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Ontario Geological Survey
Open File Report 5882

Quaternary Geology of the Huntsville–Penetanguishene Area, Central Ontario

1994

Ministry of
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ONTARIO GEOLOGICAL SURVEY

Open File Report 5882

Quaternary Geology of the Huntsville–Penetanguishene Area, Central Ontario

By

A.F. Bajc

1994

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ABSTRACT

This report presents information on the distribution and characteristics of the Quaternary deposits and features of the Huntsville-Penetanguishene area. The information can be used for a variety of applications including: 1) land use planning; 2) the identification of potential sources of granular aggregates; 3) engineering and soil studies; 4) environmental and hydrogeological studies; and 5) drift prospecting programs.

Both Precambrian and Paleozoic-aged rocks are found within the report area. The sediments that overlie each of these terrains vary not only in composition and thickness but in internal complexity. Overburden thicknesses within Paleozoic terrain range up to several hundred metres whereas a much thinner drift cover (up to several 10's of metres) is characteristic of Precambrian terrain.

Several drift packages predating the main, Late Wisconsinan till sheet have been identified in areas underlain by Paleozoic bedrock. These deposits core the uplands of the Penetanguishene Peninsula. The ages of these deposits are unknown, however, a non-glacial, weathering interval has been recognized within the sequence and is probably of Middle Wisconsinan or Sangamonian age.

Late Wisconsinan ice flow was remarkably consistent across the report area and directed towards 190°. Late Wisconsinan deposits, consisting of tills and stratified deposits, drape the uplands of the Penetanguishene Peninsula and veneer a rock-dominated landscape within the shield regions. These deposits were largely produced shortly before or during deglaciation of the report area. Glacial Lake Algonquin fronted the margin of the retreating margin of the ice sheet over much of the report area. The landscapes and deposits observed in areas affected by this lake strongly reflect this depositional environment.

Water levels fluctuated within the Huron basin following deglaciation in response to ice retreat, outlet availability and isostatic processes. The well dated Nipissing transgression is represented within the report area by buried organic sequences and paleosols and strong, erosional bluffs. Buried organic remains have been radiocarbon dated at 6 to 7 ka BP. By 4 ka BP, water levels began to fall to their present level with only minor, climate-related fluctuations.

The then newly exposed upland areas and lake floors were affected by subaerial processes of erosion and deposition and were rapidly colonized by vegetation. Eolian activity affected sandy upland areas whereas sediment-filled lowlands were and continue to be dissected, terraced and infilled with peat and alluvial deposits.

Quaternary Geology of the Huntsville-Penetanguishene Area, Central Ontario

by A.F. Bajc[1]

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Funding for this project was provided by the Ontario Ministry of Natural Resources, the District Municipality of Muskoka and the Ministry of Northern Development and Mines, Ontario Geological Survey.

INTRODUCTION

Purpose

This report presents information on the distribution and characteristics of the Quaternary deposits and features of the Huntsville-Penetanguishene area. The information can be used for a variety of applications including: 1) land use planning; 2) the identification of potential sources of granular aggregates; 3) engineering and soil studies; 4) environmental and hydrological studies; and 5) drift prospecting programs.

Location and Access

The Huntsville-Penetanguishene report area is located in the southeastern corner of Georgian Bay and occupies a land mass of approximately 4000 km^2 (Figure 1). It falls within parts of Parry Sound and Muskoka Districts and Victoria and Simcoe Counties. This irregularly-shaped report area (backwards L) consists of 5, 1:50 000 scale NTS map sheets including the Huntsville (NTS 31E/6), Bracebridge (NTS 31E/3), Gravenhurst (NTS 31D/14), Penetanguishene (NTS 31D/13), and Christian Island (NTS 41A/16) areas.

The towns of Hunstville, Bracebridge, Gravenhurst, Penetanguishene and Midland are the major population centres providing trade and retail facilities for much of the region. Residential development is greatest in close proximity to these urban centres. Numerous smaller settlements are scattered between these centres and provide additional services to the rural areas. Gibson Indian Reserve 31

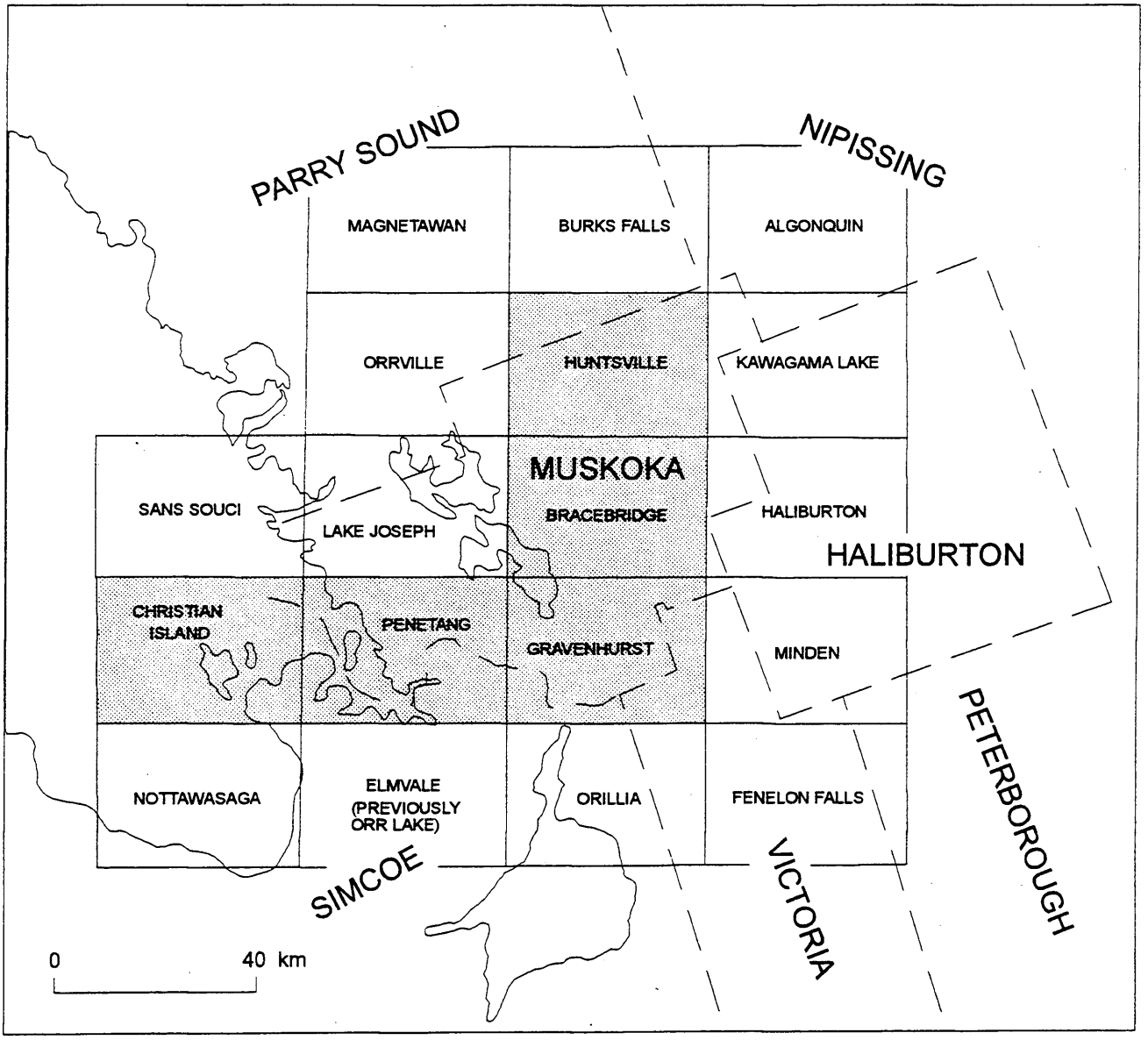


Figure 1. Location map of study area. Names in small bold refer to the 1:50 000 National Topographic System grid. Names in large bold refer to the districts and counties of south-central Ontario within which the study area is situated.

(Mohawks of Gibson First Nation) and Christian Island Indian Reserve 30 (Beausoleil First Nation) are also located within the report area.

Located in one of Ontario's most popular cottage and resort areas, the population and economy of this region depends to a large extent on the seasonal influx of tourists. Georgian Bay Islands National Park and Arrowhead, Six Mile Lake and Awenda Provincial parks provide additional camping and recreational facilities to the region.

Provincial Highways 11 and 69 are the main transportation corridors and provide connecting routes from Toronto to Sudbury and North Bay. Additional access through the report area is provided by provincial Highways 12, 27, 60, 117, 118, 141, 169, 518, 592 and 660. Township, concession, forest access and cottage roads complement the primary road network and facilitate access to most areas. A vehicle ferry to Christian Island from Cedar Point provides access to the island which is traversed by several roads and bush trails. Much of the remaining coastline of Georgian Bay and its islands are only accessible by boat. Hope, Beckwith and Giants Tomb islands do not contain a road or trail network.

Methods

The field program associated with this report resulted in the production of 1:50 000 scale Quaternary geology maps of the Huntsville-Bracebridge (Bajc and Henry 1991), Gravenhurst (Bajc and Paterson 1992a) and Penetanguishene-Christian Island

(Bajc and Paterson 1992b) N.T.S. map sheets (back pocket). Summaries of field work highlighting the major activities and findings of the 1990 and 1991 field seasons are contained in Ontario Geological Survey Miscellaneous Papers (Bajc 1990, 1991).

Field methods during Quaternary mapping consisted of digging testpits, hand augering and probing as well as examining available man-made and natural exposures. Bedrock outcrops were examined for striations. Descriptions of approximately 1100 field stations and innumerable secondary observation sites were recorded in the study area. Field station records include observations of colour, texture, structure, thickness, nature of contacts and vertical relationships of the sediments.

A sonic drilling program was undertaken on the Penetanguishene Peninsula whereby 5 continuously-cored, 10 cm diameter boreholes were obtained. Additional information was drawn from water well records, exploration assessment files and reports from various government and private agencies. Field work was supplemented by the interpretation of 1:15 840 scale (1 inch to 1/4 mile) aerial photographs. Sampling of glacial and non-glacial sediments for laboratory analysis was undertaken at an interval dictated by the sediment's thickness and areal extent. Paleocurrent measurements were taken from sedimentary structures ranging from ripple-drift, cross-laminated sands to large-scale, steeply-dipping foreset beds. Pebbles (greater than 4.75 mm diameter) were collected for

lithologic study from surface and borehole samples of till and glaciofluvial gravel.

Previous Work

Existing knowledge of the nature and distribution of Quaternary deposits within the mapped area is provided by both reconnaissance and detailed studies. These include the early works of Spencer (1888, 1891a, 1891b, 1894), Taylor (1894), Goldthwait (1910), Antevs (1925) and Stanley (1936) whose studies dealt primarily with the glacial lake record within the region east of Lake Huron. More recent reports include those of Chapman (1975) and Chapman and Putman (1984) whose studies focussed on the physiographic features within the region. Reports and maps dealing with terrain and aggregate resource evaluation include the Southern Ontario Engineering Geology Terrain Study series (Mollard 1980), an aggregate resources assessment for the District Municipality of Muskoka (Staff of the Algonquin Region, Ministry of Natural Resources 1983) and an Aggregate Resources Inventory Paper for the towns of Bracebridge and Gravenhurst (Ontario Geological Survey 1990). Peatland evaluation and resource inventories were undertaken by Monenco Ontario Limited (1984). A reconnaissance study of surficial drift geochemistry within the Grenville Province was undertaken by the Geological Survey of Canada (Kettles 1988; Kettles and Shilts 1989; Kettles et al. 1991). The information produced as part of this

Geological Survey of Canada study is applicable to environmental assessment and mineral exploration issues.

Several graduate and undergraduate theses dealing with aspects of the Quaternary geology of the report area have been completed as well. Warner (1978) studied the origin and depositional history of the Big East River delta near Huntsville. Jamieson (1979) undertook a detailed investigation of several exposures of varved Glacial Lake Algonquin sediments in the Huntsville-Bracebridge area in an attempt to correlate between sites. Cronin (1984) studied the raised shorelines of the northern Penetanguishene Peninsula and Vasco (1987) investigated the dispersion of Ordovician carbonate and clastic rocks from the Skeleton Lake basin located west of Port Sydney. Delorme (1989) reported on the sedimentology and depositional environment of subaquatic fan deposits located near Ullswater, Ontario. Finally, Paterson (1991) studied dewatering structures in subaquatic fan deposits in an attempt to relate various structure types to depositional settings.

The current project completes mapping in an area of southern Ontario within which no detailed Quaternary geology maps were available. Information obtained during the 1990 and 1991 field seasons was supplemented with data collected from earlier mapping programs (Sharpe 1978; Batterson 1981). Mapping of the surrounding areas was undertaken by both the Ontario Geological Survey and the Geological Survey of Canada. The Quaternary geology of the Lake Joseph-Sans Souci,

Orrville, Magnetawan and Burk's Falls map sheets (Figure 1) is summarized in Ontario Geological Survey Open File Report 5796 (Kor 1991). Preliminary maps at a scale of 1:50 000 are contained in this report. Mapping of the Algonquin and Kawagama Lake areas (Figure 1) was undertaken by the Ontario Geological Survey as well. Open File Report 5600 (Ford and Geddes 1986) contains preliminary maps of this area as well as a description of the Quaternary deposits and features of the Algonquin Park region. Quaternary mapping of the Haliburton and Minden map sheets (Figure 1) was undertaken by the Geological Survey of Canada at a scale of 1:50 000 (unpublished GSC maps). A model of glacial and proglacial sedimentation within this portion of the Canadian Shield is highlighted in a paper by Kaszycki (1987). Mapping of the Orillia (Finamore and Bajc 1984), Fenelon Falls (Finamore and Bajc 1983), Orr Lake (western half)-Nottawasaga (eastern half) (Burwasser and Boyd 1974) and Elmvale (eastern half) (Barnett 1992) map sheets (Figure 1) was undertaken by the Ontario Geological Survey. A regional survey of the Pleistocene geology of the Lake Simcoe District is summarized in a Geological Survey of Canada report (Deane 1950).

GEOLOGICAL SETTING

Bedrock Geology

Both Precambrian and Paleozoic-aged rocks are found within the report area (Figure 2). The areal distribution of these rock types is relatively well known (Hewitt 1967 and Liberty 1969). The type of rock found within a particular area strongly affects both the regional and local topographic trends as well as the compositional characteristics of glacial drift dispersed from the various rock types. For this reason, a brief summary of the bedrock geology of the report area follows.

Precambrian Geology

Much of the study area east of Georgian Bay lies within the Central Gneiss Belt of the Grenville Province; a structural subdivision of the Canadian Shield (Wynne-Edwards 1972). The belt consists mainly of quartzofeldspathic gneissic and migmatitic rocks which have been metamorphosed to upper amphibolite and locally, to granulite facies (Photo 1). The dominant structures and foliations within these rocks are north to northwest trending and manifested by parallel sets of long, narrow lakes and wetlands over much of the map area. Most of the gneisses and migmatites within the Huntsville and Bracebridge map areas are tectonized to such a high degree that their protoliths are indeterminable. Where the rocks are less metamorphosed, both igneous and metasedimentary precursors have been recognized (Davidson et al. 1985).

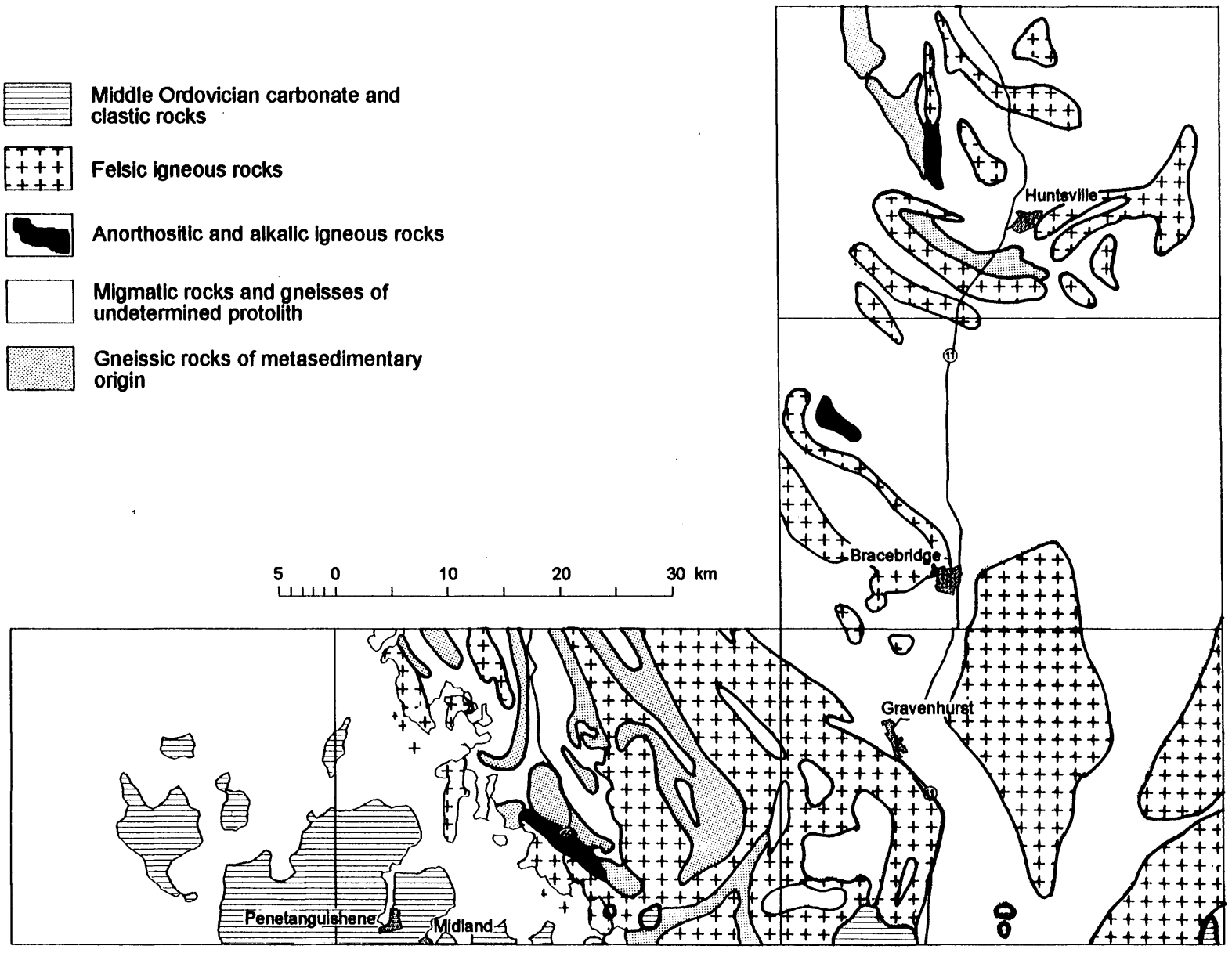


Figure 2. Bedrock geology map of the report area.

Photo 1. Outcrop of highly deformed quartzofeldspathic gneiss, Gibson Township.

Metasedimentary rocks have been identified primarily within the Penetanguishene map area and the west-central portion of the Huntsville map area whereas felsic igneous rocks have been identified mainly within the Gravenhurst and Penetanguishene map area (Figure 2).

The Central Gneiss Belt consists of a variety of Archean to Mesoproterozoic crustal segments, several of which have been recognized within the report area. These crustal segments, referred to as domains and subdomains, are defined by their rock assemblages, structural styles, metamorphic overprints and geophysical characteristics. They are separated by subparallel zones of intense deformation (Davidson et al. 1985). Deep-seated, northwest directed ductile thrusting and imbrication during the Grenville orogeny resulted in the stacking of these segments into their present positions. The Fishog and Parry Sound domains and the Kiosk, Novar, Huntsville, Seguin, McLintock, Rosseau, Moon River and Go Home subdomains have been recognized within the report area.

Small, plug-like mafic to ultramafic intrusions are randomly scattered throughout the report area. Many of these have been investigated for their base metal potential. An intrusion of note is the Port Cunnington peridotite which is located in Franklin Township. The intrusion is unusual in that it is intensely weathered to an unknown depth. The saprolite is most likely a product of post-Precambrian weathering. Because of its protected leeside setting, the

saprolite escaped processes of glacial erosion following its formation. This friable rock has been exploited as a local source of aggregate (Hewitt 1967).

Paleozoic Geology

The Precambrian-Paleozoic contact lies beneath Georgian Bay in the report area (Figure 2). Its exact position is unknown, however, it likely occurs along the northern edge of Simcoe County and extends southeastward along Severn Sound to Waubashene. To the east, near Sparrow Lake, a small segment of the contact extends northward into the Gravenhurst map sheet. On the Precambrian terrain, several small Paleozoic outliers occur near Honey Harbour, Port Severn, Matchedash Bay, Coopers Falls and Uphill (Liberty 1969).

The Paleozoic sequence within the report area consists primarily of the Middle Ordovician, Shadow Lake and Gull River formations. Soft, red and green shales, siltstones and arkoses of the Shadow Lake Formation are overlain by more resistant lithographic to sublithographic limestones of the Gull River Formation (Photo 2). Fine-grained, argillaceous limestones and calcarenites of the Bobcaygeon Formation (also Middle Ordovician in age) overlie the Gull River Formation south of Sparrow Lake (Liberty 1969). The Gull River Formation is, by far, the most common surface unit of Paleozoic bedrock within the report area. The Shadow Lake and Bobcaygeon formations have limited outcrop.

Photo 2. Contact between the Middle Ordovician, Shadow Lake (lower) and Gull River (upper) formations, Orillia Township (contact marked by arrow).

Skeleton Lake is located along the border of the Huntsville and Bracebridge map areas, on the western side of the report area. It is contained within a circular depression which truncates the regional geological and physiographic trends of the local Precambrian gneisses and migmatites. Geologic and geophysical evidence support the hypothesis that Skeleton Lake is the eroded remnant of a meteorite impact crater which formed during the Early Paleozoic (Waddington and Dence 1979). Glacial dispersal studies carried out in the vicinity of Skeleton Lake, attest to the presence or pre-existence of an erosional remnant of Ordovician, fossiliferous limestone, with lesser amounts of arkosic sandstone and siltstone on the lake bottom (Vasco 1987).

Physiography and Drainage

Three distinct physiographic regions, as defined by Chapman and Putnam (1984), have been identified within the report area. These are: 1) the Algonquin Highland; 2) the Georgian Bay Fringe; and 3) the Simcoe Upland (Figure 3). Topography, drift thickness and bedrock type are the main elements which differ between the physiographic regions. Each region also displays a unique sediment record that varies not only in composition and thickness but in internal complexity.

The landscapes and deposits observed in the Algonquin Highland and the Georgian Bay Fringe physiographic regions were produced mainly during deglaciation approximately 11 000 years ago. The Simcoe Upland, on the other hand, displays a

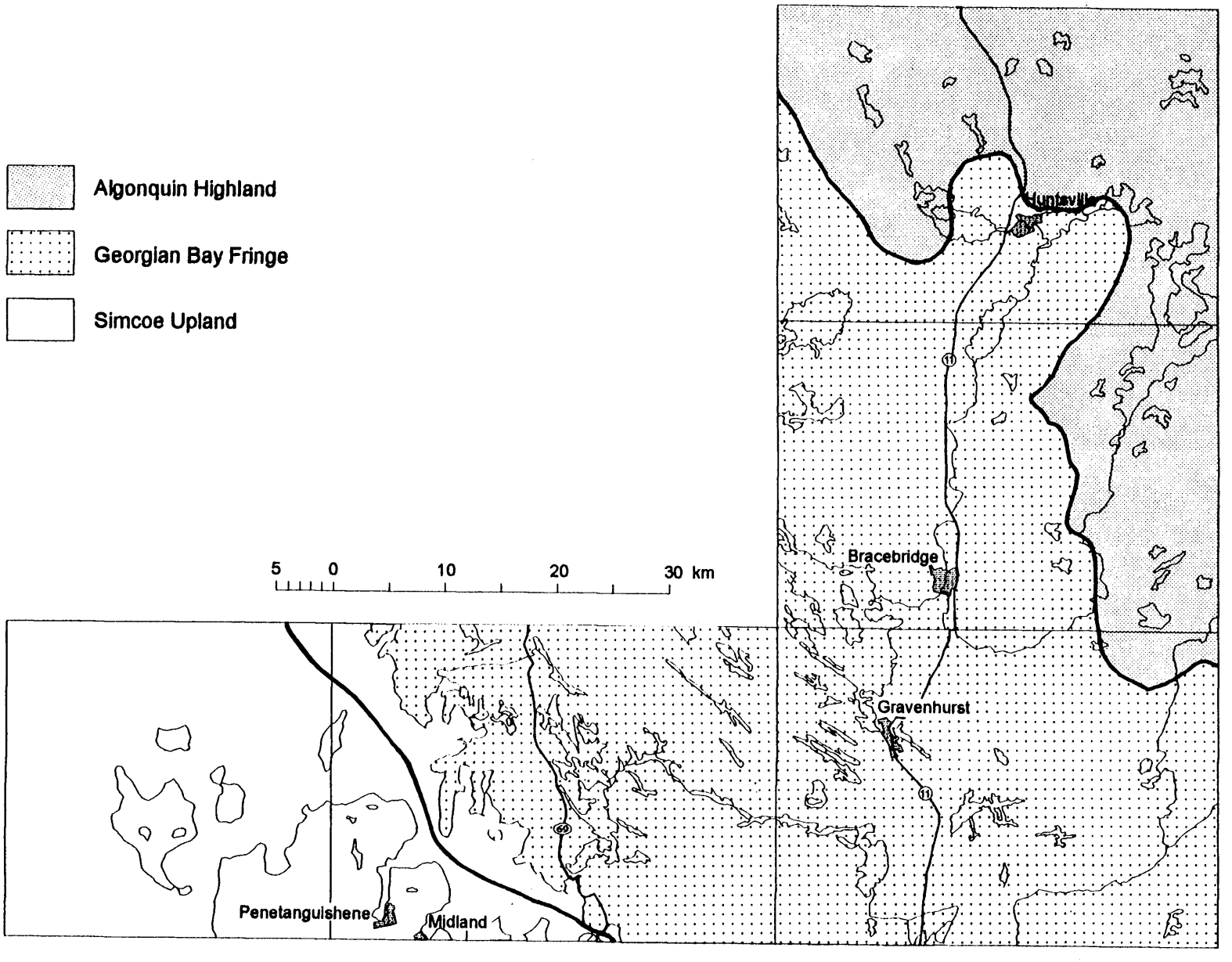


Figure 3. Physiographic regions of the report area.

striking contrast of physiography and contains a much more complex sediment record. A palimpsest landscape, modified by erosional and depositional processes of the last glaciation, the Simcoe Upland is cored with older drift units of unknown age. These units have not been observed on the Algonquin Highland and Georgian Bay Fringe physiographic regions.

The Algonquin Highland occupies the northern and eastern quadrants of the Hunstville map area and the eastern quadrants of the Bracebridge map area. It is defined as a bedrock-controlled, Precambrian upland (elevation range of 335 to 455 m) with moderate to high topographic relief (over 100 m) and locally to regionally extensive drift cover. The Algonquin Highland region consists of undulating terrain with rock knobs and deep, narrow valleys which are, most often, structurally controlled.

The Georgian Bay Fringe physiographic region occupies the remaining shield portion of the report area and is characterized as a low-relief, driftless plain. The land surface of this physiographic region slopes gently and evenly to the southwest from an elevation of 350 m above sea level in the northeast to 177 m above sea level (mean level of Georgian Bay) in the southwest. Northwest trending bedrock ridges provide 15 to 20 m of local relief in this region. Aside from a few isolated areas, Quaternary deposits are largely absent.

The Simcoe Upland physiographic region is located southwest of the Precambrian-Paleozoic contact and includes the following areas: the Penetanguishene Peninsula and Giants

Tomb Island, Beckwith Island, Hope Island and Christian Island. Bedrock outcrops are uncommon within this area. Glacial and postglacial processes of erosion and deposition have modified this palimpsest landscape considerably. Elevations range from 328 m above sea level at Lafontaine Hill to 177 m above sea level at Georgian Bay. Wave-cut notches formed by ancestral, Huron basin lakes reach heights of 50 m. Broad, south-trending, U-shaped valleys transect the landscape and reach widths of 2 to 3 km and depths of 100 m or more.

The report area is located entirely within the Great Lakes watershed and contains a well integrated drainage network. The main stream flow within the Algonquin Highland and Georgian Bay Fringe physiographic regions is directed towards the south and west into Georgian Bay. Well established, in some cases, mature river systems linking large, irregularly-shaped lakes occur throughout these 2 physiographic regions. Many of these lakes, for example, Buck Lake, Fox Lake, Fairy Lake, Mary Lake and Lake of Bays are dammed at their outlets and therefore dampen seasonal fluctuations in river flow. Six rivers carry the majority of surface runoff from this part of the report area into Georgian Bay. These include the Buck, Big East, North Branch Muskoka, South Branch Muskoka, Black, and Severn rivers.

The Simcoe Upland physiographic region contains a drainage network with very few permanent streams. Many of the permanent streams are spring-fed and display a preferred northward orientation. Surface runoff following spring melt

and heavy rainfall is channelled into these streams as well as smaller, ephemeral creeks. Since the Penetanguishene Peninsula is draped by a thick sequence of permeable, sandy sediments, much of the remaining surface water percolates into the subsurface before it can be channelled into these streams. North-flowing creeks are found mainly along the eastern Penetanguishene Peninsula (eg. Sucker Creek and Copeland Creek) as well as to the south of the report area between the small peninsulas at Port McNicoll, Victoria Harbour and Waubashene. The western half of the Penetanguishene Peninsula is drained by a spring-fed creek which originates at the 18th concession of Tiny Township near Macey Lake and flows just south of the report area to Wahnekewaning Beach on Georgian Bay.

QUATERNARY GEOLOGY

Drift Thickness

The Precambrian and Paleozoic terrains of the report area display markedly different drift thickness patterns. Each area will be discussed separately in this section.

Owing to the irregular nature of the Precambrian surface within the report area, only generalizations with respect to drift thickness are possible. Thicknesses of glacial and nonglacial deposits are extremely variable. Much of the Georgian Bay Fringe physiographic region is a driftless peneplain with local accumulations of winnowed till, glaciolacustrine sediments and organic soils that seldom exceed 2 to 3 m in thickness. Thicker overburden sequences occur along the Highway 11 corridor, along the lowlands occupied by the Black River and Gartersnake Creek and within the basin due east of Matchedash Bay.

The overburden cover generally becomes more extensive within the Algonquin Highland where a high to moderate relief bedrock terrain is somewhat subdued by an overburden cover that may reach several tens of metres in thickness. Local accumulations in excess of 100 m have been encountered in water wells along the valleys of the Big East River and the North and South Branches of the Muskoka River.

The contact between Precambrian and Paleozoic rocks is strongly reflected by drift thickness. A north-facing escarpment composed entirely of glacial drift marks the contact between the 2 rock types. Limestone of the Gull River

Formation does, however, outcrop over much of the area north of Port McNicoll. Drift thicknesses on the peninsulas east of Midland are generally less than 30 m and most often less than 20 m. Drift thickness increases rapidly to the west, on the main part of the Penetanguishene Peninsula, where water-well records indicate overburden thicknesses in excess of 150 m. Most of the water-wells in this area do not reach bedrock. A water well located approximately 2 km southwest of Macey Lake on Tiny Township Concession 18 encountered 4 feet of "black granite" at 180 m depth. It is uncertain whether bedrock was encountered in this borehole. Several boreholes situated just above lake level along the west coast of the Penetanguishene Peninsula encountered bedrock at depths of 45 to 60 m. Limited information is available for drift thickness on Christian Island. The maximum reported depth on the island is 41 m along the southeast coast.

Striae and Associated Ice Flow Features

Both erosional and depositional ice flow indicators were observed in the Huntsville-Penetanguishene area. Erosional forms consist of glacial striae, grooves, chattermarks, crescentic fractures and roches moutonnées (Photo 3). Depositional forms consist of crag and tail features, fluted ground moraine and low relief drumlins. Fluted and drumlinized till plains are confined primarily to the Simcoe Upland and a few areas of more extensive till cover on the Algonquin Highland.

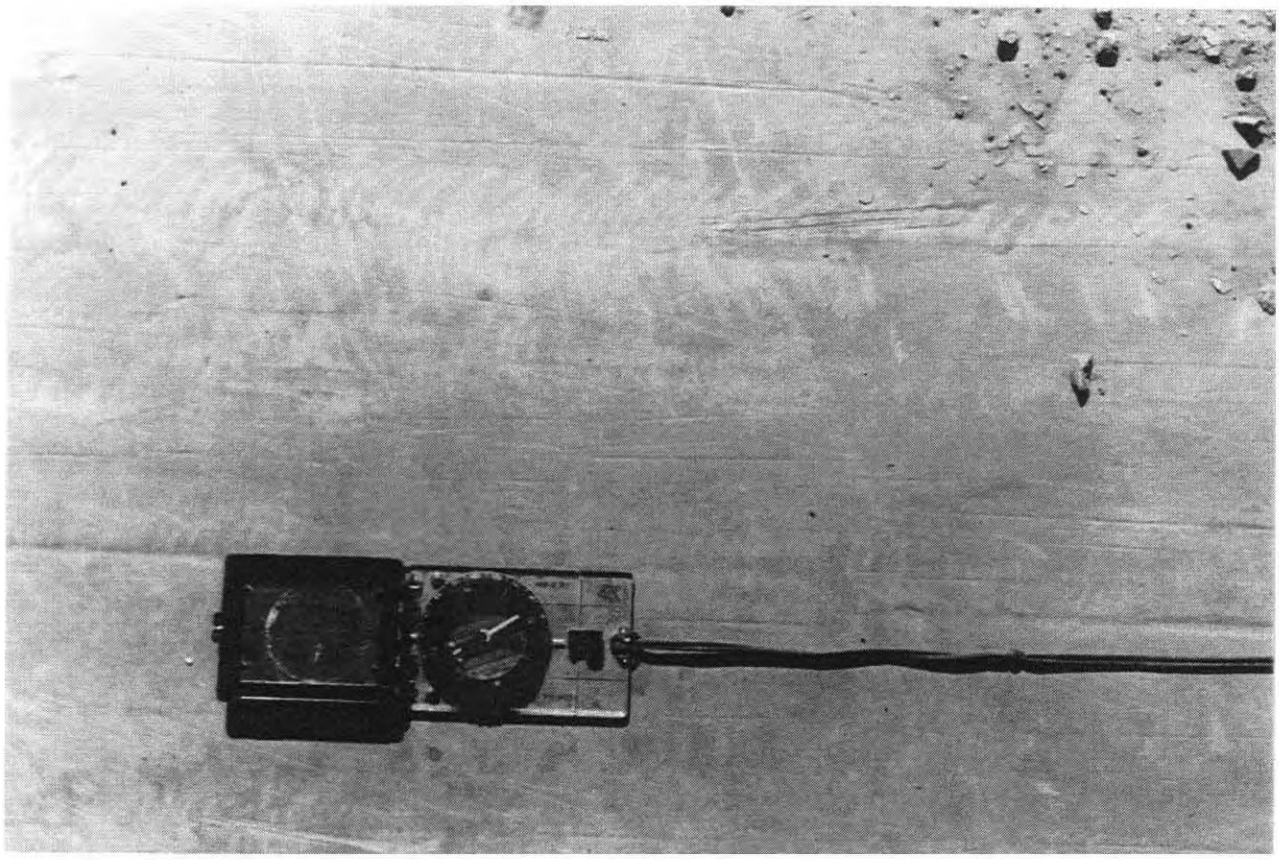


Photo 3. Crescentic fractures and striae on polished, lithographic limestone of the Gull River Formation, Orillia Township.

Much of the gneissic Precambrian rocks are coarse-grained, heavily weathered and lack glacial polish. Subglacial water-erosion forms, as exist to the north along the shores of Georgian Bay (Kor et al. 1991), are not common. However, potholes and other varieties of s-forms have been locally recognized.

Over 200 ice flow indicators were measured across the report area. Together, they suggest a remarkably consistent ice flow towards 190^{o} with a standard deviation of 10^{o} and a range of 155^{o} to 220^{o} (Figure 4). Local variations from the mean are best explained by minor deflections around local topographic obstructions and draw down into topographic depressions during the waning stages of glaciation. Earlier ice flow events have not been recognized in the striation record of the report area.

Deposits Pre-dating the Main Late Wisconsinan Till Sheet

On the Simcoe Upland, several drift packages predating the main, Late Wisconsinan till sheet have been identified both in surface exposures and in sonic boreholes. At least 2 pre-Late Wisconsinan or older tills with intervening layers of stratified sediment have been recognized. The ages of these sediments are unknown. They may represent either the deposits of ice fluctuations early in Late Wisconsinan time or events pre-dating the main Late Wisconsinan glaciation (ie. Early Wisconsinan Substage or older).

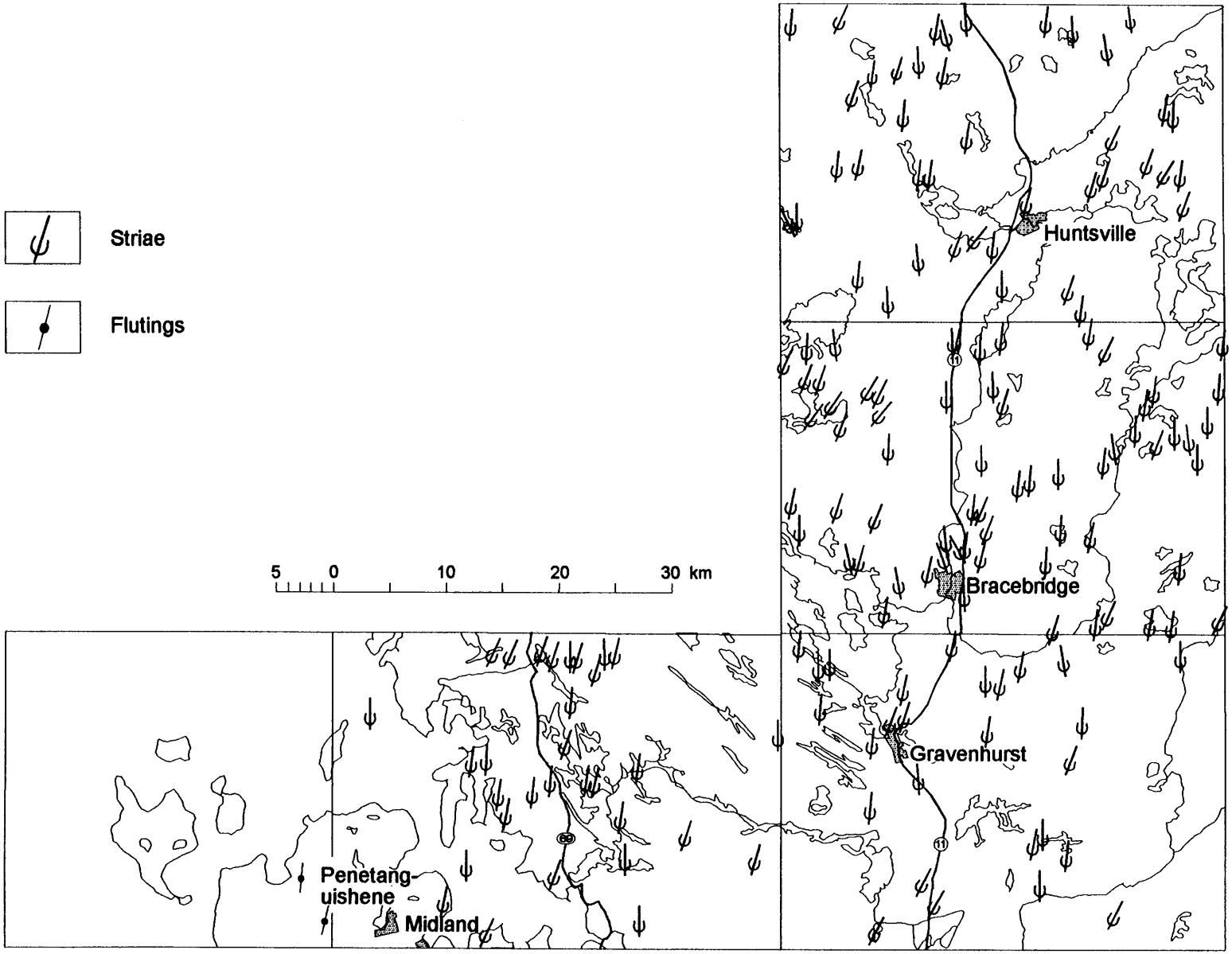


Figure 4. Ice flow patterns across the report area.

Till

Two distinct textural and compositional classes of till have been recognized beneath the main, Late Wisconsinan till sheet. These 2 classes may represent 2 or more distinct till units. However, in the 3 boreholes in which both of the 2 older till units are present, they both occur in the same stratigraphic sequence; that is, a coarse-textured till is overlain by a fine-textured till. If the fine and coarse-textured tills are correlatable across the Penetanguishene Peninsula, a distance of about 20 km, their upper surfaces occur at significantly different elevations (i.e. up to 130 m difference) and may drape over older, palimpsest surfaces.

The older, coarse-textured till was encountered beneath the fine-textured till in 3 of the 5 sonic boreholes drilled as part of this project (Figure 5, back pocket). Sonic borehole logs are contained in Appendix A. Surface exposures of this till have not been recognized. The till rests on bedrock in 2 of the 3 boreholes and is underlain by, at least, 30 m of stratified drift in the other. The till has a maximum observed thickness of 13 m in borehole P92-01 and is only 0.4 m thick in borehole P92-02.

The till has an average grain size composition of 48% sand, 38% silt and 13% clay with a total carbonate content of 34% and a calcite to dolomite ratio of 2.0 (Table 1). Where the till lies directly upon Paleozoic carbonate bedrock, as in borehole P92-04, it contains very high concentrations of Paleozoic carbonate pebbles (90%). In contrast, where the

Table 1. Summary table of grain size and carbonate content for till samples.

		% Sand	% Silt	%Clay	Total % Carbonate	Ca/Do Ratio
Silty flow tills on Paleozoic terrain N=2	Mean	36	54	11	16	1.1
	Range	29-42	49-59	9-12	-	0.9-1.3
	STD	7	5	2	0	0.2
Surface sand till on Paleozoic terrain N=36	Mean	65	27	8	19	1.0
	Range	42-86	10-47	4-16	1-57	0.2-7.2
	STD	10	9	3	13	1.2
Sand till on Precambrian terrain N=79	Mean	69	29	2	1	0.4
	Range	38-83	15-56	0-6	0-2	0.1-1.0
	STD	7	6	1	0	0.2
Older, fine-textured till on Paleozoic terrain N=27	Mean	30	50	19	30	2.4
	Range	10-61	30-70	9-36	5-53	0.5-4.9
	STD	11	9	7	10	1.0
Older, coarse-textured till on Paleozoic terrain N=7	Mean	48	38	13	34	2.0
	Range	33-66	24-48	6-19	17-55	1.0-3.3
	STD	12	8	5	14	0.9

till is underlain by Precambrian bedrock, as in borehole P92-01, it contains reduced concentrations of carbonate pebbles (60 to 75%).

In the 2 boreholes, where a substantial thickness (greater than 5 m) of this till was encountered, the till is massive, dense, over-consolidated and probably has a subglacial, lodgement origin.

The upper, fine-textured till has been observed both in surface exposures and in sonic drill core. Surface exposures of the upper, fine-textured till can be seen at several locations on the Penetanguishene Peninsula (Photo 4). They occur in poorly exposed roadcuts, along the flanks of the till capped uplands. Notable examples occur on the 18th concession of Tiny Township, about 3 km southwest of Farlain Lake; on the 21th concession of Tiny Township along the eastern flanks of Lafontaine Hill; and along the slopes of the upland just west of Reynold's Point on Penetang Harbour. This till was also encountered in 4 of 5 sonic boreholes drilled as part of this project.

The fine-textured till is silty (30% sand, 50% silt, 19% clay), stone-poor, averages 30% total matrix carbonate with a calcite to dolomite ratio of 2.4 and contains a high proportion of Paleozoic carbonate clasts in the pebble-size fraction (Table 1).

At several sites, the till is interbedded with and/or overlies fine-grained, glaciolacustrine deposits suggesting deposition within a glacial lake basin. In borehole P92-02

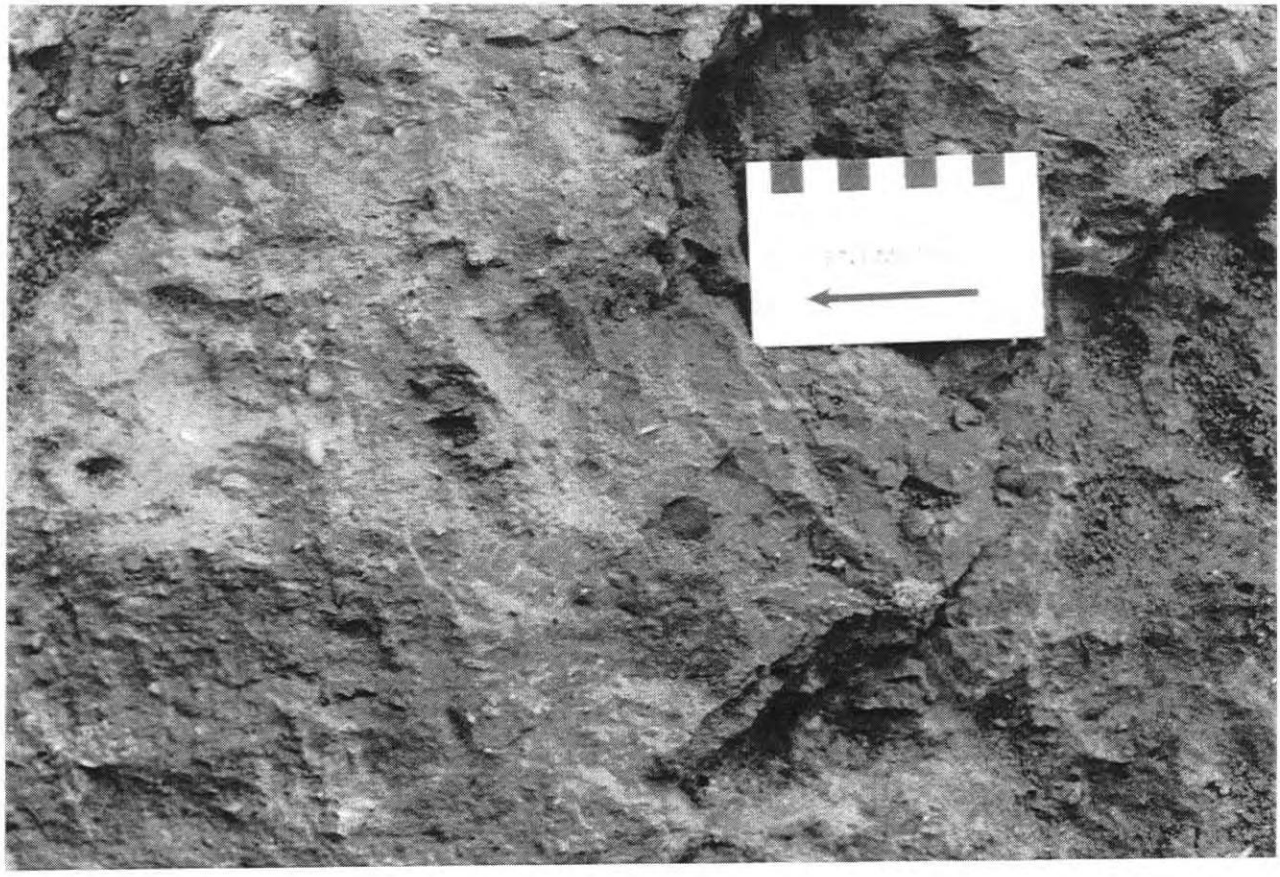


Photo 4. Pre-Late Wisconsinan, fine-textured, stone-poor till exposed along the northern flank of Lafontaine Hill, Tiny Township.

(Figure 5, back pocket), approximately 9 m of dense, massive, subglacial till is overlain by 19 m of subaquatic flow tills interbedded with well laminated silts and silty very fine sand containing ice-rafted debris. The lower and upper facies represent the deposits of ice advance and retreat, respectively.

The fine-grained nature of the till matrix coupled with the abundance of Paleozoic carbonate clasts suggest a northwesterly source (Georgian Bay Lobe) for the till. A similar, fine-textured till was encountered in the Barrie-Elmvale area to the south beneath a sandy surface till (Barnett 1991).

Stratified Drift

Stratified sediments separating and underlying the pre-Late Wisconsinan tills have been identified in surface exposures and sonic borehole cores across much of the Penetanguishene Peninsula. However, only the youngest stratified unit has been observed in surface exposures.

Over 30 m of well bedded, sand and pebbly sand, of probable glaciolacustrine origin, underlies the older, coarse-textured till in borehole P92-02. This unit has not been documented in any of the other sonic boreholes drilled as part of this study. The vertical and lateral extent of this unit is unknown.

A stratified unit separating the older, fine-textured till from the older, coarse-textured till is only positively

observed in sonic core. In borehole P92-01, where it is thinnest, it consists of 0.3 m of poorly sorted, medium to coarse sand. In borehole P92-02, this unit is about 25 m thick and consists of a fining-upward sequence of fine and medium sand to silt and sandy silt. A similar fining-upward sequence was encountered in borehole P92-04 where it attains a thickness of 19.5 m. A glaciolacustrine origin is assigned to this unit as well.

Stratified deposits separating the older, fine-textured till from the surface sandy till have been observed both in surface exposures and sonic drill core. Surface exposures of this unit have been observed primarily in steep shore bluffs of ancestral Huron basin lakes. The most notable exposures occur in the Lake Algonquin bluff surrounding Lafontaine Hill and in the Nipissing bluff along the east side of Thunder Bay. In each case, the stratified deposits are sandy to silty and contain little or no clay or gravel. These sediments are interpreted to be glaciolacustrine deposits of possible, subaquatic fan origin.

Other examples of the upper stratified unit occur at isolated surface exposures in Tay Township near Port McNicoll, Midland and St. Andrews Lake. In Port McNicoll, a sand pit cut into the side of a drumlin exposes about 5 to 6 m of cross-bedded, fine sand and pebbly, fine sand with large channel scours 4 to 5 m wide and up to 1 m deep beneath up to 3 m of silty, very fine sand till (Photo 5). The sands are interpreted to represent the mid-fan channel facies of a

Photo 5. Subaquatic fan sands underlying the surface, sandy till near Port McNicoll, Tay Township.

subaquatic fan deposit (Rust 1977). Along the western edge of the town of Midland, about 7 m of silty, very fine sand till is underlain by a minimum of 5 m of massive to laminated, silty, very fine sand grading down to fine and very fine sand of glaciolacustrine origin. To the north, glaciolacustrine silt and very fine sand underlies till along a roadcut 2 km east of St. Andrews Lake. The glaciolacustrine sediments contain abundant ice-rafted debris.

Glaciolacustrine sediments, believed to represent the upper, stratified unit, also occur as an erosional remnant on the Nipissing terrace north of St. Andrews Lake. Here the deposit consists of rhythmically laminated silt and clay which, in some cases, is capped by a boulder lag that represents the winnowed remains of the surface till.

An additional occurrence of varved silts and clays has been recorded near lake level at Asylum Point on Penetang Harbour. At this locality, the varved silts and clays are presumed to underlie the surface till which outcrops further upslope to the east. However, it is possible that these sediments represent the deposits of Glacial Lake Algonquin and overlie the surface till within the Penetang Harbour valley.

The upper stratified unit was encountered in all sonic boreholes drilled as part of this project (Figure 5, back pocket). It is sandy in all cases and probably of glaciolacustrine origin. The maximum observed thickness of this unit is just over 40 m.

The presence of buried, sandy deposits of the upper stratified unit has been inferred along shore bluffs of the Penetanguishene Peninsula where surface exposure is lacking. For example, where cohesive, relatively impermeable sediment, such as till overlies sandy, stratified deposits, wave attack has created steep cliffs.

Also, if a fine-grained unit is present at the base of the bluff, groundwater piping may occur along its upper surface resulting in the formation of large, amphitheatre-shaped, erosional scars. This erosional pattern has been observed along the Algonquin bluff, on the eastern side of Lafontaine Hill, as well as on the northeast flank of an Algonquin island just north of the hamlet of Laurin.

The upper, stratified unit appears to represent an important glaciolacustrine event that post-dated the deposition of the fine-textured till. As should be expected for a glaciolacustrine deposit, this unit gets thinner at higher elevations. There may be a time break between the deposition of this unit and the overlying surface till.

Varved silts and clays were encountered on the Nipissing plain at Silver Birch Beach northeast of Thunder Bay. The varved silts and clays, most likely, represent an erosional remnant of an older stratigraphic unit which extends eastward, in the subsurface, beneath the upland sediments. A boulder lag overlies the varves in places suggesting the prior removal of a coarse-textured deposit. The glaciolacustrine deposits occur over 100 m below the upper surface of the till plain

which is situated at the top of the shorebluffs to the east. The stratigraphic assignment of this unit is unknown.

Paleosols

In borehole P92-01, the upper portion of what has been interpreted as "the older, fine-textured till", shows signs of being oxidized and leached. The upper 0.3 m is depleted of matrix carbonate and displays an orangy-brown colour. Oxidation extends nearly 3 m into the unit as indicated by mottles of orangy-brown and buff-grey sediment.

The top of the oxidation horizon occurs about 9 m below the present level of Georgian Bay (i.e. 168 m asl). If the leaching and oxidation represents a period of soil formation as a result of subaerial exposure, a non-glacial interval during which water levels could fall to levels below the present must have existed. An ice margin north of Algonquin Park and possibly as far north as North Bay would have allowed for the opening of eastern outlets to the Ottawa River valley and hence, a corresponding decline in water levels. The Middle Wisconsinan Interstadial is most likely the non-glacial interval during which soil formation occurred. This would suggest at least an Early Wisconsinan age for the older till units recognized on the Simcoe Upland.

Late Wisconsinan Deposits

In this section, deposits associated with the final retreat of the Laurentide Ice Sheet from the report area will be discussed. Late Wisconsinan deposits found on the Simcoe

Upland are often markedly different in character from those found on the Georgian Bay Fringe and Algonquin Highland physiographic regions.

Till

In the shield portion of the report area, till most commonly occurs as a thin, discontinuous, draping veneer over bedrock. Within a large proportion of the Georgian Bay Fringe physiographic region, the till cover is not extensive or thick enough to warrant delineation on the map. Areas of patchy, thin till are included within the bedrock-drift complex. The till in these areas is often deeply weathered and washed in the upper metre. In places, the till has been completely removed by glaciolacustrine processes leaving nothing more than scattered boulders upon a bare bedrock surface.

Thicker and more widespread accumulations of till occur locally, within portions of the Algonquin Highland physiographic region (Photo 6). Till thicknesses of 3 to 5 m are common in swales between bedrock knolls and ridges. In these areas, the surface expression of the underlying bedrock topography is greatly subdued. Areas of fluted ground moraine, generally less than 1 km in length, have been identified in Brunel, Franklin and Perry townships. In these areas, the till cover is continuous and of sufficient thickness to completely mask the underlying bedrock topography.

Photo 6. Massive, subglacial facies of surface sandy till found on the Algonquin Highland, Chaffey Township.

The average grain size composition of till collected from the Precambrian Shield terrain is 69% sand, 29% silt and 2% clay. This sand till contains very low levels of matrix carbonate (0 to 2%) (Table 1). Although not valid for such low concentrations, an average calcite to dolomite ratio of 0.4 is reported. Aside from those samples collected down ice from Skeleton Lake, few samples contain Paleozoic carbonate pebbles.

Several facies of till have been recognized on the shield portion of the report area. The most abundant facies is a loose, silty, sandy, stone-poor till with numerous stringers of stratified sand and a high proportion of abraded and faceted clasts. This facies represents the deposits of both subglacial meltout and stacked ice-marginal debris flows.

A loose, sandy, stony till facies containing a high proportion of stratified sediment and few glacially abraded clasts occurs locally within upland areas of the Algonquin Highland. This facies is probably a result of deposition by supraglacial meltout. Several occurrences of similar material have been observed in low-lying areas, draping the leesides of bedrock obstructions. These deposits are interpreted as subglacial meltout tills derived from the melting of debris-rich ice charged with local bedrock.

Few till exposures exhibiting features suggestive of grounded, active ice (i.e. shear planes, fissility, boulder pavements, etc.) were found within the shield terrain during the course of mapping. Where they were observed, they usually

occur on the stoss side of bedrock highs. The till at these sites is generally massive, silty to sandy, stone-poor, moderately dense, slightly fissile and contains negligible amounts of stratified sediment. These tills are interpreted to be the deposits of lodgement processes.

The least common till facies recognized within the shield terrain is sandy, silty and stone-poor. It occurs as distinct layers, seldom greater than 1 m thick, and is often interbedded with glaciolacustrine deposits. This facies is confined to low-lying, glaciolacustrine basins. It is interpreted as a deposit of subaqueous debris flows, most likely of glacigenic origin.

The thickness and character of the surface, sandy till changes dramatically as one proceeds southward onto Paleozoic terrain (Figure 5, back pocket). This is probably a reflection of the change in susceptibility to erosion of the softer, Paleozoic rocks and overlying pre-Late Wisconsinan deposits as compared to the hard crystalline rocks of the Grenville Province.

Within Paleozoic terrain, outcroppings of till occur primarily on upland surfaces, notably those areas unaffected by glacial lake processes (i.e. Algonquin islands). Less frequently, till forms the surface material at lower elevations on the upland areas where processes of nearshore erosion were less vigorous.

The maximum documented thickness for the surface sand till was recorded on Lafontaine Hill where about 18 m was

intersected in a sonic borehole (P92-02). More commonly, a thickness of 5 to 10 m was observed on the Penetanguishene Peninsula.

This till is finer-textured than that observed on the Precambrian Shield. The shift in grain size is best depicted on a ternary diagram (Figure 6). The till has an average grain size composition of 65% sand, 27% silt and 8% clay (Table 1). The striking difference between the 2 subareas is the marked increase in average clay content. The sand till in the Penetanguishene Peninsula area also displays a dramatic compositional change. The average matrix carbonate content rises to 19% and displays a calcite to dolomite ratio of 1.0. A corresponding increase in the carbonate pebble content was observed as well. Carbonate pebble contents of 60 to 70% are typical for this unit.

Where thick sequences of till were observed, there appeared to be a progressive upward change from till with interbeds and lenses of sand, near the base to massive till near the surface. A thin capping of interbedded till and laminated sand and/or silt was locally encountered near the surface. The lower facies was probably deposited as either ice-marginal debris flows or subglacial cavity fills. The massive facies is most likely, a subglacial lodgement till. Surface flutings have been identified on the peninsula between Midland and Victoria Harbour, on Lafontaine Hill and on the upland due east of Thunder Bay confirming a subglacial origin for at least a portion of the till package (Photo 7).

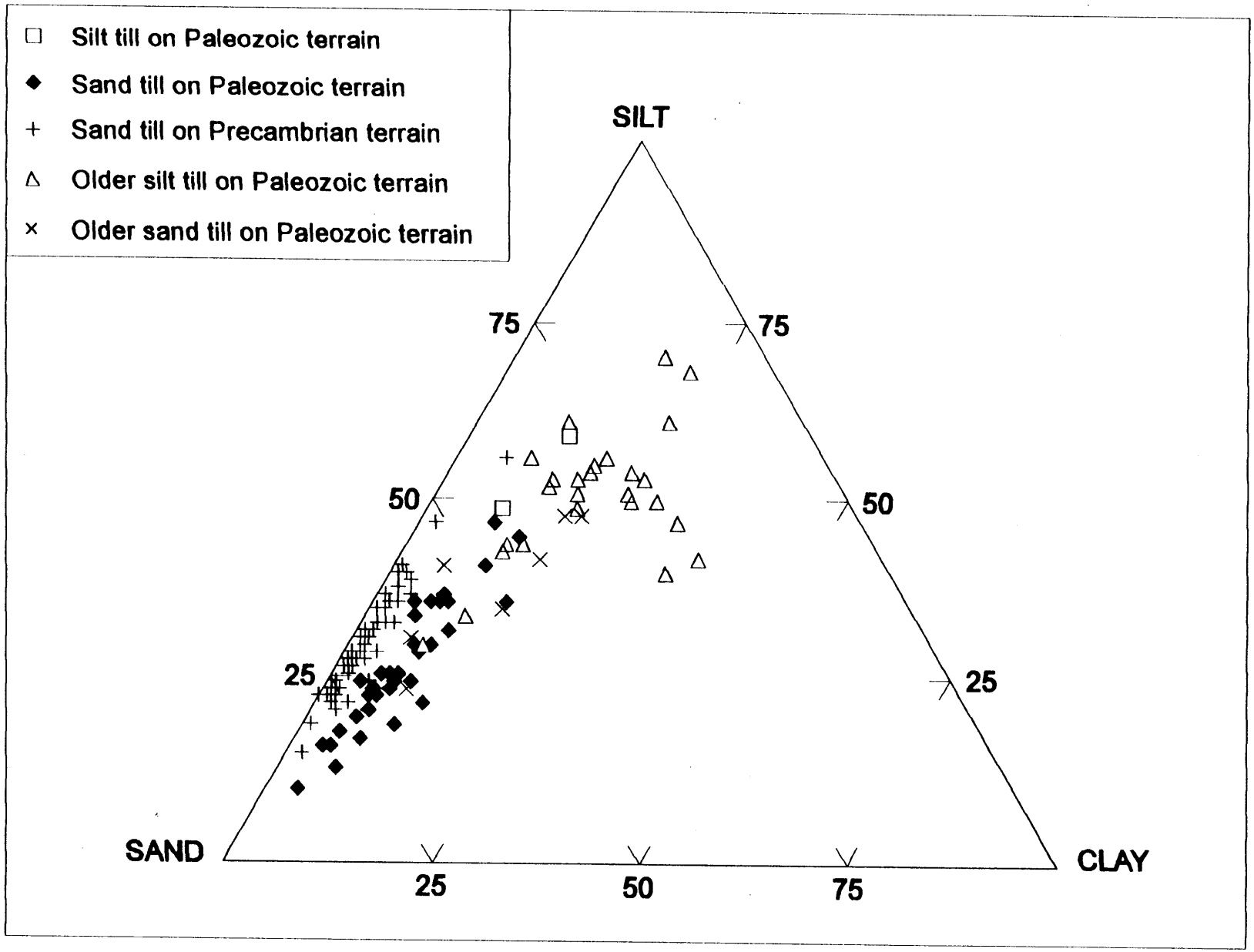


Figure 6. Ternary diagram of grain size for till.

Photo 7. Aerial photograph of a portion of the Penetanguishene Peninsula displaying fluted till plains on the upland surfaces, Tiny Township (photo ref.# A19542-52).

Late stage, glacial stagnation on the uplands resulted in the local accumulations of the upper, substratified till facies. Ice-marginal debris flows and meltout tills form an important component of this facies. Similar deposits have been observed on upland areas to the south, in the Barrie-Elmvale areas (Barnett 1991).

A fine-textured diamicton of gritty silt composition was encountered in surface exposures along the western edge of the Christian Island map area. The diamicton occurs as thin layers of subaquatic flow till interbedded with sandy to silty glaciolacustrine sediments. Based on 2 analyses, the diamicton has an average grain size composition of 36% sand, 54% silt and 11% clay with a matrix carbonate content of 16% and a calcite to dolomite ratio of 1.1 (Table 1, Figure 6).

This unit is probably equivalent to a fine-textured (sandy silt) till identified to the south in the Nottawasaga area (Burwasser and Boyd 1974). In this area, east-southeast-trending fluted landforms on this till surface suggest a Georgian Bay source for the deposit. The till was probably deposited during a late-stage reactivation, or surge event, of the Georgian Bay ice lobe. The diamicton deposits observed in the report area along the western edge of the Penetanguishene Peninsula are probably ice-marginal and associated with this same advance. A subglacial equivalent has not been recognized within the report area.

Glaciofluvial Deposits and Features

Ice-contact Deposits

Deposits of ice-contact stratified drift are sporadically distributed throughout the report area. Within the Algonquin Highland, they occur as: either isolated esker ridges or esker complexes; flat-topped kame terraces fringing valley walls; and kames in low-lying areas. Compositionally, these features are variable, consisting of boulder gravel to very fine sand and silt.

Several esker systems have been recognized within the report area. The systems are generally short (i.e. less than a few km long) and consist of small, sinuous, esker ridges, usually not exceeding 10 m in height.

The most extensive esker complex mapped within the report area is about 12 km long. It originates at Clear Lake, located along the north-central margin of the Huntsville map area, and extends southward through Novar to Waseosa Lake. Here, it bifurcates into 2 systems which terminate in sandy outwash plains. The esker sediments in this system are predominantly, coarse-textured.

A smaller, esker-kame complex occurs about 2.5 km west of Britannia at the northwest corner of Lake of Bays. The complex is about 2.5 km long and consists of an anastamosing system of esker ridges, 3 to 10 m in height. At the southern end of the system, the ridges are bounded by small ice-block depressions, 100 to 200 m in diameter. The esker complex

terminates at a flat-topped, fan-shaped, ice-marginal deposit of sand and gravel, 300 m long and 200 m wide.

Several, smaller, ice-contact systems have been identified within the report area as well. An esker-kame complex along the southeast margin of Lake of Bays extends southward through Grandview Lake, where it terminates in a broad outwash plain north of Echo Lake. An esker-kame complex originating at Heck Lake, which is located in the northeast corner of the Huntsville map area, extends southward into Bella and Rebecca lakes where it bifurcates into 2 systems. One system extends southwestward into the Benson Lake basin and the other, to the southeast into the Solitaire Lake basin.

As with the esker systems, kame complexes are confined primarily to low-lying areas within the Algonquin Highland and are of limited size.

Within the Georgian Bay Fringe physiographic region, ice-contact deposits occur as buried esker complexes and ice-marginal facies of subaquatic fans. Many of the buried esker systems terminate at subaquatic fans. In most cases, thick sequences of glaciolacustrine sand, silt and clay conceal the coarse, ice-contact, fan cores (Photo 8). For this reason, the fans generally fail to display positive relief and are, therefore, difficult to identify on aerial photographs. They are usually confined to bedrock valleys, however, their cores are difficult to trace at depth. Compositionally, the ice-contact cores are quite variable ranging from dirty, boulder gravel to silt and clay.

Photo 8. Gravelly, ice-contact fan core overlain by fine-textured glaciolacustrine sands and silts, Macauley Township.

A deposit of sand and gravel, located 2.5 km south of Lake Vernon, is a notable example because of its large size and excellent exposures. This deposit has a north trending ice-contact core which is, in places, buried by well over 20 m of fine sand to silty very fine sand. The ice-contact core was probably deposited subglacially, within a conduit, and was later buried by proglacial subaquatic fan sediments.

Within the report area, 3 major subaquatic fan systems, linked by buried esker complexes, have been identified. The fans mark former ice-margin positions. These systems, which extend for several tens of kilometres, are probably fed by meltwater systems confined to subglacial conduits.

The valleys of the South and North Branches of the Muskoka River and the lowland extending from Skeleton Lake, south through Three Mile Lake into Lake Muskoka, contain the most important subaquatic fan systems. Numerous sand and gravel operations situated along these corridors are contained within the subaquatic fan deposits. The conduit deposits are probably buried beneath excessive thicknesses of fine sediments between the fans.

A less extensive system, extending southeastward from Clear Lake towards Morrison Lake, has been recognized in the barren rocky landscape southwest of Lake Muskoka. This system is fairly continuous although of limited areal extent.

Few deposits of ice-contact stratified drift have been identified on the Penetanguishene Peninsula. Kames and crevasse-fills are present above the Lake Algonquin shoreline,

on the west edge of Awenda Provincial Park and along the southern side of Lafontaine Hill. They consist primarily of fine to very fine sand with minor pebbly sand and gravel. Numerous boulders are scattered on the surface of these features.

Most of the remaining ice-contact deposits occur below the Lake Algonquin shoreline and are therefore, extensively modified by nearshore processes. Exposures within these deposits are poor thus preventing a more specific evaluation of their origin. Several isolated, ice-contact deposits have been recognized north of Lafontaine Hill. A deposit situated between the 16th and 17th concessions of Tiny Township, just north of Lafontaine Hill, may represent the ice-proximal facies of a subaquatic fan deposit. A steep, east trending ridge of sand with minor gravel, located approximately 1 km south of Macey Lake, most likely represents deposits that accumulated along an ice margin. Hummocks of sand and gravelly sand with surface accumulations of large boulders occur about 1 km northeast of Lafontaine Hill. These deposits have been interpreted as kames.

A broad, northwest trending belt of ice-contact stratified drift occurs above the Nippising bluff on the western edge of the Penetanguishene Peninsula. This belt represents an ice-marginal deposit associated with a late-glacial advance of the Georgian Bay lobe. The moraine has a surface expression consisting of low-relief hummocks with numerous surface boulders. Materials ranging from boulder

gravel to fine sand and silt have been observed within the feature. Locally, morainic sediments exceed 30 m in thickness. These sediments were most likely deposited in a subaquatic environment as coalescing subaquatic fans. Cross-bedded, rippled and planar laminated medium to fine sands with paleocurrents directed towards the south-southeast were observed in several sections. Well laminated, glaciolacustrine silts and fine to very fine sands with interbeds of silty diamicton occur at the surface throughout much of the moraine. The surface boulders may be ice-rafted. Hummocks of cobble to boulder gravel occur in the northwest end of the feature between the 18th and 19th concessions. The southern and northern spurs of Christian Island may represent the northern extensions of this moraine. Ice-marginal deposits associated with this advance have not been recognized to the south in the Nottawasaga area.

Outwash Deposits

Glaciofluvial outwash deposits are defined as those sediments deposited within shallow, meltwater streams beyond the ice margin. They are typically well sorted and display a fining trend away from the glacier margin.

Outwash deposits are only found in upland areas above the limit of Glacial Lake Algonquin. As low-level northern outlets to the Ottawa valley opened with ice retreat, lake levels fell in a series of steps. The newly exposed lake plains received negligible amounts of glaciofluvial sediment,

because of the distant ice source. For this reason, glaciofluvial deposits have not been recognized within the Georgian Bay Fringe physiographic region.

Within the Algonquin Highland, glaciofluvial deposits are restricted to areas situated above 300 m near Bracebridge and 335 m near Huntsville. On the Simcoe Upland, glaciofluvial deposits are found only at elevations above 260 m.

Several glaciofluvial systems have been identified within the Algonquin Highland. They are usually flat to gently undulating and confined to deep, narrow, bedrock valleys. Broad, outwash systems, up to 2 or 3 km wide, are less common. The most notable outwash systems are situated: 1) along the upper reaches of the Big East River; 2) along the South Branch Muskoka River; 3) in McLean Township, along the valley of Kawpakwakog Creek; 4) in McMurrich Township, on the upland south of Sprucedale; and 5) within an intricate network of channels crossing the highland bounded by Mary Lake, Fairy Lake, Peninsula Lake and Lake of Bays.

Aside from those deposits along the upper reaches of the North Branch Muskoka River and those adjacent to Grandview and Echo lakes, most of the outwash deposits are sandy and contain negligible amounts of gravel. The deposits are generally well graded and contain broad, nested channel forms and large-scale trough and planar cross-beds (Photo 9). Ice-block depressions are found only locally within these deposits.

Deposits of medium to very fine sand of probable glaciofluvial origin occur within the Simcoe Upland on the

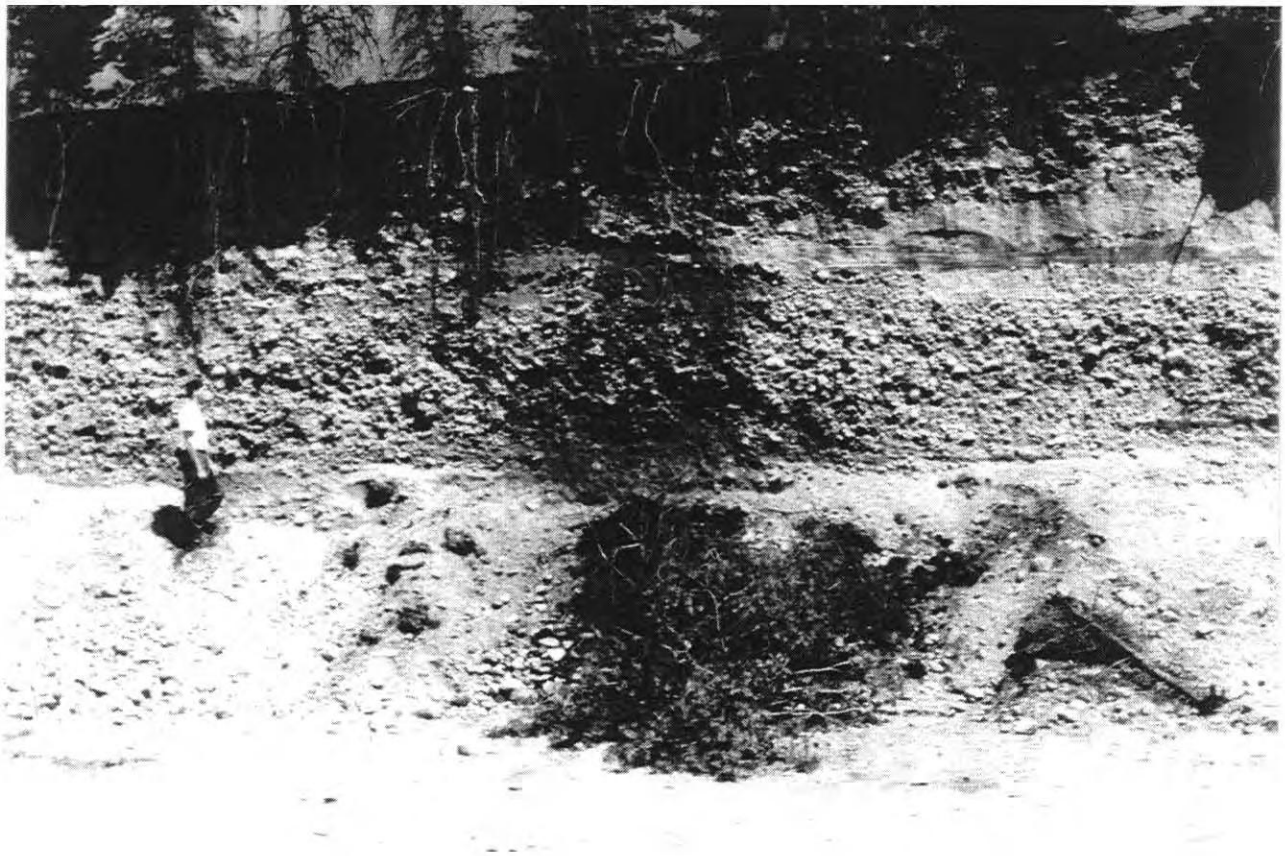


Photo 9. Glaciofluvial outwash sand and gravel, McMurrich Township.

tops of Lafontaine Hill and the upland due east of Thunder Bay. These deposits have an undulating surface expression and are confined to low-lying areas between fluted till uplands. A lack of exposures within these deposits has hindered the determination of unit thickness. They are most likely, less than 3 to 4 m in thickness.

Glaciolacustrine Deposits and Features

Glacial Lake Algonquin, a large, ancestral, Huron basin water body, fronted much of the retreating ice sheet within the report area (Figures 7 and 8). Aside from a few scattered islands, the lake inundated most of the Georgian Bay Fringe and Simcoe Upland physiographic regions. Water depths in the order of 85 m existed along the present shores of Georgian Bay and progressively decreased inland towards the outer fringe of the Algonquin Highland. Water levels fell in a step-like manner as low-level northern outlets to the Ottawa River valley were uncovered with ice retreat. With the opening of the lowest level outlet at North Bay, water levels in the Huron basin fell to extremely low levels. Bottom coring from the northwest corner of Lake Huron suggest the existence of lake levels more than 100 m below the present lake level (Eschman and Karrow 1985).

Both deep and shallow-water sediment facies associated with these lake phases have been recognized. Shallow water deposits consist of ice-contact deltas and other littoral features including beach ridges, bars and spits. Deep-water

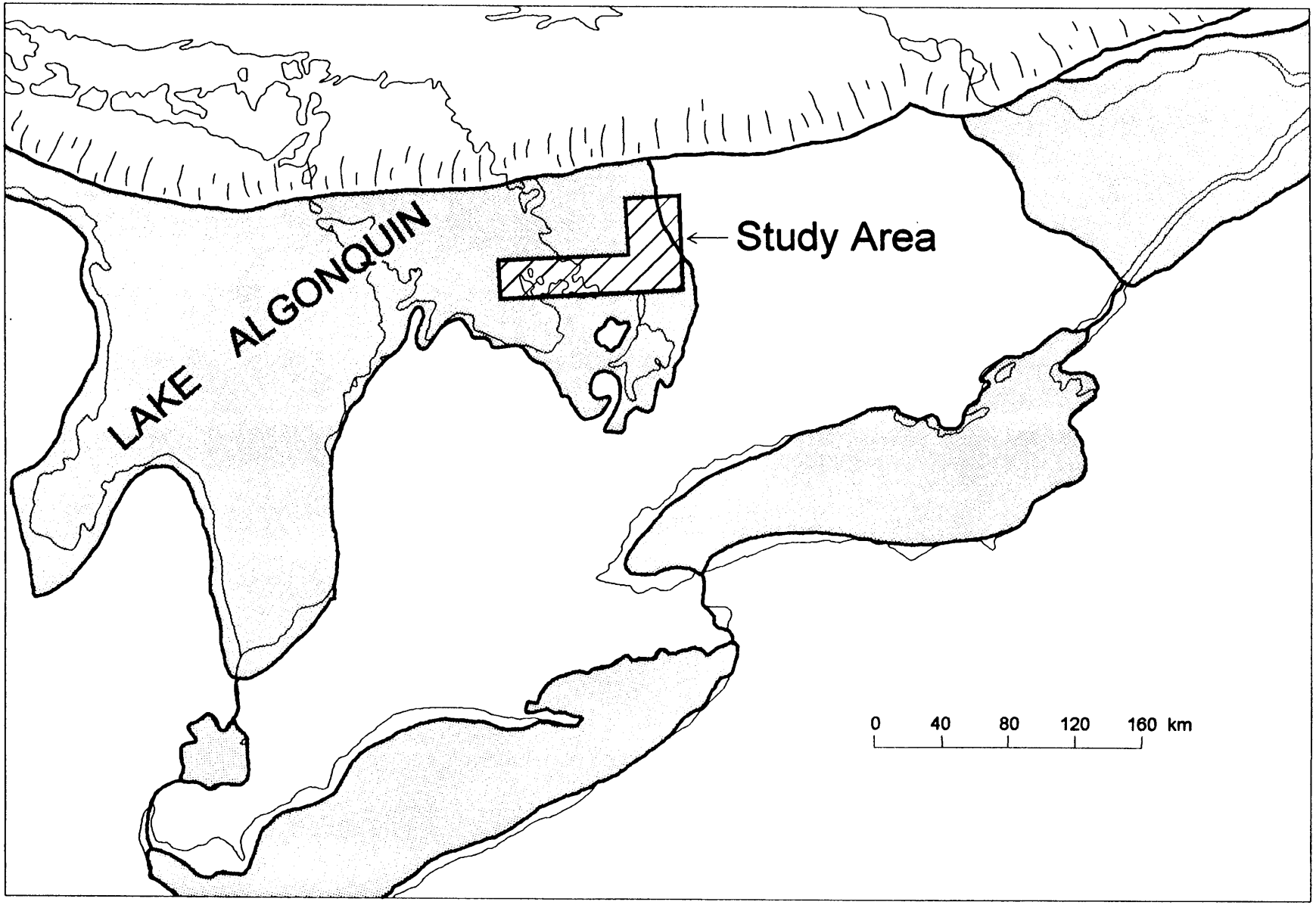


Figure 7. Regional paleogeographic reconstruction of the lower Great Lakes, 11 ka B.P.

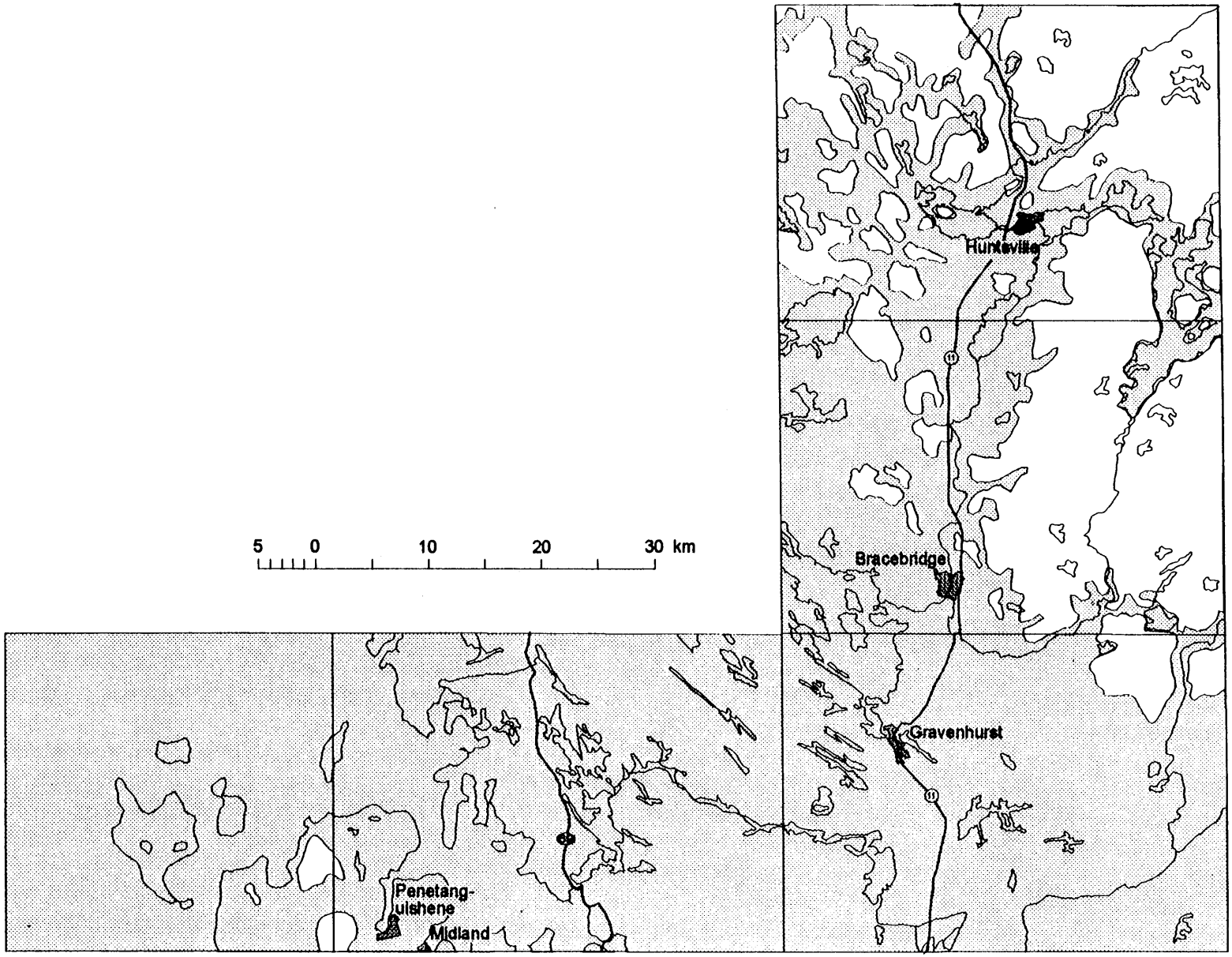


Figure 8. Paleogeographic reconstruction of the Lake Algonquin shoreline within the report area.

deposits occur as both sandy facies of subaquatic fans and as fine-textured basin fill sediments. Aside from constructional features, numerous erosional landforms were produced along the shorelines of Lake Algonquin and its successors. Wave-cut notches and bluffs, boulder lags and winnowed drift have been observed throughout the report area. These features are best developed within the Simcoe Upland where unconsolidated sediments were abundant and most susceptible to wave attack.

Deltas

Several ice-contact deltas have been identified within the report area. They are all found either within the Algonquin Highland or along its outer edges. These features are important in that they define the levels of Glacial Lake Algonquin in the Huron basin at specific times during deglaciation.

A large, ice-contact delta flanks the northwest rim of the Fish Lake basin near Novar. The delta is fed by an anastamosing esker complex that follows the Little East River valley. A steep, ice-contact slope marks the northwest edge of the delta where it crosses the valley. To the southwest, a bedrock upland flanks the delta on its ice-proximal side. A large sand and gravel pit located just north of Fish Lake displays steeply-dipping, sandy to gravelly foreset beds and horizontally-bedded, coarse-textured topset beds. The topsets occur at an elevation of 340 to 345 m asl.

A large ice-contact delta flanks the Big East River, 3 to 4 km north of the town of Huntsville. The deposit displays a steep ice-contact slope on its northwest flank and is confined by high ground on its eastern and western margins. The delta topsets occur at an elevation of 335 m asl Remnant ice-block depressions, 300 to 400 m in diameter, scatter the delta surface.

A smaller ice-contact delta is situated about 1 km south of Rock Island on the south shore of Lake Vernon. The deposit lies on the southwest flank of a prominent bedrock ridge, has a flat upper surface and occurs at an elevation of 325 to 330 m asl.

Glaciofluvial meltwater systems grade to the level of Lake Algonquin along the outer fringes of the Algonquin Highland. The transition from the subaerial to the subaquatic environment is often indistinct and difficult to recognize in the field on a geomorphic basis. The boundary between these depositional environments is based largely, on sedimentological criteria.

Nearshore Deposits

Littoral glaciolacustrine features and deposits are abundant within the Simcoe Upland and relatively uncommon within the remainder of the report area. This is attributed to the abundance of unconsolidated sediments on the Simcoe Upland and their inherent susceptibility to wave attack in contrast to the rock-dominated, shield terrain of the Georgian

Bay Fringe and Algonquin Highland. In the shield portion of the report area, littoral deposits consist primarily of regressive, blanket sands and gravels. Beach deposits are usually poorly developed. There are, however, exceptions within the shield region. The most notable of these are described below.

At the Bracebridge town dump, 2.5 m of nearshore, pebble gravels overlie a sequence of well bedded, slightly pebbly, medium to very fine sands. The lower sands displays abundant dewatering structures and were probably deposited along the outer margins of a subaqueous fan. The upper beach deposits occur at an elevation of approximately 305 m asl, a level consistent with the Main Algonquin phase of the Huron basin.

Much of Beausoleil Island is mantled by nearshore deposits of post-Algonquin, Huron basin lakes. Well over 10 m of nearshore sands and gravels were observed in an overgrown pit near the middle of the island. The nature of the sediments from which these beach deposits were derived is not known as very little subsurface information is available for the island. At least 2 distinct, wave-cut bluffs have been recognized around the perimeter of the island (Cedar Point and Nipissing scarps). They appear to be best developed on the eastern side of the island where they reach heights of several tens of metres.

A wave-cut notch and foreshore platform of glacial Lake Algonquin is located on the south shore of Fairy Lake, about 0.5 km east of Timber Bay. It is best seen in a cleared

pasture on the east side of a cottage road leading to the lake. The notch occurs at an elevation of 335 m asl. The foreshore platform is about 100 m wide and slopes gently to the north. Up to 1 m of well sorted, horizontally-bedded, nearshore sand overlies till on the platform. Similar shoreline features and deposits have been recognized at a similar elevation along the flanks of the upland due west of Highway 11, 2 km north of the hamlet of Melissa.

Regressive blanket sands overlie varved silts and clays in lowland areas north of Lake Muskoka as well as along the lower reaches of the North Branch Muskoka River valley. Varved silts and clays exposed in a sand and gravel pit located 3 km north of Milford Bay, are capped by 2 to 3 m of steeply-dipping, fine sands. The sands are found at an elevation of 260 m asl and were probably deposited within a migrating, post-Algonquin spit.

Regressive blanket sands and littoral deposits are an important component of the surficial geology of the Simcoe Upland. All areas situated below the Lake Algonquin shoreline (260 m asl) have been subjected to extensive washing, winnowing and redistribution of sediments.

Nearshore facies in this physiographic region consist of beaches, bars and spits. Beach deposits are situated around the perimeters of Lake Algonquin islands and on headland areas exposed to wave attack. They are derived largely from the washing of fines from the surface till with subsequent sorting of the remaining coarse fraction. As a result, the beach

deposits contain abundant Paleozoic carbonate clasts. The thickest observed accumulations of beach deposits are situated along the northwest corner of the Penetanguishene Peninsula, west of Thunder Bay. Thicknesses of 4 to 5 m are common in this area. Shallower deposit depths appear to be more common throughout the remaining portions of the peninsula. Large areas mapped as glaciolacustrine beach deposits (e.g. area around hamlet of Laurin; foreshore platform of Lake Algonquin east of Lafontaine Hill; area due west of Farlain Lake; areas along the north end of Awenda Provincial Park; and area south of Sawlog Bay east of Gignac Lake) are untested for their thickness and texture. Gravelly, storm beach ridges, up to 2 or 3 m in height, are common within these areas and may locally add to the total thickness of the deposits.

Spits, offshore bars and regressive blanket sands account for a significant proportion of the littoral deposits within the Simcoe Upland. The spits and bars are generally sandy to gravelly-textured whereas the regressive blanket sands usually contain little pebble-sized material. A large, Lake Algonquin spit extends off the northeast corner of Lafontaine Hill. The spit contains a coarse, high energy core on its eastern flank and a thick sequence of overwash sand and silt on its western flank. Both facies dip steeply towards the west and are unconformably overlain by 1 to 2 m of horizontally bedded sands and gravels. The total thickness of the deposit is well over 18 m.

Wave-cut notches and boulder lags of ancestral glacial lakes are fairly common within the Simcoe Upland (Photo 10). Within the Georgian Bay Fringe and Algonquin Highland, these deposit types are usually poorly developed and difficult to trace through the densely forested terrain. An intricate archipelago of islands probably dampened the effects of nearshore processes and prevented the development of strong shoreline features across this region.

Of the shorelines identified, the highest is correlated with that of Lake Algonquin which occurs at or just above 335 m asl in the vicinity of Huntsville and Novar. The level of this shoreline falls to the south to approximately 305 m asl near Bracebridge and 260 m asl on the Penetanguishene Peninsula. Figure 8 presents a paleogeographic reconstruction of this important lake phase within the report area.

Several lower levels, associated with falling Huron basin water levels, have been identified throughout the report area as well. On the Penetanguishene Peninsula, Stanley (1936) recognized 4 distinct water planes between the prominent Lake Algonquin shoreline and the younger Nipissing shoreline. These he named, in descending order, the Wyebridge, Penetang, Cedar Point and Payette levels. As suggested by their names, the type shorelines for these water planes are found within this part of the Huron basin. Subsequently, Cronin (1984) reinvestigated the shoreline record on the Penetanguishene Peninsula and recognized 6 well developed and several weakly developed water planes in the same interval. Figure 9 (back

Photo 10. Wave-cut notches at Waubashene. The ridge in the foreground is the Nipissing shoreline.

pocket) presents a summary diagram of the main shoreline features identified on the Penetanguishene Peninsula and adjacent islands.

Offshore Deposits

Offshore glaciolacustrine deposits can be subdivided into 2 basic types. Within the report area, both types were deposited at water depths well below wave base. The first type consists of both the proximal and distal, sandy facies of subaquatic fan deposits. These were formed by bottom-hugging, traction currents and suspended sediment plumes transporting and depositing large volumes of sediment from feeder conduits to both proximal and distal fan settings. The second deposit type is represented by the distal, fine-textured material deposited in quiet, basinal settings where settling of suspended sediment clouds was the primary depositional mechanism.

The sandy facies of subaquatic fans are usually confined to bedrock depressions and are closely associated with the main subglacial drainage systems described earlier in the section on ice-contact stratified drift. The deposits, some of which were laid down at water depths of 50 to 70 m, generally fine upward and to the south in response to a retreating ice margin. They consist primarily of massive, rippled, and planar laminated, occasionally pebbly, fine to silty, very fine sands. Multiple pulses of sediment are represented by repeating sequences of Type-A to Type-B ripple

laminae followed by sinusoidal or drape laminae (Photo 11). Loading and dewatering structures are common within these sediments. They result from the rapid deposition of water-saturated sediments and may be spatially associated with distinct environments of the subaquatic fan architecture (Paterson 1991).

Sandy, subaquatic fan deposits are most common along the Highway 11 corridor within the Georgian Bay Fringe as well as in low-lying areas around Fox Lake, Lake Vernon, Mary Lake and the north shore of Lake of Bays. Thick sand sequences (up to several tens of metres) have been recorded from the valleys of the North Branch Muskoka River and the Big East River. Less extensive deposits are found along the Black River, Gartersnake Creek and within an intricate network of channels north of Skeleton Lake and Lake Vernon. Few examples of this facies have been recognized within the Simcoe Upland. The most notable is located along Highway 27 due south of Penetanguishene. Other deposits undoubtedly exist, however, they are probably concealed beneath thin sequences of nearshore deposits

Sandy subaquatic fan deposits grade both laterally and vertically into fine-textured, glaciolacustrine deposits. The fine deposits consist of massive to well laminated silts and rhythmically laminated or varved silts and clays. The rhythmites are associated with deep, quiet water, basinal settings as existed around the perimeters of Sparrow Lake, Lake Muskoka, Three Mile Lake, Mary Lake, Lake Vernon, Fairy

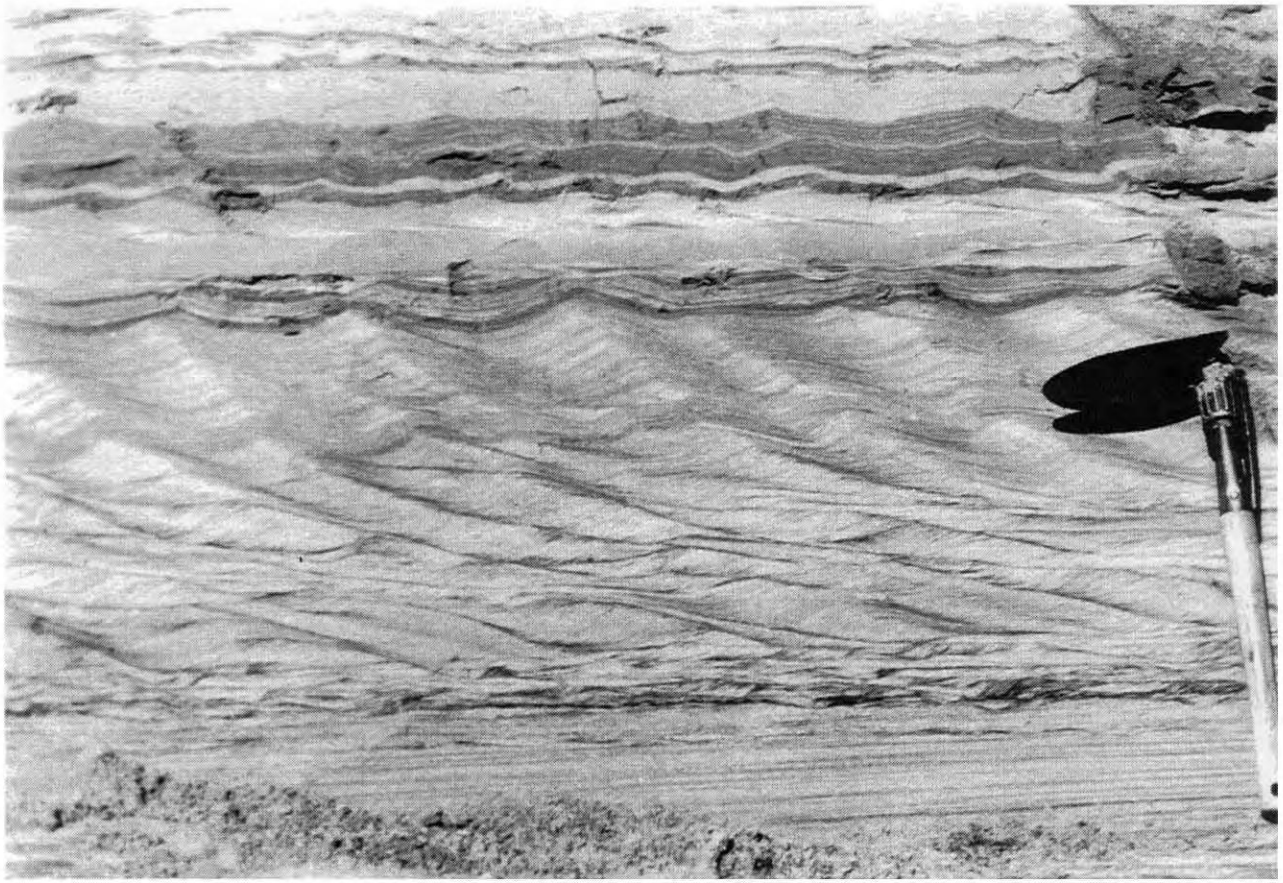


Photo 11. Glaciolacustrine sands comprising the mid to distal facies of a subaquatic fan, Stephenson Township. Note the transition from Type A to Type B to sinusoidal ripples.

Lake and Peninsula Lake. Ice-rafted debris is infrequently encountered. The rhythmites, most commonly, consist of alternating layers of light grey silt and dark grey clay (Photo 12). Within the Lake Muskoka basin, the dark grey clay layers are replaced by reddish-brown units. The source of the red colour is as yet unknown. In most cases, the total thickness of the couplets decrease up section in response to a retreating sediment source. Similarly, silt layers decrease in thickness, however, clay layers become slightly thicker. Burrows and trace fossils are commonly observed within the silt laminae of the rhythmites (Photo 13).

At least 15 m of varved silts and clays have been observed along Sharpe Creek, 2 to 3 km east of the town of Bracebridge. Antevs (1925) reported the occurrence of nearly 800 rhythmites in the same general area. Jamieson (1979) reported approximately 650 rhythmites in a house excavation near Huntsville. These are some of the longest and most complete records of Lake Algonquin sedimentation known to date (Finamore 1985). Attempts to correlate varve sequences between basins has proven unsuccessful (Jamieson 1979).

Well laminated silts with minor very fine sand and clay are also present on the Simcoe Upland. The most notable occurrences are situated within the lowland due south of Thunder Bay as well as in isolated low lying areas between Penetanguishene and Midland. Abundant ice-rafted debris was observed in an exposure of glaciolacustrine silt just north of the 16th concession in the hamlet of Lafontaine. These

Photo 12. Rhythmically laminated silts and clays exposed along Buck River, Stisted Township.

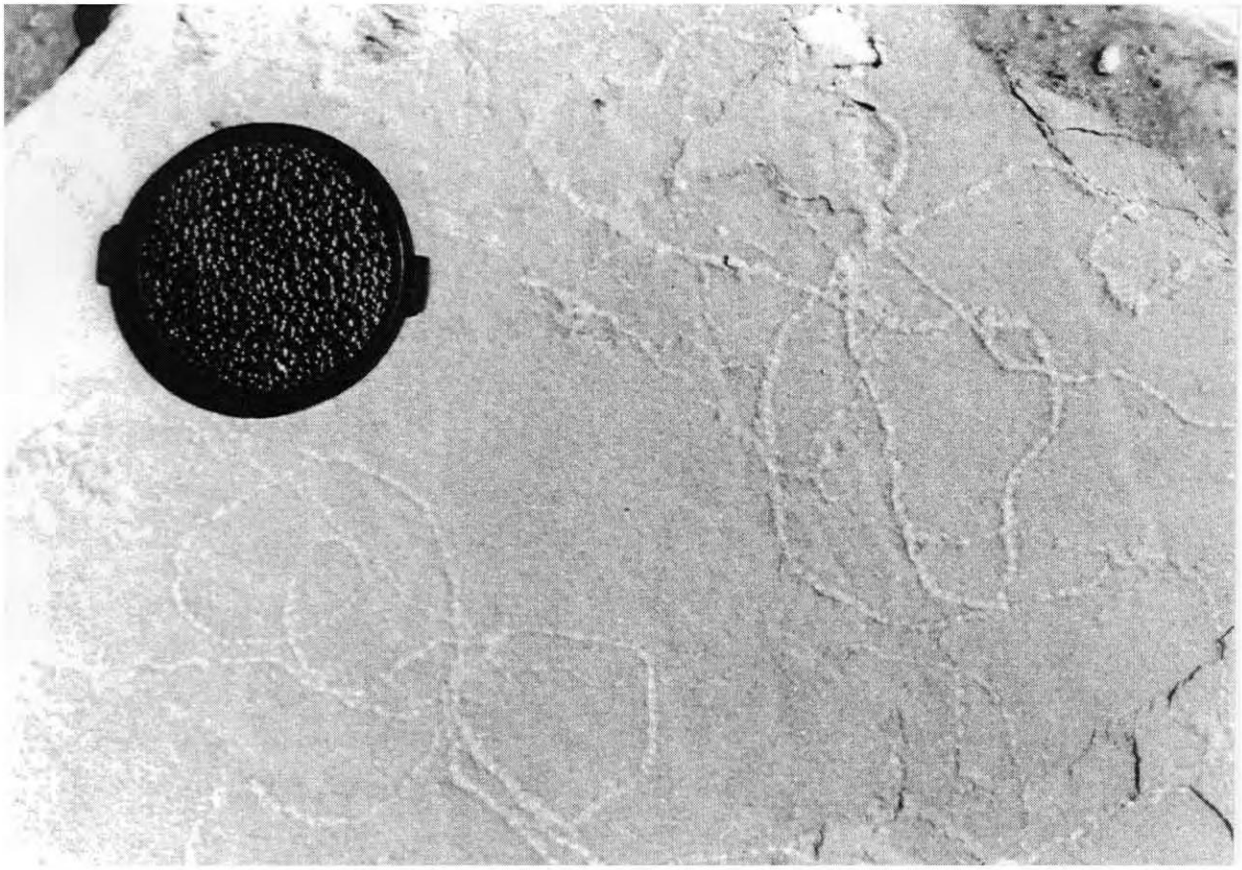


Photo 13. Burrows and tracks of bottom-dwelling organisms are preserved along the bedding planes of silt laminae of rhythmically laminated silts and clays, Chaffey Township.

sediments are probably associated with Glacial Lake Algonquin sedimentation.

Lacustrine Deposits and Features

The Nipissing Phase of the Upper Great Lakes represents a major transgressive event which began approximately 8400 years BP (Larsen 1987) and culminated 4500 to 4000 years BP (Larsen 1985; Cowan 1978). At culmination, the waters within the Huron, Superior and Michigan basins were confluent and formed one large water body of roughly the same shape and size as the present Upper Great Lakes.

The elevation of the Nipissing Great Lakes was initially controlled by the elevation of the outlet sill at North Bay. Outflow was eventually transferred to the southern Port Huron and Chicago outlets of the Huron and Michigan basins, respectively, as the North Bay outlet was uplifted by isostatic effects and eventually abandoned. It was this isostatic uplift of the North Bay sill that caused the Nipissing transgression. Water levels in the Huron basin, rose up to 195 m asl, 18 m above the present level of Lake Huron. The record of the Nipissing Phase is, therefore, restricted to those areas below 195 m asl (i.e. the outer edges of the Simcoe Upland and low-lying areas along the coastline of Georgian Bay).

Nipissing Phase sediments are classified as lacustrine rather than glaciolacustrine deposits because the lake basin was no longer bordered by glacial ice nor fed by glacial

meltwater. The margin of the Laurentide Ice Sheet had retreated to a position well north of the Great Lakes drainage divide by the time lake levels in the Huron basin had transgressed above their present elevation.

Nearshore Deposits

Thick accumulations of Nipissing Phase, nearshore deposits are present on the Penetanguishene Peninsula and adjacent islands within Georgian Bay. They form extensive beach ridge and foreshore deposits, offshore bars and spits. Spectacular shorebluffs exceeding 50 m in height occur locally on west facing headlands. Boulder lags are common on the Nipissing plains below these bluffs. The boulders are probably derived from the erosion and winnowing of till and stratified drift within or at the base of the shorebluffs.

Beach ridge and foreshore deposits range from less than 1 m to over 5 m in thickness. As with the boulder lags, the coarsest deposits appear to be situated on west facing Nipissing plains. Sandier deposits are concentrated within protected bays and eastern, leeward settings. A remarkable suite of offshore bars occurs on the Nipissing plain within Thunder Bay. The bars have an amplitude of 1 to 2 m and are composed primarily of fine sand. Similar features are currently forming in the offshore setting of this bay.

Several Nipissing Phase spits have been recognized as well. The most notable are located on Christian Island where they formed large bay-mouth bars to lagoons now occupied by 2

oval-shaped lakes, informally referred to as Jerry's Lake and Douglas Lake. As with the offshore bars, these spits are composed primarily of sand. Smaller Nipissing spits have been recognized on the Penetanguishene Peninsula within Awenda Provincial Park. These spits form barrier bars to lagoons now occupied by Kettles and Gignac lakes, at the base of Penetang Harbour and along the coastline of Georgian Bay just east of Cedar Point.

Sandy to gravelly Nipissing nearshore deposits are of limited extent within the Georgian Bay Fringe physiographic region. The most notable deposits are located along the eastern flanks of the 2 Paleozoic outliers located north of Coldwater and Waubashene. The deposit north of Coldwater consists of a sequence of storm beach ridges. The beach ridges, which lie either directly on bedrock or on very thin till overlying bedrock, are composed of gravelly sand derived from the reworking of local till and bedrock. These deposits are only 1 to 2 m thick. The deposit north of Waubashene consists of a 2 to 3 m sequence of nearshore sand. This deposit is of particular interest in that it contains abundant organic remains. Nearshore sands also occur locally along the shoreline of Georgian Bay within narrow troughs bounded by bedrock ridges. In many cases, these deposits are overlain by variable thicknesses of peat and/or water. Only a few very small deposits were outlined on the Quaternary map (back pocket) within this region.

Fossil mollusc remains have been encountered at several sites in Nipissing Phase beach deposits (Cronin 1984; Miller et al. 1985). The freshwater gastropod, *Goniobasis livescens*, has been recognized as an indicator of Nipissing-aged deposits within the Huron basin (Miller et al. 1985) and was recovered from several Nipissing beach deposits within the report area.

Offshore Deposits

Silty and clayey Nipissing Phase sediments occur primarily in low-lying areas along the present shoreline of Georgian Bay. The most extensive deposits are situated in the Precambrian lowland north and east of Matchedash Bay. Less extensive deposits are situated near the mouth of the Trent-Severn Waterway west of Port Severn and within the Sucker Creek lowland on the peninsula east of Penetang Harbour.

These sediments consist of well laminated silts and clayey silts with minor very fine sands. They do not contain ice-rafted debris nor are they rhythmically laminated as are older, deposits of Glacial Lake Algonquin. Fine-textured Nipissing deposits seldom exceed 1 to 2 m in thickness. They either unconformably or disconformably overlie older glacial deposits. Macroscopic organic remains have not been encountered in the fine-textured facies.

Fossil Remains and Radiocarbon Dates

During the low-water lake stage which preceded the Nipissing Phase in the Georgian Bay basin (Lake Hough), peat and limnic sediments accumulated in isolated topographic lows,

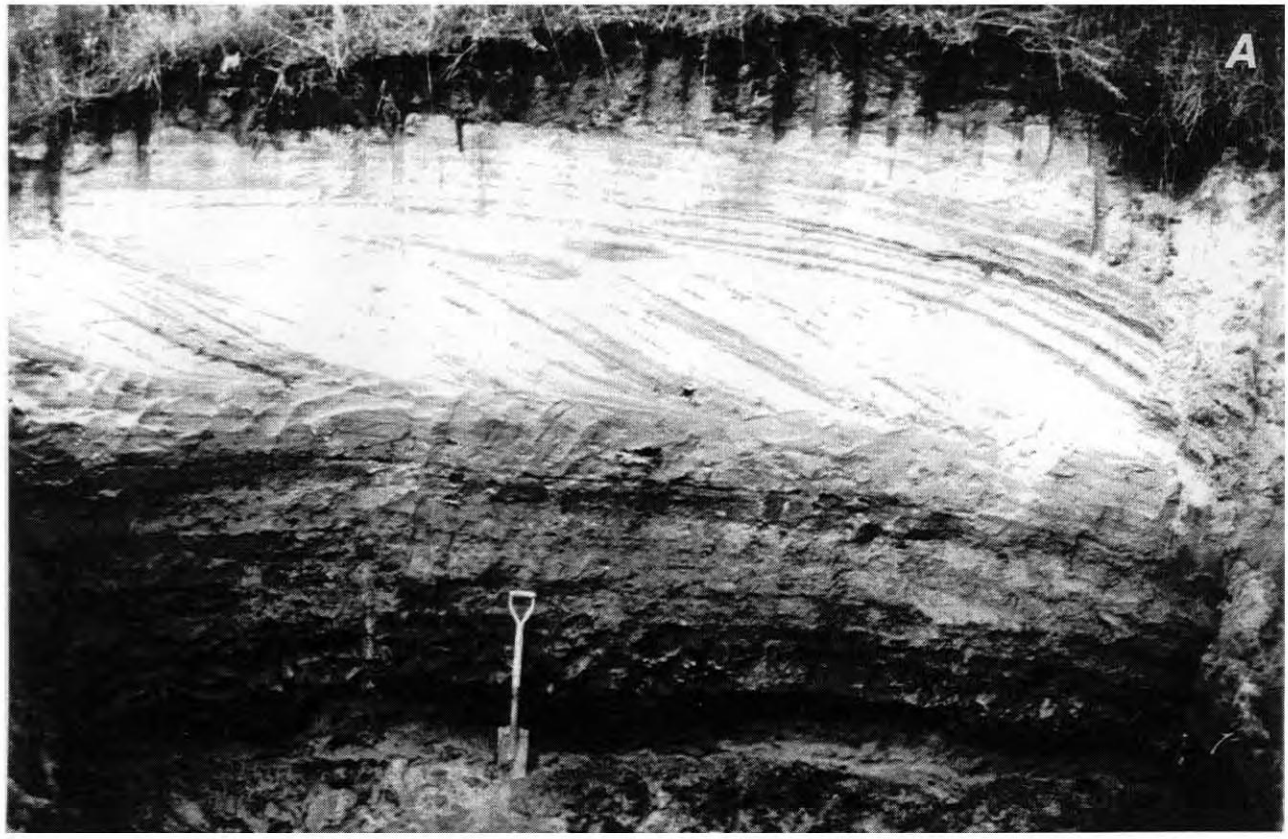
soils developed on exposed materials and alluvial deposits accumulated within channels and floodplains of creeks and river systems. Deposits situated below the Nipissing shoreline were later partially eroded and buried by transgressive lacustrine deposits. Several buried organic deposits have been found within the report area. Two of these were selected for radiocarbon dating and one was selected for further paleoecological analyses because of its rich fossil assemblage.

The first site on which radiocarbon dating was completed is located on the 17th concession of Tiny Township just east of Picotte's Creek. It occurs on a relatively flat plain which has an elevation of about 190 m asl. The organic bearing horizon is about 10 cm thick and rests on faintly laminated, Lake Algonquin silt and clayey silt. The organic horizon is capped by 0.8 m of faintly stratified, fine to very fine sand. The organic horizon consists of organic-rich laminae of sand, silt and clay with discontinuous pods of woody peat. The unit is extremely humified and contains abundant fragments of wood and charcoal. Wood from this horizon was radiocarbon dated at 5725±100 years BP (BGS-1508). The organic bearing horizon probably accumulated within a restricted pond or lagoonal setting which was subsequently transgressed by rising Nipissing waters and buried by offshore bar sands. The radiocarbon date is consistent with other published dates for the Nipissing transgression within the Upper Great Lakes.

The second radiocarbon dated site is located just east of Highway 69 about 3 km north of Waubashene. The site is located in a partially rehabilitated borrow pit along the eastern flank of a topographic high underlain by Paleozoic bedrock (Photo 14a). It occurs at approximately 190 m asl. The entire organic-bearing sequence is about 3 m thick and is underlain by Lake Algonquin pebbly sands grading down to well laminated silty clay and clay (Figure 10).

The organic-bearing sequence has been subdivided into 5 distinct units (Figure 10). The lowest unit (Unit 5) consists of a humified, woody, forest litter, 10 to 30 cm thick (Photo 14b). Roots originating from this unit penetrate into the underlying glaciolacustrine deposits (Unit 6). The forest litter is abruptly overlain by 0.3 m of silty to clayey gyttja grading upwards to fibrous peat (Unit 4)(Photo 14b). These limnic deposits are overlain by 1.0 m of well bedded silt and sand with numerous layers of organic bearing sand and woody peat (Unit 3). This unit is in turn overlain by 0.9 m of steeply-dipping, very fine to medium sand containing thin layers of detrital organic remains at the bases of the foreset beds (Unit 2). This unit is capped by 0.6 to 1.9 m of gently dipping fine to medium sand with thin layers of organic-bearing sand (Unit 1).

Unit 5 represents the organic remains of a forest litter which developed on the subaerially exposed Lake Algonquin lake plain. Radiocarbon dates from this horizon range from 6960±90 years BP to 6400±90 years BP Unit 4 documents a sudden rise



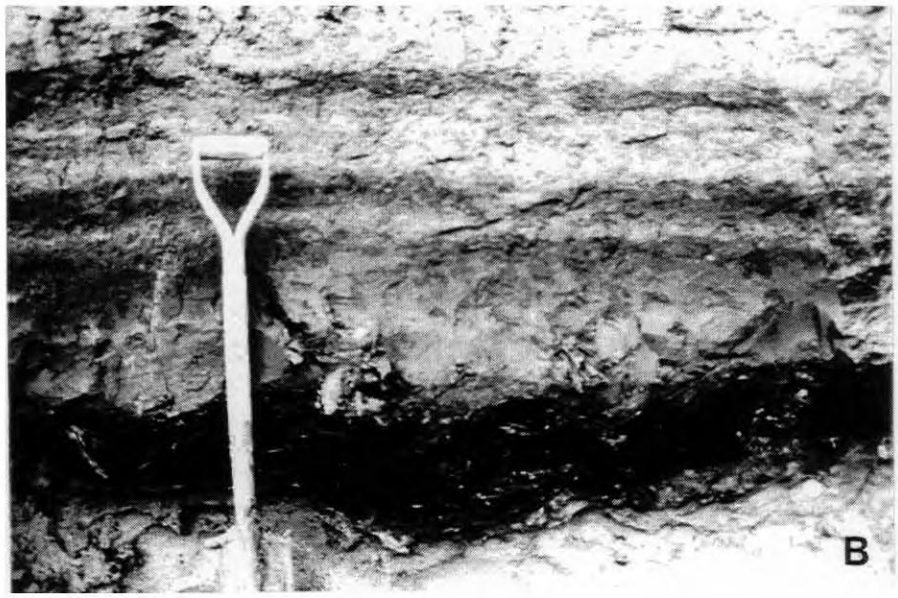


Photo 14. **a.** Overview of Nipissing organic site along Highway 69 just north of Waubashene. **b.** Close-up of the lower, forest litter and the overlying limnic deposits.

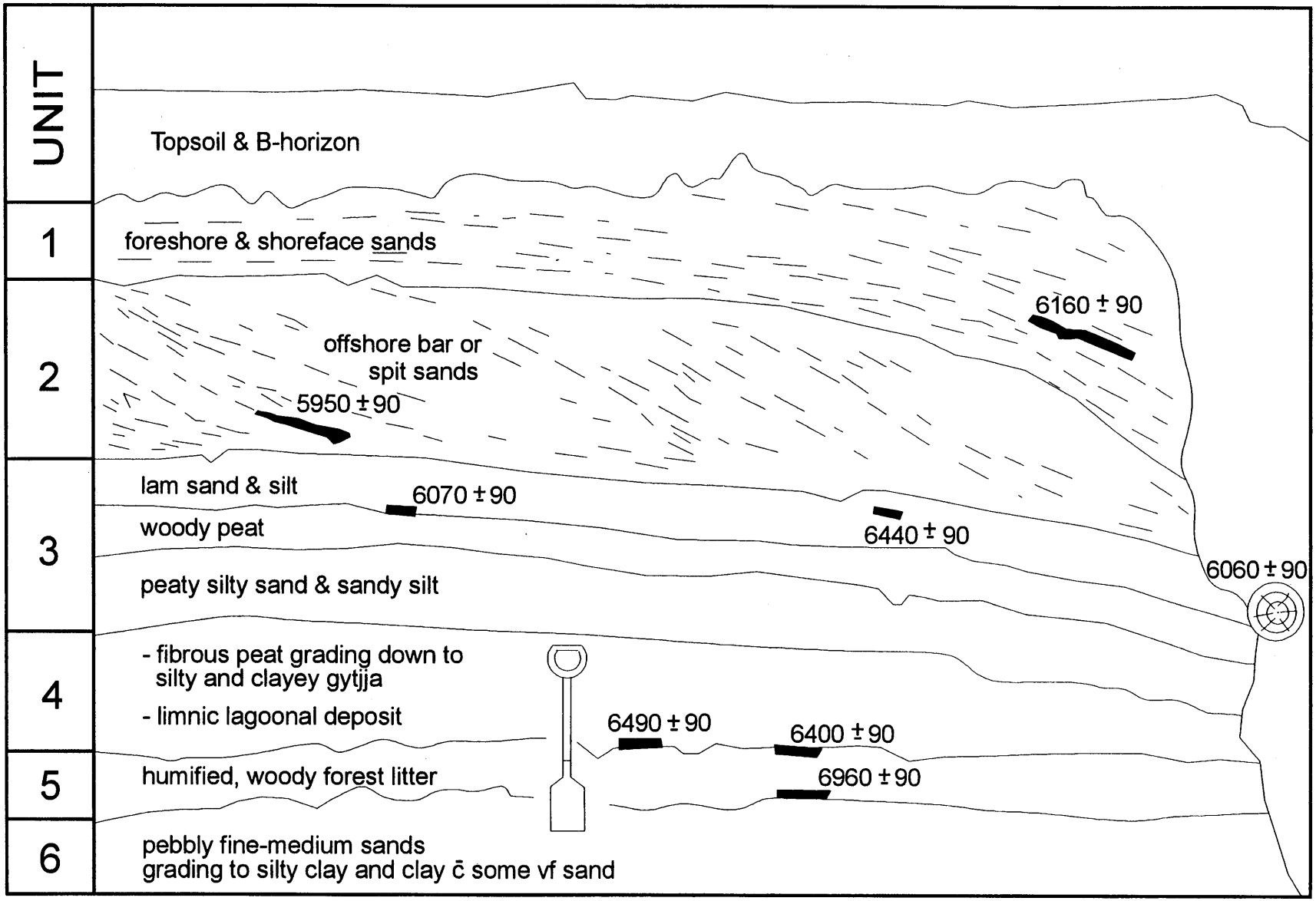


Figure 10. Schematic representation of the major sedimentary units exposed at the Nipissing site north of Waubashene.

in lake levels. These limnic deposits probably accumulated in a lagoonal setting behind a Nipissing Phase spit. Pulses of overwash sediment and flotsam debris entered the lagoonal basin as the spit migrated closer to the sampling site. These overwash sediments are represented by Unit 3. Radiocarbon dates from Unit 3 range from 6490±90 years BP to 6060±90 years BP. Inverted dates within this sequence suggest that organic remains were being reworked from older units. Eventually, the spit migrated over the sampling site resulting in the deposition of Unit 2. Wood recovered from flotsam layers at the toes of the foreset beds have been radiocarbon dated at 5950±90 years BP Eventually the swash zone migrated over the bar surface resulting in the deposition of the foreshore and shoreface deposits of Unit 1. Wood recovered from this unit has been radiocarbon dated at 6160±90 years BP.

The stratigraphic sequence and radiocarbon dates listed above provide a complete record of the Nipissing transgression within the Georgian Bay basin of Lake Huron. Nipissing waters transgressed the site by about 6500 years BP.

Samples were collected from the fossiliferous sequence (Units 1 to 5) for loss on ignition as well as plant macrofossil and pollen identifications (Figures 11 and 12, back pocket). Unit 6 was barren of organic remains. The loss on ignition data indicates that the section is dominated by silicates except in Unit 5 where organic matter predominates. Calcium carbonate is low throughout the sequence.

Fossil pollen was poorly preserved and mostly degraded, especially within the lower units. With the exception of Unit 5, pollen occurs at concentrations far below those of contemporary lake sediments. Only one pollen assemblage zone (McAndrews 1981) is present within the sampled sequence (subzone 3a). This zone has high concentrations of *Tsuga* (Hemlock) and moderate concentrations of *Fagus* (beech) and *Acer saccharum* (sugar maple). Subzone 3a, based on regional pollen zonations determined from local lake sediment cores, began about 6000 years BP and ended at 4450 years BP. The pollen spectrum of the site is dominated by white pine, which is typically overrepresented when it does occur, and several other tree species including birch, oak, elm, sugar maple, basswood, hemlock and beech. Pollen of aquatic plants is sparse.

Macrofossils are abundant, varied and well preserved throughout the entire fossiliferous sequence. Aquatic herbs predominate within the lower half of the section and are replaced by tree fossils within the upper half. This trend is not unexpected considering the sedimentological changes that occur through the sequence. Most striking was the abundance throughout Units 3 to 6 of the submerged aquatic *Najas flexilis*. This plant is commonly found within shallow ponds and probably thrived within the Nipissing lagoon. The presence of numerous aquatic types within Unit 5 is not consistent with the field interpretation which suggests that it is an *insitu* forest litter. Perhaps this unit represents

the remains of a littoral shrub community which was often submerged during wet periods.

Eolian Deposits

Eolian deposits occur as thin, irregular sheets of fine to very fine sand and as more extensive, dune fields throughout the report area. The sheet sands are found in restricted areas and are derived from the reworking and modification of sandy glaciolacustrine sediments. The sheet sands display a slightly rolling, low-relief surface expression and, in some cases, contain small parabolic dunes with amplitudes of 2 to 3 m. Few exposures were found that display the internal structures of the eolian deposits. Those that were found displayed diffuse ripples and planar laminae. The most notable accumulations of sheet sands are situated: along Highway 518, 2 km east of Sprucedale; along the valley of the South Branch Muskoka River, about 1 km southwest of the High Falls generating station; along the Trent-Severn Waterway, about 2 km southwest of Severn Bridge; and between the 17th and 18th Concession of Tiny Township just inland from the Nipissing shore bluff.

Larger accumulations of eolian sand, often associated with coastal dune complexes have been mapped on the Penetanguishene Peninsula. They may occur either as: 1) cliff top dunes such as those above the Nipissing shorebluffs in Awenda Provincial Park, on Christian and Hope islands in Georgian Bay and on the northeast corner of the

Penetanguishene Peninsula opposite Beausoleil Island, or 2) as coastal dune complexes in raised coastal plain settings. The cliff top dunes attain heights of 20 to 30 m and are, for the most part, stabilized. Coastal dune complexes are still active along the west coast of Christian Island (Photo 15) and along the east coast of Giants Tomb Island. Dune development in the coastal setting is, in all cases, dependent upon the abundant supply of sandy sediments in the coastal setting. Those stretches of shoreline along the Penetanguishene Peninsula and its adjacent islands where dunes do not exist are bouldery to gravelly.

Parabolic dunes on the Lake Algonquin and post-Algonquin lake plains indicate a prevailing paleowind direction from the north-northeast. Those associated with the Nipissing shoreline indicate a paleowind direction from the northwest. Assuming that the dunes were active shortly after abandonment of the lake plains upon which they formed or during occupancy of the shoreline, in the case of cliff-top dunes, it would appear that prevailing winds changed directions from northeast to northwest between 10 000 and 6 000 years BP.

Older Alluvial Deposits

Falling Huron basin water levels from the Nipissing high stand to their present level resulted in the incision of valleys and the development of the present drainage systems. The Big East, Black and Oxtongue rivers as well as the North and South Branches of the Muskoka River all follow ancestral

Photo 15. Coastal dune complex along the west shore of Christian Island.

meltwater discharge routes. Fluvial terraces associated with falling base levels have been identified along these waterways. The best examples of older alluvial deposits are found along the valley of the Big East River. The river, a complex of meander channels and oxbow lakes, traverses a flat valley floor which attains a width of 1 to 2 km over much of its length. Progressive incision of the river through its floodplain deposits has resulted in older alluvial deposits standing several metres above the present floodplain. These deposits are mainly sandy and contain some silt and gravel. Organic remains were observed in a few exposures along the banks of the Big East River.

At least 2 perched fluvial terraces have been identified along the southern course of the South Branch Muskoka River valley. The terraces occur at approximately 260 and 245 m asl and are probably graded to post-Algonquin water planes. Older alluvial deposits have not been recognized on the Simcoe Upland and adjacent islands.

Recent Deposits

Swamp and Organic Deposits

Deposits of peat and muck are abundant within the shield portion of the report area and virtually absent from the remaining areas. These deposits are confined primarily to bogs and swamps that occupy local topographic depressions within the gneissic bedrock terrain as well as lowlands adjacent to lakes and along the courses of meandering streams

and rivers. Those deposits controlled by bedrock structure are generally narrow, linear and of shallow depth. Many are water-filled during the wet seasons or contain a floating organic mat along the basin rims for the entire season. Extensive peatlands have been mapped in the vicinity of Axe Lake, Round Lake, Fish Lake, Siding Lake, Fawn Lake, Sparrow Lake and along Brandy Creek. Peat in excess of 12 m in thickness has been documented within the Brandy Creek deposit. Many of the smaller peat bogs are underlain by "diatomaceous earth", a siliceous, skeletal deposit of diatoms which flourished within isolated basins following drainage of Glacial Lake Algonquin (Hewitt 1967). The Axe Lake and Round Lake peatlands have been evaluated for their resource potential by Monenco Ontario Limited (1984).

On the Simcoe Upland, swamp and organic deposits are found either in lagoonal settings of ancestral Huron basin lakes (e.g. Kettles and Gignac lakes) or within lowlands along the course of present drainage systems (e.g. Picotte's and Copeland creeks). Both Kettles and Gignac lakes are actively accumulating marl in banks surrounding the lakes.

Modern Alluvial Deposits

Accumulations of modern alluvium consisting of organic rich sand, silt and clay are found along the floodplains of major water courses. In many cases, these water courses terminate in organic terrains resulting in a transitional zone between these 2 deposit types. The Axe Creek, Black Creek,

Wallington Creek, Little East River, Beaver Creek, Boyne River, Kawpakwakog River, Sage Creek, Brandy Creek, Sharpe Creek and the Black River are the major waterways along which deposits of modern alluvium are accumulating. These waterways carry most of their sediment load during the spring following snow melt.

GEOLOGICAL HISTORY

The Quaternary deposits and features observed within the shield portion of the report area are believed to be Late Wisconsinan and Holocene in age. Older deposits may be present at depth within valley fill sequences. On the Simcoe Upland, where drift thicknesses are much greater, several older drift units have been recognized beneath the main, Late Wisconsinan deposits. The ages of these deposits are speculative.

A brief review of the non-glacial record of the Wisconsinan stage for the central Great Lakes region may assist in assessing the possible ages of these units. There is considerable debate about the extent of ice retreat during the Middle Wisconsinan Interstadial (65 000 to 23 000 years BP), the last major nonglacial interval in southern Ontario. One school of thought purports that the Hudson Bay Lowland remained ice covered throughout the Wisconsinan Stage with shifts in ice flow accounting for variations in till composition and structure (Dredge and Nielsen 1985). At the other extreme, it is suggested that Hudson Bay was ice free, allowing the incursion of marine waters, on several occassions throughout the Middle Wisconsinanan Substage (Andrews et al. 1983).

Southwestern Ontario was undoubtedly ice-free throughout much of the Middle Wisconsinan as recorded by numerous subtill organic sites dated at 45 000 to 23 000 years BP (Karrow 1984). The extent of ice retreat is the main point in

question. The Clarksburg site, which is located south of Georgian Bay, between Owen Sound and Wasaga Beach, records the northern most known interstadial site of probable, Middle-Wisconsinan age in southern Ontario. This site has a radiocarbon age of greater than 36 000 years BP (Karrow 1984). The sediment record at the site suggests ice retreat far enough north to allow for the lowering of glacial lake levels within the Huron basin. A position north of Algonquin Park is likely.

Continuity of the surface, sandy till from the report area south to the Oak Ridges Moraine suggests that it is related to the main, Late Wisconsinan advance. All deposits that underlie this till are therefore, either pre-Late Wisconsinan or early, Late Wisconsinan in age. A weathering profile developed on the upper surface of the older, fine-textured till of borehole P92-01 probably records a Middle Wisconsinan, non-glacial interval. Pebble lags developed at the tops of the same unit in boreholes P92-02, P92-03 and P92-04 may suggest a similar period of erosion.

The advance of the Late Wisconsinan ice sheet resulted in the blockage of low level northern outlets causing a basin-wide, transgression. This glaciolacustrine event is well recorded within the Penetanguishene Peninsula by glaciolacustrine deposits separating the surface sandy till and the underlying sediment package containing the older, fine-textured till.

Assuming the older, fine-textured till was weathered during the Middle Wisconsinan Interstadial, an Early Wisconsinan or Illinoian age is assigned to the older till units. Glaciolacustrine deposits separating and underlying these older tills probably represent similar glaciolacustrine episodes as those occurring higher up in the sequence.

The older, fine-textured till was probably deposited by ice flowing out from the Georgian Bay basin (i.e. towards the southeast) whereas the older, coarse-textured till was probably deposited from ice flowing off the shield towards the south-southwest.

Late ice flow patterns associated with the Late Wisconsinan ice advance were directed towards the south-southwest. Over 200 ice flow indicators, including glacial striae, crescentic fractures, crag and tail features, and fluted till surfaces were measured. Together, they suggest a remarkably consistent ice flow pattern towards 190^{o} with a standard deviation of 10^{o}. Variations from the mean are best explained by minor deflections around local topographic obstructions and draw down into topographic depressions during the waning stages of glaciation. Converging ice flow patterns, as were recorded to the north in the Abitibi-Timiskaming region (Veillette 1986), were not observed within the report area.

The chronology of deglaciation within the report area is based largely on minimum deglaciation dates obtained from lake sediment cores collected from both within and around the

report area. Harrison (1972) reported basal gyttja radiocarbon dates of 11 800 and 9 860 years BP for 2 small lakes situated just outside the northwest corner of Algonquin Park. At Found Lake, in west-central Algonquin Park, the spruce-pine transition is radiocarbon dated at 10 400 years BP (McAndrews 1981). A sediment core from Mayflower Lake, in Arrowhead Provincial Park, yielded a pollen record which extends back beyond the spruce-pine transition (Gold 1977). Assuming that the spruce-pine transition occurred at around the same time at these 2 lakes, it would appear that Mayflower Lake was deglaciated well before 10 400 years BP. Based on their studies of the age of glacial Lake Algonquin, Karrow et al. (1975) suggested a deglaciation date for the region north of Algonquin Park of around 10 400 years BP. Together, these dates suggest a deglaciation chronology for the report area of slightly greater than 11 800 years BP. Huron basin water levels probably declined from their Lake Algonquin maximum as early as 10 400 years BP.

Glacial Lake Algonquin fronted the retreating margin of the Laurentide Ice Sheet over much of the report area. Most of the Algonquin Highland stood above the level of Lake Algonquin and was, therefore, unaffected by glacial lake processes. An archipelago of islands fringed the outer edges of this highland region. Aside from a few small upland areas within the Simcoe Upland most of the remaining portions of the report area were submerged by up to 100 m of water.

The landscapes and deposits observed in the Algonquin Highland and the Georgian Bay Fringe physiographic regions were largely produced shortly before or during deglaciation. Meanwhile, the gross physiographic features present on the Simcoe Upland are probably, largely palimpsest. Broad, south-trending, U-shaped valleys cross the upland and extend southward into the Barrie and Elmvale map areas where they have been interpreted as tunnel valleys, carved subglacially by the catastrophic release of ponded subglacial meltwaters (Barnett 1990). Glaciolacustrine and lacustrine processes created the large wave-cut bluffs, beach ridges and bars that are now superimposed upon this landscape.

Each physiographic region displays a unique sediment record that varies not only in composition and thickness but in internal complexity. The Algonquin Highland is characterized by deposits and landforms associated with subglacial and subaerial environments whereas, those within the Georgian Bay Fringe and Simcoe Upland are generally associated with subglacial and subaquatic settings.

A combination of subglacial erosive processes (both ice and water) and glaciolacustrine processes have aided in removing much of the overburden cover, if it ever existed, from much of the Georgian Bay Fringe physiographic region. Water erosion forms consisting of shallow scallops, troughs, potholes, etc. have been observed throughout this region and indicate the episodic release of subglacial meltwater, at least locally, late in deglaciation. Large boulders strewn

about barren, rocky landscapes suggest that either some overburden was removed by subglacial sheet floods or glaciolacustrine processes, or that the boulders were transported subglacially within confined conduits by meltwater flowing at very high velocities. Large tunnel valleys, identified to the south in the Barrie-Elmvale areas and possibly within the Penetanguishene Peninsula, although at a much larger scale, may support the hypothesis that large volumes of water were transported subglacially during the late stages of deglaciation.

A variety of surface till types or facies were deposited during the advancing and waning stages of the last or Late Wisconsinan glaciation. The till sheet is a lithostratigraphic unit which is time transgressive across the report area and is tentatively correlated with the Faraday till of the Bancroft area to the east (Barnett 1989). Thin deposits of lodgement till were deposited in the shield terrain on the stoss sides of rock knobs and ridges by pressure melting of debris from the base of actively flowing ice. These deposits have been observed primarily within the upland regions of the Algonquin Highland. Thicker, more extensive lodgement tills were deposited on the Simcoe Upland as fluted till plains. Deposits of loose, sandy till containing faceted and striated clasts and abundant lenses and interbeds of sorted sands were observed within the Algonquin Highland and Simcoe Upland and locally, within the Georgian Bay Fringe physiographic regions. These deposits were

produced by the stacking of ice-marginal debris flows generated by the release of subglacial debris at the glacier terminus. In some cases, it appears that they may have been produced by subglacial meltout under passive or stagnant ice conditions. Properties suggestive of subglacial deposition by passive meltout have been observed at several sites. However, this process does not appear to be regionally significant. Unlike areas to the east, characterized by zonal stagnation (Kaszycki 1987), ice decay within the report area appears to have been regionally characterized by ice marginal recession of an active glacier. Within the Algonquin Highland, hummocks of the surface stony, sandy till with chaotically-bedded inclusions of sorted sand and gravel have been observed. These deposits were generated by the melting out and accumulation of debris on the glacier surface. These deposits were subsequently let down upon the preexisting substrate following complete disintegration of the ice. Ice stagnation deposits, consisting of intercalated till and stratified deposits, have been observed as well within the Simcoe Upland on what were previously islands in glacial Lake Algonquin. Silty, stone-poor till facies containing deformed inclusions of glaciolacustrine silt and clay have been observed within those areas affected by glacial Lake Algonquin. These deposits are intimately associated with glaciolacustrine deposits and represent subaquatic debris flows, which were generated at the grounding line of the glacier and flowed down slope along the lake bottom by gravity processes.

Subglacial drainage systems developed within the shield portion of the report area along several subparallel, south oriented valleys late in the deglacial history. Within the Algonquin Highland, conduit fills consisting of sand to boulder gravel are now preserved as esker and fan complexes. Within the Georgian Bay Fringe, subglacial conduit deposits are confined primarily to low lying areas, now filled with glaciolacustrine sands, silts and clays. Where the glacier margin stabilized for short durations, subaquatic fans were built at the mouths of conduits. These fans occur at regular intervals along the lengths of major conduit systems and indicate a retreating ice margin of an active glacier. The fans contain coarse, ice-contact cores on their proximal sides and are draped by thick sequences of pebbly sands to silts and clays. The fining-upward sequences preserved in the fans may represent either a retreating sediment source or a shutoff of the subglacial drainage system in response to changing subglacial conditions.

Several ice-contact deltas were built into glacial Lake Algonquin at the mouths of feeder conduits and channels near the town of Huntsville. Within the Algonquin Highland kame complexes formed in local topographic depressions where large ice blocks became separated from the retreating ice mass. Lakes rimmed by glaciofluvial sediments support this interpretation. In the highland region, glaciofluvial deposits were laid down in braided river settings along fault and lithologically controlled lineaments.

Sandy glaciolacustrine sediments were deposited adjacent to subaquatic fans and in littoral settings of Lake Algonquin and its successors. Massive to well laminated silts and clays were deposited in quiet water settings away from the main sediment sources. Nearly 800 rhythmites of silt and clay (varves) were counted at a clay pit near Bracebridge (Antevs 1925). This represents the longest record of Lake Algonquin sedimentation known to date. Many of the rhythmites contain remnant trace fossils (i.e. burrows and tracks) attributed to burrowing and bottom-dwelling organisms which flourished in the lake following deglaciation. However, fossil remains have not been recovered from Lake Algonquin sediments within the report area.

The levels of glacial Lake Algonquin and its successors are marked by strong shoreline features on the Simcoe Upland and by subtle features that are difficult to trace through the densely forested terrain within the shield portion of the report area. Wave-cut notches, foreshore platforms, boulder lags and other forms of winnowed drift have been recognized throughout the map area. An intricate archipelago of islands along the outer fringe of the Algonquin Highland probably dampened the effects of nearshore processes preventing the development of strong shoreline features in this area. The highest shoreline features are attributed to Glacial Lake Algonquin and are found at around 350, 305 and 260 m asl at Huntsville, Bracebridge and Penetanguishene, respectively.

This difference in elevation is attributed to the differential effects of isostatic uplift across the report area.

Progressive retreat of the ice margin to the northern edge of Algonquin Park uncovered the first of a series of low outlets to the Ottawa River valley. An arm of Lake Algonquin extended eastward along the ice margin into the north-central part of the park. A controlling sill at White Partridge Lake was operational until further ice retreat uncovered a series of progressively lower outlets to the north (Ford and Geddes 1986). Water levels in the Georgian Bay basin dropped stepwise by as much as 50 m (Chapman 1975) by the time the lowest controlling sill at North Bay was uncovered. The level of Georgian Bay stood well below its present level at this time.

Much of the lake floor within the report area was exposed to processes of subaerial erosion when the North Bay outlet was uncovered with ice retreat. Fluvial terraces were cut into glaciolacustrine sands along the Big East, the Black and the Oxtongue rivers as well as the North and South Branches of the Muskoka River. In isolated areas, the newly-exposed, sandy, Algonquin lake floor was subjected to reworking by eolian processes creating blowouts and small parabolic dunes. Peat accumulated in poorly-drained, low-lying areas.

Following deglaciation of the North Bay outlet, water levels in the Huron Basin began to rise in response to isostatic uplift of the controlling sill. This transgressive event, referred to as the Nipissing Transgression, culminated

approximately 4 500 to 4 000 years BP when outflow once again returned southward through the Port Huron outlet. Water levels stood at 195 m asl, 18 m above the present level of Georgian Bay. Prominent shorebluffs were eroded into glacial deposits on the Simcoe Upland.

Low lying areas adjacent to Georgian Bay, previously subjected to subaerial erosional and depositional processes became submerged during the transgressive event. Nipissing Phase sediments overlie these older deposits and surfaces in most depressions affected by the transgression. Organic bearing accumulations are present at the interface of the Nipissing Phase deposits and the older sediments in some locations. By 4000 years BP, water levels began to fall to their present level with only minor, climate-related fluctuations (Larsen 1985). Peat accumulation resumed in bedrock-controlled depressions along the edges of Georgian Bay.

APPLIED QUATERNARY GEOLOGY

Sand and Gravel

The major producing sand and gravel operations within the shield portion of the report area are situated along the Highway 11 corridor. Reserves of high quality, coarse, crushable material are available at only a few locations within this corridor and are rapidly being depleted. This aggregate is considered hard and durable and is generally suitable for most applications (Ontario Geological Survey 1990).

An esker system trending south from Novar to Waseosa Lake is largely unexploited and may prove useful as a future aggregate source. Reserves of unexploited coarse aggregates are also present along the north flank of the Big East River, just south of Williamsport, at Brooks Mill between Rebecca Lake and Bella Lake, in north-central Macauley Township along the North Branch Muskoka River and in southwest McLean Township along the South Branch Muskoka River.

Most of the exploited deposits along the Highway 11 corridor are situated within subaquatic fans. These deposits contain large volumes of fine to very fine sand which limits the products that can be produced. Smaller deposits of sand and gravel occur sporadically throughout the shield portion of the report area and serve local markets. Those deposits situated immediately south of Skeleton Lake may contain up to 70% limestone and friable siltstone clasts in the pebble

fraction. These deposits have been avoided when high quality aggregates are required.

Deposits of sand and gravel are currently being extracted from a limited number of licenced operations on the Simcoe Upland. The largest operations are located on the 16th and 17th concessions of Tiny Township (Lafontaine Sand and Gravel Limited and E.J. Mailloux Limited, respectively). At the Lafontaine Sand and Gravel Limited operation, which is located at the north end of Lafontaine Hill, up to 15 m of Lake Algonquin spit sands and gravels are being extracted. The deposit may contain an ice-contact core which has been extensively reworked by nearshore processes. The E.J. Mailloux deposit is located on the flank of a Nipissing bluff which is located 2.5 km east of Farlain Lake. The deposit consists of 6 to 18 m of ice-contact sands and gravels which, most likely, stratigraphically underlie the surface till sheet. At this deposit, the surface till has probably been removed by nearshore processes.

A third licenced operation in Tay Township due south of St. Andrews Lake exposes 4 to 20 m of well bedded beach sands and gravels. Variably textured, ice-contact deposits and till are exposed at the base of several pit faces. A borehole drilled adjacent to the deposit indicates the presence of at least 40 m of stratified sands with minor gravel beneath the exposed till.

Numerous smaller operations, both licenced and unlicenced, are scattered throughout the remaining portions of

the Simcoe Upland. Most of these operations are located in beach and nearshore sand and gravel deposits. These deposits are of limited thickness and are often underlain by till. Several small deposits of ice-contact stratified drift which form kames, crevasse fills and ice-proximal cores of subaquatic fans are currently being used as a local source of aggregate. Because of their small size and variable composition, these deposits have limited resource potential.

The headland situated west of Thunder Bay in Tiny Township has been extensively washed by ancestral Huron basin glacial lakes. Small borrow pits within this area expose a minimum thickness of 4 to 5 m of nearshore sands and gravels. This large area has potential as a local source of aggregate.

Unlike the aggregate deposits of the Shield portion of the report area, the deposits of the Simcoe Upland contain large quantities of Paleozoic carbonate lithologies. They also contain negligible quantities of shale and chert. The deposits produce durable, good quality, coarse aggregate that is suitable for many road building and construction products.

High quality aggregates are being produced at several bedrock quarries within the report area as well. The most notable of these are located along the east end of Tay Township, at the south end of the Penetanguishene N.T.S. map sheet (Allan G. Cook Limited) and along the 12th concession of Orillia Township, at the south end of the Gravenhurst N.T.S. map sheet (Beamish Construction). At both sites, limestone of the Gull River Formation is being quarried and crushed for a

wide range of products, including concrete, asphalt, granular base, rip-rap, etc. Certain beds within the formation are alkali reactive (i.e. chemically reactive with Portland cement mixes). Concretes produced from this aggregate can deteriorate when subjected to moist conditions and/or road salts. These beds must either be avoided or diluted with non-reactive aggregate for concrete uses.

Three additional limestone quarries, now inactive, occur within the report area. These are located: on Quarry Island, along the east coast of Georgian Bay; at Grandview Beach, just north of Port McNicoll; and 1.5 km north of Waubashene, on the west side of Highway 69. At each of these quarries, limestone of the Gull River Formation was extracted for building stone and crushed aggregates.

Precambrian, gneissic bedrock is also being quarried at several locations within the report area. These quarries are situated: along Highway 69, just west of Gibson Lake (Ministry of Transportation); within a sand and gravel pit, 3 km north of Milford Bay, in Monck Township; within a sand and gravel pit, 4 km north of Huntsville, in Chaffey Township (Lehman Quarry Limited) and on the northwest corner of Franklin Township (Huntsville Quarry Limited). These sites produce high quality, durable, crushed stone from quartzofeldspathic gneiss. This product can be used for a wide variety of applications. Flagstone, landscaping stone and building stone are also produced at several of these sites.

Clay, Diatomite and Peat

Clay deposits of the area have been exploited for drainage tile and brick production. A seasonally operated brick plant, located in Chaffey Township near Huntsville, produced red-face brick from a 3 to 4 m bank of thinly varved, grey-brown clay exposed on the property. A tile plant, located in Draper Township on the outskirts of the town of Bracebridge, produced drainage tile, brick and flue liners from a 3 m bank of uniform, olive-green to red-brown varved clay exposed on the property. These plants ceased production in the late 1960's (Hewitt 1967).

Diatomite is commonly encountered beneath, and intercalated with, peat deposits throughout the shield portion of the report area. Attempts to produce commercial diatomite products have been short-lived because of the impurities within and the small size of the deposits (Hewitt 1967). Diatomaceous muds reach thicknesses of 2 to 5 m in places. Unfortunately, many of these deposits grade only 10 to 20% diatomite.

Presently, there are no known commercial peat operations within the study area. Reconnaissance evaluations and resource inventories have been conducted for a large peatland immediately north of Axe Lake and a smaller peatland just north of Round Lake (Monenco Ontario Limited 1984). More detailed work is needed to systematically evaluate and identify the potential peat resources of the region.

Drift Geochemistry

The geochemical composition of surficial deposits within the report area has been addressed at a reconnaissance level within this study. The locations of samples collected are shown in Figure 13 (back pocket). A more comprehensive investigation of the drift geochemistry was undertaken as part of a regional study encompassing much of the south-central Canadian Shield (Kettles and Shilts 1989; Kettles et al. 1991). The primary objectives of this research was to map geochemical terrains and demonstrate how this information could be applied to acid rain research studies. This information could also be applied to programs of mineral exploration that involve drift geochemistry.

All till samples collected as part of this study were analyzed for total matrix carbonate (Appendix B). Samples collected from the shield portion of the report area contain extremely low levels of matrix carbonate (0-2% total carbonate). The buffering capacity of surficial deposits within this area is poor. Surface till samples collected from Paleozoic terrain contain very high levels of matrix carbonate (average 19% total carbonate). The buffering capacity of surface deposits within this region is considered to be very high.

The silt and clay fraction of all till samples collected as part of this study were also analyzed for a suite of trace elements including: Au, As, Sb, Mo, Ag, Cu, Pb, Zn, Ni, Cr and Co. Table 2 contains a list of summary statistics for these

Table 2. Summary table of geochemistry for till samples.

SAND TILL ON PRECAMBRIAN TERRAIN

	Au	As	Sb	Mo	Ag	Cu	Pb	Zn	Ni	Cr	Co
TOTAL	78	79	79	79	79	79	79	79	79	79	79
MAX	11	1.8	-0.1	-10	-2	57	23	133	108	245	23
MIN	-2	-1	-0.1	-10	-2	10	-10	47	11	36	9
MEAN	NA	NA	NA	NA	NA	26	NA	73	24	57	13
STD	NA	NA	NA	NA	NA	9	NA	19	14	27	3

SURFACE SAND TILL ON PALEOZOIC TERRAIN

	Au	As	Sb	Mo	Ag	Cu	Pb	Zn	Ni	Cr	Co
TOTAL	28	28	28	28	28	28	28	28	28	28	28
MAX	5	1.9	0.2	-10	-2	29	17	71	105	133	14
MIN	-2	-1	-0.1	-10	-2	12	-10	40	15	35	8
MEAN	NA	NA	NA	NA	NA	21	NA	50	36	76	10
STD	NA	NA	NA	NA	NA	4	NA	8	16	23	1

OLDER SILT TILL ON PALEOZOIC TERRAIN

	Au	As	Sb	Mo	Ag	Cu	Pb	Zn	Ni	Cr	Co
TOTAL	11	11	11	12	11	11	11	12	11	11	11
MAX	11	1.5	0.15	-10	-2	26	11	69	63	155	12
MIN	-2	-1	-0.1	-10	-2	11	-10	27	29	67	5
MEAN	NA	NA	NA	NA	NA	21	NA	51	44	105	10
STD	NA	NA	NA	NA	NA	4	NA	12	10	27	2

elements. The geochemical database developed from this study is contained in Appendix C. This information compliments the existing regional geochemical database mentioned above. It provides additional baseline information on surface geochemistry within the report area and can be used to better define background geochemical signatures.

Hydrogeology

Some generalizations can be made with regard to hydrogeological properties of Quaternary deposits found within the report area. Within the shield portion of the report area, coarse textured glaciofluvial deposits serve as the most productive aquifers. These deposits are well sorted, lack excessive fines and are relatively extensive. They are usually confined to bedrock valleys or depressions and directly overlie either bedrock or till.

Where the glaciofluvial deposits occur as ice proximal facies of subaquatic fans, a confining layer of silt and/or clay often overlies the aquifer. This sediment can both isolate the aquifer from the surface environment and prevent rapid recharge. Facies transitions occur rapidly within the subaquatic fan deposits. Coarse textured, glaciofluvial deposits grade laterally into moderately permeable fine to very fine sands and silts which in turn give way to well laminated, fairly impermeable silts and clays. Coarse textured conduit deposits may underlie these impermeable

sediments and connect the subaquatic fan aquifers hydrogeologically.

Within the Simcoe Upland, the subsurface stratigraphy is much more complex (Figure 5, back pocket, Appendix A). However, there are some generalizations that can be made with regards to hydrogeology. These generalizations are based primarily on information obtained from sonic borehole data and surficial geological mapping. Three and possibly 4 important aquifers have been identified within the Simcoe Upland. The lower 2 or 3 are confined by either till or fine-textured glaciolacustrine deposits.

The upper aquifer is unconfined and occurs in either glaciolacustrine beach and nearshore deposits or in ice-contact stratified drift. These deposits are typically well sorted, clean and have a high water-bearing capacity. The underlying, surface, sandy till, however, is relatively permeable and, only locally, serves to perch the water table.

The second aquifer from the surface consists of well sorted, glaciolacustrine sands that are confined above by the sandy, surface till and below by a silty till. This sand unit ranges from less than 1 m thick on Lafontaine Hill to 16 m thick along the west coast of the Penetanguishene Peninsula and greater than 40 m thick on the eastern side of the peninsula. This aquifer appears to be regionally widespread, fairly uniform in character and thickest within lowland areas. Where the silty till outcrops on the sides of uplands of the Penetanguishene Peninsula, springs flow out along its upper

surface. Examples of such springs can be seen along the southeast flanks of Lafontaine Hill as well as along the southeastern flanks of an upland between Macey Lake and Thunder Bay.

The third aquifer down has been identified across the entire Penetanguishene Peninsula. It consists of a fining upward sequence of clean, well sorted, glaciolacustrine sands and pebbly sands to well laminated silts and sandy silts. It is confined above by the silty till and below by a relatively impermeable, dense, sand till. In borehole P92-01, this aquifer is at its thinnest. It consists of 0.3 m of poorly sorted, silty, medium to coarse sand. In borehole P92-03, the sand is nearly 50 m thick and consists primarily of well bedded fine to coarse sand. In borehole P92-02, this unit is interrupted by a thin diamict layer which may suggest the presence of a fourth aquifer. Where this diamicton has been identified in other boreholes, it rests directly on bedrock.

Samples of subtill stratified units from the sonic boreholes were collected at regular intervals for grain size analysis. The grain size distribution of the sand fraction of these samples is presented in Appendix D. This information will help to better characterize the aquifers of the report area and assist water well drillers in their determination of screen sizes to be used for the producing wells.

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APPENDIX A

SONIC BOREHOLE LOGS

Borehole P92-01
UTM Coordinates: 586225 m E; 4959600 m N
Collar Elevation: 229-244 m asl

0.0-2.1 m -well bedded, pebbly, fine to medium sand.

2.1-5.8 m -well bedded, sandy gravel and gravelly sand.

5.8-17.4 m -well bedded, pebbly and pebble-free, fine to medium sand with minor, silty, fine to very fine sand.
-thin, light, buff-grey, sandy, diamicton layers at 7.6, 14.3, 15.5 and 17.1 m.
-diamictons contain a high proportion of Paleozoic carbonate clasts.

17.4-22.6 m -well bedded, gravelly to pebbly, fine to medium sand and pebble-free, fine to medium sand.
-lower 2 m contains abundant silt.

22.6-29.0 m -well laminated, sandy silt, silty, very fine sand and very fine sand.

29.0-48.2 m -well bedded, fine to medium sand with some layers of silty, very fine sand and pebbly, fine to medium sand.

48.2-60.0 m -well bedded, pebbly, fine to coarse sand with some layers of pebble-free, medium to very fine sand.

60.0-61.0 m -well laminated, fine to medium sand.

61.0-67.1 m -orangy-brown to mottled, light, orangy-brown and buff-grey to light buff-grey silty, very fine sand to sandy silt till.
-thin bed of slightly pebbly, fine to very fine sand between 61.3 to 61.6 m.
-upper 3 m of unit appears oxidized (weathered?).
-contains a high proportion of Paleozoic carbonate clasts (85%).

67.1-67.4 m -massive, poorly sorted, silty, medium to coarse sand (dirty).

67.4-80.5 m -light, grey-brown, silty sand till.
-contains a moderately high proportion of Paleozoic carbonate clasts (60-75%).

80.5-87.8 m -bedrock.
-moderately weathered, mafic intrusive (eclogite).
-minor disseminated pyrite and quartz veining.

Borehole P92-02
UTM Coordinates: 580275 m E; 4958100 m N
Collar Elevation: 305-320 m asl

0.0-13.1 m -light, olive-grey, pebbly, silty sand till with thin interbeds of silt and very fine sand at 4.6 and 6.7 m.
-till contains an equal proportion of Precambrian and Paleozoic clasts.

13.1-15.2 m -laminated silt with some clay.
-numerous pebble-size dropstones.

15.2-18.3 m -light, buff-grey, pebbly, silty sand till.
-contains a moderately high proportion of Paleozoic carbonate clasts (70%).

18.3-19.5 m -sandy, pebble gravel.
-thin layer of sandy diamicton near base of unit.

19.5-21.3 m -grey, stone-poor, sandy silt till.
-contains a high proportion of Paleozoic carbonate clasts (85%).

21.3-27.1 m -well laminated, silt with thin interbeds of light, buff-grey, stone-poor, sandy silt till.

27.1-35.1 m -well laminated, silt and sandy silt.
-one thin layer of sandy silt till between 31.7 and 32.0 m.

35.1-38.4 m -interbedded, laminated, silt and massive, grey-brown, clayey silt till.
-till and silt occur in equal proportions.

38.4-47.2 m -brown-grey to grey, gritty, clayey silt till.
-contains a high proportion of Paleozoic carbonate clasts (80-85%).

47.2-72.8 m -well bedded, silt and sandy silt grading down to fine to medium sand with some silt.

72.8-73.2 m -grey, pebbly, silty sand till.
-contains a moderately high proportion of Precambrian clasts (60-65%).

73.2-106.7 m -well bedded, very fine, fine and medium sand with some pebbly layers and minor silt.

Borehole P92-03
UTM Coordinates: 580880 m E; 4959400 m N
Collar Elevation: 244-259 m asl

0.0-1.5 m -fill.

1.5-14.0 m -well bedded, fine to very fine sand.

14.0-14.3 m -pebbly, fine to medium sand.

14.3-17.4 m -well bedded, fine to very fine sand with some medium sand.

17.4-18.6 m -massive, sandy silt grading down to well laminated silty clay.
-some ice-rafted debris.

18.6-23.2 m -well laminated, very fine sand grading down to silt with some sandy silt.

23.2-25.9 m -light, buff-grey, stone-poor, silty, very fine sand till.
-contains a moderately high proportion of Precambrian clasts (60%).

25.9-26.4 m -well bedded, fine sand and pebbly fine sand.

26.4-28.7 m -well laminated, very fine sand grading down to silt and sandy silt.

28.7-32.9 m -interbedded, grey to light, grey-brown, stone-poor, sandy silt till and well laminated silt, sandy silt and silty very fine sand.
-till layers contain a high proportion of Paleozoic carbonate clasts (75%).

32.9-36.6 m -well laminated, very fine sand grading down to well laminated silt and clay with some ice-rafted debris.

36.6-41.8 m -well bedded, medium to coarse sand, fine to very fine sand and sandy silt to silt.
-a few pebbly horizons.

41.8-81.7 m -well bedded, fine to very fine sand with some silty, very fine sand and silt layers.

Borehole P92-04
UTM Coordinates: 568940 m E; 4955850 m N
Collar Elevation: 177-183 m asl

0.0-5.2 m -well bedded, pebble gravel and sandy gravel with some gravelly sand.

5.2-8.2 m -grey to buff-grey, pebbly, silty sand till.
-contains a moderately high proportion of Precambrian clasts (60%).

8.2-24.4 m -well bedded, medium, fine and very fine sand with some layers of silty, very fine sand.
-a few grits and small granules noticed near base of unit.

24.4-28.0 m -buff-grey, stone-poor, clayey silt till.
-contains a high proportion of Paleozoic carbonate clasts.

28.0-47.5 m -well bedded, fine to very fine sand with some layers of silty, very fine sand and silt and minor clay.
-lower 0.3 m slightly pebbly.

47.5-53.8 m -light, grey-brown, pebbly, sandy silt till.
-contains a very high proportion of Paleozoic clasts.

53.8-59.7 m -bedrock.
-slightly fossiliferous, dolomitic limestone.

Borehole P92-06
UTM Coordinates: 569700 m E; 4959525 m N
Collar Elevation: 251-259 m asl

0.0-13.4 m -interbedded, fine to very fine sand, pebbly to cobbly, fine to medium sand, pebble to cobble gravel and grey-brown to buff-grey, pebbly, silty, very fine sand till.
-higher proportion of stratified sediments in lower half of unit.
-till layers contain a moderately high proportion of Precambrian clasts (60-70%)

13.4-50.9 m -well bedded, pebbly, fine to medium sand and pebble to cobble gravel with minor very fine sand and silty, very fine sand.
-most of this unit was extremely dry and required small amounts of water for drilling.
-much of this unit shows signs of being disturbed by drilling (i.e. washing, sorting, removal of fines).

APPENDIX B

GRAIN SIZE AND CARBONATE DATA

Grain size distribution determined by hydrometer and seive techniques using ASTM guidelines. Carbonate contents determined by Chittick apparatus.

SAMPLE NUMBER	DEPTH (M)	NORTHING (M)	EASTING (M)	MATERIAL	SAND %	SILT %	CLAY %	CARB %	CA/DO
H-15	SURFACE	5039250	621900	eolian	94	6	0		
H-26	SURFACE	5033050	623400	till	75	23	2	1	0.3
H-28	SURFACE	5031650	625350	till	70	28	2	1	0.2
H-62	SURFACE	5028300	629400	till	68	31	1	1	0.3
H-65	SURFACE	5026700	630200	till	62	36	2	1	1.0
H-89	SURFACE	5022950	626750	till	76	22	2	1	0.5
H-94	SURFACE	5014650	621700	till	67	29	4	1	0.2
H-119	SURFACE	5035200	632650	till	75	24	1	1	0.3
H-124	SURFACE	5032050	637150	till	70	28	2	2	0.4
H-125	SURFACE	5031950	636950	till	69	29	2	1	0.7
H-148	SURFACE	5028400	633700	till	75	24	1	2	0.4
H-151	SURFACE	5026800	637000	till	72	26	2	1	0.2
H-158	SURFACE	5023800	634800	till	71	28	1	1	0.2
H-163	SURFACE	5023300	636650	till	66	32	2	2	0.4
H-169	SURFACE	5022600	640750	till	70	29	1	1	0.2
H-173	SURFACE	5022300	641850	till	70	28	2	1	0.2
H-174	SURFACE	5021300	639350	till	59	40	1	1	0.2
H-179	SURFACE	5025250	641100	till	69	28	3	2	0.7
H-180	SURFACE	5026550	645500	till	74	25	1	1	0.2
H-181	SURFACE	5027150	645400	till	58	41	1	0	0.0
H-187	SURFACE	5022400	645400	till	76	23	1	1	0.5
H-193	SURFACE	5024150	652250	till	72	27	1	1	0.3
H-195	SURFACE	5021200	654050	till	58	40	2	2	0.7
H-196	SURFACE	5020550	653750	till	60	38	2	1	0.2
H-198	SURFACE	5018450	651750	till	65	33	2	2	0.4
H-201	SURFACE	5023800	629600	till	64	35	1	2	0.4
H-203	SURFACE	5023300	630400	till	62	37	1	2	0.4
H-206	SURFACE	5020250	629950	till	63	35	2	2	0.4
H-221	SURFACE	5014600	634600	till	75	24	1	0	1.0
H-239	SURFACE	5017200	637300	till	80	19	1	1	0.3
H-240	SURFACE	5017700	636750	till	77	23	0	0	1.0
H-244	SURFACE	5012500	639100	till	59	37	4	1	0.3
H-246	SURFACE	5015300	642700	till	75	23	2	2	0.5
H-251	SURFACE	5019700	643650	till	68	31	1	1	0.7
H-263	SURFACE	5034500	639350	till	63	33	4	1	1.0
H-302	SURFACE	5019900	651200	till	51	47	2	1	0.4
H-304	SURFACE	5018250	650300	till	74	24	2	2	0.7
H-307	SURFACE	5015600	650650	till	62	36	2	1	0.3
H-318	SURFACE	5013900	655750	till	64	35	1	1	0.5
H-320	SURFACE	5025350	653750	till	75	23	2	2	0.7
H-324	SURFACE	5029950	653050	till	70	28	2	2	0.4
H-330	SURFACE	5035100	654600	till	83	15	2	1	0.3
B-2	SURFACE	5002400	649250	till	68	31	1	0	1.0
B-4	SURFACE	5007200	651650	till	68	30	2	1	0.2
B-7	SURFACE	5010700	657150	till	72	26	2	1	0.2
B-9	SURFACE	5003250	657300	till	69	29	2	1	0.3
B-11	SURFACE	5001900	649900	till	70	28	2	2	0.1
B-17	SURFACE	4994700	655550	till	74	24	2	1	0.2
B-18	SURFACE	4988700	636350	clay	2	43	55		
B-23	SURFACE	4992750	642800	till	71	27	2	1	0.3

SAMPLE NUMBER	DEPTH (M)	NORTHING (M)	EASTING (M)	MATERIAL	SAND %	SILT %	CLAY %	CARB %	CA/DO
B-26	SURFACE	4992900	645050	till	67	31	2	1	0.2
B-35	SURFACE	4989950	653200	till	74	24	2	1	0.2
B-44	SURFACE	5003200	624000	till	75	23	2	2	0.4
B-45	SURFACE	5004400	625800	till	70	28	2	2	0.4
B-47	SURFACE	5004750	621200	till	61	36	3	2	0.4
B-54	SURFACE	5009450	620550	till	69	28	3	2	0.3
B-71	SURFACE	4990100	631650	till	38	56	6	1	0.3
B-101	SURFACE	5006800	649100	till	58	39	3	1	0.1
B-106	SURFACE	5012000	651550	till	72	26	2	1	0.1
B-107	SURFACE	5009950	648550	till	60	38	2	0	0.0
B-108	SURFACE	5007150	646400	till	70	29	1	1	0.7
B-109	SURFACE	5008250	645900	till	69	29	2	0	0.0
B-112	SURFACE	5005950	647300	till	67	32	1	2	0.6
B-113	SURFACE	5003500	646800	till	69	29	2	2	0.4
B-124	SURFACE	4995950	635900	till	76	23	1	2	0.5
B-130	SURFACE	5002700	639350	till	68	30	2	1	0.3
B-131	SURFACE	5003700	637100	till	64	33	3	2	0.4
B-133	SURFACE	5006200	639200	till	74	24	2	2	0.4
B-137	SURFACE	5009950	637650	till	68	31	1	1	0.2
B-138	SURFACE	5010000	643600	till	74	24	2	1	1.0
B-153	SURFACE	4995800	626250	till	66	32	2	1	0.3
B-165	SURFACE	4985600	620100	till	80	19	1	1	0.2
B-166	SURFACE	4986800	620200	till	63	33	4	1	0.3
CI-9	SURFACE	4956100	577850	till	74	20	6	1	0.5
CI-12	SURFACE	4956350	577350	till	67	25	8	16	0.9
CI-33	SURFACE	4958050	572350	till	71	25	4	2	0.7
CI-42	SURFACE	4957400	568250	till	71	23	6	15	0.7
CI-52	SURFACE	4956850	570400	till	29	59	12	16	1.3
CI-57	SURFACE	4956200	569650	till	67	26	7	15	1.0
CI-61	SURFACE	4959800	569050	till	62	30	8	31	1.0
CI-67A	SURFACE	4962700	571700	till	77	18	5	1	0.5
CI-67B	SURFACE	4962700	571700	till	79	16	5	2	0.4
CI-67C	SURFACE	4962700	571700	till	35	56	9	11	0.9
CI-67D	SURFACE	4962700	571700	till	28	55	17	25	2.0
CI-72	SURFACE	4960250	573300	till	12	70	18	17	2.0
CI-80	SURFACE	4961600	578850	till	22	42	36	38	3.8
CI-83	SURFACE	4961100	577600	till	86	10	4	3	1.4
CI-84	SURFACE	4960950	577850	till	80	13	7	14	0.7
CI-84D	SURFACE	4960950	577850	till	80	13	7	14	0.7
CI-94	SURFACE	4961600	575600	till	22	47	31		
CI-108	SURFACE	4955350	578700	till	72	21	7	13	0.9
CI-113A	SURFACE	4956650	580100	till	70	24	6	32	7.2
CI-113B	SURFACE	4956650	580100	till	44	44	12	32	4.9
CI-122	SURFACE	4958100	580650	till	33	49	18	34	3.8
CI-122D	SURFACE	4958100	580650	till	33	50	17	34	3.7
CI-129A	SURFACE	4957900	577450	till	67	26	7	17	0.9
CI-129B	SURFACE	4957900	577450	till	26	56	18	31	3.2
CI-129C	SURFACE	4957900	577450	till	62	31	7	25	1.6
CI-133	SURFACE	4959850	580350	till	80	16	4	13	1.1
CI-165	SURFACE	4961400	883800	till	70	23	7	10	0.5

SAMPLE NUMBER	DEPTH (M)	NORTHING (M)	EASTING (M)	MATERIAL	SAND %	SILT %	CLAY %	CARB %	CA/DO
CI-166	SURFACE	4961300	583650	till	62	29	9	14	0.6
CI-171	SURFACE	4958600	582200	till	10	68	22	26	2.6
CI-172	SURFACE	4967050	580950	till	34	53	13	27	1.4
CI-175	SURFACE	4960450	588250	till	66	26	8	17	0.2
CI-177	SURFACE	4961800	585550	till	55	36	9	7	0.4
CI-179	SURFACE	4959900	588750	till	45	43	12	13	0.5
CI-181	SURFACE	4959700	586750	till	68	24	8	17	0.5
CI-184	SURFACE	4956330	586500	till	60	34	6	16	0.3
CI-189	SURFACE	4956100	570300	till	42	49	9	16	0.9
CI-202	SURFACE	4955700	597100	till	65	25	10	31	0.3
CI-203	SURFACE	4955850	598900	till	56	36	8	42	0.3
CI-208A	SURFACE	4956150	593200	till	57	36	7	25	1.0
CI-208B	SURFACE	4956150	593200	till	35	52	13	53	2.7
CI-209	SURFACE	4956400	592800	till	44	47	9	36	0.8
CI-209D	SURFACE	4956400	592800	till	44	46	10	36	0.9
CI-211	SURFACE	4962050	569700	till	48	36	16	22	1.1
CI-212	SURFACE	4959000	570100	till	75	17	8	10	0.4
G-2	SURFACE	4956250	626400	till	42	45	13	3	0.3
G-142	SURFACE	4983250	634200	till	76	21	3	1	0.7
G-148	SURFACE	4967200	640700	till	68	26	6	2	0.4
G-176	SURFACE	4977500	640200	till	70	28	2	1	0.5
G-177	SURFACE	4982700	639200	till	67	29	4	2	0.4
P-41	SURFACE	4978700	598150	till	70	25	5	1	0.5
P-42	SURFACE	4977600	599300	till	70	25	5	2	0.6
P-47	SURFACE	4957750	602550	till	60	30	10	24	0.9
P-56	SURFACE	4983100	602000	till	71	27	2	1	0.0
P-115	SURFACE	4970650	597950	till	74	22	4	2	0.6
P-115D	SURFACE	4970650	597950	till	78	18	4		
P-01-01	7.6-7.9	4959600	586225	till	65	22	13	57	2.1
P-01-02	14.3-14.8	4959600	586225	till	70	19	11	45	1.4
P-01-03	18.3-19.2	4959600	586225	sand	65	31	4		
P-01-04	23.2	4959600	586225	sand	63	34	3		
P-01-05	27.4	4959600	586225	silt	18	77	5		
P-01-06	27.7-29.0	4959600	586225	sand	95	2	3		
P-01-07	38.4-38.7	4959600	586225	sand	95	2	3		
P-01-08	42.7	4959600	586225	sand	90	5	5		
P-01-09	47.5	4959600	586225	sand	79	16	5		
P-01-10	59.7	4959600	586225	sand	95	1	4		
P-01-11	60.8	4959600	586225	till	61	30	9	5	0.7
P-01-12	61.0	4959600	586225	till	54	34	12	41	2.6
P-01-13	61.6-62.5	4959600	586225	till	42	44	14	46	2.6
P-01-14	63.1	4959600	586225	till	28	61	11	36	1.5
P-01-15	66.6	4959600	586225	till	32	51	17	41	2.4
P-01-16	71.6	4959600	586225	till	53	41	6	21	1.1
P-01-17	77.1	4959600	586225	till	49	35	16	48	3.1
P-02-01	9.4	4958100	580275	till	59	36	5	14	0.3
P-02-02	14.8	4958100	580275	silt	13	72	15		
P-02-03	17.4	4958100	580275	till	48	41	11	23	1.4
P-02-05	20.4	4958100	580275	till	23	50	27	33	3.2
P-02-06	25.5	4958100	580275	till	23	53	24	31	2.8

SAMPLE NUMBER	DEPTH (M)	NORTHING (M)	EASTING (M)	MATERIAL	SAND %	SILT %	CLAY %	CARB %	CA/DO
P-02-07	31.7-32.0	4958100	580275	till	26	51	23	30	2.7
P-02-08	41.8	4958100	580275	till	27	40	33	37	3.7
P-02-09	44.8	4958100	580275	till	27	40	33	35	1.9
P-02-10	57.0	4958100	580275	silt	14	76	10		
P-02-11	72.8-73.2	4958100	580275	till	66	24	10	27	3.3
P-02-12	82.3	4958100	580275	sand	97	1	2		
P-02-13	91.9-92.5	4958100	580275	sand	95	1	4		
P-02-14	104.7	4958100	580275	sand	97	0	3		
P-03-01	5.2	4959400	580880	sand	91	6	3		
P-03-02	23.5	4959400	580880	till	68	26	6	15	0.6
P-03-03	28.7-28.8	4959400	580880	till	31	53	16	27	1.5
P-03-04	30.5	4959400	580880	till	29	54	17	26	1.6
P-03-05	31.5	4959400	580880	till	26	50	24	27	2.1
P-03-06	32.0	4959400	580880	till	24	54	22	26	1.9
P-03-07	38.6-39.3	4959400	580880	sand	87	8	5		
P-03-08	60.4	4959400	580880	sand	86	11	3		
P-03-09	66.4	4959400	580880	sand	79	18	3		
P-03-10	79.9	4959400	580880	sand	89	8	3		
P-04-01	6.4	4955850	568940	till	55	37	8	16	0.7
P-04-02	11.3	4955850	568940	sand	98	0	2		
P-04-03	20.1	4955850	568940	sand	45	51	4		
P-04-04	23.8	4955850	568940	sand	91	8	1		
P-04-05	26.4	4955850	568940	till	16	61	23	28	2.4
P-04-06	45.1	4955850	568940	sand	93	4	3		
P-04-07	48.2	4955850	568940	till	41	42	17	17	2.3
P-04-08	50.4	4955850	568940	till	35	48	17	55	1.0
P-04-09	50.6-53.8	4955850	568940	till	33	48	19	43	1.5
P-05-01	8.5-8.7	4959525	569700	till	57	32	11	25	2.4
P-05-02	10.1-10.5	4959525	569700	till	70	23	7	21	1.5

APPENDIX C

GEOCHEMISTRY DATA

Geochemical analyses were performed on the silt and clay fraction (-63 μm) of surface till samples using an aqua regia digestion and the following finishes:

Au: AAS Flame

As: AAS Hydride

Sb: AAS Hydride

Mo: AAS Flame

Ag: AAS Flame

Cu: AAS Flame

Pb: AAS Flame

Zn: ICP OES

Ni: AAS Flame

Cr: AAS Flame

Co: AAS Flame

SAMPLE NUMBER	NORTHING (M)	EASTING (M)	Au PPB	As PPM	Sb PPM	Mo PPM	Ag PPM	Cu PPM	Pb PPM	Zn PPM	Ni PPM	Cr PPM	Co PPM
H-26	5033050	623400	-2	1.7	-0.10	-10	-2	23	15	90	19	44	11
H-28	5031650	625350	-2	-1.0	-0.10	-10	-2	22	13	62	17	36	12
H-62	5028300	629400	-2	-1.0	-0.10	-10	-2	14	12	56	11	69	10
H-65	5026700	630200	-2	-1.0	-0.10	-10	-2	20	13	52	13	43	9
H-89	5022950	626750	-2	-1.0	-0.10	-10	-2	32	13	74	15	36	11
H-94	5014650	621700	-2	-1.0	-0.10	-10	-2	57	13	112	30	49	16
H-119	5035200	632650	-2	-1.0	-0.10	-10	-2	21	12	56	16	46	13
H-124	5032050	637150	-2	-1.0	-0.10	-10	-2	29	12	120	25	64	20
H-125	5031950	636950	-2	-1.0	-0.10	-10	-2	22	15	60	13	37	9
H-148	5028400	633700	3	-1.0	-0.10	-10	-2	10	13	47	12	38	9
H-151	5026800	637000	-2	-1.0	-0.10	-10	-2	27	11	68	19	41	11
H-158	5023800	634800	-2	-1.0	-0.10	-10	-2	40	14	73	18	39	12
H-163	5023300	636650	-2	-1.0	-0.10	-10	-2	42	12	86	25	51	12
H-169	5022600	640750	-2	-1.0	-0.10	-10	-2	20	-10	78	20	58	14
H-173	5022300	641850	-2	-1.0	-0.10	-10	-2	27	11	133	19	54	18
H-174	5021300	639350	-2	-1.0	-0.10	-10	-2	18	12	57	14	45	11
H-179	5025250	641100	-2	-1.0	-0.10	-10	-2	43	14	103	26	54	15
H-180	5026550	645500	-2	-1.0	-0.10	-10	-2	28	14	62	18	51	13
H-181	5027150	645400	-2	-1.0	-0.10	-10	-2	14	14	50	15	49	12
H-187	5022400	645400	-2	-1.0	-0.10	-10	-2	29	12	72	22	61	14
H-193	5024150	652250	-2	-1.0	-0.10	-10	-2	20	12	68	21	52	15
H-195	5021200	654050	-2	-1.0	-0.10	-10	-2	30	11	72	20	51	13
H-196	5020550	653750	-2	-1.0	-0.10	-10	-2	22	13	67	20	49	13
H-198	5018450	651750	-2	-1.0	-0.10	-10	-2	25	13	60	17	48	11
H-201	5023800	629600	-2	-1.0	-0.10	-10	-2	33	12	74	20	52	12
H-203	5023300	630400	-2	-1.0	-0.10	-10	-2	19	12	50	15	42	9
H-206	5020250	629950	-2	-1.0	-0.10	-10	-2	19	13	50	15	42	9
H-221	5014600	634600	-2	-1.0	-0.10	-10	-2	28	14	70	18	46	14
H-239	5017200	637300	-2	-1.0	-0.10	-10	-2	33	15	86	20	48	14
H-240	5017700	636750	-2	1.2	-0.10	-10	-2	37	14	84	21	51	13
H-244	5012500	639100	-2	1.1	-0.10	-10	-2	41	13	96	30	58	14
H-246	5015300	642700	-2	-1.0	-0.10	-10	-2	34	14	86	21	46	11
H-251	5019700	643650	-2	-1.0	-0.10	-10	-2	30	14	62	20	56	12
H-263	5034500	639350	-2	-1.0	-0.10	-10	-2	26	15	78	17	48	12
H-302	5019900	651200	-2	-1.0	-0.10	-10	-2	30	12	66	32	91	14
H-304	5018250	650300	-2	-1.0	-0.10	-10	-2	24	13	56	19	49	12
H-307	5015600	650650	-2	-1.0	-0.10	-10	-2	43	17	72	25	65	13
H-318	5013900	655750	-2	-1.0	-0.10	-10	-2	28	12	105	21	80	18
H-320	5025350	653750	-2	-1.0	-0.10	-10	-2	22	14	64	20	44	13
H-324	5029950	653050	-2	-1.0	-0.10	-10	-2	38	12	62	47	42	17
H-330	5035100	654600	-2	-1.0	-0.10	-10	-2	19	14	100	22	56	13
B-2	5002400	649250	3	-1.0	-0.10	-10	-2	25	12	72	18	51	13
B-4	5007200	651650	-2	-1.0	-0.10	-10	-2	18	12	69	15	46	12
B-7	5010700	657150	-2	-1.0	-0.10	-10	-2	15	13	70	18	54	13
B-9	5003250	657300	-2	-1.0	-0.10	-10	-2	36	11	121	32	65	20
B-11	5001900	649900	-2	-1.0	-0.10	-10	-2	18	12	71	22	49	15
B-17	4994700	655550	-2	-1.0	-0.10	-10	-2	25	14	104	25	58	19
B-23	4992750	642800	-2	-1.0	-0.10	-10	-2	24	14	62	15	39	11
B-26	4992900	645050	-2	-1.0	-0.10	-10	-2	18	-10	56	18	48	12
B-35	4989950	653200	-2	-1.0	-0.10	-10	-2	28	-10	132	51	80	23
B-44	5003200	624000	-2	-1.0	-0.10	-10	-2	18	13	54	15	52	10

SAMPLE NUMBER	NORTHING (M)	EASTING (M)	Au PPB	As PPM	Sb PPM	Mo PPM	Ag PPM	Cu PPM	Pb PPM	Zn PPM	Ni PPM	Cr PPM	Co PPM
B-45	5004400	625800	-2	-1.0	-0.10	-10	-2	19	13	66	14	45	10
B-47	5004750	621200	-2	-1.0	-0.10	-10	-2	28	16	84	25	52	14
B-54	5009450	620550	-2	-1.0	-0.10	-10	-2	36	17	76	23	43	12
B-71	4990100	631650	-2	-1.0	-0.10	-10	-2	15	12	60	16	41	9
B-101	5006800	649100	-2	-1.0	-0.10	-10	-2	46	14	83	47	55	15
B-106	5012000	651550	-2	-1.0	-0.10	-10	-2	34	11	91	24	53	15
B-107	5009950	648550	-2	-1.0	-0.10	-10	-2	21	11	59	16	46	10
B-108	5007150	646400	-2	-1.0	-0.10	-10	-2	18	12	59	13	41	9
B-109	5008250	645900	-2	-1.0	-0.10	-10	-2	28	12	74	18	50	12
B-112	5005950	647300	-2	-1.0	-0.10	-10	-2	14	11	52	15	48	11
B-113	5003500	646800	-2	-1.0	-0.10	-10	-2	11	-10	50	11	41	10
B-124	4995950	635900	-2	-1.0	-0.10	-10	-2	23	13	78	23	51	20
B-130	5002700	639350	-2	-1.0	-0.10	-10	-2	23	12	65	18	50	12
B-131	5003700	637100	-2	-1.0	-0.10	-10	-2	38	11	73	27	53	16
B-133	5006200	639200	-2	-1.0	-0.10	-10	-2	40	12	80	32	64	15
B-137	5009950	637650	-2	-1.0	-0.10	-10	-2	20	14	61	18	47	11
B-138	5010000	643600	-2	-1.0	-0.10	-10	-2	13	-10	56	14	53	12
B-153	4995800	626250	-2	-1.0	-0.10	-10	-2	20	13	67	17	46	11
B-165	4985600	620100	-2	-1.0	-0.10	-10	-2	23	13	72	20	58	14
B-166	4986800	620200	-2	-1.0	-0.10	-10	-2	27	11	74	19	53	11
CI-9	4956100	577850	4	1.7	-0.10	-10	-2	28	14	58	56	125	12
CI-12	4956350	577350	-2	1.0	-0.10	-10	-2	16	-10	50	40	98	10
CI-33	4958050	572350	-2	1.3	-0.10	-10	-2	15	-10	45	30	70	11
CI-42	4957400	568250	-2	1.2	0.19	-10	-2	20	13	50	36	78	11
CI-52	4956850	570400	-2	1.1	-0.10	-10	-2	24	-10	58	56	128	13
CI-57	4956200	569650	3	-1.0	-0.10	-10	-2	21	-10	48	35	74	10
CI-61	4959800	569050	-2	1.3	-0.10	-10	-2	25	10	43	35	84	8
CI-67A	4962700	571700	-2	-1.0	-0.10	-10	-2	26	10	51	34	72	11
CI-67B	4962700	571700	-2	-1.0	-0.10	-10	-2	29	11	50	31	73	10
CI-67C	4962700	571700	-2	-1.0	-0.10	-10	-2	22	-10	54	43	90	11
CI-67D	4962700	571700	-2	-1.0	-0.10	-10	-2	26	-10	61	63	155	11
CI-72	4960250	573300	11	1.4	0.15	-10	-2	25	-10	69	35	84	8
CI-80	4961600	578850	-2	1.3	-0.10	-10	-2	19	-10	47	36	87	9
CI-83	4961100	577600	5	1.6	0.13	-10	-2	23	12	50	30	67	11
CI-84	4960950	577850	-2	-1.0	-0.10	-10	-2	22	11	47	22	58	9
CI-84D	4960950	577850	-2	-1.0	-0.10	-10	-2	21	11	47	22	57	9
CI-108	4955350	578700	-2	1.0	-0.10	-10	-2	22	-10	53	23	56	11
CI-113A	4956650	580100	-2	-1.0	0.14	-10	-2	12	-10	41	15	42	9
CI-113B	4956650	580100	2	-1.0	-0.10	-10	-2	15	-10	45	40	98	10
CI-122	4958100	580650	8	1.4	-0.10	-10	-2	21	-10	45	46	115	9
CI-122D	4958100	580650	-2	1.4	-0.10	-10	-2	20	-10	45	46	116	9
CI-129A	4957900	577450	-2	-1.0	-0.10	-10	-2	17	-10	42	23	50	9
CI-129B	4957900	577450	2	1.1	-0.10	-10	-2	19	-10	41	52	130	9
CI-129C	4957900	577450	3	1.3	-0.10	-10	-2	19	-10	42	42	103	9
CI-133	4959850	580350	-2	1.1	0.17	-10	-2	22	-10	49	46	110	9
CI-165	4961400	883800	-2	1.2	-0.10	-10	-2	26	-10	71	39	99	12
CI-166	4961300	583650	5	1.1	-0.10	-10	-2	26	-10	68	35	82	12
CI-171	4958600	582200	-2	1.5	0.11	-10	-2	26	-10	69	56	137	12
CI-172	4967050	580950	4	1.1	0.12	-10	-2	22	-10	47	46	116	11
CI-175	4960450	588250	-2	-1.0	-0.10	-10	-2	22	-10	44	29	59	9
CI-177	4961800	585550	3	-1.0	-0.10	-10	-2	18	11	57	28	58	10

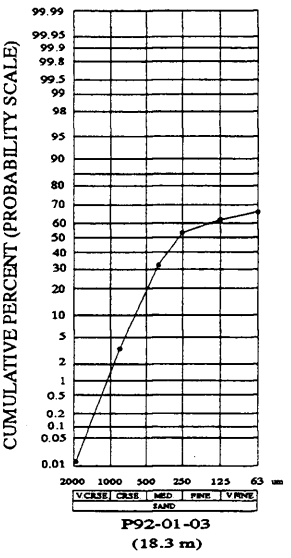
SAMPLE NUMBER	NORTHING (M)	EASTING (M)	Au PPB	As PPM	Sb PPM	Mo PPM	Ag PPM	Cu PPM	Pb PPM	Zn PPM	Ni PPM	Cr PPM	Co PPM
CI-179	4959900	588750	3	1.0	-0.10	-10	-2	20	11	62	35	74	11
CI-181	4959700	586750	-2	-1.0	-0.10	-10	-2	19	17	46	27	59	9
CI-184	4956330	586500	-2	-1.0	-0.10	-10	-2	13	10	42	19	45	8
CI-189	4956100	570300	-2	1.0	-0.10	-10	-2	20	-10	50	30	62	10
CI-202	4955700	597100	-2	1.2	-0.10	-10	-2	22	-10	45	32	105	9
CI-203	4955850	598900	-2	-1.0	-0.10	-10	-2	21	-10	44	26	66	8
CI-208A	4956150	593200	-2	1.0	-0.10	-10	-2	23	-10	52	37	82	10
CI-208B	4956150	593200	-2	-1.0	-0.10	-10	-2	11	-10	27	29	67	5
CI-209	4956400	592800	2	1.6	-0.10	-10	-2	18	-10	40	36	81	8
CI-209D	4956400	592800	-2	1.6	-0.10	-10	-2	17	-10	40	36	81	7
CI-211	4962050	569700	-2	1.9	-0.10	-10	-2	22	11	53	40	89	11
CI-212	4959000	570100	-2	1.3	-0.10	-10	-2	25	-10	51	34	65	10
G-2	4956250	626400	4	1.0	-0.10	-10	-2	22	-10	66	105	35	14
G-142	4983250	634200	8	-1.0	-0.10	-10	-2	13	13	60	35	91	11
G-148	4967200	640700	11	1.8	-0.10	-10	-2	42	23	97	60	136	15
G-176	4977500	640200	2	-1.0	-0.10	-10	-2	23	14	58	33	76	10
G-177	4982700	639200	3	-1.0	-0.10	-10	-2	10	13	51	27	64	11
P-41	4978700	598150	3	-1.0	-0.10	-10	-2	40	15	68	108	245	14
P-42	4977600	599300	-2	-1.0	-0.10	-10	-2	26	15	69	38	83	12
P-47	4957750	602550	5	-1.0	0.20	-10	-2	23	12	56	55	133	11
P-56	4983100	602000	-2	-1.0	-0.10	-10	-2	36	16	66	41	93	12
P-115	4970650	597950		-1.0	-0.10	-10	-2	19	13	60	51	123	11
P-115D	4970650	597950	-2	-1.0	-0.10	-10	-2	19	13	60	51	123	11
P92-01-01	4959600	586225				-6	2	18	-10	28	28		7
P92-01-02	4959600	586225				-6	2	18	-10	28	24		8
P92-01-11	4959600	586225				-6	-2	27	14	63	58		15
P92-01-12	4959600	586225				-6	-2	18	-10	38	33		9
P92-01-13	4959600	586225				-6	-2	14	-10	32	28		8
P92-01-14	4959600	586225				-6	-2	13	-10	36	14		8
P92-01-15	4959600	586225				-6	-2	15	-10	37	23		8
P92-01-16	4959600	586225				-6	-2	20	-10	48	35		12
P92-01-17	4959600	586225				-6	-2	11	-10	27	23		6
P92-02-01	4958100	580275				-6	-2	15	12	51	19		10
P92-02-03	4958100	580275				-6	-2	19	10	50	28		10
P92-02-05	4958100	580275				-6	-2	18	-10	46	31		9
P92-02-06	4958100	580275				-6	-2	19	10	50	27		10
P92-02-07	4958100	580275				-6	2	18	-10	46	28		10
P92-02-08	4958100	580275				-6	-2	21	-10	52	31		10
P92-02-09	4958100	580275				-6	-2	19	-10	48	38		9
P92-02-11	4958100	580275				-6	2	18	-10	31	18		8
P92-03-02	4959400	580880				-6	2	18	10	52	20		11
P92-03-03	4959400	580880				-6	-2	21	-10	60	39		13
P92-03-04	4959400	580880				-6	-2	19	-10	58	29		12
P92-03-05	4959400	580880				-6	-2	24	-10	65	30		14
P92-03-06	4959400	580880				-6	-2	22	-10	64	32		13
P92-04-01	4955850	568940				-6	2	17	-10	51	23		12
P92-04-05	4955850	568940				-6	-2	18	-10	48	34		11
P92-04-07	4955850	568940				-6	-2	14	-10	28	19		7
P92-04-08	4955850	568940				-6	-2	13	-10	33	17		7
P92-04-09	4955850	568940				-6	-2	17	-10	44	21		9
P92-05-01	4959525	569700				-6	-2	21	-10	49	51		13

SAMPLE NUMBER	NORTHING (M)	EASTING (M)	Au PPB	As PPM	Sb PPM	Mo PPM	Ag PPM	Cu PPM	Pb PPM	Zn PPM	Ni PPM	Cr PPM	Co PPM
P92-05-02	4959525	569700				-6	-2	28	-10	52	48		13

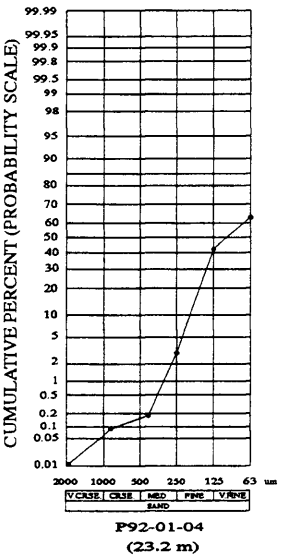
APPENDIX D

AQUIFER AND AQUITARD GRAIN SIZE CHARACTERISTICS

The sediment distribution of the sand fraction of stratified sediment samples collected from the sonic drilling program are presented on cumulative percent probability plots. The steepest curves represent the best sorted samples.



P92-01-03
(18.3 m)



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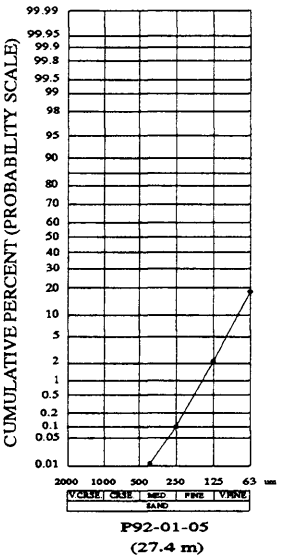
(23.2 m)



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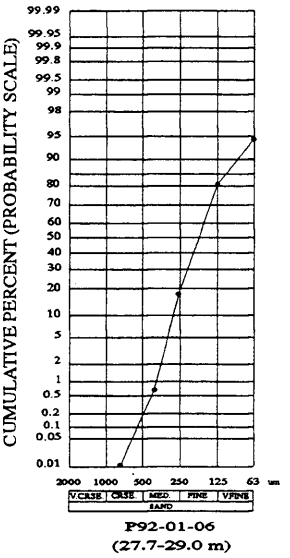
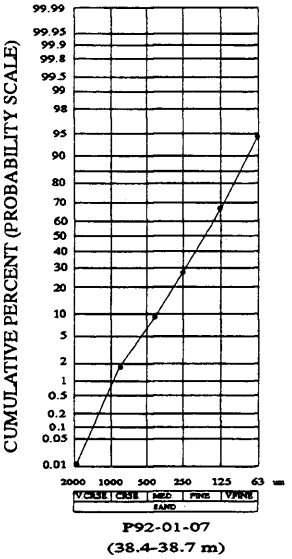
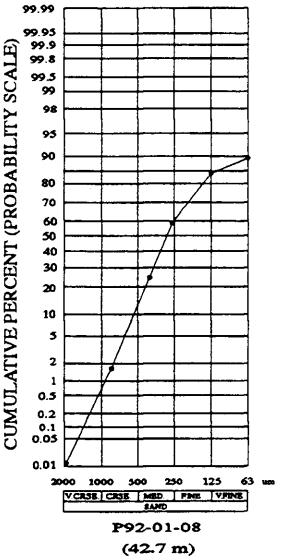
(27.4 m)



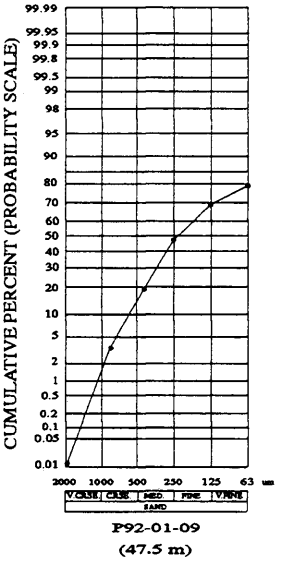
P92-01-06
(27.7-29.0 m)



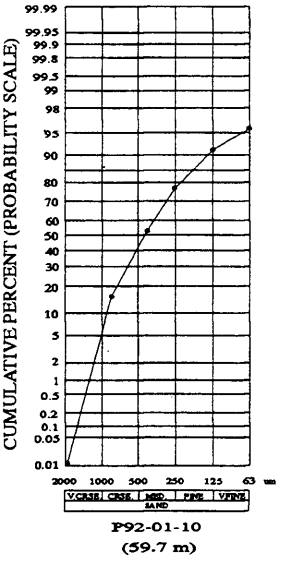
P92-01-07
(38.4-38.7 m)



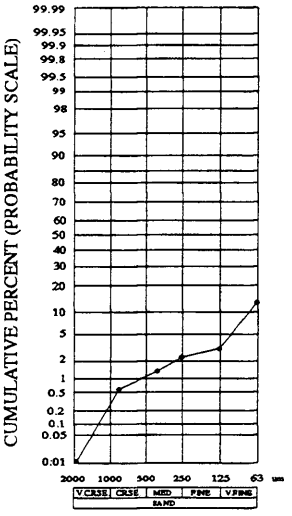
P92-01-08
(42.7 m)



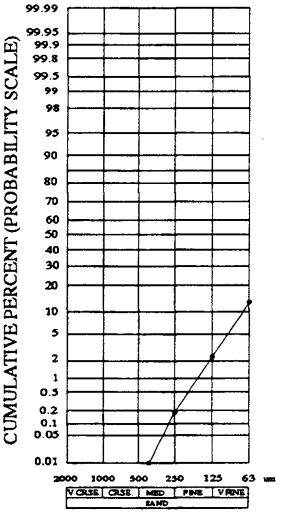
P92-01-09
(47.5 m)



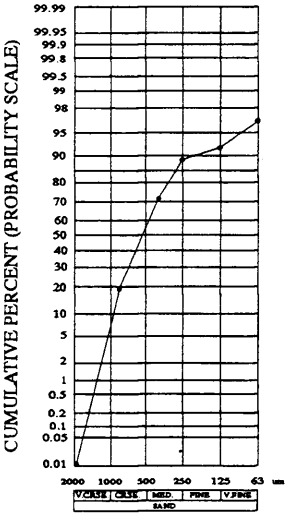
P92-01-10
(59.7 m)



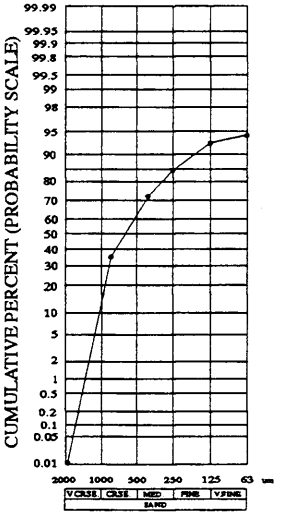
P92-02-02
(14.8 m)



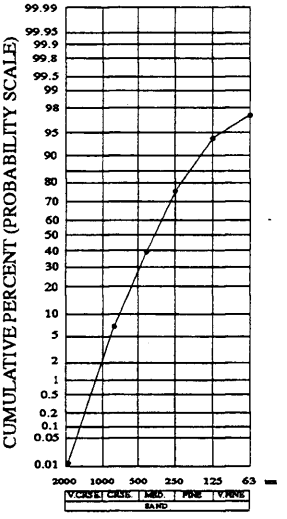
P92-02-10
(57.0 m)



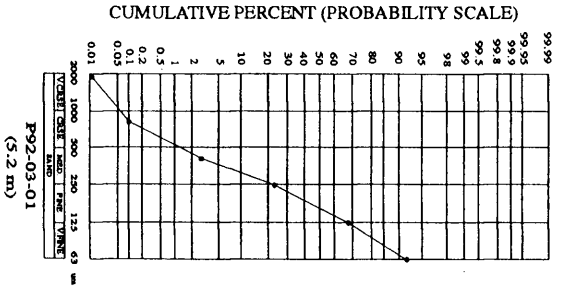
P92-02-12
(82.3 m)

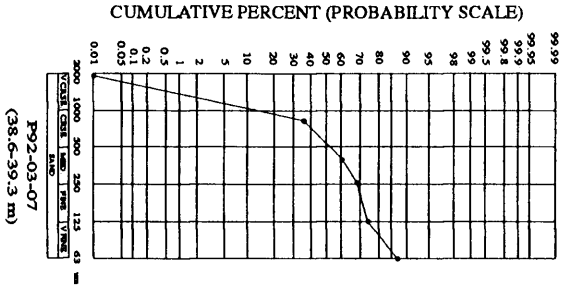


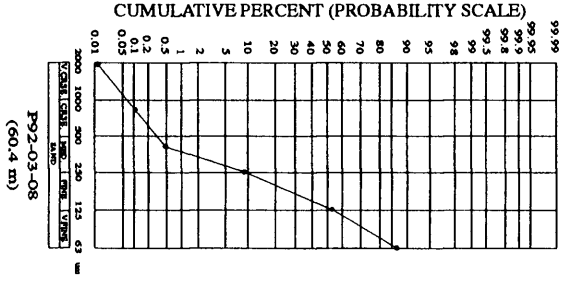
P92-02-13
(91.9-92.5 m)

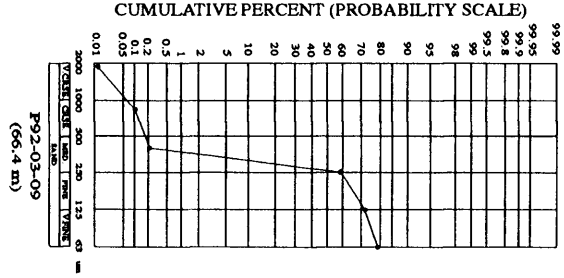


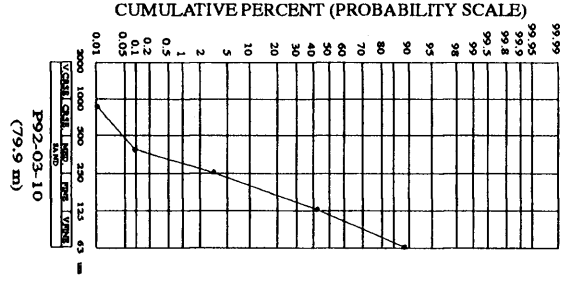
P92-02-14
(104.7 m)

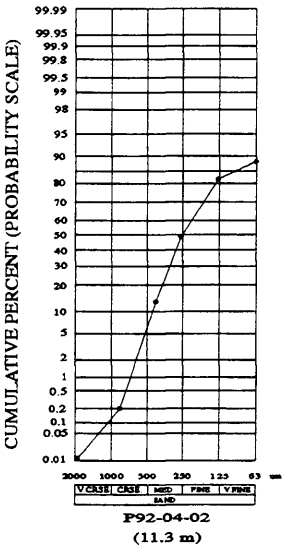

CUMULATIVE PERCENT (PROBABILITY SCALE)
P92-03-01
(5.2 m)


CUMULATIVE PERCENT (PROBABILITY SCALE)
P92-03-07
(38.6-39.3 m)

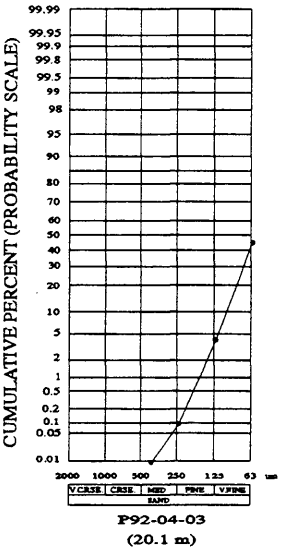

CUMULATIVE PERCENT (PROBABILITY SCALE)
P92-03-08
(60.4 m)


CUMULATIVE PERCENT (PROBABILITY SCALE)
P92-03-09
(66.4 m)

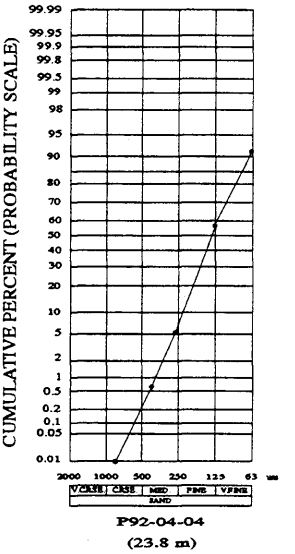

CUMULATIVE PERCENT (PROBABILITY SCALE)
P92-03-10
(79.9 m)



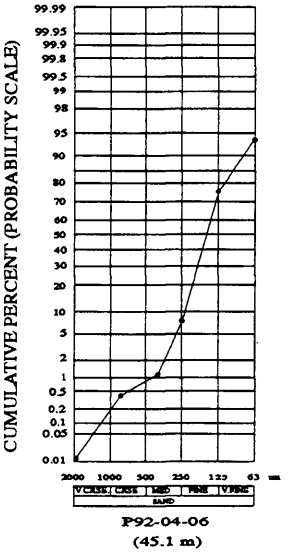
P92-04-02
(11.3 m)



P92-04-03
(20.1 m)



P92-04-04
(23.8 m)



P92-04-06
(45.1 m)

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	25.4	mm
1 cm	0.393 70	inches	1 inch	2.54	cm
1 m	3.280 84	feet	1 foot	0.304 8	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	1.609 344	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	6.451 6	cm^2
1 m^2	10.763 9	square feet	1 square foot	0.092 903 04	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	16.387 064	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	4.546 090	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	31.103 476 8	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	0.453 592 37	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	907.184 74	kg
1 t	1.102 311	tons (short)	1 ton (short)	0.907 184 74	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	1016.046 908 8	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	1.016 046 908 8	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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ISSN 0826–9580
ISBN 0-7778-2459-0

LEGEND[a]

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

10 **Modern alluvium:** sand and silt with detrital organic remains.

9 **Swamp and organic deposits:** peat and muck.

PLEISTOCENE

8 **Older alluvium:** sand and silt, minor gravel; occur in terrace remnants.

7 **Glaciolacustrine coarse-grained deposits:** fine to very fine sand, minor pebbly sand and silt; includes sandy, subaquatic fan deposits.

6 **Glaciolacustrine fine-grained deposits:** silt and clay, minor sand; massive to well laminated.

5 **Glaciofluvial outwash deposits:** undifferentiated sand and gravel.

5a: fine to coarse sand, minor gravel.
5b: sandy gravel to gravel.

4 **Glaciofluvial ice-contact stratified drift deposits:** sand, gravel and boulders, minor till.

4a: in eskers, kames and kame terraces.
4b: in subaquatic fans; may be overlain by thin deposits of glaciolacustrine sand, silt and clay.

3 **Till:** silty fine to very fine sand with variable stone content; low matrix carbonate content; typically loose; may contain some bedrock outcrops.

2 **Bedrock-drift complex:** thin, discontinuous drift cover; contains areas of drift greater than 1 m thick, although not large enough to delineate at the scale of this map.

PRECAMBRIAN

1 **Bedrock:** exposed or with very thin drift cover

[a] Deposits on this sheet are mapped only where they reach one metre or more in thickness. Thinner deposits are not shown.

SYMBOLS

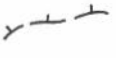
Geological boundary (approximate).

Glacial striae; direction of ice movement known or assumed; dot represents actual site location.

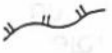
Fluting

Ice-contact slope.

Trend of moraine crest.



Bedrock escarpment.



Wave-cut notch or shore bluff.

Beach ridge or bar

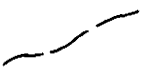
Small area of bedrock outcrop in areas of extensive drift cover.

Parabolic dunes and blowout depressions.

Sand and gravel pit.

Bedrock quarry.

SYMBOLS



Geological boundary (approximate)

Glacial striae; direction of ice movement known or assumed; dot represents actual site location.

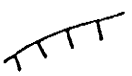
Fluting

Esker ridge; direction of flow known or assumed.

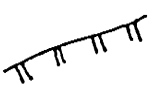
Ice-contact slope

Kettle depression

Trend of moraine crest



Fluvial terrace escarpment



Wave-cut notch or shore bluff

Parabolic dunes and blowout depressions

Small area of bedrock outcrop in areas of extensive drift cover.

Sand and gravel pit

SOURCES OF INFORMATION

Basemap derived from Map 31D/14 (Gravenhurst) of the National Topographic System. Contour interval 50 feet, scale 1:50 000.

Aerial photography by the Ontario Ministry of Natural Resources, Toronto.

Magnetic declination approximately $10^{o}13'$ in 1978.

CREDITS

Geology by A.F. Bajc, J.T. Paterson and assistants, 1991.

Every possible effort has been made to ensure the accuracy of the information presented on this map; however, the Ontario Ministry of Northern Development and Mines does not assume any liability for errors that may occur. Users may wish to verify critical information.

Issued 1992.

The Ontario Ministry of Natural Resources and the District Municipality of Muskoka provided financial assistance to the field program of this project.

Information on this publication may be quoted if credit is given. It is recommended that reference to this map be made in the following form:

Bajc, A.F. and Paterson, J.T., 1992. Quaternary geology of the Gravenhurst area, southern Ontario; Ontario Geological Survey, Open File Map 1995, scale 1:50 000.

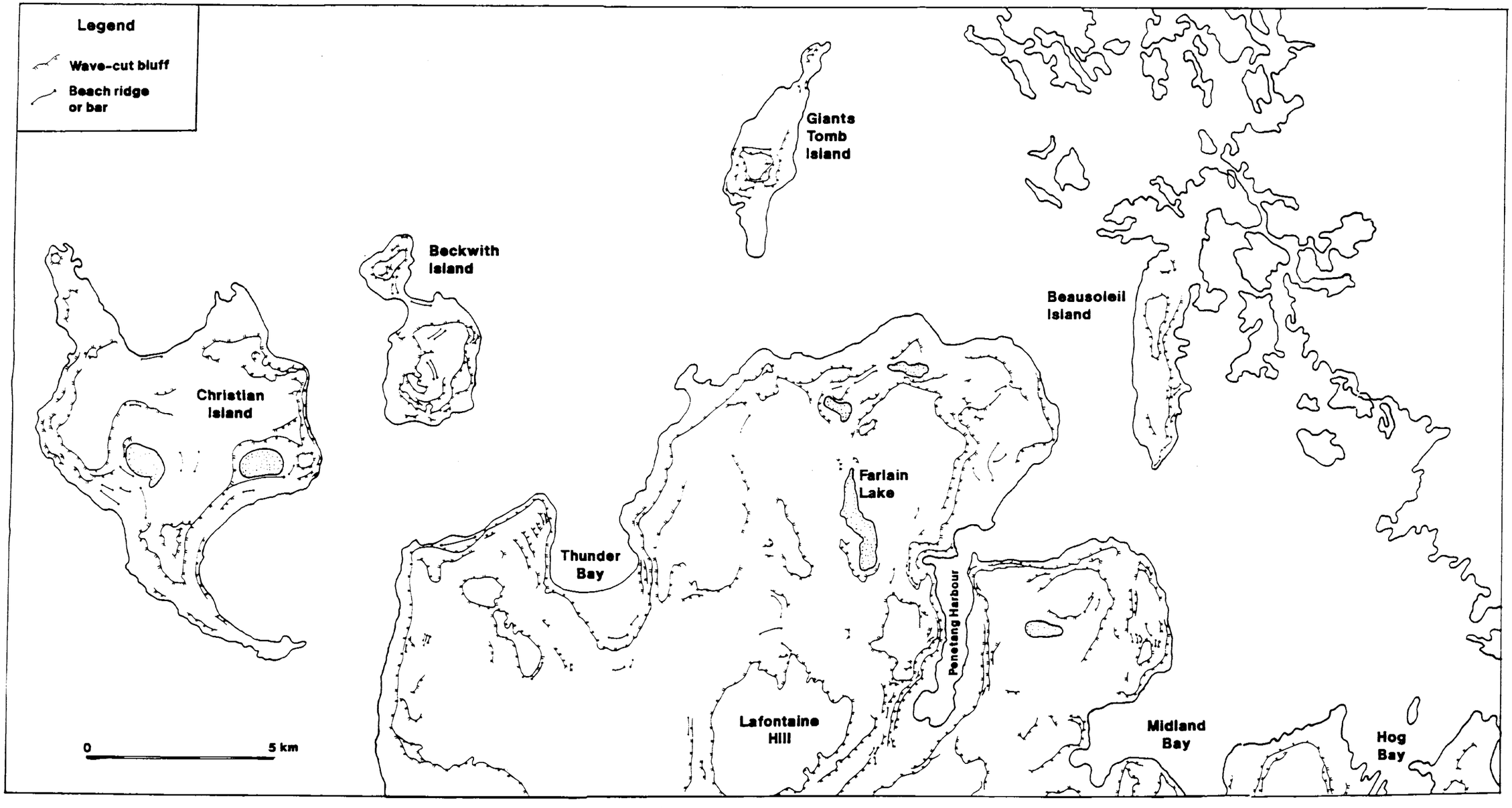


Figure 9. Shoreline features of the Simcoe Upland.

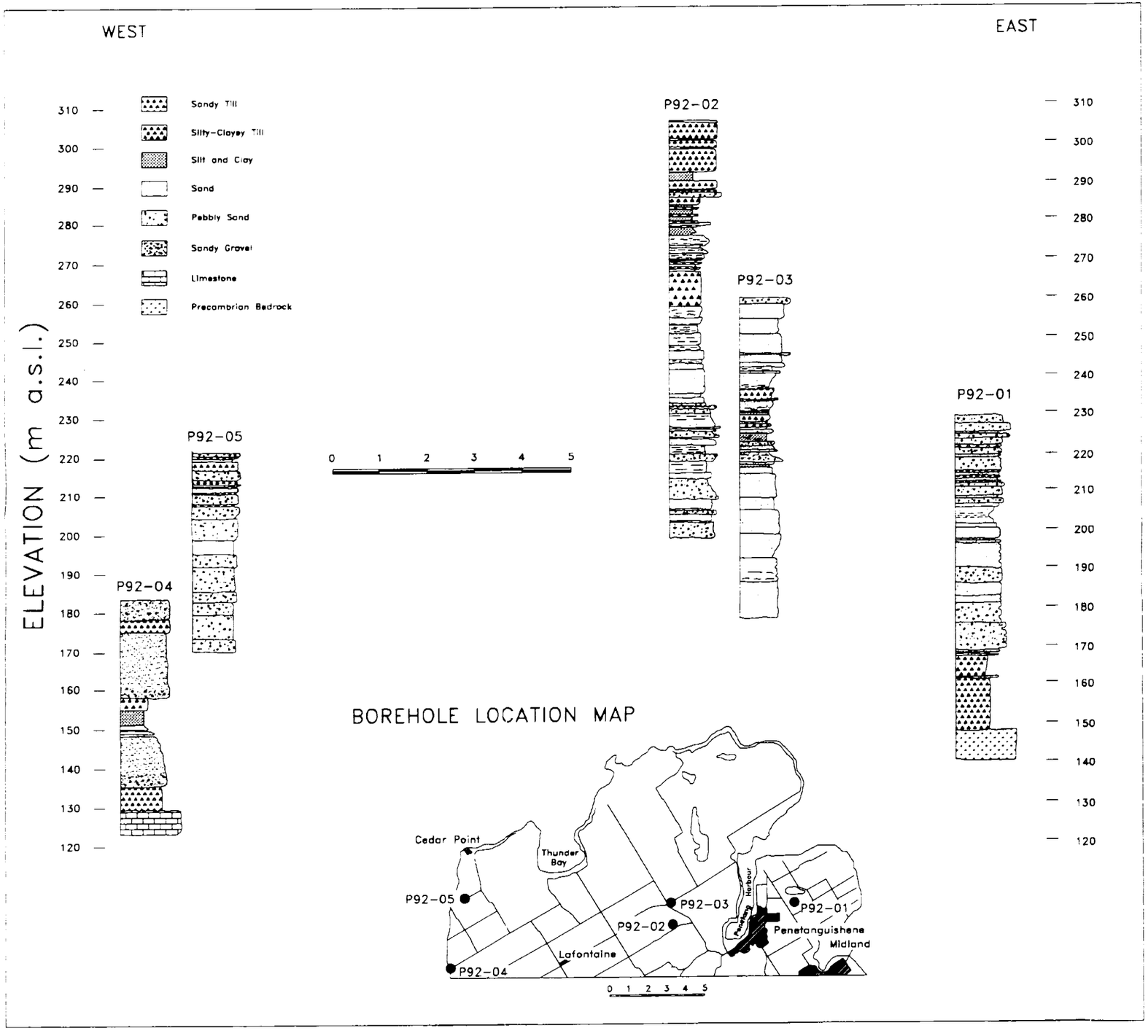


Figure 5. Subsurface profile across the Penetanguishene Peninsula.

Waubashene Nipissing Transgression Site Main Pollen

Analyses by D. Siddiqi, Royal Ontario Museum

44°47'N, 79°41'W; ca. 190m a.s.l.

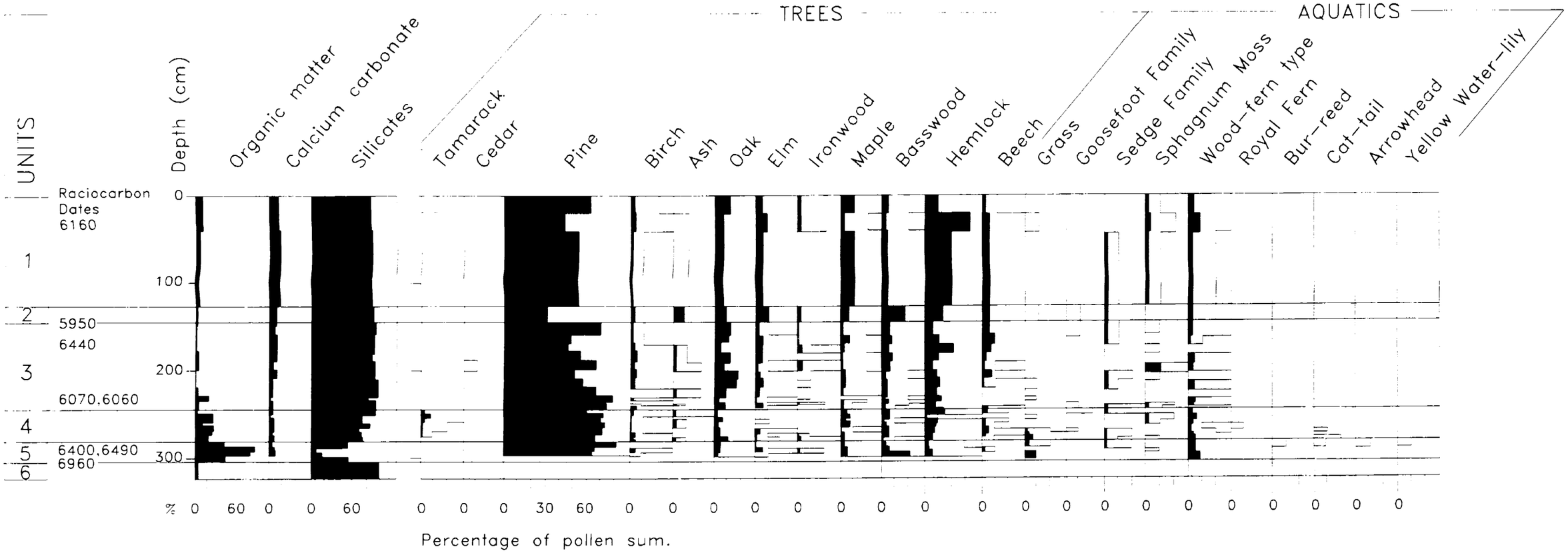


Figure 11. Pollen diagram for the Nipissing site north of Waubashene.

GRAVENHURST
ONTARIO
Scale 1:50 000 Échelle

Miles 1 0 1 2 3 Miles
Metres 1000 0 1000 2000 3000 4000 Mètres
Yards 1000 0 1000 2000 3000 4000 Verges

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Ministère de l'Énergie, des Mines et des Ressources

Roads — Routes

	Unpaved / Non-revêtue	Dual / Double chaussée
hard-surface, all weather — pavée, toute saison	2 lanes / 2 voies	4 lanes or more / plus de 2 voies
hard-surface, all weather — pavée, toute saison	1 lane / 1 voie	less than 2 lanes / moins de 2 voies
loose or stabilized surface, all weather — gravelée, egalisée, toute saison	2 lanes or more / 2 voies ou plus	less than 2 lanes / moins de 2 voies
loose surface, dry weather — chaussée non revêtue, temps sec		
unclassified streets — rues non classées		
cart track — chemin de terre		
road, trail or portage — route, piste ou sentier, piste ou portage		

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CONVERSION SCALE FOR ELEVATIONS
Metres 50 100 150 200 250 300 350 400 Mètres
Feet 100 200 300 400 500 600 700 800 900 1000 Pieds

ÉCHELLE DE CONVERSION DES ALTITUDES

CONTOUR INTERVAL 50 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

ÉQUIDISTANCE DES COURBES 50 PIEDS
Altitudes en pieds
Système de référence géodésique nord-américain 1927
Projection transverse de Mercator

Military users, refer to this map as: Référence de cette carte pour usage militaire:

SERIES	A 751	SÉRIE
MAP	31 D/14	CARTE
EDITION	3 MCE	EDITION

GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Arena	Aréna
City Limit	Limite de ville
Cuttings	Déblais
Ditch	Fossé
Dugout	Abreuvoir
Dump	Dépotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferrailles
Kiln	Four
Lookout	Belvédère
Mine Waste	Débris de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Patinoire
Senior Citizens Home	Foyer de 3 âge d'or
Ski Area	Station de ski
Strong Bog	Tourbière acidophile
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Winter Road	Chemin d'hiver

For a complete glossary see reverse side
Pour un glossaire complet, voir au verso

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonnée ou
C	Cemetery	Cimetière
CO	County	Comté
E	Ellipsoid	Ellipsoïde
Ky	Ferry	Traverse
IR	Indian Reserve	Réserve indienne
H	Helipad	Héliport
L	Lot	Lot
Micro	Microwave	Micro-onde
Mun	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale du Canada
Res	Reservoir	Réservoir
Trans Sta	Transformer Station	Poste de transformateurs
TL	Timber Limit	Limite de vente de bois

ONE THOUSAND METRE UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 17
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSEL DE MERCATOR

GRID ZONE DESIGNATION / DÉSIGNATION DE LA ZONE DU QUADRILLAGE	100 000 m SQUARE IDENTIFICATION / IDENTIFICATION DU CARRÉ DE 100 000 m
17S	PV

EXAMPLE OF METHOD USED TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA METHODE EMPLOYÉE POUR TROUVER DES REPÈRES À 100 METRES PRÈS

REFERENCE POINT / POINT DE REPÈRE: CHURCH / Église

EASTING: Read number on grid line immediately to left of point
ABSCISSE: Notez le chiffre de la ligne de quadrillage immédiatement à gauche du repère
Estimate tenths of a square from this line eastward to point
Estimez le nombre de dixièmes de carré entre cette ligne et le repère en direction est

NORTHING: Read number on grid line immediately below point
ORDONNÉE: Notez le chiffre de la ligne de quadrillage immédiatement au-dessous du repère
Estimate tenths of a square from this line northward to point
Estimez le nombre de dixièmes de carré entre cette ligne et le repère en direction nord

GRID REFERENCE: 964
RÉFÉRENCE AU QUADRILLAGE: 17TQM64

Nearest 1 000 m grid reference is 17TQM64 (when referring to nearest 1 000 m square)
La référence au quadrillage de 1 000 m la plus proche est 17TQM64

TABLEAU D'ASSEMBLAGE DU SYSTÈME NATIONAL DE RÉFÉRENCE CARTOGRAPHIQUE

INDEX TO ADJOINING MAPS OF THE NATIONAL TOPOGRAPHIC SYSTEM

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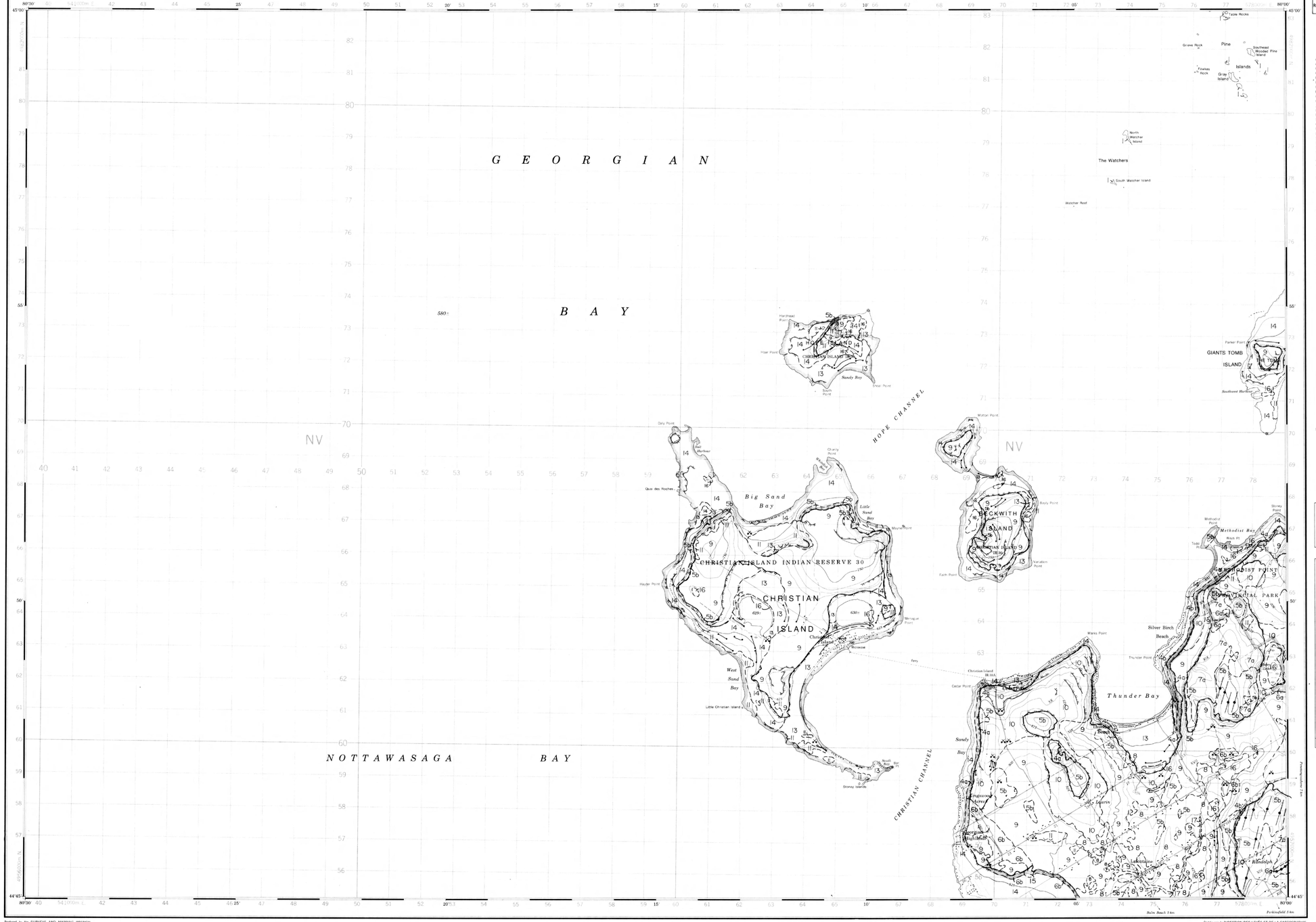
GRAVENHURST
31 D/14
EDITION 3


G E O R G I A N B A Y
NOTTAWASAGA B A Y
HOPE CHANNEL
CHRISTIAN CHANNEL
CHRISTIAN ISLAND INDIAN RESERVE 30
CHRISTIAN ISLAND
BECKWITH ISLAND
GIANTS TOMB ISLAND
THE TOMB
Big Sand Bay
Thunder Bay
Methodist Bay
Sandy Bay
Southwest Harbour
Parker Point
Hoar Point
Daly Point
Quai des Roches
Harbour
Cherry Point
Little Sand Bay
Muskrat Point
Hayden Point
Mohegan Point
West Sand Bay
Little Christian Island
Stonoy Islands
Christian Island IR 30A
Cedar Point
Marks Point
Thunder Point
Silver Birch Beach
Stoney Point
Todd Point
Farth Point
Variation Point
Bluffy Point
Mutton Point
Parkinsfield 3 km
Bulls Beach 3 km
The Watchers
North Watcher Island
South Watcher Island
Watcher Reef
Table Rocks
Grave Rock
Pine Islands
Southeast Wooded Pine Island
Gray Island
Fireless Rock
Hardman Point
Sandy Bay
Sharp Point
Ewan Point
Sharp Point
Ingleside
Moira
Lakeshore
Randolph
St. Laurin
Penetanguishene
Penetanguishene Bay
Penetanguishene Harbour
Midland
Midland Bay
Wye Marsh Wildlife Centre
Wye River
Wye Marsh
Wye Creek
Sturgeon Bay
Sturgeon Point
Hogg Bay
Hogg Point
Hogg Bay Provincial Park
Hogg Bay Provincial Park
Hogg Bay Provincial Park

GEORGIAN BAY

NOTTAWASAGA BAY

CHRISTIAN ISLAND INDIAN RESERVE 30

CHRISTIAN ISLAND

HOPE CHANNEL

CHRISTIAN CHANNEL

THE WATCHERS

GIANTS TOMB ISLAND

BECKWITH ISLAND

CHRISTIAN ISLAND 30A

Hardhead Point
Hoar Point
Sandy Bay
Shoal Point
South Point
Daly Point
Quai des Roches
Big Sand Bay
Little Sand Bay
Hayter Point
Mayne Point
Messagué Point
West Sand Bay
Little Christian Island
Christian Island
Wharf
Microwave
Ferry
South Bay
Star Pt
Stoney Islands
Chardy Point
Whaling Bay
Motter Point
Bayly Point
Variation Point
Faith Point
Table Rocks
Grieve Rock
Pine
Southeast Wooded Pine Island
Islands
Fawkes Rock
Gray Island
North Watcher Island
South Watcher Island
Watcher Reef
Parker Point
Southeast Harbour
Methodist Point
Methodist Bay
Ways Pt
Todds Pt
Stoney Pt
METHODIST POINT
PROVINCIAL PARK
Silver Birch Beach
Marks Point
Thunder Point
Thunder Bay
Cedar Point
Sandy Bay
Fingerroost Acres
Laurin
Lafontaine
Randolph
Parkwood Heights
Baie Beach 5.8m
Perkinsfield 5.8m

580±

NV

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Department of Energy, Mines and Resources

Roads	Routes	dual highway / 2 chaussées séparées	more than 2 lanes / plus de 2 voies
hard surface, all weather	pavée, toute saison		plus de 2 voies
hard surface, all weather	pavée, toute saison	2 lanes / 2 voies	less than 2 lanes / moins de 2 voies
loose or stabilized surface, all weather	gravier, agglomérat, toute saison	2 lanes or more / 2 voies ou plus	less than 2 lanes / moins de 2 voies
loose surface, dry weather	de gravier, temps sec		
unclassified streets	rues hors classe		
cart track	de terre		
trail, cut line or portage	sentier, percée ou portage		

FOR COMPLETE REFERENCE SEE REVERSE SIDE POUR UNE LISTE COMPLÈTE DES SIGNES VOIR AU VERSO

CHRISTIAN ISLAND
ONTARIO

Scale 1:50,000 Échelle

Miles 1 0 1 2 3 Miles
Metres 1000 0 1000 2000 3000 4000 Mètres
Yards 1000 0 1000 2000 3000 4000 Verges

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CONVERSION SCALE FOR ELEVATIONS

Metres 30 20 10 0 50 100 150 200 250 300 Metres
Feet 100 50 0 100 200 300 400 500 600 700 800 900 1000 Pieds

CONTOUR INTERVAL 25 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

ÉQUIDISTANCE DES COURBES 25 PIEDS
Élevations en pieds au dessus du niveau moyen de la mer
Système de référence géodésique nord-américain, 1927
Projection transverse de Mercator

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Military users, refer to this map as: / Référence de cette carte pour usage militaire: SERIES A 751 SÉRIE; MAP 41 A/16 CARTE; EDITION 3 MCE EDITION

GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Area	Zone
City Limits	Limites de ville
Customs	Douane
Ditch	Fossé
Disused	Abandonné
Dump	Dépotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferraille
Kiln	Four
Lookout	Belvédère
Mine Waste	Déblais de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Patinoire
Senior Citizens Home	Foyer de 3 âge d'or
Ski Area	Station de ski
Sleeping Bag	Installations d'hébergement
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Weir Road	Chemin d'eau

For a complete glossary see reverse side
Pour un glossaire complet, voir au verso

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonné ou
C	Cemetery	Cimetière
CO	County	Comté
E	Elevation	Élévation
Fy	Ferry	Traversier
IR	Indian Reserve	Réserve indienne
H	Hospital	Hôpital
L	Lot	Lot
Mtce	Maintenance	Mise en condition
Mun	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale Canadienne
Res	Reservoir	Réservoir
Trans Sta	Transformer Station	Poste de transformateur
TH	Town Hall or Township Hall	Hôtel de ville ou de canton

Use diagram only to obtain numerical values.
APPROXIMATE MEAN DECLINATION 1977
FOR CENTRE OF MAP
Annual change increasing 1'E

N'utiliser le diagramme que pour obtenir les valeurs numériques.
DÉCLINAISON MOYENNE APPROXIMATIVE
AU CENTRE DE LA CARTE EN 1977
Variation annuelle croissante 1'E

ONE THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 17
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSELLE DE MERCATOR

GRID ZONE DESIGNATION / DÉSIGNATION DE LA ZONE DU QUADRILLAGE	100,000 M SQUARE IDENTIFICATION / IDENTIFICATION DU CARRÉ DE 100,000 M
17 T	NV

EXAMPLE OF METHOD USED TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS

	CHURCH / ÉGLISE	(as above / ci-dessus)
REFERENCE POINT / POINT DE REPÈRE		
EASTING: Read number on grid line immediately to left of point. LONGITUDE EST: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère.		97
Estimate tenths of a square from this line eastward to point. Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est		5
		975
NORTHING: Read number on grid line immediately below point. LATITUDE NORD: Noter le chiffre de la ligne du quadrillage immédiatement en dessous du repère.		98
Estimate tenths of a square from this line northward to point. Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord		4
GRID REFERENCE / RÉFÉRENCE AU QUADRILLAGE		9759 84

Nearest corner grid reference (100,000 metres) about 5 miles.
La prochaine référence voisine est à 100,000 mètres environ 63 milles.

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CHRISTIAN ISLAND
41 A/16
EDITION 3

Ministry of Northern Development and Mines
Ontario

Mines and Minerals Division
Ontario Geological Survey

Open File Map 161

Quaternary Geology of the Huntsville–Bracebridge Area

Southern Ontario

Scale 1:50 000

1000 m 0 1 2 km

UNEDITED MANUSCRIPT

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Roads / Routes

hard surface / revêtement dur
loose or stabilized surface,all weather / gravier aggloméré, toute saison
loose surface, dry weather / gravier, temps sec
unclassified road or street / route non classifiée ou rue
cart track / de ferme
trail / sentier, gare de eu portage

FOR COMPLETE REFERENCE SEE REVERSE SIDE — POUR UNE LISTE COMPLÈTE DES SIGNES, VOIR AU VERSO

BRACEBRIDGE

MUSKOKA DISTRICT MUNICIPALITY

ONTARIO

Scale 1:50 000 Échelle

Miles 1 0 1 2 3 Milles

Metres 1000 0 1000 2000 3000 4000 Metres

Information concerning bench marks and horizontal survey monuments can be obtained from Geodetic Survey, Surveys and Mapping Branch, Ottawa.

CONVERSION SCALE FOR ELEVATIONS

Metres 30 20 10 0 50 100 150 200 250 300 Metres

Feet 100 50 0 100 200 300 400 500 600 700 800 900 1000 Feets

CONTOUR INTERVAL 50 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Projection transverse de Mercator

Pour tout renseignement concernant les repères et bornes arpentés-géodésiques, s'adresser aux vieux géodésiques, Direction des levés et de la cartographie, Ottawa

ÉCHELLE DE CONVERSION DES ALTITUDES

EQUIDISTANCE DES COURBES 50 PIEDS
Altitudes en pieds
Système de référence géodésique nord-américain 1927
Projection transverse de Mercator

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