbeds
1.3	up to 2 cm of twigs, cone bracts, fir needles in reduced condition; dated at 9380 ± 150 years b.p. (GSC-287, Dyck *et al.* 1966)
1.3-2.3	weak red clay and grey silt; contorted by loading, possible varved sequence
2.3-4.7	brown fine sand; weathered, thinly bedded trough cross-laminated, interbedded with very thinly bedded weak red clay, varved, at least 150 depositional cycles

BT 71455

0.0-0.8	weathered brown fine sand with occasional pebble; gritty, ripple cross-laminated
0.8-1.8	brown (10 YR 5/3) sandy silt till; compact, fissile, sand stringers thrust 305°
1.8-2.6	brown sand; fine to medium, coarser at base, ripple cross-laminated, load cast, medium bedded

BT 71460 (Photo 7)

0.0-1.2	light brown fine sand, very silty, thinly bedded, weathered, slightly pebbly
1.2-5.7	sand and gravel; medium to thick bedded, medium to coarse sand with 40 percent medium pebbles to small cobbles, several thin beds of dark grey medium sand containing high concentrations of heavy mineral grains
5.7-7.1	sand and gravel; medium bedded medium sand to fine pebbles containing up to 40 percent medium to coarse pebbles, foreset to 120°

BT 71480

0.0-1.7	brown silt; very sandy, weathered, medium bedded
1.7-3.9	red brown gravel; angular pebbles and small cobbles of shale, medium bedded, interbedded with coarse sand and fine pebbles of shale, foreset to 035°

BT 71483

0.0-1.5	brown silt; clayey, weathered, medium to thin bedded, interbedded with light brown sand, thinly bedded, weathered
1.5-3.0	brown clay; silty, thinly laminated, no distinct cycle of deposition discernable

BT 71487

0.0-0.8	brown clay; silty, blocky, no internal structure
0.8-1.6	weathered red brown (5 YR 5/3) clay till; slightly gritty, minor sand stringers

BT 71493

0.0-1.2	brown clay; very silty, weathered, horizontally thin bedded, moderately dense
1.2-2.1	light brown clay; slightly silty, moderately dense, waterlogged, horizontally thin to medium bedded

BT 71494

0.0-1.2	brown fine sand; silty, contains 40 percent organic debris, wet
1.2-2.4	brown fine sand; very silty, ripple laminated, thin bedded
2.4-3.2	brown silt; clayey, thin bedded, indistinct cyclic deposit

BT 71503

0.0-2.0	gravel; flat and elongated small to medium cobbles in a matrix of granules to medium pebbles, medium bedded, imbricated to 005°
2.0-4.5	sand and gravel; coarse to medium sand containing 20 percent flat and elongated, angular medium cobbles, thick bedded, slight dip to 110°
4.5-9.2	slump

BT 71598

0.0-0.7	weathered brown fine sand; silty, no internal structure
0.7-1.6	brown fine sand, silty, thin to medium bedded ripple laminated
1.6-2.7	brown clay; thin bedded, interbedded with thin bedded brown silt, varved, 73 cycles

BT 71651

0.0-0.7	peat; decomposed organic debris in silt, wet
0.7-1.9	brown fine sand; silty, medium to thin bedded
1.9-2.5	brown clay; thin to medium bedded, interbedded with thin to medium bedded fine sandy silt

APPENDIX B

Description of Superior Brick and Tile Limited properties
(from Guillet 1967, p.189-193)

SUPERIOR BRICK AND TILE COMPANY LIMITED

The plant of Superior Brick and Tile Company Limited is located at Rosslyn, seven miles west of Fort William, on the north bank of the Kaministikwia River. The plant and clay pit are in lots 11 and 12, concession I, N.R., Paipoonge township, Thunder Bay district. A buff-burning clay is obtained at Dorion some 50 miles east of Fort William.

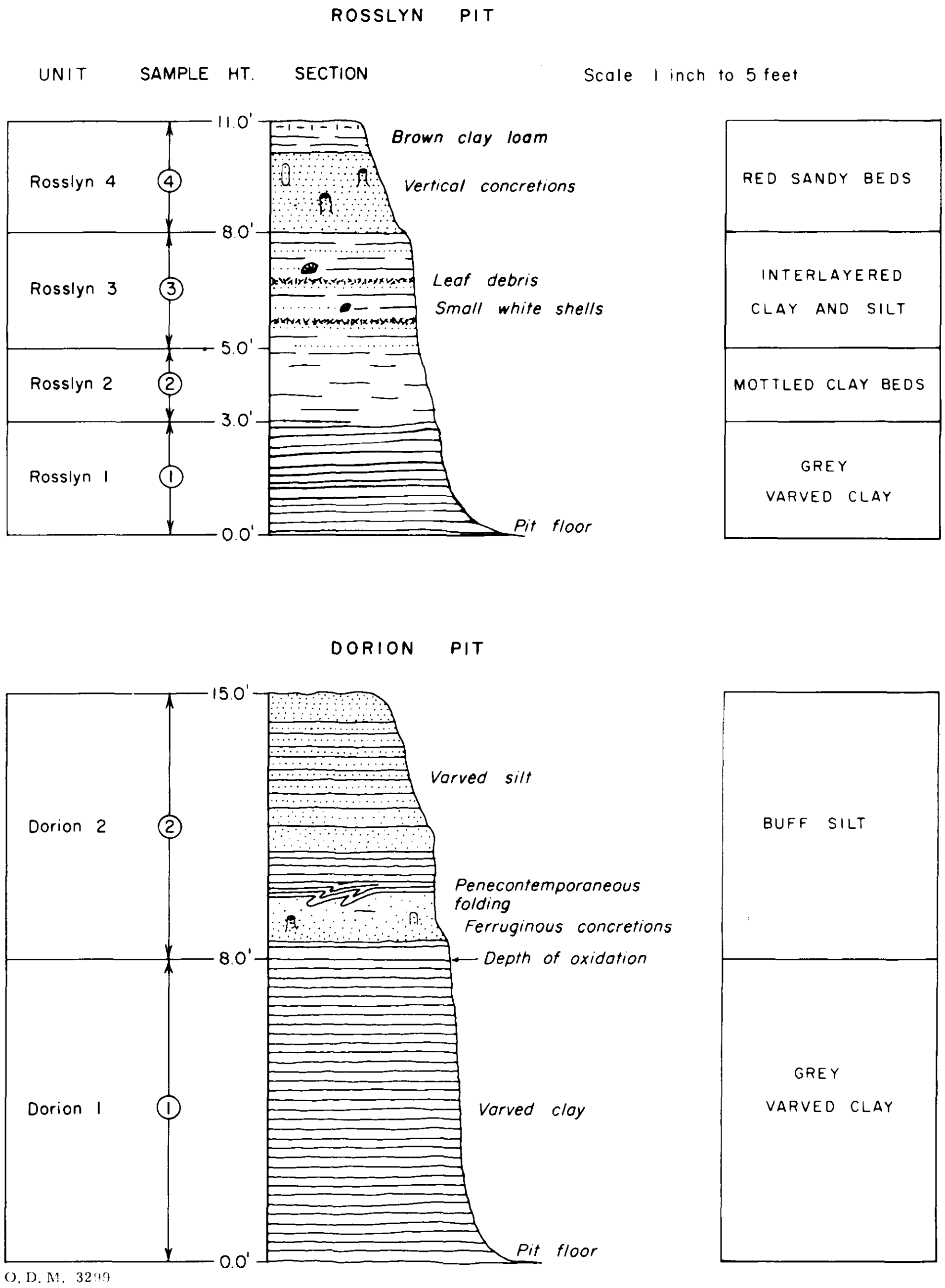
GEOLOGY

Great thicknesses of varved clay were reported by Keele (1924, pp.127-128) in pits worked by former brick plants near the mouth of the Kaministikwia River at Fort William. The clay was deposited in glacial Lake Algonquin. As exposed in the river banks, the clay rests on gravel that may indicate that the Kaministikwia River was also a pre-Algonquin spillway. As Lake Algonquin receded, thin deltaic deposits of stratified sand and silt were spread over the varved clays (Zoltai 1963, p.108).

At Rosslyn, six miles north of Fort William, the varved clay section is thin, and feed for the brick plant is largely stratified silt, sand, and clay deposited on the flood plain of the Kaministikwia River. Black leaf and pine needle debris, and scattered small white pelecypod shells, interlayered with the flood plain deposits, indicate a warmer climate than that which prevailed during deposition of the varved clays.

The clay pit of Superior Brick and Tile Company Limited is located on the east bank, fifty feet above the river. The pit is semicircular, 700 by 400 feet, with gently sloping faces to a maximum depth of eleven feet. A typical section is illustrated in figure 48 and described in the accompanying notes.

The company also obtains clay from Dorion, fifty miles east of Fort William. The pit is located at roadside, on the south bank of the Fish Hatchery creek, one mile west of the Dorion intersection on highway no. 17. The 15-foot section of varved Algonquin clay and silt is also illustrated and described in figure 48.



Superior Brick and Tile Co. Ltd., pit section.

SELECTED REFERENCES

Anrep, A.
1922a: Investigations of Peat Bogs in Ontario; Geol. Surv. Canada, Sum. Rept. 1921D, p.7-11. Accompanied by 3 maps, scale 1:28,800 (1 inch to 2,400 feet).
1922b: Synopsis of Information concerning the Peat Situation in Canada; Geol.Surv. Canada, Sum. Rept. 1921D, p.12-16.

Bauer, A.M.
1970: A Guide to Site Development and Rehabilitation of Pits and Quarries; Ontario Dept. Mines, IMR 33, 62p.

Boissonneau, A.N.
1966: Glacial History of Northeastern Ontario, I. The Cochrane–Hearst Area; Canadian J. Earth Sci., Vol.3, p.559-578.

Bostock, H.S.
1970: Physiographic Subdivisions of Canada; p.9-30 *in* Geology and Economic Minerals of Canada, Geol. Surv. Canada, Econ. Geol. Rept. No.1, 5th ed., 838p. Accompanied by Map 1254A, scale 1:5,000,000.

Burwasser, G.J.
1973: Quaternary Geology and Industrial Mineral Resources of the City of Thunder Bay; Ontario Div. Mines, Prelim. Map P.817, Geol. Ser., scale 1:50,000. Geology 1971.

Chamberlin, T.C.
1888: The Rock Scorings of the Great Ice Invasions; U.S. Geol. Surv., 7th Ann. Rept. 1885-86, p.147-248.

Crane, H.R.
1956: University of Michigan radiocarbon dates I; Science, Vol.124, p.664-672.

Dreimanis, A. and Vagners, V.J.
1971: Bimodal Distribution of Rock and Mineral Fragments in Basal Tills; p.237-250 *in* Till Symposium, R.P. Goldthwait, ed., Ohio State University Press, 402p.

DuBois, P.M.
1962 Paleomagnetism and Correlation of Keweenawan Rocks; Geol. Surv. Canada, Bull.71, 75p.

Dyck, W., Lowdon, I.A., Fyles, J.G. and Blake, W., Jr.
1966: Geological Survey of Canada Radiocarbon Dates V; Geol. Surv. Canada, Paper 66-48, 32p.

Elson, J.A.
1957: Lake Agassiz and the Mankato–Valders Problem; Science, Vol.126, p.999-1002.
1967: Geology of Glacial Lake Agassiz; p.37-96 *in* Life, Land & Water, W. Mayer-Oakes, ed., Univ. of Manitoba Press, Winnipeg, 416p.

Farrand, W.R.
1960: Former Shorelines in Western and Northern Lake Superior Basin; PhD. Thesis, publ. by Univ. Microfilm, Inc., Ann Arbor, Mich. 1965, 226p.
1962: Postglacial Uplift in North America; American J. Sci., Vol.260, p.181-199.
1969: The Quaternary History of Lake Superior; Proc. 12th Conf. Great Lakes Research, p.181-197.

Flint, R.F.
1971: Glacial and Quaternary Geology; John Wiley and Sons, Inc., Toronto, 892p.

Guillet, G.R.
1967: The Clay Products Industry of Ontario; Ontario Dept.Mines, IMR22, 206p. Accompanied by 2 maps, scale 1:1,013,760 (1 inch to 16 miles).

Hewitt, D.F.
1962: Urban Expansion and Mineral Industries in the Toronto–Hamilton area; Ontario Dept. Mines, IMR8, 11p.
1968: Some Aspects of Environmental Geology; Ontario Dept. Mines, IMR26, 19p.

Hills, G.S. and Morwick, F.F.
1944: Reconnaissance Soil Survey of Parts of Northwestern Ontario; Ontario Soil Surv., Rept. No.8, 56p. Accompanied by 3 maps, scale 1:253,440 (1 inch to 4 miles).

Hoffman, D.W.
1971: Unpublished Soil Map of the Lakehead Area; Ontario Soil Surv., University of Guelph, Guelph, Ontario, scale 1:50,000.

Hough, J.L.
1958: Geology of the Great Lakes; Univ. of Illinois Press, 373p.
1962: Geological Framework; p.3-27 *in* Great Lakes Basin, H.J. Pincus, ed., American Assoc. Adv. Science, Publ. No.71, 308p.
1963: The Prehistoric Great Lakes of North America; American Sci., Vol.51, p.84-109.

Keele, J.
1924: Preliminary Report on the Clay and Shale Deposits of Ontario; Geol. Surv. Canada, Mem.142, 176p.

Lawson, A.C.
1893: Sketch of the Coastal Topography of the North Side of Lake Superior with Special Reference to the Abandoned Strands of Lake Warren; Geologic and Natural History of Minnesota, 20th. Ann. Rept., 1891, p.181-289.

Leverett, F.
1929: Moraines and Shorelines of the Lake Superior Region; U.S. Geol. Surv. Prof. Paper 154-A, 72p.

Leverett, F. and Taylor, F.D.
1915: The Pleistocene of Indiana and Michigan and the History of the Great Lakes; U.S.Geol. Surv. Mem. 53, 529p.

McGlynn, J.C.
1970: Superior Province; p.54-70 *in* Geology and Economic Minerals of Canada, Geol. Surv. Canada, Econ. Geol. Rept. No. 1, 5th ed. p.838.

Moorhouse, W.W.
1960: Gunflint Iron Range in the Vicinity of Port Arthur; Ontario Dept. Mines, Vol.69, Part 7, 40p. Accompanied by 8 maps, scale 1:31,680 (1 inch to ½ mile).

Palmer, H.C.
1970: Paleomagnetism and Correlation of some Middle Keweenawan Rocks; Canadian J. Earth Sci., Vol.7, p.1410-1436.

Prest, V.K.
1968: Nomenclature of Moraines and Ice-flow Features as Applied to the Glacial Map of Canada; Geol. Surv. Canada, Paper 67-57, 32p.
1970: Quaternary Geology of Canada; p.675-764 *in* Geology and Economic Minerals of Canada, Geol.Surv. Canada, Econ. Geol. Rept. No. 1, 5th ed., 838p.

Pye,E.G. and Fenwick, K.G.
1965: Atikokan–Lakehead Sheet, Districts of Kenora, Rainy River, and Thunder Bay; Ontario Div. Mines, Geol. Comp. Ser., Map 2065, scale 1:253,440 (1 inch to 4 miles).

Saarnisto, M.
1974: The Deglaciation History of the Lake Superior Region and its Climatic Implications; Quat. Res., Vol.4, p.316-339.
1975: Stratigraphical Studies on the Shoreline Displacement of Lake Superior; Canadian J. Earth Sci., Vol.12, p.300-319.

Sharp, R.P.
1953: Glacial Features of Cook County, Minnesota; American J.Sci. Vol.251, p.855-883.

Stanley, G.M.
1938: The Submerged Valley through Mackinac Straits; J. Geol., Vol.46, p.966-974.
1941: Minong beaches and water plane in Lake Superior basin (Abstract); Geol. Soc. America, Bull., Vol.52, p.1935.

Tanton, T.L.
1922: An exploration north of Thunder Bay, Ontario; Geol. Surv. Canada, Sum. Rept. 1921D, p.1-6.
1929: Fort William and Port Arthur Sheet, Thunder Bay District, Ontario (Surface Deposits); Geol. Surv. Canada, Map 197A, scale 1:63,360 (1 inch to 1 mile).
1931: Fort William and Port Arthur, and Thunder Cape Map Areas, Thunder Bay, Ontario; Geol. Surv. Canada, Mem. 167, 222p. Accompanied by 3 maps, scale 1:63,360 (1 inch to 1 mile).

Taylor, F.B.
1894: The Limit of Post-Glacial Submergence in the Highlands east of Georgian Bay; American Geologist, Vol.14, p.272-285.
1895: The Nipissing Beach on the North Superior Shore; American Geologist, Vol.15, p.304-314.
1897: Notes on the Abandoned Beaches of the North Coast of Lake Superior, American Geologist, Vol.20, p.111-128.
1931: Submerged Peat Beds among the Apostle Islands; Science, Vol.74, p.265-267.

Wright, H.E. Jr.
1971: Retreat of the Laurentide Ice Sheet from 14,000 to 9,000 years ago; Quat. Res., Vol.2, p.316-330.

Wright, H.E. Jr., Matsch, C.L. and Cushing,E.J.
1973: Superior and Des Moines Lobes; p.153-185 *in* The Wisconsinan Stage, R.F. Black, R.P. Goldthwait and H.B. Willman, eds., Geol. Soc. America, Mem.136, 334p.

Wright, H.E. Jr. and Ruhe, R.V.
1965: Glaciation of Minnesota and Iowa; p.29-41 *in* The Quaternary of the United States, H.E. Wright, Jr. and D.G. Frey, eds., VII Cong. Intern. Assoc. Quart. Res., Princeton Univ. Press., 922p.

Zoltai, S.C.
1961: Glacial History of Part of Northwestern Ontario; Proc. Geol. Assoc. Canada, Vol.13, p.61-83.
1963: Glacial Features of the Canadian Lakehead Area; Canadian Geogr. Vol.7, p.101-115.
1965a: Glacial Features of the Quetico–Nipigon Area, Ontario; Canadian J. Earth Sci., Vol.2, p.247-269.
1965b: Thunder Bay Surficial Geology; Ontario Dept. Lands & Forests, Map S265, scale 1:-506,880 (1 inch to 8 miles).

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CHART B

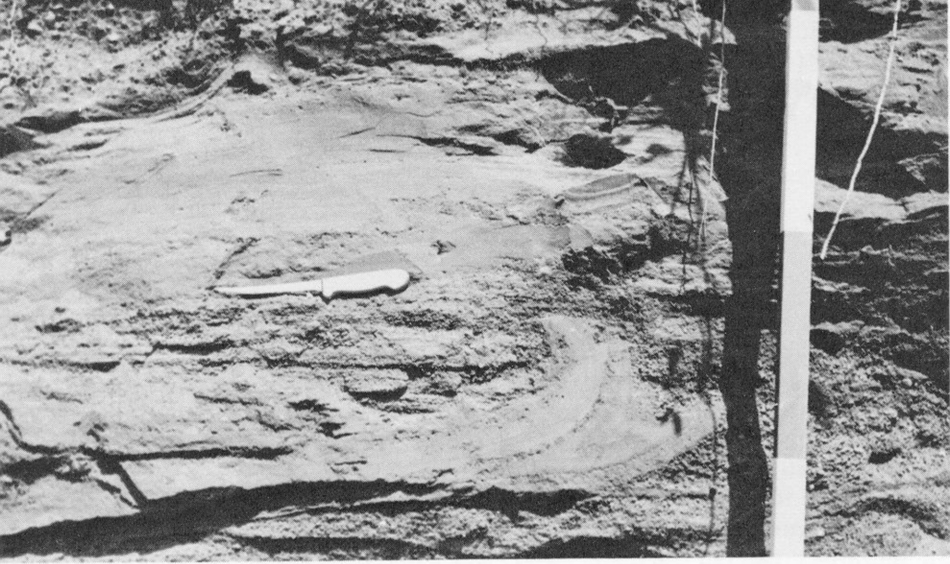
APPENDIX C

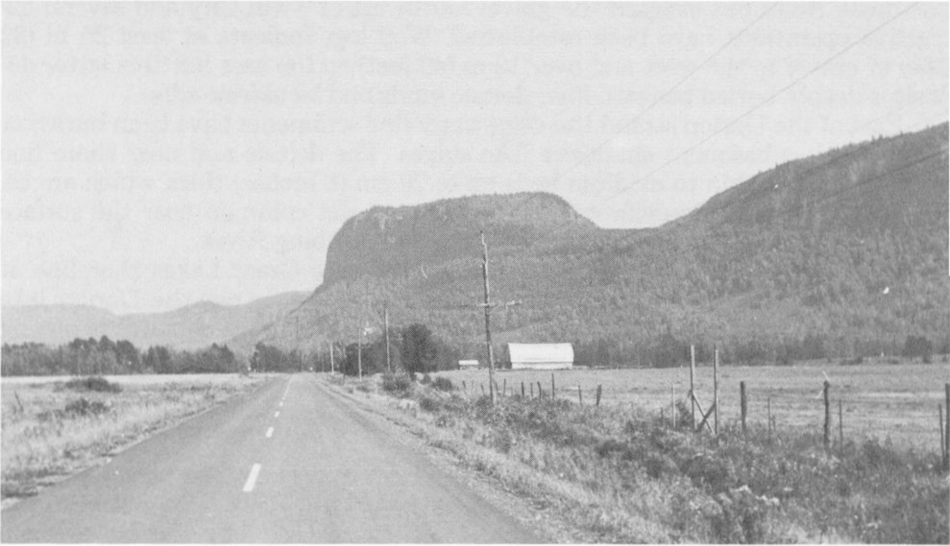
INFORMATION ON GRANULAR RESOURCE PROPERTIES

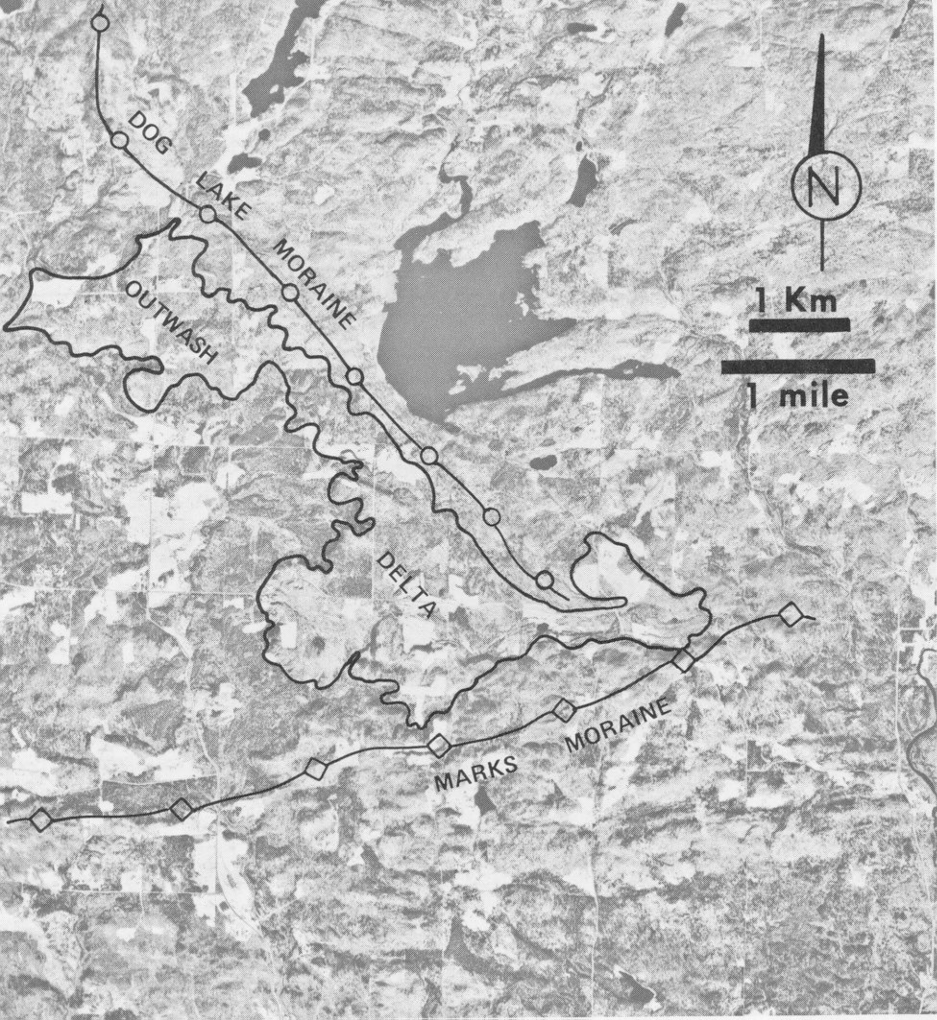
Property Number (See Fig. 10, back pocket)	OWNER OR OPERATOR	LOCATION										COMPOSITION						PEBBLE LITHOLOGY (?)										
		Map Number (1:50,000 or 1:25,000 - 52A/)	UTM Grid Coordinate	Township	Concession	Lot	Station Number	Thickness of Overburden in metres (feet)	Observed Thickness of Deposit in metres (feet)	Reported Thickness of Deposit in metres (feet)	Estimated Reserves	% Sand (estimated)	% Gravel (estimated)	% Stone > 2.5 cm (1 inch)	% Stone > 10 cm (4 inches)	Maximum clast size in metres (feet)	Origin of Deposit	Felsic igneous rocks	Mafic igneous rocks	Quartzite	Volcanic rocks	Monomineralic rocks	Argillite	Arkose	Siltstone	Chert and Flint	MTC Pit Number	LIMITATIONS
1	MTC and Strom	5W	961 655	O'Connor	VII	11	516	1.5(5)	7.6(25)	—	S	90	10	5	1	1(3.5)	outwash	34	50	3	2	1	2	6	1	1	K17-11	Not suitable for H.L. sand.
2	Twp. of Conmee and Maclean	5E	015 685	Conmee	III	7	527B	1(3.5)	4.5(15)	—	M	75	25	25	2	0.2(0.7)	outwash	27	30	8	0	2	15	15	2	1	K17-18	Sand control required. Some not suitable for H.L. sand or gravel.
3	Parcellawa	5E	017 538	Gillies	VI	4	—	—	—	12(40)	U	50	50	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	K17-24	
4	Hacquoil Construction Ltd.	12E	042 751	Conmee	VII	2	—	0.6(2)	—	6(20)	U	30	70	65	10	—	outwash	—	—	—	—	—	—	—	—	—	S20-34	Not suitable for H.L. sand. Clay throughout pit.
5	Leeyus	12E	043 750	Conmee	VII	2	551	2(7)	12(40)	23(75)	U	40	60	40	10	0.6(2)	ice-contact	30	25	7	0	2	18	16	0	2	S20-21	Clay coating on coarse aggregate.
6	Oikonen	5E	068 747	Conmee	VI	B	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	K17-11	Clay sections. Coarse aggregate is clay coated.
7	Hacquoil Construction Ltd.	5E	072 737	Conmee	VI	C	538B	7.6(25)	40(130)	21(70)	L	50	50	10	1	0.3(1)	ice-contact	39	34	6	0	2	17	2	0	0	K17-1	Clay coating throughout pit.
8	MTC and Anderson	5E	047 693	Conmee	III	1	529A	2.5(8)	12(40)	18(60)	M	75	25	40	5	0.3(1)	outwash	42	28	7	0	4	5	12	0	2	K17-2	Not suitable for H.L. sand. Clay coatings on coarse aggregate.
9	Longrin	5E	084 676	Conmee	II	E	518ϕ	—	2(7)	—	S	85	10	10	2	0.2(0.7)	outwash	38	50	2	1	4	4	1	0	0	K17-13	
10	Twp. of Conmee and Anderson	5E	075 670	Conmee	I	D	533	—	1.5(5)	—	S	90	10	10	2	0.2(0.7)	outwash	42	45	5	0	3	5	0	0	0	K17-14	
11	Pifer	5E	052 665	Conmee	I	1	532	0.3(1)	9(30)	9(30)	L	99	1	5	0	0.1(0.3)	lacustrine	—	—	—	—	—	—	—	—	—	K17-9	Blending required for H.L. sand.
12	MNR	5E	048 650	Oliver	I	20	513	2(7)	3.6(12)	—	S	80	20	25	5	0.3(1)	outwash	29	54	1	3	7	2	4	0	0	—	
13	Crane	5E	053 603	Paipoonge	E	11	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	K17-17	
14	Sipala	12E	075 865	Ware	III	21	560	1(3.5)	4.5(15)	—	U	70	30	50	20	0.3(1)	outwash	22	43	7	5	4	16	3	0	0	S20-36	
15	Inkman	12E	076 855	Ware	III	21	—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	S20-41	
16	Doyle	12E	087 806	Forbes	A	19	—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	S20-5	Coarse aggregate clay coated.
17	Montag	12E	085 800	Forbes	A	20	562	1.3(4)	9(30)	18(60)	M	65	35	40	5	0.6(2)	outwash	26	47	2	4	4	10	6	1	0	S20-6	Clay and silt pockets. Sand blending required for H.L.
18	Kam Aggregates Ltd.	12E	092 804	Ware	II	19	562A	1(3.5)	9(30)	15(50)	M	90	10	50	15	0.6(2)	outwash	—	—	—	—	—	—	—	—	—	—	
19	MacDonald	12E	089 790	D.R.L. (Ware)	B	20	561	—	3(10)	6(20)	M	60	40	60	20	0.3(1)	outwash	52	36	2	1	5	2	1	0	1	S20-11	Heavy clay coating on coarse aggregate.
20	CPR	12E	088 786	D.R.L. (Ware)	B	19	560A	—	3(10)	—	M	55	35	50	15	0.3(1)	outwash	—	—	—	—	—	—	—	—	—	—	
21	CPR	12E	089 783	D.R.L. (Ware)	A	19	560B	0.3(1)	4.5(15)	6(20)	M	40	60	60	10	0.6(2)	outwash	51	38	3	1	2	1	2	1	1	S20-42	Sand control required for GBC "A" and "B".
22	Kam Aggregates Ltd.	12E	108 787	D.R.L. (Ware)	A	14	547A	0.6(2)	15(50)	—	L	60	40	40	10	0.8(2.6)	outwash	22	50	6	2	4	15	1	0	0	S20-37	Commercial source. Some blending required.
23	MTC and Metnot	12E	151 767	D.R.L. (Ware)	A	1	545	1(3.5)	1.8(6)	—	U	65	35	10	1	0.1(0.3)	ice-contact	33	52	5	2	1	7	0	0	0	S20-9	
24	MTC	11W	179 757	Oliver	VIII	4	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	—	
25	MTC	5E	072 635	Paipoonge	D	20	510C	1.3(4)	3(10)	—	L	80	20	25	0	0.1(0.3)	outwash-delta	31	40	1	0	2	21	2	3	0	K17-22	
26	Currie	5E	077 635	Paipoonge	D	20	—	1(3.5)	—	—	M	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	K17-5	
27	Sinclair	5E	075 645	Oliver	I	16	512	—	3.6(12)	—	L	95	5	50	—	—	outwash	39	43	1	0	4	5	6	1	1	K17-23	
28	A. Cooper and Co.Ltd.	5E	077 638	Oliver	I	16	511	0.3(1)	4.5(15)	11(35)	L	90	10	15	—	—	outwash	39	46	2	2	1	3	6	1	0	K17-4	Silt sections in pit.
29	Hewitson Construction Co.Ltd.	5E	093 634	Paipoonge	IIINR	35	—	0.3(1)	—	7.6(25)	L	50	50	60	5	0	outwash	—	—	—	—	—	—	—	—	—	K17-16	Stone unsuitable for H.L. 4 & 5/8 cr.
30	Heereme	5E	075 619	Paipoonge	C	14	509A	1(3.5)	3(10)	—	U	95	5	25	0	0.7(0.3)	outwash	29	47	1	0	5	10	6	1	1	K17-40	
31	O'Brien	5E	089 611	Paipoonge	C	12	534B	0.6(2)	4.5(15)	12(40)	L	90	10	10	5	0.2(0.7)	outwash	50	25	3	1	4	6	10	1	0	K17-21	Stone unsuitable for coarse aggregate.
32	Hacquoil Construction Ltd.	5E	095 609	Paipoonge	IINR	34	505B	0.6(2)	6(20)	12(40)	S	60	40	25	5	0.1(0.3)	outwash-delta	48	34	2	1	0	4	9	1	1	K17-6	Stone unsuitable for H.L. 4.
33	Hacquoil Constuction Ltd.	5E	094 613	Paipoonge	IINR	34	507	1(3.5)	4(13)	—	M	60	40	40	10	0.2(0.7)	outwash	38	28	2	0	1	15	11	4	1	K17-3	
34	Kam Aggregates Ltd.	5E	102 604	Paipoonge	INR	32	—	0.3(1)	—	—	M	80	20	10	—	—	outwash	—	—	—	—	—	—	—	—	—	K17-32	Silt sections in pit.
35	Pechiwa	5E	110 608	Paipoonge	INR	31	—	0.3(1)	—	7.6(25)	S	75	25	10	—	—	outwash	—	—	—	—	—	—	—	—	—	K17-25	Silt sections in pit.
36	McFarlane	5E	129 613	Paipoonge	IINR	26	—	—	—	3(10)	U	50	50	—	—	—	outwash	48	13	0	2	0	6	17	3	11	K17-26	
37	Dobroski	5E	145 601	Paipoonge	INR	22	—	0.3(1)	—	12(40)	M	50	50	50	5	—	outwash	—	—	—	—	—	—	—	—	—	K17-36	Stone quality unsuitable for H.L.4. Clay sections in pit.
38	Smith	6d	169 596	Paipoonge	INR	15	453	0	7.6(25)	—	U	95	5	15	0	—	outwash-lacustrine	32	39	2	0	2	8	13	2	2	T15-29	
39	MTC and H. Dickson Ltd.	6e	185 613	Paipoonge	IIINR	12	337	0	1(35)	—	U	95	5	20	0	—	outwash-lacustrine	16	9	0	0	0	52	22	1	0	T15-30	
40	Pauluik	6d	182 604	Paipoonge	IINR	12	455C	0	7.6(25)	—	U	95	5	10	0	0.1(0.3)	outwash-lacustrine	31	41	5	0	3	9	10	1	0	T15-21	
41	Smid	6d	167 590	Paipoonge	INR	16	446	0.3(1)	3(10)	—	M	60	40	25	0	0.1(0.3)	outwash	38	29	1	0	1	6	22	2	1	T15-20	
42	Superior Brick and Tile Co.Ltd.	6d	183 593	Paipoonge	INR	12	447	1(3.5)	4.5(15)	6(20)	M	25	60	35	5	0.2(0.7)	outwash	28	44	3	1	0	8	13	1	2	T15-44	Excessive clay in western end of pit. Stone quality improves with depth.
43	A. Cooper and Co.Ltd.	6d	202 597	Paipoonge	INR	7	443A	0.6(2)	3(10)	6(20)	M	55	45	30	2	0.2(0.7)	outwash	18	17	2	0	2	9	49	2	1	T15-12	Material unsuitable for H.L. Silt and clay sections in pit.
44	Anderson	6d	216 596	Paipoonge	INR	4	439C	0.3(1)	6(20)	7.6(25)	S	55	40	10	0	0.1(0.3)	outwash	28	22	1	0	2	14	31	1	1	T15-4	Clay seams in pit.
45	A. Cooper and Co.Ltd.	6d	212 588	Paipoonge	B	5	460B	0.3(1)	7.6(25)	12(40)	M	60	40	25	5	0.2(0.7)	outwash	20	46	5	1	2	8	15	2	1	T15-18	Stone unsuitable for H.L.4.
46	A. Cooper and Co.Ltd.	6d	205 587	Paipoonge	B	7	463C	0.3(1)	9(30)	18(60)	M	50	50	40	15	0.2(0.7)	outwash	24	25	5	1	1	18	23	3	0	T15-3	Stone unsuitable for H.L.4. Silt and clay sections in pit.
47	Twp. of Paipoonge	6d	204 588	Paipoonge	B	7	464A	0.3(1)	4.5(15)	—	M	60	40	20	2	0.1(0.3)	outwash	25	36	4	0	2	12	20	1	0	—	
48	A. Cooper and Co.Ltd.	6d	202 587	Paipoonge	B	7	465A	0.6(2)	15(50)	18(60)	M	50	50	35	5	0.3(1)	outwash	29	46	4	0	1	6	13	1	0	T15-3	
49	Huchinson	6d	191 587	Paipoonge	B	10	467C	0.6(2)	3(10)	—	S	85	15	25	0	—	lacustrine	30	28	0	0	1	12	26	1	2	T15-41	
50	Spence	6d	188 587	Paipoonge	B	11	466	0.6(2)	3(10)	—	M	80	20	10	2	0.2(0.7)	outwash	37	25	4	0	0	11	17	4	2	—	
51	Von faasen	6d	164 580	Paipoonge	A	17	—	0	—	1.5(5)	M	85	15	2	0	—	outwash	—	—	—	—	—	—	—	—	—	—	
52	Lamke	6d	158 573	Paipoonge	A	18	470C	0	3(10)	—	M	75	25	5	0	—	outwash	34	38	4	0	1	8	12	1	2	—	
53	Twp. of Paipoonge	6d	155 576	Paipoonge	A	19	474	0.6(2)	3(10)	—	M	80	15	10	0	—	outwash	26	28	3	0	1	32	9	1	0	T15-2	
54	Kam Aggregates Ltd.	6d	156 580	Paipoonge	A	19	473	0	3(10)	—	M	75	20	5	0	0.1(0.3)	outwash	25	34	6	0	1	10	20	2	1	T15-43	
55	Sideen-Ostrum	5E	100 598	Paipoonge	A	30	542	0.6(2)	3(10)	3(10)	M	50	20	15	10	0.3(1)	ice-contact	14	20	6	0	1	37	22	0	0	K17-31	Material unsuitable for GBC.
56	Sideen	5E	106 587	Paipoonge	A	32	—	0.6(2)	—	4.5(15)	S	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	K17-30	Silt pockets in pit.
57	Clapp	6d	156 487	Blake	II	11	—	—	—	—	U	—	—	—	—	—	till	—	—	—	—	—	—	—	—	—	T15-8	
58	Hanna	6d	197 551	Paipoonge	IIISR	9	—	—	—	—	U	—	—	—	—	—	lacustrine	—	—	—	—	—	—	—	—	—	T15-52	
59	Grate	6d	219 550	Paipoonge	IIISR	3	480	0	1(3.5)	—	S	50	50	0	0	—	lacustrine	—	—	—	—	—	—	—	—	—	T15-32	
60	Bodnar	6d	237 573	Neebing	ISR	24	—	—	—	—	U	—	—	—	—	—	delta	—	—	—	—	—	—	—	—	—	T15-47	
61	Harnibrook	6c	221 614	Paipoonge	IIINR	1	—	—	—	—	U	—	—	—	—	—	till	—	—	—	—	—	—	—	—	—	—	
62	Templeman	6e	221 616	Paipoonge	IIINR	1	—	—	—	—	U	—	—	—	—	—	till	—	—	—	—	—	—	—	—	—	T15-27	
63	MTC	6f	265 611	Neebing	IVNR	17	—	—	—	—	U	—	—	—	—	—	lacustrine	—	—	—	—	—	—	—	—	—	T15-19	
64	Black	6f	270 630	Neebing	VNR	16	4	0.3(1)	1.5(5)	4.5(15)	S	80	20	15	2	0.5(1.5)	lacustrine, bdrk.	—	—	—	—	—	—	—	—	—	T15-51	Sand unsuitable for H.L. Silt pockets in pit.
65	A. Cooper and Co.Ltd.	6f	269 639	McIntyre	Sect.D		27A	0.3(1)	3(10)	6(20)	S	50	50	30	10	0.2(0.7)	lacustrine bdrk.	13	21	5	2	1	18	36	3	1	T15-54	Sand unsuitable for H.L.
66	Biloski Bros.	6f	286 645	McIntyre	Sect.2		31	0.9(3)	4.5(15)	4.5(15)	S	70	30	30	20	0.3(1)	lacustrine, bdrk.	—	—	—	—	—	—	—	—	—	T15-37	Material unsuitable for GBC "C"
67	H. Dickson Ltd.	6f	306 654	McIntyre	Sect.49		48	0.6(2)	1.5(5)	3(10)	S	90	10	10	2	0.3(1)	outwash, lacustrine	21	57	12	0	1	5	13	0	0	T15-33	Sand blending required.
68	Hewitson Construction Co.Ltd.	6f	304 654	McIntyre	Sect.49		46	0.3(1)	1.5(5)	—	M	75	25	10	2	0.2(0.7)	outwash, lacustrine	27	52	2	0	0	6	12	1	0	—	
69	V.D. Rigato Ltd.	6f	299 658	McIntyre	W	48	56	1(3.5)	11(35)	12(40)	L	0	0	0	100	—	bedrock quarry	30	43	2	1	0	15	7	0	2	T15-31	Decomposed rock to be avoided.
70	Hewitson Construction Co.Ltd.	6f	310 662	McIntyre	Sect.49		88	0.3(1)	1.5(5)	—	S	50	20	20	2	0.2(0.7)	outwash,till	43	30	6	0	0	10	7	2	2	—	
71	Biloski Bros.	6f	312 665	McIntyre	Sect.41		90B	0.3(1)	3(10)	3(10)	S	90	10	50	2	0.5(1.5)	outwash, lacustrine	23	37	2	1	0	22	10	2	3	T15-34	Material unsuitable for H.L.
72	Kurchina	6f	299 679	McIntyre	Sect. K		110	0.3(1)	1.5(5)	—	S	60	10	20	2	0.5(1.5)	outwash,till	31	43	4	2	0	6	13	1	0	T45-48	
73	Harde	6f	257 688	McIntyre	Sect.32		114A	0.6(2)	4.5(15)	4.5(15)	S	70	30	25	10	0.6(2)	outwash	13	11	2	0	0	5	65	3	1	T15-10	Stone unsuitable for H.L. Silt pockets in pits.
74	Municipality of Shuniah	11W	249 757	McIntyre	Sect.8		—	—	—	—	U	Quarry					bedrock	53	47	0	0	0	0	0	0	0	ϕ12-44	Screenings require testing for H.L.
75	V.D. Rigato Ltd.	11W	247 763	Gorham	I	18	—	0.6(2)	—	18(60)	M	75	25	35	10	—	ice-contact	—	—	—	—	—	—	—	—	—	ϕ12-26	Sand control required for GBC "A".
76	Lempiala Sand and Gravel Ltd.	11W	255 780	Gorham	I	17	—	0.6(2)	—	11(35)	S	60	30	35	5	—	ice-contact	66	14	0	3	0	3	3	7	4	ϕ12-39	Silt sections. Sand control required fro GBC "A".
77	Superior	11W	244 781	Gorham	I	18	—	—	—	14(45)	S	85	15	—	—	—	ice-contact	35	20	2	0	0	5	37	0	1	ϕ12-31	Clay and silt sections. Sand blending required for H.L.
78	Okerlupd	11W	244 785	Gorham	II	18	—	3(10)	—	7.6(25)	M	75	25	—	—	—	ice-contact	45	29	0	3	0	2	15	3	3	ϕ12-43	Clay and silt pockets. Sand control required for crushing.
79	Kapush	11W	255 784	Gorham	II	17	—	0.3(1)	—	7.6(25)	M	65	30	40	—	—	ice-contact	67	13	0	0	2	6	5	2	5	ϕ12-28	Clay pockets. Sand control required for 3/8", GBC "A" and "B".
80	Wickstrom	11W	265 782	Gorham	II	16	—	1(3.5)	—	7.6(25)	S	50	40	40	2	—	ice-contact	18	59	2	6	1	0	12	2	0	ϕ12-20	Silt and clay seams. Sand control required for 3/8", GBC "A" and "B".
81	MTC	11W	268 790	Gorham	II	16	—	0.6(2)	—	9(30)	S	90	10	0	0	0	ice-contact	35	22	2	3	2	0	35	0	1	ϕ12-13	Commercial source. Sand control required for crushing.
82	Lempiala Sand and Gravel Ltd.	11W	263 790	Gorham	II	16	—	—	—	6(20)	U	80	20	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	—	
83	Crown	11W	275 785	Gorham	II	15	—	0.3(1)	—	6(20)	S	75	15	—	—	—	ice-contact	69	20	2	4	1	1	2	0	1	ϕ12-38	Clay and silt pockets. Sand control required for GBC "A" and "B".
84	Lempiala Sand and Gravel Ltd.	11W	281 803	Gorham	III	14	—	0.3(1)	—	9(30)	L	65	35	10	—	—	deltaic-outwash	44	36	3	4	3	0	5	4	1	ϕ12-40	Insufficient stone for crushing.
85	Crown	11W	285 806	Gorham	III	14	—	1(3.5)	—	12(40)	M	90	10	—	—	—	deltaic-outwash	39	48	5	1	2	0	3	2	0	ϕ12-45	Sand control required for GBC "A","B". Insufficient stone for H.L.4.
86	Tahkanen	11W	293 811	Gorham	III	13	—	0.3(1)	—	18(60)	M	65	35	15	2	—	deltaic-outwash	35	23	0	6	2	3	29	2	0	ϕ12-14	Extensive sand control required for crushing.
87	Tahkanen	11W	296 814	Gorham	IV	13	—	0.3(1)	—	6(20)	M	50	50	30	—	—	deltaic-outwash	—	—	—	—	—	—	—	—	—	ϕ12-16	Sand control required for crushing.
88	Hacquoil Construction Ltd.	11W	303 810	Gorham	III	11	—	0.3(1)	—	6(20)	M	35	65	50	5	—	deltaic-outwash	15	15	0	3	4	34	14	2	12	ϕ12-6	Clay pockets. Sand blending required for H.L.
89	Dixon	11W	313 813	Gorham	IV	10	—	0.9(3)	—	6(20)	S	65	35	0	—	—	ice-contact	18	57	0	6	2	1	13	2	1	ϕ12-37	Not a crushing prospect.
90	Jussila, Salli, Inkonen	11W	278 815	Gorham	IV	14	—	—	—	—	U	—	—	—	—	—	deltaic-outwash	—	—	—	—	—	—	—	—	—	—	
91	Karjalainen	11W	274 813	Gorham	III	15	—	—	—	12(40)	S	70	30	5	—	—	ice-contact	35	45	0	1	2	4	11	1	1	ϕ12-21	Not a crushing prospect.
92	Osterbacha	11W	280 830	Gorham	IV	14	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	—	
93	Maki	11W	282 833	Gorham	V	14	—	0.6(2)	—	9(30)	S	40	60	40	5	—	deltaic-outwash	—	—	—	—	—	—	—	—	—	ϕ12-36	Elongated particles present, Sand control required for GBC "A" and "B".
94	Olson	11W	267 853	Gorham	VI	16	—	0.3(1)	—	11(45)	U	30	70	50	10	—	ice-contact	—	—	—	—	—	—	—	—	—	ϕ12-7	Silt sections. Sand control required for GBC "A". Commercial source.
95	Hewitson Construction Ltd.	11W	269 858	Gorham	VI	16	—	0.6(2)	—	6(20)	M	50	50	60	—	—	ice-contact	31	10	0	1	0	0	55	0	—	ϕ12-4	Sand control required for GBC "A".
96	Morgan	6f	249 686	McIntyre	Sect.31		127	0.6(2)	3(10)	—	S	95	5	10	0	—	outwash	12	15	2	1	2	18	46	2	2	—	
97	City of Thunder Bay	11E	343 812	Gorham	IV	6	—	—	—	4.5(15)	U	25	25	—	—	—	till,outwash	21	54	0	5	1	3	14	2	0	ϕ12-34	Pockets of crushable material. Sand control required.
98	City of Thunder Bay	11E	342 808	Gorham	III	6	—	—	—	6(20)	U	40	60	—	—	—	till, icsd	31	36	0	4	2	6	19	1	1	ϕ12-35	Large quantity of elongated particles.
99	Salo	11E	345 778	Gorham	II	6	—	—	—	3(10)	U	50	40	—	—	—	ice-contact	15	36	1	8	2	4	31	1	2	ϕ12-41	Clay sections in pit. Sand blending required for H.L.4.
100	Biloski Bros.	11E	346 770	Gorham	I	6	—	0.3(1)	—	12(40)	S	30	60	45	2	—	till, icsd	22	18	2	33	1	13	7	3	1	ϕ12-42	Stone unsuitable for H.L.4.
101	Annium	11E	345 769	Gorham	I	6	—	—	—	6(20)	U	35	60	—	—	—	till, icsd	26	35	1	7	0	13	15	0	3	ϕ12-33	Silty sections in pit. Some sand blending required.
102	Sandaken	11W	328 756	McIntyre	Sect.4		—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	—	
103	Johnson	11W	331 746	McIntyre	Sect.4		—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	—	
104	Dubee	6f	325 736	McIntyre	Sect.19		204C	0.9(3)	4.5(15)	—	S	40	60	40	10	0.6(2)	outwash	36	30	3	1	3	7	14	2	4	T15-22	Silt and clay coatings on coarse aggregate.
105	V.D. Rigato Ltd.	6f	332 733	McIntyre	Sect.19		210	0.9(3)	4.5(15)	12(40)	M	50	50	40	5	0.6(2)	outwash	27	26	2	0	0	3	39	2	1	T15-25	Material unsuitable for H.L., GBC "A" or "C".
106	Heydon	6f	322 732	McIntyre	Sect.19		207C	0.6(2)	3(10)	—	M	90	10	40	10	0.2(0.7)	outwash	38	35	2	0	2	13	15	2	3	T15-15	Material suitable for selected subgrade.
107	Twp. of McIntyre	6f	312 723	McIntyre	Sect.18		197B	0.9(3)	4.5(15)	—	M	40	60	70	50	0.6(2)	outwash	16	19	2	2	0	7	51	2	1	T15-36	
108	Kauppi and Giediatis	6f	322 718	McIntyre	Sect.19		233	0.9(3)	3(10)	—	S	50	50	25	5	0.2(0.7)	outwash	21	17	2	3	3	6	44	3	1	T15-35	
109	Squire and Jacobson	6f	330 716	McIntyre	Sect.18		229C	0.6(2)	4.5(15)	6(20)	S	75	25	20	0	0.1(0.3)	outwash	20	25	6	3	1	6	36	2	1	T15-26	Material unsuitable for GBC "A","C" or H.L. Clay and silt sections in pit.
110	Peltala	6f	334 712	McIntyre	Sect.17		239B	0.9(3)	9(30)	9(30)	M	50	50	10	2	0.3(1)	outwash	13	25	7	0	1	24	28	1	1	T15-6	Material unsuitable for GBC "A","C" or H.L. Clay and silt sections.
111	A. Cooper and Co.Ltd.	6g	337 706	McIntyre	Sect.17		240	0.9(3)	6(20)	9(30)	M	30	65	30	2	0.2(0.7)	outwash	7	16	6	0	0	62	6	2	1	T15-24	Material unsuitable for GBC "A", "C" or H.L. Clay and silt sections.
112	Guerrjeri Bros.	6g	338 736	McIntyre	Sect.20		243	0.3(1)	3(10)	4.5(15)	S	40	60	25	5	0.2(0.7)	outwash	27	25	0	0	4	10	30	4	0	T15-23	Material unsuitable for H.L.4 and GBC "A". Clay sections in pit.
113	Twp. of McIntyre	11E	343 744	McIntyre	Sect.3		—	0.6(2)	—	9(30)	M	35	60	30	2	—	outwash	—	—	—	—	—	—	—	—	—	ϕ12-24	Depleted.
114	Ypma	11E	346 745	McIntyre	Sect.3		—	1.9(6)	—	12(40)	S	60	20	55	10	—	outwash	—	—	—	—	—	—	—	—	—	ϕ12-23	Heavy clay overburden. Highly cemented coarse aggregate.
115	Kankkunen	11E	344 749	McIntyre	Sect.3		—	0.6(2)	—	9(30)	M	45	55	20	—	—	outwash	30	13	1	14	2	10	20	3	7	ϕ12-25	Silt and clay pockets. Sand blending required.
116	Kankkunen	11E	343 757	McIntyre	Sect.3		—	0.3(1)	—	18(60)	M	40	60	25	0	—	outwash	23	32	3	3	2	18	5	2	12	ϕ12-17	Material unsuitable for H.L.
117	A. Cooper and Co.Ltd.	11E	343 761	Gorham	I	7	—	4.5(15)	—	15(50)	M	40	60	60	5	—	outwash	20	10	3	0	2	10	37	0	18	ϕ12-79	Cemented seams to be avoided. Some sand blending required.
118	Faron Construction Ltd.	11E	390 756	MacGregor	D	18	—	—	—	—	U	—	—	—	—	—	till, icsd	—	—	—	—	—	—	—	—	—	ϕ12-46	Stone unsuitable for H.L.4.
119	Smith	11E	401 769	MacGregor	C	18	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	ϕ12-29	
120	Geisser, Goddard, Stirret	11E	411 770	MacGregor	C	17	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	ϕ12-32	
121	Geisser	11E	422 773	MacGregor	B	16	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—		
122	J.N. Pitts Ltd.	11E	425 765	MacGregor	C	16	298B	0.6(2)	11(35)	—	M	60	40	50	25	0.6(2)	ice-contact	28	36	4	4	1	17	9	1	0	ϕ12-10	
123	Jacobson	11E	423 754	MacGregor	D	16	—	—	—	4.5(15)	U	75	25	—	—	—	till, icsd	67	5	0	4	0	6	16	0	2	ϕ12-47	Sand control required for crushing. Sand blending required for H.L.4.
124	Wadson	6g	427 734	MacGregor	Sect.1		297	0	1.5(5)	—	L	99	1	0	0	—	outwash	27	14	5	1	4	36	12	1	0	T15-5	
125	Wadson	11E	430 740	MacGregor	Sect.1		294B	1.5(5)	9(30)	—	M	60	40	50	1	0.2(0.7)	ice-contact	26	31	2	0	4	12	22	3	0	ϕ12-49	
126	Wadson	11E	440 740	MacGregor	Sect.2		302	1.5(5)	11(35)	—	M	85	15	40	15	0.2(0.7)	outwash-lacustrine	26	32	2	0	1	20	18	1	0	—	
127	Pyhtila Bros. and Leino	6h	444 736	MacGregor	Sect.6E		304	1(3.5)	3(10)	—	M	70	30	15	1	0.1(0.3)	outwash-lacustrine	24	47	2	0	2	14	11	0	0	T15-16	
128	Crown	6h	458 728	MacGregor	Sect.7E		320A	0.3(1)	3(10)	—	M	85	15	25	5	0.2(0.7)	lacustrine	24	29	1	0	0	14	31	1	0	T15-7	
129	Hadley	6h	461 731	MacGregor	Sect.6E		314A	0.3(1)	4.5(15)	—	M	80	20	10	2	0.3(1)	outwash-lacustrine	29	47	2	0	0	13	9	0	0	—	
130	Hadley	6h	452 737	MacGregor	Sect.7E		308C	0.3(1)	7.5(25)	—	L	95	5	60	50	1(3.5)	outwash-lacustrine	27	49	4	0	1	15	4	0	0	—	
131	Pyhtila Bros.	11E	484 750	MacGregor	Sect.16E		—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	—	
132	Pyhtila Bros.	11E	484 744	MacGregor	Sect.16E		—	—	—	—	U	—	—	—	—	—	outwash	—	—	—	—	—	—	—	—	—	ϕ12-8	
133	Pyhtila Bros.	11E	485 775	MacGregor	Sect.5H		—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	ϕ12-27	
134	Blunt and Lehtonen	11E	523 795	MacGregor	B	10	—	—	—	—	U	—	—	—	—	—	ice-contact	—	—	—	—	—	—	—	—	—	—	


N
500 metres
1/4 mile

N
1/4 Mile
1/2 Kilometre







DOG
LAKE
MORAINE
OUTWASH
DELTA
MARKS
MORAINE
1 Km
1 mile
N

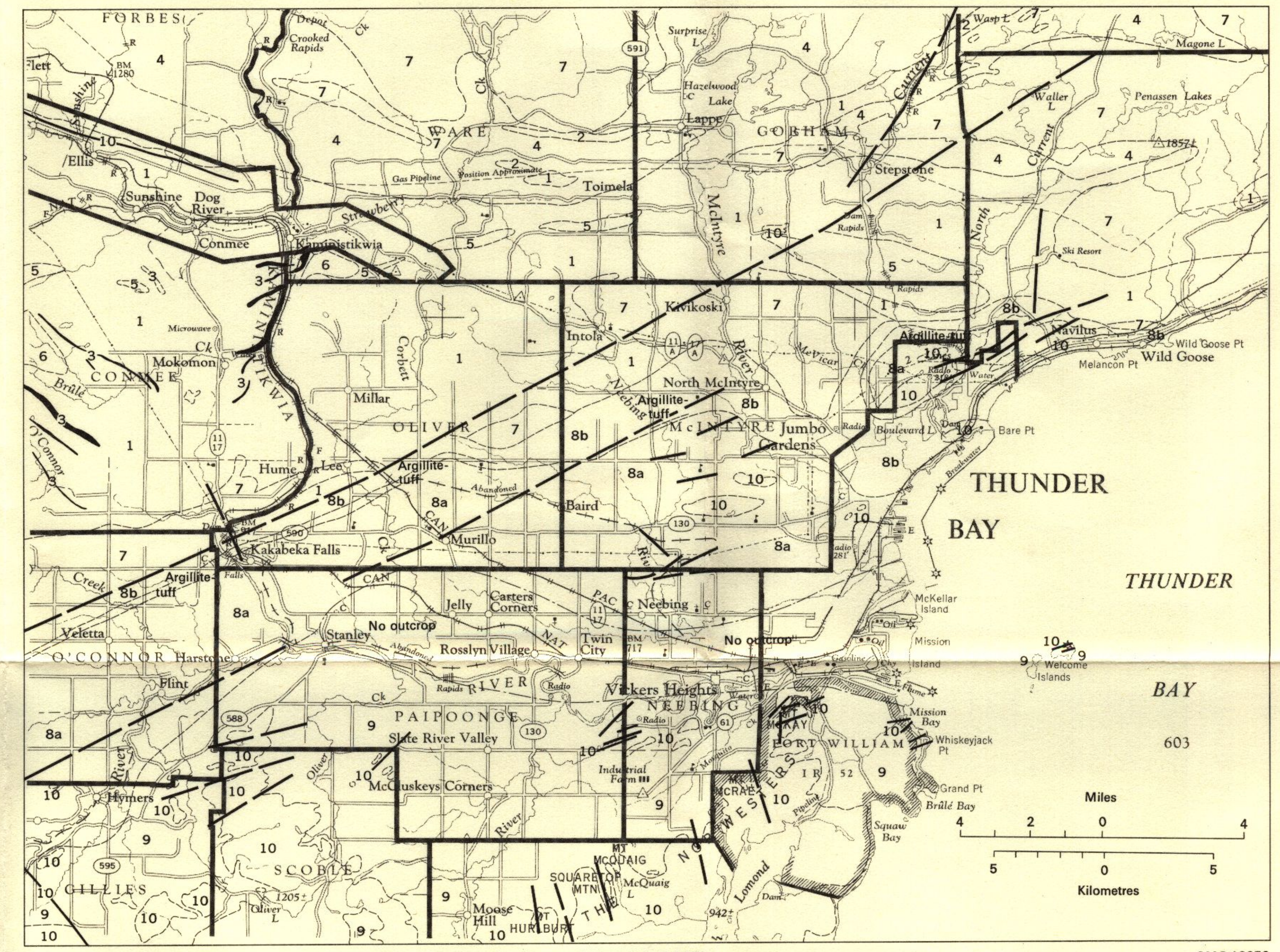


Figure 2. Precambrian geology of Thunder Bay and Vicinity, after Pye and Fenwick (1965).

SMC 13656

LEGEND

PRECAMBRIAN
MIDDLE TO LATE PRECAMBRIAN
KEEWEENAWAN

10 *Intrusive igneous rocks.*

INTRUSIVE CONTACT
ANIMIKIE
9 ROVE FORMATION
GUNFLINT FORMATION
8a *Upper Gunflint Formation.*
8b *Lower Gunflint Formation.*

UNCONFORMITY
EARLY PRECAMBRIAN

7 METAMORPHOSED FELSIC INTRUSIVE ROCKS

INTRUSIVE CONTACT
6 MAFIC AND ULTRAMAFIC IGNEOUS ROCKS

INTRUSIVE CONTACT
METASEDIMENTS

5 *Conglomerate, arkose, greywacke, etc.*

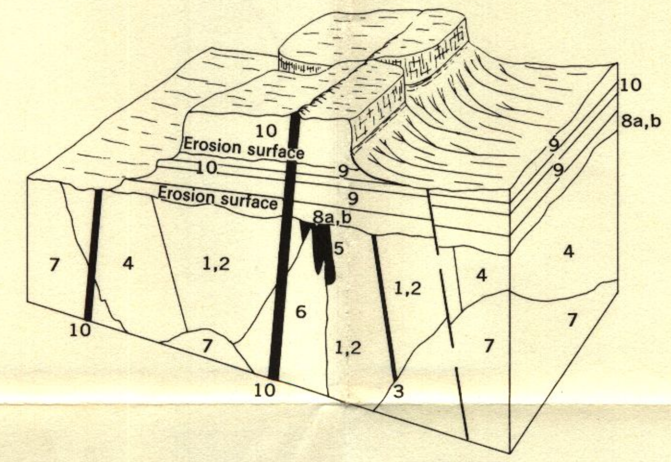
4 *Arkose, greywacke, gneisses, etc.*

3 *Iron formation.*

METAVOLCANICS

2 *Mafic to intermediate metavolcanics.*

1 *Unsubdivided metavolcanics and some metasediments.*



SMC 13657

Figure 3. Known and inferred age relations of the Precambrian rocks.

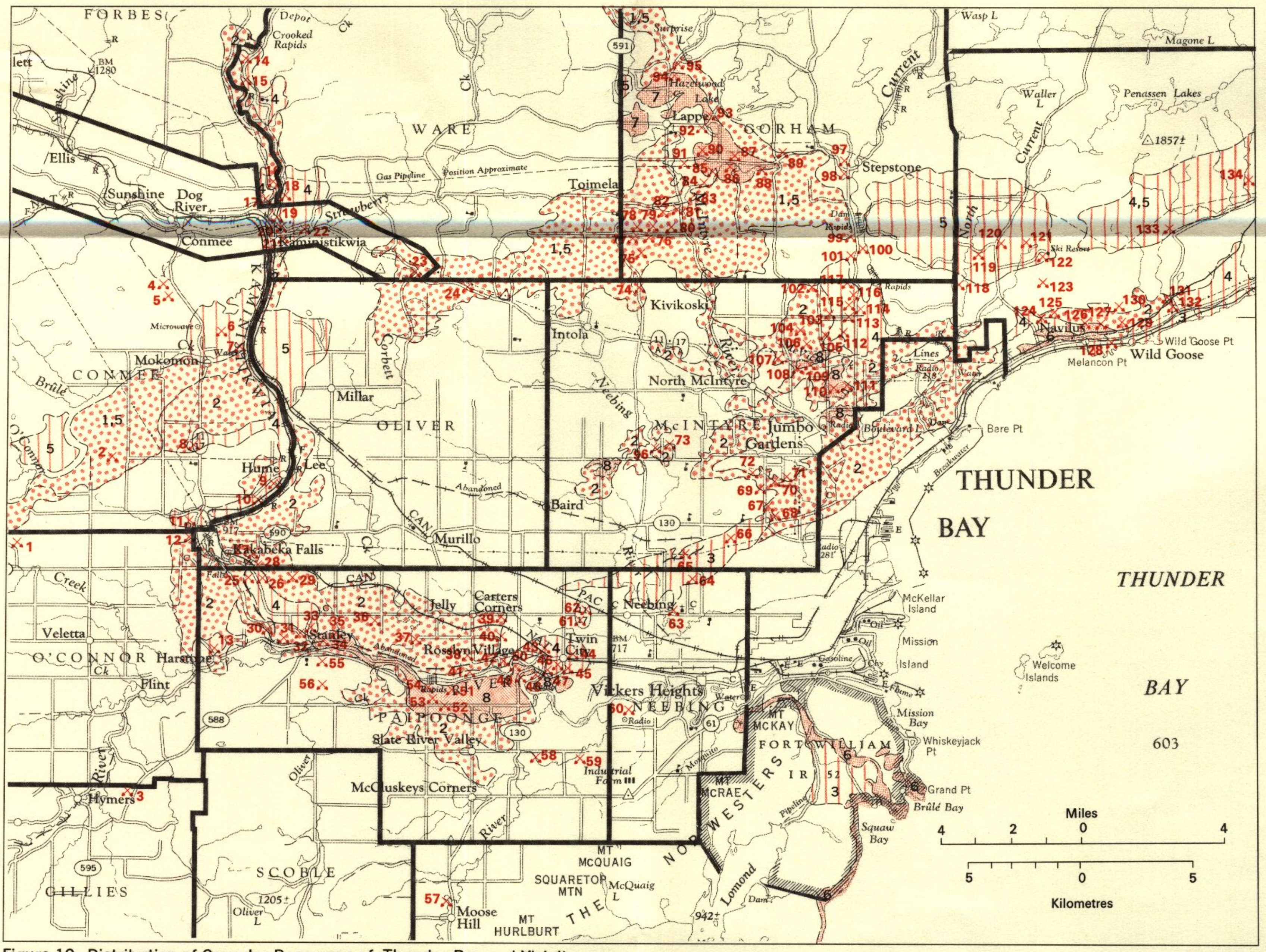


Figure 10. Distribution of Granular Resources of Thunder Bay and Vicinity.

SMC 13664

LEGEND

Area predominately gravel; possibility of locating economic deposits of usable granular materials is moderate to high.

8 *Outwash gravel and sand; coarse to medium grained deposits of meltwater channels.*
7 *Deltaic gravel and sand; medium to coarse grained deposits in outwash deltas formed during former lacustrine intervals.*
6 *Shore gravel and sand; coarse to medium grained deposits of former lacustrine strandlines.*

Area of mixed sand and gravel; possibility of locating economic deposits of usable granular materials is moderate.

5 *Ice-contact stratified drift; gravel, sand and till irregularly interbedded.*
4 *Outwash sand with low to moderate gravel content.*
3 *Shore sand with low to moderate gravel content.*

Area predominately sand; possibility of locating economic deposits of usable granular materials is low to moderate.

2 *Outwash sand with very low gravel content.*
1 *Till; sand-silt matrix, pebbles scarce, gravel pockets very rare.*

63 *Sand and gravel pit, (see appendix C).*

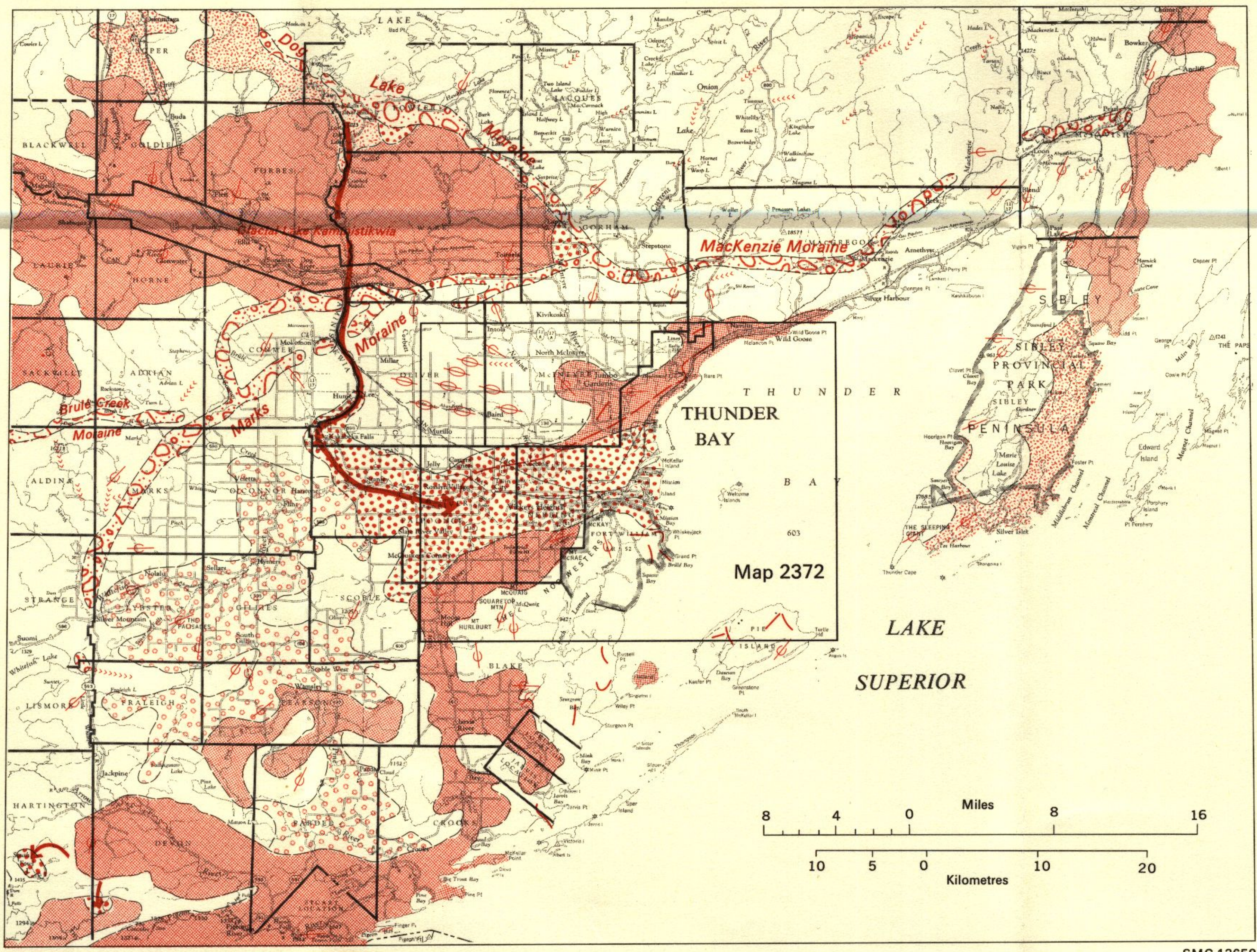


Figure 4. Generalized surficial geology of Thunder Bay and Vicinity, after Zoltai (1965b).

SMC 13658

LEGEND

GROUND MORAINE

Sandy or silt till.

Clayey till (overriding Glacial Lake O'Connor sediments).

END MORAINE, INTERLOBATE MORAINE

Dog Lake Moraine and Marks Moraine partly modified by lake action.

LACUSTRINE DEPOSITS

Varved or massive clay (Glacial Lake Kaministikwia sediments underlain by sandy till).

Fine and medium sand.

Deltaic sand (partly underlain by outwash sand and gravel).

SYMBOLS

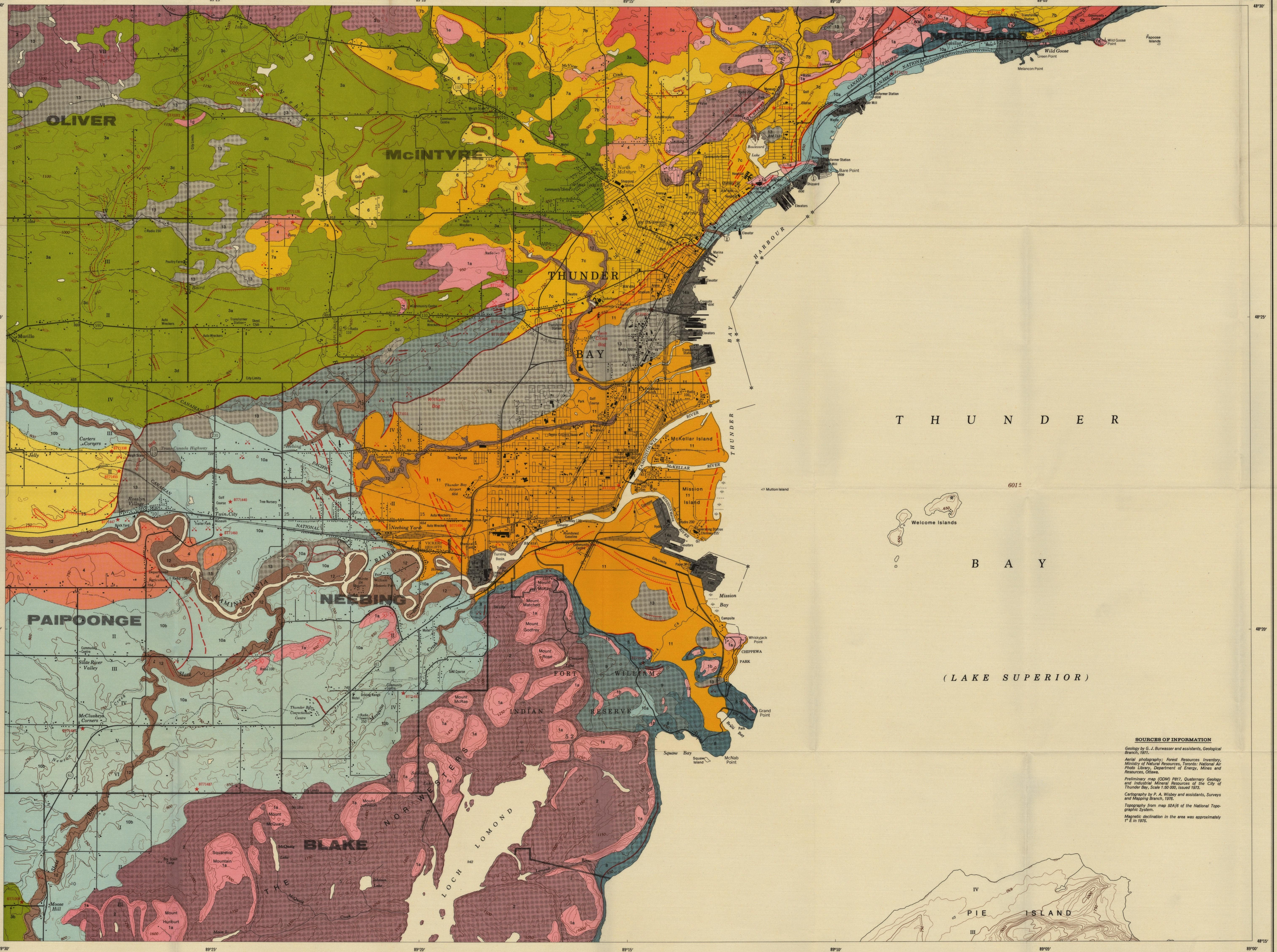
Striae (earlier direction shown by broken line).

Drumlin.

Esker.

Kaministikwia River Spillway and meltwater channel.

Raised shoreline.



Ministry of Natural Resources
Ontario

Hon. Leo Bernier
Minister

Dr. J. K. Reynolds
Deputy Minister

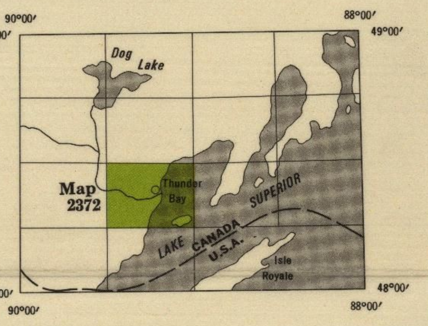
Ontario Geological Survey
Map 2372

THUNDER BAY

Thunder Bay District

Quaternary Geology

NTS 52A/6 Scale 1:50 000



MAP COVERAGE: INDUSTRIAL MINERALS, QUATERNARY OR PLEISTOCENE GEOLOGY SERIES (EXCLUDING PRELIMINARY MAPS)

LEGEND

CENOZOIC
QUATERNARY
RECENT

14 — *Cultural deposits:*
14a Constructional; large fills, tip-heaps.
14b Depositional; tailings ponds, settling basins.

13 — *13 Swamp deposits: mud, muck, peat.*

12 — *12 Alluvium: silt, sand, very minor gravel.*

PLEISTOCENE

11 — *11 Fluviolacustrine deposits: deltaic sediments in part modified by lake action, and transitional to lacustrine deposits: sand with minor silt.*

10 — *Fine-grained lacustrine deposits:*
10a Silt and silty fine sand.
10b Clay and silty clay.

9 — *9 Medium-grained lacustrine deposits; sand with very minor fine gravel.*

8 — *8 Coarse-grained lacustrine deposits; gravel and gravelly sand.*

7 — *Discontinuous glaciofluvial deposits: thin outwash sand:*
7a Over till.
7b Over bedrock.
7c Over till or bedrock, reworked by subsequent lacustrine action.

6 — *6 Glaciofluvial outwash sand.*

5 — *Discontinuous glaciofluvial deposits; thin outwash gravel and sand:*
5a Over till.
5b Over bedrock.

4 — *4 Glaciofluvial outwash gravel.*

3 — *Till deposited by the Superior ice lobe:*
3a Gritty silt till facies, ground moraine; compact, fissile, light red-brown, drumlins and drumlinized bedrock knobs common.
3b Clay till facies, ground moraine; stiff, calcareous, weak red, incorporated blocks of lacustrine sediments common.
3c Gritty silt till facies, stagnation moraine; compact to loose, light red-brown, irregular patches of knob and kettle topography, corrugated moraine and crevasse fillings common, partly overridden.
3d Silt till facies, stagnation moraine; brown, compact, fissile, thrust features, and flow structures common.

UNCONFORMITY

PRECAMBRIAN

2 — *2 Bedrock-drift complex: rock, till, colluvium.*

1 — *Bedrock (minor drift cover):*
1a Diabase dikes and sills.
1b Rove Formation; argillite, shale.
1c Upper Gunflint Formation; conglomerate, argillite, taconite.
1d Lower Gunflint Formation; conglomerate, argillite, taconite.
1e Felsic intrusive rocks.
1g Metavolcanic rocks.

SYMBOLS

Geographic township; Indian Reserve boundary.
Topographic contours.
Glacial striae; direction of ice movement known, unknown.
Intersecting glacial striae; relative age shown by numbers.
Drumlin; direction of ice movement known, unknown.
Direction of glacial thrust.
Direction of paleocurrent.
Abandoned meltwater or river channel.
Esker.
Crevasse filling.
Prominent escarpment marking former lake level.
Beach or bar formed during former lacustrine inundation.
Moraine crest.
Stoss and lee feature.
Geological boundary.
Quarry.
Sand, gravel pit.
BT71503 *Measured section locality; (see report).*

For other conventional signs refer to 1:50 000 National Topographic System maps.

Scale 1:50 000

Metres 1000 0 1 2 3 4 5 6 7 Kilometres

Chains 80 40 0 1 2 3 Miles

Published 1976