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ONTARIO GEOLOGICAL SURVEY
Open File Report 5553

# Quaternary Geology of the Kirkland Lake Area
Districts of Cochrane and Timiskaming

by
C.L. Baker
1985

THIS PROJECT IS PART OF THE KIRKLAND LAKE INITIATIVES PROGRAM (KLIP) WHICH WAS FUNDED EQUALLY BY THE FEDERAL DEPARTMENT OF REGIONAL ECONOMIC EXPANSION (DREE) AND THE ONTARIO MINISTRY OF NORTHERN AFFAIRS UNDER THE COMMUNITY AND RURAL RESOURCE DEVELOPMENT AGREEMENT.

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V. G. Milne

**V. G. Milne, Director**
**Ontario Geological Survey**

# FOREWORD

The Kirkland Lake area has a history of development dating back to the turn of the century. In order to assist the further growth of the region, the Ontario Geological Survey completed the Quaternary mapping as part of a multi-disciplinary program.

This report describes the types of glacial deposits, their form and distribution. Subglacial and proglacial depositional environments are identified and the post-glacial history of the area is reconstructed.

The Quaternary materials in the Kirkland Lake area are diverse and their lateral and vertical relationships complex. A thorough understanding of the genesis of all deposit types is essential to ensure that optimum use is made of the land surface and the underlying materials. This report provides a framework for the utilization of the glacial drift in mineral exploration, land use planning, engineering and environmental studies.

This work is part of the Kirkland Lake area geoscientific surveys and was funded equally by the Federal Department of Regional Economic Expansion and the Ontario Ministry of Northern Affairs under the Community and Rural Resource Development Subsidiary Agreement.

V. G. Milne
Director
Ontario Geological Survey

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# ABSTRACT

The Kirkland Lake area is situated along the continental drainage divide in northeastern Ontario. The bedrock geology of the area consists of Early Precambrian (Archean) metamorphosed intrusive and layered assemblages and an unmetamorphosed Middle Precambrian (Proterozoic) layered assemblage. Drift thicknesses on the rock highlands are generally shallow (1-2 m) with outcrops common, although drift in excess of 30 m is found in the intervening valleys.

All Pleistocene deposits examined are believed to be Wisconsinan in age. The oldest unit occurring at the surface is a silty sand till deposited by a glacial advance to the SSE (165° azimuth). This advance deposited subglacial, supraglacial and flow tills.

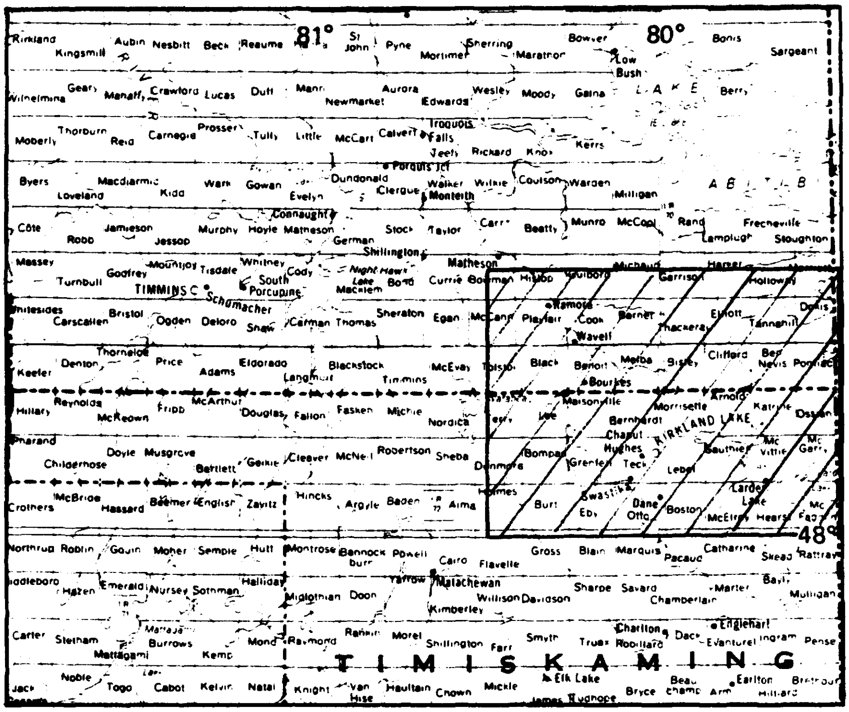
During the waning stages of ice cover, ice-contact glaciofluvial sediments were deposited as eskers, subaqueous fans and morainic landforms. Three major depositional environments are recognized in the esker deposits.

The melting back of the glacier, circa 10,000 years B.P., allowed the land to be inundated by the waters of glacial Lakes Barlow and Ojibway. Coarse-grained

glaciolacustrine sediments (sand with minor gravel) were deposited as a facies of ice-contact glaciofluvial sediments and in high energy, shallow-water settings. Fine-grained glaciolacustrine sediments consisting mainly of varved clay, were deposited contemporaneously in the quieter and more distal portions of the glacial lakes.

As the lake levels dropped, till and glaciofluvial sediments were reworked by wave action, producing beach and nearshore features throughout the map-area. During the regression of the lake, progressively lower drainage channels (spillways) were utilized, resulting in minor fluvial deposits. Following withdrawal of the glacial lakes, warmer conditions allowed eolian landforms to develop on sand plains. After deglaciation and withdrawal of the lakes, organic deposits began to form in bogs and swamps .

Large deposits of aggregate material in the report area are of sufficient volume to meet local demand for the foreseeable future. The map-area also contains large volumes of clay and peat, although to date there has been no commercial venture using or extracting these resources.



Scale : 1 : 1 548 000 or 1 inch to 25 miles

Figure 1 - Location map, Kirkland Lake Area.

# GEOLOGY OF THE
# KIRKLAND LAKE AREA
# DISRICTS OF COCHRANE AND TIMISKAMING

C.L. Baker[1]

## INTRODUCTION

### Location

The Kirkland Lake map-area (Figure 1) is located between latitudes 48°00' and 48°30'N and longitudes 79°30' and 80°30'W. Topographic coverage is provided by the National Topographic Series map sheets: Larder Lake (32D/4); Magusi River (32D/5); Kirkland Lake (42A/1); and Ramore (42A/8). The area lies within the Districts of Cochrane and Timiskaming, Ontario and Comtè Témiscamingue, Quebec. This area includes thirty-five townships in their entirety and parts of twenty-one other townships in the Province of Ontario and small portions of four townships within the Province of Quebec. Esker Lakes Provincial Park is situated in Bisley and Clifford Townships near the centre of the report area.

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[1] Geologist, Engineering and Terrain Geology Section, Ontario Geological Survey, Toronto.

Manuscript approved for publication by Owen L. White, Section Chief, Engineering and Terrain Geology Section, March 28, 1985. This report is published by permission of V.G. Milne, Director, Ontario Geological Survey.

## Access

Major access routes within the map-area are the King's Highways 11 and 66, the latter connecting with Quebec Highway 59. Secondary roads include Highways 112, 564, 570, 572, 624 and 650. Additional access is available via a limited number of roads maintained by townships or the Ontario Ministry of Natural Resources. There also exists an irregularly distributed network of drilling and lumbering roads which vary widely in their passability.

The main line of Ontario Northland Railway passes through the area, from Boston Creek in the south to Ramore in the north. A branch line, originating in Swastika, continues eastward through Kirkland Lake and Dobie, terminating in Noranda, Quebec.

An airport with a 1524 m runway is located 8 km north of the Town of Kirkland Lake, south of Nettie Lake.

## Population

The population density of the area is low with the majority of the inhabitants located in the towns and villages. Population centres of the area are: Kirkland Lake; Larder Lake; Virginiatown-Chesterville; Swastika; Ramore; King Kirkland; Holtyre; Dobie; Sesekinika and Boston Creek. The remaining population is rural, concentrated along the major highways and larger lakes.

## Present Geological Survey

The mapping of the field area commenced in 1978 and was completed in 1981. Data were obtained from the examination of materials in natural and man-made excavations. These observations were supplemented by traverses along roads, abandoned drilling and lumbering trails and by test pitting as well as the use of hand augers and soil probing equipment. Remote areas within the map-area were investigated using helicopter support. Additional information was drawn from water well records, exploration assessment files, construction site investigation reports and records and reports available from various government and private agencies. Air photographs at a scale of 1:15 840 and 1:63 360 were used extensively during the course of the mapping.

The information gained by the mapping of the Quaternary geology has allowed the distribution, properties and stratigraphic relationship of the various Quaternary sediments to be determined. This data will provide a framework on which to base future studies in several related fields.

Preliminary maps of the surficial geology of the area have been published previously (Baker and Storrison 1979; Baker 1980; Baker et al 1980; Baker et al 1982).

## Acknowledgments

Competent assistance in the field was provided by K.G. Steele, D.J. Storrison and A.A. Seaman, each of whom mapped independently, and A. Britton, J.E. Campbell, P.M. Ebling, L.J. Kerr-Lawson and G.M. Werniuk.

The assistance of H.L. Lovell and G. Grabowski, Resident and Resource Geologist respectively, of the Kirkland Lake Resident Geologist's office, in the investigation and subsequent discussion of material is acknowledged. The help provided by this office in the researching of pertinent data contained within assessment files is also acknowledged.

Aid, information and resources supplied by the staff of the Ministry of Natural Resources, Kirkland Lake District Office, Swastika is gratefully acknowledged. Access to data on granular materials was obtained with the help of the staff of the Ministry of Transportation and Communications, New Liskeard. Engineering data was made available by the Engineering Division of the Town of Kirkland Lake. Laboratory analyses were performed by the Geoscience Laboratories, Ministry of Natural Resources.

This report benefited from information supplied by and discussion with past and present members of the Engineering and Terrain Geology Section, Ontario Geological Survey, (OGS). Dr. L.S. Jensen, Precambrian Geology Section, O.G.S. and Mr. F.R. Ploeger, Lac Minerals, took time to

share their knowledge of the Precambrian geology of the area. Dr. Ian Thomson, Placer Developments, and Dr. J.A.C. Fortescue, Geophyscis/Geochemistry Section, O.G.S., reviewed results and made available their interpretations of overburden sample geochemistry. The writer extends his thanks to each of the above individuals and to the many residents of the Kirkland Lake area who permitted access to private properties.

The study of the Quaternary geology of the Kirkland Lake area was completed as part of the Kirkland Lake Initiatives Program (KLIP). The program was funded equally by the Federal Department of Regional Economic Expansion and the Ontario Ministry of Northern Affairs under the Community and Rural Resource Development Subsidiary Agreement.

## Previous Work

As a result of the mineral potential of the map-area, information and work pertaining to the bedrock geology is extensive. Much of the early geological work was compiled by Savage (1964). The bedrock geology of individual townships has been mapped and reported on by numerous authors with the regional geology summarized by Pyke et al (1973) and Lumbers and Milne (1978). The most recent interpretations are those of Goodwin (1980), Jensen (1978a,b; 1980; 1982a), Pyke and Jensen (1976), and Ridler (1970, 1975).

Geophysical, high resolution aeromagnetic maps have been produced jointly by the Ontario Ministry of Natural Resources (Ontario Division of Mines) and the Geological Survey of Canada (1975). The Ontario Geological Survey has published an airborne electromagnetic-magnetic survey of the Kirkland Lake area (1979) with Pitcher (1979) providing a limited interpretation of the data.

Early work which contributed to an understanding of the Quaternary history of this region was completed by Kay (1904), Baker (1909), Coleman (1909), Cook (1922), Antevs (1925, 1928), Wilson (1938) and Norman (1939). Tentative ice marginal positions are shown on a map by Prest (1969). Small scale maps which include the surficial geology of the report area have been compiled by Wilson (1958), Boissonneau (1965a, 1965b) and Prest _et al_ (1967). Quaternary events are discussed on a regional basis by Boissonneau (1968) and Prest (1970). The surficial geology of the western half of the map area was reported on by O.L. Hughes of the Geological Survey of Canada (1956, 1959, 1960, 1965). Mapping of the Englehart (King and Morton, 1979) and New Liskeard (Morton _et al_, 1979) area to the south was undertaken for the Ontario Geological Survey. Steele mapped Marquis and Savard Townships southwest of Round Lake in the course of this survey and has presented his results in a B.Sc thesis at Carleton University (1980). The Quaternary geology of the Rouyn NTS (32D/3) map sheet, which lies wholly within the Province of Quebec, has been studied by Tremblay (1974). Veillette (1983a) has mapped the surficial geology of the Lac Barrière area which adjoints the southeastern corner of the report area.

Till studies have been carried out in the Abitibi clay belt to investigate the relationship of till to mineralized bedrock by: Garrett (1971); Gleeson and Cornier (1971); Skinner (1972); Shilts (1976); and Thompson (1979). Detailed exploration research using glacial deposits in the Kirkland Lake area was undertaken by Lee (1963, 1964). Drilling and geochemical sampling of glacial sediments within the study area, has been reported by Thomson and Guindon (1979), Thomson and Wadge (1980, 1981), Thomson and Lourim (1981), Averill and Thomson (1981), Routledge _et al_ (1981), Averill and Fortescue (1983) and DiLabio (1983). The feasibility of using eskers as a means of tracing mineral and rock fragments to their bedrock source was studied by Lee (1965, 1967, 1968a, 1968b) and Baker (1981a, 1982a).

Other work undertaken in the area includes the tracing and delineation of buried bedrock valleys (Hobson and Grant 1964; Lee 1965; Hobson and Lee 1967) and studies on the grain-size and sedimentology of varved glaciolacustrine sediments (Agterberg and Banerjee 1969; Banerjee 1973).

Engineering geology and terrain evaluation maps for the area, at a scale of 1:100 000, were prepared by Lee (1979a, 1979b).

## Physiography

The Kirkland Lake area contains three major physiographic units: 1) Bedrock controlled landscape; 2) Sand plains; and 3) Clay plains (Figure 2).

### Bedrock Controlled Landscape

The bedrock controlled landscape is the dominant physiographic unit within the map-area. In these areas bedrock is exposed or thinly mantled by a veneer of drift. The drift cover is typically 1 to 2 metres in depth; however, in lowland areas and in small rock basins the drift thickness increases to several metres. Till is the most prevalent material on the highlands, with glaciolacustrine clay being common in the valleys separating rock knobs. Relief within the bedrock controlled landscape is commonly in the range of 15 m to 45 m; however, elevation differentials in excess of 120 m occur regularly.

Ridges of Huronian age, Cobalt Group sedimentary rocks form a distinct sub-division of the bedrock controlled landscape. These topographic highs occur in the southeastern corner of the map-area in McGary and McFadden Townships. These southwardly dipping ridges have fault

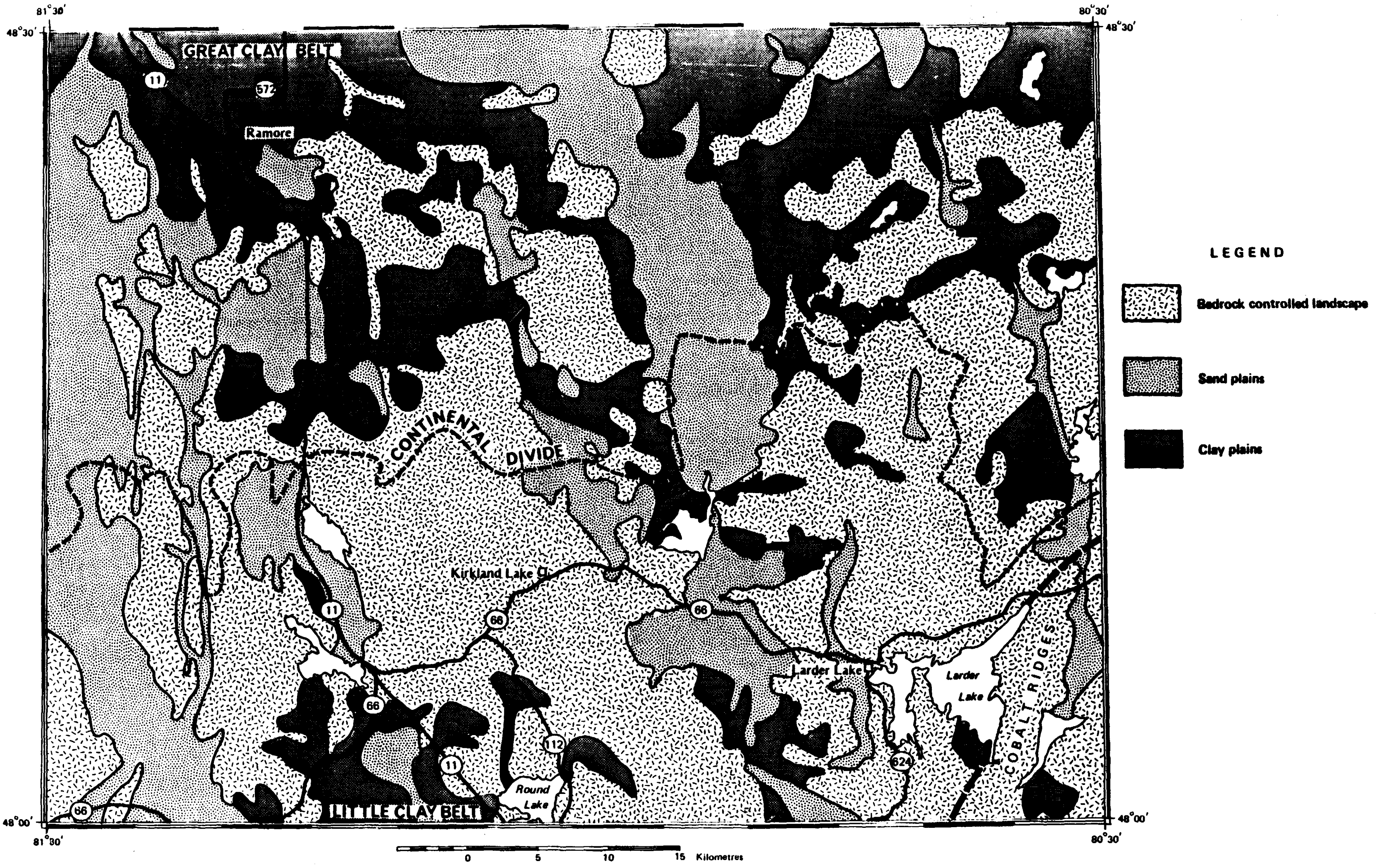


FIGURE 2 – Physiographic regions of the Kirkland Lake area.

controlled northwestward facing slopes which form near vertical cliffs. In places these cliffs approach 150 m in height. At numerous locations a large talus slope is present at the foot of the rock face due to spalling of the thinly bedded sedimentary rock.

A local point of interest is Mount Cheminis (Photo 1) located south of Highway 59 in Dufay Township, Quebec. A detached remnant of the largest Huronian ridge, it has a near circular shape rising steeply on all sides to over 165 m above the surrounding ground.

## Sand Plains

The sand plains in the Kirkland Lake area are usually ribbon shaped features oriented in a north-south direction. In a majority of cases sand plains flank eskers which trend parallel to the direction of glaciation.

Relief and surface morphology within the sand plains are a function of distance from the esker crest. Near the crest, ridge and kettle topography is common with relief (in the case of the Munro Esker in Thackeray Township) approaching 60 m. Elevational differences about the crest are generally in the range of 10 m to 20 m.

As the distance away from the crest increases the topography levels off into a hummocky plain. Relief in this zone is usually 5 m to 10 m.

Photo 1: Mount Cheminis is a detached remnant of a Huronian Cobalt Group sedimentary rock ridge. Nearly circular in shape this feature stands over 165 m above the surrounding ground. A large accumulation of talus is present around the base of the hill (UTM 119326).

The sub-unit furthest from the esker ridges is level to gently rolling ground. Relief is less than 5 m unless increased by stream dissection or local outcroppings of bedrock.

Where the sand plains broaden and there is sufficient fetch over which a strong wind can develop, eolian landforms in the form of parabolic sand dunes are present. The dunes frequently measure 5 m to 10 m in height with larger dunes standing 15 m to 20 m above the plains from which they were developed.

### Clay Plains

The third physiographic unit, the clay plains, is topographically flat lying except where the clay thins against or is draped over bedrock. Additional relief exists where rivers, such as the Black and Pike, have cut down into the sediments.

The continental drainage divide transects the map-area from east to west. The divide separates the Great Clay Belt to the north and the Little Clay Belt to the south. Within the map-area rock knobs and ridges regularly protrude through the clay, illustrating the rugged nature of the bedrock topography.

Large tracts of the clay belt have a thin covering of organic material, evidence of the poor drainage network developed on the plains. In several instances, the poor drainage is due to rock sills which effectively act as dams. These silts prevent a significant amount of river incision and drainage development further upstream.

## Drainage

The Atlantic (St. Lawrence)-Hudson Bay (Arctic) drainage divide bisects the map-area in an east-west direction. The divide extends from northern McGarry Township in the east, to northern Dunmore Township in the west. The exact position may be determined on topographical and geological maps by placing a line through the highlands separating northward and southward draining basins.

Major waterways and drainage basins in the northern (Arctic) portion of the area are, from west to east: 1) Tolstoi Creek; 2) the Black River, into which flow the Whiteclay River and the Little Black River; 3) the Pike River; 4) the Ghost River; 5) the Magusi River, which is fed by Dokis and Webster Creeks; and 5) the Dasserat River draining Clarice and Pontiac Creeks as well as Labyrinth Lake.

Drainage to the south is accomplished by : 1) the Englehart River; 2) the Blanche River network which includes Sesekinika, Kenogami and Round Lakes, in addition to Crooked and Boston Creeks; 3) the Misena River-Howard Lake chain also draining Victoria Lake; and 4) the Larder River, emptying Larder, Raven and Ward Lakes.

A major factor controlling the orientation of streams and rivers in the Kirkland Lake area is the intersecting pattern of bedrock lineaments. The effects of this pattern are evident in the large number of waterways which are oriented north-south and northwest-southeast. Creeks and rivers often make sharp bends to follow the trend of both regional and local bedrock faults. Slight depressions in the overburden covering these faults and erosion of the bedrock in the fault zone allows drainageways to develop over and along them.

## Drift Thickness

Drift thickness maps of the four NTS map sheets comprising this report area have been compiled by the author (Baker 1981b, 1982b, 1982c, 1982d). These maps incorporate previous data, exploration drill hole logs and waterwell logs. Outlined on the maps are areas of abundant bedrock exposure (map unit 1) and bedrock-drift complex (map unit 2), defined as extensive but discontinuous drift cover, in places sufficiently thick to subdue the bedrock topography. With local exceptions, the distribution of data points on these maps is poor. Regional drift thickness trends, however, can be ascertained from drill hole data, the distribution of surficial sediments and surface topography.

The overburden deepens in the northern portions of the Ramore and Magusi River map sheets. In these areas, drift thickness in excess of 20 m is common between outcrops. Drill hole concentrations illustrate the irregular and rugged nature of the underlying bedrock surface. Thick drift is also present in 1) the south central portion of the Kirkland Lake map sheet south of Kengami Lake; and 2) a poorly defined (buried bedrock?) valley extending from Tolstoi to Gross Townships along the western border of the report area.

Buried bedrock valleys are suspected to underlie major eskers. They are believed to be the result of preglacial erosion of major bedrock lineaments and faults which transect the area. It is for this reason that most fault controlled bedrock channels have north-south, northwest-southeast or, in a lesser number of instances, northeast-southwest orientations. Little information is presently available on the depth and character of these bedrock valleys.

Some information is available for the buried bedrock valley which is infilled by the Munro Esker. The portion of this valley south of Victoria Lake has been outlined by seismic data (Hobson and Lee 1967) and exploration drilling. Drift thickness in the valley is consistently over 45 m, with one drill hole in Gauthier Township penetrating 225 m of drift before encountering bedrock. The shape and extent of this valley is unknown north of Victoria Lake. However, bathymetic soundings of Lallan Lake, indicating depths of 43.9 m (Frey 1975), and overburden thicknesses greater than 60 m in Michaud Township, suggest the valley continues northward.

The 225 m of overburden reported in Gauthier township is believed to be a result of unique geological conditions. Hypotheses to explain this thickening are speculative and include erosion of: 1) a highly suspectible rock type, such as a kimberlite; and, 2) the intersection of two major joint or fault sets.

Faulting may also be the cause of the sudden and dramatic thickening of glacial sediments adjacent to rock outcrops. In numerous cases drill holes sited within a few tens of metres of a rock knob have encountered 30 m or more of drift before reaching basement.

## BEDROCK GEOLOGY

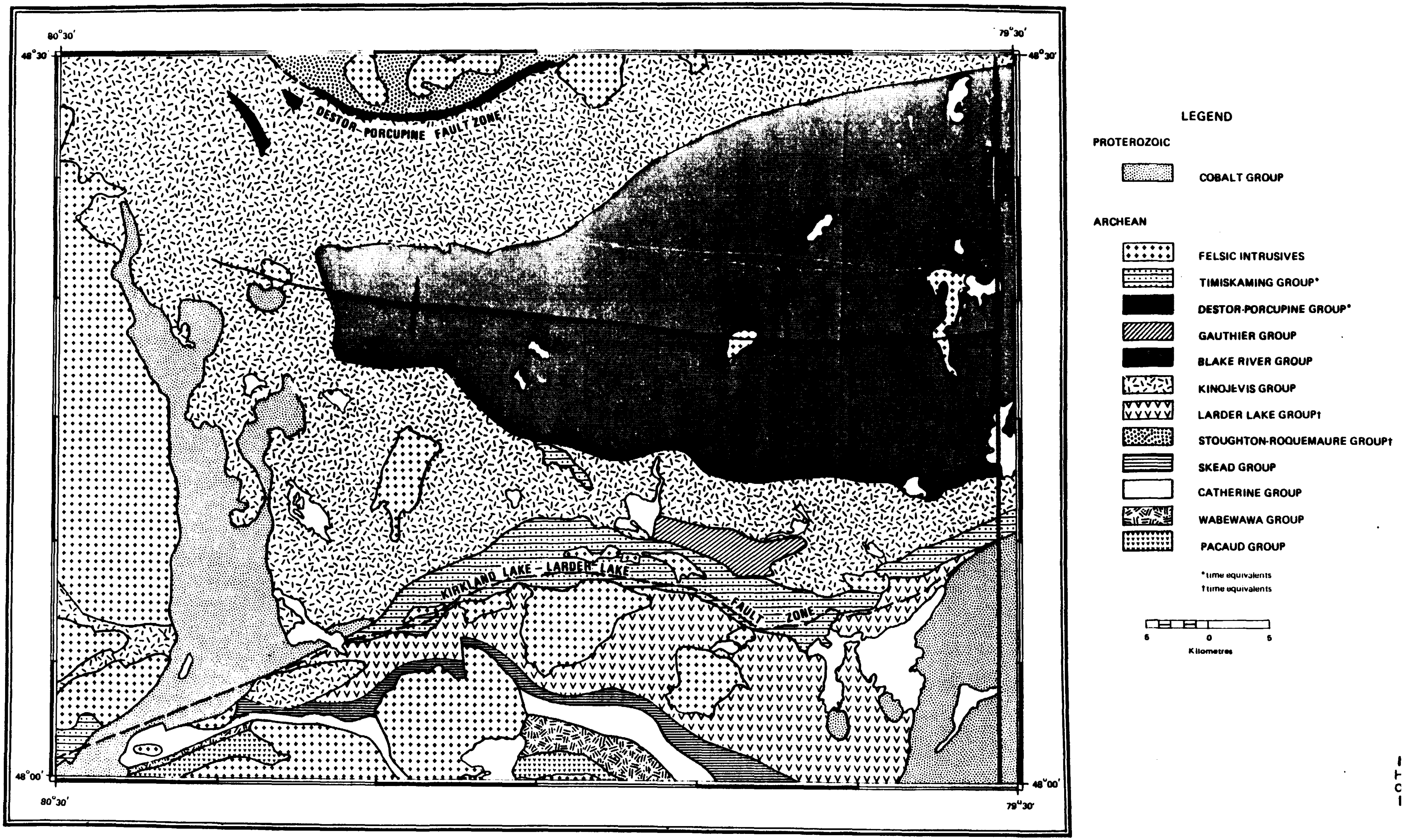
Detailed bedrock mapping of most townships in the Kirkland Lake area has been completed by the Ontario Geological Survey (and its predecessors). The township mapping has been augmented by regional synoptic mapping of the Abitibi Greenstone Belt. The following summary of the general geology of the Kirkland Lake area is taken primarily from Jensen (1978a, pp.68-71, 1979, p.65). Further detail and description of units and stratigraphic information is contained in Jensen (1978a,b, 1980; 1982a, 1982b; 1983).

Bedrock in the area consists of Early Precambrian (Archean) metavolcanic, metasedimentary and plutonic rocks. Middle Precambrian (Proterozoic) sedimentary rocks unconformably overlie the Early Precambrian rocks in parts of the area.

In the Kirkland Lake area, the volcanic stratigraphy consists of a succession of volcanic piles. These are composed of komatiitic rocks at the base which are overlain by tholeiitic and calc-alkalic rocks and in the case of the youngest pile, capped by alkalic volcanic rocks. Two such volcanic piles plus the top of an older third pile are preserved in the Kirkland Lake area. The volcanic succession is preserved in a large east-plunging synclinorium 80 to 120 km wide (Figure 3).

On the southern limb of the synclinorium the Pacaud Group contains the oldest rocks of the area. This group consists of calc-alkalic basalt, andesite and dacite, mainly in the form of tuff and tuff breccia. The group is conformably overlain by the Wabewawa Group. This group contains ultramafic and basaltic komatiite and Mg-rich tholeiitic basalt interlayered with calc-alkalic basalt, andesite dacite and rhyolite tuffs and sedimentary rocks.

The Catharine Group conformably overlies the Wabewawa Group and is composed of Mg-rich and Fe-rich tholeiitic basalt flows with Fe-rich tholeiitic basalt. The Skead Group (SG) consists mainly of massive calc-alkalic volcanic



(modified after Jensen 1978a, 1979, 1980, 1983)

Figure 3 - Generalized Bedrock Geology of the Kirkland Lake Area

fragmental rocks of basalt, andesite, dacite and rhyolite composition. Fragmental rocks range from crystal tuff to tuff-breccia and flow breccia.

Disconformably overlying the volcanic pile topped by the SG is a basal komatiitic section of a younger volcanic pile. The lowest formation of this pile is the Larder Lake Group. The Larder Lake Group (LLG) consists of peridotitic komatiites, basaltic komatiites and magnesium-rich tholeiitic basalts interlayered by turbiditic conglomerate, greywacke, argillite, carbonate and iron formation.

The stratigraphic equivalent of the LLG on the north limb of the synclinorium is the Stoughton-Roquemaure Group (SRG). This group is similar in composition to the Larder Lake Group.

Both the SRG and LLG are conformably overlain by tholeiitic rocks belonging to the Kinojevis Group. The Kinojevis Group consists of magnesium-rich and iron-rich tholeiitic basalt, with tholeiitic andesite, dacite and rhyolite occurring toward its top.

Above the Kinojevis Group is a calc-alkalic sequence called the Blake River Group (BRG). It consists of magnesium-rich tholeiitic basalt plus calc-alkalic basalt, andesite, dacite and rhyolite flows and pyroclastic units. These are derived from two or more volcanic centers represented by massive rhyolite domes at the center of the synclinorium.

The Gauthier Group is separated from the other layered assemblages because of its distinctiveness and uncertain stratigraphic positon. It is composed of fragmental rocks with K-rich calc-alkalic basalt, andesite and dacite compositions. Minor cherty rhyolite tuff occurs towards the top of the group.

Unconformably overlying the Kinojevis Group, the BRG and possibly the LLG, is the Timiskaming Group. It consists of alkalic volcanic rocks interlayered with fluviatile sedimentary rocks.

The time-stratigraphic equivalent of the Timiskaming Group on the north limb of the synclinorium is the Destor-Porcupine Group (DPG). In fault contact with the SRG and the Kinojevis Group, the DPG is comprised of turbidites, fluvial sediments and mafic to felsic alkalic volcanic rocks.

The intrusive assemblages have similar ages to and are spatially associated with the volcanic rocks of similar composition.

Subalkalic ultramafic to mafic rocks occur as plugs of peridotite (serpentinite) and as sills composed of peridotite. Pyroxenite and gabbro are intruded into the Wabewawa Group, the Larder Lake Group and the underlying Pacaud and Skead Groups. Subalkalic mafic to intermediate intrusive rocks mainly occur in the Kinojevis and Black River Groups.

Subalkalic felsic intrusive rocks occur as trondhjemite in the Round Lake Batholith and as granodiorite in the Watabeag Batholith. Small stocks of quartz diorite cut the Black River Group.

The alkalic intrusive rocks are ultramafic to felsic in composition and vary from Na-rich syenodiorite to K-rich syenite. The larger more felsic bodies include the Otto Stock, Lebel Stock, and Murdock Creek Stock.

Diabase dikes occur throughout the area, the highest concentrations being in the west part of the Kirkland Lake map-area. They are mainly north trending Matachewan-type quartz diabase dikes.

Shallow dipping to horizontal Middle Precambrian sedimentary rocks unconformably overlie the above Early Precambrian rocks. They consist of boulder conglomerate, arkose, wacke and argillite of the Coleman member, Gowganda Formation.

## MINERAL PRODUCTION

Several mining operations are, or recently have been in production within the map-area. The most senior of these is Kerr-Addison Mines Ltd., a gold producer, located in Virginiatown, McGarry Township. In 1981, 271,666 tons of ore were milled yielding 51,539 oz of gold and 2,532 oz of silver. Kerr-Addison also operated an open pit gold mine on the Bufonta property, Garrison Township. Before closing in late 1981, the ore was trucked to the Virginiatown mill. No production figures are available for this operation.

Long Lac Minerals' Macassa Mine in Kirkland Lake milled 115,161 tons of ore in 1981. This resulted in production of 51,190 oz of gold and 6,071 oz of silver.

Pamour-Porcupine Mines Ltd. operates two mines in Hislop Township, both of which truck gold ore to Timmins for processing. In 1981 the Canadian Arrow Mine shipped 156,202 tons before closing in early 1982 due to low gold prices. Figures for the Ross Mine, located at Holtyre are not available, although production has been continuous for several years.

The Adams Iron Mine, a large open pit operation owned by Dafasco Inc., is located in Boston Township. Ore averaging 22 percent iron is concentrated in a 1,150,000 ton per year plant that produces pellets of 65 percent iron.

## QUATERNARY GEOLOGY

A summary of the Quaternary deposits present in the Kirkland Lake area is detailed in Table 1. Also listed are the materials which comprise each type of deposit and the features or landforms with which they are associated.

Surface deposits yield evidence of only one major ice advance, to the south-southeast, across the region. All

|  | DEPOSIT | MATERIALS | LANDFORMS |
|---|---|---|---|
| Recent | Mine Excavations, Tailings | Crushed Rock, Sand | Waste Dumps and Tailings Ponds |
|  | Alluvium | Silt, Sand, Gravel | Present Day Floodplain and Channel Deposits |
|  | Bog and Swamp | Peat, Muck | Filled Depression, Creek and River Courses |
| Pleistocene Late Wisconsinan | Eolian | Fine to Medium Sand | Dunes |
|  | Beach | Sand, Gravel | Scarps |
|  | Fluvial | Sand, Gravel | Channel Fills |
|  | Coarse-grained Glacio-lacustrine | Sand, Minor Gravel | Sand Plains |
|  | Fine-Grained Glacio-lacustrine | Silt, Clay | Clay Plains, Depressions |
|  | Ice-Contact Stratified Drift | Sand, Gravel | Eskers, Kames, Deltas |
|  | Till | Gravelly Sand Till | Discontinuous Sandy Ground Moraine |

TABLE 1 - QUATERNARY DEPOSITS OF THE KIRKLAND LAKE AREA

drift examined within the report area was judged to be either Late Wisconsinan or Recent in age.

Drill logs filed as assessment work describe a thin clay till below the surface sandy till in east central Guibord Township. This clay till occurs over bedrock at depths of between 24 to 30 m. The possibility exists that this till may be the equivalent of the lower till noted by Brereton and Elson (1979) in Currie Township, suggesting it may be of Pre-Wisconsinan age.

## GLACIAL DEPOSITS AND FEATURES

### Ice Flow Direction

Within the study area the most abundant indicators of ice movement are glacial striae, chatter marks, roche moutonnée and crag and tails (Photo 2). The examination of these features indicates the last major ice advance across the area centred on 165° azimuth (S15°E). This orientation is in agreement with other workers in the region, illustrating the widespread strength and extent of the advance.

At a limited number of localities older striae trending approximately 200° azimuth were observed. Most often these striae were found on the southern side of rock knobs where they had been protected from subsequent glacial erosion. The position and orientation of the striae suggest they can

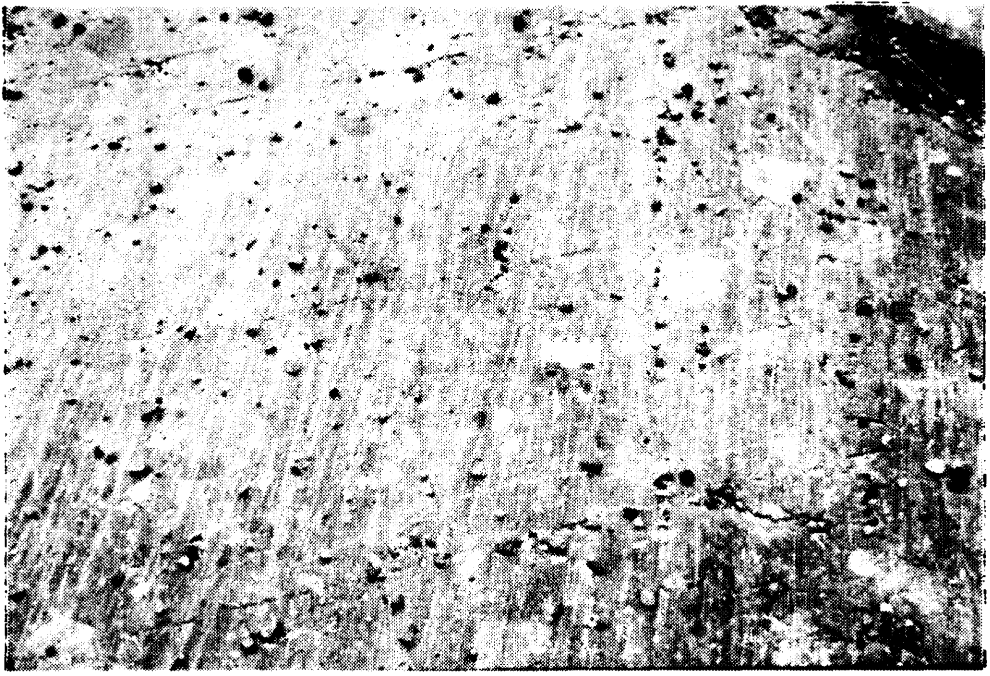


Photo 2: Well striated outcrop of Huronian tillite. Striae trend 171° azimuth (S9°E) close to the regional average of 165° azimuth (UTM 553434).

be assigned to an early advance noted by Veillette (1983b) in the New Liskeard area.

Infrequently, younger striae having variable orientations crosscut the 165° set. These appear to have been caused by minor readvances or glacial pulses. The orientation of these striae suggests the ice producing them was thin and controlled by the bedrock topography.

## Till

Till, map unit 3, is the most widespread glacial deposit within the report area. Till is a sediment that has been transported and is subsequently deposited by or from glacier ice, with little or no sorting by water (Dreimanis 1982).

Only one mappable till unit occurs in the map area. This till is the stratigraphic equivalent of the Matheson Formation as defined by Hughes (1965) and may be the equivalent of the Adam Till (Skinner, 1973) as defined in the Moose River Basin.

The character of this till varies widely across the report area. This variation is attributed to several factors including: mode of deposition; texture; post-glacial weathering; colour; compactness; clast content and lithologies present. A summary of the properties of the till found in the Kirkland Lake area is presented in Table 2. A full listing of the till data is given in Appendix A.

| | Matrix Texture (<2 mm) | | | | Carbonate Content | Heavy Mineral Content | |
|---|---|---|---|---|---|---|---|
| | % Clay | % Silt | % Sand | Md (mm) | % Total | % Total | % Magnetic |
| Mean ($\bar{x}$)<br>Range | 1.81<br>0-11 | 25.66<br>6-75 | 72.67<br>24-93 | 0.201<br>0.035-0.707 | 2.71<br>0.88-8.73 | 4.74<br>1.30-16.50 | 10.59<br>3.01-24.09 |
| Standard Deviation ($\sigma$) | 1.82 | 11.83 | 12.49 | 0.134 | 0.90 | 2.27 | 4.50 |
| Number of Samples (n) | 73 | 73 | 73 | 73 | 73 | 73 | 73 |

TABLE 2 - PROPERTIES OF TILL, KIRKLAND LAKE AREA

In order to characterize the till, trace element geochemistry was determined on the minus 400 mesh (-0.037 mm) fraction. Results are listed in Appendix B. Locations of the sample points are indicated on the Quaternary geology maps (backpocket).

Textural analyses of the till matrix, the minus 2 mm (-10 mesh) material, shows the till to be highly variable. Sand content, while averaging 73 percent, ranges between 24 and 93 percent. The silt content fluctuates inversely to the sand, varying between 6 and 75 percent and averages 26 percent. The amount of clay in the till samples is low, usually less than 4 percent. As such, the matrix of the till can be described as being either a silty-sand or sandy-silt. Textural parameters of the till samples are shown graphically in Figure 4.

The clast content of the till, that material greater than 2.0 mm, is commonly 10 to 15 percent. This figure, however, varies widely in the 5 to 40 percent range. Boulders of up to 1.5 m were found in till outcrops although clasts of over 0.5 m are infrequent.

Bedrock lithologies produce distinct assemblages with regard to angularity and shape in till. Regional and somewhat generalized observations are that the felsic and mafic intrusive clasts appear slightly less angular than metavolcanic or sedimentary clasts. The metavolcanic suites are typically more angular than the intrusives, particularly

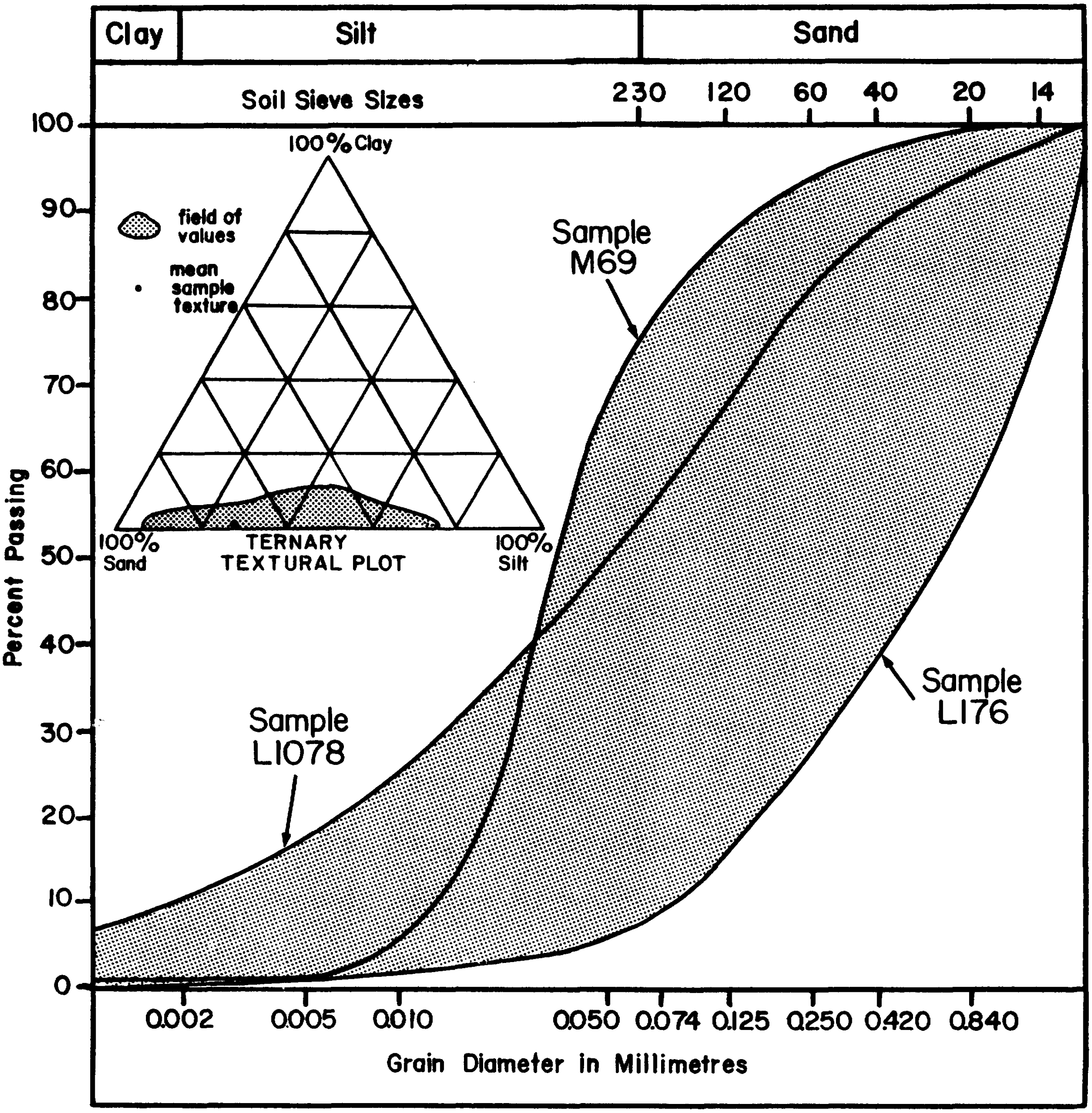


Figure 4 - Grain Size Distribution of Till Matrix Samples, Kirkland Lake Area.

when a fault or shear zone has just been overridden. In these areas the till becomes charged with highly angular, sharp edged rock fragments. Lee (1963) noted such an occurrence south of the Larder Lake fault where plates of schistose chlorite act as an indicator. Clasts of the fine-grained units of the sedimentary Huronian Gowganda Formation are distinctive in character within the till. These lithologies in the till are blocky, often soled and display unique, conchoidal pressure fractures on their surfaces.

Heavy minerals (>2.96 S.G.) in the minus 0.25 mm to plus 0.105 mm (-60 to +140 mesh) fractions were found to average 4.7 percent. The percentage of these heavy minerals which are magnetic averaged 10.6 percent; however, variation was considerable. The sample (L583, UTM 832248) containing the greatest percentage magnetics (24.1%) was taken southeast of the iron formation in Boston Township.

Information on the percentage of heavy minerals (>3.3 S.G.), and mid-density minerals (>2.8-<3.3 S.G) for Kirkland Lake area tills is contained in Averill and Thomson (1981), Routledge _et_ _al_ (1981) and Averill and Fortescue (1983).

The colour of fresh unweathered till, as determined from Munsell Soil Colour Charts (1973), varies from a grey (2.5YR 6/0) to a dark brown (7.5YR 4/2). The colour of the till is a reflection of the colour and character of the bedrock lithology beneath or directly up ice. Weathering processes, chiefly oxidation and leaching, result in a gradation of colours from those of fresh tills. A till in an advanced state of weathering typically approches a yellowish red (5YR 5/8).

Kirkland Lake area surface tills are essentially non-calcareous, averaging 2.7 percent total carbonate. The majority of this, 2.3 percent, is dolomite with the remainder calcite. Tests to ascertain the Atterberg Limits of the tills showed them to be non-plastic.

Several till types, each related to a specific mode of deposition, are present in the map-area. The majority of the till is derived from material abraded and transported within the basal traction zone of the glacier.

Material which was deposited subglacially, that is beneath the ice, by the processes of lodgement and melt-out will be collectively termed basal till in this report. Characteristics of the lodgement facies of basal till are its dense, compact nature, local provenance, well developed fabric and striated, faceted clasts (Photo 3). Sections through this type of till demonstrated an inverse relationship between clast content and the till thickness. The thinner the till the greater the clast content (Photo 4). Lodgement material is most often unsorted and massive; however, thin sand stringers and lenses were occasionally encountered. The lodgement facies is "deposited directly beneath a glacier from moving glacier ice as a result of

Photo 3: Typical moderately weathered exposure of basal till. The majority of the clasts were derived from the bedrock below or slightly up ice from this site. Till matrix is composed primarly of silty sand with minor amounts of clay (UTM 974484).

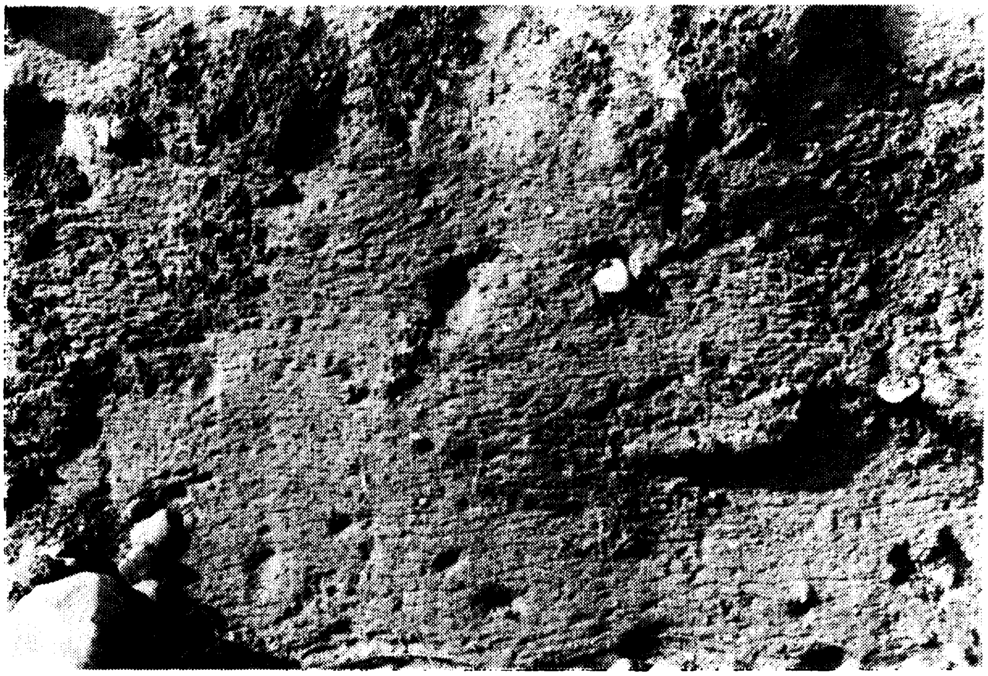


Photo 4: Lightly weathered exposure of the lodgement facies of basal till. Till outcrop displays fissility and is atypically clast poor (UTM 586486).

drag of glacially transported debris against the bed" (Boulton 1976, p.69).

The subglacial melt-out facies of basal till is more variable in appearance. This facies is deposited below the glacier by the melting of debris-rich ice. During melting, stratification (eg. sandy or gravelly layers) which was present in the basal ice is retained in the till (Photo 5). Although usually over-consolidated, meltout till can range from massive to material containing abundant thin semi-sorted, usually sandy, layers. Clasts are striated, with the majority reflecting the local bedrock. Fabric development in the meltout facies was found to be weaker than in the lodgement facies.

A second major type of till is collectively termed flow till. Flow till is derived from glacial debris that has accumulated and subsequently "flowed" downslope. The resulting deposit retains the general appearance of a till, but exhibits sorting and stratification. The structures that result in such a movement of material, the environment in which this takes place and the distance and volume of material moved, yield deposits that are highly variable and complex in appearance. In section, flow material can occur as a massive diamicton that can be separated from basal till only where sufficiently large and unweathered exposures exist. Alternatively, this till type was encountered as a weakly sorted, stratified material containing sandy layers

Photo 5: Subglacial melt-out facies of basal till. Thin, poorly sorted sand layers are present throughout the section. These layers form drapes or caps over the angular clasts (UTM 533233).

(Photo 6). Occasionally, when these flow till deposits are examined parallel to flow, gradations from massive to sorted have been noted.

Flow tills have been identified as having originated in three distinct depositional environments in the Kirkland Lake area. The most common environment occurs in subglacial cavities such as those which occur in the lee, or down ice side, of bedrock knobs. Basal till is squeezed into the cavity and flows to the base of the opening. Depending on the size of the cavity and the amount of free water available, the resultant till can be massive or highly washed with distinct stratification.

The second depositional environment occurs where debris moves into a body of water resulting in flows that thin over distance and undergo rapid facies changes. Segregation, washing by wave action and interbedding with glaciolacustrine deposits make recognition of this type of flow till difficult. Mapping has shown this environment is largely restricted to the nearshore zone within shallower portions of glacial lakes.

Thirdly, flow till can develop from basal till on steep slopes resedimenting itself after the ice load was removed. Saturation of the till by glacial lake water appears to have been a contributing factor. In most instances the length of these flows is limited to a few metres.

Photo 6: A massive layer of flow till is overlain by stratified, washed, poorly sorted sand derived from glacial debris. Clasts within the flow units are angular and striated.

Basal and flow tills in the Kirkland Lake area are derived from basal transported glacial debris. Tills formed from englacial material are uncommon within the map-area. This is due to the majority of the map-area having been inundated by post-glacial lakes. These lakes did not allow the ice to stagnate and melt slowly; instead, retreat took place by calving. As the icebergs melted in the lake, basal and englacial debris held in the floating ice was released and fell to the lake bottom. Accumulations of this "ice-rafted" debris directly overlie basal or flow tills and have a maximum of thickness of 0.3 m. In some sections the "ice-rafted" debris appears to grade upwards from basal till to stratified waterlain material.

Minor occurrences of supraglacial meltout till are present in highland areas above the maximum lake level where grounded ice had the opportunity to stagnate and downwaste. This type of loose. stony till is usually less than a metre thick. Due to the tills' thinness, weathering has significantly altered the original character of the till.

Other workers in the region have reported the widespread occurrence of ablation till. The author agrees with Hughes (1965) that this ablation material is, for the most part, highly weathered basal till.

Where unprotected by overlying material, till is usually highly weathered to a depth of 0.3 m to 0.5 m. Within this weathered zone leaching removes carbonates and sulphides are oxidized. Below this zone less severe weathering affects the till to a depth of one metre, making recognition of till facies difficult. Light to moderate weathering highlights the fissility and jointing common in till.

Till thickness varies greatly across the report area. Commonly, the till outcrops as a thin, 0.5 to 1.0 m, discontinuous veneer on bedrock. In such settings, the lateral extent is often limited, with till confined to hollows on the rock surface or the sides of rock walls. An impression gained from mapping was that till thicknesses tended to increase northward across the area.

The deposition of till appears to have been controlled by the topography of the bedrock surface and ice dynamics. Hughes (1959, p.18) noted that till occurs "on the lee-sides (south-southeast) of hills where the till constitutes the tails of crag-and-tail forms". From observations made in Boston Township, Lee (1963, p.6) "gained the impression that the best place ....to look for till was on the stoss (up ice) side of outcrops where the glacier had placed the till in depressions between bedrock highs and around the nose of these highs". The present mapping in the Kirkland Lake area lead to the conclusion that till is more abundant on the stoss side of outcrops.

The extent of the till beneath glaciolacustrine sediments is poorly known. Diamonds drillers in the

Kirkland Lake region report substantial thicknesses of a dense, bouldery material over bedrock in numerous boreholes. Referred to as hardpan, it is likely that this is till. These reports combined with surficial evidence and existing overburden drilling, suggest that subsurface till deposits are widespread but discontinuous.

During the course of the present mapping no landforms which could be termed drumlins were found. Previous workers in the area have used the term to describe glacially modified rock ridges aligned parallel, or nearly so, to the direction of glacial flow. Although these features have a thin, discontinuous till cover they are best called drumlinoid forms. The shape of some of these features allow them to be classified as roche moutonnees.

Fluted till plain was identified in Bernhardt and Maisonville Townships along the border between the Kirkland Lake and Ramore map-sheets. Flutes, mirrored by the overlying clay, are present in western Tannahill Township.

Areas in which till is the dominant surface material are numerous. The largest of these are: 1) the northeast quadrant of the Kirkland Lake map-sheet; 2) the highlands north of Highway 66 between the village of Larder Lake and Ben Nevis Township; and 3) overlying the Huronian ridges, east of Larder Lake and from Burt to Black Townships.

## Ice-Contact Glaciofluvial Deposits

Ice-contact glaciofluvial materials are defined as sediments deposited in contact with, or adjacent to the glacial ice by waters derived directly from the glacier. The disruptive influence of an active ice front combined with the dynamics of fluvial systems allows such deposits to have a wide variety of textures and sedimentary structures.

### Esker Complexes

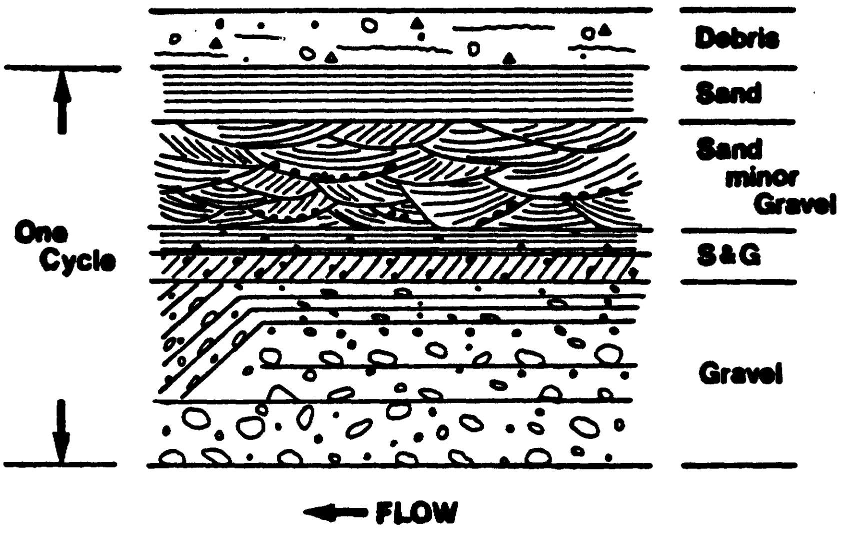
The majority of the ice-contact deposits within the report area occur within esker complexes. These eskers range in length from two kilometres, to several tens of kilometres. Six major esker systems are present in the area. From west to east these are the: Watabeag; Highway; Airport; Munro; Misema, and Boundary eskers. Although the name Munro has become formalized through usage, the remainder of the esker names are informal. These names have been adopted from local use or prominent geographic features.

The orientation of eskers in the Kirkland Lake area is a reflection of eroded lineaments in the Archean terrain and on Huronian rocks, valleys between highlands. This results in segments of the eskers having north-south and northwest-southeast alignments. The preferential location of eskers along intersecting fault lines, some of which are enhanced by pre-glacial erosion, is well illustrated by the course of the Highway esker. From the southern border of the Kirkland Lake map-sheet it trends northwest to Highway 16, north to Kenogami Lake, northwest to Sesekinika Lake, north to Mount Kempis and then northwest towards Ramore and Matheson.

Mapping of the esker complexes has indicated the presence of three major depositional environments. The most easily recognized of these environments is the esker crest or ridge. The esker crest deposits occur as segments which range from a few hundred metres to three kilometres in length. Relief within the crest environment is variable. The Munro Esker crest stands 50 m above the surrounding land surface while a small unnamed esker in Lee Township rises only 4 m. Kettles often flank the crests, or when an esker is multi-ridged, separate the ridges.

The crest stratigraphy consists of a series of upward fining stacked cycles (Fig. 5a). The base of each sequence consists of coarse gravel, occurring as foreset, massive, or multi-storied assemblages. This is overlain by parallel-bedded sand and gravel capped by trough cross-stratified material. In rare instances this assemblage is topped by a thin ripple-drift unit. All units are tabular and dip southward, making the occurrence of sand as the surface material much more likely at the southern end of the ridges. Each cycle or sequence may represent an annual accumulation of sediments. The crest portion of the esker

a) CREST STRATIGRAPHY



b) ICE-WALLED CHANNEL STRATIGRAPHY

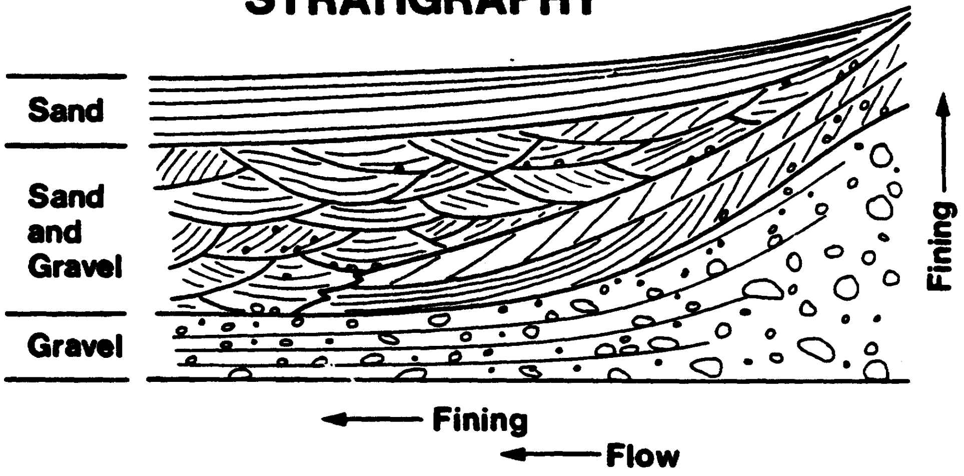


Figure 5 - Composite stratigraphy of: A) the esker crest facies, in which cycles may represent annual sediment accumulations; and B) "ice-walled channel" environment in which sediments fine both horizontally and vertically.

is interpreted as having formed in a subglacial tunnel or a narrow, open topped conduit extending back from the ice front. Growth of these time transgressive features was by extention of their headward (northern) end although all flow was southward toward the glacier margin. Melting of the ice walls during deglaciation caused faulting and slumping commonly encountered along the sides of the crest.

In a small number of localities where the crest stands above the level of the glacial lake which fronted on the ice, the crest is capped by a poorly sorted debris-like material. This is interpreted as having formed from the collapse of an ice roof and subsequent melting and transportation of englacial and supraglacial material.

The second esker depositional environment is informally termed the ice-walled channel. The material in this environment was deposited within a re-entrant in the ice-front. The sides of the re-entrant were ice supported, and deposition occurred subaerially, at least in the upper portion, making this type of deposit the equivalent of outwash. Upward fining stacked sequences occur here also (Fig. 5b). The basal unit is a fan-shaped gravel layer up to 10 m thick on the proximal side which thins to the south. Structures indicate that movement of material was by "sheet" flow and migrating gravel bars. The gravel grades upward into layers of parallel-bedded and tabular cross-stratified sand to pebbly sand. These deposits are in turn overlain by large-scale trough cross-stratification (migrating dunes) which may achieve a thickness of several metres. These stream deposits are intermittently capped by ripple-drift or parallel-bedded sands (Photo 7).

These deposits have been identified in only one location: on the Munro Esker south of Victoria Lake in Gauthier and Lebel Townships. Morphologically, this environment has a hummocky kettled surface with relief on the order of 20 m. These hummocks are formed by the melting of buried ice blocks.

The third depositional environment is collectively termed "deltaic" although two distinct types of sedimentation are present. One delta form is the Gilbert type (Fig. 6a). These flat topped delta features were developed where glaciofluvial material built up to the standing level of the glacial lake. The lake was ponded in front of the glacier as it receded. These deltas are sedimentologically simple, consisting of foresets overlain by thin topsets. Occasionally, braided stream deposits are encountered on the delta top. These streams transported material to the front of the delta slope during the final stage of deposition.

The second type of deltaic deposition is referred to as sub-aqueous fans (Fig. 6b). Material comprising the fans was debouched from the esker conduits and laid down on the lake bottom. Sub-aqueous fans account for the largest

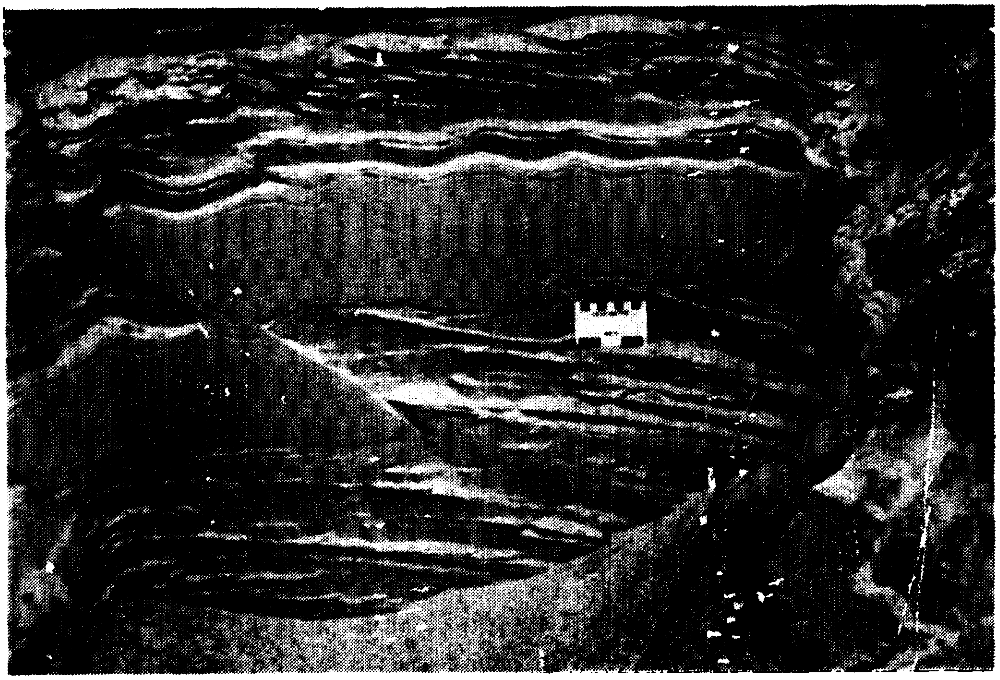
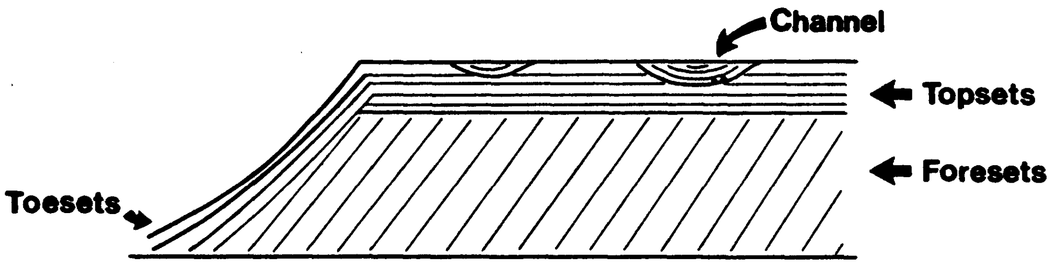


Photo 7: An exposure of fine to medium sand in the "ice-walled channel" environment in the Munro Esker. Reverse faults cut climbing ripples (top and bottom) and a thinly bedded sand unit (UTM 826312).

# DELTAS

## a) GILBERT TYPE



## b) SUB-AQUEOUS FAN

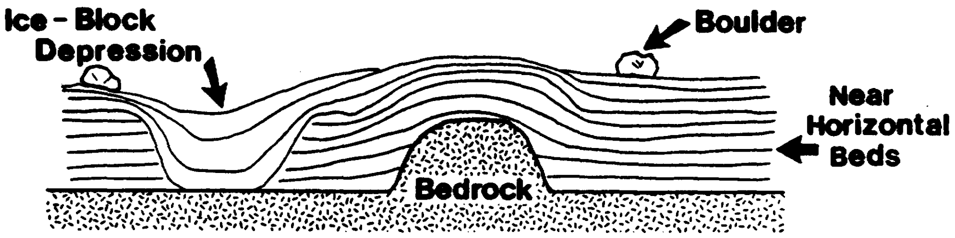


Figure 6 - Deltaic deposits in the Kirkland Lake area present in two forms: A) Gilbert type deltas, the top of which marks the level of the then existing lake; and B) Sub-aqueous fans deposited by currents on the floor of the glacial lake.

volume of sediments mapped as eskerine with fans ranging in size from a few square hectares to tens of square kilometres. Morphologically, these fans vary from flat-topped,near level surfaced, to hummocky, kettled terrain. Proximal sediments consist of trough cross-stratified deposits that grade into rippled sands and then to more distal parallel-bedded sands. This facies change is marked by a textural fining of the sediments, with gravelly layers being confined to the near-ice environment.

## Kames

A small number of ice-contact deposits in the highland areas above the maximum glacial lake level were mapped as kames. Areally restricted and difficult to outline at a 1:50 000 scale, the kames are located along the sides of bedrock ridges. Formed by streams depositing drift between the glacier and a rock wall, these features are best classified as kame terraces. Texturally the kames are highly variable over short distances. Faulting and slumping are common in these deposits.

## Deltaic Deposits

Numerous deltaic deposits not associated with eskers are located throughout the report area. The term deltaic is used here, as it was with esker complexes, to denote both Gilbert type deltas and sub-aqueous fan deposits. These deposits were formed by rivers and streams flowing off the ice mass into glacial Lakes Barlow and Ojibway.

Two examples of Gilbert type deltas are present in Burt Township. The smaller of the two, located near the Swastika Nursery (UTM 484194), displays coarse gravel foresets and topsets (Photo 8), which grade into gravelly sand bottomsets. A repetition of this delta sequence a short distance to the north suggests these deposits formed during successive halts in the ice front. The ice-contact face of the southern delta sequence is highly contorted due to removal of the supporting glacial ice after deposition.

The larger delta, south of Burt Lake (UTM 464227), marks a longer ice halt position during which a greater volume of sediment accumulated. Coarse material is present along the northern edge of the deposit; however, the majority of the surface sediment is sand. This sand was laid down as bottomsets in front of the delta face.

Morphologically, the Gilbert type deltas are relatively flat. Relief, however, can be established by ice collapse structures, erosion, or the presence of bedrock knobs.

Sub-aqueous fans are formed by material deposited on the floor of the glacial lake. The coarsest sediments associated with these fans were deposited near the ice front. As the competancy of the flow decreased along the lake bottom, sedimentation of progressively finer grained sediments took place.

Photo 8: Ice-contact Gilbert type delta located in Burt Township. Photo shows apparent dip in foresets overlain by approximately 1.5 m thick topsets. Flow depositing delta was from left to right (UTM 484190).

The sub-aqueous fans are primarily made up of fine to medium sand. In the proximal environment, the most common sedimentological structure is trough cross-stratification, which with increasing distance grades into ripple-drift and then thin parallel beds. The surface of the fans is generally rolling to level unless the deposit is thin and influenced by the topography of the bedrock.

The argument could justifiably be made for calling deltaic sequences, including those associated with eskers, glaciolacustrine. However, since they are inherently part of glaciofluvial deposits, which in total are logically termed ice-contact, they also will be classified as such.

## Ice-marginal Features

Several features which indicate brief halts in the northward retreat of the glacier are present in the Kirkland Lake area. The most common and easily recognized are the deltas built in association with the eskers. Although their outline in plan view varies considerably, their general characteristic is a broadening or widening of the esker complex. The Highway esker on the Kirkland Lake map-sheet provides an excellent example. Deltas are located: 1) along the border of the map sheet in Blain Township; 2) southeast of Highway 66 in Eby Township; 3) along the northeastern side of Kenogami Lake; 4) south of Sesekinika Lake in line with Graves Lake; and 5) west of Sesekinika Lake just north of Mooseridge Lake. The ice-contact (northern) side of these deltas contains the coarsest material. This undergoes a rapid southward facies change, with the result that the bulk of the surface sediments are sandy.

Other ice-marginal features are minor morainic deposits. These deposits are best displayed along the Boundary esker within the Larder Lake map sheet. Between Raven and Labyrinth Lakes are several small, low relief (4 m to 5 m) ice-contact deposits appearing as transverse arms off the esker trunk. These rarely exceed half a kilometre in length and have a spacing of approximately 1 km.

Similar, though less frequent, morainic features are present on the Airport and Misema eskers. The esker crest segment extending northward from a morainic ridge was formed contemperanously.

An additional ice-marginal feature is the ice-contact slope or face. Two examples exist: 1) in Morrisette Township associated with the Airport esker; and 2) in Benoit and Black Townships associated with the Highway esker. These ice-contact faces mark an ice-margin position against and in front of which sediments accumulated. When the ice was removed a steep scarp was left on the ice-contact side. Due to subsequent modification by falling lake levels, the ice-contact slope in Black and Benoit Townships is the weaker and less well defined of the two.

The large ice-margin glaciofluvial deposits are located between the Butler-Malloch Lakes area and Wildgoose Lake on the Watabeag esker complex. Large volumes of sediment were carried off the ice and deposited in a broad band broken by bedrock highlands. Overburden drilling in Benoit and Melba Townships indicates the glaciofluvial material continues to the east beneath glaciolacustrine clay (Routledge _et al_ 1981). This drilling also suggests that ice retreat was not continuous in this area. Thin layers of till recording minor pulses of the ice front were found intercalated with sorted sedments.

## Glaciolacustrine Deposits

Glaciolacustrine deposits within the report area have been formally named the Barlow-Ojibway Formation by Hughes (1965). These deposits have been classified as either fine or coarse-grained glaciolacustrine sediments.

### Fine-grained Deposits

Fine-grained glaciolacustrine sediments are defined in this report as deposits in which clay or silt dominates. Deposition took place in the deep water environment of the post-glacial lakes. The deposits in the Kirkland Lake area occur on either side of the present day drainage divide.

They form the northern portion of the Little Clay Belt and the southern rim of the Great Clay Belt (Fig. 2). These sediments overlie till, glaciofluvial material and bedrock.

The majority of the fine-grained glaciolacustrine deposits consist of varved clay (Photo 9). Varve couplet thickness averages 1-2 cm but, considerable variation is present. As reported by earlier researchers, the varve thickness decreases upward in section due to the melting back of the glacier which served as the sediment source.

The term varve is used to denote a cyclic annual sedimentation process. The annual sedimentation of Kirkland Lake area varves is supported by the abundance of pollen and spores in summer layers and their rarity in winter layers (Dreimanis, 1964).

In section, varved clay deposits appear as alternating layers of light silty and dark clayey material. The lighter or summer part of the varved couplets ranges from white (5YR 8/1) to light grey (10YR 7/0) in colour. The darker winter layer varies from a very dark gray (7.5YR 3/0) to a reddish brown (5YR 4/3) colour when oxidized. Oxidation, leaching and other soil forming processes destroy the varved appearance of these deposits to a depth of 0.2 to 0.4 m from the ground surface.

Textural analyses of glaciolacustrine samples from the map-area are listed in Appendix C and are summarized in

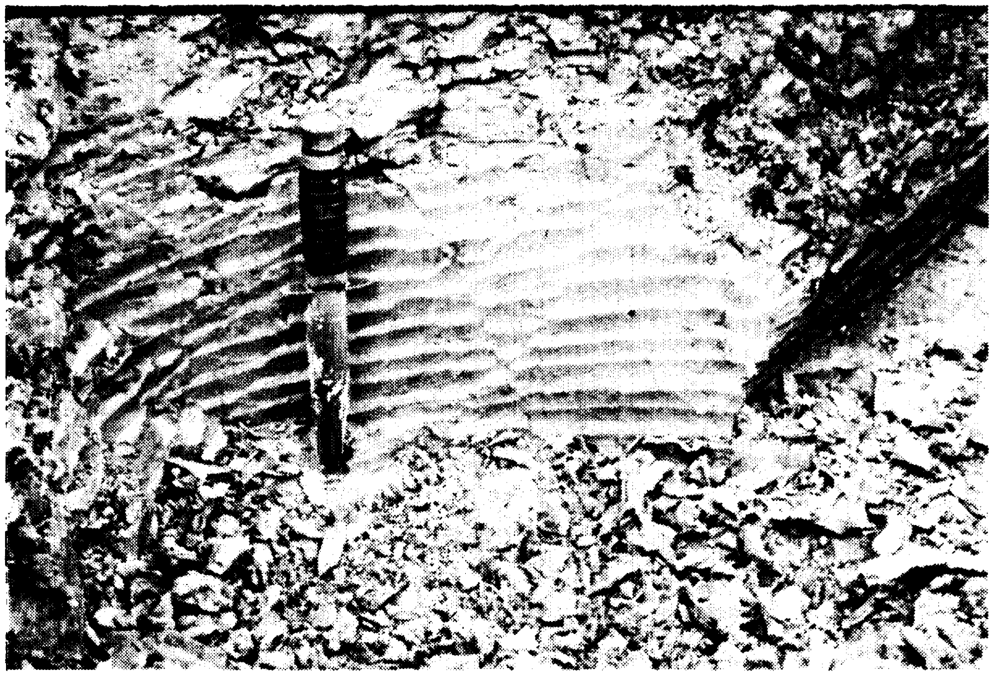


Photo 9: Glaciolacustrine varved clay as it occurs in the Ramore area. Light coloured silt, deposited in the spring and summer, grades upward into dark coloured silty clay. Several post-depositional faults are present to the right of the knife (UTM 517648).

Table 3. Samples of the varved clay contains an average of 45.8% clay, 53.5% silt and less than one percent sand.

Samples taken in the Magusi River area (numbers M300 and M461, Appendix C) were excluded from the averaging calculations because they were not varved clay. Sample M300 (UTM 805650) was collected from an esker flank setting where the material was undergoing a transition from a coarse-grained glaciofluvial facies to a fine-grained glaciolacustrine facies. The sample appears in the field as a laminated clayey silt. Sample M461 (UTM 985496), a silt with occasional grits, is coarser than average as it represents deposition in a shallower, higher energy environment than the varved clay.

The grain size envelope for fine-grained glaciolacustrine sediments is presented as Figure 7. The distinctly bimodal grain size distribution evident in some of the curves reflects the different size fractions in the summer and winter layers of the varves.

The carbonate content of these glaciolacustrine samples ranged from just under three percent to nearly thirty percent. Generally where the total carbonate percentage exceeds twenty, the calcite to dolomite ratio was greater than one.

All samples having a greater than average total carbonate content (>15%) were collected from the upper portion of glaciolacustrine exposures where the clay

| | Matrix Texture (< 2 mm) | | | | Carbonate Content | | | |
|---|---|---|---|---|---|---|---|---|
| | % Clay | % Silt | % Sand | Md (mm) | % Calcite | % Dolomite | % Total | Carbonate Ratio Cal:Dol |
| Mean ($\bar{x}$) | 45.8 | 53.5 | 0.6 | 0.003 | 6.86 | 7.68 | 14.55 | 0.74 |
| Range | 7-68 | 26-92 | 0-7 | <0.001-0.009 | 0.59-19.3 | 2.01-12.2 | 2.62-29.4 | 0.17-1.95 |
| Standard Deviation ($\sigma$) | 16.2 | 16.0 | 0.9 | 0.002 | 6.35 | 3.62 | 9.37 | 0.53 |
| Number of Samples (n) | 25 | 25 | 25 | 25 | 27 | 27 | 27 | 27 |

TABLE 3 - PROPERTIES OF FINE-GRAINED GLACIOLACUSTRINE DEPOSITS, KIRKLAND LAKE AREA

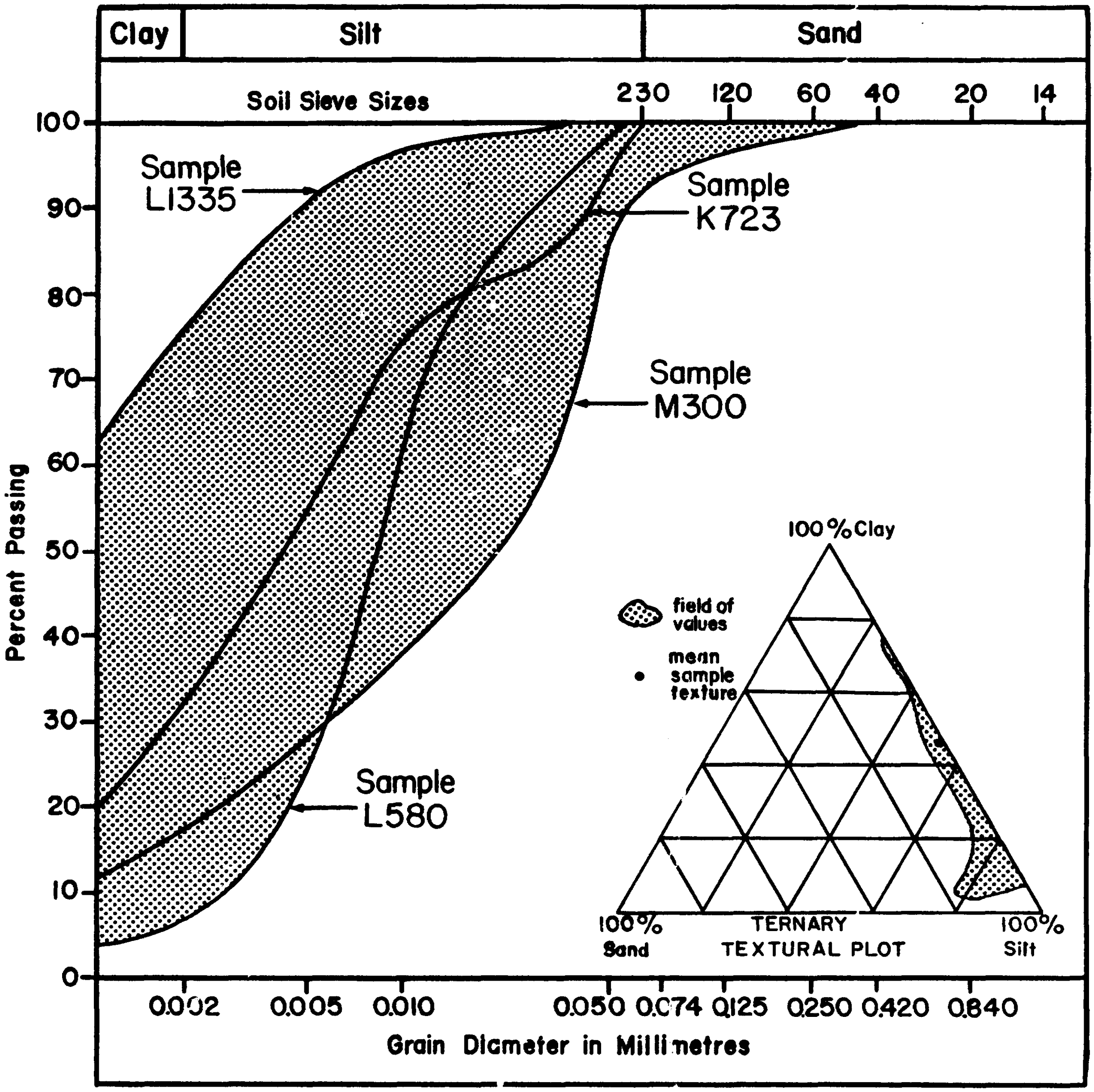


Figure 7 - Grain Size Distribution of Glaciolacustrine Samples, Kirkland Lake Area.

thickness was a minimum of 10 m. This suggests that the bulk of the calcite in the Kirkland Lake area has a distant origin. It is possible that this calcite may have its source in the James Bay Lowlands.

Mineralogy of the varved clay samples, listed in Table 4, shows illite, chlorite and feldspar(s) to be the major minerals. Analyses of Lake Barlow and Ojibway clays by Guillet (1977), Townsend and Metcalf (1964) and Soderman and Quigley (1965) also established illite and chlorite to be abundant in the clay size fraction.

This mineralogy indicates that a significant portion of the clay minerals are derived from the bedrock in the Abitibi Greenstone Belt. These clay sized grains resulted from glacial abrasion of bedrock at the base of the glacier. The clay particles were subsequently released from the melting ice and carried out into the lake.

Varved clay exposures throughout the area display minor tectonic structures such as faults, shears and overturned bedding. These structures do not affect an entire section, but are confined to a small number of varves. Above and below the disturbed varves, bedding is regular. It is believed that dewatering and differential loading are the major factors causing such structures.

Disruptions of bedding also result from ice-rafted material, dropstones, which range in size from grits to cobbles. The dropstones are usually located in the lower

| SAMPLE | ABUNDANT | MODERATE | MINOR | TRACE |
|---|---|---|---|---|
| K42 | | Feldspar | Amphibole<br>Calcite<br>Chlorite<br>Dolomite<br>Illite<br>Quartz | |
| L439 | Calcite<br>Plagioclase | Illite<br>Chlorite<br>Dolomite<br>Quartz | K-Feldspar<br>Amphibole | |
| L1714 | Chlorite<br>Illite* | Plagioclase | Amphibole<br>Quartz<br>K-Feldspar | |
| R1210 | Chlorite | Feldspar<br>Illite | Amphibole<br>Calcite<br>Quartz | Dolomite |

*probably mixed layered - mostly illite component.

TABLE 4 - CLAY FRACTION MINERALOGY OF X-RAY DEFRACTOMETRY

portion of the varved sequence. A greater amount of such deposition occurred near the ice front.

The mechanics of varve sedimentation, with application to Lake Barlow and Lake Ojibway sediments, have been studied by several workers (Antevs, 1925, 1928; Hughes, 1959, 1965; Agterberg and Banerjee, 1969, and Banerjee 1973). General agreement has been indicated for Kuenen's (1951) proposal that the silt layers are a result of periodic turbidity currents caused by sediment charged meltwater entering a glacial lake. The number of graded beds within the silt layers suggests multiple flows spreading out from the ice front each year. The clay or winter portion of the varves was deposited by flocculation of suspended colloid material. Field relationships in the map-area confirm the concept of esker foresets grading laterally into proximal then distal varves.

## Coarse-Grained Deposits

Coarse-grained glaciolacustrine deposits are defined in this report, as sediments consisting of sand or silty sand which may contain minor gravel. This unit is equivalent to the upper part of the Barlow-Ojibway Formation as outlined by Hughes (1965).

The majority of the coarse-grained glaciolacustrine sediments were deposited as an intermediate facies between glaciofluvial and fine-grained glaciolacustrine (usually clay) material. As such, they are transitional to both types (Fig. 8a). Examples of coarse-grained material flank all major and most minor esker systems. The separation of the deltaic facies of ice-contact material and sandy glaciolacustrine sediments was arbitrary where no distinct sedimentological break occurred between the two. This is shown on the Quaternary geology maps by the use of gradational contacts. In the field, material was classified as glaciolacustrine if it contained silty or clayey beds, signifying an environment distal to, or quieter than, that associated with ice-contact deposits. It is important to note that the distribution of the glaciolacustrine sand is source and energy dependent. Depth of water in which deposition takes place plays a role but is not a controlling factor.

During mapping, the contact between the coarse and fine-grained glaciolacustrine sediments was determined largely by sediment texture. Material was classified as fine-grained when the silt and clay components were more dominant than sand. In the field, the facies change between the two types of glaciolacustrine sediments was infrequently exposed. The more common situation is depicted in Figure 8b, where the transition from sand to clay sediments is abrupt on the surface. This is due to onlapping clays covering the gradational contact. This distribution of materials resulted from: 1) the northward ablation of the

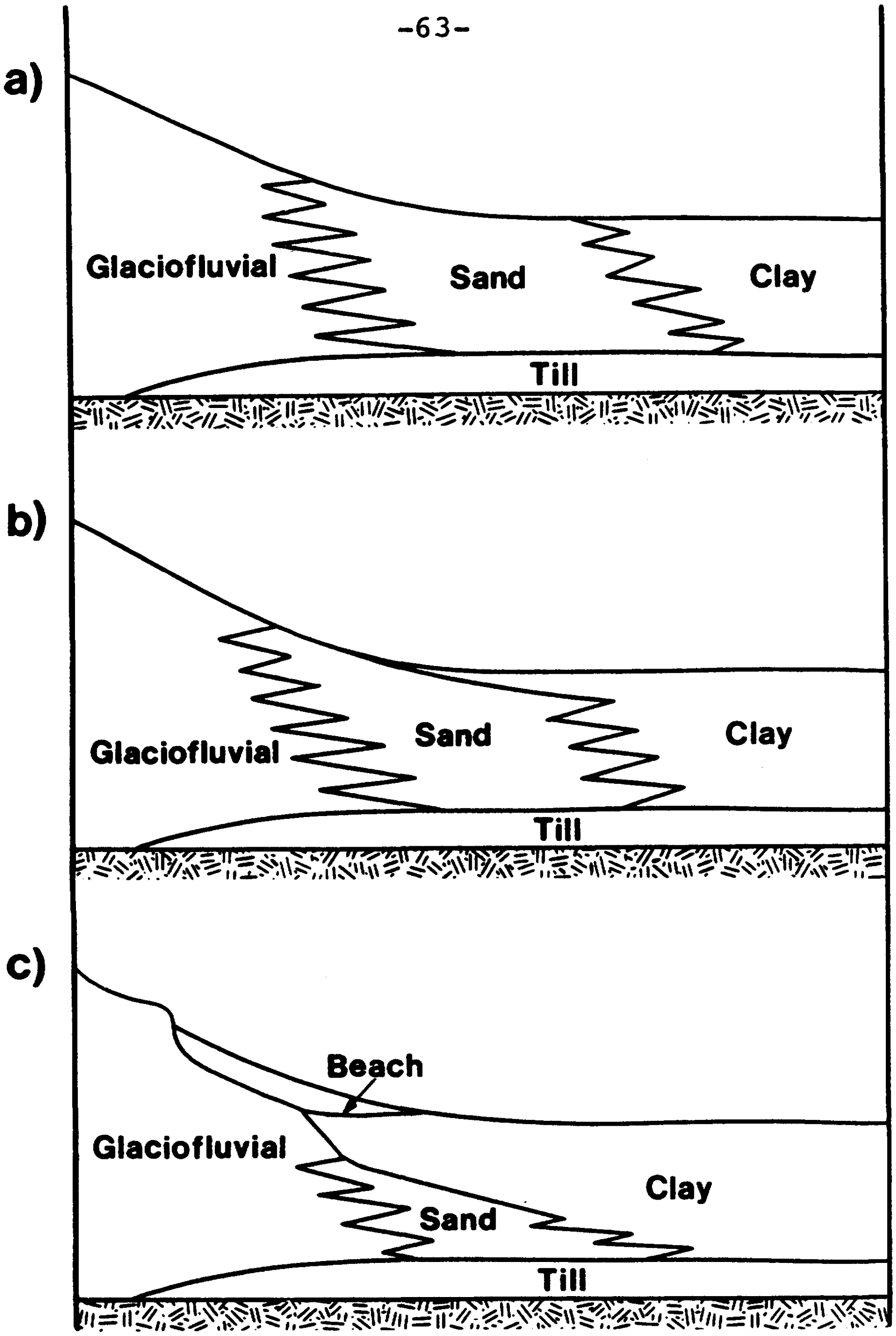


Figure 8: Examples of common lateral relationships of glaciofluvial and glaciolacustrine sediments. A, B and C represent deposition in progressively deeper water. Beaches, as shown in C, are frequenly developed on glaciofluvial deposits.

ice mass, thus terminating a proximal source of sand size sediment; and 2) continued glacial lake cover. While the lake remained at a high level, deposition of clays on top of the gradational contact took place.

In some instances, the clays encroach upon the glaciofluvial sediments and "buried" the glaciolacustrine sand. This relationship is illustrated in Figure 8c with the added complication that beach development has taken place during the falling stages of the lake. Shoreline reworking of the glaciofluvial material has washed beach sediments out over the clay for a short distance.

As glaciofluvial material grades into, and varved fine-grained sediments grade out of the glaciolacustrine sands, it is clear that a continuum exists between the three. The sand then represents the near ice or proximal varve (Photo 10) equivalent of the varved clay. This lateral facies has previously been noted by Antevs (1925), Hughes (1965) and Banerjee (1973).

Proximal varves of up to 14 m thick were reported by Banerjee (1973) in the Cochrane area, while Hughes (1959, p.73) viewed varves consisting "of one to three, and exceptionally, 10 feet of sand, possibly even some gravel, capped by an inch or so of clay". Drilling in the Kirkland Lake area has shown that coarse-grained varves deposited near the ice-margin often consist of a number of upward

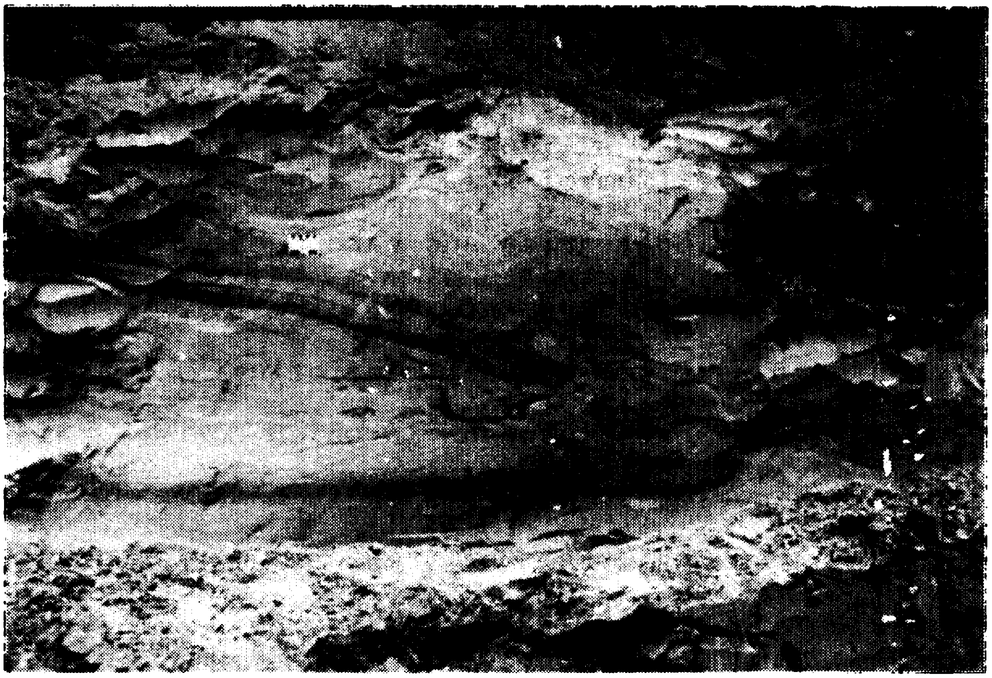


Photo 10: Glaciolacustrine proximal varves in creek cut Ben Nevis Township. The varves at this location range between 0.5 m to 1.0 m in thickness. They consist of fine to medium sand capped by 3-5 cm of clayey silt (UTM 013554).

fining cycles. In section, varves fine and thin upward, reflecting the regressing sediment source.

Overburden drilling and a limited number of observations indicate that varved clay can in some areas undergo downward gradation into silty sand and sandy material. Stratigraphic and textural evidence suggest these materials were deposited in a proximal glaciolacustrine environment. Thickness of this sandy zone is usually limited to a maximum of 2 m. In some of these sandy deposits occasional grits and rare pebbles are present. As would be expected, sandy proximal varves are most frequently encountered near ice-contact glaciofluvial deposits.

A localized environment in which coarse-grained glaciolacustrine sediments occur is small bedrock channels or valleys. The deposits, which may be gravelly, are buried by overlying clays and can reach thicknesses of several metres. The sediments are interpreted as being emplaced by turbidity currents which were preferentially channelled through the valleys after leaving the glacier. The valleys in which these sediments are emplaced are a result of preglacial erosion of bedrock faults and joints.

The largest continuous glaciolacustrine sand body stretches along the western side of the report area, from Gross Township in the south to Tolstoi Township in the north. On the surface, this feature is made up of clean, well-sorted fine to medium sand. Relief on the sand plain has been increased by extensive eolian reworking and downcutting by waterways including the Englehart River.

Exposures along creeks tributary to the Englehart River in Burt and Gross Townships just north of the nursery station show several types of glaciolacustrine deposition. Lowermost in section, having a minimum observed thickness of 10 m, are proximal varves. These varves thin upperward, with those at the base of the section being approximately 2 m in height. This decreases to 0.1 m in overlying sediments where a gradation to typical silt-clay varves takes place. The proximal varves are composed of very fine to fine sand which become slightly silty 5 to 10 cm from the top of the couplet. The varves are capped by 2 cm of silty clay to clay, marking winter deposition. The thickness of the clay layers varies very little between varves, indicating a constant rate of sedimentation during freeze-up, regardless of distance from the ice front.

The varves into which the proximal varves grade are thicker than the regional average. They are, however, comprised primarily of silt and clay couplets. The uppermost varves are in turn overlain by parallel bedded fine to medium sands with occasional silty beds. The sands are up to 5 m thick in Burt Township.

The proximal varve sequence is interpreted as proglacial lacustrine deposition taking place as the ice withdrew northward through the bedrock valley in which the sands occur. The minimum water depth in which deposition took place was 45 m (150 ft). This height is the difference in elevation between nearby ice-contact deltas and the base of the viewed sections. The thick sandy varves formed as a result of large volumes of sediment rich meltwater being directed through the relatively narrow channel between the highlands. Flow velocities sufficiently high to transport sand down the channel for a considerable distance were maintained.

As the glacier withdrew, a quieter deep water environment ensued, allowing the varved clays to be laid down. The parallel bedded sand above the varves is thought to have been deposited as glacial lake levels fell. The position of the ice at this time is speculative.

The nature of the sediments present below the proximal varves is unknown; however, they may be glaciofluvial. The Watabeag esker, present along the western side of the Ramore map-sheet, becomes buried by glaciolacustrine sand west of Dunmore Township. The possibility exists that at this point, the esker may have a southeast-northwest orientation down the valley, parallel to the course of the Englehart River.

Coarse-grained glaciolacustrine deposits have also been derived from till. This occurred as these sediments were reworked during the regression of Lakes Barlow and Ojibway. Glaciolacustrine sediments originating from till form a shallow and discontinuous veneer over outcrops. As erosion was influenced by the position and size of both the till and bedrock outcrops, the texture of this type of shallow water deposit can be highly varied. Where lightly reworked and weathered, till grades into a poorly sorted diamicton. Separation of the two is often arbitrary, especially when the deposits are thin and have undergone heavy oxidation and leaching. More extensive erosion produces cleaner, better sorted sand which may contain occasional pebbles and cobbles that are often angular and striated. Sustained wave action has formed beaches in a number of locations.

Erosion and redeposition of ice-contact material in a shallow water environment also produced glaciolacustrine sediments. This reworked material is usually sand-sized, although pebbly and gritty layers are common near a coarse source. Deposits are wedge-shaped in profile, thinning with distance from the source. The proximal edge of this type of deposit can be on the order of several metres thick.

## Beach Deposits

Beaches, representing the shorelines of former glacial lakes, are of several types and have various morphological expressions. The most easily recognizable form is that of the erosional scarp or bluff. Bluffs are most commonly cut into glaciofluvial material, where bluff heights of up to 7 m have been noted. Well developed examples of erosional scarps are present in Bowman Township, west of Grove and Froude Lakes in Playfair Township, south of Dell and Mobbs Lakes.

The material the bluffs are composed of varies from a coarse gravel to a fine to medium grained sand. Scarp development appears to be more continuous laterally if the material is sandy with only a moderate clast percentage.

Only rarely are beach bluffs eroded into the relatively more resistant glaciolacustrine clay. The one example is located in Hislop Township, west of Holtyre. Here, weakly developed scarps mark a recessional level of Lake Ojibway. The poor development of shorelines in the clay, when compared to the New Liskeard area to the south (Morton et al, 1979), suggests the lake height did not remain at any level for a long period of time.

Deposits developed in a beach environment within the Kirkland Lake area are localized, and as with the scarps, preferentially developed on glaciofluvial material susceptible to reworking. In instance, these deposits are separated with difficulty from the sediments from which they were derived. The rounding and sorting displayed by the beach sediments is usually not developed much beyond that of the glaciofluvial parent material. Compounding the problem, is the fact that beach material and its source often have the same type of bedding: thin, gently sloping beds displaying a preferred imbrication of the clasts. A strong erosional surface, however, may help delineate the boundary between the sediment types.

Beaches that were developed on a moderate to steep glaciofluvial slope during the recessional stages of the proglacial lakes often have a clay unit separating beach and glaciofluvial material (Fig. 8c). The clay was deposited in the early stages of lake development prior to isostatic recovery. Falling water levels subsequently eroded the clay on the top of the glaciofluvial deposit and reworked the sand and gravel lying below.

The result is the clay pinches out against the glaciofluvial material beneath the beach sediments. In cross section, the beach sediments appear winged-shaped. A slight fining takes place away from the glaciofluvial source. The lateral extent of this type of deposits rarely exceeds a few tens of metres.

Nearshore features associated with the beaches are represented by offshore bars and spits. The bar deposits are linear, usually arcuate, and have a height of about 0.5 m, although bars of up to 2.5 m were found. Typically, the bars occur in sets and are made up of pebbly sand displaying overwash sedimentary structures. Well developed offshore bars that are clearly visible on airphotos are present in Playfair Township and in Holloway Township. At the former site the bars are built on glaciolacustrine sand, while in the latter instances glaicofluvial sand and gravel is the parent material.

Material deposited in the form of spits has a restricted distribution, having been identified only in Bowman Township along the eastern side of the Watabeag esker (Photo 11). The spits, one east of McMillan Lake and another east of Cherry Lake, are distinguished on the basis of their morphology and internal sedimentological structures. The spits are dome like ridges splaying off the esker at an acute angle and are composed of stacked, normally graded (upward fining) cycles approximately 1 m in thickness. There is an overall upward coarsening of material reflecting deposition in a progressively higher energy environment which was created as the lake level fell.

An additional shoreline form frequently occurring in the report area is cobble beaches (Photo 12). These are a result of wave washing of gravel deposits during which the matrix material was removed. The beaches appear as strands of cobble and boulder sized material. This type of beach is most commonly encountered on the flanks of eskers and other glaciofluvial deposits; however, weakly developed examples do occur about till draped bedrock knobs. The most prominent cobble beach in the map-area is located in Bowman Township, northwest of Hislop Lake. Here a two metre high beach extends for approximately a kilometre along the east side of the Watabeag esker. Other strong boulder beaches

Photo 11: Nearshore spit developed in glacial Lake Ojibway, Bowman Township. Material in spit coarsens upward reflecting deposition in a progressively higher energy environment created as the lake fell (UTM 396710).

Photo 12: Cobble beach developed on the crest of the Watabeag esker, Bowman Township. Beach is the result of wave washing which removed the fine matrix material (UTM 397705).

were formed on the crest of the Munro Esker on the eastern side of Victoria Lake and along portions of the Boundary esker in Ossian Township.

Lake erosion in beach, nearshore and shallow-water zones has resulted in reworking of the ground surface to produce cobble-boulder lags. These differ from the beaches in that lags appear as a litter of large clasts which armour the surface.

Lags occur on both glaciofluvial and till material. Good examples of the former can be seen on the esker deposits north of Mount Kempis. Lags developed from till are common, although heavy vegetation cover makes their recognition difficult. As a general rule, the lags present on till consist of larger and more angular clasts.

The most frequent results of beach and nearshore erosion are the numerous bedrock knobs and highland areas that have been "washed" of glacial deposits. Where such areas are of sufficient size, they have been included in map unit 1. The lack of drift resulting in classification as unit 1, bedrock with minor drift cover, was not solely due to erosion by Lakes Barlow and Ojibway. The washing that aided in the development of the cobble beaches marks a more severe form of erosion than the lag deposits.

## Fluvial Deposits

Fluvial, or spillway deposits, were laid down in lake drainage channels as the level of Lake Barlow and Ojibway fell. As the land rebounded and the glacial lakes shallowed, formerly submerged bedrock valleys served as drainage channels. Where easily eroded drift (glaciofluvial material or, less commonly, till) was present along these channels, it was reworked and redeposited. The fluvial deposits thus reflect the mineralogical and clast composition of the parent material.

The time-stratigraphic positon of the fluvial deposits places them above till, glaciofluvial and glaciolacustrine sediments. Field exposures have illustrated the relationship of the glaciofluvial and glaciolacustrine deposits to the spillway material. Although till has not been observed to underlie fluvial deposits, its presence is inferred. The extent of a till plain under fluvial material is likely to be limited, due to the discontinuous nature of the till and its erosion prior to fluvial deposition.

The fluvial deposits are level surfaced, consisting of stratified upward fining cycles of sand and gravel. Occasional large scale cross-bedded units are encountered. The texture of the matrix material varies across exposures but usually consists of a poorly sorted, clean sand with abundant grits. Clasts in the fluvial deposits are moderately to well rounded. Huronian argillitic sediments display a unique conchoidal fracture on fracture surfaces.

Fluvial deposits occur on either side of the report area. To the east, they are located along the edge of Ward Lake in Rattray and McFadden Townships. The material in this deposit was derived from the Boundary Esker which lies adjacent to it. An associated fragment of the same drainage channel is located to the northeast between Raven Lake and Lac Buies. A gravel pit exposure displayed a 7 m face of stratified, well sorted, rounded pebbles and cobbles, the majority of which were 5 cm to 20 cm in diameter.

Larger fluvial deposits are located near the southwestern portion of the map-area in Bompas and Burt Townships. The southern fragment of this system, southwest of Burt Lake, reworked the northern side of an ice-contact delta. Beds in the upper (northeastern) end of the spillway are tabular and horizontal. Deltaic deposition occurred 1.5 km southwest of Burt Lake as indicated by the presence of foresets overlain by topsets. This would suggest a lower phase of a glacial lake standing at this elevation during at least part of the spillway deposition.

The most extensive fluvial deposits in western Bompas Township occupy the Burt Creek valley and the bedrock valley immediately to the west. The deposits are ribbon shaped, being confined by the valley walls, and have lengths of 6 and 8 km. The high water table in these deposits prevented a detailed examination of the materials. Augering and test pitting, however, suggest the deposits are composed of stratified sand and gravel derived from glaciofluvial sediments in northern Bompas and Lee Townships. The material in the western valley, close to the Bompas-Burt Township line, undergoes a facies change from a gravel to gritty medium sand. This sand is separated from similar underlying glaciolacustrine material with difficulty. No data exists on the depth of these sediments, although it is likely they do not exceed a few metres.

Spillway deposits are also present as a thin veneer over glaciofluvial material to the north of Ellis Lake, Bompas Township and northward into Lee and Black Townships. Use of the Sarsfield-Tomwood Creek valley as a meltwater channel has reworked and winnowed the underlying deposits resulting in a clast strewn lag surface with low relief. Discontinuous cobble-boulder terraces are occasionally developed along the sides of the valley.

## Eolian Deposits

Within the study area, eolian deposits, primarily in the form of dunes, occur on glaciofluvial and glaciolacustrine sand plains. The areas in which significant sand dune development has taken place are: 1) along the western boundary of the Ramore and Kirkland Lake map-sheets from Tolstoi to Dunmore Townships; 2) in Michaud

Township; 3) a zone along and to the east of the Munro Esker from Thackeray to Arnold Townships (Photo 13); and 4) areas in Gauthier and McElroy Townships in the Larder Lake map-sheet. In addition to these areas, several patches of small, low relief dunes are developed on narrow sand plains flanking eskers such as the Boundary and Misema.

The dunes are composed of very fine to medium sand (Fig. 9) that has been derived from material of a similar texture. Locally, the dunes may contain thin layers (<1 cm) of coarse to very coarse sand.

The sand dunes are easily discerned on the basis of their morphology with interdunal areas generally having only a thin veneer of eolian material. The dunes may be grouped into three forms: 1) transverse, 2) parabolic or upsiloidal; and 3) blowouts. Combinations and inter-actions of the various forms, however, provides a variety of outlines. The parabolic shape is most common with plan views ranging from symmetrical U-shapes through hairpin, fishhook and fork shapes. This is regarded as the order of development, a sequence that agrees well with previous work (Lindroos 1972).

The height and length to which dunes were built varies from one dune field to another. The main factor controlling the size is the fetch of the wind across the sand bodies. This is well illustrated along the western edge of the report area. In Terry Township where the fetch exceeds 18

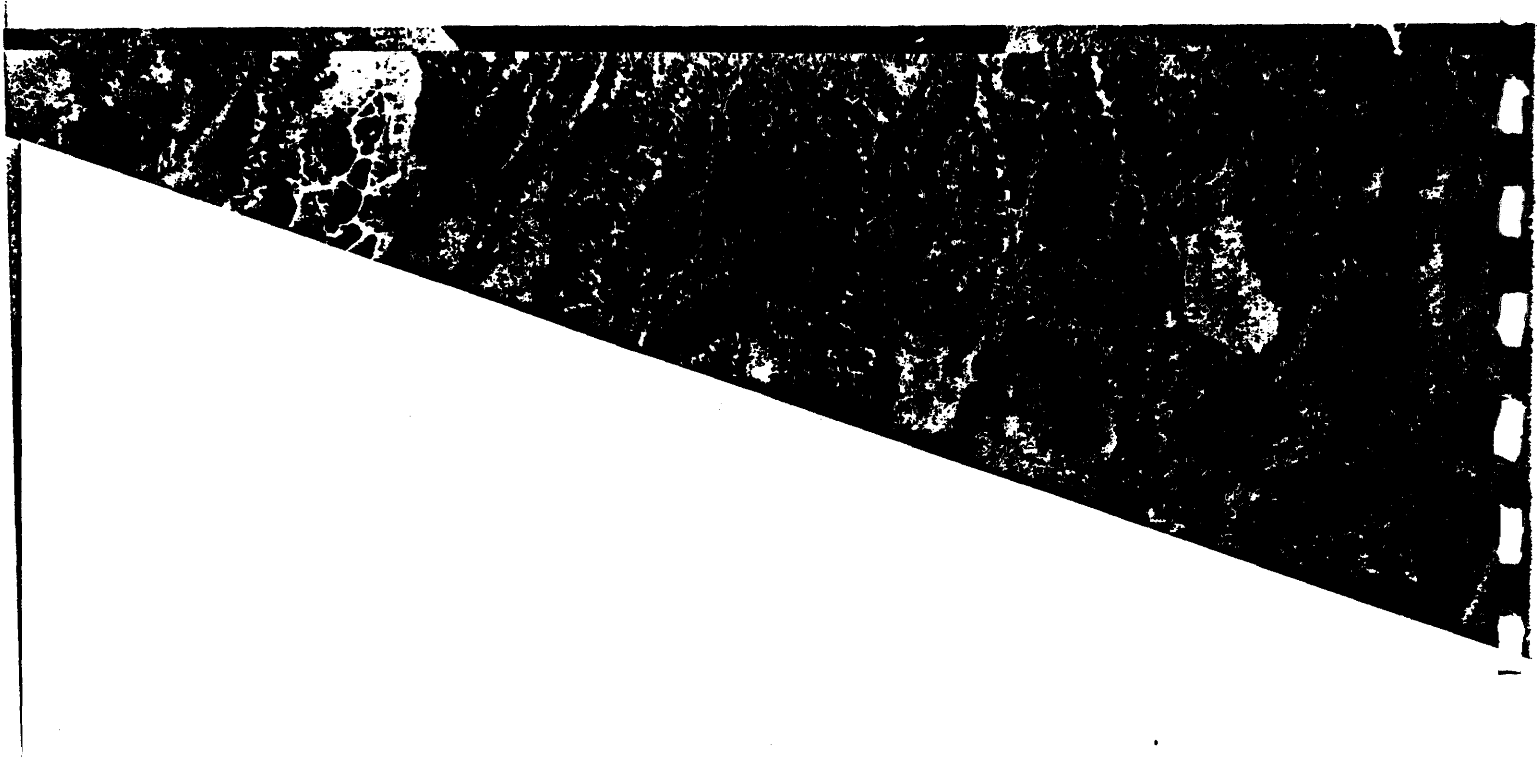


Photo 13: Steroscopic pair of Arnold Township dune field. Lakes in lower left hand corner are kettles flanking a short segment of the crest of the Munro Esker. Photo Numbers 70-4810 2-214 and 215).

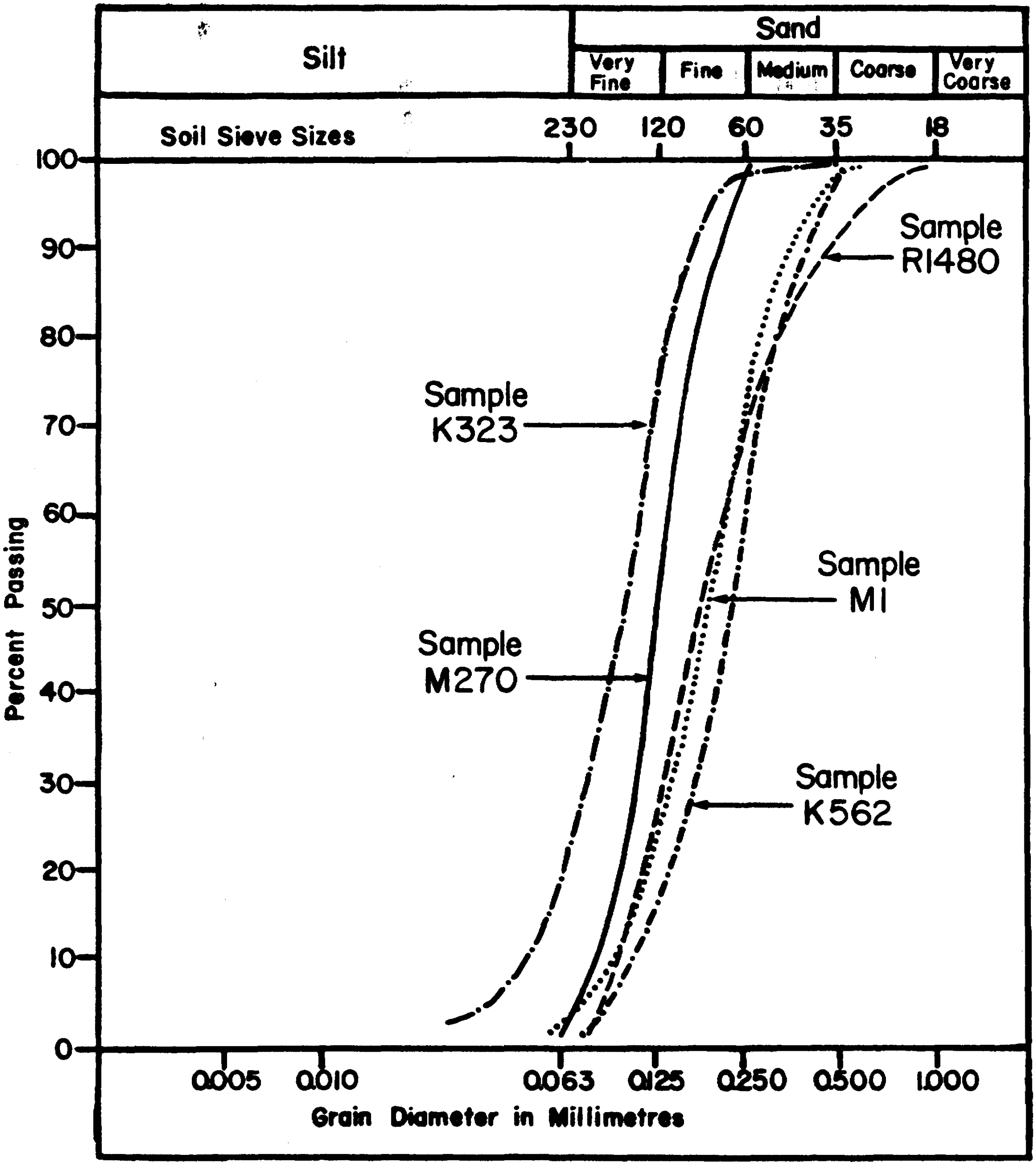


Figure 9 - Grain Size Distribution of Eolian Samples, Kirkland Lake Area.

km, dunes of greater than 20 m in height have been constructed. On the same sand body in Holmes Townshipdune heights decrease to a maximum of 10 m where the fetch is only 4 to 5 km. In other parts of the map-area dune heights are usually 5 to 10 m. Individual dune limbs frequently reach 0.5 to 1.0 km in length, with coalescence creating limbs several kilometres in length.

The internal structure of dunes examined in road cuts show them to be comprised of thin stratifications or laminae which dip steeply (20° to 30°) to the east-southeast. In a limited number of exposures, primarily dune limbs, the stratification was near horizontal or dipped to the northwest at a shallow angle. The difference in the dip is interpreted as representing foreset or avalanche and backset deposition respectively.

The dunes probably began to form when the lake level, and subsequently the ground water level, had lowered sufficiently to allow for the surface material to remain dry for some time. The time of dune stabilization has not been determined, but the relatively short distance of migration suggests development was not a lengthy process. A radiocarbon date of 1500 years B.P. (H.A. Lee, as cited in Frey 1975, p.23) was obtained from a peat sample overlying dune sand in Arnold Township and serves as a minimum date of fixation.

This date also serves as a minimum time as to when the water table rose after the hypsithermal and bogs began to develop about the dunes. Hughes (1959) believed that in addition to climatic change, the effects of isostatic uplift and the perpetuation of poor drainage once bogs were established, would be factors in the existence of swamps around dunes.

There is a high probability that the dune fields have on occasion become active due to local destruction of the covering flora by fire or other means. Knight _et_ _al_ (1919) described such a happening in Michaud and McCool Townships and found rapid regeneration of stabilizing grasses within a year's period.

The natural vegetation found on eolian sand is pine _(Pinus)_ with minor spruce _(Picea)_. Shrubs are also abundant, especially on the deposits which have recently been lumbered. The main species are blueberry _(Vaccinium myrtilloides)_ and sweet fern _(Camptonia peregrina)_.

The orientation and shape of modern small scale eolian features forming on barren or stripped sand deposits indicates that the present prevailing wind direction is the same as that during the construction of the dunes. The shape and outline of both sets of features indicates a wind direction from the west-northwest.

## Organic Deposits

Organic deposits of the Kirkland Lake area occur in three distinct settings: 1) on glaciolacustrine plains,

2) along creeks and streams

3) in bedrock basins

The majority of the organic deposits are developed on glaciolacustrine material, both clay and sand. Significant deposits are located on the Great Clay Belt in the eastern half of the Ramore map sheet and in Blain, Eby and Otto Townships on the Little Clay Belt. Large wetlands are also present in the areas between and surrounding sand dunes, as illustrated by the Dunmore bog, Dunmore Township. Organic deposits on glaciolacustrine plains can attain a size of several tens of hectares.

Depths of deposits are variable with the majority in the 1 m to 2 m range. Locally, however, thicknesses of greater than 4 m can be obtained.

In areas of high relief the organic material commonly occurs along waterways. These deposits vary markedly in length from short fragments to several kilometres. The material flanking creeks and streams is seldom more than a few metres in width and is usually shallow (<2.0 m). This type of deposit is generally floored by glaciolacustrine sediments. Organics mapped along drainage paths differ from alluvial sediments in that they consist of decaying organic material deposited in situ with little to no terrigenous material, although such water course organics often have a significant inorganic component deriving from the sediment load of streams.

The third group of organic deposits, those occurring in bedrock basins, are small both in area and volume. The depth of these features, developed as a result of restricted drainage or pondings, is variable (1 m to 6 m) and is controlled by the bedrock surface, which in most cases forms their base.

In the Kirkland Lake area the organic deposits are of three major types: fens, bogs and swamps. The fens are dominated by Carex and grasses (graminoids) or by shrubs. Tamarack (larch) is the characteristic tree species. Fens commonly develop on calcareous substratum, notably glaciolacustrine clays and silts. Depth of material in the fens is usually less than 2 m.

Bogs tend to be dominated by Sphagnum mosses, shrubs and black spruce, but may also have strong graminoid elements. Compared with fens, bogs have restricted lateral movement of water, with their major source of water and nutrients being precipitation.

Swamps are heavily treed peatlands, usually dominated by black spruce or tamarack.

Organic deposits in the bedrock basins are predominantly bogs, while those occurring along water courses are mainly swamps or fens. The large organic areas on the glaciolacustrine deposits are classified as fens where there is sufficient nutrient enrichment through the lateral migration of water. This is usually the case along streams and surrounding lakes, or where organic deposits are thin. Thicker accumulations of organics tend to remove the peatland surface from the mineral-rich clay substrates, and on such sites bogs are most common.

## RADIOCARBON DATES

Five samples of organic material were collected from sites in the Larder Lake map-sheet for radiocarbon dating. Their location and pertinent details are given in Table 5.

The date of 9,990±260 years B.P. (GGS-552)[2] obtained from a bog on the Adams Iron Mine property, Boston Township, is the oldest determination in the region. As the bog stood above the highest level of Lake Barlow the date serves as a minimum time figure for deglaciation of the district.

The material that yielded the date came from a peat bog in which the organics displayed an upward gradational change from clay with reeds, to a spongy peat that contains wood fragments and roots near surface. This is thought to represent a transition from a pond environment to a bog which with time become treed over.

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[2] Brock University, Department of Geological Sciences

| Sample Number | Type of Material | Location | UTM Grid Reference | Depth of Sample | Approx.Height A.S.L. | Age Years B.P. | Remarks |
|---|---|---|---|---|---|---|---|
| BGS 552 | Clay with organics | North of the west pit Adams Mine | 792245 | 4.0m | 354m | 9990±260 | Grades upwards into peat |
| BGS 553 | Peat | 2km south of Dobie | 872299 | 2.2-2.5m | 287m | 7070±150 | Glaciolacustrine sands beneath |
| BGS 554 | Peat | Munro Esker McElroy Twp. | 896190 | 7.9-8.1m | 326m | 6140±110 | Kettle bog |
| BGS 555 | Peat | Skead Twp. | 973179 | 1.5-1.7m | 317m | 4740±100 | Bog over sand |
| BGS 556 | Peat | 1km north of Larder Lake on Hwy. 66 | 960283 | 1.6-1.8m | 290m | 3730±110 | Reduced varved clay below peat |

TABLE 5 - SUMMARY OF RADIOCARBON DATED SAMPLES

## Alluvial Deposits

Alluvium deposited along the channels of rivers and streams, often represents near continuous deposition from the recent past to present. The type of sediment present at any one given locality is highly influenced by the underlying or parent material. Where the surficial material is fine-grained glaciolacustrine sediments the alluvium is likely to be a poorly sorted clayey silt. Alluvium derived from till, glaciofluvial or glaciolacustrine sand is composed of fine sand, locally silty or gravelly. Additional parameters, such as stream competency and channel dimensions, are also controlling factors in the transport and deposition of alluvium.

Alluvial sediments contain organic material in a variety of forms ranging from twigs and undecayed detritus through highly decomposed organic matter. Organic material imparted a dark tone to the alluvial deposits and is occasionally present as thin peaty laminae.

Major alluvial deposits within the report area are located in the larger river valleys. Several metres of alluvium is present in the Englehart River valley where deposits are 100 m to 700 m in width. Large alluvial deposits are present along this river due to the ease in eroding and transporting the sand along the river channel.

Other significant recent alluvial deposits are present along the Blanche, Magusi and Misema Rivers. Alluvium along smaller creeks and rivers is present in quantities that are unmappable at the present report scale.

## MINE EXCAVATIONS AND TAILINGS

The widespread mining activity occurring throughout the Kirkland Lake area and, in particular, along the trend of the Larder Lake Break (Fault) has resulted in high volumes of mine waste. Eight major tailings ponds are located in the immediate vicinity of the Town of Kirkland Lake. Other large deposits of mine waste are located west of Virginiatown (Kerr-Addison Mine), north of Dobie (Upper Canada Mine), and north of Holtyre (Ross Mine). The largest single deposit of mined and waste rock in Boston and McElroy Townships is a result of operations at the Adams Iron Mine.

Mine waste is produced in two forms: crushed rock and tailings or slimes. The former is a product of stripping and excavation in non-mineralized zones. Crushed rock is abundant about the Adams Iron Mine where large quantities are stock piled. It is also found on the sites of many small abandoned mines, often in non-mappable proportions, where test shafts were sunk.

Tailings or slimes (Photo 14) account for the greatest percentage of mine waste and consist of rock ground to minus 225 mesh (-65 microns). It is transported to the dump site

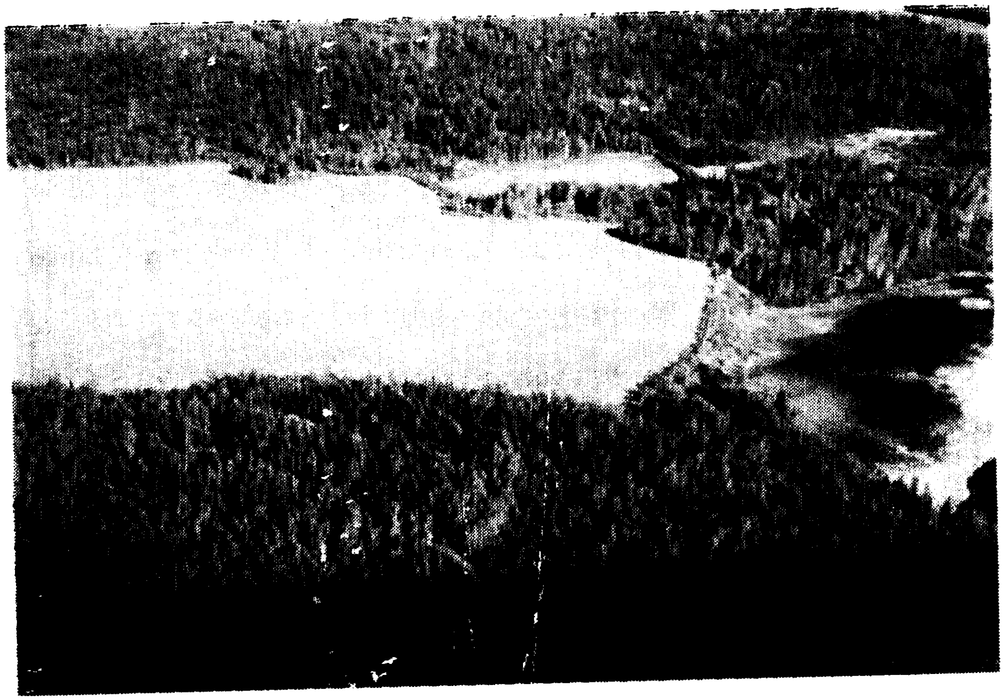


Photo 14: Tailings or slimes located north of the Town of Kirkland Lake. Tailings resulted from the grinding of ore to the silt size range for the purpose of extracting gold. Vegetation is typically lacking on such deposits.

in a slurry, it rapidly fills depressions, and spreads unless confined.

Both types of deposits are easily recognizable on the ground and in air photos. The rock dumps, generally consisting of angular cobble material, appear as circular or cone shaped mounds and on occasion as fans below rock escarpments. Tailings are usually level surfaced or slightly inclined and have limited to moderate vegetation cover.

## HISTORICAL GEOLOGY

The Kirkland Lake area has undoubtedly been affected by glaciation prior to the Wisconsinan. The effects and resulting deposits from such activity are, however, largely speculative. This is due to a absence of surface exposures displaying pre-Wisconsinan deposits in the report area.

Deposits that have been assigned to a pre-Wisconsinan glaciation are exposed in the James Bay Lowlands. Skinner (1973) noted the presence of three tills in the Moose River Basin which underlie interglacial sediments. These tills, which he believed recorded oscillations of a retreating ice margin, were deposited by ice advances from the northeast. These tills are separated by intertill glaciolacustrine sediments displaying south facing paleocurrents indicating blockage of the natural drainage to the north.

Overlying the till sequence in the Moose River Basin is a series of deposits termed the Missinaibi Formation (Skinner 1973). Skinner assigned the formation interglacial status as it contained abundant fossil and organic material, including a buried soil layer.

Pre-Wisconsinan deposits located nearer the Kirkland Lake area have been reported in Currie Township, approximately 23 km west of the village of Ramore by Brereton and Elson (1979). They describe the stratigraphy below Wisconsinan age till as (top to bottom):

1) varved clay and organic rich sand which have yielded a radiocarbon date of >37,000 yr. B.P. (GSC-2148). This unit is tentatively correlated with the Missinaibi Formation by Brereton and Elson (1979) who have also suggested it is of Sangamonian age;
2) varved clay;
3) till of variable composition over bedrock.

Another site in the Kirkland Lake region where interglacial material has been encountered is the Lower Notch hydroelectric dam at the mouth of the Montreal River on Lake Timiskaming. Here organic rich sand, silt and gravel underlie a grey stony till (Wisconsinan?). Wood fragments yielded a date of <42,000 yr. B.P. (GSC-1299) (Lowdon et al 1971). Skinner (1970, 1971) stated that the unit containing the organics may be the southern equivalent of the Missinaibi Formation.

The author examined an exposure a kilometre south of Lower Notch Dam in which a silty sandy till overlies a thick exposure of a younger silt till. The upper till is judged to be Wisconsinan; however, no age was established for the lower till nor was the relationship of these tills to the units at the dam site determined.

A second two till section in the Cobalt area is located on the shore of Lake Timiskaming (Pertunnen 1980). The lower till is a calcareous clayey silt unit whereas the upper till has a sandy texture. Here again, the upper sandy till is assumed to be the equivalent of the regional Wisconsinan till. The presence of two tills in these sections in this region may also be related to the complex history of glacial flow directions, described by Veillette (1982, 1983b).

Multi-till sections have frequently been reported in the Timmins-Kirkland Lake area by individuals and companies engaged in overburden drilling. These occurrences are concentrated in the Great Clay Belt north of the present day continental drainage divide. Datable organic material positioned between the tills was either lacking or not recovered. In such instances, the upper till is considered Wisconsinan while the age of the lower till is unknown. Examples of multiple tills encountered during exploration drilling in Currie and Macklem Townships are detailed by Gray (1983). Drill logs indicate that where more than one till exists, the units are often separated by fine-grained lacustrine deposits. These intertill sediments are characteristically over-consolidated probably because of the loading by the weight of the ice depositing the upper till.

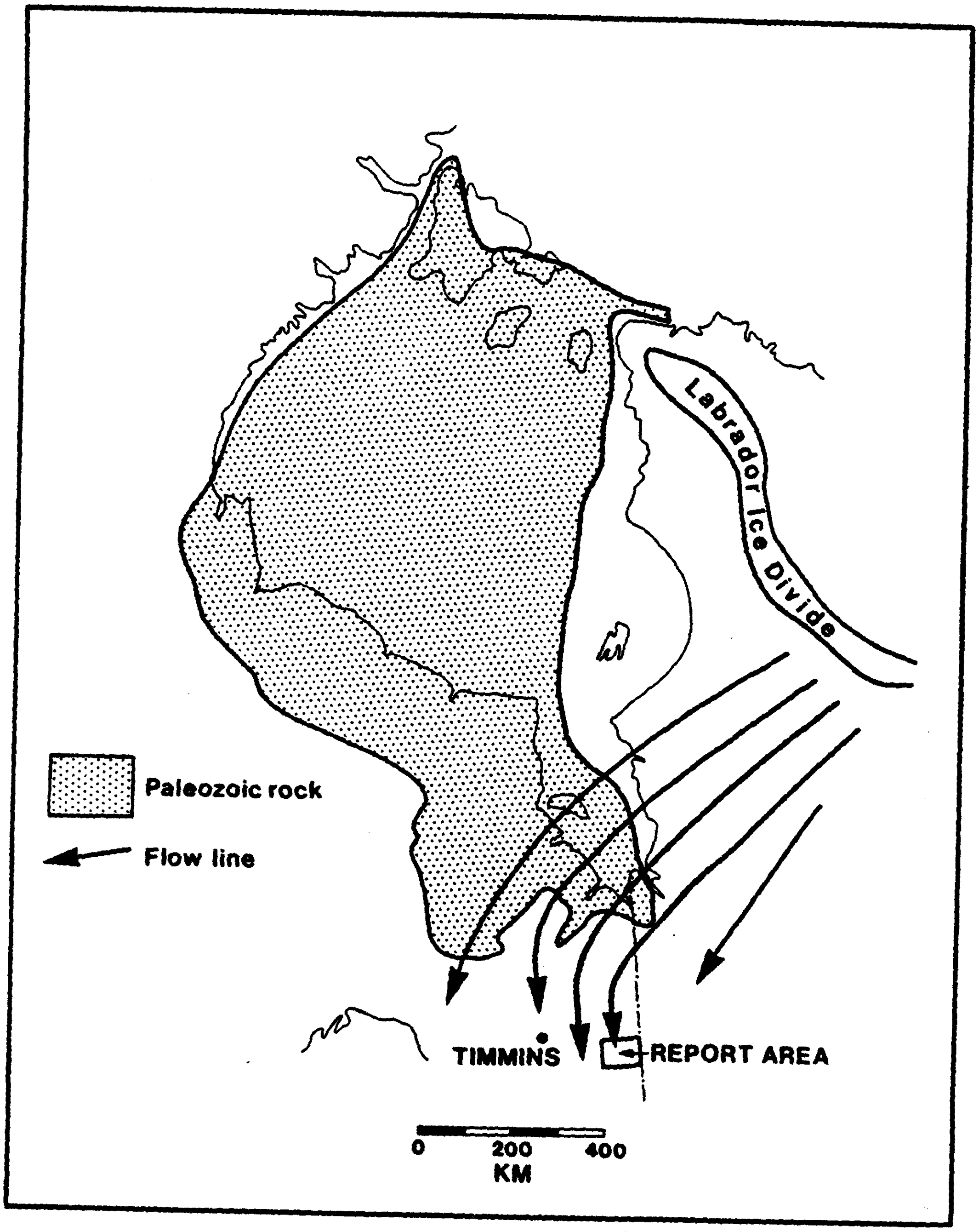
At this stage, little is known about the direction of ice movement responsible for the deposition of any tills occurring below the regional Wisconsinan till. Eighteen kilometres northwest of Holtyre stripping on the Maud Lake Gold Mines property in Beatty Township exposed a two till section. The upper till advanced toward 170° az. and directly overlies the lower till. Striae assoicated with the lower till indicated ice movement was from the northeast (240° az).

Sampling of other occurrences of older till may allow a provenance to be established on a site by site basis. This may lead to a regional correlation of older tills.

Traditionally northern Ontario has been considered as being ice covered for the majority of Wisconsinan time. Recently, this has been challenged by Andrews et al (1983). On the basis of amino acid data obtained from shells collected in the Hudson Bay Lowland, these authors propose a date of 130,000±5000 yr. B.P. for the Bell Sea, a water body correlative with the oldest deposits of the Missinaibi Formation. Other groupings of shell data suggest Hudson Bay may have been free of ice along its southern shore approximately 35,000, 75,000 and 105,000 yr. B.P. before the Tyrrell Sea incursion 8000 yr. B.P.

Patterns of Wisconsinan ice flow, as it affected the northeastern portion of Ontario, have recently been discussed by Shilts (1980), Denton and Hughes (1981) and Dyke et al (1982). Regional ice flow orientations to the north of the Kirkland Lake area are inferred from the distribution of carbonate clasts derived from the James Bay Lowlands in the glacial deposits of the Kirkland Lake area. Paleozoic rocks from the Lowlands account for up to ten percent of the clasts in sediments in the Timmins area to the west. The ice flow lines suggested by Shilts (1980, Fig. 3) would account for such a distribution. Ice covering the report area originally advanced from the Labrador Ice Divide (New Quebec Ice centre) in a southwesterly direction, flowing south of carbonate bedrock in the Lowlands (Fig. 10). After reaching a position now marked by the Ontario-Quebec boundary, the glacier was deflected southward. The ice affecting the Timmins area had a more northern track, crossing the carbonate rocks before turning southward. If this model is correct, a rather abrupt increase in carbonate clasts in till and glaciofluvial material can be expected just to the west of the study area. Such an increase was recorded by Hughes (1959, p.15) who noted "In the Smooth Rock map area and the north half of the Iroquois Falls map area, 10 to 32 percent of the total pebbles are Paleozoic rocks. In the Kirkland Lake map area, representation of Paleozoic rocks in reduced to between one and three percent".

Striae measurements recorded within the Kirkland Lake area provide firm evidence for major ice flow averaging 165° azimuth. This advance deposited the ubiquitous silty sand till present in the map-area. Subglacial deposition resulted in lodgement and subglacial melt-out till facies, collectively termed basal till, as well as flow tills formed in cavities at the rock-ice interface. As the ice mass



**(modified after Shilts 1980)**

Figure 10 - Reconstructed ice flow patterns illustrating southwest movement away from the Labrador Ice Divide. Ice affecting the Kirkland Lake area did not traverse the Paleozoic rocks before being deflected southward. Thus, glacial deposits of the report are free of carbonate clasts.

ablated and the glacier front receded northward, till which has accumulated on the ice surface was deposited as: 1) thin supraglacial melt-out (ablation) till on the highlands above the maximum lake level; or, 2) flow tills.

During the waning stage of glaciation, ice-contact glaciofluvial material in the form of eskers was deposited in the area. The major esker systems were preferentially oriented along intersecting fault lineaments while the course of small eskers was influenced by the local bedrock topography. Ice-marginal positions along the eskers are indicated by the presence of deltas, ice-contact faces and morainic features. The local nature of these features precludes the reconstruction of regional ice front positions during the retreat of the glacier.

Deglaciation was completed in part by ice calving into the lake that fronted on the ice mass. The melting out of material held in floating ice resulted in thin and patchy accumulations of ice-rafted or "rain-out" debris.

Also deposited in the lake were coarse-grained glaciolacustrine sediments consisting of sand with minor gravel. These were deposited either as facies of ice-contact material adjacent to the larger eskers or in shallow water, high energy environments.

The existence of extensive deposits of varved and laminated glaciolacustrine clay in the Timiskaming District has long been known (Coleman 1909; Kay 1904). The name

"Saugeen clay" was applied to these types of deposits in the Lake Abitibi region (Baker 1909) on the misunderstanding that such sediments were related to those of Lake Algonquin to the south.

Coleman (1909) applied the name Ojibway to a lake occurring to the north of the St. Lawrence-Hudson Bay divide. He believed this lake existed after the North Bay-Mattawa outlet was uncovered, allowing waters south of the continental divide to fall to the Nipissing level. He contended that the beaches in the New Liskeard-Englehart district probably belonged to the Nipissing Great Lakes.

Continuing work in the region by Wilson (1918) lead him to conclude that glacial Lake Algonquin was not responsible for the glaciolacustrine deposits found in the vicinity of and north of Lake Timiskaming. He determined that the clay deposits were continuous across the continental divided and were, at least in part, laid down by the same body of water. Wilson proposed the name Barlow for this lake and suggested it was formed by an ice lake damming the Timiskaming trench. At this time the relationship between Lakes Barlow and Ojibway was not resolved.

Work by Antevs (1925, 1928) lead him to conclude that the existence of Lake Barlow was due to drift barrier damming the outlet at Timiskaming. He envisioned a single lake crossing the drainage divide as the ice retreated northward and suggested the name Barlow-Ojibway.

Prest (1970) presented a regional history of the lake stages in diagrammatic form in Chapter XII, Figures 16n to 16t inclusive. The areal extent of Lake Barlow-Ojibway and its associated phases has been outlined in Wilson et al (1958) and updated by Prest et al (1968). A more detailed delineation of these deposits in the Province of Ontario is presented by Boissonneau (1965a and b).

The most recent interpretation of the proglacial lakes inundating the area is that of Vincent and Hardy (1979). The authors demonstrate that lake development took place in stages due to the northward migration of the drainage outlet. Early Lake Barlow outlets were located at Aylen and La Cave, respectively, on the Ottawa River system. By the time the glacier had receded to the Kirkland Lake area, drainage was controlled by an outlet at Temiscaming, Quebec creating the Temiscaming Phase of Lake Barlow which still occupied the Timiskaming Basin.

Lake Ojibway came into existence when the water body was cut in two by the emergence of the Angliers sill on the Des Quinge River. This Angliers Phase of Lake Ojibway, affecting only the northern portion of the report area, co-existed with the Late Temiscaming Phase of Lake Barlow which still occupied the Timiskaming Basin.

In the earliest study of the Barlow-Ojibway sediments, Antevs (1925, 1928) numbered and correlated varves which he termed the Timiskaming series, on a regional basis. Hughes

(1959) divided these glaciolacustrine deposits of Barlow-Ojibway into lower and upper parts. The lower division being comprised of varves and the upper consisting of shallow water sand and gravel deposits. The lower division was broken into three sequences: 1) lower, varves 1 to 1527 of Antevs; 2) the Frederickhouse, varves 1528 to 2014; and 3) the Connaught, made up of over 60 varves associated with the Cochrane readvance. The break between the two older sequences occurs at a point where a sudden increase in varve thickness takes place. The bottom of the Connaught sequence is marked by a slight disconformity.

The increase in varve thickness at varve 1528 was attributed by Antevs to increased melting of the ice front and by Hughes (1959) to a deepening of the glacial lake. The author agrees with Vincent and Hardy's (1979) interpretation that varve thickness increased due to a minor ice readvance. An isopach map of varve 1528 (Banerjee 1973, p.8) lends support to this theory. In the report area varve 1528 was identified, with uncertainty, at one location, along the Pike River in Guibord Township (UTM 536717).

Beaches attributed to a given phase of either Lake Barlow or Lake Ojibway occur at progressively higher elevations northeasterly through the report area. This is due to differential uplift of the ground surface following deglaciation. The southern portion of the report area recovered from crustal depression caused by the weight of the ice before the northern portion. As the greatest amount of isostatic rebound took place shortly after deglaciaiton, and the rate of recovery subsequently slowed, beach lines of the various lake stages rise at differing rates. Early shoreline levels of Lake Barlow rise at a greater rate than levels of the later Lake Ojibway. This is a result of the northern part of the area gradually "catching up" to the rebound that had occurred in the south. The line of maximum tilt of the beaches has an orientation of approximately N20°E (Vincent and Hardy 1979).

The highest shorelines present in the area indicate they were formed during the Temiscaming Phase of Lake Barlow (Vincent and Hardy 1979, Fig. 3E). This was determined from the elevations of the beach features, wash limits and ice-contact deltas. These features rise in elevation northward across the area reaching a maximum of approximately 325 m in the Workman Hills area of Katrine Township. Beach strands in Holloway and Marriott Townships, along the northern edge of the map area, also occur near this height. Due to the effect of differential isostatic recovery, however, they are assigned to a transition stage between the Temiscaming phases of Lake Barlow and the Angliers phase of Lake Ojibway (Vincent and Hardy 1979, Fig. 3F and G). Such an interpretation would require the glacier to be positioned north of the present day drainage divide prior to the emergence of the Angliers outlet.

Shorelines developed during the Angliers phase of Lake Ojibway are represented by the strong beaches present on the Watabeag esker in Bowman Township.

The date of formation of Lake Barlow can only be estimated at present. Harrison (1972) states the retreat of the ice from south of Mattawa and the consequential opening of the Mattawa-Ottawa drainage route occurred prior to 10,100±240 years B.P. but after 10,870±130 years B.P. Karrow et al (1975, p.49) placed the opening of the North Bay outlet shortly after 10,400 years B.P.

The maximum age of the Temiscaming phase of the lake, and hence deglaciation in the Kirkland Lake area, is not known accurately. A sample of peat collected at the Adams Iron Mine in Boston Township was dated at 9990±260 years B.P. (BGS-552)[3], providing a minimum date for ice retreat. The date was obtained from the base of a bog developed in a bedrock basin above the level of lake incursion.

A partial key as to how long Lake Barlow existed is given by two radiocarbon dated samples from the Englehart River delta (King and Morton 1979). The samples from Evanturel Township, south of the map-area were collected at an elevation of approximately 200 m. Radiocarbon dates of 8,210±150 years B.P. (BGS-559) and 8,300±170 years B.P. (BGS-562) indicate that the water level dropped to this level roughly 1750 years after deglaciation of the Kirkland Lake region.

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[3] Brock University, Department of Geological Sciences.

As the lake level fell, reworking of glaciofluvial and till deposits produced shoreline features at scattered elevations. Fluvial deposits were developed by reworking glaciofluvial material in valleys.

The withdrawal of Lakes Barlow and Ojibway and the onset of warmer conditions allowed the development of eolian landforms on exposed sand plains. Dune formation is thought to have occurred in a relatively brief period before the spread of vegetation halted the movement of the sand.

The build up of organic material in swamps and bogs on the highlands began shortly after vegetation re-established itself following deglaciation. Organic accumulations on the glaciolacustrine plains commenced when the lakes retreated and a drainage pattern similar to that of the present day developed. Coincident with this, alluvial material built up along the courses of the larger streams and rivers as they became incised and developed flood plains.

## Soils

Mapping of the soils of the Kirkland Lake area has been completed by the Ontario Institute of Pedology (1978a,b). In general, podzol soil profiles have developed on the coarse textured, well drained Quaternary materials. Gleysol or luvisol soil profiles are most common on fine-grained glaciolacustrine deposits. Organic deposits, including bogs, swamps and alluvial sediments, have a wide variety of soil types developed on them with the most frequent being fibrisols, mesisols and humisols. The major soil subgroups have been correlated with map units of the Quaternary maps in Table 6.

## ENGINEERING GEOLOGY

Surficial materials of the Kirkland Lake area do not present many difficult engineering problems. The irregular bedrock surface often requires blasting to obtain road and railway right-of-ways of a suitable grade. In an effort to minimize construction costs, transportation routes are commonly built circumjacent to large bedrock highlands. All rock types witin the area have a high bearing capacity and perform well as foundations for bridges, buildings, roadways and transmission towers.

A stony, silty sand till, locally silty or gravelly is widespread in the Kirkland Lake area. The till matrix (-10 mesh; <2 mm) averages 2 percent clay, 26 percent silt and 72 percent sand. The clast content of the till is typically 10-15 percent, however, this varies widely in the 5-40 percent range. In fresh exposures the till is compact, dense and non-plastic. Upon weathering the till becomes loose and appears sandier.

| MAP UNIT | MATERIAL | MAJOR SOIL SUBGROUPS | DRAINAGE |
|---|---|---|---|
| Rock<br>Bedrock Drift Complex | Rock<br>Discontinuous Cover over rock | Rocky orthic humo-ferric podzol<br>Gleyed humo-ferric podzol | Well<br>Imperfect/poor |
| Till | Till | Orthic humo-ferric podzol | Well |
| Glaciofluvial<br>Coarse-grained Glaciolacustrine<br>Eolian | Sand and Gravel<br>Sand | Orthic humo-ferric podzol<br>Orthic humic gleysol | Well<br>Poor |
| Fine-grained Glaciolacustrine | Varved Clay<br>Silt | Orthic humic gleysol<br>Gleyed gray luvisol<br>Gleyed humo-ferric podzol | Poor<br>Imperfect<br>Imperfect |
| Bogs and Swamps<br>Alluvium | Organics | Typic fibrisol<br>Typic mesisol<br>Terric humisol | Poor<br>Poor<br>Poor |

TABLE 6 - CORRELATION OF SOIL SUBGROUPS WITH QUATERNARY MAP UNITS

The till is frost susceptible, due to its fines content, but appears to have good strength and low compressibility when compacted. The compact, stony nature of the till might necessitate ripping during excavation. Machinery capable of handling boulder sized material may also be required. Till has been used for fill and dam construction where sufficient quantities exist.

Sand and gravel deposits of ice-contact, glaciolacustrine, eolian and fluvial origin are widespread in the report area. Ice-contact deposits, esker complexes and deltas, are usually well drained features of positive relief. Material forming these deposits varies from coarse gravel to well sorted, clean sand. In general esker sediments fine laterally away from the central ridge or crest. Coarse-grained glaciolacustrine deposits consist primarily of sand containing only minor gravel. Eolian deposits, derived from wind reworking of the above material types, are well sorted very fine to medium sands occurring as parabolic shaped dunes. Areas of fine sand may provide compaction problems where new roads are being built across them or when the material is used in construction. Locally, glaciolacustrine sand may contain silty layers in sufficient amounts to make the material susceptible to ground ice segregation and subsequent frost heave.

Fine-grained glaciolacustrine deposits consist of clay, varved clay and silt deposited in glacial lakes Barlow and

Ojibway during deglaciation of the area. Tests performed on fine-grained glaciolacustrine samples were carried out in accordance with the American Society for Testing and Materials (A.S.T.M.). These test results (grainsize and Atterburg limits) were used to classify the samples according to the American Association of State Highway Officials (A.A.S.H.O.) system, the United States Department of Agriculture (U.S.D.A.) system and the unified soil classification system. The origins of, basis for, and significance of these classification systems are outlined comprehensively by the Portland Cement Association (1973).

Glaciolacustrine clay, varved clay and silt are moderately plastic (liquid limit 23-50, plasticity index 2-27; Table 7, Appendix D). Activity values, the ratio of the plasticity index to the percent clay-size fraction, indicate the contribution of clay minerals to the cohesion and plasticity of a soil. Values from the Kirkland Lake area samples were below 0.65, with most between 0.2 and 0.3 (Table 7, Appendix D). This suggests low quantities of clay minerals and indicates dominance of "rock flour" in the clay-size fraction.

Bulk samples of varved clay from a New Liskeard bridge boring were tested by Soderman and Quigley (1965). As this site is a southern extension of the "Clay Belt" it is believed their properties and characteristics are similar to

| n=27 | Grain Size Analysis<br>% Clay | <br>% Silt | <br>% Sand | Liquid Limit | Plastic Limit | Plasticity Index | Activity Ratio | Classification<br>Unified | <br>A.A.S.H.O. |
|---|---|---|---|---|---|---|---|---|---|
| Range | 5-74 | 26-92 | 0-18 | 23-50 | 17-33 | 2-27 | 0.13-0.42 | CL to ML & OL | A-4 to A-7 |
| Average | 43 | 55 | 2 | 34 | 22 | 12 | 0.26 | | |

TABLE 7 - SUMMARY OF ENGINEERING PROPERTIES OF FINE-GRAINED GLACIOLACUSTRINE SAMPLES, KIRKLAND LAKE AREA

the like material in the report area. Shear strength of the New Liskeard samples near the surface was 1000 to 1800 lb/ft$^2$ (47.9 to 86.2 kPa) which decreased to 800 to 2000 lb/ft$^2$ (38.3 to 95.8 kPa) at depths of 3 m to 18.2 m. Sensititivy of the clays ranged from 0.3 to 1.0. The material had an average unit weight of 103 lb/ft$^3$ (161.8 N/M$^3$). Roads constructed on fine-grained glaciolacustrine sediments are subject to severe frost heaving unless sufficient quantities of suitable base are emplaced.

Several small landslips were located in the Ramore map-sheet where stream development has cut into the clay plains. The limited number of such features in the report area may be due to the moderate heights of the river and stream banks. Outside the map-area landslips have been reported along the sides of creeks and rivers cut into glaciolacustrine clay in the Englehart (King and Morton, 1979) and New Liskeard (Morton et al 1979) areas.

Where impermeable clays are overlain by porous sands seepage zones commonly occur at the contact.

The widespread occurrence of peat, bog and swamp deposits makes avoidance of such material difficult and in most instances impractical. The usual procedure is the excavation of the material and replacement by high quality fill. The majority of bogs and swamps are less than 2.0 m in depth.

## ECONOMIC GEOLOGY

### Sand and Gravel

The sand and gravel deposits of the Kirkland Lake area can be classified as to their potential for high-grade aggregate products. The main criteria used to rank the deposits are size (quantity) and clast content and lithology. Sand and gravel resources maps for the report area have been published by Baker (1982e, 1982f, 1982g, 1982h) and Lee (1979c).

### Areas of Primary Potential

Areas of primary aggregate potential are confined or immediately adjacent to: 1) the ridges or central cores of the major esker systems; 2) the proximal edge of ice-contact deltas (Photo 15); and 3) fluvial (spillway) deposits. In these deposits, there is a good probability of gravel content being sufficiently high to produce aggregate products including (using Ontario Ministry of Transportation and Communications criteria) Granular Base Course A and C, Hot Laid 4 (H.L. 4) asphaltic sand and stone, and 16 mm crushed stone.

Gravel rich zones in such deposits can be expected to range from 2 to 10 m in thickness and be separated by sandy units. The clasts are of good quality for aggregate since they are derived from metavolcanic, metasedimentary, and

Photo 15: Aggregate resources in the Kirkland Lake area are abundant. Pits such as this ice-contact delta are active on demand. Sand and gravel sources are dispersed throughout the area and can supply a wide range of high quality aggregate products.

granitic rocks. These lithologies yield satisfactory results (Ontario Ministry of Transportation and Communications specifications) when tested for petrographic number, water absorption, and abrasion. The only deleterious materials noted in existing pits were very small quantities of weathered (rotten) granites and talc-chlorite schists. Oversized material, clasts larger than 20 cm, should be expected. Stripping of up to 1.5 m may be required in some localities in order to remove organic-rich soil or fine-grained sediments.

## Areas of Secondary Potential

Areas of secondary aggregate potential are the deltaic and ice-contact environments along the esker systems. Delta positions along the eskers are often indicated by a marked widening of the glaciofluvial complex in which the material fines to the south-southeast. While the northern ice-contact side is a favoured exploration target, gravel may be present at depth in other parts of the delta complex.

Sorting of material varies greatly. As a general rule, sand rich deposits are uniform and commonly horizontally stratified. Within gravelly deposits, bedding and clast content may be expected to alter across short distances.

Pits developed in this zone could produce Granular Base Course C and sand for H.L. 4 although blending could be required in the latter case. Where gravel content is sufficient, Granular Base Course A and H.L. 4 stone are potential aggregate products.

Clast quality, size and stripping requirements are the same as described in the preceding section. Silty layers may be a problem that will require monitoring in certain deposits.

## Areas of Tertiary Potential

Tertiary areas are of limited significance due to the stone-poor, sandy nature of the material. The bulk of this material occurs in sand plains of deltaic or glaciolacustrine origin which have been modified over large areas by eolian action. Sorting in the sand plains is very good, with material being uniform both laterally and vertically. Adjacent to the eskers, thin, discontinuous gravelly lenses are present but would account for a low percentage of the material in a pit.

Additional areas of shallow sand and gravel deposits overlying bedrock knobs have also been included in the classification. These have an ice-contact glaciofluvial genesis and are considered poor targets due to their thin nature and low reserve.

Possible products from these deposits include Granular Base Course C and H.L. 4 sand. Glaciolacustrine sand may contain silty layers which are difficult to avoid in excavations. The sand could be used as fill although problems might arise with compaction and frost heaving.

## Clay

In the Abitibi Clay Belt occurrences of clay being used in the manufacture of brick and tile products are reported by Baker (1906), Guillet (1967) and Hughes (1956). There is no record, however, of commercial extraction of clay in the map-area.

Chemical and mineral analyses, as well as testing of the ceramic properties of varved clay in the Englehart area to the south and the Matheson-Night Hawk Lake area to the north by Guillet (1967, 1977), has shown the material to be variable in composition. Generally, the clays tend to be slightly limy which results in an open porous structure. Should the high lime concentrations occur in clasts or pebbles, "pops" or surface flaking may result. Hughes (1956) reports that bricks made near Matheson weathered and disintegrated rapidly. However, Guillet (as quoted in Leahy 1965, p.19) noted that the area's clays have no unusual ceramic properties and with suitable additions of sand and minor additives, most could be used to produce brick or drain tile.

Plentiful resources of clay exist in the Kirkland Lake area, but prior to the establishment of any brick or tile manufacturing industry, extensive site-specific testing would be required. Examinations and observations made to date indicate that the properties of the clay may change rapidly over relatively short vertical distances. Depending on the degree of oxidation of the clay, finished products may range from a dark red to a tan colour. The material from some sources would be unusable in the production of decorative brick as the product would be speckled or mottled.

## Peat

No commercial operation involving the extraction of peat exists in the map-area, nor is there any record of any having existed in the past. The possibility exists of a commercial venture developing one or more sites for horticultural moss or fuel peat where sufficiently large reserves are available.

Horticultural peat would require extraction of surficial peat with humification values of H1 to H4 (Von Post scale of humification; Monenco Ontario Ltd. 1981). The deposits should be largely moss peats in composition, with a minor presence of graminoids (sedges and grasses), and contain little to no wood stumps and roots. Preferable deposits would be at least 1.5 m to 2.0 m thick.

Fuel peat requires material with high heating values and with a capacity to burn leaving only minor amounts of ash and non-combustibles. Humification values required for this type of product are H4 to H8. A fuel peat operation can utilize shallow, areally large deposits or thicker deposits with a smaller surface area.

Quaternary mapping of the study area has shown that large reserves of peat are present in:-

1) the northeast quadrant of the Ramore map-sheet;
2) Eby and Blain Townships;
3) Dunmore and Terry Townships;
4) Morrisette Township.

In order to assess the feasibility of a peat harvesting operation, detailed site-specific sampling is necessary to determine depth of the deposit, type of organic material present and its physical characteristics. Additional factors which must be considered prior to setting up a commercial operation are: 1) drainage of deposit; 2) access; and, 3) the shipping distance to market.

The Ontario Ministry of Natural Resources currently extracts peat for horicultural purposes from a large organic deposit in Dunmore Township. Here two metres of peat is removed by mechanical equipment and trucked to the Forestry Nursery Station in Burt Township. After drying and screening the material is added to the sandy soil to serve as a soil conditioner and as a source of organic matter.

As part of a regional evaluation detailed and reconnaissance peat and peatland inventories have been completed on selected sites in the Kirkland Lake area by Northland Associates Limited (in prep.). Detailed inventories were undertaken in northcentral Dunmore Township (the Dunmore Bog) and on a westcentral Garrison Township deposit. Deposits studied at a reconnaissance level were located in central Thackaray Township and northcentral Gross Township.

## GLOSSARY

These definitions pertain to the use of terms in this report.

### GENERAL

Abitibi Clay Belt
- a general term used to refer to the area covered by glaciolacustrine clay deposits on and surrounding the Abitibi Greenstone Belt.

Basal Traction Zone
- a debris rich zone a few metres thick at the base of a glacier in which erosion and transportation of clasts occurs. Particle or clast to clast contact results in abrasion (grinding), striation and comminution of individual clasts and bedrock.

Bedrock Drift Complex
- areas of extensive but discontinuous drift cover; in places the drift is sufficiently thick to subdue the bedrock topography.

Couplet
- see varve.

Diamicton
- a comprehensive, nongenetic term for non-sorted or poorly sorted, nonlithified deposits that contain a wide range of particle sizes.

Englacial
- a) glacial debris contained, embedded or carried within the body of a glacier above the basal load and usually in the form of widely spaced bands; b) the zone between and separating the subglacial and supraglacial environments.

Glacial Debris
- a) material transported in or on a glacier; b) a general, nongenetic term for accumulations of glacially transported material in, on or in front of the glacier.

Great Clay Belt
- a region of fine-grained glaciolacustrine sediments deposited in glacial lakes Barlow or Ojibway occurring north of the present day continental drainage divide.

Hypsithermal
- the Holocene interval when most of the world entered a period when mean annual temperatures exceeded those of the present. It affected the Kirkland Lake area from approximately 8000 yrs. B.P. to 4000 years B.P.

Little Clay Belt
- a region of fine-grained glaciolacustrine sediments deposited in glacial lakes Barlow and Ojibway occurring south of the present day drainage divide.

Proximal Varve
- the near ice facies of a varve. Proximity to a sediment source is reflected in varve thickness and the sandy texture of the summer layer. Proximal varves grade into more distal silt-clay couplets.

Subglacial
- a) pertaining to the area at or immediately above the base of a glacier; b) referring to deposits formed or accumulated in or by the lower-most portion of the glacier.

Supraglacial
- a) pertaining to the upper surface or zone of a glacier including the sloping surface of the ice front; b) referring to deposits carried upon or deposits from the upper surface of the glacier.

Varve
- a pair of graded glaciolacustrine layers deposited in a glacial lake in front of a glacier within one year's time. A glacial varve includes a light coloured summer layer and a dark winter layer.

TILL TYPES

Basal Till
- till deposited in a subglacial environment i.e. at the base of the glacier; includes lodgement till facies and subglacial (basal) meltout till facies.

Flow Till
- the result of gravity induced downslope movement of any type of till. Flowage subjects the till to processes which produce sorting and stratification. Flows may take place in a subareal or subaquatic environment.

Lodgement Till
- subglacially transported glacial debris deposited beneath a moving glacier as a result of frictional drag developed between the debris and the underlying bed. The majority of the constituents are local in derivation.

Melt-out Till
- till deposited by the slow <u>in situ</u> melting out of glacial debris from glacial ice without flowing or internal mixing during its deposition; includes both subglacial and supraglacial melt-out till.

Subglacial Melt-out Till
- melt-out till deposited either at the base of a stagnant glacier or a stagnant zone underneath a moving glacier. Derived primarily from basally transported debris.

Supraglacial Melt-out Till
- melt-out till deposited at the surface of the glacier by slow downward melting of interstitial ice. Derived from basal or englacial debris.

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# APPENDIX A

## Summary of Till Sample Analysis, Kirkland Lake Area.

Notes:-

1) All analyses were carried out by the Geoscience Laboratory, Ontario Geological Survey.

2) Sand-silt boundary 0.062 mm; clay-silt boundary 0.002 mm; Md. is medium diameter in millimetres.

3) Carbonate analyses were done on material finer than 200 mesh (0.074 mm) using the Chittick apparatus.

4) Heavy mineral separation was completed on the -60 +140 mesh fraction (-0.25 mm + 0.105 mm) using acetylene tetrabromide (S.G. 2.96).

APPENDIX A

| Sample Number | UTM Grid Reference | Grain Size Analysis Clay % | Silt % | Sand % | Md(mm) | Carbonates Calcite % | Dolomite % | Total | Cal:dol ratio | Heavy Minerals % Total | % Magnetics |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K 148 | 556395 | 2 | 31 | 67 | 0.120 | 0.41 | 1.49 | 1.90 | 0.275 | 3.08 | 9.19 |
| K 154 | 579382 | 2 | 17 | 81 | 0.215 | 0.00 | 2.18 | 2.18 | - | 3.62 | 10.16 |
| K 251 | 738344 | 3 | 27 | 70 | 0.155 | 0.48 | 2.95 | 3.43 | 0.163 | 3.81 | 6.22 |
| K 305 | 617254 | 2 | 17 | 81 | 0.180 | 0.61 | 2.05 | 2.66 | 0.298 | 3.76 | 10.23 |
| K 328 | 376163 | 3 | 22 | 75 | 0.385 | 0.59 | 2.51 | 3.10 | 0.235 | 2.12 | 21.88 |
| K 389 | 473233 | 2 | 6 | 92 | 0.590 | 0.61 | 2.05 | 2.66 | 0.298 | 1.30 | 19.94 |
| K 408 | 482257 | 7 | 24 | 69 | 0.190 | 0.59 | 2.72 | 3.31 | 0.217 | 2.68 | 18.36 |
| K 466 | 513245 | 2 | 7 | 91 | 0.700 | 0.52 | 1.70 | 2.22 | 0.306 | 1.61 | 12.02 |
| K 531 | 509279 | 2 | 24 | 74 | 0.195 | 0.41 | 1.70 | 2.11 | 0.241 | 2.70 | 13.06 |
| K 614 | 434378 | 1 | 17 | 82 | 0.255 | 0.36 | 2.39 | 2.75 | 0.151 | 3.64 | 16.05 |
| K 623 | 734167 | 2 | 32 | 66 | 0.120 | 0.59 | 2.30 | 2.89 | 0.257 | 16.50 | 10.35 |
| K 635 | 728228 | 0 | 15 | 85 | 0.212 | 0.41 | 1.80 | 2.21 | 0.228 | 6.86 | 17.36 |
| K 677 | 729317 | 1 | 38 | 61 | 0.100 | 0.14 | 2.20 | 2.34 | 0.064 | 4.43 | 12.33 |
| K 705 | 697324 | 1 | 35 | 64 | 0.105 | 0.59 | 1.99 | 2.58 | 0.296 | 3.88 | 11.31 |
| K 773 | 502407 | 3 | 28 | 69 | 0.125 | 0.36 | 2.51 | 2.87 | 0.143 | 3.49 | 10.06 |
| K1549 | 579229 | 1 | 22 | 77 | 0.200 | 0.48 | 2.20 | 2.68 | 0.218 | 3.87 | 12.78 |
| K1553 | 565229 | 3 | 31 | 66 | 0.115 | 0.36 | 2.62 | 2.98 | 0.137 | 3.68 | 8.29 |
| K1560 | 536231 | 1 | 8 | 91 | 0.175 | 0.50 | 2.05 | 2.55 | 0.244 | 2.55 | 11.15 |
| | | | | | | | | | | | |
| L 176 | 824332 | 1 | 7 | 92 | 0.275 | 0.71 | 2.68 | 3.39 | 0.265 | 4.48 | 7.70 |
| L 193 | 796348 | 1 | 36 | 63 | 0.125 | 0.32 | 3.25 | 3.57 | 0.098 | 3.88 | 19.05 |
| L 262 | 751348 | 1 | 19 | 80 | 0.160 | 0.61 | 1.86 | 2.47 | 0.328 | 4.11 | 12.60 |
| L 583 | 832248 | 2 | 35 | 63 | 0.125 | 0.59 | 2.10 | 2.69 | 0.281 | 8.85 | 24.09 |
| L1036 | 996421 | 2 | 29 | 69 | 0.165 | 0.48 | 2.10 | 2.58 | 0.229 | 6.50 | 6.43 |
| L1066 | 046361 | 1 | 24 | 75 | 0.155 | 0.59 | 2.30 | 2.89 | 0.257 | 5.11 | 5.28 |
| L1078 | 046395 | 11 | 44 | 45 | 0.050 | 0.25 | 2.30 | 2.55 | 0.109 | 5.57 | 5.47 |
| L1113 | 019310 | 3 | 23 | 74 | 0.245 | 0.71 | 2.10 | 2.81 | 0.338 | 7.72 | 14.13 |
| L1125 | 011301 | 2 | 24 | 74 | 0.200 | 0.59 | 2.41 | 3.00 | 0.245 | 8.84 | 9.25 |
| L1280 | 116343 | 1 | 30 | 69 | 0.175 | 0.73 | 1.66 | 2.39 | 0.440 | 6.40 | 5.47 |
| L1296 | 077328 | 7 | 45 | 48 | 0.055 | 1.44 | 7.29 | 8.73 | 0.198 | 5.73 | 4.76 |
| L1491 | 115226 | 2 | 17 | 81 | 0.420 | 0.59 | 2.41 | 3.00 | 0.245 | 1.81 | 9.43 |
| L1719 | 016242 | 3 | 21 | 76 | 0.375 | 0.48 | 2.10 | 2.58 | 0.229 | 1.66 | 9.46 |
| L1723 | 023236 | 1 | 6 | 93 | 0.650 | 0.25 | 2.10 | 2.35 | 0.119 | 0.44 | 6.66 |
| | | | | | | | | | | | |
| M 16 | 885466 | 2 | 38 | 60 | 0.095 | 0.0 | 1.09 | 1.09 | - | 4.58 | 7.44 |
| M 60 | 871492 | 1 | 6 | 93 | 0.240 | 0.27 | 2.39 | 2.66 | 0.118 | 1.35 | 8.08 |

APPENDIX A (continued)

| Sample Number | UTM Grid Reference | Grain Size Analysis | | | Md(mm) | Carbonates | | | | Heavy Minerals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Clay % | Silt % | Sand % | | Calcite % | Dolomite % | Total | Cal:dol ratio | % Total | % Magnetics |
| M 69 | 859504 | 1 | 75 | 24 | 0.035 | 0.27 | 2.16 | 2.43 | 0.125 | 3.44 | 10.45 |
| M 70 | 865505 | 0 | 20 | 80 | 0.170 | 0.14 | 2.17 | 2.31 | 0.065 | 5.27 | 7.89 |
| M 78 | 869517 | 1 | 6 | 93 | 0.340 | 0.27 | 2.16 | 2.43 | 0.125 | 10.97 | 22.13 |
| M 163 | 804455 | 1 | 12 | 87 | 0.301 | 0.89 | 1.82 | 2.71 | 0.489 | 6.14 | 9.91 |
| M 173 | 803461 | 1 | 21 | 78 | 0.225 | 0.00 | 0.88 | 0.88 | - | 5.56 | 9.83 |
| M 177 | 789459 | 1 | 25 | 74 | 0.177 | 0.27 | 2.28 | 2.55 | 0.118 | 5.40 | 11.61 |
| M 228 | 836579 | 1 | 23 | 76 | 0.176 | 0.39 | 2.28 | 2.67 | 0.171 | 5.31 | 7.33 |
| M 266 | 787572 | 0 | 18 | 82 | 0.222 | 0.14 | 2.18 | 2.32 | 0.064 | 5.74 | 10.83 |
| M 318 | 777696 | 0 | 22 | 78 | 0.210 | 0.00 | 1.53 | 1.53 | - | 4.25 | 12.30 |
| M 321 | 787690 | 0 | 19 | 81 | 0.247 | 0.36 | 2.53 | 2.89 | 0.141 | 4.52 | 15.08 |
| M 331 | 776713 | 0 | 10 | 90 | 0.707 | 0.61 | 2.83 | 3.44 | 0.216 | 5.44 | 19.51 |
| M 333 | 766714 | 0 | 24 | 76 | 0,147 | 0.16 | 1.38 | 1.54 | 0.116 | 4.06 | 9.17 |
| M 362 | 863708 | 0 | 26 | 74 | 0.161 | 0.14 | 2.28 | 2.42 | 0.061 | 5.48 | 7.74 |
| M 386 | 901698 | 0 | 23 | 77 | 0.210 | 0.00 | 2.41 | 2.41 | - | 6.03 | 3.67 |
| M 409 | 853713 | 1 | 28 | 71 | 0.124 | 0.27 | 2.16 | 2.43 | 0.125 | 4.52 | 7.82 |
| M 420 | 768493 | 1 | 29 | 70 | 0.140 | 0.00 | 1.97 | 1.97 | - | 4.17 | 7.23 |
| M 425 | 777509 | 1 | 28 | 71 | 0.145 | 0.00 | 1.97 | 1.97 | - | 4.30 | 9.58 |
| M 453 | 990481 | 1 | 23 | 76 | 0.179 | 0.39 | 2.39 | 2.78 | 0.163 | 5.82 | 7.09 |
| M 461 | 985496 | 5 | 46 | 49 | 0.058 | 0.39 | 2.28 | 2.67 | 0.171 | 5.63 | 4.48 |
| M 462 | 981497 | 1 | 46 | 53 | 0.073 | 0.39 | 2.39 | 2.78 | 0.163 | 4.70 | 5.12 |
| M 472 | 969484 | 2 | 38 | 60 | 0.115 | 0.02 | 2.18 | 2.20 | 0.009 | 5.92 | 5.21 |
| M 474 | 978464 | 0 | 31 | 69 | 0.166 | 0.25 | 2.62 | 2.87 | 0.095 | 7.16 | 7.39 |
| M 478 | 961464 | 0 | 28 | 72 | 0.202 | 0.02 | 2.18 | 2.20 | 0.009 | 6.59 | 6.67 |
| M 486 | 946459 | 0 | 15 | 85 | 0.250 | 0.27 | 1.93 | 2.20 | 0.140 | 6.36 | 6.77 |
| M 493 | 975450 | 1 | 33 | 66 | 0.150 | 0.14 | 2.05 | 2.19 | 0.068 | 6.10 | 7.10 |
| M 546 | 052450 | 0 | 37 | 63 | 0.125 | 0.30 | 1.47 | 1.77 | 0.204 | 5.47 | 3.01 |
| M 967 | 778609 | 1 | 23 | 76 | 0.210 | 0.50 | 2.37 | 2.87 | 0.211 | 4.72 | 12.20 |
| M1991 | 770698 | 4 | 34 | 62 | 0.100 | 0.36 | 2.62 | 2.98 | 0.137 | 4.72 | 16.39 |
| R 700 | 700492 | 2 | 33 | 65 | 0.115 | 0.36 | 2.39 | 2.75 | 0.151 | 4.38 | 12.27 |
| R1228 | 563367 | 3 | 31 | 66 | 0.140 | 0.34 | 3.08 | 3.42 | 0.110 | 3.46 | 9.05 |
| R1377 | 586486 | 4 | 28 | 68 | 0.125 | 0.39 | 2.39 | 2.78 | 0.163 | 3.14 | 9.36 |
| R1593 | 492504 | 4 | 25 | 71 | 0.170 | 0.73 | 2.93 | 3.66 | 0.249 | 4.53 | 9.45 |
| R1610 | 448481 | 3 | 25 | 72 | 0.210 | 0.57 | 3.41 | 3.98 | 0.167 | 5.23 | 15.31 |
| R1650 | 450551 | 3 | 26 | 71 | 0.135 | 0.61 | 2.18 | 2.79 | 0.280 | 2.90 | 8.79 |
| R1651 | 454547 | 2 | 56 | 42 | 0.045 | 0.36 | 2.72 | 3.08 | 0.132 | 3.14 | 12.62 |
| R1670 | 440545 | 1 | 16 | 83 | 0.130 | 0.50 | 2.39 | 2.89 | 0.209 | 3.82 | 12.41 |
| R1887 | 424451 | 1 | 17 | 82 | 0.200 | 0.73 | 2.83 | 3.56 | 0.258 | 3.58 | 12.87 |
| R2003 | 548450 | 4 | 29 | 77 | 0.180 | 0.48 | 2.49 | 2.97 | 0.193 | 3.46 | 11.66 |
| R2012 | 443672 | 2 | 19 | 79 | 0.225 | 0.36 | 2.93 | 3.29 | 0.123 | 3.86 | 9.41 |

# APPENDIX B

Distribution of Selected Trace Elements in Till Samples from the Kirkland Lake Area.

Notes:

1) All sample analyses carried out by the Geoscience Laboratory, Ontario Geological Survey.

2) Trace element analyses completed on minus 400 mesh (0.037 mm) sized material.

3) A total extraction ($HNO_3$-HF) was used and varied slightly for uranium extraction.

4) Concentrations were determined by Atomic Absorption, except for uranium which was determined by ultra-violet fluorescence and thorium which was determined by X-ray fluorescence.

APPENDIX B

| Sample Number | UTM Grid Reference | Au (ppm) | Au (ppb) | Cr | Cu | Fe(%) | Mn | Ni | Pb | Th | $U_3O_8$ | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K 148 | 556395 | <2 | 10 | 94 | 38 | 2.54 | 490 | 37 | 29 | 10 | <1 | 37 |
| K 154 | 579382 | <2 | 15 | 72 | 20 | 2.02 | 420 | 30 | 23 | <10 | <1 | 29 |
| K 251 | 738344 | <2 | 10 | 118 | 52 | 3.44 | 560 | 58 | 13 | <10 | <1 | 48 |
| K 305 | 617254 | <2 | 48 | 97 | 46 | 3.10 | 810 | 50 | 25 | <10 | <1 | 85 |
| K 328 | 376163 | <2 | 12 | 88 | 62 | 3.07 | 460 | 33 | 24 | <10 | 2 | 45 |
| K 389 | 473233 | <2 | 3 | 124 | 46 | 3.86 | 560 | 47 | 14 | <10 | 2 | 54 |
| K 408 | 482257 | <2 | 7 | 130 | 56 | 4.08 | 460 | 46 | 14 | <10 | 3 | 48 |
| K 468 | 513245 | <2 | 4 | 129 | 49 | 3.42 | 600 | 61 | 32 | 10 | 2 | 100 |
| K 531 | 509279 | <2 | 4 | 80 | 26 | 2.27 | 360 | 26 | 21 | 50 | 1 | 36 |
| K 614 | 434378 | <2 | 9 | 60 | 16 | 1.80 | 380 | 20 | 22 | <10 | <1 | 33 |
| K 623 | 734167 | <3 | <10 | 220 | 58 | 4.50 | 700 | 99 | 29 | <10 | <5 | 70 |
| K 635 | 728228 | <2 | 8 | 145 | 75 | 3.36 | 680 | 81 | 25 | 70 | 1 | 55 |
| K 677 | 729317 | <3 | <10 | 170 | 24 | 2.40 | 495 | 29 | 12 | <10 | <5 | 27 |
| K 705 | 697324 | <3 | <10 | 151 | 20 | 2.07 | 380 | 28 | 13 | 10 | <5 | 25 |
| K 773 | 502407 | <2 | 10 | 67 | 18 | 2.07 | 420 | 20 | 20 | <10 | <1 | 28 |
| K1549 | 579229 | <3 | <10 | 178 | 26 | 2.14 | 535 | 22 | 14 | <10 | <5 | 26 |
| K1553 | 565229 | <2 | 13 | 84 | 28 | 2.42 | 460 | 33 | 21 | <10 | <1 | 32 |
| K1560 | 536231 | <2 | 30 | 99 | 44 | 3.80 | 780 | 37 | 29 | <10 | <1 | 44 |
| L 176 | 824332 | <3 | <10 | 104 | 26 | 2.68 | 285 | 55 | 17 | - | <5 | 36 |
| L 193 | 796348 | <3 | <10 | 124 | 36 | 2.53 | 535 | 26 | 14 | <10 | <5 | 26 |
| L 262 | 751348 | <3 | <10 | 196 | 22 | 2.41 | 460 | 32 | 23 | <10 | <5 | 55 |
| L 583 | 882248 | <3 | <10 | 410 | 76 | 5.00 | 795 | 320 | 21 | <10 | <5 | 88 |
| L1036 | 996421 | <3 | <10 | 144 | 28 | 2.36 | 660 | 28 | <10 | <10 | <5 | 32 |
| L1066 | 046361 | <3 | <10 | 146 | 14 | 2.49 | 500 | 22 | 13 | <10 | <5 | 28 |
| L1078 | 046395 | <3 | <10 | 120 | 38 | 3.13 | 490 | 42 | 16 | <10 | <5 | 58 |
| L1113 | 019310 | <3 | <10 | 180 | 50 | 3.54 | 790 | 57 | 16 | <10 | <5 | 45 |
| L1125 | 011301 | <3 | <10 | 191 | 92 | 3.83 | 790 | 83 | 27 | <10 | <5 | 54 |
| L1280 | 116343 | <3 | <10 | 123 | 32 | 2.73 | 565 | 30 | 11 | 10 | <5 | 36 |
| L1296 | 077328 | <3 | <10 | 113 | 24 | 2.65 | 470 | 28 | 15 | <10 | <5 | 40 |
| L1491 | 115226 | <3 | <10 | 135 | 64 | 3.47 | 540 | 41 | 18 | <10 | <5 | 56 |
| L1719 | 016242 | <3 | <10 | 160 | 88 | 3.85 | 610 | 310 | 34 | 20 | <5 | 800 |
| L1723 | 023236 | - | <10 | 177 | 108 | 4.80 | 660 | 109 | 19 | - | <5 | 80 |

APPENDIX B (continued)

| Sample Number | NTS Grid Reference | Au (ppm) | Au (ppb) | Cr | Cu | Fe(%) | Mn | Ni | Pb | Th | $U_3O_8$ | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M 16 | 885466 | <2 | 4 | 79 | 30 | 2.42 | 420 | 29 | 14 | 75 | <1 | 68 |
| M 60 | 871492 | <2 | 120 | 100 | 16 | 2.48 | 450 | 32 | 14 | 75 | <1 | 56 |
| M 69 | 859504 | <2 | 8 | 72 | 11 | 2.08 | 400 | 30 | 14 | 55 | <1 | 38 |
| M 70 | 865505 | <2 | 3 | 83 | 18 | 2.30 | 460 | 30 | 10 | 65 | <1 | 36 |
| M 78 | 869517 | <2 | 9 | 188 | 56 | 4.20 | 480 | 88 | 15 | 115 | <1 | 62 |
| M 163 | 804455 | <2 | 15 | 90 | 48 | 2.90 | 570 | 38 | 11 | 90 | <1 | 44 |
| M 173 | 803461 | <2 | 7 | 78 | 26 | 2.51 | 520 | 33 | 10 | 75 | <1 | 38 |
| M 177 | 789459 | <2 | 7 | 87 | 33 | 2.80 | 480 | 39 | 12 | 85 | <1 | 40 |
| M 228 | 836579 | <2 | 12 | 83 | 34 | 2.68 | 500 | 38 | 11 | 85 | <1 | 42 |
| M 266 | 787572 | <2 | 18 | 92 | 34 | 2.58 | 600 | 39 | 11 | 80 | <1 | 33 |
| M 318 | 777696 | <2 | 14 | 84 | 16 | 2.31 | 390 | 36 | 22 | 65 | 1 | 38 |
| M 321 | 787690 | <2 | 25 | 94 | 24 | 2.38 | 500 | 51 | 52 | 65 | <1 | 42 |
| M 331 | 776713 | <2 | 35 | 173 | 62 | 2.50 | 800 | 119 | 20 | 65 | 1 | 46 |
| M 333 | 766714 | <2 | 8 | 99 | 22 | 1.80 | 440 | 50 | 10 | 60 | 2 | 32 |
| M 362 | 863708 | <2 | 5 | 78 | 22 | 2.15 | 420 | 29 | 16 | 65 | 2 | 36 |
| M 386 | 901698 | <2 | 6 | 71 | 17 | 1.81 | 340 | 30 | <10 | 60 | <1 | 32 |
| M 409 | 853713 | <2 | 8 | 74 | 15 | 2.16 | 420 | 29 | 10 | 55 | <1 | 32 |
| M 420 | 768493 | <2 | 20 | 78 | 33 | 2.20 | 400 | 28 | 10 | 70 | <1 | 34 |
| M 425 | 777509 | <2 | 4 | 80 | 26 | 2.25 | 440 | 34 | 10 | 70 | <1 | 30 |
| M 453 | 990481 | <2 | 5 | 102 | 56 | 3.40 | 640 | 53 | 11 | 95 | <1 | 70 |
| M 461 | 985496 | <2 | 4 | 104 | 48 | 2.85 | 560 | 44 | 14 | 80 | <1 | 70 |
| M 462 | 981497 | <2 | <2 | 73 | 16 | 2.03 | 390 | 28 | 11 | 65 | <1 | 36 |
| M 472 | 969484 | <2 | 3 | 95 | 28 | 2.46 | 500 | 29 | 11 | 75 | <1 | 40 |
| M 474 | 978464 | <2 | <2 | 70 | 20 | 2.10 | 390 | 23 | 11 | 65 | <1 | 29 |
| M 478 | 961464 | <2 | 2 | 68 | 16 | 1.98 | 400 | 26 | 10 | 50 | <1 | 30 |
| M 486 | 946459 | <2 | 11 | 71 | 24 | 2.16 | 460 | 31 | <10 | 60 | <1 | 33 |
| M 493 | 975450 | <2 | 8 | 78 | 21 | 2.30 | 440 | 34 | <10 | 60 | 1 | 38 |
| M 546 | 052450 | <2 | 6 | 65 | 15 | 1.88 | 340 | 26 | <10 | 50 | <1 | 30 |
| M 967 | 778609 | <2 | 25 | 70 | 14 | - | - | 25 | 12 | <10 | <1 | 26 |
| M1991 | 770698 | <2 | 9 | 84 | 24 | - | 400 | 30 | 13 | 10 | <1 | 40 |
| R 700 | 700492 | <2 | 10 | 84 | 20 | 2.31 | 340 | 28 | 16 | <10 | 1 | 30 |
| R1228 | 563367 | <2 | 6 | 85 | 14 | 2.38 | 470 | 57 | 23 | <10 | 1 | 30 |
| R1377 | 586486 | <2 | 6 | 95 | 32 | 2.60 | 480 | 43 | 22 | <10 | <1 | 38 |
| R1593 | 492504 | <2 | 7 | 114 | 44 | 3.34 | 510 | 52 | 22 | <10 | <1 | 41 |
| R1610 | 448481 | <2 | 4 | 86 | 24 | 2.65 | 460 | 31 | 21 | <10 | <1 | 36 |
| R1650 | 450551 | <2 | 5 | 63 | 12 | 1.98 | 330 | 18 | 21 | <10 | <1 | 25 |
| R1651 | 454547 | <2 | 2 | 74 | 14 | 2.20 | 350 | 26 | 21 | 10 | <1 | 30 |
| R1670 | 440454 | <2 | 14 | 68 | 43 | 2.39 | 450 | 16 | 22 | <10 | <1 | 26 |
| R1887 | 424451 | <2 | 12 | 62 | 12 | 1.88 | 400 | 18 | 20 | <10 | <1 | 27 |
| R2003 | 548450 | <2 | 36 | 67 | 33 | - | - | 25 | 15 | <10 | <1 | 25 |
| R2012 | 443672 | <2 | 320 | 85 | 44 | 2.97 | 490 | 42 | 20 | 60 | <1 | 50 |

# APPENDIX C

Summary of Fine-Grained Glaciolacustrine Sample Analysis, Kirkland Lake Area.

Notes:

1) All analyses were carried out by the Geoscience Laboratory, Ontario Geological Survey.
2) Sand-silt boundary 0.062 mm; silt-clay boundary 0.002 mm; Md. is medium diameter in millimetres.
3) Carbonate analyses were done on material finer than 200 mesh (0.074 mm) using the Chittick apparatus.

## APPENDIX C

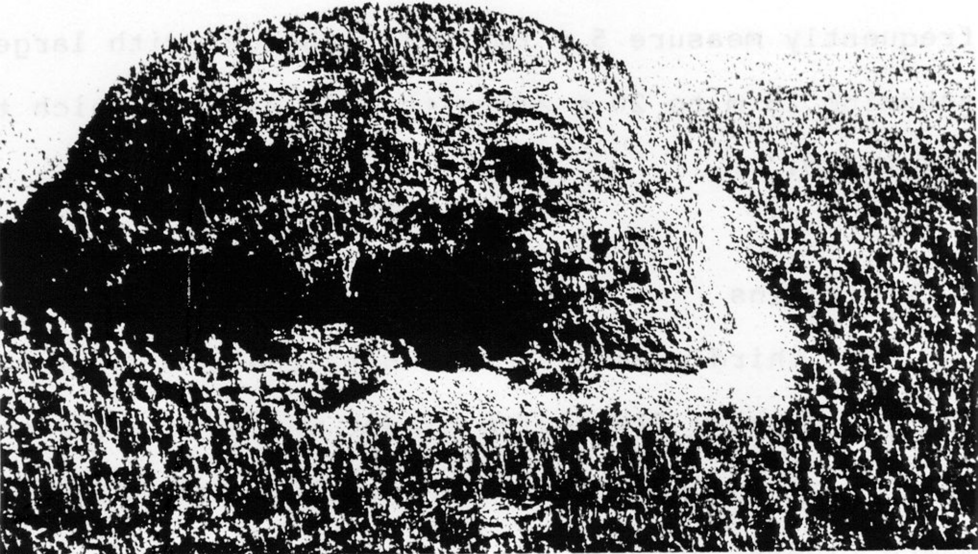
| Sample Number | UTM Grid Reference | Grain Size Analyses Clay % | Silt % | Sand % | Md(mm) | Calcite % | Dolomite % | Total | Cal:Dol Ratio |
|---|---|---|---|---|---|---|---|---|---|
| K 42 | 613283 | 15 | 85 | 0 | 0.005 | 11.5 | 15.5 | 27.0 | 0.74 |
| K 646 | 700247 | 58 | 42 | 0 | 0.002 | 4.37 | 7.40 | 11.8 | 0.59 |
| K 608 | 718322 | 26 | 71 | 3 | 0.005 | 3.46 | 7.16 | 10.6 | 0.43 |
| K 723 | 655262 | 32 | 67 | 1 | 0.004 | 0.61 | 2.01 | 2.62 | 0.30 |
| K 736 | 694197 | 64 | 35 | 1 | 0.001 | 5.78 | 12.2 | 18.0 | 0.47 |
| K 748 | 662222 | 53 | 46 | 1 | 0.002 | 9.49 | 9.91 | 19.4 | 0.96 |
| K 754 | 652236 | 45 | 54 | 1 | 0.003 | 11.4 | 10.6 | 22.0 | 1.08 |
| K 772 | 693166 | 53 | 46 | 1 | 0.002 | 9.76 | 11.6 | 21.4 | 0.84 |
| L 399 | 888221 | 44 | 56 | 0 | 0.003 | 0.73 | 2.24 | 2.97 | 0.33 |
| L 439 | 783176 | 41 | 57 | 2 | 0.003 | 15.1 | 10.7 | 25.8 | 1.41 |
| L 574 | 853227 | 50 | 50 | 0 | 0.002 | 13.7 | 9.21 | 22.9 | 1.48 |
| L 580 | 840244 | 7 | 92 | 1 | 0.009 | 2.91 | 6.05 | 8.96 | 0.48 |
| L 592 | 827243 | 70 | 30 | 0 | <0.001 | 0.48 | 2.79 | 3.27 | 0.17 |
| L 603 | 805229 | 36 | 61 | 3 | 0.004 | 0.93 | 2.60 | 3.53 | 0.36 |
| L 704 | 813369 | 40 | 60 | 0 | 0.003 | 6.69 | 8.28 | 15.0 | 0.81 |
| L1335 | 083246 | 74 | 26 | 0 | <0.001 | 0.77 | 3.79 | 4.56 | 0.20 |
| L1402 | 964235 | 58 | 42 | 0 | 0.002 | 3.37 | 8.46 | 11.8 | 0.40 |
| L1700 | 969243 | 68 | 31 | 1 | 0.001 | 0.59 | 2.56 | 3.15 | 0.23 |
| L1702 | 982247 | 39 | 61 | 0 | 0.003 | 3.73 | 8.13 | 11.9 | 0.46 |
| L1714 | 002246 | 52 | 47 | 1 | 0.001 | 1.18 | 5.03 | 6.21 | 0.24 |
| L1762 | 035259 | 25 | 75 | 0 | 0.006 | 2.07 | 8.59 | 10.7 | 0.24 |
| M 390 | 805650 | 17 | 76 | 7 | 0.021 | 2.53 | 7.84 | 10.37 | 0.32 |
| M 461 | 985496 | 5 | 77 | 18 | 0.022 | 1.09 | 2.16 | 3.25 | 0.51 |
| R1141 | 536715 | 57 | 43 | 0 | 0.002 | 18.8 | 10.6 | 29.4 | 1.77 |
| R1161 | 494680 | 55 | 45 | 0 | 0.002 | 19.3 | 9.89 | 29.2 | 1.95 |
| R1210 | 482647 | 45 | 55 | 0 | 0.002 | 18.2 | 11.0 | 29.2 | 1.65 |
| R1269 | 502634 | 39 | 61 | 0 | 0.003 | 16.7 | 11.1 | 27.8 | 1.50 |

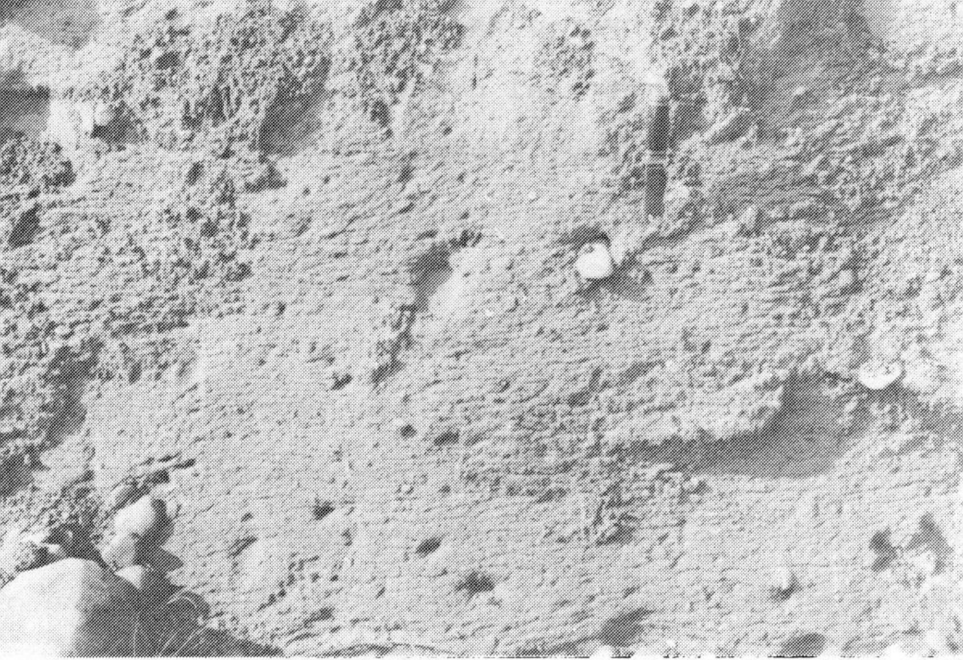
# APPENDIX D

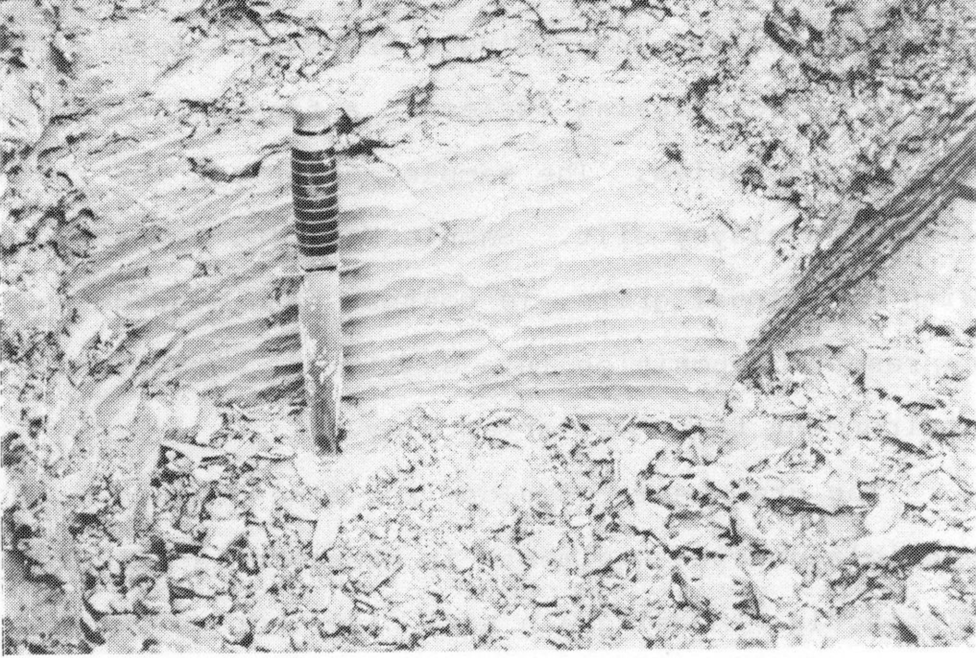
Engineering Properties of fine-grained glaciolacustrine samples, Kirkland Lake area.

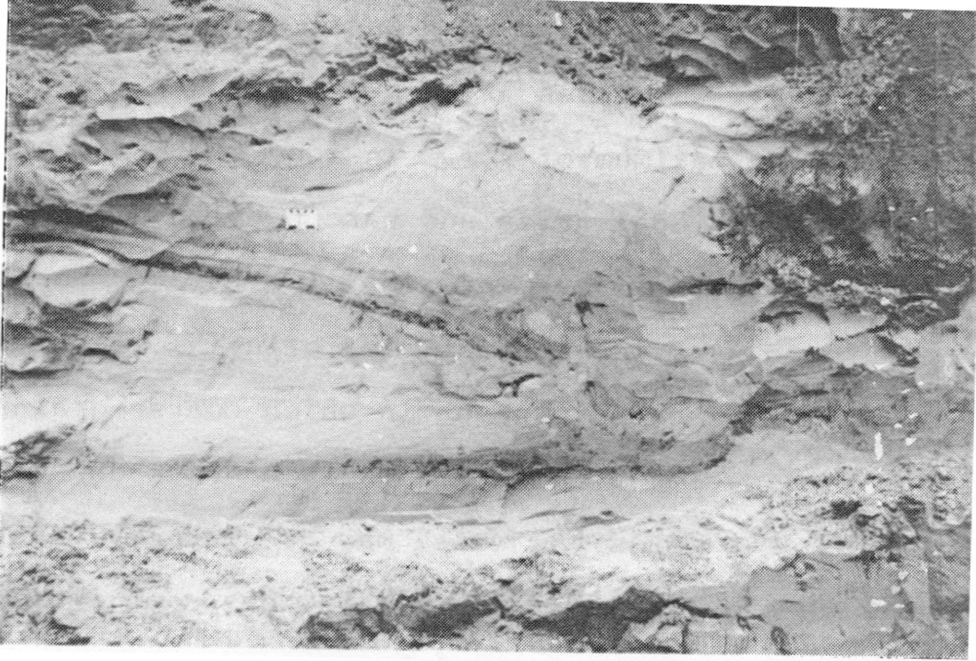
APPENDIX D

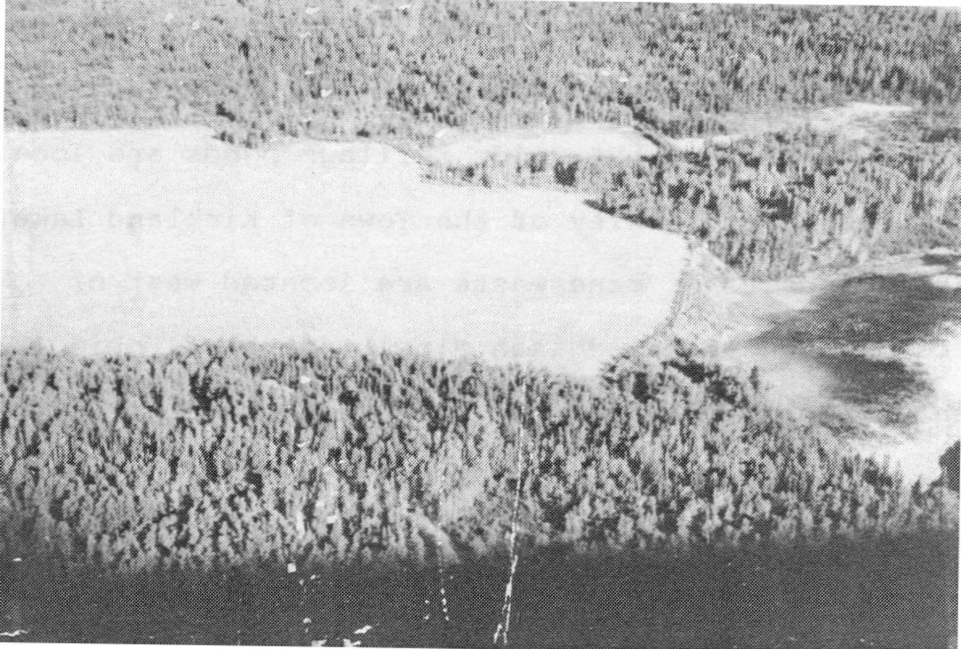
| Sample Number | UTM Grid Reference | Grain Size Analyses Clay % | Silt % | Sand % | Liquid Limit | Plastic Limit | Plasticity Index | Activity Ratio | U.S.D.A. | Unified | A.A.S.H.O. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| K 42 | 613283 | 15 | 85 | 0 | 25 | 23 | 2 | 0.13 | Silty Loam | ML & CL | A-4 |
| K 646 | 700247 | 58 | 42 | 0 | 39 | 27 | 12 | 0.21 | Silty Clay | ML & CL | A-6 |
| K 688 | 718322 | 26 | 71 | 3 | 27 | 19 | 8 | 0.31 | Silty Loam | CL | A-4 |
| K 723 | 655262 | 32 | 67 | 1 | 30 | 22 | 8 | 0.25 | Silty Clay Loam | CL | A-4 |
| K 736 | 694197 | 64 | 35 | 1 | 50 | 23 | 27 | 0.42 | Clay | CL | A-7-6 |
| K 748 | 662222 | 53 | 46 | 1 | 36 | 22 | 14 | 0.26 | Silty Clay | CL | A-6 |
| K 754 | 652236 | 45 | 54 | 1 | 33 | 20 | 13 | 0.29 | Silty Clay | CL | A-6 |
| K 772 | 693166 | 53 | 46 | 1 | 38 | 23 | 15 | 0.28 | Silty Clay | CL | A-6 |
| L 399 | 888221 | 44 | 56 | 0 | 28 | 20 | 8 | 0.18 | Silty Clay | CL | A-4 |
| L 439 | 783176 | 41 | 57 | 2 | 31 | 20 | 11 | 0.27 | Silty Clay | CL | A-6 |
| L 574 | 853227 | 50 | 50 | 0 | 34 | 20 | 14 | 0.28 | Silty Clay | CL | A-6 |
| L 580 | 840244 | 7 | 92 | 1 |  | Non-Plastic |  |  | Silt | - | - |
| L 592 | 827243 | 70 | 30 | 0 | 42 | 28 | 14 | 0.20 | Clay | ML & CL | A-7-6 |
| L 603 | 805229 | 36 | 61 | 3 | 23 | 17 | 6 | 0.17 | Silty Clay Loam | CL & ML | A-4 |
| L 704 | 813569 | 40 | 60 | 0 | 23 | 22 | 7 | 0.18 | Silty Clay | CL & ML | A-4 |
| L1335 | 083235 | 74 | 26 | 0 | 48 | 33 | 15 | 0.20 | Clay | ML & CL | A-7-5 |
| L1402 | 964235 | 58 | 42 | 0 | 38 | 24 | 14 | 0.24 | Silty Clay | CL | A-6 |
| L1700 | 969243 | 68 | 31 | 1 | 41 | 25 | 16 | 0.24 | Clay | CL | A-7-6 |
| L1702 | 982247 | 39 | 61 | 0 | 30 | 21 | 9 | 0.23 | Silty Clay Loam | CL | A-4 |
| L1714 | 002246 | 52 | 47 | 1 | 44 | 25 | 19 | 0.37 | Silty Clay | CL | A-7-6 |
| L1762 | 035259 | 25 | 75 | 0 | 23 | 20 | 3 | 0.12 | Silty Loam | ML & CL | A-4 |
| M 300 | 805650 | 17 | 76 | 7 | 28 | 17 | 11 | 0.65 | Silt Loam | CL | A-6 |
| M 461 | 985496 | 5 | 77 | 18 |  | Non-Plastic |  |  | Silt Loam | - | - |
| R1141 | 536715 | 57 | 43 | 0 | 33 | 23 | 10 | 0.18 | Silty Clay | CL | A-4 |
| R116[illegible] | 494680 | 55 | 45 | 0 | 40 | 24 | 16 | 0.29 | Silty Clay | CL | A-6 |
| R1210 | 4[illegible]2647 | 45 | 55 | 0 | 30 | 20 | 10 | 0.22 | Silty Clay | CL | A-4 |
| R1269 | 502634 | 39 | 61 | 0 | 33 | 22 | 11 | 0.28 | Silty Clay Loam | CL | A-6 |
| Range |  | 5-74 | 26-92 | 0-18 | 23-50 | 17-33 | 2-27 | 0.13-0.42 |  |  |  |
| Average |  | 43 | 55 | 2 | 34 | 22 | 12 | 0.26 |  |  |  |











# MARGINAL NOTES

Quaternary mapping of the Ramore NTS map sheet 42A/8 was completed during the 1979 field season. The authors were ably assisted by Anne Britton and J. E. Campbell. Mapping involved the examination and assessment of materials as they occur in natural and man-made exposures such as rivers, creeks, road-cuts and excavations. These were supplemented by traverses along abandoned drilling and lumbering roads as well as by test pitting and the use of hand augering and soil probing equipment. Extensive use was made of aerial photographs at the scales of 1:15 840 and 1:63 360. The present study provides additional detail and local control to the mapping of Hughes (1960) and the regional work of Boissonneau (1965a, b).

## BEDROCK GEOLOGY

Regional compilation of bedrock geology has been completed by Lumbers and Milne (1978) and Pyke *et al.* (1973). Interpretation of the Precambrian stratigraphy of the Ramore area has been undertaken by Jensen (1974, 1975, 1976). Early Precambrian (Archean) metavolcanics, largely of mafic composition, underlie the majority of the map-area. Occurrences of felsic metavolcanics are scattered throughout the area, with the largest outcrops located in the southeast quadrant. Timiskaming Group metasediments form a kilometre-wide band from Halfway Lake, Garrison Township to the Town of Holtyre – Playfair Township line. Early Precambrian mafic intrusive rocks are widespread in the southern half of the map area with the largest occurrences centred on Butler Lake. Areally smaller bedrock outcrops are common in Melba, Benoit, Lee, and Maisonville Townships. Felsic intrusives, primarily granodiorite and syenite, are the second most prevalent rock-type within the study area. A large triangular-shaped area of these rocks with its northern limit in south-central Bowman Township broadens southward to encompass most of Tolstoi and all of Terry Townships. Other notable occurrences are located in western Guibord Township; in western-central Michaud Township; and in Black Township, along the eastern side of Butler Lake. Additional smaller outcrops exist in Playfair and Hislop Townships as well as the area between Meyers and Wolf Lakes. Diabase dikes transect all of the above rock types and appear to have an even distribution across the study area. In the great majority of instances the dikes trend north–south; however, northeast–southwest orientations are common. Middle Precambrian (Proterozoic) age rocks are represented in the area by Huronian Cobalt Group sediments. A slender strip of outcrop extends southward from north of Mooreland Lake into Tolstoi and Black Townships where it widens eastward before narrowing again at Verona Lake, Lee Township. These sedimentary rocks are also encountered in the area between Meyers and Lower Twin Lake, and to either side of Malloch Lake.

## SURFICIAL GEOLOGY

All surficial materials examined during the present field investigation were probably Late Wisconsinan in age. The probability of subsurface pockets of older Missinaibi Formation, similar to that encountered in Currie Township (Brereton and Elson 1979), approximately 7 km west of the area, is quite high. A radiocarbon data on peat material collected in the Larder Lake map-area give a minimum date of 9 990 ± 260 year B.P. (BGS552) for deglaciation of the region. Regional scale mapping and interpretation of glacial deposits were first carried out by Hughes (1956, 1959a, 1965) and Boissonneau (1966, 1968). Vincent and Hardy (1979) have proposed an evolutionary history of glacial lakes Barlow and Ojibway, the waters of which inundated the area after ice had left the area.

### Till

A stony, silty sand till (map unit 2), locally silty or gravelly, is widespread in the area. Hughes (1959a) informally referred to the unit as the Matheson formation, and Skinner (1973) named its stratigraphic equivalent the Adam Till. The till is most evident on the higher ground above the clay plain such as is present in Bernhardt, Melba, Barnet, Lee, Black, Tolstoi, and McCann Townships. The ground moraine is generally thin (less than 1.0 m thick) and discontinuous over the bedrock, although sections of several metres are not uncommon. In a fresh exposure the till is compact and dense, with little plasticity. In several sites the till exhibited fissility; however, this was most often highlighted along the bedrock–till interface where groundwater staining was present. Till near the surface, and to depths of 0.5 m, is usually highly oxidized and weathered; thus, it appears orangy-brown, loose and sandy. The boulder–pebble content of the till is most commonly in the 20 to 40 percent range, with this variance being due in part to resistance to erosion of the varying bedrock. Different lithologies are also reflected by changes in the till's texture, colour, and thickness, as well as clast roundness and size. The intrusive rocks as a whole tend to be more highly rounded than the metavolcanic, metasedimentary, or sedimentary rocks. The ice that deposited the till advanced southeast across the area (azimuth 164°), as determined from striae, chatter marks, flutings, and grooves. Boreholes filed as assessment work indicate the possibility of a second (lower) till unit in northeastern Guibord Township. Described only as a clay till of limited thickness, this may correlate with the lower till noted by Brereton and Elson (1979) in Currie Township.

### Ice-Contact Deposits

Ice-contact and glaciofluvial deposits (map-unit 3) in the Ramore map-area are dominated by four major esker systems. In the northwest corner of the map-sheet, trending northeast–southwest, is the morphologically distinct, multicrested Watabeag esker. Although the crests are well defined, heavy modification of the flanks of this esker by lake action has taken place in several locations. In the centre of the map-area lies a continuation of the Highway esker (also referred to as the Butler Lake esker), which extends northward from Meyers Lake to Mount Kempis. At this point, the esker appears to change its orientation to the northwest, following the route marked by Highway 11. Limited evidence within the map-area, however, suggests there may also be a northward continuation of the esker, connecting it with glaciofluvial material in northern Hislop Township (Hughes 1959b). The southern portion of the esker is well defined, often multi-ridged, and, in places, sinuous. Located in the southeast corner of the map sheet, stretching northward from Ferguson Lake into Melba and Barnet Townships, is the Airport esker. The crest of this feature is rarely prominent; this perhaps is due to wave-washing by glacial lakes Barlow and Ojibway. On the northernmost fragment of the esker is an ice-marginal morainic ridge that was deposited when a brief stabilization of the ice-front took place during deglaciation of the area. The Munro Esker, one of the largest in northern Ontario, is present in Garrison and Michaud Townships in the northeast corner of the study area. Rising over 40 m above the flanking sand plains, the surface of the Munro is hummocky and marked by a large number of kettles that usually occur on either side of the crests.

All of the eskers are flanked for the majority of their length by deltaic sediments deposited into lakes Barlow and Ojibway. Positions where the ice-front halted during retreat are marked by local widenings of the esker systems. A major example of this is located in the vicinity of Butler Lake, where an ice-contact face runs from Highway 11 southwestward to Errett Lake. Sediment discharged from the ice at this time is represented by a kettled sand plain surrounding Malloch and Benoit Lakes and glaciofluvial material to the northwest of McVittie Lake. The continued broad nature of the glaciofluvial deposits north of the ice-contact face may suggest an ice halt or halts near Mount Kempis. A substantial widening of the Watabeag esker takes place immediately to the north of Wildgoose Lake, with related deltaic sediments extending 2 km eastward of Mooreland Lake and up to 2 km south of Francesa Lake. The static ice margin causing this esker–delta complex possibly was contemporaneous with deposition of the deltaic materials adjacent to the Highway esker. In the extreme southeastern corner of the map-sheet, there exists a portion of two ice-contact faces of limited length. These represent the proximal side of a re-entrant into the glacial front. Two eskers, and possibly a third, of very limited length are positioned in Benoit and Melba Townships east of the Ontario Northland Railway right of way.

Kame and kame terrace deposits are not frequently encountered in the Ramore area. Only a few small deposits have been outlined in areas of high topographical relief typified by Black and Bernhardt Townships. These deposits do not appear on the map because they are too small to show on the present map scale.
A third major ice-contact environment is that of deltaic sedimentation not associated with the eskers. Examples of this are present in Benoit Township north of Wolf Lake, south-central Playfair Township, and surrounding Talbock Lake. In the case of the deposit in southern Playfair Township, its position would indicate that it may have been emplaced during the formation of the large deltaic complex on the Watabeag esker. The surface material around Talbock Lake is considered deltaic in origin; however there is evidence, as was mentioned previously, that esker deposits may exist at depth.

### Glaciolacustrine Deposits

Glaciolacustrine deposits within the Ramore map-area, including both deep-water (map unit 4) and shallow-water (map unit 5) deposits, have been formally named the Barlow – Ojibway Formation by Hughes (1965). The deep-water sediments are composed of clay, varved clay, and silt deposited in the early stages of glacial lakes Barlow and Ojibway as they fronted on the ice during deglaciation of the area. The distribution of these fine-grained sediments is for the most part confined to areas below 320 m (1050 feet) a.s.l., and as such, extensive clay plains exist over much of the northern half of the map sheet. This plain is a portion of the "Great Clay Belt", a broad extension of glaciolacustrine sediments occurring to the north of the continental divide. In Barnet, Cook, and the contiguous townships to the south, the clay deposits occupy the low ground in valleys, thus surrounding rock outcrops. The thickness of the glaciolacustrine deposits is markedly irregular between rock exposures, with borehole data indicating thicknesses of clay in excess of 50 m occurring only tens of metres away from bedrock knobs. Thicknesses of clay in excess of 80 m have been recorded in southwestern Cook Township. Incision by rivers and creeks, particularly in the northeast quadrant of the map-area, provides good exposures of varved sediments. Numerous cuts display sections of several metres in height, in which it is not uncommon for well over a hundred varves to be visible. Although thickness of individual couplets can vary from over 0.1 m to less than 5 mm, an average size for these yearly accretions is on the order of 10–12 mm. In several instances faults and folds, often on a micro scale, were noted in exposures. These were usually confined to a few varves in a section, with undisturbed layers continuing above. The majority of such structures are attributed to dewatering or settlement phenomena.

Shallow-water glaciolacustrine deposits have been emplaced by a combination of events and actions. As the lake level fell, the reworking in the nearshore or shallow-water high-energy environments modified previously existing deposits. Most markedly affected by this were till and ice-contact materials. Wave-washing of the former has resulted in a series of end products, ranging from a poorly sorted, stony diamicton to well sorted, clean sands. These for the most part occur as small, thin pockets on and about bedrock outcrops. Wave action on the extensive sand and gravel deposits is recorded by sand plains circumjacent to most glaciofluvial deposits. This reworked material is composed primarily of sand-sized sediment, although pebbly and gritty layers are common near a coarse source. Deposits are wedged-shaped in profile, thinning with distance from the source. The proximal edge of this type of deposit can be on the order of several metres thick. The largest occurrence of shallow-water sand is located in Terry and Tolstoi Townships, and covers approximately 43 square kilometres. The origin of this sediments appears to be linked to one or all of: 1) sand being debouched during the formation of the Watabeag esker; 2) glacial recessional halt(s) immediately to the north; 3) subsequent erosion and redeposition by lake action of esker and deltaic material. Observations of the material in this area have shown it to be fine- to medium-grained sand with the occasional silty horizon.

Brief stabilization of the receding lakes has been marked by the development of beaches, bars, spits (map unit 5a), and terraces cut into the clay plain. A number of these features exist on the Watabeag esker in Bowman and McCann Townships, where up to four sets of beach scarps are present on either side of the esker complex. Here, well developed beaches have eroded material from the esker ridge forming bluffs, the largest of which is over 6 m in height. Two large spits have been built with reworked esker sediments; one on the east side of Cherry Lake and a second to the east of McMillan Lake. Beach scarps have also been cut into the glaciofluvial material in southwestern Playfair Township, obtaining a maximum height of 5 m. To the north of these terraces are a series of low relief, 0.5 – 1.0 m, beach ridges or off-shore bars. Elevations of the beaches in the map-area are bracketed by 328 m (1075 feet) and 312 m (1025 feet) a.s.l. A weakly developed erosional scarp 2.5 km west of Holtyre occurs at approximately 290 m (950 feet) a.s.l. Lag cobble–boulder concentrates capping ice-contact deposits were encountered at 297 m (975 feet).

### Fluvial Deposits

Fluvial deposits (map unit 6), developed from the reworking of glaciofluvial material in drainage channels of glacial lakes Barlow and Ojibway are present in Black and Lee Townships. The fluvial sediments form a discontinuous, thin veneer in this area and appear to have been transported only a short distance. Emplacement of these deposits took place relatively rapidly as lake levels fell, occupying a series of progressively lower draining valleys.

### Eolian Deposits

Extensive eolian deposits (map unit 7), mainly parabolic dunes, are located in the southwest corner of the map sheet and in Michaud Township. These dunes are generally developed on shallow-water glaciolacustrine sands, although eolian material also occurs on deltaic and esker deposits. The largest dunes exceed 20 m in height, although 10–15 m is more common in Tolstoi Township and 5–10 m in Michaud Township. Coalescence has created dune limbs several kilometres in length. Paleowind direction, as indicated by the dunes, is identical to the present: from the west-northwest.

### Alluvium and Swamp Deposits

The impermeable fine-grained glaciolacustrine sediments have large areas of bog and swamp deposits (map unit 8) developed on them. Areally extensive individual deposits are most prevalent in the eastern half of the map sheet. More widespread because of the area's restricted drainage is the accumulation of thin (less than 1.0 m thick), organic-rich surface deposits on the underlying clays. Limited development of swamps has taken place on glaciolacustrine sands, most notably between dune forms. Shallow bedrock basins also serve as points of accumulation for swamp deposition in the rock highlands.

Alluvial deposits (map unit 9) occur as narrow bands along the courses of creeks and rivers. In the Ramore map-area the alluvium is generally silty, due to its deposition by waterways flowing primarily through glaciolacustrine deep-water deposits.

### Mine Tailings

Mine tailings or slimes (map unit 10), resulting from production of the Ross Mine, are located 1 km north of Holtyre. The bulk of these are contained within a diked setting pond approximately one-half square kilometre in size.

## ECONOMIC GEOLOGY

The Ramore map-area has a large volume of aggregate material available for extraction. High grade, gravel-rich material is contained within eskers, particularly the crests (map unit 3a), and on the proximal side of ice-contact features. Gravel pits developed in these ice-contact environments are often capable of producing coarse aggregate such as Granular A for road construction. Deposits of deltaic origin (map unit 3c) contain much less gravel and as such are largely restricted to the production of fine aggregate. Four areas which can be expected to contain gravel-rich reserves are: 1) the Watabeag esker from Wildgoose Lake northward to the map boundary; the associated beach deposits also hold high potential; 2) the highway esker from north of Meyers Lake to Mount Kempis, including an east–west strip to the south of the ice-contact face; 3) the Airport esker in Bernhardt and Melba Townships; and 4) the Munro Esker in Garrison and Michaud Townships. Areas of moderate potential for workable deposits of sand and gravel are: 1) those deposits along and within 3 km of Highway 11, to the northwest of Mount Kempis; 2) the deposits in south-central Playfair Township; 3) the valley-confined deposits extending from northwest Black Township and passing McVittie, Verona and Tomwool Lakes; 4) all glaciofluvial deposits east of the railway line in Benoit Township. The remainder of the glaciofluvial and shallow-water glaciolacustrine sediments are considered to be of low economic potential. Sorting in ice-contact features, notably eskers, varies widely when compared to deltaic and shallow-water glaciolacustrine material. The lake-deposited sediments can locally contain silty layers that restrict its use as fill because of problems with compaction and frost heaving.

Limited requirements for aggregate and the large number of pits in the Ramore area preclude the continuous operation of any site on a full time basis. Given the large volume of sand and gravel available for extraction and the light demand in the foreseeable future reserves appear to be assured for several decades.

Despite the extensive clay plain in the Ramore area, no commercial production of brick or tile has taken place. Hughes (1965) reports that bricks made near Matheson weathered and distintegrated rapidly, whereas Guillet (as quoted in Leahy 1965) suggests about 25 percent sand be added to clay to reduce plasticity and drying shrinkage. Although no site-specific testing has been done within the study area, Guillet (1977) in a regional study states that clays of the area are generally limy and of marginal interest.

Peat bogs within the Ramore map-sheet have not been developed commercially due to the limited local market. The areal extent of the deposits may, however, allow for their use sometime in the future.

# References

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# SYMBOLS

| | |
|---|---|
| Geological boundary (observed or interpreted) | Esker: direction of flow known |
| Geological boundary (gradational or assumed) | Kettle hole |
| Glacial striation with orientation: ice movement direction indicated | Ice-contact slope |
| Fluting | Trend of moraine crest |
| Shore bluff or scarp | Landslide scar |
| Beach ridge or near-shore bar | Sand dune: outline of dune, crest only |
| Meltwater channel with direction of flow indicated | X Small bedrock outcrop |
| | Sand or gravel pit |

Ontario
Ministry of Natural Resources
Hon. James A. C. Auld
Minister
Dr. J. K. Reynolds
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
PRELIMINARY MAP P. 2381
GEOLOGICAL SERIES

Stock No. 11922

# QUATERNARY GEOLOGY OF THE RAMORE AREA

## DISTRICTS OF COCHRANE AND TIMISKAMING

**Scale: 1:50 000**

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 42A/8
ODM–GSC Aeromagnetic Map: 289G
ODM Geological Compilation Map: 2205

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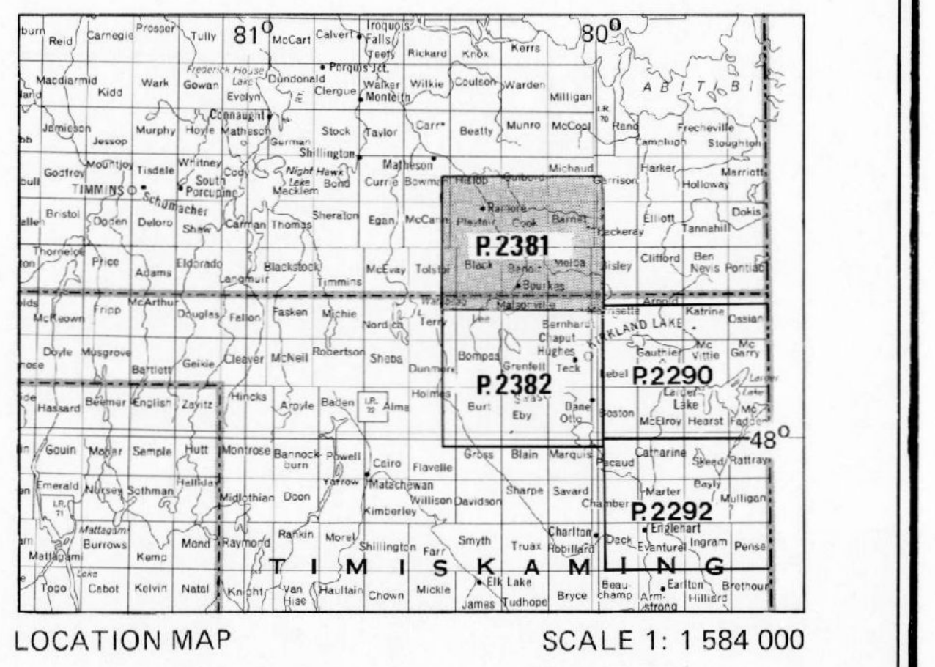

LOCATION MAP SCALE 1: 1 584 000

# LEGEND

CENOZOIC
QUATERNARY
RECENT

| | |
|---|---|
| 10 | Mine excavations, tailings |
| 9 | Alluvial deposits: mainly sand and silt with minor gravel |
| 8 | Swamp deposits: mud, muck, peat |
| PLEISTOCENE | |
| 7 | Eolian deposits: fine to medium sand |
| 6 | Fluvial deposits: sand, gravel |
| 5 | Glaciolacustrine shallow-water deposits: sand with minor gravel<br>5a Beach and nearshore deposits; sand, gravel |
| 4 | Glaciolacustrine deep-water deposits: clay, varved clay, silt |
| 3 | Ice-contact deposits:<br>3 undifferentiated: sand, gravel, cobbles<br>3a Eskers: sand, gravel, cobbles<br>3b Kames: sand, gravel, cobbles, boulders<br>3c Deltas: sand with minor gravel |
| 2 | Till: stony, silty sand till |
| 1 | Bedrock drift complex:<br>1a Abundant bedrock exposures with thin cover<br>1b Extensive but discontinuous drift cover, in places sufficiently thick to subdue the bedrock topography. |

### Notes

Materials have been mapped as they occur at a depth of one metre. Within compound units the stratigraphically lowest material is prevalent at a depth of one metre although overlying deposits may locally thicken to excess of 1.0 m.

Compound units list material is descending stratigraphic order. The last material listed is the one most extensive over the area outlined.

Shallow water lacustrine sand (unit 5) is commonly associated with till (unit 2) because of the latter's reworking by lake action. This has not been indicated on the map in order to simplify map unit labels. For example a map division labelled 2/1a could be represented 5/2/1a.

### COMPOUND UNITS—EXAMPLES

| | |
|---|---|
| 8/4 | Thin peat and muck deposits, locally deepening, developed on glaciolacustrine deep-water clay and varved clay. |
| 7/5 | Eolian sands derived from underlying lacustrine or ice-contact sands, mainly in dune form |
| 4/2/1b | Deep-water lacustrine clay and silt, overlying till bedrock complex |
| 2/1a | Thin discontinuous till overlying bedrock |

# SOURCES OF INFORMATION

Topography from Map 42A/8 of the National Topographic Series.

Aerial Photography: Ontario Ministry of Natural Resources, Toronto and National Air Photo Library, Ottawa.

Additional information from the assessment files of the Resident Geologist's office, Ontario Ministry of Natural Resources, Kirkland Lake, water well records of the Ontario Ministry of the Environment and aggregate and engineering files of the Ministry of Transportation and Communications, New Liskeard.

Geology is not tied to surveyed lines.

Contour interval: 50 feet.

Magnetic declination: 10° 52′, 1974.

Metric conversion factor: 1 foot = 0.3048 m

# CREDITS

Geology by C. L. Baker, A. A. Seamen, K. G. Steele, and assistants, 1979.

Every possible effort has been made to ensure the accuracy of the information presented on this map; however, the Ontario Ministry of Natural Resources does not assume any liability for errors that may occur. Users may wish to verify critical information; sources include both the references listed here, and information on file at the Resident or Regional Geologist's office and the Mining Recorder's office nearest the map area.

This compilation project is part of the Kirkland Lake Area Incentives Program. It is equally funded by the Federal Department of Regional Economic Expansion and the Ontario Ministry of Northern Affairs under the Community and Rural Resource Development Agreement.

Issued 1980.

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

Baker, C. L., Seaman, A. A, and Steele, K. G.
1980: Quaternary Geology of Ramore Area, Districts of Cochrane and Timiskaming; Ontario Geological Survey Preliminary Map P. 2381, Geological Series. Scale 1:50 000. Geology 1979.

Ontario

Ministry of Natural Resources

Hon. James A. C. Auld
Minister
Dr. J. K. Reynolds
Deputy Minister

Stock No. 11923

ONTARIO GEOLOGICAL SURVEY
PRELIMINARY MAP P. 2382
GEOLOGICAL SERIES

# QUATERNARY GEOLOGY OF THE KIRKLAND LAKE AREA

## DISTRICT OF TIMISKAMING

Scale: 1:50 000

Mile 1 — 0 — 1 Mile
Metres 1000 — 0 — 1 Kilometre

NTS Reference: 42A/1
ODM–GSC Aeromagnetic Map: 289G
ODM Geological Compilation Map: 2205

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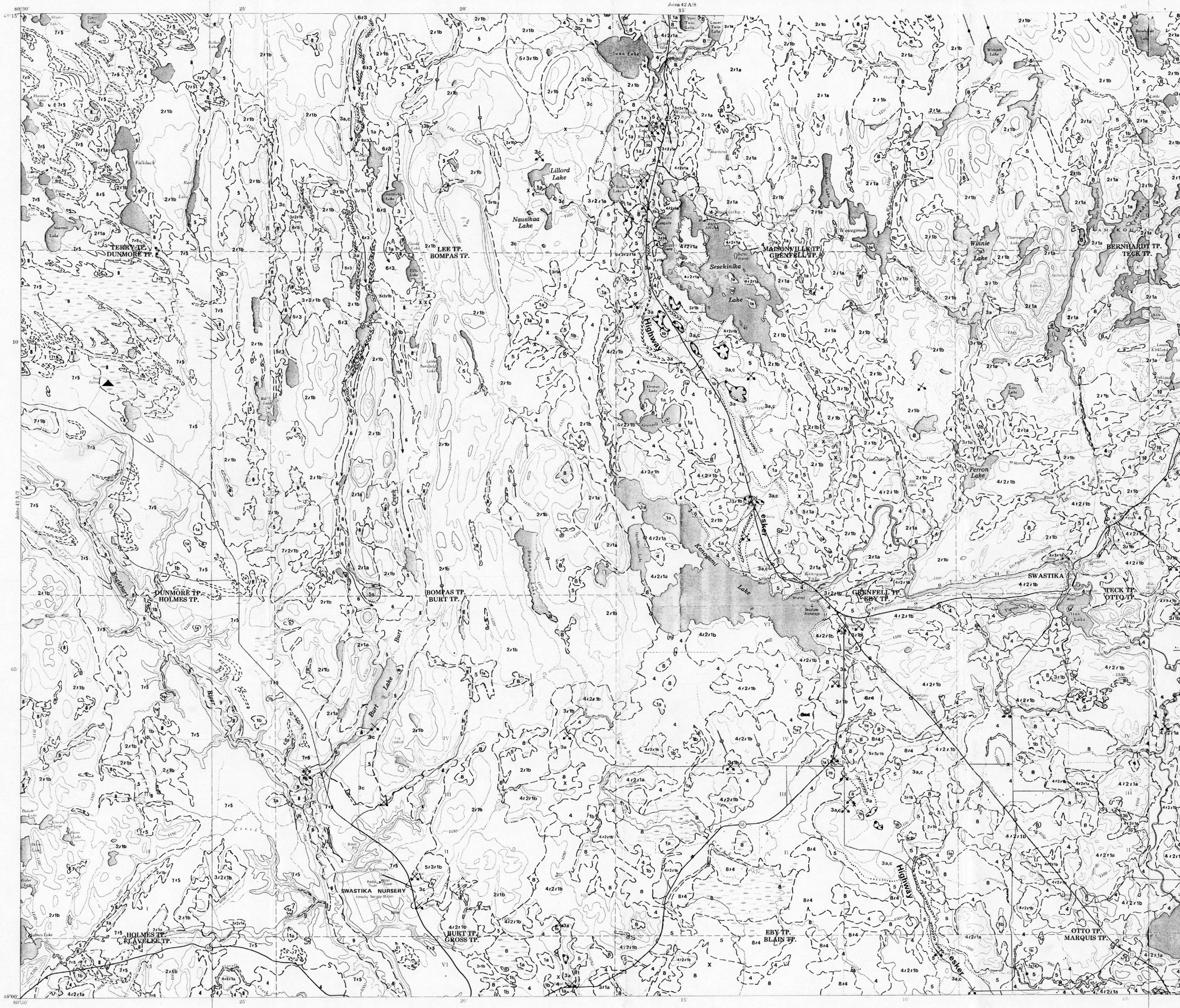

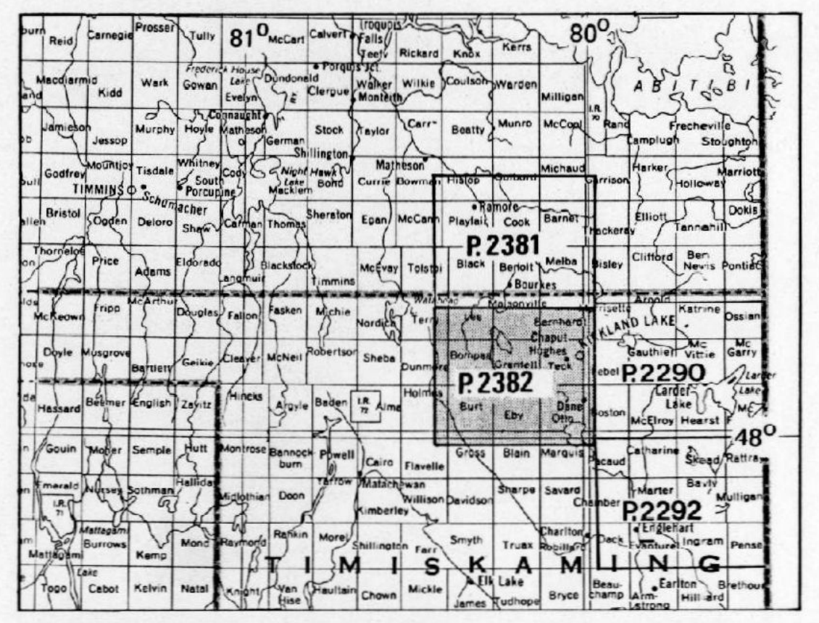

LOCATION MAP — SCALE 1: 1 584 000

## LEGEND

CENOZOIC
QUATERNARY
RECENT

| | |
|---|---|
| 10 | Mine excavations, tailings |
| 9 | Alluvial deposits: mainly sand and silt with minor gravel |
| 8 | Swamp deposits: mud, muck, peat |

PLEISTOCENE

| | |
|---|---|
| 7 | Eolian deposits: fine to medium sand |
| 6 | Fluvial deposits: sand, gravel |
| 5 | Glaciolacustrine shallow water deposits: sand with minor gravel |
| 4 | Glaciolacustrine deep-water deposits: clay, varved clay, silt |
| 3 | Ice-contact deposits:<br>3 Undifferentiated: sand, gravel, cobbles<br>3a Eskers: sand, gravel<br>3b Kames: sand, gravel, cobbles, boulders<br>3c Deltaic: sand with minor gravel |
| 2 | Till: stony, silty sand till |
| 1 | Bedrock drift complex<br>1a Abundant bedrock exposures with thin cover<br>1b Extensive but discontinuous drift cover, in places sufficiently thick to subdue the bedrock topography |

### Notes

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**COMPOUND UNITS—EXAMPLES**

| | |
|---|---|
| 8/4 | Thin peat and muck deposits, locally deepening, developed on glaciolacustrine deep-water clay and varved clay |
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| 4/2/1b | Deep-water lacustrine clay and silt, overlying till bedrock complex |
| 2/1a | Thin discontinuous till overlying bedrock |

## MARGINAL NOTES

Quaternary mapping of the Kirkland Lake NTS map sheet 42A/1 commenced during the 1978 field season and was completed in the summer of 1979. The author was assisted by K. G. Steele and D. J. Sharpe (both of whom supplied data through independent mapping) as well as Anne Britton, J. E. Campbell, and G. M. Werniuk. Mapping involved the examination and assessment of materials as they occur in natural and man-made exposures, river and creek banks, road-cuts, and excavations. These were supplemented by traverses along abandoned drilling and lumbering roads and by test pitting, as well as by the use of hand augers and soil probing equipment. Extensive use was made of aerial photographs at the scales of 1:15 840 and 1:36 360. The present study provides additional detail and local control to the mapping of Hughes (1960) and the regional work of Boissonneau (1965a and b).

### BEDROCK GEOLOGY

Regional compilation of the bedrock geology has been completed by Lumbers and Milne (1978) and Pyke *et al.* (1973). Interpretation of Precambrian stratigraphy in the Kirkland Lake district has been undertaken by Ridler (1970, 1975) and Jensen (1976, 1977, 1978, 1979). Geologic reports cover the map area, except for Dunmore and Terry Townships.

Ultramafic, mafic, and intermediate, metavolcanics underlie a large portion of the Kirkland Lake map sheet. Felsic metavolcanics commonly occur in narrow bands. These assemblages are of Early Precambrian (Archean) age and represent the oldest bedrock in the study area. Above these metavolcanics are the interbedded metasediments and metavolcanics of the Timiskaming Group. These rocks host the main gold ore of the Kirkland Lake camp and trend northeastward from Kenogami Lake past the town of Kirkland Lake to Gull Lake. Archean mafic intrusive rocks occur as a series of outcrops extending northwest from the northern edge of the Timiskaming Group through Teck, Grenfell, and Maisonville Townships. Additional areas of exposure of this rock are located in northeastern Eby Township and to either side of the southern portion of the Burt–Holmes Township line. Early Precambrian felsic intrusive rocks, the second most prevalent lithology, form the bedrock along the majority of the western edge of the map-area, including most of Holmes, Dunmore, and Terry Townships. Other outcrops are located in Gross, Blain, and southern Eby Townships, and along the Bernhardt–Maisonville Township line. Middle to Late Precambrian felsic intrusive rocks predominate in Marquis and Otto Townships. Middle Precambrian rocks are represented in the area by Huronian (Cobalt Group) sediments, which form a band trending southward through Lee, Bompas, and Burt Townships, where they narrow and swing southwest into Holmes and Flavelle Townships.

### SURFICIAL GEOLOGY

Mapping and regional interpretation of glacial deposits was first carried out by Hughes (1956, 1959, 1965) and Boissonneau (1966, 1968). Vincent and Hardy (1979) have proposed a detailed history of glacial lakes Barlow and Ojibway, which flooded much of the area. All surficial materials encountered during the present field investigations are deemed to be Late Wisconsinan in age, although the possibility exists that older sediments (Missinaibi Formation) may be encountered in boreholes (Brereton and Elson 1979). A radiocarbon date of 9 990±260 years B.P. (BGS 552) on peat material collected in the Larder Lake map-area gives a minimum date for deglaciation of the region.

Striae, chatter marks, flutings, and associated directional indicators show that glacial movement across the map area was in a south-southeast direction (165° azimuth).

#### Till

A stony, silty sand till (map-unit 2), locally silty or gravelly, is widespread in the area. Hughes (1959) informally referred to the unit as the Matheson formation, and Skinner (1973) named its stratigraphic equivalent the Adam Till. This till is best exposed in areas above the clay plain, such as the district to the northwest of the Town of Kirkland Lake and on the Cobalt Group rocks in Burt, Bompas, and Lee Townships. The till typically occurs on bedrock outcrops as a thin, discontinuous veneer, usually less than a metre thick, although depths of several metres are common. Till thicknesses of 0.5 m or less are generally highly oxidized, loose, and sandy. Fresh material is highly compacted and dense. Occasionally a faint jointing is noted by way of staining where groundwater movement through the till has occurred.

Estimates of stone content of the till are usually 20–40 percent. This variance is largely attributed to the hardness of underlying bedrock lithology. Marked differences exist in the rounding of the clasts in the till. The slates and argillites of the Cobalt Group (Gowganda Formation) are angular and exhibit a conchoidal fracture. Metasedimentary and metavolcanic rocks are chiefly subangular to subrounded, whereas pebbles and cobbles of felsic and mafic intrusives are often subrounded.

#### Ice-Contact Deposits

Located throughout the map-sheet, the ice-contact glaciofluvial deposits (map unit 3) represent several depositional environments. Predominant among these are the esker and esker–delta complexes, which traverse the area either northwest–southeast or north–south. This mirrors the regional pattern of faults or lineaments along which, in some cases, erosion has created bedrock valleys. The most extensive esker–delta system is that which begins at the southern edge of the map sheet in Blain and Marquis Townships and continues northward past Kenogami and Sesekinika Lakes, where its position is marked by the route of Highway 11. Deltas, formed during the retreat of the ice, are marked by significant widenings of the esker such as occur at the southern edge of the map-area and in east-central Eby Township. A near-continuous occurrence of deltaic accumulation is seen in Grenfell Township between Kenogami Lake and Sesekinika Lake. The surface of the delta, which is composed of sand with gravel lenses, ranges from level to hummocky and is pitted with kettles. The crest of this esker shows intermittently along its length. Generally, the crest rises only to a limited height above the surrounding sediments and for the most part is rounded; this is due to wave washing of glacial lakes Barlow and Ojibway.

Located in the extreme northeast corner of the map sheet is a large deltaic accumulation developed on either side of the Airport esker. A notable occurrence of this feature is a well developed ice-contact face located to the north of Lawgrave Lake. This represents an ice-marginal position during deposition of the material. The surface of the delta complex is for the most part level, except for numerous large kettles that are adjacent to the crest of the esker or its buried continuation.

A third esker system occurs in Bompas and Lee Townships, where it follows Tomwool Creek southward, then crosses the drainage divide. From there it is confined to a valley running parallel and to the west of one occupied by Sarsfield and Burt Creeks. The esker is thin, generally of low relief, and is multi-crested for much of its length. Associated deltaic deposits and reworking by falling lake levels have caused a lateral accretion of the deposits.

Several smaller eskers, often with no identifiable central ridge, are present within the map-area. The largest of these is located within the town limits of Kirkland Lake (Teck Township), stretching in a discontinuous manner from Perron Lake to Winnie Lake.

A large area of deltaic glaciofluvial sand with occasional surface pockets of gravel, which occupies approximately twelve and a half square kilometres, is centred on Lillord and Nausikaa Lakes (Lee Township). Topography in the southern half of this feature varies from gently rolling to lightly hummocky. Relief is greater in the northern half of the deposits: this possibly reflects the underlying bedrock geology.

Kame and kame terrace deposits usually are of limited areal extent and are dispersed across the map-area (with higher concentration of mappable occurrences in the southeast quadrant). This may in part be due to two controlling factors: 1) a more extensive road network has been developed in this district, thus increasing the probability of encountering these small deposits in exposures; and/or 2) the moderate to high topography of the area favours the deposition of such features. Development of additional access over the remainder of the map sheet, in particular the highlands northwest of Kirkland Lake, would probably uncover more kame deposits.

#### Glaciolacustrine Deposits

As the ice front retreated to the north, Lake Barlow, called Lake Ojibway at its later stage, inundated the area. During early deep-water stages of the lake, glaciolacustrine clays and silts (map unit 4) were deposited, usually as varves. The areal distribution of these sediments is largely confined to land presently below 320 m (1 050 feet) a.s.l. These deposits occur as plains of limited area in the southeast corner of the area and in associated pockets: 1) in the Kirkland Lake– – Swastika region; 2) to either side of Highway 11, north of Kenogami Lake. Thicknesses vary considerably over short distances; however, there is a general deepening of the varved material to the south, as the deposits become more extensive and form the northern edge of the "Little Clay Belt". Proximal varves composed of fine to coarse sand with couplet thicknesses in excess of 0.1 m were noted at a limited number of sites. Far more common are varve thicknesses of 3–4 mm to 6–7 cm. Good exposures of deep-water glaciolacustrine sediments are limited, due to the shallow depth of incision of the creeks and rivers.

As the level of lakes Barlow and Ojibway fell, high-energy environments that existed in the nearshore and shallow-water zones developed beach scarps and reworked previously deposited materials. Glaciofluvial deposits and thin sandy till were highly modified by this reworking. The combination of this reworking and the receding lake produced off-lapping fine to medium sands, with occasional minor gravel, circumjacent to ice-contact deposits. Wave action on till can produce a variety of end products, ranging from clean, well sorted sand through a near-massive, stony diamicton. The depths to which sediments may accumulate vary from several metres when esker sand and gravel provides a nearby source to a thin veneer formed from eroding till.

The largest continuous deposit of shallow-water sand occurs in a swath along the western side of the map sheet through Terry and Dunmore Townships, and hence parallel to the Englehart River, which splits the sand plain (5 km wide) in half. The source of this sand, which achieves thicknesses in excess of 15 m, lies to the north and west of the map-area. Its origin appears tied to one or both of the following factors: 1) an esker, which terminates 5 km west of Marmil Lake, Lee Township, debouching significant amounts of material that was subsequently carried down the Englehart River valley; and/or 2) a recessional halt of the glacier in the Ramore map sheet to the north, at which time the sediment discharge from the ice migrated southward.

Relatively few beach ridges (erosional or depositional) exist in the study district: this makes local and regional correlation difficult. The highest scarp observed was approximately 350 m (1150 feet) a.s.l. with other groupings present at 328 m (1075 feet) and 305 m (1000 feet) a.s.l. Up to four distinct terrace levels can be defined along the edge of the Englehart River valley in Burt and Holmes Townships. These lie between 290 m (950 feet) and 305 m (1000 feet) a.s.l. and probably represent a tributary to a late stage of Lake Ojibway.

#### Fluvial Deposits

Fluvial deposits (map unit 6) developed from the reworking of glaciofluvial material in drainage channels of glacial lakes Barlow and Ojibway are present in Bompas and Burt Townships. Emplacement of these deposits took place relatively rapidly, as lake levels fell to occupy a series of progressively lower draining valleys. Esker sand and gravel was the source of the material in Bompas Township, whereas the deposits located to the southwest of Burt Lake appear to have been derived from an adjoining ice-contact feature of deltaic origin.

#### Eolian Deposits

Eolian deposits (map unit 7), generally in the form of parabolic dunes, have developed on the sand plain located along the western edge of the map area. Dune heights commonly exceed 15 m and, as a result of the coalescence of several dunes, reach lengths greater than 3 km. Dune dimensions decrease south of Dunmore Township, due to the limited fetch of the wind across the relatively narrow sand plain in the area. Paleo-wind direction as indicated by dunes is identical to that of the present day, from the west-northwest.

#### Alluvial and Swamp Deposits

Large areas of swamp and bog deposits (map unit 8) are located on the poorly-drained impermeable clays of Blain, Eby, and western Otto Townships. Additional major areas of organic accumulation exist in Dunmore and Terry Townships, where swamp development atop fine-grained sand has, in some cases, served to separate and surround dunes. Other notable occurrences are found in bedrock depressions throughout the area.

Alluvial deposits (map unit 9) are restricted to limited accumulations along river and stream courses. Usually deposits are narrow; however, alluvium deposited along the Englehart River flood plains stretches for approximately 18 km and reaches widths of 0.7 km.

#### Mine Tailings

Located about the Town of Kirkland Lake, mine tailings or slimes (map unit 10) consist of rock ground to the fine sand range. The deposits have a level surface and occupy the lowlands between rock outcrops.

### ECONOMIC GEOLOGY

Large reserves of sand and gravel occur within the map boundaries. The bulk of this aggregate material is located within ice-contact features, notably eskers, with smaller amounts present in fluvial deposits.

The Highway esker, the course of which is followed by Highway 11, currently produces the bulk of the material being extracted. Here, as in other eskers, gravel-rich facies occur in the crest and in the up-ice (northern) side of ice-marginal deltas. Several pits visited in this esker were capable of producing Granular A and all have a size distribution to allow the production of Granular C. Areas of high potential for large gravel-rich reserves are: 1) the Airport esker in the areas surrounding Dorothy, Lawgrave, and Edwards Lakes; 2) the northwest side of the glaciofluvial deposit southwest of Burt Lake; 3) the glaciofluvial (esker) and fluvial (spillway) deposits that extend northward from the Burt–Bompass Township line through Lee Township to the map boundary. The large areas of shallow-water, fine- to medium-grained sand may be used as a source of fill or sub-base; however, silt content and compactional difficulties are problems to be expected.

Pits excavated in fluvial deposits exhibit a high degree of sorting and grading, both vertically and horizontally. Esker material ranges from well to poorly sorted sand and gravel, whereas, of all aggregate deposits exposed, kames demonstrated the poorest consistency.

All pits within the map-area operate on an "on demand" basis and are thus in use only sporadically. With this level of demand, reserves are far in excess of foreseeable local requirements.

A regional study of clay composition by Guillet (1977) has shown fine-grained glaciolacustrine sediments to be limy, and hence unsuitable for clay products. Since specific testing has not been carried out at any specific sites within the map area, the possibility of a commercial-grade clay source cannot be ruled out.

No commercial extraction of peat takes place in the Kirkland Lake map-area, although the areal extent of the larger bogs may allow for this consideration. The Ministry of Natural Resources operates a peat-cutting site in Dunmore Township to supply the Swastika Nursery, Burt Township.

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## SYMBOLS

| | |
|---|---|
| – – – | Geological boundary (observed or interpreted) |
| ······ | Geological boundary (gradational) |
| ↘ | Glacial striation with ice movement direction indicated |
| —●— | Fluting |
| ⌒ | Shore bluff or scarp |
| ↙ | Meltwater channel: direction of flow indicated |
| ≪≪ | Esker: direction of flow known |
| ◌ | Kettle hole |
| ▼ | Ice-contact slope |
| > | Sand dune: outline of dune, crest only |
| X | Small bedrock outcrop |
| ⚒ | Sand or gravel pit |
| ▲ | Peat pit |

## SOURCES OF INFORMATION

Topography from Map 42A/1 of the National Topographic Series.

Aerial Photography: Ontario Ministry of Natural Resources, Toronto and National Air Photo Library, Ottawa.

Additional information from files of the Resident Geologist's Office, Ontario Ministry of Natural Resources, Kirkland Lake; water well records of the Ontario Ministry of the Environment; and aggregate and engineering files of the Ministry of Transportation and Communications, New Liskeard.

Geology is not tied to surveyed lines.

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Metric conversion factor: 1 foot = 0.3048 m

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Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

W.T. Foster
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

MAP P.2483

GEOLOGICAL SERIES - PRELIMINARY MAP

# QUATERNARY GEOLOGY OF THE MAGUSI RIVER AREA

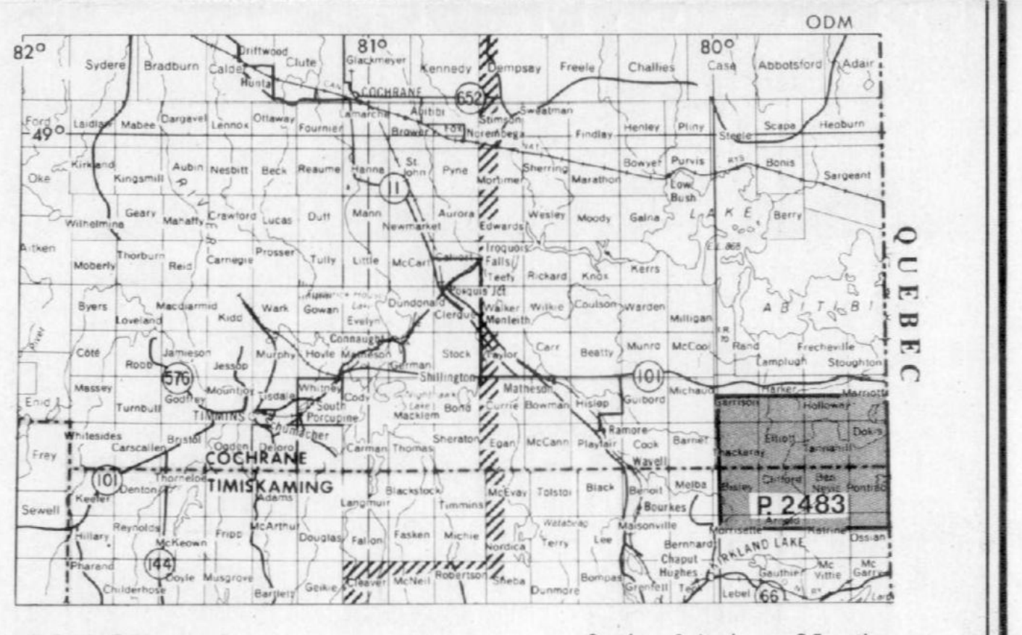
## COCHRANE AND TIMISKAMING DISTRICTS

Scale 1:50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 32 D/5
ODM-GSC Aeromagnetic Map: 289G
ODM Geological Compilation Map: 2205

This map is published with the permission of E.G. Pye, Director, Ontario Geological Survey.



LOCATION MAP Scale: 1 inch to 25 miles

## LEGEND

CENOZOIC
QUATERNARY
RECENT

| | |
|---|---|
| 9 | Alluvial deposits; mainly sand and silt with minor gravel |
| 8 | Swamp deposits: mud, muck, peat |

PLEISTOCENE

| | |
|---|---|
| 7 | Eolian deposits: fine- to medium-grained sand |
| 6 | *Fluvial deposits: sand, gravel |
| 5 | Glaciolacustrine shallow water deposits: sand with minor gravel |
| 4 | Glaciolacustrine deep-water deposits: clay, varved clay, silt |
| 3 | Ice-Contact deposits:<br>3 Undifferentiated: sand, gravel, cobbles<br>3a Eskers: sand, gravel<br>3b Kames: sand, gravel, cobbles, boulders<br>3c Deltaic: sand with minor gravel |
| 2 | Till: stony, silty sand till |
| 1 | Bedrock drift complex:<br>1a Abundant bedrock exposure with thin cover<br>1b Extensive but discontinuous drift cover, in places sufficiently thick to subdue the bedrock topography. |

* Not present in the Magusi River area.

NOTES

Materials have been mapped as they occur at a depth of one metre. Compound units list material in descending stratigraphic order. The last material listed is the one most extensive over the area outlined and is prevalent at a depth of one metre, although overlying deposits may locally thicken to excess of 1.0 m.

Shallow-water lacustrine sand (unit 5) is commonly associated with till (unit 2) because of reworking of the latter by lake action. This has not been indicated on the map, in order to simplify map unit labels. For example, a map division labelled 2/1a could be represented 5/2/1a.

Compound Units-Examples

8/4—Thin peat and muck deposits, locally deepening, developed on glaciolacustrine deep-water clay and varved clay

7/5—Eolian sands derived from underlying lacustrine or ice contact sand, mainly in dune form

4/2/1b—Deep-water lacustrine clay and silt, overlying till bedrock complex

2/1a—Thin discontinuous till overlying bedrock

## SYMBOLS

Geological boundary (observed or interpreted)
Geological boundary (gradational)
Glacial striae: relative age of intersecting striae shown where discernible
Fluting
Shore bluff or scarp
Beach ridge or near-shore bar
Meltwater channel: direction of flow known, unknown
Esker: direction of flow indicated
Kettle hole
Ice-contact slope
Trend of moraine crest
Sand dune: outland of dune, crest only
× Small bedrock outcrop
Sand or gravel pit

## MARGINAL NOTES

Quaternary mapping of the Magusi River NTS map sheet (32 D/5) was completed in the 1980 field season after having been initiated the previous year. Competent assistance was provided to the authors by P.M. Ebling, L.J. Kerr-Lawson, J.E. Campbell, and Anne Britton. Mapping involved the examination and assessment of materials as they occur in natural and man-made exposures, such as river and creek banks, road cuts, and excavations. These were supplemented by traverses along roads, abandoned drilling and lumbering trails and by test pitting, as well as by the use of hand augers and soil probing equipment. Remote areas in the northeastern quadrant of the map-area were investigated using helicopter support. Extensive use was made of aerial photographs at the scale of 1:15 840 and 1:63 360. The present study provides additional detail and local control to the regional work of Boissonneau (1965a and b) published at a scale of 1:506 880. An engineering geology terrain evaluation map for the Magusi River area has been prepared by Lee (1979).

## BEDROCK GEOLOGY

Regional compilation of the bedrock geology has been completed by Lumbers and Milne (1979) and Pyke *et al.* (1973). With the exception of Holloway and Marriott Townships, geologic reports covering the area have been produced by the Ontario Geological Survey (formerly Ontario Division of Mines). Synoptic mapping in the Magusi River area by Jensen (1978, 1979, 1980) has allowed the recognition of a Precambrian volcanic stratigraphy.

The oldest volcanic sequence within the map-area is the Kinojevis Group, a member of the Archean age Abitibi Upper Supergroup (Pyke and Jensen 1976). The group is described by Jensen (1980) as Mg-rich and Fe-rich tholeiitic basalt with minor tholeiitic andesite, dacite and rhyolite flows. Conformably overlying these rocks is the Blake River Group which occurs south of a line drawn from northwest Bisby Township to the northeast corner of the map sheet. This group consists of calc-alkalic basalt, andesite, dacite and rhyolite flows, and pyroclastic rocks with minor Mg-rich tholeiitic basalt. Both groups are intruded by gabbro and diorite bodies. These mafic intrusives are most frequent in the eastern half of the map-area. This may in part be a reflection of limited bedrock exposure in the western part of the area due to extensive overburden cover. Felsic intrusives, granodiorite, quartz diorite, and rhyolite domes occur primarily in the Blake River Group in east- central Clifford Township and about Clarice Lake. A large granitic body, however, is located in the Kinojevis Group in Garrison Township. Diabase dikes, ranging in orientation from northwesterly to northeasterly, transect all of the above rock types.

## SURFICIAL GEOLOGY

Deglaciation of the Magusi River Region took place a minimum of 10 000 years before present based on a radiocarbon date from Boston Township 12 km south of the map-area (Baker 1980). Although all sediments viewed on surface and in section are judged to be Wisconsinan in age, there exists the possibility that pockets of older Missinaibi Formation may be present at depth (Brereton and Elson 1979). Boissonneau's (1966,1968) regional scale glacial map and interpretation followed Hughes' (1956, 1960, 1965) mapping of the contiguous area to the west. Vincent and Hardy (1979) have proposed an evolutionary history of glacial lakes Barlow and Ojibway the waters of which inundated the area during the retreat of the ice.

### Till

Till (map unit 2), widespread throughout the map-area, has previously been referred to informally as the Matheson formation (Hughes 1959), while Skinner (1973) named its stratigraphic equivalent the Adam Till. The till appears as a discontinuous surface sediment in the rock highlands particularly in the southeastern quadrant, the southwest corner of the area, and in central Garrison Township. The till is texturally a silty sand to sand material containing 20 to 40 percent clasts.

The majority of exposures of fresh till show the material to be dense and massive although fissility is common. The abundance of locally derived bedrock, the overconsolidated nature, clast shapes, and surface markings suggest this material to be deposited subglacially either as lodgement or subglacial melt-out till. In a number of instances stratified or banded till was encountered. While clast shape was similar to that of subglacial tills, thin layers of sand to sandy grit defined bedding. Such material is considered to represent a flow till having originated on the glacier surface and subsequently "flowed" downslope and been subjected to processes which produced sorting and stratification.

Till thicknesses of between 0.5 and 1.0 m are usual although depths of several metres are common. Surface exposures of till are highly oxidized and weathered to a depth of about 0.5 m giving this portion of the till a sandier appearance. The ice that deposited the till advanced southeast across the area (azimuth 166°), as determined from striae, chatter marks, flutings, and grooves.

### Ice Contact Deposits

Two large esker systems contain the bulk of the glaciofluvial ice-contact deposits (map unit 3) in the Magusi River map-area. The larger of these, the Munro Esker, trends northward through Esker Lakes Provincial Park then northwestward to Garrison Township. A feature of the Munro Esker is a 3.5 km branch protruding northward through Elliot Township to the west of Ghost Lake. Seismic work (Hobson and Lee 1967) and exploratory drilling has shown that the esker follows the course of a fault controlled buried bedrock valley. Bathymetry measurements of the kettle lakes in Clifford Township have revealed depths of 43.9 m. The Munro Esker varies from 2 to 5.5 km in width and generally stands 20 to 30 m above the flanking glaciolacustrine plains.

The Boundary esker is located near the provincial border along the southern edge of the map-area and trends north-northwest exiting the area in Holloway Township. For the majority of its length it has a distinct multi-ridged crest with the esker achieving heights of 45 m. This esker has an average width of less than 1 km, however, in Holloway Township it widens to 3 km, perhaps due to deposition in front of the ice as the glacier stabilized during its retreat.

Parts of several small eskers are present throughout the area. The largest of these is located in Ben Nevis and Katrine Townships.

The topography of the eskers ranges from well defined crests (map unit 3a) flanked by kettles to rolling terrain. The crests were found to be stacked, upward fining gravel to sand sequences with individual units thinning to the south. The crests are surrounded by hummocky terrain (map unit 3a,c) consisting primarily of sand although thin layers of gravel, usually close to the crest, are occasionally encountered. Level surfaced ground composed of sand with rare thin layers of coarse or gritty material has been mapped under the general heading of deltaic (map unit 3c). These sediments represent bottomsets of sub-aqueous fans or deltas and as such display horizontal bedding except where influenced by the bedrock surface.

Several morainic ridges exist on the eskers. These ridges are oriented in an east-west direction. Two ridges located on the Munro Esker were test pitted and found to consist of fine- to medium-grained sand. This combined with their elevation would suggest deposition in a near ice, deepwater, low energy environment. The most pronounced morainic ridge, marking an ice retreat position, is located in Harker Township southwest of Harker Lake. Here a ridge 7 to 8 m in height, composed of coarse-grained sand and gravel, sits on a level to hummocky sub-aqueous fan-delta. The southern edge of the deposit consists of sand which grades northward into coarse gravelly material. This deposit formed in a re-entrant in the glacier front which in turn allowed a small esker, running northward from Imperial Lake, to develop.

### Glaciolacustrine Deposits

Deposits resulting from the existence of glacial lakes Barlow and Ojibway have been named formally the Barlow-Ojibway Formation by Hughes (1965). The deposits may be split into two divisions; 1) glaciolacustrine fine-grained sediments (map unit 4) consisting of clay, varved clay, and silt; and 2) coarse-grained material (map unit 5) made up of sand with minor gravel.

The fine-grained deposits form the southern rim of the "Great Clay Belt" and occur in two areas divided by the Munro Esker. The most extensive deposits are located in Harker, Elliott, and Tannahill Townships with clays in the surrounding townships being restricted to the low ground between rock knobs. West of the esker, in Bisley and Thackeray Townships, rock protrusions through the clay are numerous. Sediments, which are usually varved, are poorly exposed due to lack of dissection by drainage channels and a thin cover of organic material. Varve thicknesses as determined from soil probes are on the order of 1 to 2 cm but considerable variation is present. The thickness of clays has been found in boreholes to exceed 30 m in several townships in the western half of the map sheet. In some instances this occurred close to bedrock outcrops illustrating the rugged nature of the buried bedrock topography.

Coarse-grained glaciolacustrine sediments have two principle origins: 1) as a facies of glaciofluvial deposits, and 2) reworking of till or glaciofluvial deposits in the high energy nearshore zone as the glacial lake level fell. The former is best developed on either side of the Munro Esker and along the southern half of the Boundary esker. The deposits are frequently level surfaced bottomsets in which the bedding is generally horizontal, however, where the sands thin about rock knobs layering may be conformable with the bedrock topography. The material fines away from the eskers grading from a fine- to medium-grained sand with small gravel lenses on the proximal side to fine-grained sand containing thin silty layers on the distal side. The transition from sandy to fine-grained sediments is usually abrupt on the surface due to onlapping clays covering the gradational contact. Till and glaciofluvial material reworked by glacial lake waters range in appearance from a stony, poorly sorted diamicton to well sorted sand. Modified till is commonly located in pockets on and surrounding bedrock highlands with such deposits rarely exceeding 1.0 m in depth. Reworked glaciofluvial sediments are developed up to several metres in thickness and in places are separated from the parent material with difficulty, particularly when texture and internal structures are similar.

Wave washed scarps attributed to the earliest (highest) levels of Lake Barlow are found in the Workman, Pushin, and Lawson Hills areas of Katrine and Ben Nevis Townships. These scarps occur at an elevation of approximately 381 m above sea level in Katrine Township and appear at progressively higher elevations toward the northeast along the line of maximum tilt (Vincent and Hardy 1979). A well defined set of erosional scarps exists on both sides of the HollowayMarriott Township line also at an elevation of approximately 381 m. The greater relative isostatic uplift in the northern part of the map-area would preclude the same lake stage being responsible for both the southern and northern scarp-sets.

A well developed beach formed by erosion of glaciofluvial material is present on the Boundary esker in Holloway Township. The scarp is at approximately 320 m and smaller, low relief (1 to 2 m) off-shore bars occur to the south and east at elevations ranging from 305 to 320 m.

Brief stabilizations of the lake during its regression are recorded at numerous locations and elevations in the form of boulder beaches, washed outcrops, and lag concentrates. Correlation of these fragmentary features may in future allow a detailed lake stage chronology to be developed.

### Eolian Deposits

Eolian deposits (map unit 7) are well developed along the length of the Munro Esker, preferentially on the eastern side. Wind action has reworked fine- to medium-grained sand of glaciofluvial and glaciolacustrine origin. The most extensive eolian deposits are located in Arnold and Clifford Townships where parabolic dunes, commonly coalescing, reach heights of 10 m and have lengths in excess of 1 km. Dunes greater than 15 m in height are developed on the esker in Thackeray Township. Orientation and internal structures of the dunes indicates a paleowind direction from the west-northwest.

### Alluvial and Swamp Deposits

Bog and swamp deposits (map unit 8) are scattered throughout the map-area with the largest occurrences located on the impermeable glaciolacustrine clay and fine-grained sands adjacent to the Munro Esker. Pockets of organic materials less than a metre thick occur on the surface of the clay (map code 8/4) due to the immature nature of the drainage network. Swamp deposits also occur in small bedrock basins such as those found in the highlands of Ben Nevis and Pontiac Townships.

Alluvial deposits (map unit 9) of notable depth are restricted in occurrence to the flood plains of the Magusi River and McDiarmid Creek. The composition of the alluvium, organic rich clayey silt with minor sand, reflects the fact that the water courses traverse lacustrine plains.

## ECONOMIC GEOLOGY

Within the Magusi River map-area a large quantity of aggregate material is available for development; a significant percentage is high grade. The vast majority of the sand and gravel suitable for extraction is located in ice-contact stratified drift deposits. The remainder is present in deltas and glaciolacustrine sand plains. Material suitable for production of coarse aggregate, including Granular A and 16 mm crushed stone, can be expected in the crests of eskers (map unit 3a) and on the proximal side of ice-contact deposits. Deposits containing large volumes of gravel rich material are: 1) the Munro Esker from Arnold to Garrison Townships; 2) the Boundary esker from Ossian to Holloway Townships; 3) an unnamed esker located in northern Katrine and southern Ben Nevis Townships, and 4) an ice-marginal (deltaic) deposit positioned about Harker Lake, Harker Township. The esker-delta deposits (map unit 3a,c) are likely to contain a limited percentage of gravel, hence, pits operating in them can be expected to produce fine aggregate such as Granular C. Deposits of deltaic origin (map unit 3c) and shallow-water glaciolacustrine sand are of limited economic use. Although these sediments are used locally for fill, the good sorting of the material makes compaction difficult and silty layers in the glaciolacustrine material results in problems with frost heaving.

The demand for aggregate in the Magusi River area is low due to the lack of nearby population centres. To date only small pits have been developed to supply material for local access and timber roads.

There is no record of use of clay deposits of the Magusi River area. While no site specific testing has been performed to assess the local potential, Guillet (1977) found that the clays of the Great Clay Belt are "generally limy and of marginal interest for clay products".

None of the numerous peat bogs within the map-area has been commercially developed for extraction of horticultural peat moss or fuel products.

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