



**Ontario Geological Survey
Open File Report 5925**

**Quaternary Geology of the
Chatham – Wheatley Area,
Southern Ontario**

1995



ONTARIO GEOLOGICAL SURVEY

Open File Report 5925

Quaternary Geology of the Chatham–Wheatley Area, Southern Ontario

by

R.I. Kelly

1995

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GEOLOGICAL MAP

1-P.3337 - Quaternary geology, Chatham area, southern Ontario;
scale 1:50 000. back pocket
2-P.3338 - Quaternary geology, Wheatley area, southern Ontario;
scale 1:50 000. back pocket

Abstract

Quaternary deposits of the Chatham-Wheatley area range from less than 17 m to over 60 m thick. No bedrock outcrops occur within the study area. The Quaternary sediments observed at the surface are of Late Wisconsinan age. In the subsurface no sediments older than Late Wisconsinan age were encountered. Quaternary sediments overlie Middle and Upper Devonian limestones and shales.

The oldest surface till in the area is a clast-poor, clayey silt to silt till. This till occupies most of the southern part of the map area. It is the major component of the Blenheim and Charing Cross moraines. This till is proposed to be a Huron lobe till of early Port Bruce Stadial age and is tentatively correlated with the Tavistock Till.

A second, younger till, the Port Stanley Till (Port Bruce Stadial), is a clast poor, clayey silt till. This till occurs in the extreme southeast and southwest corners of the study area. It comprises a minor part of the Blenheim Moraine and forms small morainic ridges southeast of Wheatley.

The northern half of the map area is covered by glaciolacustrine and non-glacial deposits. Following retreat of the Port Bruce Stadial ice margin the area was covered by a succession of progressively lower glacial and non-glacial lakes. A developing Thames River deposited sediments into these lakes.

The aggregate resources of the area are limited. Outwash and beach deposit sources are nearly depleted. The largest single aggregate source within the area, the buried deposit at Pinehurst, contains an abundance of shale. Shale is considered to be a deleterious component in aggregate and limits use for many purposes. The area will continue to depend on external resources to supply its aggregate demands.

Introduction

The Chatham-Wheatley area is situated between lat. 42° 30' and 42° 00' N and long. 82° 00' and 82° 30' W. The study area is located largely in Kent County and partly in the county of Essex (Figure 1). The major urban centre is the City of Chatham. The towns of Tilbury, Blenheim, Wheatley and Merlin are the other major communities in the area. Access to the area is via provincial highways 2, 3, 40, and 401 (MacDonald-Cartier Freeway). County and township roads provide additional access. Rail access is provided by VIA rail, a federal government crown corporation. Lakes Erie and St. Clair provide water access to shoreline areas. The Thames River allows inland access to pleasure boats. Chatham Airport provides access to the area by small aircraft.

The area is dominated by the agricultural industry both at the primary and secondary levels. A wide variety of crops are grown in this area, largely due to the warm climate and long growing season. A number of food processing operations are located within the area.

Oil and gas are currently the most important geologic related commodities produced within the area. Recent discoveries of large, Ordovician period, oil pools has stimulated increased exploration by a number of firms. Favourable and increasing demand for natural gas in southern Ontario has also stimulated exploration activity in this area. Sand, gravel and clay are also extracted, but are of lesser economic value.

PRESENT GEOLOGICAL SURVEY

The purpose of mapping of Quaternary materials is to determine the areal extent and distribution of the various geological materials that occur in the area. Within the study area this objective was accomplished by the use of soil probes, augers, and examination of natural and man-made exposures. Air photographs were also extensively employed. Other specialized airborne techniques, including infrared aerial photographs and LANDSAT 5 images, were utilized as well.

The study of natural and man-made exposures, as well as examination of water-well and oil and gas-well records, proved useful in understanding the relationship of various materials in the subsurface with regard to their distribution and time of deposition. Additional subsurface data was obtained through completion of a sonic drilling program at selected locations within the map area. Field observations of the physical characteristics of sediments were augmented by laboratory analyses.

The preceding information is useful in outlining the natural geologic resources of the area and determining their quality, quantity and availability. Other uses of the data include identification of potentially hazardous areas that are related to geologic conditions. An example of a potential hazard in the Chatham-Wheatley area is local, enhanced erosion of the Lake Erie bluffs due to variations in sediment composition and stratigraphic layering. Geologic information may also be used in land-use planning studies, soil surveys, engineering, environmental and hydrogeological studies.

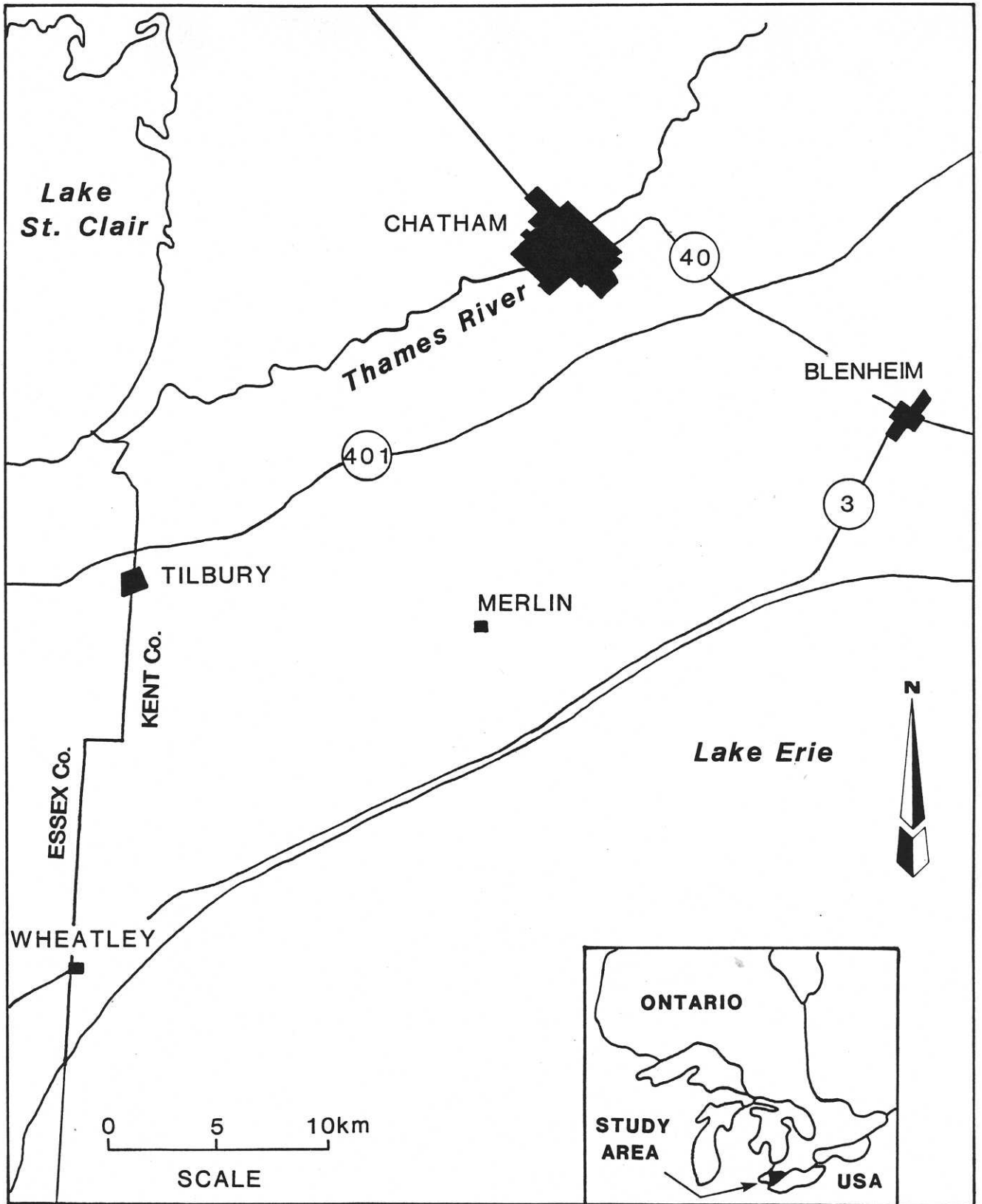


Figure 1: Location of the Chatham - Wheatley Study Area

PREVIOUS WORK

Local Work

Although the region has long been settled and developed, very few Quaternary studies related specifically to the Chatham-Wheatley area have been conducted.

Quaternary geological mapping for the area was previously undertaken by Fitzgerald (1979) and Sado (1981). Mapping was completed as part of the present survey during the summers of 1988 and 1989.

Preliminary maps on the Quaternary geology of the Windsor-Essex area (Vagners 1972a, 1972b), Bothwell-Ridgetown area (Cooper and Baker 1978), Wallaceburg-St. Clair Flats area (Fitzgerald and Hradsky 1980) and Essex area (Morris 1994), describe the Quaternary deposits of adjacent map areas. Morris (1994) provides a report of the Quaternary geology for the adjacent Essex area.

Preliminary information on surface till geochemistry at selected locations in the Windsor-Lake St. Clair area was documented by Arroyas (1988).

Sand and gravel resource inventories for the townships of Raleigh and Harwich have been completed by the Sedimentary Geoscience and Geochemistry Section of the Ontario Geological Survey (1991). In the Pinehurst area, east of Chatham, Vanderveer (1992) completed a study that investigated the use of seismic, resistivity and conductivity surveys to delineate buried aggregates. Extensive drilling and augering were carried out in conjunction with this work to verify survey results.

Soil surveys of Kent and Essex counties have been completed by the Ontario Agricultural College (1930, 1949). Recently, the soil survey of Kent County has been updated by the Ontario Centre for Soil Resource Evaluation, Ontario Ministry of Agriculture, Food and Rural Issues (1994). The early soil surveys provide useful information regarding the nature and distribution of soil materials. The recent update for Kent County incorporates and utilizes Quaternary information as a basic part of mapping. The consulting firm Ecological Services for Planning, Guelph, under a contract to Ontario Hydro, has provided updated soils information and basic Quaternary geology information for Kent County as part of an agricultural soils update (Ecological Services for Planning 1988).

Regional Studies

Regional studies of the Quaternary and Recent geological history for southwestern Ontario are numerous.

Early work by Spencer (1891) delineated glacial lake beaches in southern Ontario. His work included observations relevant to the Chatham-Wheatley area. The major moraines present within the region were described by Taylor (1913) and later by Chapman and Putnam (1943a). Leverett and Taylor (1915) outlined the physiography and glacial history for the

area. Chapman and Putnam (1943b, 1951, 1966, 1984) discussed the physiography of the region and also provided an interpretation of the glacial history.

Glacial ice flowing out of the lakes Huron and Erie basins deposited glacial sediments over large areas of southwestern Ontario. Glacial deposits of the Erie lobe have been discussed by Goldthwait et al. (1965). Deposits of the Huron and Erie lobes are outlined by Dreimanis and Goldthwait (1973) and Karrow (1974, 1984, 1989). Brown (1989) describes clay dispersal patterns within tills immediately north of the Chatham-Wheatley area.

Geotechnical studies of sediments from Lake St. Clair have been conducted by Golders Associates (1973), Zeman (1979) and Rukavina (1987). Geotechnical and stratigraphic studies of Lake Erie bottom sediments are numerous, including those by Lewis (1966), Lewis et al. (1966, 1973), Coakley et al. (1975), Rukavina and St. Jacques (1978), Davis (1979), Zeman (1979) and Rukavina (1983).

Lake history studies for the Huron and Erie basins have been carried out by Lewis (1969), Sly and Lewis (1972), Barnett (1985), Calkin and Feenstra (1985), Coakley (1985), Coakley and Lewis (1985), and Eschman and Karrow (1985). Studies specific to the St. Clair basin are few. Dreimanis (1964) discusses an early low water stage in the history of this lake.

Studies of the St. Clair delta have been carried out by Wrightman (1961), Pezzetta (1968) and Raphael and Jaworski (1982). Coakley (1976, 1989) has outlined the formation and evolution of both Point Pelee and Rondeau Bay (Point-aux-Pins) within the Erie basin.

PHYSIOGRAPHY AND DRAINAGE

The Wheatley - Chatham map area encompasses 3 distinct physiographic regions as defined by Chapman and Putnam (1984). These are; the extensive St. Clair Clay Plain in the west and south, the Bothwell Sand Plain in the northeast, and the Erie Spits, which are minor in extent, in the southwest and southeast corners of the map area (Figure 2).

The St. Clair Clay Plain has been subdivided into the Essex Clay Plain, Lambton Clay Plain, Chatham Flats and St. Clair Delta (Chapman and Putnam 1984). The Essex Clay Plain and Chatham Flats are the major subregions present in the map area (Figure 2). The Essex Clay Plain, which covers the southern part of the map area, is essentially a low relief till plain smoothed by the action of glacial lakes that covered the area following final glacial retreat.

The continuity of the clay plain is interrupted by a thin discontinuous cover of glaciolacustrine sand and silt near the town of Wheatley. This glaciolacustrine unit extends southwest to the sand spit of Point Pelee (Kelly 1992).

A gravel-rich beach ridge rises a few metres above the clay plain east of Wheatley and extends eastward to the village of Cedar Springs. Highway 3 closely follows the trend of this ridge. The eastern part of the Essex Clay Plain is interrupted by the rather wide (up to 11 km), low relief, southwest trending Blenheim Moraine (Kelly 1992). A series of low relief, surficially stoney ridges run parallel to the moraine on its northwest flank. The main body of this moraine

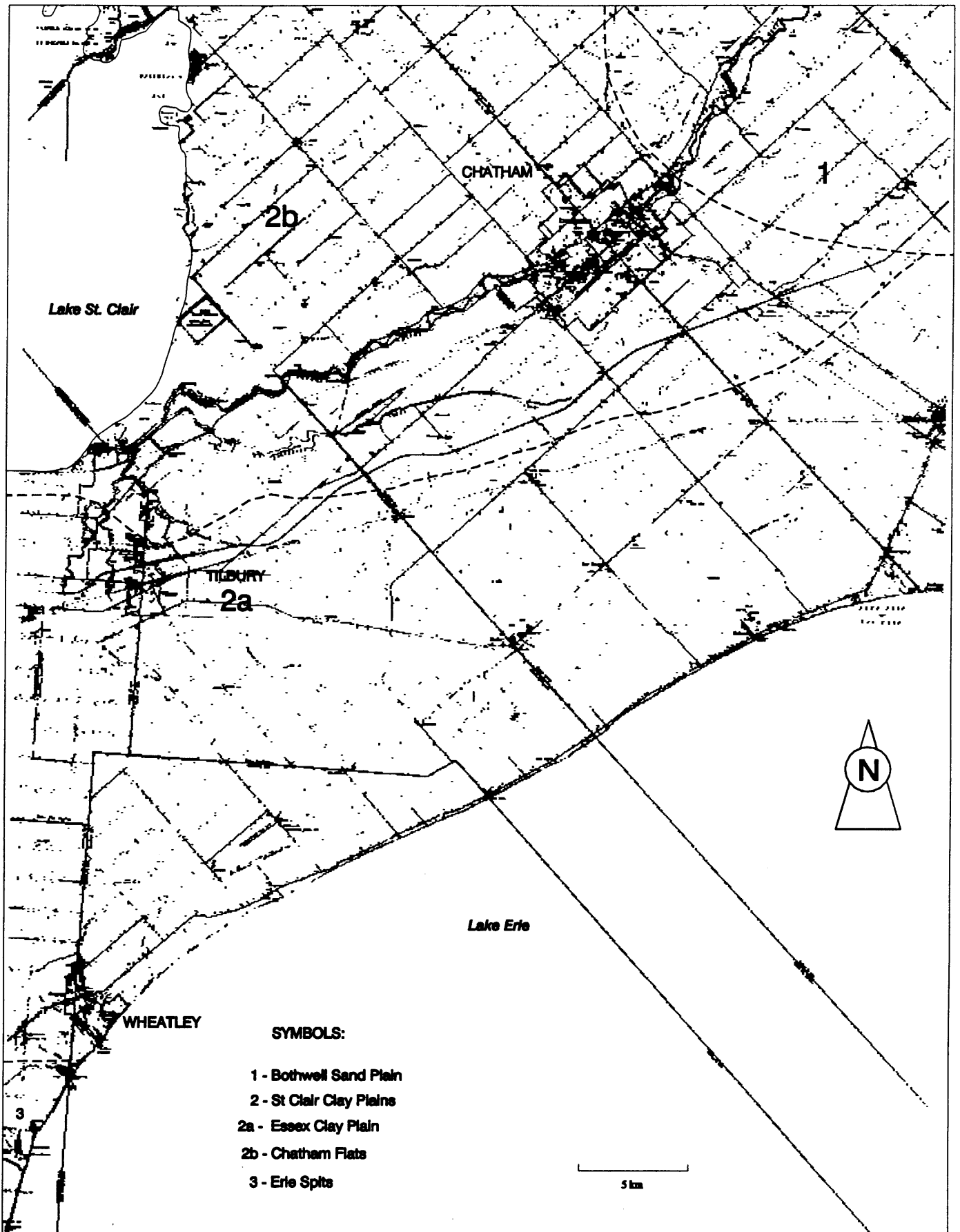


Figure 2. Physiographic regions of the Chatham-Wheatley map area (after Chapman and Putnam, 1984)

is located to the east of the map area.

The low relief of the Essex Clay Plain and the fine texture of the soils results in poor natural drainage. As a result, the use of tile drainage and drainage ditches throughout the area is extensive.

The Chatham Flats, located between Lake St. Clair and Chatham (Figure 2), is a flat lying area composed of glaciolacustrine and alluvial clays (Chapman and Putnam 1984). In Chatham Township the clays are mantled by a thin veneer of surface sands. Silts appear on surface to the south and east of the city of Chatham. In Dover Township the stratified silts and clays extend to the surface (Chapman and Putnam 1984). The southern and eastern boundaries of this subregion roughly follow the 183 m contour level.

Prior to settlement by man the Chatham Flats supported a swamp forest. Artificial drainage allowed development of the area. Numerous deep drainage ditches, and associated pumping stations, are required to maintain the drained state of the area. Soils of the Chatham Flats are considered to be some of the most fertile in southwestern Ontario.

A small part of the St. Clair Delta physiographic region (Chapman and Putnam 1984) is present in the northwest corner of the map sheet. Although most of the land associated with the delta is marshland, some areas have been reclaimed and are farmed.

The Bothwell Sand Plain covers much of the northeast part of the map area. Chapman and Putnam (1984) describe this plain as the delta of the Thames River in glacial Lake Warren. The sand-rich sediments that dominate the delta were spread thinly over the clay-rich floor of the lake. The sand plain covers some 1800 km². In some areas, eolian action has reworked the surface sand sediments into small, immature dunes. The thin layer (1 to 2 m) of permeable sands that overlies less permeable clays throughout much of this region often results in the formation of poorly drained soils. Depressions are often moist or swampy. East of and within the city of Chatham the sand plain is dissected by the Thames River.

The smallest physiographic region in the area is the Erie Spits. Parts of 2 spits, Point Pelee and Rondeau, are located within the map area. The northeast corner of Point Pelee is an area of drained land. The organic-rich soils of this area, in conjunction with a favourable climate, allows a variety of vegetable crops to be grown. The northwest corner of the spit at Rondeau is sand-rich. This area supports tender fruit crops and is also a popular location for cottages.

ACKNOWLEDGMENTS

The author would like to thank the many people of both private and public agencies who provided assistance throughout the course of this program.

Subsurface information was gained through engineering reports supplied by Ontario Hydro, the Lower Thames Valley Conservation Authority, the Canada Centre for Inland Waters and through water-well records provided by the Ontario Ministry of Environment and Energy.

Additional surface information was graciously made available by the Ontario Institute of Pedology, Ontario Ministry of Agriculture.

The completion of an overburden drilling program was made possible through the cooperation of officials of a number of Kent County townships and the County of Kent. Thanks are extended to the townships involved and the County of Kent for granting access to their properties.

Lab analyses were conducted by the Geoscience Laboratories, Ontario Geological Survey. Specialized clay analyses were provided by the Land Resource Science Department, University of Guelph.

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Paleozoic Geology

LITHOLOGY AND DISTRIBUTION

The Chatham-Wheatley area is underlain by a thick sequence of Paleozoic era rocks. In this area, oil and gas drill logs indicate that approximately 1400 m of Paleozoic strata overlie the Precambrian basement (Trevail et al. 1987).

During the Paleozoic Era 2 main areas of sedimentation were active in this region: the Michigan Basin and the Appalachian or Allegheny Basin (Brigham 1971). The Michigan Basin is centered in the State of Michigan while the Appalachian Basin is located south of, and oriented nearly parallel to, Lake Erie. These basins were separated in the northeast by a southwest trending Precambrian high known as the Algonquin Arch, and in the southwest by another Precambrian high, the Findlay Arch.

Sedimentary rocks were deposited in these basins from the Cambrian to Pennsylvanian, however, only rocks of Silurian, Devonian and Mississippian age outcrop in the Lake Erie drainage basin (Brigham 1971).

In the map area, bedrock is not exposed as it is covered by a thick sequence of Quaternary sediments. Mapping of the bedrock geology has relied on information derived from oil and gas well logs, drill core and from mapping in adjacent areas where bedrock outcrops occur. Several bedrock geology maps pertinent to the map area have been produced (Sanford 1958, 1969; Telford and Russell 1982; Uyeno et al. 1982). A generalized version of the bedrock geology map prepared from Uyeno et al. (1982) is presented in Figure 3.

The map area is underlain by Middle and Upper Devonian shales and limestones. The oldest rocks that subcrop in the area have been assigned to the Dundee Formation (Uyeno et al. 1982). This formation consists of medium- to thick-bedded, brown, fossiliferous, micritic, limestone. The rock is commonly bituminous and displays shale partings. The Dundee Formation subcrops near the village of Wheatley and further east near the hamlet of Port Alma. The Dundee is an important target in oil exploration.

Shales and limestones of the Middle Devonian Hamilton Group overlie the Dundee Formation. The Hamilton Group comprises, in ascending order, the following formations: Bell, Rockport Quarry, Arkona, Hungry Hollow, Widder, and Ipperwash (Uyeno et al. 1982). The Bell Formation, the lowest formation, consists of calcareous blue and grey shale with thin limestone lenses. The Rockport Quarry Formation consists of grey and brown, fine-grained limestone with occasional thin shale beds. In southwestern Ontario this formation is only about 6 m thick. Overlying the Rockport Quarry limestone is the blue-grey shale of the Arkona Formation. Thin, laterally discontinuous limestone beds may be present. The formation may reach thicknesses of 37 m in southwestern Ontario. Grey shale interbedded with fossil-rich limestone comprises the thin (2 m) Hungry Hollow Formation. This formation is fossil-rich, with solitary rugose corals easily obtained from the upper part of the strata. Overlying the Hungry Hollow Formation is the shale-limestone sequence of the Widder Formation. This formation is fossil-rich and reaches thicknesses of up to 14 m. The uppermost formation of the Hamilton

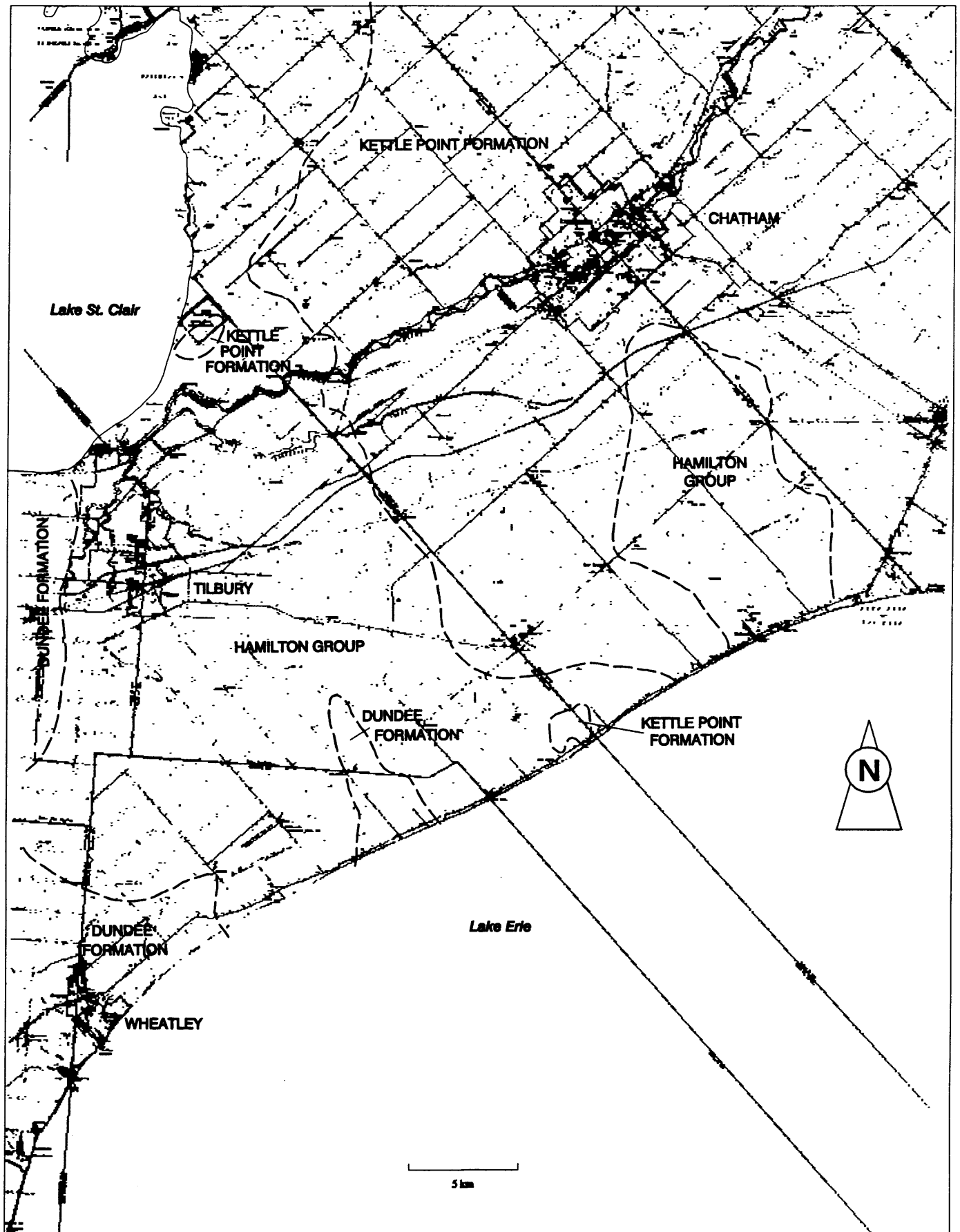


Figure 3. Bedrock geology of the Chatham-Wheatley map area (after Uyeno et al. 1982)

Group is the coarse-grained, grey-brown bioclastic limestone of the Ipperwash Formation.

The shales of the Hamilton Group are an important raw material source for the heavy clay products industry. The Hamilton Group generally subcrops in a northwest trending belt from Lake Erie to Lake St. Clair in the south central part of the map area (Figure 3). Other small subcrops occur in the northeast and southeast corners of the map area.

The youngest, and most extensive, rock unit in the area is the Upper Devonian Kettle Point Formation. The formation consists of black, highly fissile, non-calcareous shale with minor interbeds of grey-green silty shale (Uyeno et al. 1982). A unique feature of this formation is the presence of large, (up to 1.2 m) spherical or subspherical limestone concretions (Uyeno et al. 1982). Locally these concretions are referred to as "kettles". The Kettle Point Formation is pervasive in the eastern half of the map area. The Kettle Point shale has previously been tested by the Ontario Geological Survey as an oil shale resource (Johnson et al. 1985)

BEDROCK TOPOGRAPHY

Bedrock topography maps covering the area have been completed by Sado and Faught (1981a, 1981b). A generalized version of the bedrock topography is provided in Figure 4. Paleozoic rocks in southern Ontario were originally deposited as flat-lying units, but were eventually subjected to tectonic disruption. In southwestern Ontario regional dips on bedrock formation surfaces are to the south or southwest at a rate of a few metres per kilometre (Bezys and Johnson 1988). The bedrock surface in the Chatham-Wheatley area shows a shallow regional dip toward the southwest. The change in bedrock elevation from the northeast part of the map area to the southwest is greater than 45 m.

Local relief of up to 15 m occurs south of Chatham and in general coincides with southward trending bedrock valleys. These valleys may represent tributaries of an eastward draining paleo-river system that formed on the preglacial land surface of southern Ontario (Spencer 1907; White and Karrow 1971). A main, eastward trending, bedrock valley located in the Lake Erie basin was termed the Erigan River by Spencer (1907). A less pronounced bedrock valley, located east of Chatham, is coincident with the modern Thames River.

ECONOMIC GEOLOGY

Limestone and Shale

At present there are no bedrock quarrying operations in the Chatham-Wheatley area primarily due to the thick (10 to 68 m) cover of glacial drift over the bedrock surface. Small, isolated areas with drift cover of less than 15 m (a general rule as to the maximum overburden thickness that may be economically removed) are located north and northeast of Chatham. The bedrock subcropping in these areas is shale of the Kettle Point Formation. In general, the usefulness of this shale in brick or tile production or as an aggregate source is limited (Guillet

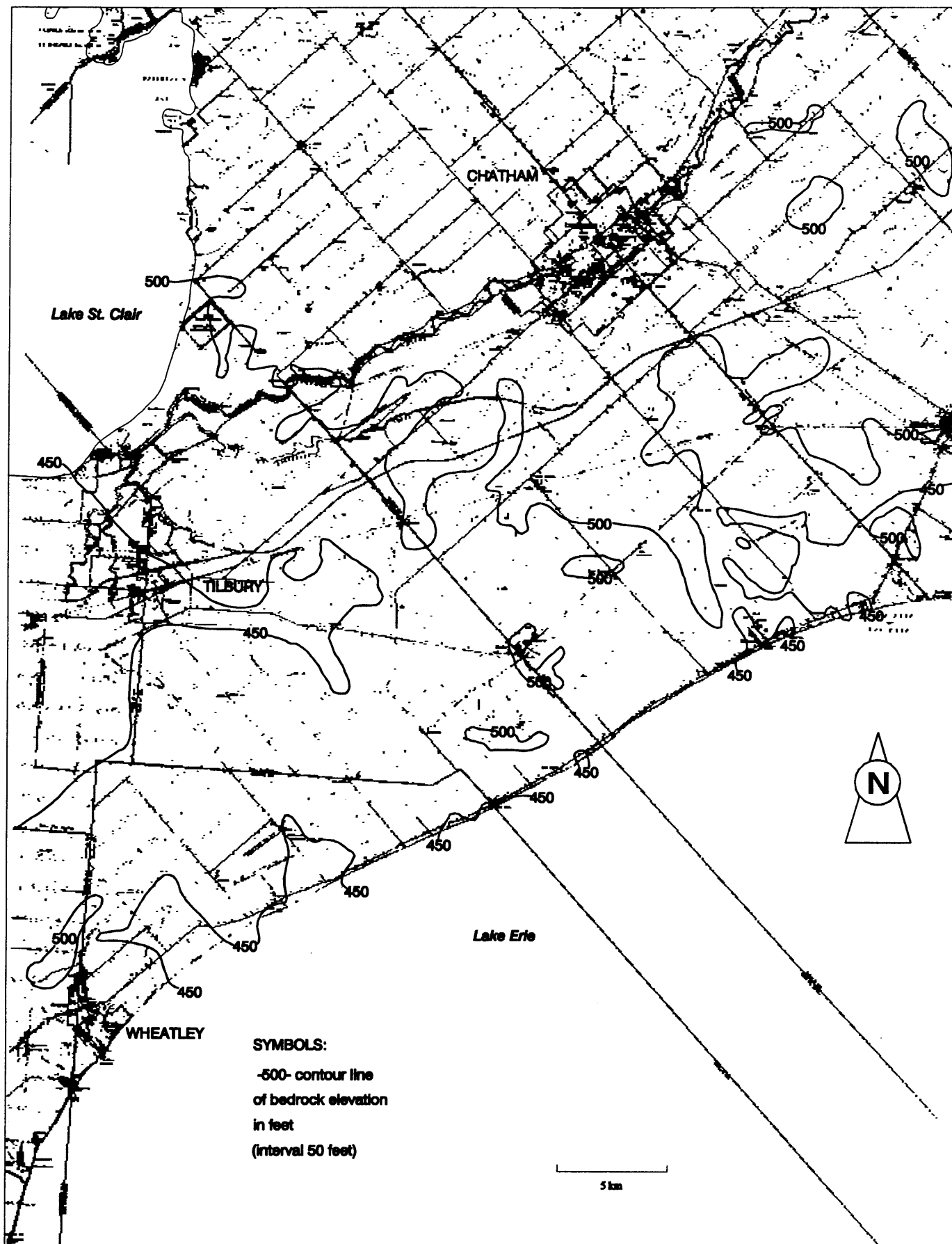


Figure 4. Bedrock topography of the Chatham-Wheatley map area(after Sado and Faught 1981a, 1981b).

1977). The Kettle Point shale has been investigated as a raw material source for the production of expanded aggregate, however, testing produced a poor quality product (R. Gorman, MTO, personal communication, 1989). The Huron Sand and Gravel Company, at its Pinehurst pits, separates Kettle Point material from usable aggregate and then crushes the shale to produce a decorative stone (R. Gorman, MTO, personal communication, 1989).

Dundee Formation limestone, which may have potential for the concrete or aggregate industry, is deeply buried by glacial drift (up to 68 m). Economic extraction of this unit through open pit quarrying is not viable in this area.

Shales of the Hamilton Group provide a valuable raw material resource for the brick industry in areas north of the Chatham-Wheatley area. Unfortunately, in the study area, the thickness of drift cover negates the use of the Hamilton strata.

In the future, if it becomes economically viable to develop the areas bedrock resources, one solution to overcome the problem of overburden thickness may be to sink an inclined shaft to access the various usable strata. Such a proposal has been previously suggested for the Toronto region (Guillet 1983). Implementation of such a solution would minimize transportation costs, disrupt the surface very little, and provide valuable underground storage space.

Oil and Gas

Oil and gas production in the study area has continued since the last century. Recently, the discovery of a number of significant new oil pools in Ordovician strata has resulted in increased exploration and drilling by private companies.

Natural gas has and continues to be produced from a number of pools in the area. The major ones include: Tilbury, D'Clute and Wolfe. Many other small pools are located in the area, some of which have been abandoned (Carter and Trevail 1989)

Oil in the area has been produced from 4 major pools; Fletcher, Romney, Richardson's Siding, and Kipp. Except for the Fletcher field all others have been abandoned. Major new producing areas are likely to develop in Dover Township and near Wheatley where large oil pools have recently been discovered. Oil and gas are produced from the Dover field (Carter and Trevail 1989).

Proven reserves of oil and gas in the area are estimated to be 651257.8 thousand m³ for gas and 1572.7 m³ for oil (Trevail et al. 1987). These estimates are likely to be low as new discoveries are not included and reserve estimates are lacking for some producing fields.

The Kettle Point Formation has been investigated for its oil shale potential as part of a Hydrocarbon Energy Resources Program (HERP) conducted by the Ontario Geological Survey (Johnson et al. 1985). Within the map area a number of boreholes were completed as part of this program. Results of this study provided the following observations on the shale. Thickness of the shale intercepted in the boreholes ranged from 10 to over 48 m (Johnson 1985; Johnson et al. 1985). Total Organic Carbon (TOC) analysis of samples indicated values

ranging from a low of 0.1% to a high of 8.6%. The average from all samples was 3.62%. Fischer Assay tests conducted on the samples indicated oil potential values ranged from a low of <4.2 / oil/tonne rock to a high of 42.5 //tonne. The average from all samples was 18.37 //tonne. Macauley et al. (1985) indicate that *in situ* oil reserves may be as high as 20,358,000 barrels per square kilometer of surface area mined to a depth of 10 m and using pyrolysis - Fischer Assay recovery values.

Quaternary Geology

INTRODUCTION

The nomenclature and stratigraphic relationships of Quaternary deposits in Ontario have been summarized by Dreimanis and Karrow (1972), Karrow (1974, 1984), Cowan et al. (1975). The classification of the Wisconsinan Stage as presented by Karrow (1984) is followed in this report. In areas adjacent to the Chatham-Wheatley map area the Quaternary geology and stratigraphic relationships have been described by previous mapping (Vagners 1972a, 1972b; Cooper and Baker 1978; Fitzgerald and Hradsky 1980; Morris 1994).

The Quaternary deposits observed in the Chatham-Wheatley area are of Late Wisconsinan and Recent age. Sediments representing the Nissouri and Port Bruce Stadials, the Mackinaw and possibly Erie Interstadials, and the Recent can be found within the Chatham-Wheatley area. Deposits older than Port Bruce Stadial age have been encountered only in the subsurface. A summary of the Quaternary deposits and events for the study area is outlined in Table 1.

DRIFT THICKNESS

Maps outlining drift thickness have previously been prepared for the Chatham - Wheatley area by Sado and Faught (1981c, 1981d). A generalized diagram of the drift thickness is provided in Figure 5.

In general, drift cover thickens southward and over moraine ridges. Locally, north of Chatham, drift cover is less than 17 m. In the Thames River valley, east of Chatham, drift thickness is generally less than 25 m. Drift cover exceeding 60 m in thickness occurs along the Blenheim Moraine. Along the north shore of Lake Erie drift thickness commonly exceeds 50 m.

GLACIAL DEPOSITS AND FEATURES

Till

Till is probably the most widespread and variable of all glacial and glacial deposits. It is also one of the most widespread sediments on earth (Dreimanis 1989). Till is considered to be, "a sediment that has been transported and is subsequently deposited by or from glacier ice, with little or no sorting by water" (Dreimanis 1982).

Two till units are exposed at surface in the Chatham-Wheatley area. Both tills were deposited during the Late Wisconsinan Substage, and more precisely during the Port Bruce Stadial. No older tills were observed to outcrop in the area, however, an older, stony, sand-rich till was encountered in the subsurface during an overburden drilling program. This till and

AGE	TIME STRATIGRAPHIC UNIT	ROCK STRATIGRAPHIC UNIT	DEPOSIT OR EVENT	MATERIALS	MORPHOLOGIC EXPRESSION
Recent			modern alluvium	sand, silts, clay	present-day floodplains
			marsh and swamplands	muck, silt, clay	open water, filled depressions
			eolian sediments	sand	barchan, ridge and barchanoid ridge dunes
			older alluvium	gravelly sand, sand, silt, clay	remnant river terraces, scroll bars, swales
			late stage lakes (Erie)	sand, silt, clay	delta, lake plain, bars, shorelines
Two Creeks Interstadial			Lake Algonquin equivalent (St. Clair basin)	sand, silt, clay, organics	delta, lake plain, bars, shoreline
			Lake Lundy	gravel, sand	bars, shoreline, delta
			Lake Grassmere ?	gravel, sand	bars, shorelines
Port Huron Stadial			Lake Warren	gravel, sand, silt, clay	lake plain, bars, spits, shorelines
			Lake Whittlesey	sand, silt, clay	lake plain, mainly buried
Mackinaw Interstadial			Lake Arkona (s) glaciolacustrine	silt, clay	lake plain, mainly buried
			Lake Maumee (s) outwash deltaic	silt, clay	lake plain, mainly buried
Port Bruce Stadial			Port Stanley Till	gravel, sand, silt	meltwater channel
			Tavistock Till	clayey silt till	till plain, end moraine, minor moraine
Erie Interstadial			Tavistock drift (?)	clayey silt till	till plain, end moraine, minor moraine
			glaciolacustrine deposits	silt, clay	buried
Missouri Stadial			outwash	gravel, sand	buried
			Catfish Creek Drift	sandy silt to silty sand till	buried

Table 1. Quaternary deposits and events in the Chatham-Wheatley map area.

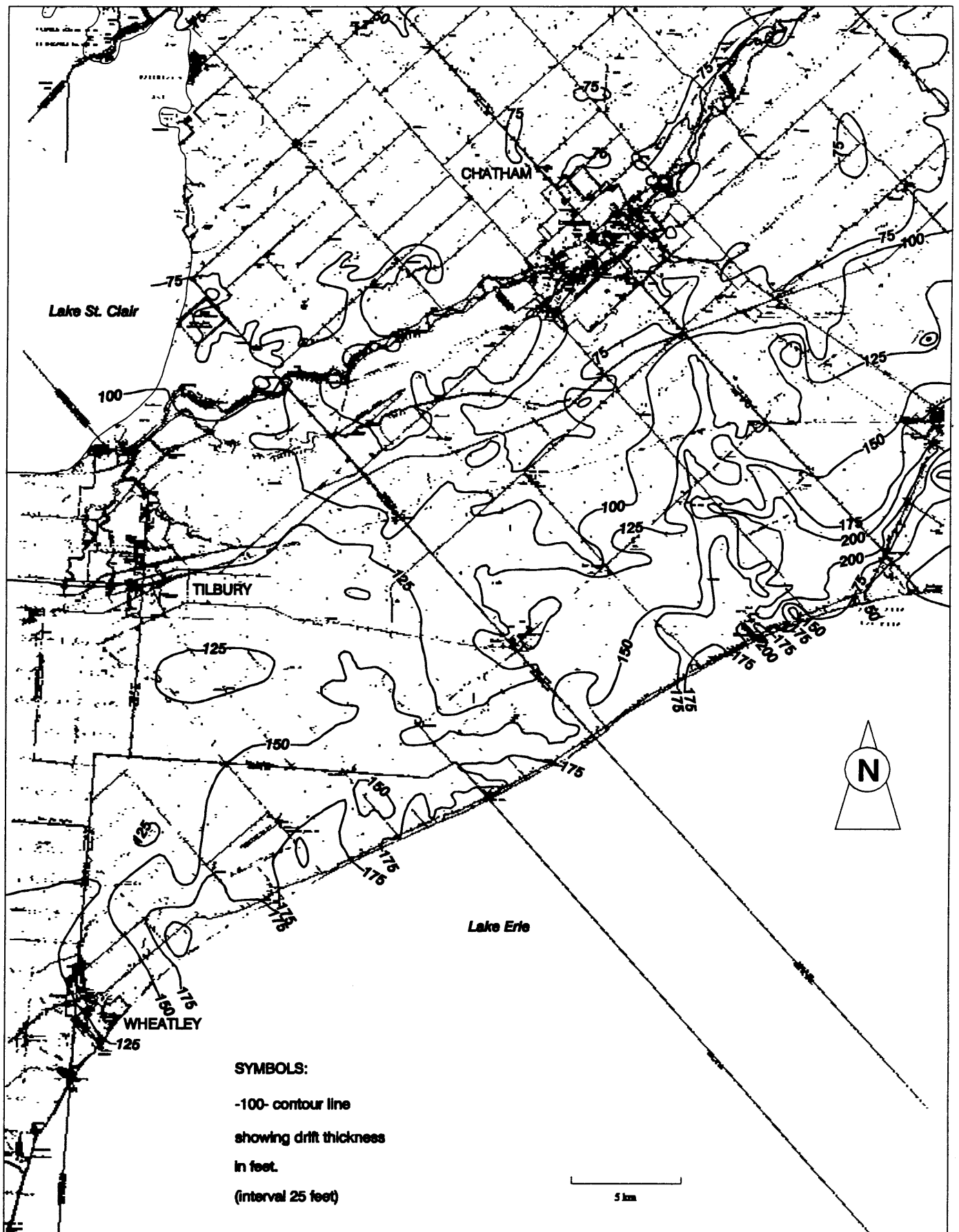


Figure 5. Drift Thickness of the Chatham-Wheatley area (after Sado and Faught 1981c,1981d)

related sediments will be discussed in the stratigraphy section of this report.

The oldest surface till in the study area was derived from glacial ice that advanced south-southeast out of the Lake Huron basin. A second, slightly younger till, was derived from glacial ice that entered the Chatham-Wheatley area from the southeast out of the Lake Erie basin.

Average physical and chemical properties for the surface and subsurface tills and are presented in Table 2. A graphical representation of the textural properties for all tills from the area is presented in Figure 6. Analytical results for individual samples are found in Appendices A,B,D and E.

TAVISTOCK TILL

The oldest till exposed in the area is a clast-poor, massive to faintly stratified, silty to clayey silt till (Photo 1). Unweathered, this till is grey (10YR5/1) to dark grey in colour (10YR4/1) and when weathered it becomes yellowish brown (10YR5/4) or brown (10YR5/3). The till is commonly leached of carbonates to depths of greater than 1.5 m below ground surface with visible oxidation observed to depths of up to 6 m.

This till is present over much of the southern part of the map area (map, back pocket) and is often veneered by a thin cover of fine-grained glaciolacustrine sediment. The maximum observed thickness of this till was 19 m in the Lake Erie bluffs at Port Crewe.

This till has been identified immediately north, west and east of the Chatham-Wheatley area by other workers (Fitzgerald 1977, 1979; Cooper and Baker 1978; Morris 1994). The name "black shale till" was informally applied to this unit by Fitzgerald (1977, 1979).

In the Chatham-Wheatley area this till has an average textural composition of 35.5% clay, 46.5% silt and 18% sand (Table 2). The till becomes slightly more sand and silt rich to the south. North of the Charing Cross Moraine the till averages 38% clay, 44.5% silt and 17.0% sand (Table 2). Samples south of the moraine average 35.0% clay, 47.0% silt and 18% sand (Table 2).

Calcite content of the silt-clay fraction averages 10.26% and dolomite content averages 8.2%, providing a calcite to dolomite ratio of 1.16 (Table 2). Total calcite remains essentially constant throughout the area, while total dolomite increases slightly toward the south (Table 2).

Atterberg limits were determined for 46 samples. Liquid limit values range from 26 to 46 (average 34.3), plastic values 14 to 22 (average 18.1), and values of plasticity index range from 12 to 24 (average 16.2) (Table 2).

	(1)north n = 12	Tavistock Till (2)south n = 34	average n = 46	Port Stanley Till n = 17	Catfish Creek Till n = 9
sand%	17.33	18.06	17.87	15.35	40.1
silt%	44.50	47.32	46.59	49.18	43.9
clay%	38.17	34.65	35.57	35.47	16.0
calcite%	10.03	10.34	10.26	12.98	17.0
dolomite%	6.91	8.65	8.20	8.58	12.7
cal/dol ratio	1.27	1.12	1.16	1.47	1.5
liquid limit	35.67	33.82	34.30	30.06	-
plastic limit	18.67	17.88	18.09	16.44	-
plasticity index	17.00	15.94	16.22	13.63	-

(1)north - Huron lobe surface till samples collected north of the Charing Cross Moraine

(2)south - Huron lobe surface till samples collected south of the Charing Cross Moraine

Table 2. Properties of tills in the Chatham-Wheatley map area.

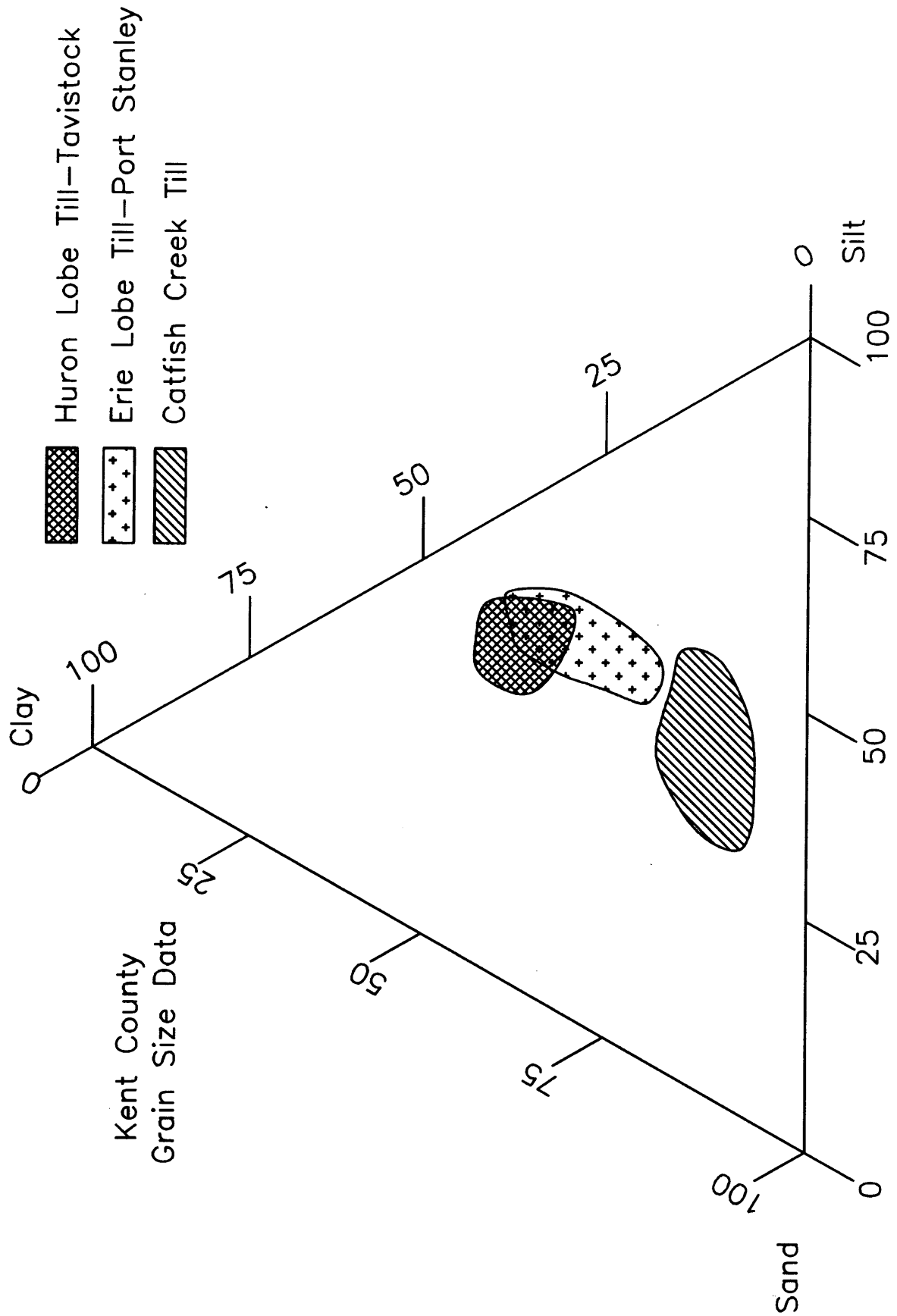
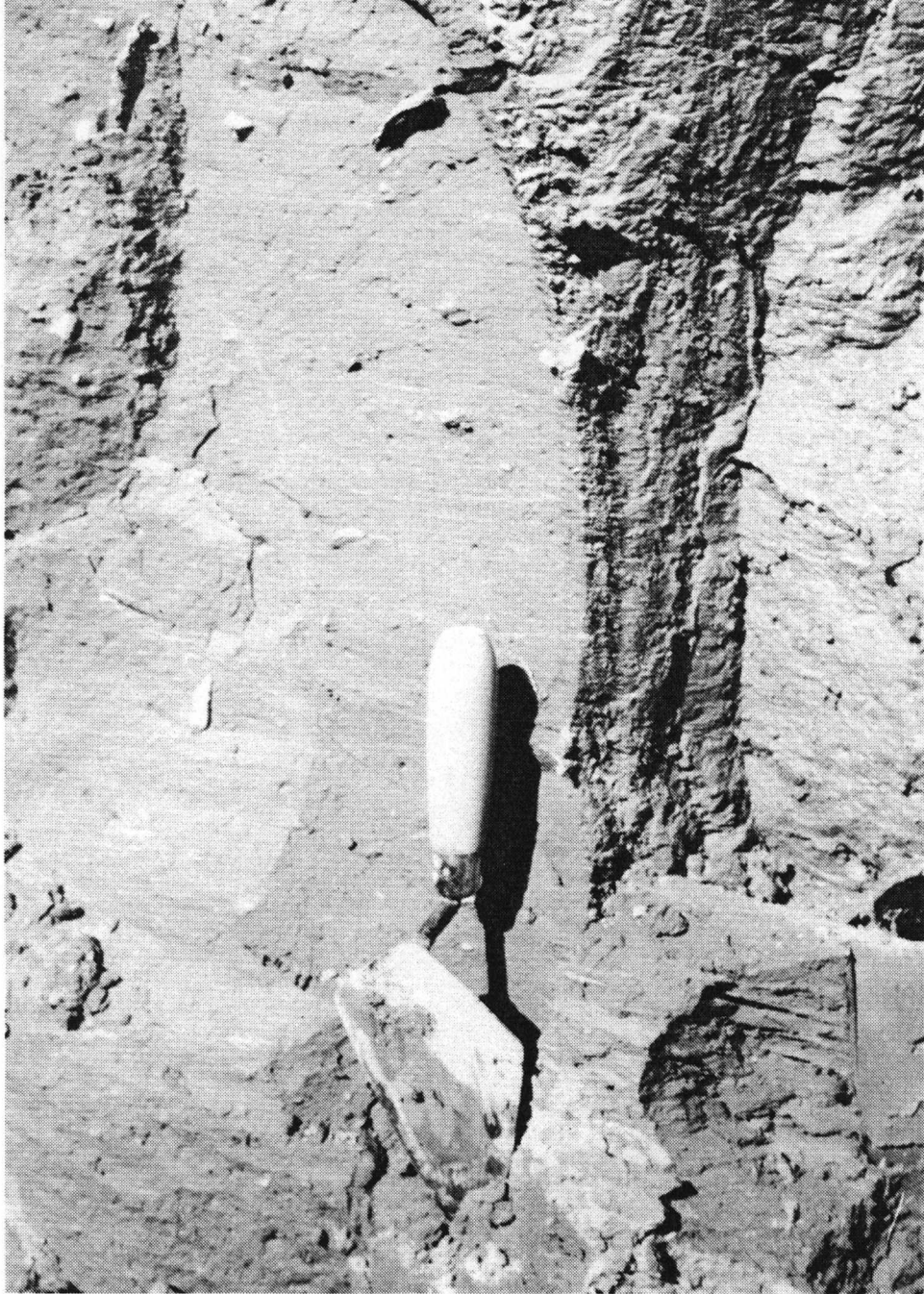


Figure 6. Textural properties of the tills of the Chatham—Wheatley area.



Photograph 1: Faintly stratified, Huron lobe, Tavistock Till

Clay mineralogical analyses (Appendix E) indicate that clay-mica (illite) and chlorite are the common clay minerals with lesser amounts of vermiculite present. Traces of smectite, kaolinite, quartz and calcite are also noted. Results of analyses for major elements Si, Al, Fe, Mg, Ca, Na, K, Ti, P, Mn, C and S are provided in Appendix B.

The stratigraphic correlation and age of this till have been unclear in the past. Workers mapping in surrounding areas, where this till has been identified, have provided various interpretations as to its history. Fitzgerald (1977, 1979), mapping north of the Chatham-Wheatley area, suggested that this till was deposited by glacial ice of the Erie lobe. Cooper and Baker (1978), working in the Bothwell-Ridgetown area correlated this till with the Port Stanley till, an Erie lobe till named by deVries and Dreimanis (1960) in the Port Stanley map area to the east. A number of observations from the present study indicate that the till is a Huron lobe derived unit. Pebble fabrics and shear structures (Figure 7) indicate ice advance toward the south-southeast. Clasts within this till included a number of diagnostic lithologies including Precambrian jasper conglomerate, tillite of the Gowganda Formation and quartzite of the Lorrain Formation. These rock types are derived from the Precambrian, Huronian Supergroup, north of Lake Huron and provide excellent provenance indicators (Karrow 1977).

The southern limit of advance for this Huron lobe ice is uncertain. Morris (OGS, personal communication, 1989) has reported finding jasper conglomerates on East Sister and Hen Islands, small islands in central Lake Erie southwest of the study area. Similar lithologies have also been recovered from Late Wisconsinan tills of Northern Ohio (R. Pavey, Ohio Geological Survey, personal communication, 1990). It is probable then that this Huron lobe ice advanced at least as far south as northern Ohio.

Correlation with other Late Wisconsinan Huron lobe tills is tenuous, but on the basis of its stratigraphic position and regional distribution it is suggested that this till is a Huron lobe correlative of the Tavistock Till. Karrow (1974) formally named the till within the Stratford area after the town of Tavistock in Oxford County. The till was subsequently recognized within the map areas of Woodstock (Cowan 1975), Orangeville (Cowan 1976), St. Marys (Karrow 1977) and Lucan (Sado and Vagners 1975).

The Tavistock Till represents ice advance during the early part of the Port Bruce Stadial by ice flowing south-southeast from the Lake Huron and Georgian Bay basins (Karrow 1974). It is considered time equivalent with the Erie lobe Port Stanley Till (Cowan 1976).

During rotasonic drilling, conducted as part of this study, interbeds of glaciolacustrine sediment were noted locally within the Tavistock Till sequence. The association of till and glaciolacustrine sediments, where present, may be more properly referred to as Tavistock Drift. Due to the limited data available the lower boundary of the drift package is arbitrarily placed at the first appearance of Tavistock Till and the upper at the last diamicton layer within glaciolacustrine sediments that contain abundant ice-rafted debris (see Appendix F, drillholes W-89-03 and W-89-09).

PORT STANLEY TILL

A second, younger, clayey silt till, was observed along the extreme southern margin of the map area, at Wheatley and south of Blenheim. This till is generally massive; however, rare, thin, stratified diamictos also occur within this unit (Photo 2). The stratified diamictos contain mud pellets and weakly developed lamination. The till is veneered by glaciolacustrine clay to sand-rich sediments. Within the map area the till ranges in colour from grey (10YR5/1) to greyish brown (10YR5/2) in an unweathered state and may be brown (10YR5/3) to yellowish brown (10YR5/4) when oxidized. The till reached an observed maximum thickness of 15 m in the Lake Erie bluffs at Port Alma.

Texturally this till has an average composition of 35.5% clay, 49% silt and 15% sand (Table 2). Total calcite averages nearly 13%, with total dolomite slightly greater than 8.5% (Table 2). The calculated calcite to dolomite ratio average is 1.47 (Table 2).

Atterberg limits were calculated for 17 samples. Liquid limits ranged from 21 to 35 (average 30.1), plastic limits range from 13 to 19 (average 16.4) providing a plasticity index range of 8 to 16 (average 13.6) (Table 2).

Clay mineralogical analyses indicate that clay-mica (illite) and chlorite are the most abundant clay minerals with lesser amounts of vermiculite present. Traces of kaolinite, quartz and calcite may be found. Smectite is only rarely found (Appendix E). Analyses for major elements Si, Al, Fe, Mg, Ca, Na, K, Ti, P, Mn, C, S are provided in Appendix B.

This till may be correlated with a fine-textured till identified by Cooper and Baker (1978), immediately east of the present study area, in the Bothwell-Ridgetown area. They mapped this till as Port Stanley Till. Sado (1981) identified a fine-grained till within the Chatham-Wheatley area which he suggested correlated with the Port Stanley Till. The Port Stanley Till represents a Port Bruce Stadial glacial advance out of the Erie-Ontario basin (Dreimanis and Karrow 1972). Till fabric analyses for this till indicate ice flow to the northwest out of the Erie basin (Figure 7). In the Tillsonburg (Barnett 1982) and St. Thomas areas (Dreimanis 1970) the Port Stanley Till has been traced northwest as far as the Ingersoll Moraine. Cooper and Baker (1978) mapped Port Stanley Till in the Bothwell-Ridgetown area north of the Blenheim Moraine. Results of this study suggest that the Port Stanley Till extends only as far north as the southern edge of the Blenheim Moraine. The till is present in the Wheatley area in a narrow band along the north shore of Lake Erie. The continuity of the till band, at the surface, is interrupted at Port Crewe, where the Tavistock Till is present.

Quaternary mapping by Dreimanis (1971) and Barnett (1982), east of the Chatham-Wheatley area, identified multiple sequences of Port Stanley Till interbedded with glaciolacustrine sediments. These deposits form the sediment package known as Port Stanley Drift (Barnett 1982). The multiple till sheets resulted from readvances of a partly floating Erie ice lobe in glacial Lake Maumee (Dreimanis 1971).

Examination of bluff sections composed of the Port Stanley Till within the Chatham-Wheatley area revealed only 1 till sheet with overlying glaciolacustrine sediments. Thin stratified diamictos were observed however, within the Port Stanley Till. These may have

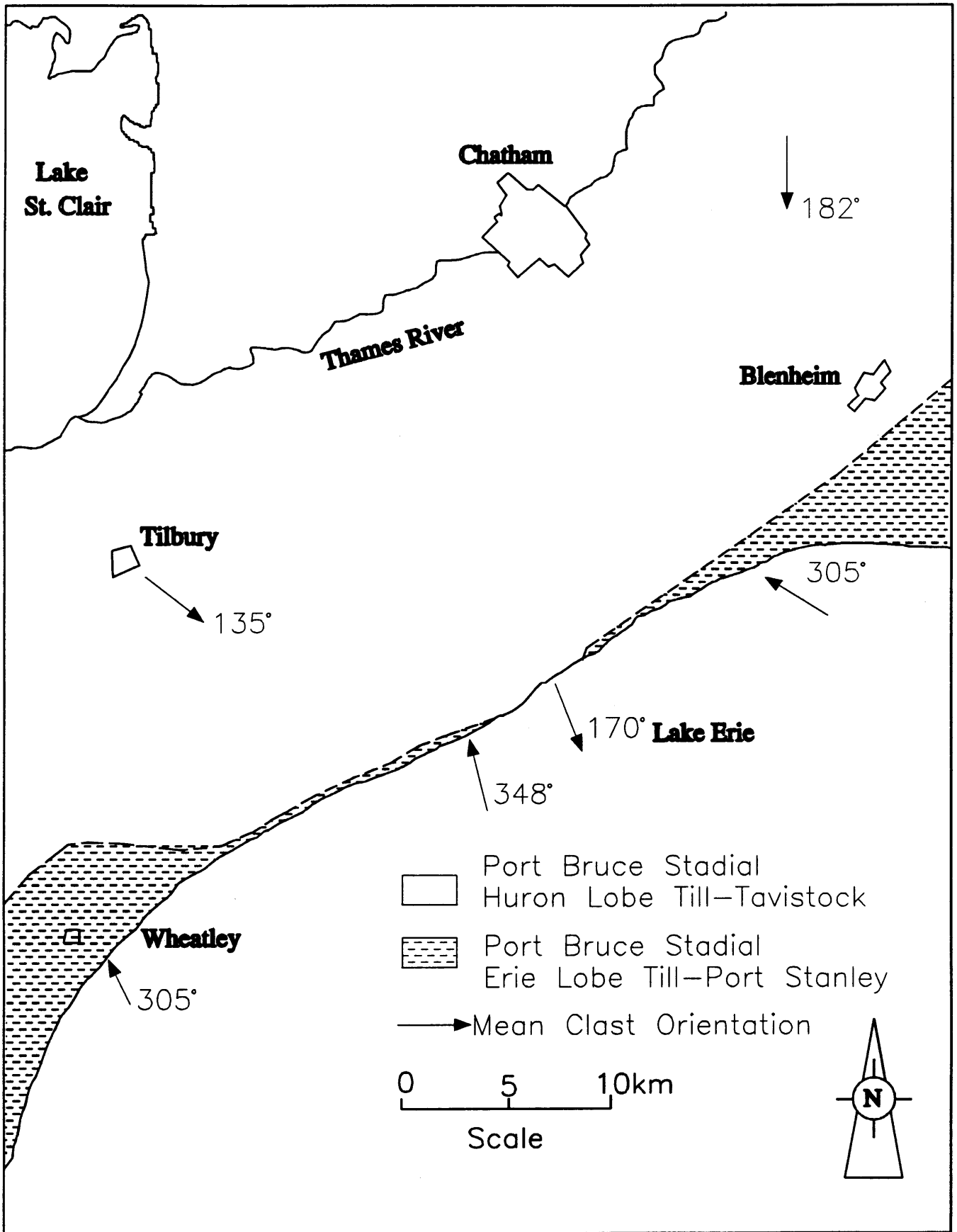
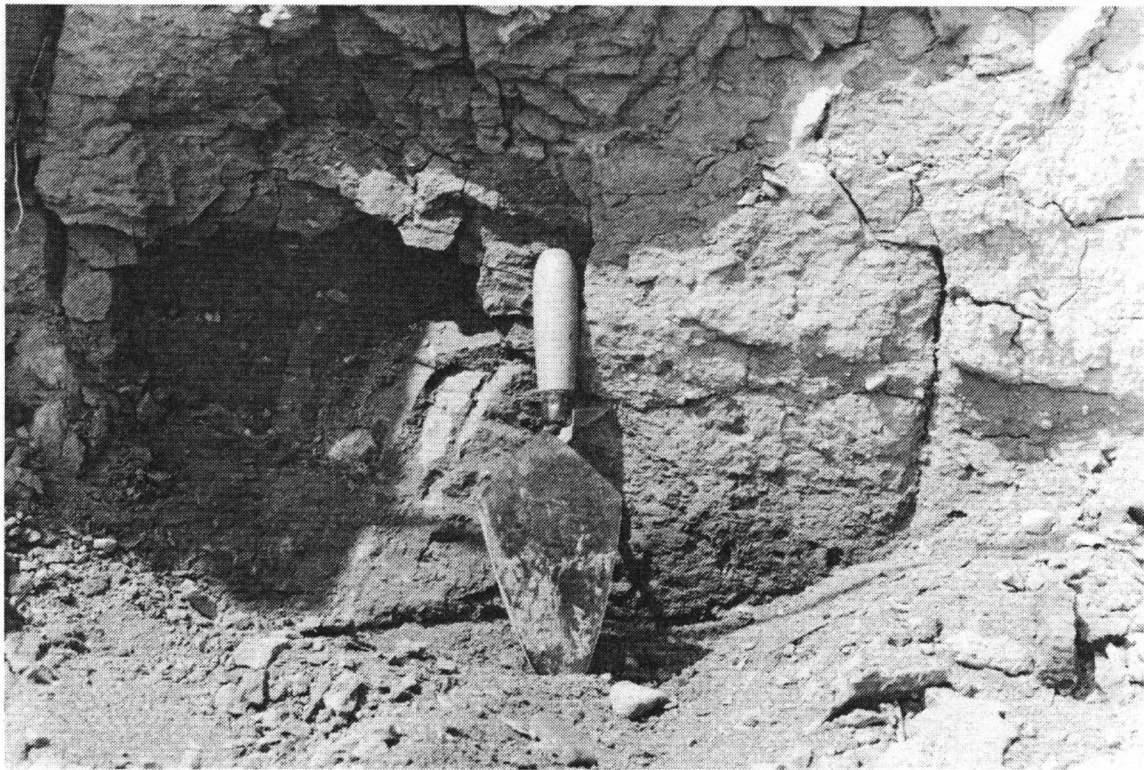


Figure 7. Mean clast orientations determined by clast fabric for surface tills.



Photograph 2: Massive, Erie lobe, Port Stanley Till

resulted when glacial ice detached from its bed to partially float, allowing localized meltout of sediments. The association of till with glaciolacustrine sediments, where present, is better referred to as Port Stanley Drift.

Moraines

Within the Chatham-Wheatley map area 2 significant moraines and several smaller, subdued morainic ridges are present (Figure 8). All of these ridges are aligned roughly eastward, except the Blenheim and Charing Cross Moraines, which trend northeast. With the exception of the Blenheim Moraine, these ridges represent standstills or minor readvances of the Lake Huron lobe ice during its advance and subsequent retreat northward into the Huron basin during the Port Bruce Stadial. The Blenheim Moraine is thought to have been deposited in an interlobate position between the Huron and Erie ice lobes during the Port Bruce Stadial. Even though this moraine was likely deposited in an interlobate position, evidence indicates it is derived primarily from Huron lobe sediments.

BLENHEIM MORAINE

The name Blenheim Moraine was first proposed by Taylor (1913) for a well-defined ridge running northeast through the town of Blenheim. The moraine has a relief of 7 to 10 m and is nearly 11 km across in some places (Chapman and Putnam 1984). In the Chatham-Wheatley area the moraine is narrow, having a width of only a kilometer or less. Taylor (1913) noted that the moraine was truncated at the Lake Erie shorebluff, southwest of Blenheim, and that between this point and Port Alma, to the west, the moraine was almost entirely cut away by the modern lake. The ridge reappears west of Port Alma and extends westward to Leamington (Taylor 1913). This study indicates that the main body of the Blenheim Moraine is separated from the ridge described by Taylor (1913) by a deposit of glaciofluvial sediments. The narrow ridge extending west from Cedar Springs is slightly younger than the Blenheim Moraine and should not be included with it.

The Blenheim Moraine is thought to be an interlobate feature developed between the Huron and Erie ice lobes (Chapman and Putnam 1984). Examination of sediments at the Orford Township sand and gravel pit, which is situated on the southeast flank of the moraine east of Blenheim, suggests that Huron lobe ice played a major role in the formation of this deposit. Numerous Precambrian, Huronian Supergroup, clast lithologies were noted throughout the pit. Diamicton flows derived from a northerly source, as indicated by clast fabrics and sediment folds, were found interbedded with the sands and sandy gravels of the deposit. Paleocurrent measurements taken from rippled and cross-bedded sand strata indicate paleoflows toward the southwest. This evidence suggests that a northern or Huron ice lobe strongly influenced both sediment supply and depositional patterns within the Orford Sand and Gravel aggregate body. The direction of paleoflows to the southwest suggests that meltwaters were confined by a flow obstruction located south or southeast of the deposit. The presence of Erie lobe ice south or southeast of the area would have provided such an obstruction.

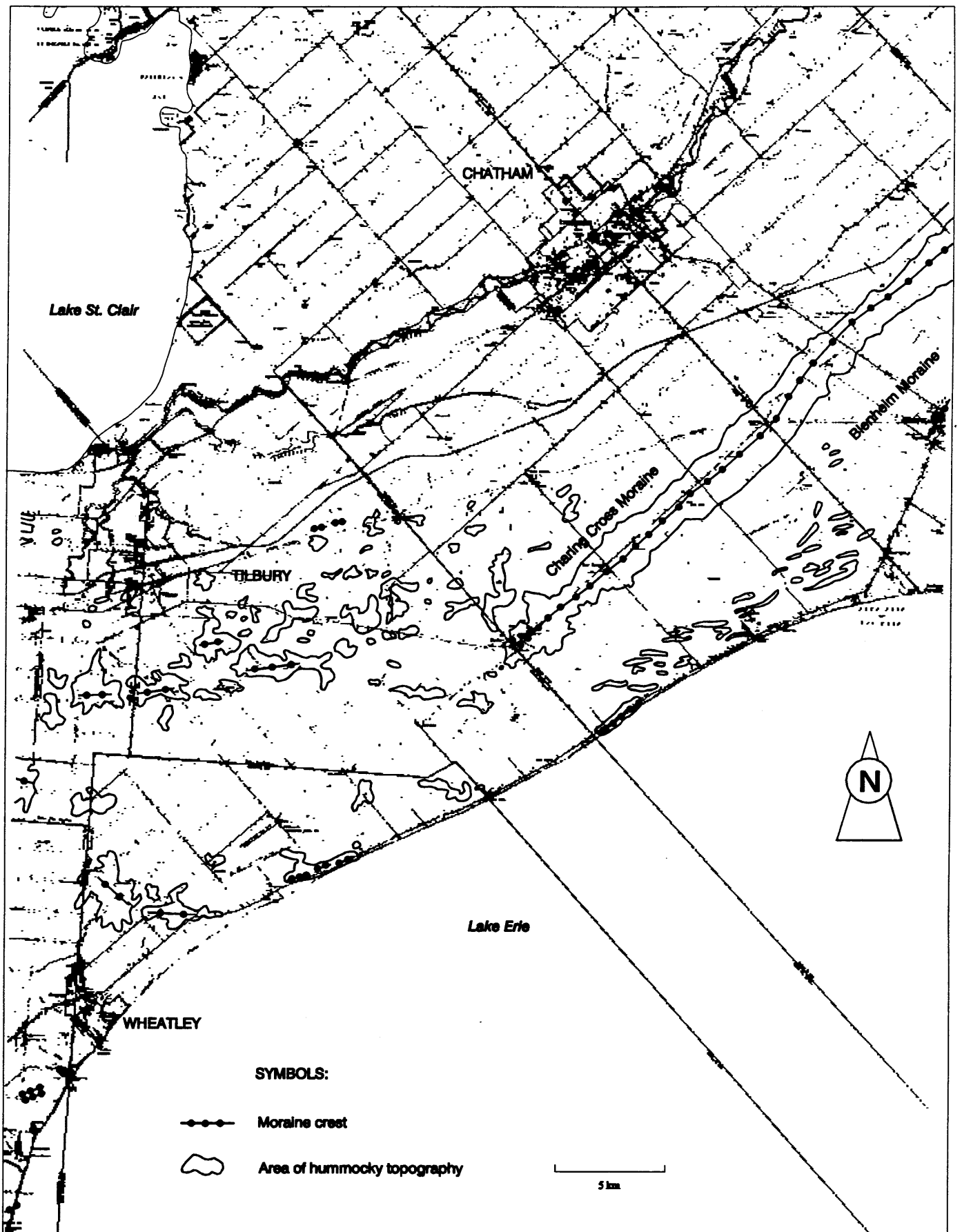


Figure 8. Moraines of the Chatham-Wheatley Map Area.

CHARING CROSS MORAINE

A low relief ridge trending northeast from Merlin, through the hamlet of Charing Cross, defines the Charing Cross Moraine. This ridge was previously noted on the Kent County soil survey map (Ontario Agricultural College 1930) and also by Chapman and Putnam (1984). The ridge is indistinct when viewed from its south side but when seen from the north the land rises gradually to the south, approximately 5 to 8 m, over a distance of a kilometre. The crest of the moraine lies at approximately 193 m a.s.l., remaining at or very near this elevation throughout its length. The Charing Cross Moraine runs subparallel to, and is a younger moraine than the Blenheim Moraine that lies to the south. Numerous Huronian Supergroup clast lithologies present on the moraine surface suggest that the Charing Cross Moraine was deposited by a standstill or minor readvance of the Huron ice front as it retreated northward.

OTHER MORAINE RIDGES

A number of previously undescribed, subtle morainic ridges have been identified by this mapping project. Some ridges are contiguous with ones identified in the Essex County area by Morris (1994). In the Chatham-Wheatley area, poorly defined, nearly eastward trending ridges are located northwest of Tilbury: west and south of Fletcher; south of Tilbury extending north through Merlin; and north of Wheatley (Figure 8). On the ground, these ridges are subtle in their expression, often rising only a couple of metres, at most, above the surrounding terrain. The most notable characteristic of these features is the presence of numerous clasts, some up to boulder size, exposed on the ground surface. Many of these clasts are Huronian Supergroup derived lithologies, such as tillite and quartzite. The moraine ridges are best seen on Landsat images and air photographs as tonal differences that result from differing drainage characteristics. The subtle nature of these ridges may be due to a number of factors including: deposition of initially small ridges because of either, a short depositional time frame or lack of sediment within the ice column; subsequent resedimentation or flow of sediments in a subaquatic environment resulting in a flattening of the moraines; and, reworking by glacial lake wave and current action with coincident partial burial by eroded sediments. The orientation of these ridges and abundance of Huronian Supergroup clast lithologies suggests deposition occurred during standstills or minor readvances of the Huron ice front as it retreated northward.

GLACIOFLUVIAL DEPOSITS AND FEATURES

Delta / Outwash

A deposit of glaciofluvial sand and gravel is present in the extreme southeastern part of the study area. Lake Erie bluff sections in this area reveal 5 to 15 m thick, coarsening upward sequences of thinly bedded silty sands to trough cross-bedded sandy gravels. Laterally this unit may be traced from just north of Cedar Springs southwestward to the lake bluffs south of Merlin (map, back pocket). At Dealtown the deposit may be traced inland for a distance of

approximately 1 km where it thins and pinches out against a small morainic ridge. Paleocurrent measurements indicate paleoflow toward the west and southwest (Figure 9). Deposition of these sediments is proposed to have occurred in an ice marginal position between the retreating Huron and Erie ice lobes that had stood at the Blenheim Moraine. The presence of the Huron ice on the north and the Erie ice on the south-southeast likely confined and forced meltwater flow toward the southwest. The coarsening upward sequence, abundance of trough-crossbedding, and channels with clayey silt caps, suggests that these sediments represent a deltaic deposit.

GLACIOLACUSTRINE DEPOSITS AND FEATURES

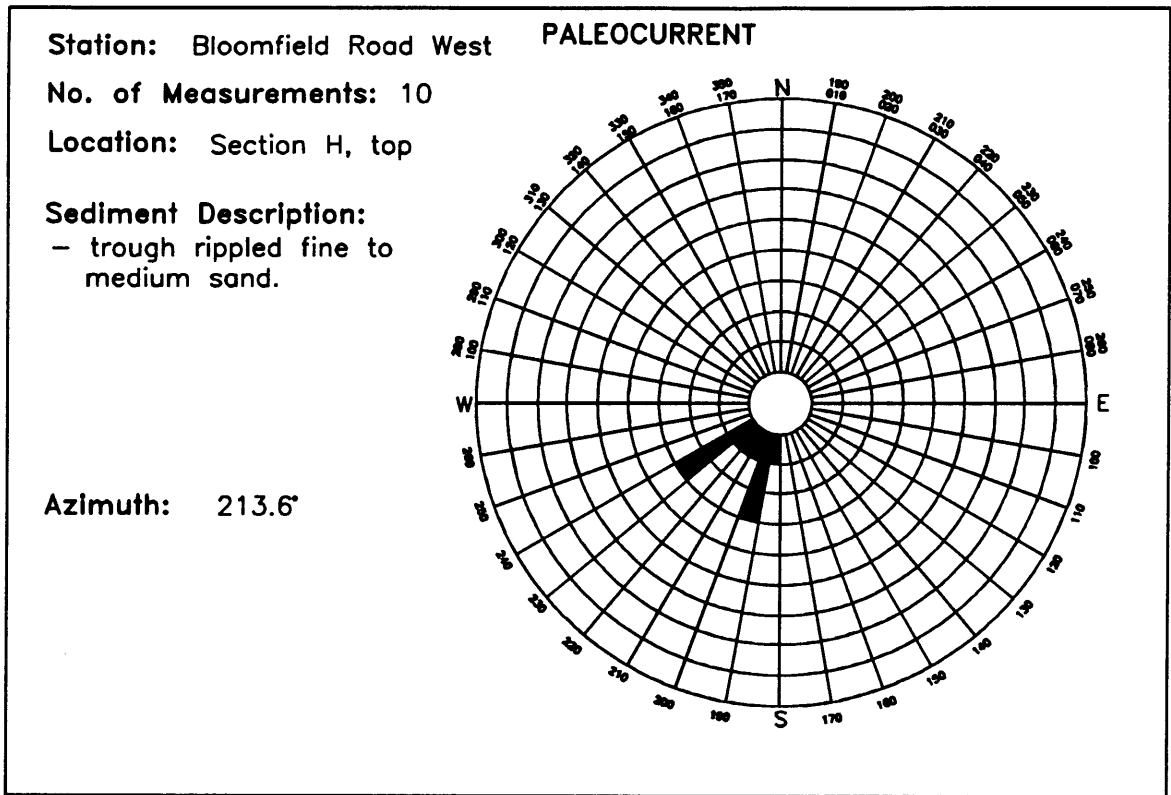
Deposits and features of high-level ancestral lakes in the St. Clair and Erie basins can be found throughout the Chatham-Wheatley area. Much of the map area is covered by various thicknesses of glaciolacustrine sand, silt or clay. Abandoned shoreline features for a number of glacial and non-glacial lakes have been recognized (Figure 10). The oldest glaciolacustrine deposits found within the area lie immediately above the tills of the Erie and Huron lobes.

Lakes Maumee and Arkona

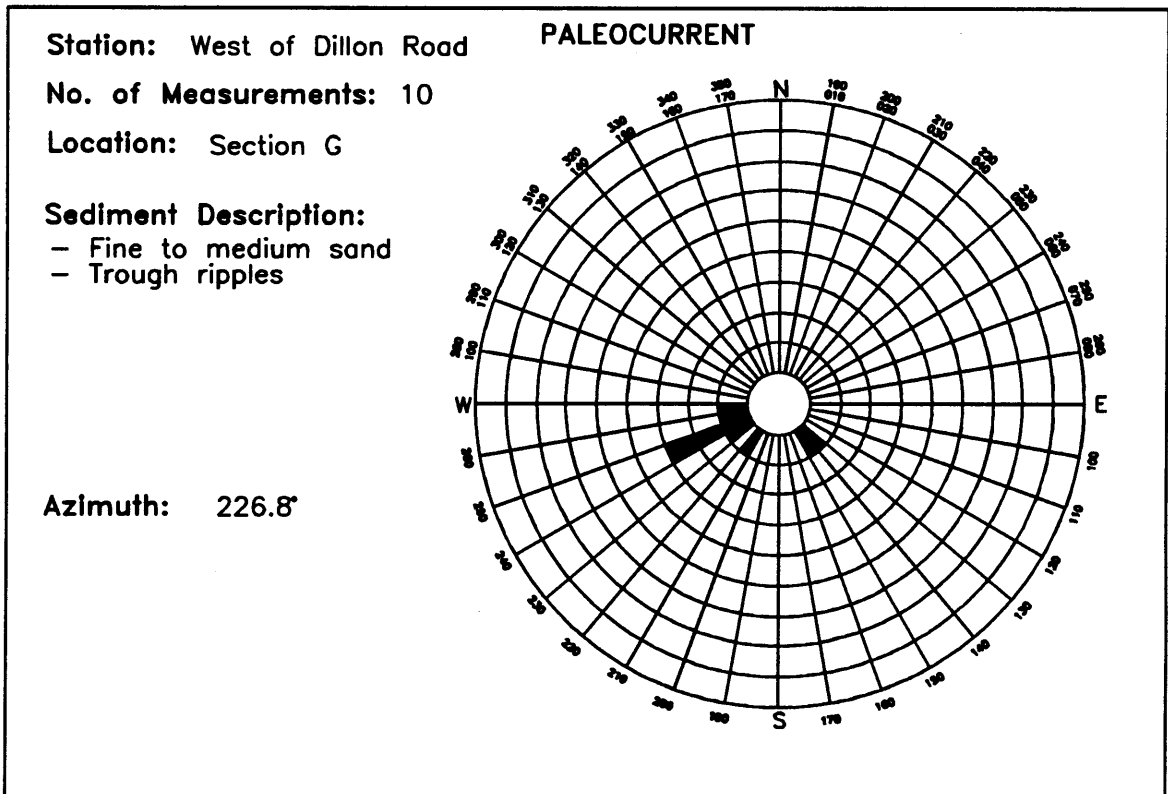
Lying immediately upon the tills in many parts of the map area are clay-rich massive to stratified glaciolacustrine sediments (Photo 3). The thickest sediment accumulations occur north of the Charing Cross Moraine and south of the Blenheim moraine.

The contact between the glaciolacustrine sediments and the underlying till is often sharp; however, interbedded contacts are also observed. Glaciolacustrine sediments contain numerous mud pellets (reddish and whitish), diamicton clots and thin diamicton flows. Texturally the sediments are very clay-rich (Appendix A), averaging 54.5% clay, 40.3% silt and 5.3% sand. Determination of paleoflow direction from these sediments is difficult. On the basis of scours, sediment shadows (sediment deposited in the lee of clasts) and faint cross-lamination, paleoflow appears to be toward the south-southeast. Results of geochemical analyses for these sediments are presented in Appendices B and C.

Glaciolacustrine sediments represent deep water deposition within expanding ice marginal lakes (Lakes Maumee and Arkona) which fronted the retreating Port Bruce Stadial ice lobes. Three levels of Lake Maumee (I,II,III) have previously been recognized within the Erie and Huron basins (Dreimanis 1964), as have 3 levels of Lake Arkona within the Erie Basin (Calkin and Feenstra 1985). The oldest and highest, Lake Maumee I, existed only in the western end of the Lake Erie basin prior to the formation of the Ingersoll Moraine (Dreimanis 1964). Initiation of the Thames River meltwater channel may have occurred at this time (Barnett 1982). Waters of all 3 levels of Lake Maumee continuously covered the Chatham-Wheatley area as did all levels of the Arkona phases. Calkin and Feenstra (1985) indicate that the lowest level Arkona III had a water level of 212 m in the Erie basin. Much of the land (till) surface in the map area lies below 200 m, indicating that the water covering the Chatham-Wheatley area was at the least a minimum of 12 m deep throughout Lakes Arkona and Maumee time.



(a)



(b)

Figure 9. Paleocurrent measurements from glaciofluvial sediments Cedar Springs area, (a) Bloomfield Road bluff section, UTM E411600 N4678400, (b) Dillon Road bluff section, UTM E408500 N4676900.

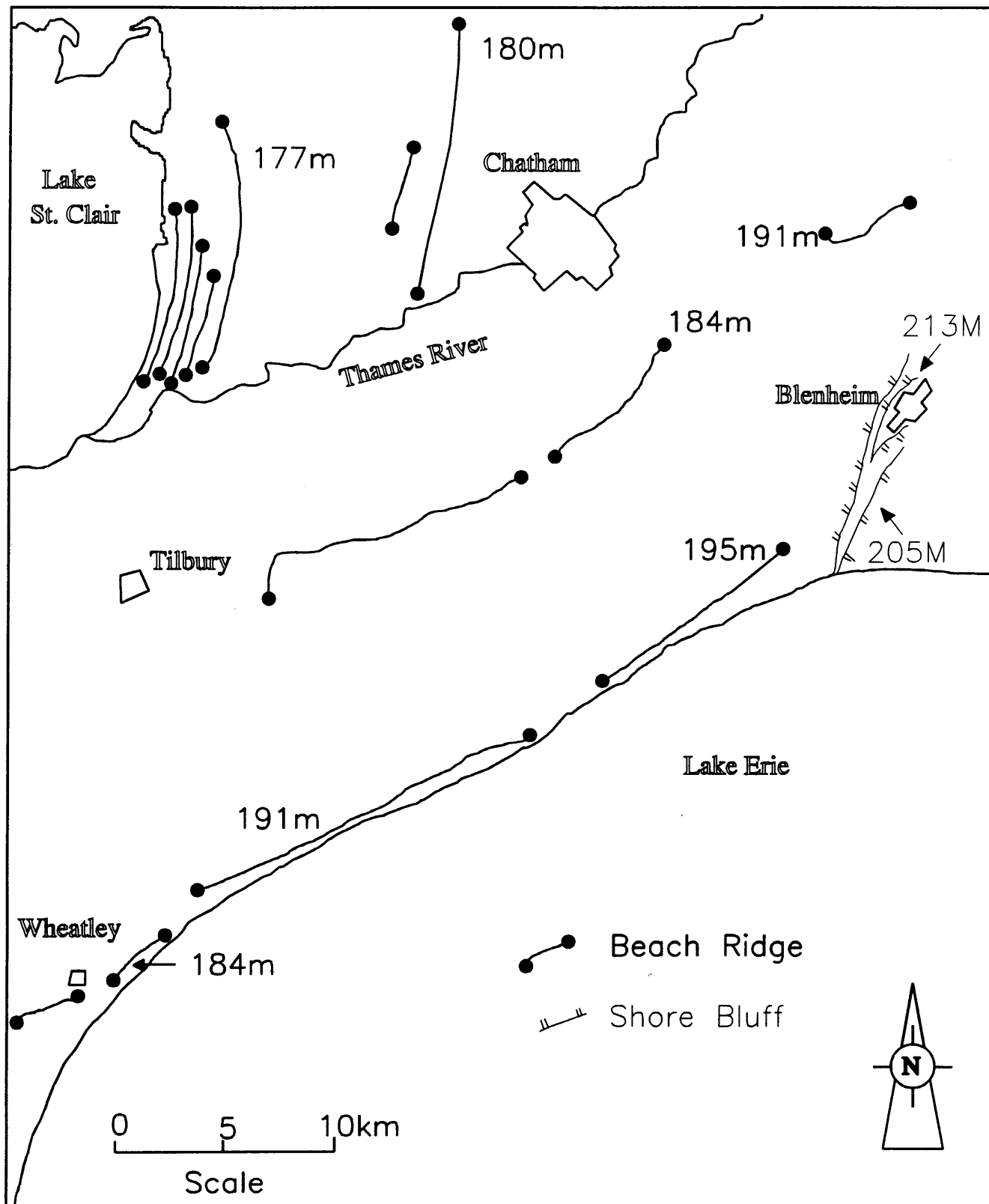
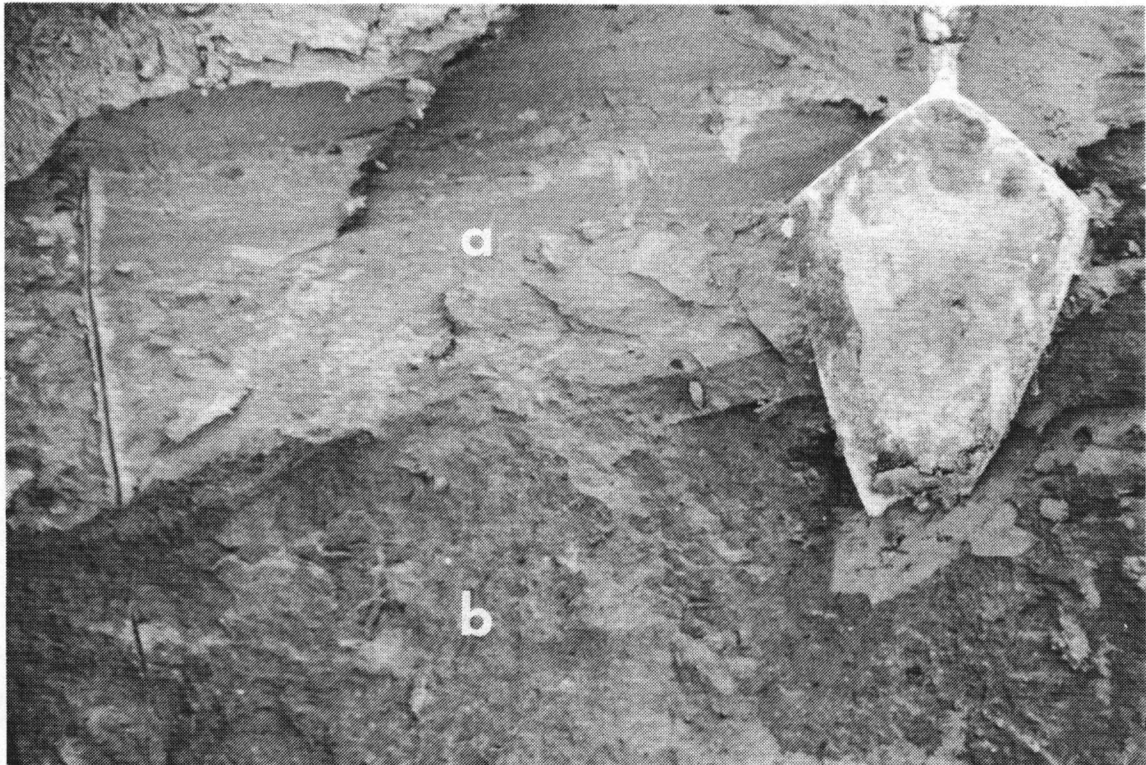


Figure 10. Shoreline features of glacial and non-glacial lakes of the Chatham-Wheatley map area.



Photograph 3: Stratified Glaciolacustrine sediments of Glacial Lakes Maumee and Arkona (a) overlying Huron lobe, Tavistock Till (b).

Lakes Whittlesey and Warren

Abandoned shorelines identified along the Blenheim Moraine in the Chatham-Wheatley area, having approximate elevations of 213 m and 205 m, continue eastward into the adjacent Bothwell-Ridgetown map area. These shorelines were previously related to Lakes Warren I and Warren II respectively, by Cooper and Baker (1978). Associated with the shorelines is a linear ridge of gravel and sandy gravel extending southwest from the Blenheim Moraine, through Cedar Springs, to the Lake Erie bluffs, where it is truncated. This deposit is interpreted to be a spit formed in Lake Warren, around the southwest end of the Blenheim Moraine. The spit was most likely developed by current reworking of underlying, older, outwash (deltaic) materials that were deposited during the initial retreat of the Erie and Huron ice lobes. Examples of gravel-rich shoreline features developed on and from underlying gravelly glaciofluvial deposits are noted in the Ottawa area (G. Gorrell, Gorrell Resource Investigations, personal communication, 1989). Specific shoreline features related to Lake Whittlesey were not found in the area.

Sand- and silt-rich glaciolacustrine rhythmites deposited in Lakes Whittlesey and Warren overlie the finer textured glaciolacustrine sediments of Lakes Maumee and Arkona throughout much of the northern half of the map area. The contact between the rhythmites and underlying glaciolacustrine sediments is sharp. The maximum observed thickness of the rhythmite unit was 3 m. Rhythmite couplets range in thickness from 0.5 to 2.5 cm. Generally the finer unit of the couplet, composed of silty clay to clayey silt, is thicker than the coarser, silty very fine sand to fine sand unit. Faint laminations are observed in the finer part while the coarser fraction contains rare, small mud pellets, pebbles, faint lamination and starved ripples. Paleocurrent observations are limited, however, paleoflow toward the west is indicated. Physical and chemical properties of the rhythmites are provided in Appendices A, C and D.

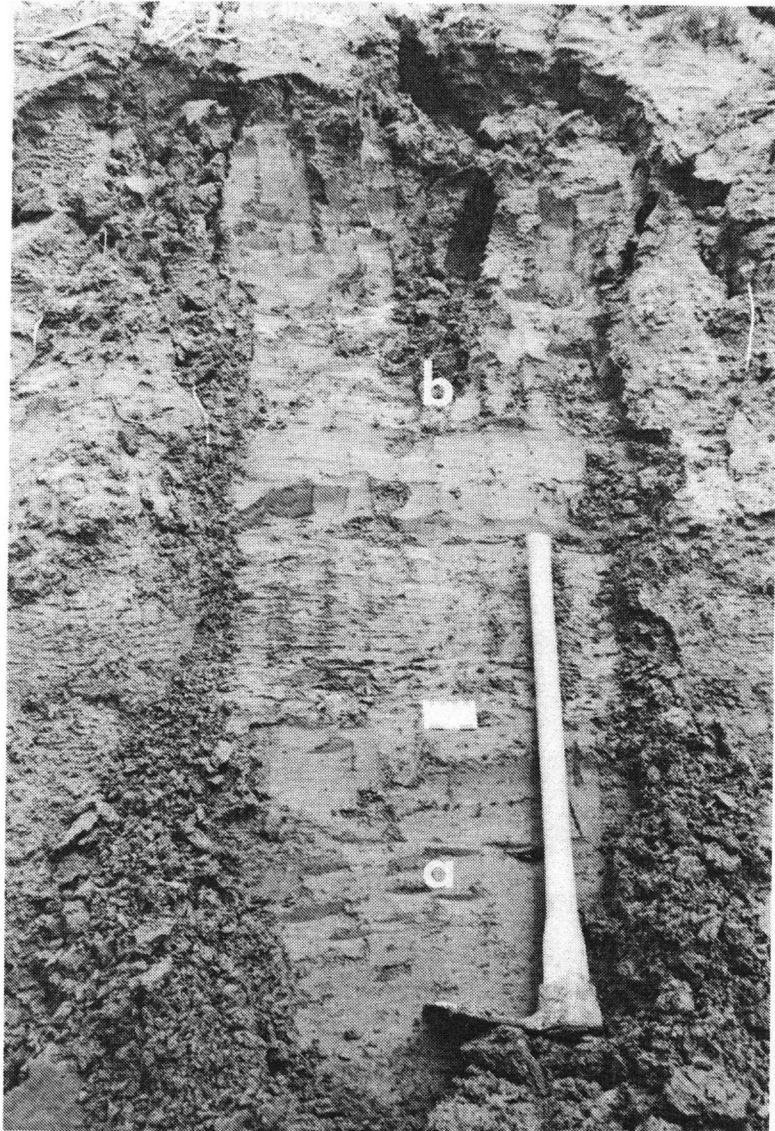
The rhythmites were likely deposited, initially, in Lake Whittlesey with formation continuing through Lake Warren time. A developing Thames River probably supplied much of the sediment comprising these rhythmites. In places, the rhythmites are overlain by younger deltaic sediments (Photo 4).

Lakes Grassmere and Lundy

Falling water levels in the Erie and Huron basins following Lake Warren were punctuated by brief pauses that saw the development of short-lived lakes. As a result, only weak and discontinuous shoreline features developed (Calkin and Feenstra 1985).

Southwest of Blenheim, trending nearly parallel to the present Lake Erie shorebluff west to Port Crewe, is a gravelly ridge with a crest elevation of approximately 195 m (Figure 10). A water level of approximately 195 m in the Lake Erie basin has been ascribed to Lake Grassmere (Calkin and Feenstra 1985). Thus, this ridge probably represents a shoreline feature of this lake level.

Gravelly ridges extending west from Port Alma to north of Wheatley and along the north side of the Charing Cross Moraine in the eastern part of the map area have elevations



Photograph 4: Glaciolacustrine rhythmites of Lakes Whittlesey and Warren (a) overlain by younger deltaic sands (b).

of approximately 191 m. Calkin and Feenstra (1985) have assigned shoreline features at this elevation elsewhere in the Erie basin to the Lake Lundy stage. These ridges then, most likely represent shoreline features of Lake Lundy.

Located between the Lake Erie shorebluff and the gravelly ridge extending west from Port Alma is a thin (2 to 3 m thick) deposit of low angle, cross-bedded, gravelly sand and gravel. This material was most likely deposited in a nearshore environment of Lake Lundy.

East of Chatham, sand-rich materials at an elevation of approximately 191 m likely represent deltaic sediments deposited by the Thames River in Lake Lundy. Sediments of this delta are limited in extent in the Chatham-Wheatley area, but are more extensive in the adjacent Bothwell-Ridgetown area (Cooper and Baker 1978).

There is evidence to suggest separation of waters in the St. Clair basin from those of the Huron basin during the Lundy stage (P. Barnett, OGS, personal communication, 1990). A topographic high related to the Port Huron Moraine, extending across the St. Clair River south of Corunna, has a crest elevation of approximately 192 m. A number of channels have been cut into this moraine and are especially evident on topographic maps covering the area. As water levels fell to the crest elevation of the moraine, formation of separate lakes in the Huron and St. Clair basins would have occurred. Further drops in water level would have initiated incision and downcutting through the moraine by flowing waters. Examination of channel shape and course and shape of mid-channel bars on topographic maps suggests water flowed southward.

Lake Algonquin Equivalent (?)

Shoreline features and deltaic deposits in the map area indicate the former presence of a lake in the St. Clair basin having an approximate elevation of 183 to 184 m.

Rather extensive sandy to gravelly ridges extending from south of North Buxton west to Tilbury and a lesser sandy ridge trending east, southwest of Wheatley, have surface elevations of approximately 183 to 184 m. Fitzgerald and Hradsky (1980) identified a northwest trending scarp at 183 m, north of the map area, in the adjacent Wallaceburg-St. Clair region.

In the immediate region of Chatham, thin (1 to 4 m thick), laterally extensive deposits of silt and sand overlie the previously discussed rhythmite unit (Photo 4). The contact between the 2 units is sharp. The surface elevation of these sediments lies at approximately 184 to 185 m. Sections through these sediments reveal the presence of interbedded parallel laminated and ripple cross-laminated sands with silt drapes (Figure 11). Locally, massive- to faintly-stratified silty clays may also be present. Paleocurrent measurements indicate paleoflows generally toward the southwest (Figure 11). These sediments are thought to represent the subaerial part of a delta that formed at the mouth of the Thames River. The level of the lake into which the delta was building must have been approximately 183 to 184 m.

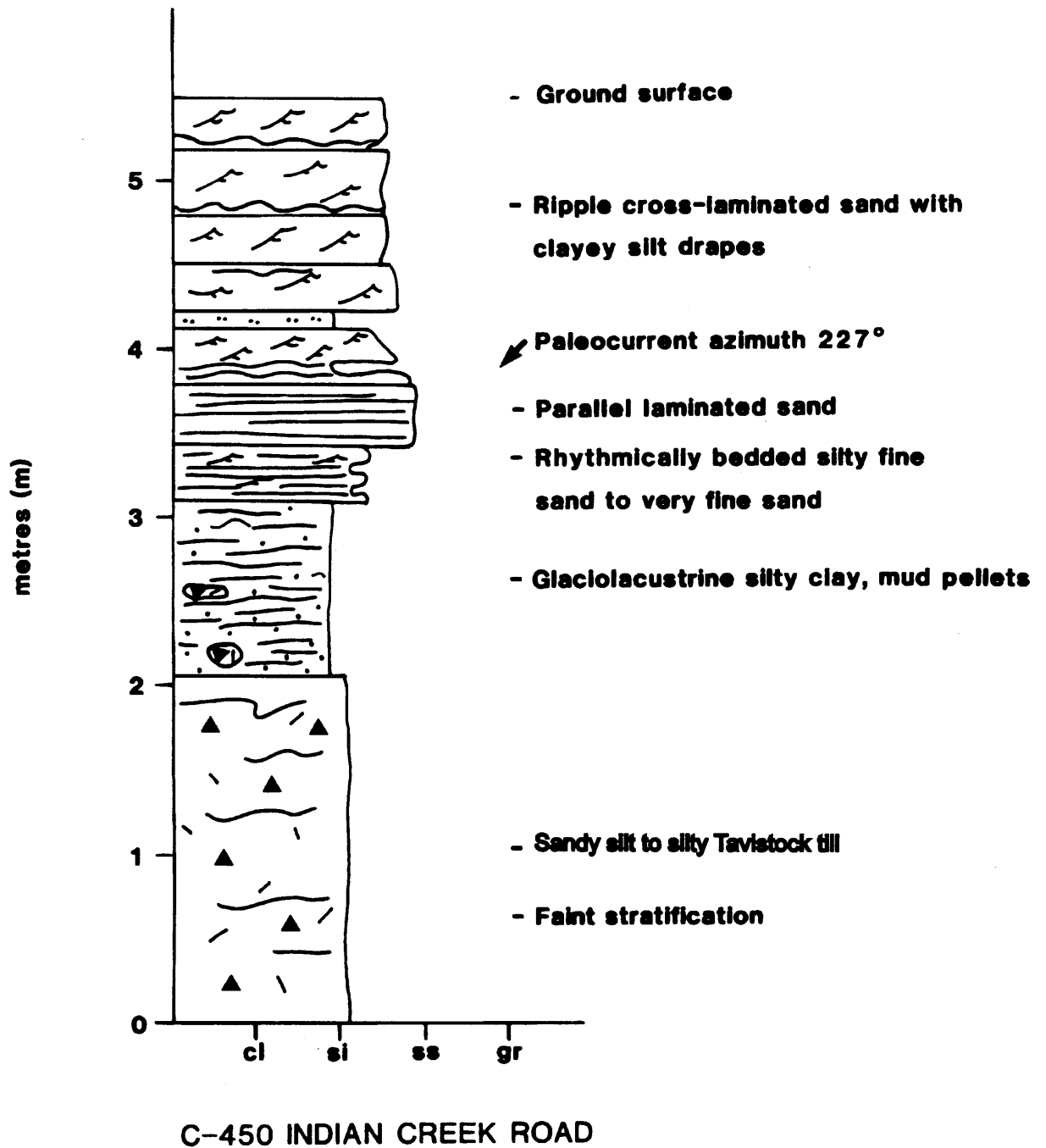


Figure 11. Excavation section at Indian Creek, UTM E405800 N4694900

West of Chatham, a fine-textured, massive, shell-rich deposit overlies the rhythmite sequence. This unit reaches a maximum observed thickness of 2 m near Lake St. Clair and thins toward Chatham, where it is covered by the deltaic sands mentioned above. The surface elevation of this unit is approximately 180 m. Correlation of these sediments is problematic but they most likely represent distal facies of the above mentioned delta.

Water level in the St. Clair basin, for this lake stage, was likely controlled by a moraine ridge across the Detroit River at Windsor. The moraine crest has an elevation of just over 185 m and has been incised by a number of channels (Morris, OGS, personal communication, 1990). This topographic high and the associated channels likely mark the outlet for a lake of elevation 183 to 184 m in the St. Clair basin.

The age of this lake is speculative. Previous studies have indicated that lake stages at approximately 184 m in the St. Clair basin occurred during early Lake Algonquin and Main Lake Algonquin time (Chapman and Putnam 1984, Eschman and Karrow 1985). Fitzgerald and Hradsky (1980) suggested that the scarp at elevation 183 m in the Wallaceburg-St. Clair area represented the presence of an early Lake Algonquin level in the Lake St. Clair basin. This elevation is similar to early Lake Algonquin levels postulated for the Huron basin (Eschman and Karrow 1985).

It is also possible that the described features are related to Main Algonquin level. Controversy exists, however, as to the possibility of a Main Algonquin stage equivalent existing in the St. Clair basin. It has been suggested that the Port Huron outlet for the Huron basin was not operative during Main Algonquin time (Kaszycki 1985; Larsen 1987). As a result, no waters from the Huron basin would have drained into the St. Clair basin. A second hypothesis suggests that the Port Huron outlet was operative during Main Algonquin, allowing waters to flow into the St. Clair basin (Eschman and Karrow 1985; Lewis and Anderson 1989). Resumed flow through Port Huron is thought to have raised water levels to approximately 184 m in the St. Clair basin during Main Algonquin time (Eschman and Karrow 1985).

Acceptance of an Early or Main Algonquin stage equivalent, or both, in the St. Clair basin must be examined in light of evidence from the Chatham-Wheatley and neighbouring regions. First, following Lake Lundy time, the moraine at Corunna would have separated the St. Clair basin from the Huron. Thus, water levels in the St. Clair basin would be increasingly controlled by barriers south of the St. Clair basin and by water level fluctuations in the Erie and Ontario basins. As water levels fell to the Early Algonquin level in the Huron basin, the moraine at Corunna would have been incised to an unknown elevation. Water level equivalency between the southern Huron and St. Clair basins may or may not have been achieved at this time. The important factor in controlling lake level in the St. Clair basin to an elevation of 183 to 184 m would have been the moraine at Windsor. Therefore, a lake nearly equivalent in time with the Early Algonquin stage in the Huron basin is possible.

A second piece of evidence suggests early subaerial exposure of sediments in the St. Clair basin. In the Wallaceburg map area, Dreimanis (1964) recovered *in-situ* wood from the surface of a sediment unit having similar lithology and stratigraphic position to the distal deltaic facies described west of Chatham. The elevation of the sediment unit was approximately 177.5 m. Radiocarbon dating of wood provided an age of 12,000 +/- 200

years. Dreimanis (1964) suggested that temporary lowering of water levels in the St. Clair basin occurred when the inflow of water from Lake Huron was cut off as ice retreat allowed the Kirkfield outlet to open, causing waters in the Huron basin to drain eastward. The resulting low water level in the Huron basin has been termed the Kirkfield low water stage (Dreimanis 1964). Dreimanis (1964) suggested that low water levels and subaerial exposure of sediments would have occurred in the St. Clair basin at this time.

Alternatively, subaerial exposure of sediments in the St. Clair basin may not have been related to opening of the Kirkfield outlet. Instead, during Early Lake Algonquin time, existence of low water levels in the Erie basin (Eschman and Karrow 1985; Calkin and Feenstra 1985) accompanied by continued downcutting through the barrier at Windsor may have effectively drained waters below the 183 to 184 m level in the St. Clair basin. Subaerial exposure of previously submerged land would have occurred at this time.

The existence of a Main Algonquin stage equivalent in the St. Clair basin does not hinge on whether waters did or did not flow through the Port Huron outlet of the Huron basin. The controlling factor would again be the moraine barrier at Windsor. If this barrier was previously eroded during Early Algonquin time to a low enough level, then no high, Main Algonquin level could have been achieved in the St. Clair basin. It would seem to be reasonable then, that the above described shoreline and deltaic sediments from the Chatham-Wheatley area are most closely associated in time with Early Lake Algonquin. It should also be noted that Morris (1994) has mapped glaciolacustrine sediments in the Windsor area that are ascribed to Lake Rouge. Lake Rouge is thought to have been a short-lived lake that formed part of a discharge route from Early Lake Algonquin (Lake Huron basin) and Early Lake St. Clair to Early Lake Erie (Vagners 1972a, 1972b).

The poorly defined sand ridge southwest of Wheatley, at 183 m, was likely formed in a short-lived lake stage in the Erie basin. This lake stage was not likely time equivalent with the above discussed lake in the St. Clair basin. Instead this level may have formed at an earlier time following immediately after Lake Lundy.

Lower Level Lakes

Poorly defined shorelines at 180 m and 177 m are found around Lake St. Clair. A poorly defined ridge along the north shore of Lake Erie in the vicinity of Wheatley, at 180 m, was also identified. Additionally, terraces are present along the Thames River at these levels, with the 180 m level being most pronounced. West of Chatham small sand-rich deltas are present having surface elevations of approximately 180 and 177 m respectively.

The 180 m level lake has been observed in the adjacent map areas of Windsor-Essex (Morris 1994) and Wallaceburg-St. Clair Flats (Fitzgerald and Hradsky 1980). The age of this lake is speculative. Two possibilities exist: firstly, that this level is simply a lower stage in the St. Clair basin following the 183 m level (the speculated Early Algonquin stage equivalent) lake; or secondly, the lake is a much later stage representing a transgression of water level from a low stage in the Erie and St. Clair basins up to the 180 m level.

The first scenario seems unlikely. The elevation of the *in-situ* wood collected by

Dreimanis (1964) described above is nearly 3 m lower than the 180 m water level of this stage. It is doubtful that sediments in the St. Clair basin would have been uncovered to the 177.5 m level during a simple fall in lake level from the 183 m stage to the 180 m level.

The second hypothesis may be most reasonable. Evidence of a late, high level lake in the Erie basin and radiocarbon dates from the base of the St. Clair delta seem to support this suggestion.

Barnett (1985) has recognized hanging terraces in the Port Burwell area at approximately 180 m, which he attributes to a late, high water level stage in the Erie basin. A transgression of water level would have occurred in the Erie basin due to isostatic rebound and closing of the Niagara Falls outlet. Coakley (1989) describes a gradual water level transgression in the Erie basin after approximately 12 000 years BP, punctuated by a rapid rise at 4 500 years BP. Water levels rose to approximately 178 m at 4 000 years BP (Coakley 1989). The cause of this rapid rise was ascribed to increased inflow to the Erie basin from northern sources (Coakley and Lewis 1985).

Basal organics collected below the sediments of the St. Clair delta provided an age of 7 300 +/- 80 years BP (Wrightman 1961). Construction of the delta is thought to have been initiated at approximately 7 000 years BP (Wrightman 1961; Pezzetta 1968; Raphael and Jaworski 1982).

Fitzgerald and Hradsky (1980) have mapped older river alluvium along the St. Clair river, north of the St. Clair delta, which has an upper elevation of approximately 180 m. These sediments likely mark the upper surface for an early St. Clair delta which is time correlative with the features identified in the Chatham-Wheatley area at the 180 m level.

Two possibilities may explain the establishment of a late stage level of approximately 180 m in the St. Clair basin. Firstly, uplift of the Niagara Falls outlet for Lake Erie would raise water levels in that basin. Rising waters in the Erie basin would be able to flow into the St. Clair basin since no barriers along the Detroit River existed to block water movement. Secondly, previous work indicates that the Port Huron outlet became operative during the Nipissing lake stage (Eschman and Karrow 1985; Lewis and Anderson 1989). Resumption of flow southward through this outlet into the St. Clair basin accompanied by rising water levels in the Erie basin may account for the establishment of a lake of elevation 180 m in the St. Clair basin.

A lower level lake having an elevation of 177 m is represented by a series of sand-rich ridges around Lake St. Clair. Immediately west of Grande Pointe a small sand-rich delta having a surface elevation of 177 m likely was built into this lake. Ditch cuts near lake St. Clair revealed sands containing concentrations of freshwater shells. The presence of *Goniobasis sp.*, a species first appearing during Nipissing time, provides a valuable time marker (Bajc, OGS, personal communication, 1990). Formation of these beaches and subsequent lower levels must be Nipissing age and younger.

Iceberg Keel Marks

In the vicinity of Tilbury, and areas north and west, peculiar dark lines were noted on airphotos (Photo 5). These lines are thought to represent remnant keel mark furrows originally developed by ice blocks that were floating in the post-glacial lakes that covered the area. Evidence of these marks on the ground surface is poor. Agricultural activity has obliterated most of the original furrows. The dark lines on airphotos are likely visible due to differential drainage between keel mark furrows and surrounding sediments. Similar features have been noted on airphotos from the Windsor area by Morris (1994).

NON-GLACIAL DEPOSITS AND FEATURES

Older Alluvium

Older alluvial deposits are found in abandoned high-level flood plains along rivers and streams. Older alluvial deposits comprise a significant depositional environment within the study area. These sediments were laid down by older rivers or streams that flowed into high-level lakes in the Erie and St. Clair basins. Each terrace level represents a different stage in the general lowering sequence of glacial lakes in the lake basins until the time of Early Lakes Erie and St. Clair.

Three abandoned terraces were identified in association with the Thames River, at elevations of 184 m, 180 m, and 177 m respectively. The 180 m level is the most pronounced terrace level. Other older alluvial deposits are found in association with the smaller streams that cross the area. Extensive lateral migration of these streams has produced large areas of gently rolling and variably textured terrain west and northwest of Chatham. Higher ridges represent point and scroll bar deposits, while low areas are considered to be swales. The texture of these deposits is variable, reflecting variation in eroded source material and depositional environment. In general, higher areas (point and scroll bars) are silty to sandy while low-lying swales are clay- and silt-rich. Very limited physical and geochemical data for these sediments are presented in Appendices A and C.

Modern Alluvium

Sediment that has been deposited along rivers and streams in the recent past is termed modern alluvium. Modern alluvium may accumulate as lateral accretion deposits on bars in rivers or as vertical accretion material on floodplains. The texture of this material is a function of source materials in the drainage area and depositional processes. In the study area the low-lying nature of the land in many areas has resulted in diversion of streams and the construction of levees along the lower reaches of the Thames River to prevent flooding. The deposition of modern alluvial sediments has been effectively restricted in these locations.

East and northwest of Chatham, and near Wheatley, modern alluvium in streams and the Thames River is predominantly silty or sand-rich with disseminated organic matter



Photograph 5: Iceberg keel marks (a) in glaciolacustrine sediments

fragments. In some stretches of the Thames River, east of Chatham, modern alluvium may be 2 to 3 m thick. Modern alluvium in other areas of the Chatham-Wheatley area is predominantly silt or clayey silt with small disseminated organic matter fragments. Materials in these areas reflect erosion of clay- and silt-rich till and glaciolacustrine deposits.

Eolian Deposits

Eolian processes have modified some sand-rich areas into small dunes imparting a rolling topography to the landscape. Examples of barchanoid ridge, barchan and linear dunes (McKee 1979) occur in the area. Dunes are developed on glaciolacustrine and deltaic sands south and northeast of Chatham (map back pocket). Linear dunes, 2 to 3 m in height, are most commonly found northeast of Chatham. Some present-day barchanoid ridge and barchan dunes in the study area reach nearly 7 to 8 m in height. Some of these dunes have been utilized as an aggregate resource and were probably much thicker in the past. The dunes are composed primarily of fine to medium sands and silts (Figure 12). A selected sample analysis is presented in Appendix A.

Dune formation has been suggested by Barnett (1978) to follow exposure of land after the lowering of glacial lakes. Barnett (1982) has also indicated that dune formation may have been initiated by the clearing of land by early settlers.

Marsh and Swamplands

The relatively flat landscape and minimal elevation of the land surface above the waters of Lake St. Clair west of Chatham and Lake Erie south of Wheatley produced large areas of marsh and swampland in these areas. Artificial drainage of large portions of this terrain for agriculture has removed much of this environment. Conservation areas at Point Pelee National Park, on Lake Erie, and along the margin of Lake St. Clair remain as the only relatively undisturbed examples of this environment in the Chatham-Wheatley area.

STRATIGRAPHY

Completion of 13 sonic drillholes and additional examination of natural Lake Erie bluff and man-made exposures provided a basis for the interpretation of the Quaternary stratigraphy and history of the area. Locations of drillholes and bluff sections are provided in Figure 13. A summary for each drillhole is provided in Appendix F.

Lake Erie Bluff Sections, Wheatley Provincial Park to Tunnel Drain

Between Wheatley Provincial Park and the Tunnel Drain, some 9 km to the east, the Lake Erie bluffs range in height from < 4 m at Wheatley to > 12 m in the east. Throughout this stretch the bluffs consist primarily of massive to faintly stratified, clayey silt Port Stanley Till. In some

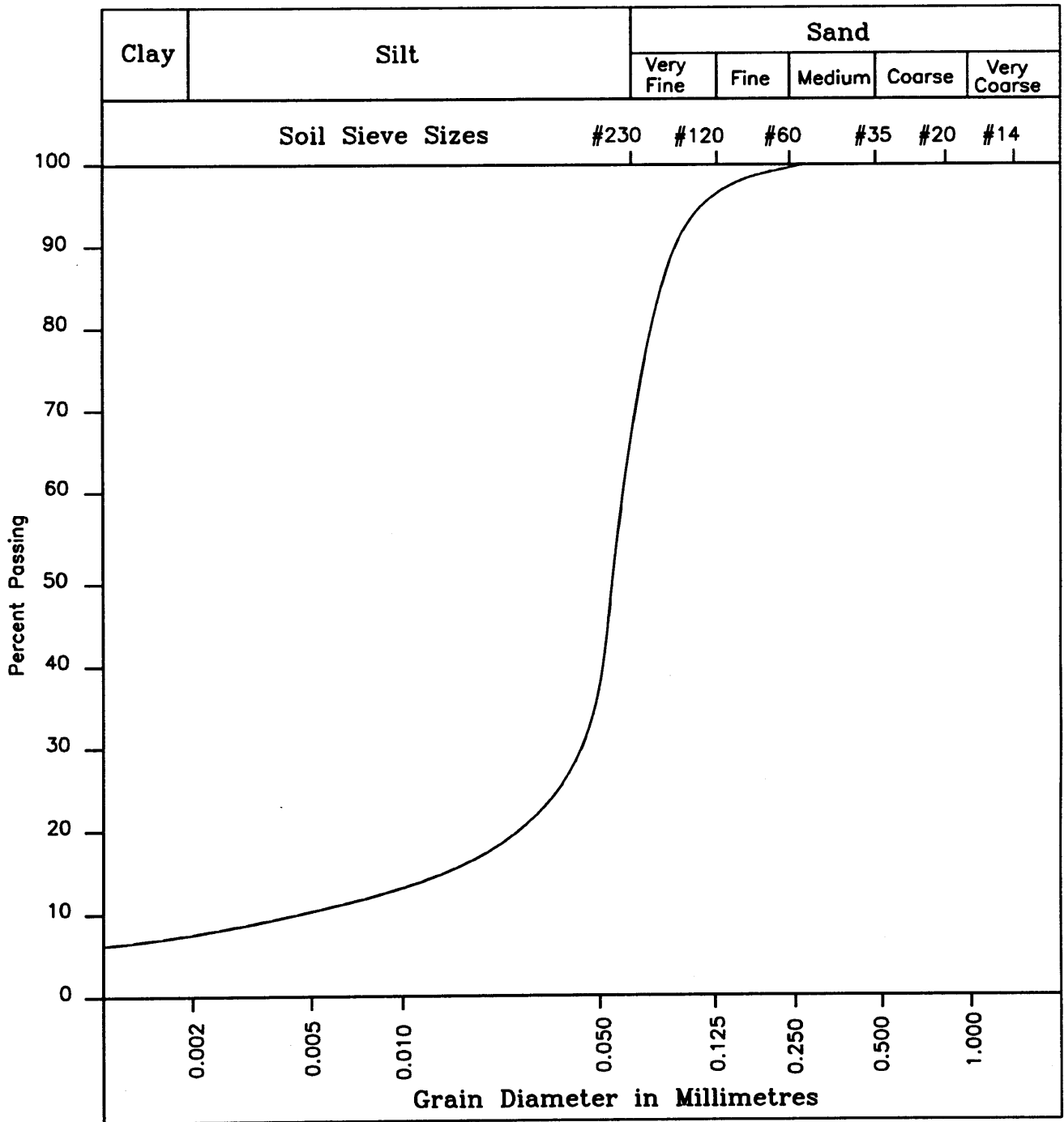


Figure 12. Grain size curve from eolian sand dune deposit, northeast of Chatham.

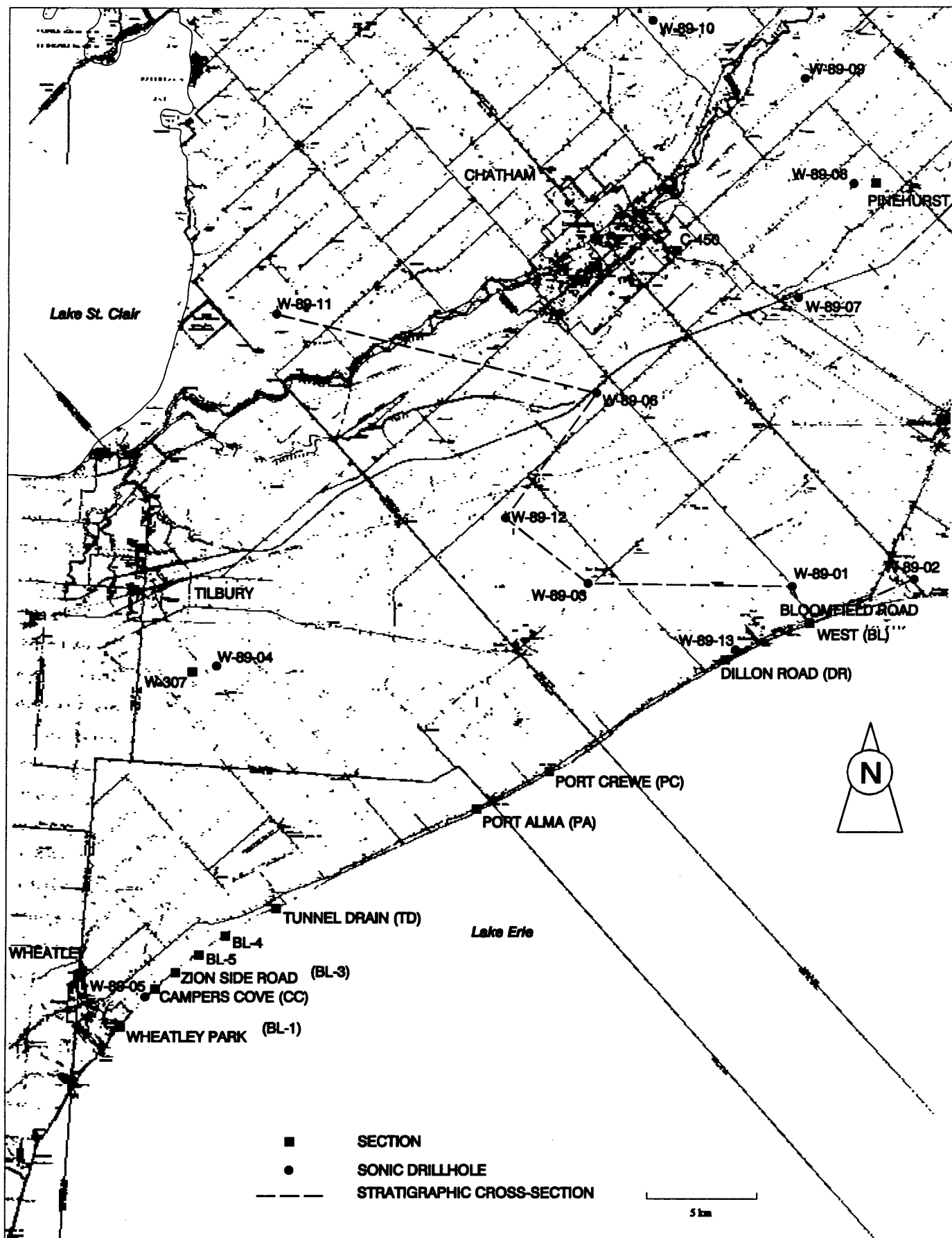


Figure 13. Location of sonic drillholes and studied bluff sections, stratigraphic cross-section is shown in Figure 24.

areas the lower 2 to 3 m of till contains silt and very-fine sand stringers and shear lenses of reddish, clay-rich diamicton. The shear lenses rise at a low angle to the northwest indicating ice movement out of the Erie basin. The remainder of the bluffs consist predominantly of massive, clayey silt till with faint, low-angle shear planes rising to the northwest. Within this massive Port Stanley Till, thin lenses containing pinkish and whitish mud pellets were noted. Till fabric analyses, 1 from each of the 3 locations examined, indicate ice movement toward the northwest to north (Figure 14). Pebble counts from bluff sections, 1 per site, show a predominance of black shale, 27 to 37%, and sparitic limestones, 23 to 32% (Figure 15).

Port Alma Bluff Section

The section consists almost entirely of massive, clayey silt Port Stanley Till that exhibits shear planes and weak fissility (Figure 16). Thin zones of stratified diamicton comprising reddish mud pellets, faint lamination and flow structures occur within the massive till. These zones are thought to have been deposited when glacial ice detached from its bed to partially float in a glacial lake, allowing localized meltout of sediments. A sand ball, incorporated within the massive till, located 2 m above lake level was found to contain small shell fragments. This sand ball may represent older interstadial sediments incorporated by overriding glacial ice.

A till pebble count showed a predominance of black shale (37%), dolostone (18%), and sparitic limestone clasts (14%) (Figure 17). Till fabric analysis indicated ice flow direction to the northeast (348°) out of the Lake Erie basin (Figure 18).

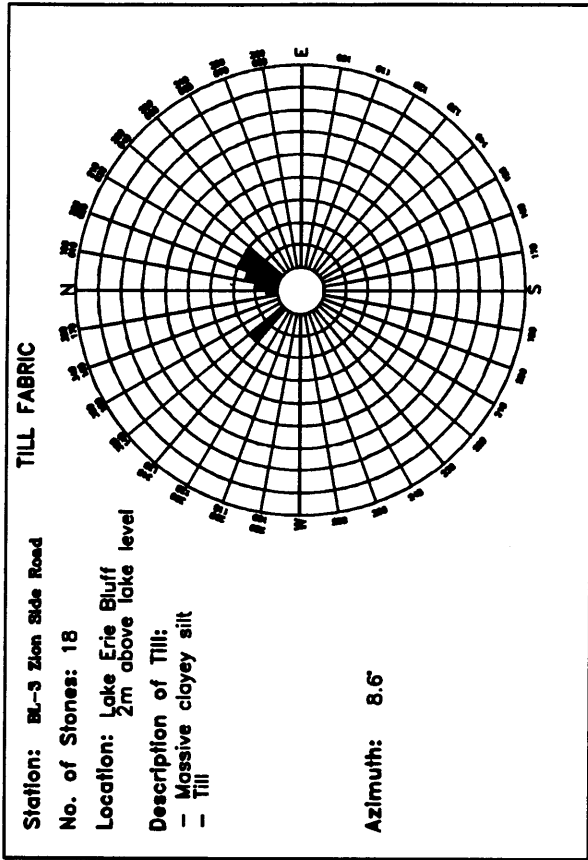
Unconformably overlying the till is a 2 to 3 m thick unit of low angle cross-bedded sandy gravel (Figure 16). This unit is interpreted to be a nearshore deposit of glacial Lake Lundy.

Port Crewe Bluff Section

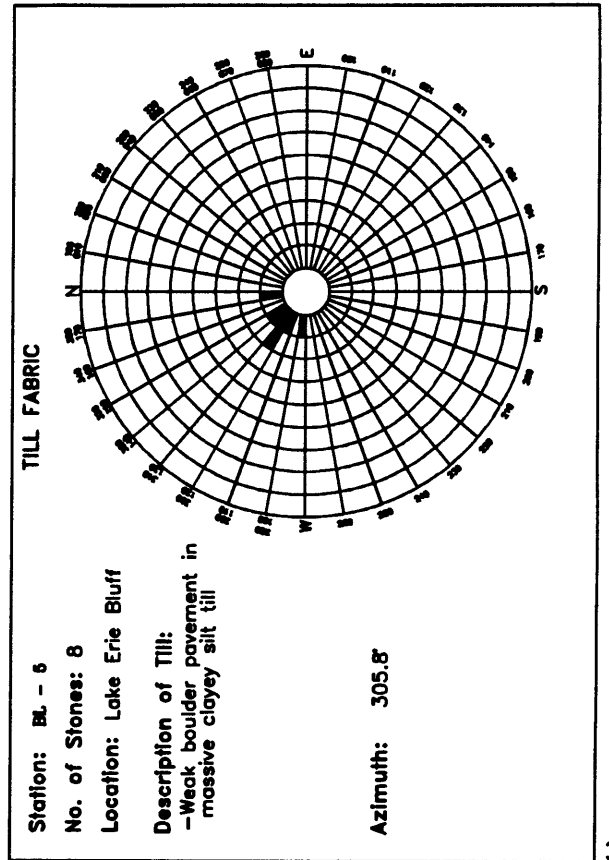
A 19 m high section at Port Crewe exhibits, at its base, a 2 m thick sequence of interbedded silty clay diamicton and thin (2 to 5 mm thick) layers of very fine- to fine-grained sands, conformably overlain by massive- to faintly-stratified clayey silt till. The till exposed within this section is interpreted to be a Huron lobe deposit. It is correlated with the Tavistock Till, which was observed to be the surface till throughout much of the map area. A pebble fabric from the massive till indicates ice flow toward the southeast (170°) (Figure 19). Pebble counts from the lower and upper parts of the section are shown in Figure 20.

Dillon Road Bluff Section

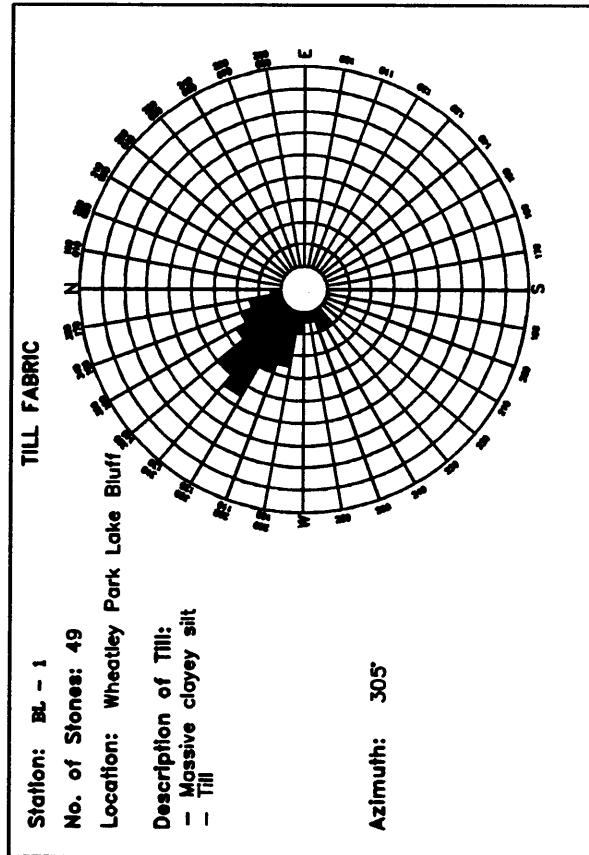
The section consists of a lower sequence of massive to stratified till, correlated with Port Stanley Till, unconformably overlain by a coarsening up sequence of sand to gravel (Figure 21).



(b)

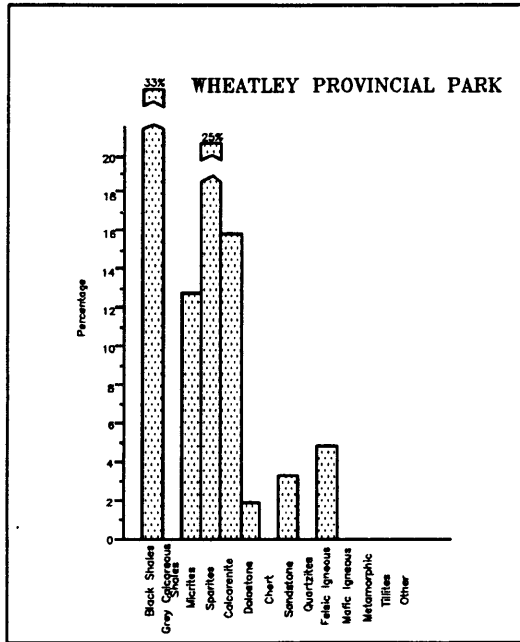


(c)

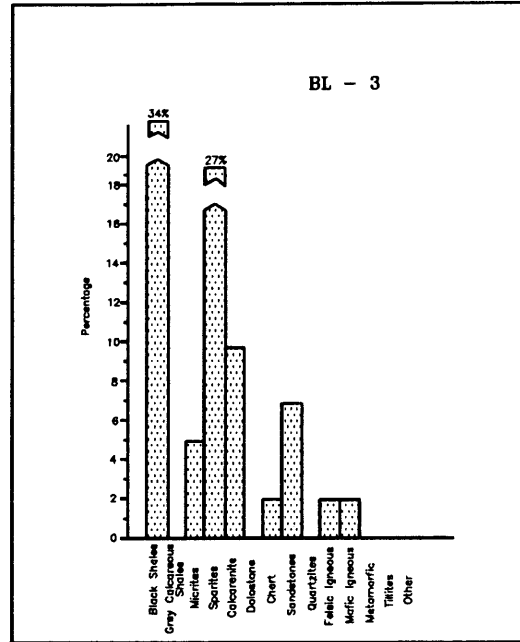


(a)

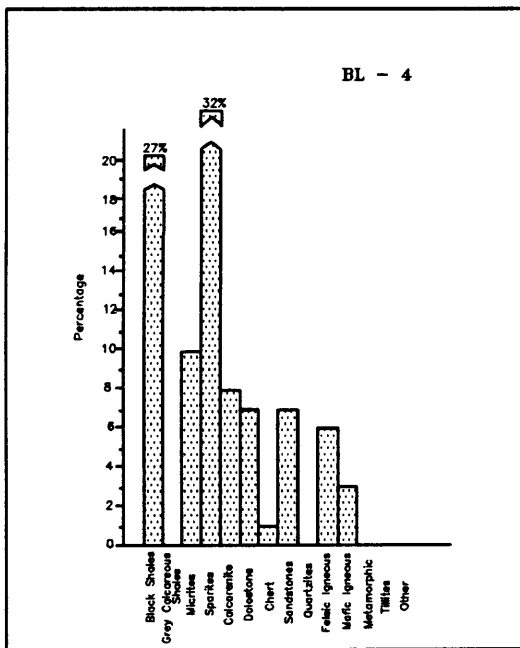
Figure 14. Till pebble fabrics from bluff sections Wheatley to Tunnel Drain,
 (a) Wheatley Provincial Park, E383400 N4660500,
 (b) section BL-3, UTM E383400 N4662800,
 (c) section BL-5, UTM E384200 N4663500.



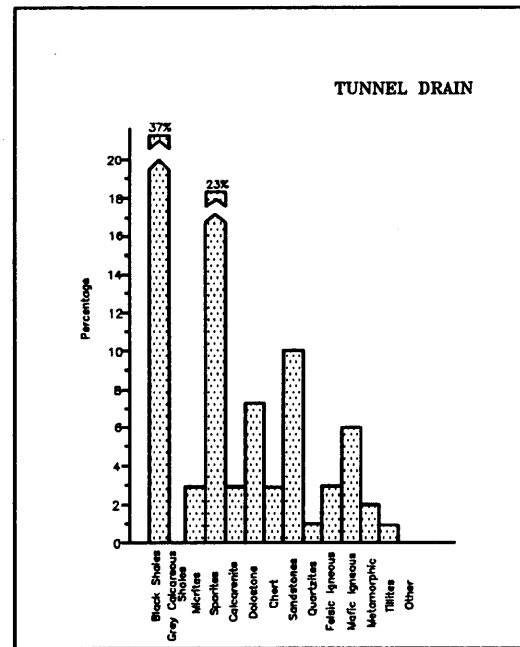
(a)



(b)



(c)



(d)

Figure 15. Till pebble lithologies from bluff sections, Wheatley to Tunnel Drain, (a) Wheatley Provincial Park, (b) section BL-3, (c) section BL-4, (d) Tunnel Drain, UTM E388300 N4665900.

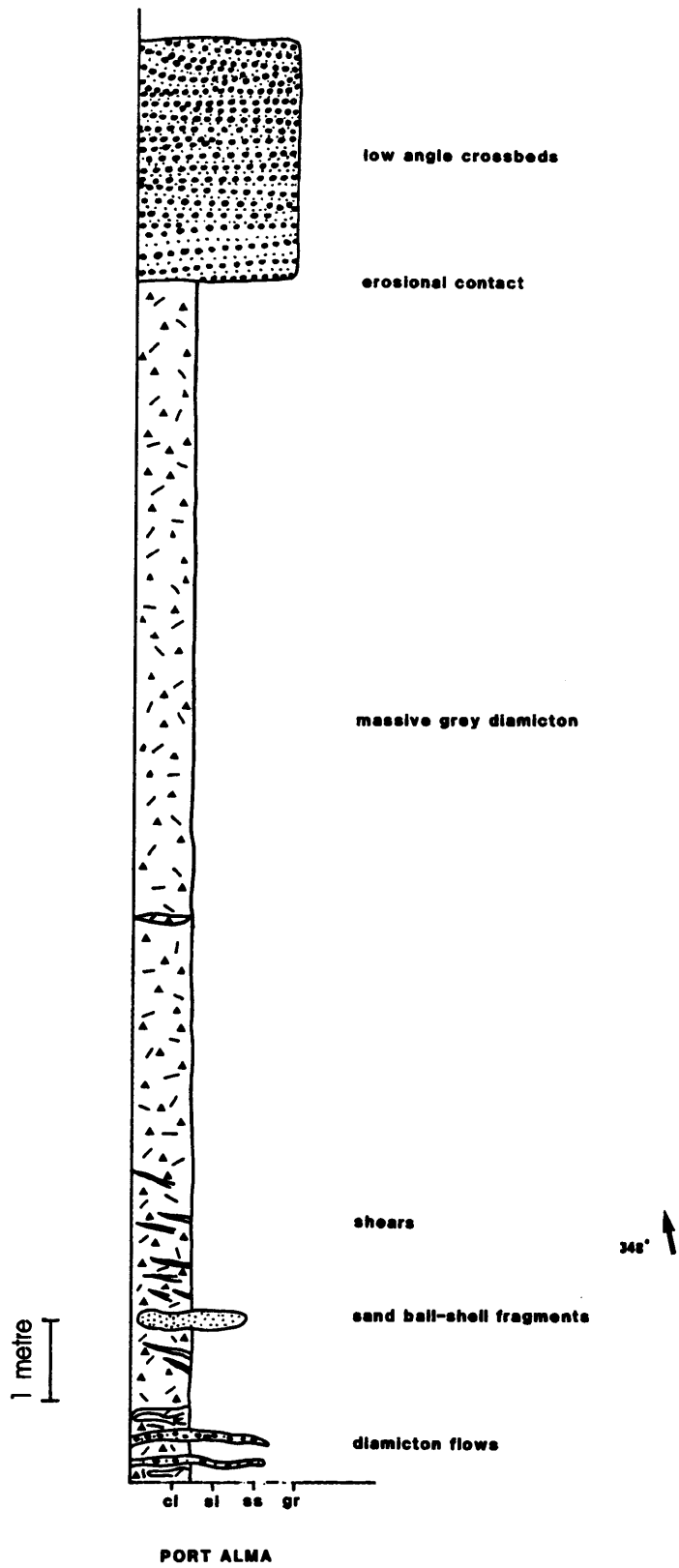


Figure 16. Bluff section diagram, Port Alma UTM E397200 N4670200
 See Appendix F for legend.

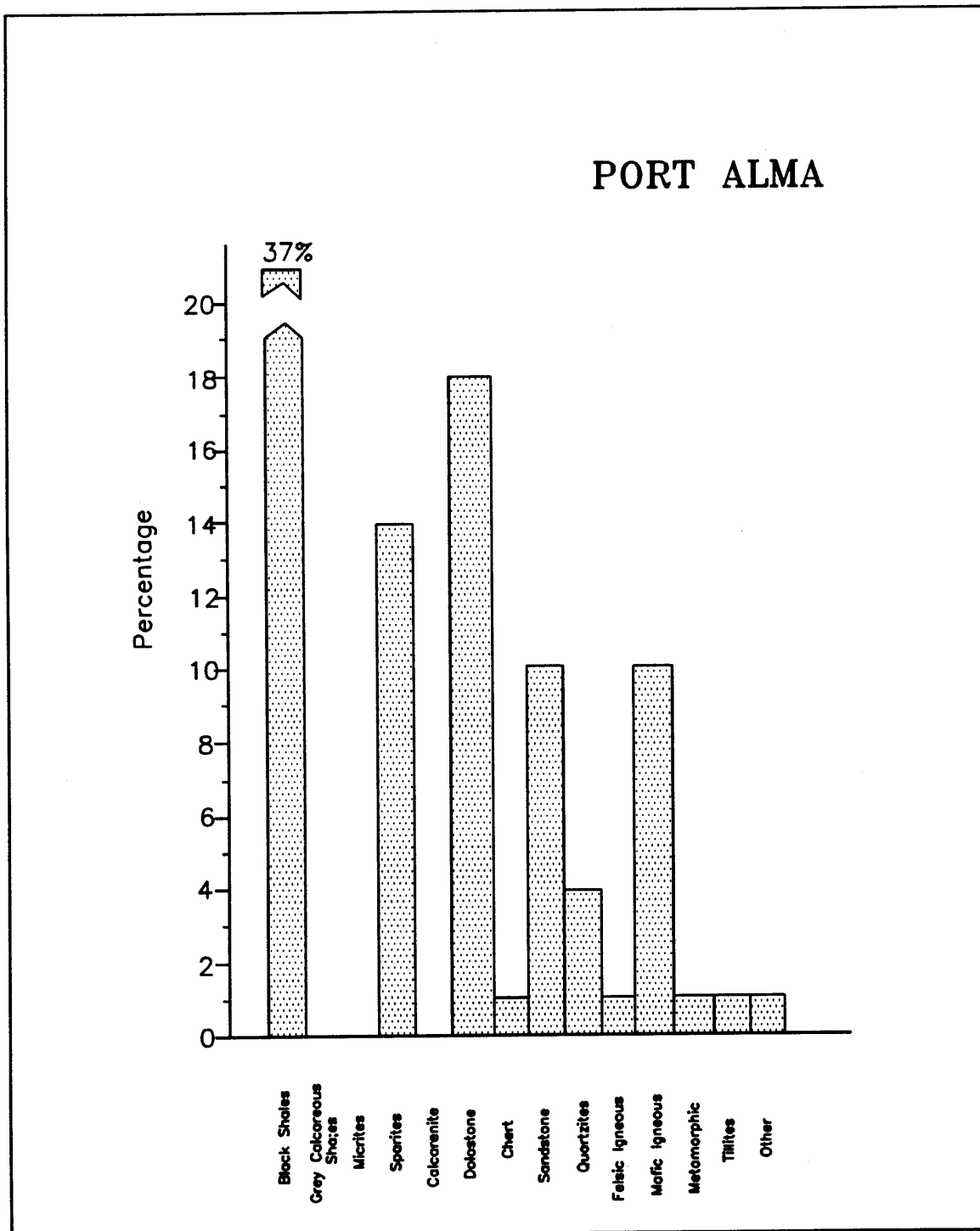


Figure 17. Till pebble lithology, Port Alma bluff section

TILL FABRIC

Station: Port Alma West

No. of Stones: 53

Location: Base of Lake Erie Bluff

Description of Till:

- Massive to faintly stratified clayey silt
- Till

Azimuth: 348°

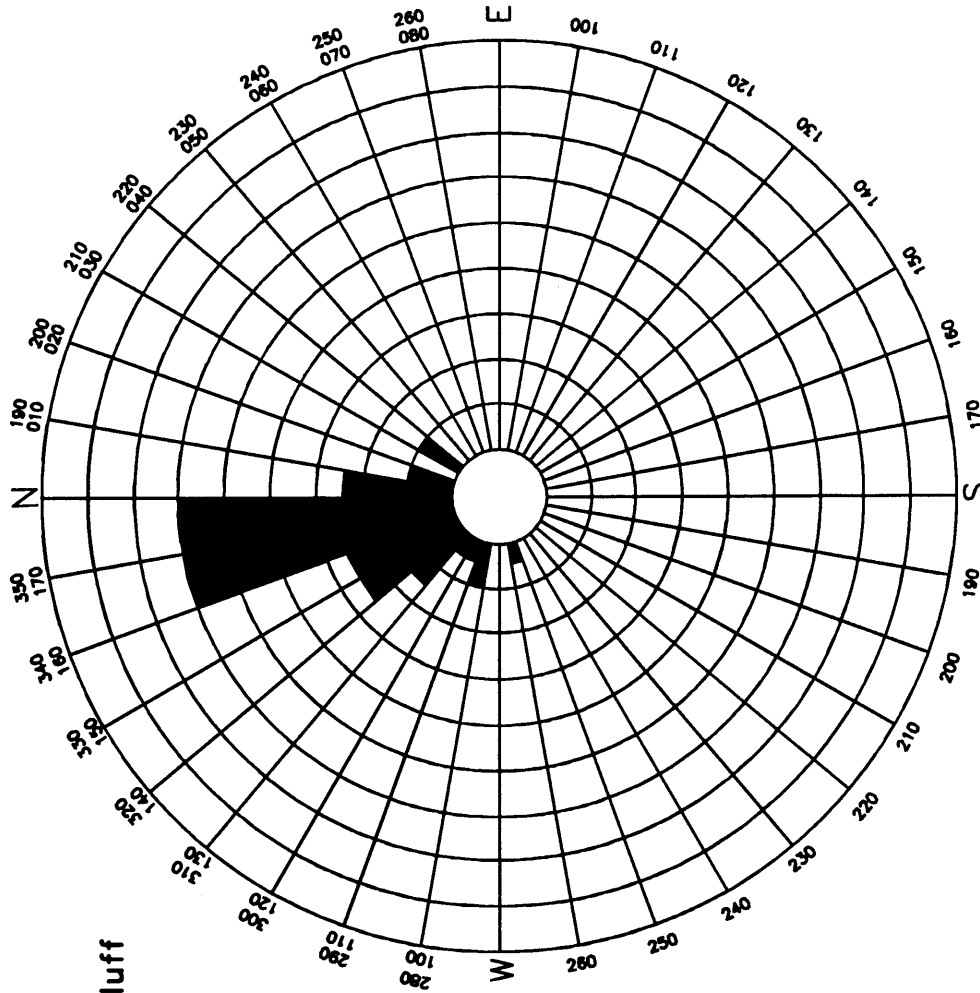


Figure 18. Till pebble fabric Port Alma bluff section.

TILL FABRIC

Station: Port Crewe

No. of Stones: 5

Location: Base of Lake Erie Bluff

Description of Till:

- Boulder pavement in massive clayey silt till

Azimuth: 170°

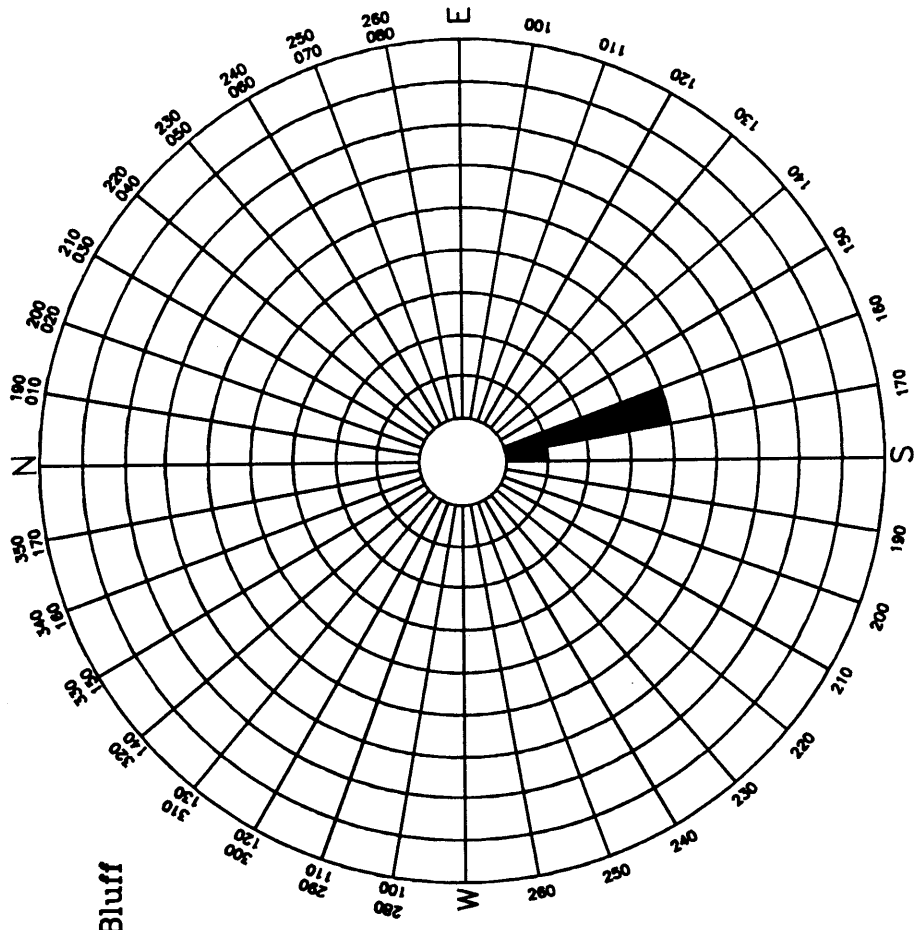
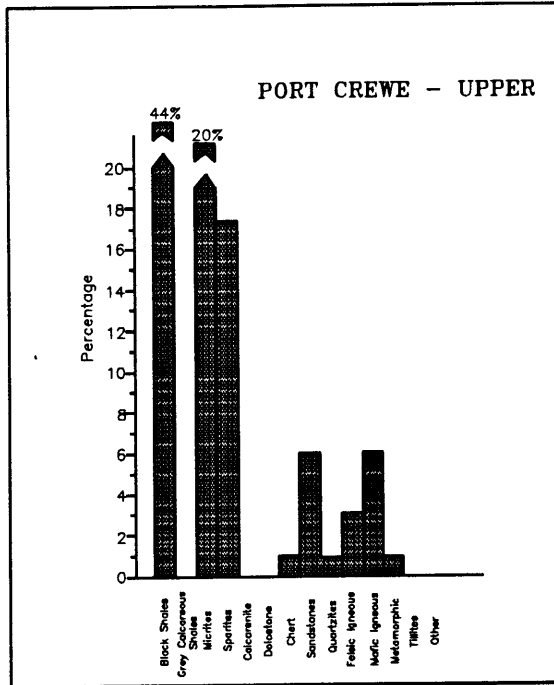
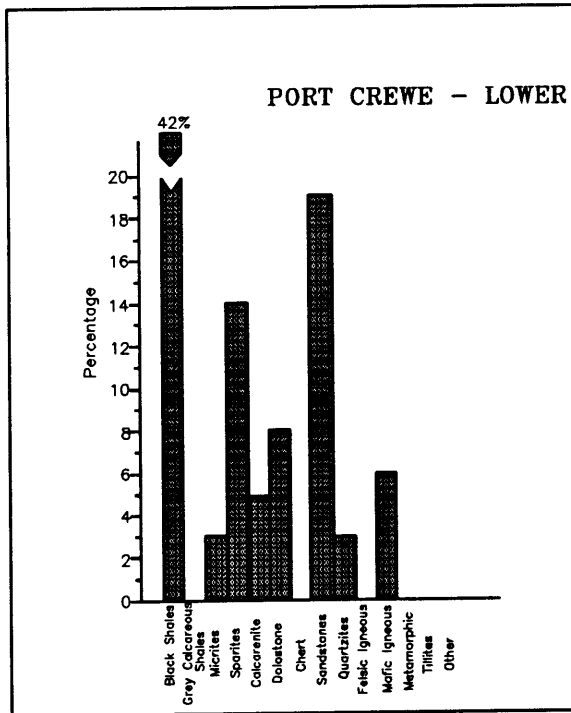


Figure 19. Till pebble fabric from boulder pavement at base of Port Crewe bluff section, UTM E400300 N4671800.



(a)



(b)

Figure 20. Till pebble lithology, Port Crewe Bluff section, (a) upper part of section, (b) base of section.

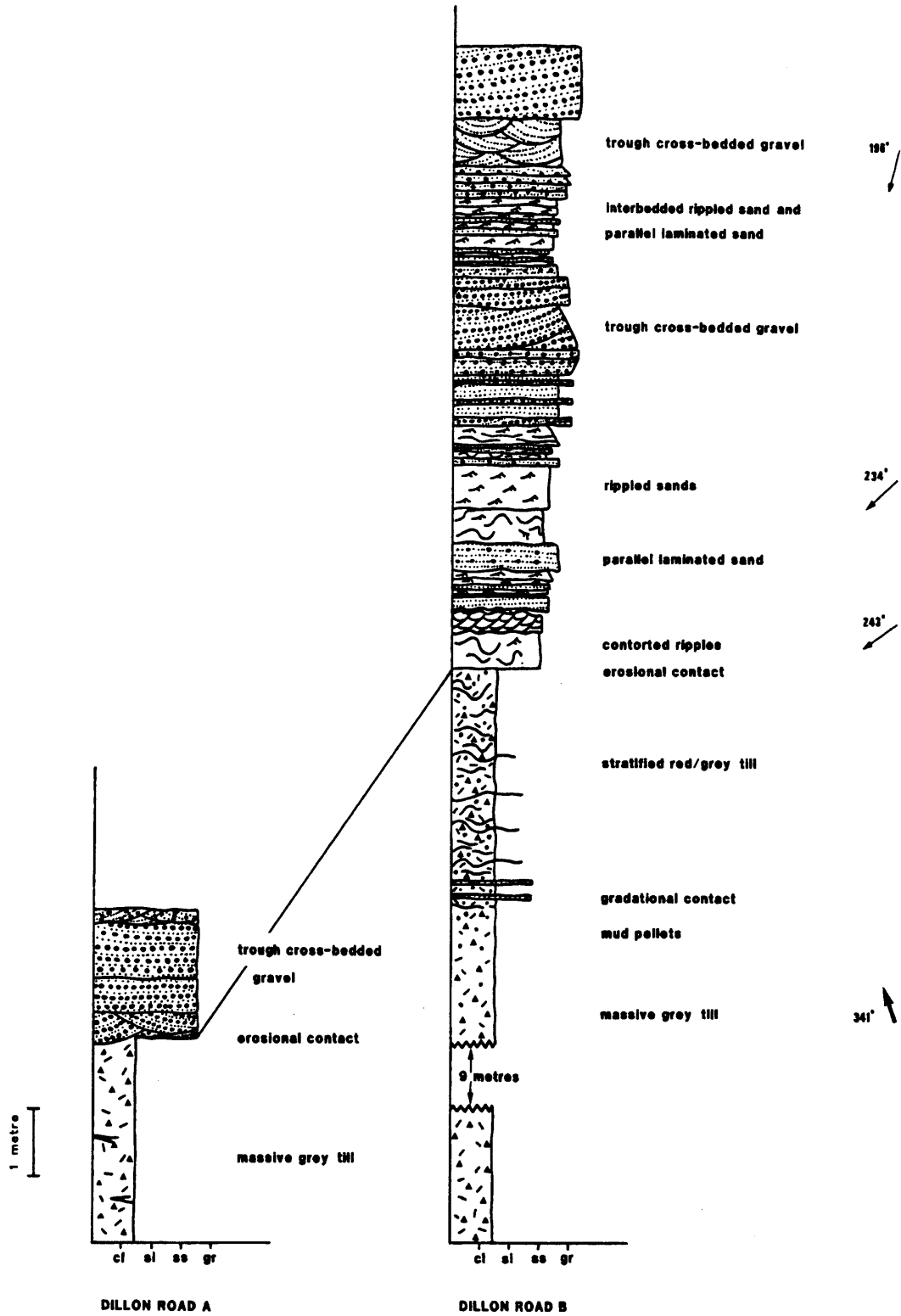


Figure 21. Bluff section diagram, Dillon Road, UTM E408500 N4676900. See Appendix F for legend.

The till sequence consists of a lower, massive, silty clay till grading upward into faintly stratified till and finally into stratified till containing distinct lenses of reddish diamicton, mud pellets, sand stringers and faint lamination. The lower, massive till contains a weak boulder pavement with clasts dipping steeply, 15 to 20°, to the southeast. A number of clasts showed characteristic bullet shapes and well-developed striations. Ice flow toward the northwest, out of the Erie basin, is indicated. The upper part of the sequence is interpreted to represent a glaciolacustrine environment developed in an ice marginal position as the Erie ice margin retreated. Diamicton derived from the ice sheet periodically flowed into the glaciolacustrine environment to become interbedded with glaciolacustrine sediments.

The contact between the till and overlying sand and gravel is erosive. Indications are that large channels were cut into the till sequence and subsequently infilled with a coarsening up sequence of sand and gravel. The sand and gravel sequence progresses upward through rippled and deformed fine sand, interbedded rippled and parallel laminated sand, flat-bedded pebbly sand, trough cross-bedded pebbly sand and gravel, and finally low-angle cross-bedded gravel (Figure 21). Paleocurrent measurements obtained from rippled sands within the section indicate paleoflows toward the southwest (Figure 21). Deposition of these sediments is interpreted to have occurred as ice of the Huron and Erie lobes retreated slightly north and southeast respectively, allowing and forcing glacial meltwater to flow southwest into an ice marginal lake. Initially, meltwaters eroded the till surface and subsequently infilled the channels with an upward coarsening sediment sequence which is best interpreted as deltaic.

Bloomfield Road Bluff Section

This section comprises a sediment sequence similar to the Dillon Road section. A coarsening up package of sand to gravel unconformably overlies a sequence of massive to stratified Port Stanley Till (Figure 22). Differences in the 2 sections are evident, including: a sharp rather than gradational contact between the massive and stratified till; a sharp, but locally loaded, contact between the till and the overlying sand-gravel succession; rhythmically bedded sand and silt at the bottom of the coarsening up package; and, 2 sets of water escape features in the lower and middle parts of the sand-gravel sequence. The water escape structures indicate local instability in the deltaic sequence induced, perhaps, by rapid water level fluctuations, rapid sediment loading, storm waves or waves generated by iceberg calving. Paleocurrent measurements from the sand-gravel succession indicate paleoflows toward the southwest and west in the lower and middle part of the sequence and toward the northwest in the top part of the sequence. This change in paleocurrent in the upper part may reflect reworking of the original glaciofluvial sediments by waves and currents of glacial Lake Warren that formed a spit around the southeast end of the Blenheim Moraine.

Pinehurst - Huron Sand and Gravel Pit

Removal of overburden to provide access to a buried aggregate body revealed a small but significant section (Figure 23). This section exposed the uppermost part of the buried aggregate sequence and an overlying glaciolacustrine/till/glaciolacustrine succession.

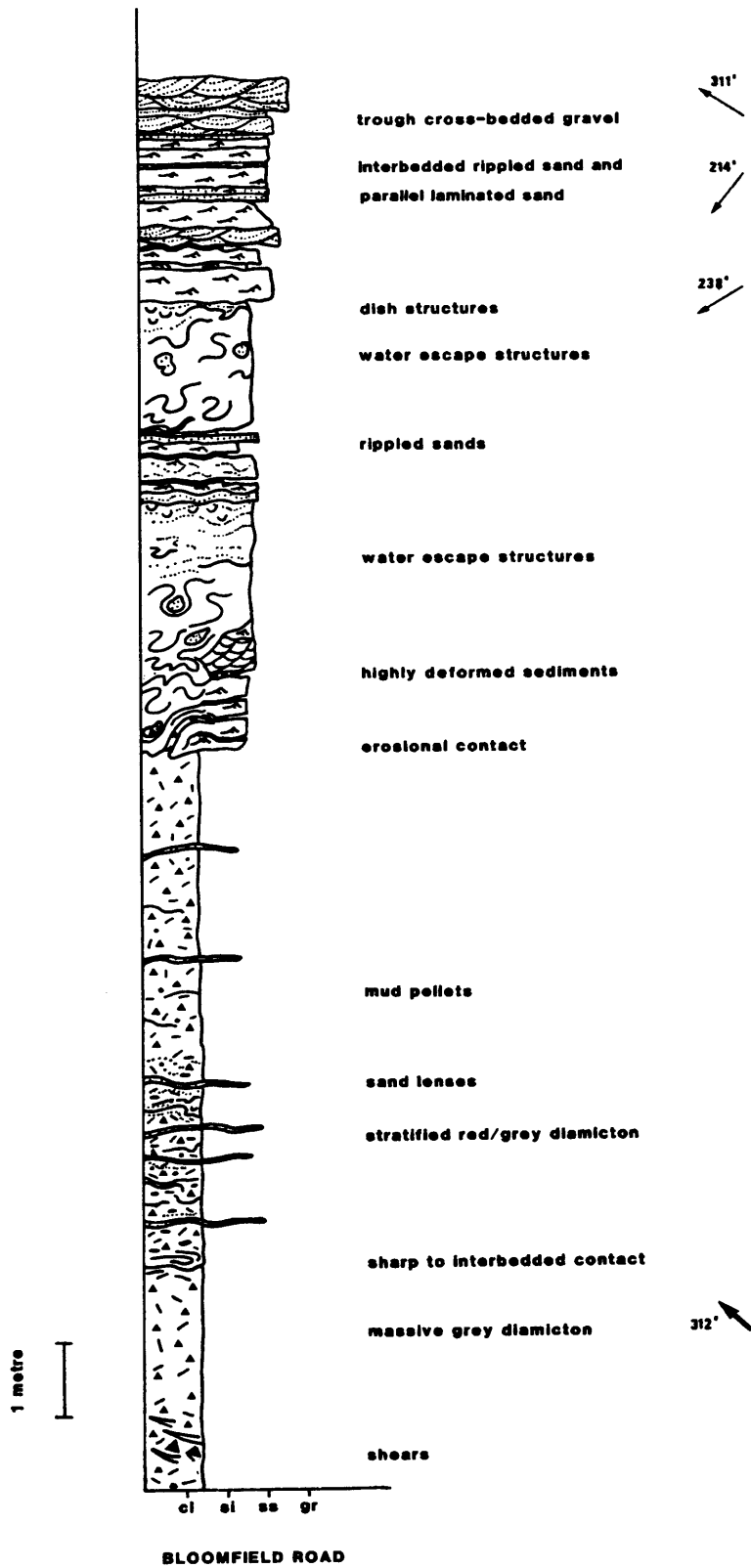


Figure 22. Bluff section diagram, Bloomfield Road, UTM E411600 N4678400. See Appendix F for legend.

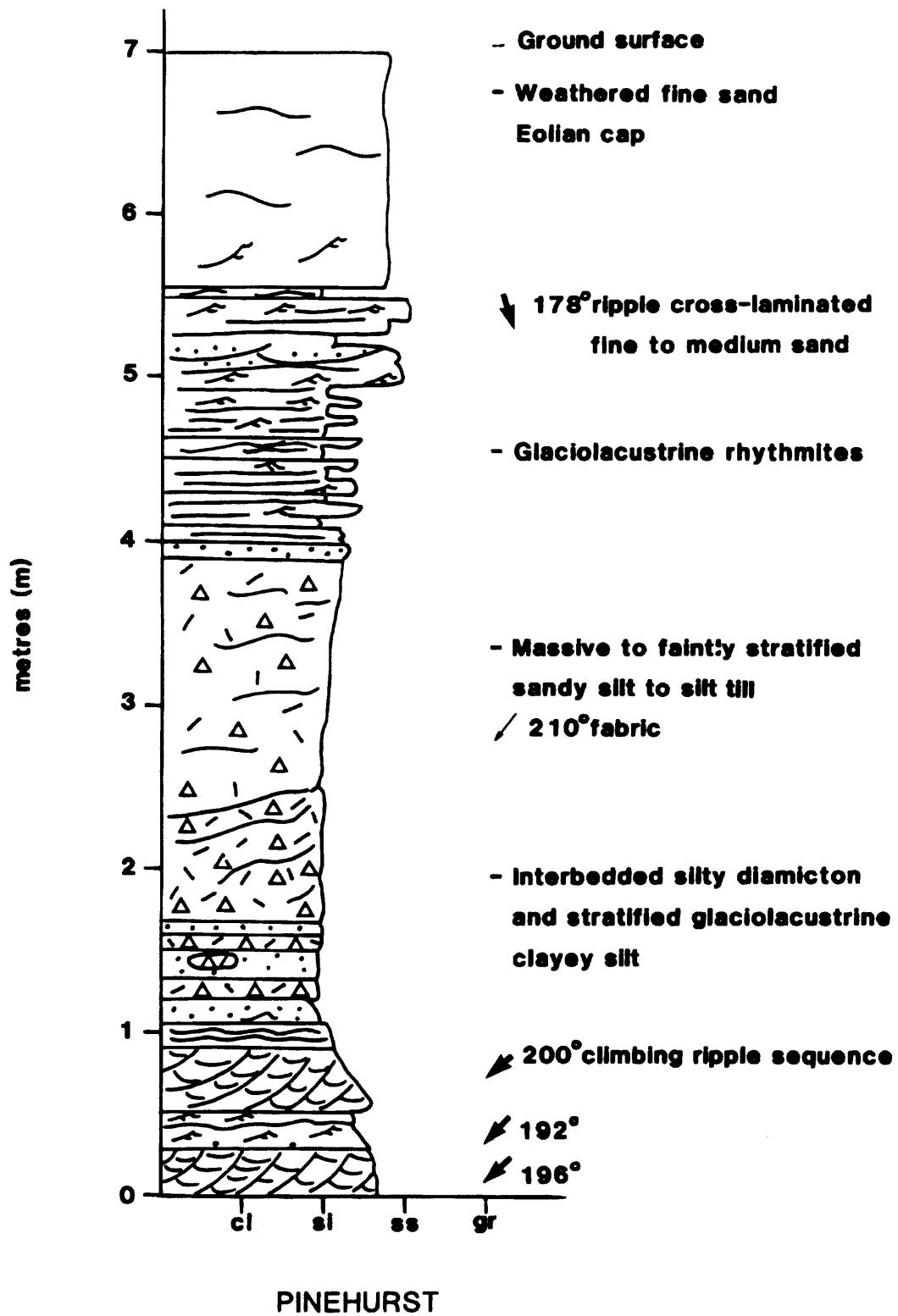


Figure 23. Exposed section at the Huron Sand and Gravel Pinehurst pit, UTM E414700 N4697900. See Appendix f for legend.

The lower 1 m of the section exposes 15 to 20 cm thick cosets of silty fine sand climbing ripples interbedded with trough rippled very fine sand. Medium- to coarse-grained sands are found in the troughs of these ripples. The sands are compact. Paleocurrent measurements indicate paleoflow toward the southwest (Figure 23). These sands are thought to have been deposited as part of the underlying aggregate sequence and are not related to the overlying glaciolacustrine-till sequence. Partial reworking of the sediments by currents may have occurred during formation of higher level lakes related to subsequent glacial advance.

Overlying the rippled sands is a fine-textured glaciolacustrine-diamicton unit of variable thickness. The maximum observed thickness was 1 m. The lower contact of this unit, with the underlying sands, is sharp and in places loaded. The lower part of the unit consists of weakly stratified, clayey silt with numerous whitish mud pellets, rare black shale clasts and diamicton clots. Upward, the unit becomes more diamicton-rich with thin (1 to 3 cm thick), diamicton layers interbedded with cleaner glaciolacustrine clayey silts. The upper part of the sequence is contorted and consists of stratified clayey silt diamicton. A compact, clayey silt to silt till, approximately 1.5 m thick overlies the glaciolacustrine-diamicton sequence. This till contains many black shale clasts and many Huronian Supergroup lithologies. Fabric analysis of *in-situ* clasts indicates ice flow toward the south-southwest.

Deposition of the above described sediment succession is thought to have been related to advance of the Huron ice lobe during the Port Bruce Stadial. Advancing ice of the Huron and Erie lobes would have blocked outlets for any glacial lakes occupying the region, thereby effectively raising their water levels. Initially, glaciolacustrine sediments would have been deposited in the glacial lake that covered the Pinehurst area. As the Huron lobe entered the area, diamictons derived from the ice sheet could periodically flow into the glaciolacustrine environment and form interbeds within the glaciolacustrine sequence. Eventually, the glacier overrode the area and deposited the compact, clayey silt to silt till. This till is correlated with the Tavistock Till.

Overlying the till a succession of glaciolacustrine clays, silt and sand-rich rhythmites, lacustrine/deltaic sands and eolian sands completes the section. The glaciolacustrine clays are thought to have been deposited in glacial lakes Maumee and Arkona, while the rhythmites are thought to represent deposits of glacial lakes Whittlesey and Warren. The overlying sands are interpreted to have been deposited as part of a delta formed at the mouth of the Thames River in Lake Lundy. Subsequent subaerial exposure and eolian action reworked sandy sediments into small dunes.

Rotasonic Drillholes

Thirteen sonic drillholes provide valuable information regarding the subsurface stratigraphy and glacial history of the study area. A summary for each of these holes is provided in Appendix F. Correlation between a number of these drillholes is provided in Figure 24.

Within all of the completed drillholes a clast-rich, compact, sandy silt to silty sand till was encountered immediately above Paleozoic bedrock. This till ranged in thickness from 0.1 to 2.0 m. Textural analysis of samples obtained from drill cores provided averages of 16%

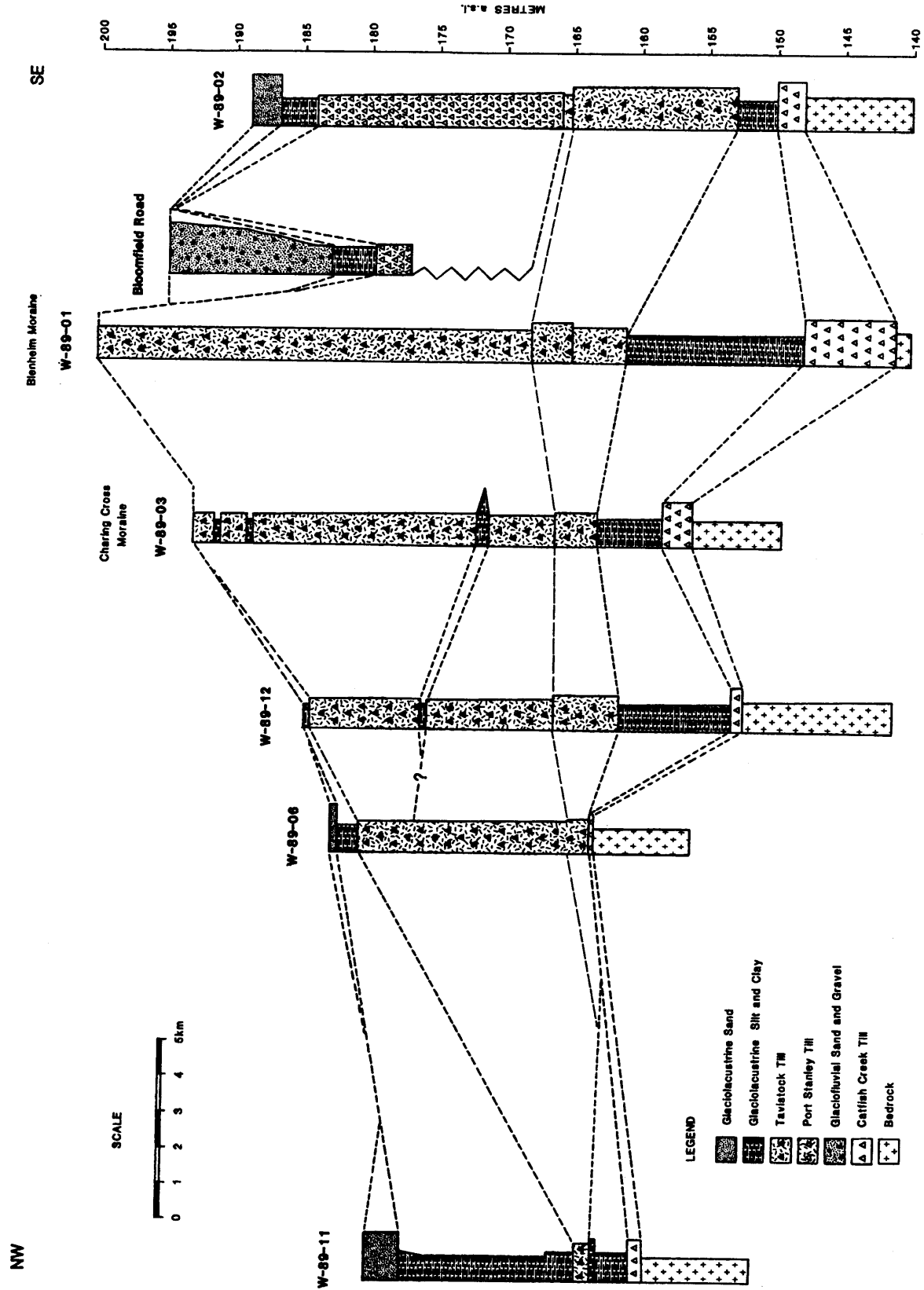


Figure 24. Generalized stratigraphic correlation from sonic drillholes and Bloomfield Road bluff section. See Figure 13 for location of drillholes and bluff sections.

clay, 44% silt and 40% sand (Table 2, Appendix F). Chemical analysis revealed high calcite (average 17%) and dolomite (average 13%) content providing a calcite to dolomite ratio of 1.49 (Table 2). The average total carbonate content from analyzed samples was 30%. Heavy mineral analysis indicated an average of 4.17% heavy minerals of which 7.22% are magnetic. Trace element analyses for Fe, Co, Cr, Cu, Ni, Pb and Zn are summarized in shown in Appendix F. Generally, average trace element values were found to be lower than in the Port Stanley and Tavistock Tills.

On the basis of stratigraphic position, texture, and carbonate content, this till is correlated with the Nissouri Stadial Catfish Creek Till. The Catfish Creek Till has been identified in Lake Erie bluff sections in the adjacent Bothwell-Ridgetown (Cooper and Baker 1978) and Windsor-Essex (Morris 1994) map areas. The Catfish Creek Till was named for its type section at Catfish Creek on the north shore of Lake Erie (de Vries and Dreimanis 1960).

In a number of holes (W-89-08,09,10, and 11) successions of interbedded silty sand to sandy diamicton, sandy gravel, sand and silt were found to occur above the Catfish Creek Till. These sediments represent deposits associated with either, retreating Catfish Creek ice front(s), or with advancing Port Bruce Stadial ice front(s). The former is indicated by the following observations. Diamictons and silty or sandy sediments were found to be interbedded in the lower part of the sequence, suggesting the existence of a deep water ice-marginal environment into which diamicton flows were deposited. Also, a general fining up sequence of sandy gravels and gravel to sands and silts occurs in the uppermost part of the succession (W-89-08, and 10). This sequence suggests ice withdrawal and removal of source materials, producing the fining-up sequence. Physical and chemical properties of diamictons, interbedded with the sands and gravels, are similar to those of Catfish Creek Till samples. The buried aggregate deposit at Pinehurst (W-89-08) most likely represents a body of ice-marginal sediments deposited, perhaps, during a standstill in the retreat of the ice front(s) that deposited the Catfish Creek Till. The interbedded sediments immediately above the Catfish Creek Till are interpreted to be part of a Catfish Creek Drift package.

In many of the holes from the southern part of the study area, a clay-rich glaciolacustrine unit lies immediately above the Catfish Creek Till or proposed Catfish Creek Drift sediments. These sediments are clay-rich, massive to faintly stratified and are often very soft. Pinkish mud pellets are common in the basal part of the unit. These glaciolacustrine sediments often show colour variation from pinkish to greyish. This unit is thickest where the bedrock surface is at a low elevation. The glaciolacustrine sediments were likely deposited in an ice marginal lake formed as glacial ice readvanced into the area during the Port Bruce Stadial. Readvancing ice would have dammed outflow outlets for any glacial lake occupying the area causing water levels to rise.

The Huron Lobe Tavistock Till immediately overlies the glaciolacustrine sediments. The till is grey, and has a sandy silt to silty clay matrix. Total thickness of this unit reaches nearly 52 m (W-89-13) (Figure 13, Appendix F). Drillholes from the northern part of the map area indicate that here the till is very thin, ranging in thickness from a few tens of centimetres to a couple of metres (W-89-08,09, and 10) (Figure 13, Appendix F). The basal part of this till has a sandy silt to silt matrix that is slightly coarser than the upper part of the unit. This coarser till facies is most prevalent in drillholes from the southern part of the map area (W-89-01,02,03,04,07, and 13) where the overall till unit is thickest, being up to 12 m.

Textural analysis indicates an average of 29.5% clay, 46.5% silt and 24% sand (Appendix F). Calcite content averages 11.6% and dolomite content 11.3%, for a calcite to dolomite ratio of 1.0. Calcite values from the basal facies are lower than those of the upper part of the till, while dolomite content is slightly higher. Total carbonate content is less in the lower facies. The coarser texture and lesser carbonate values for the lower facies of the till may be related to local incorporation of carbonate-poor Kettle Point shale bedrock. Geochemical analyses for the Huron lobe till samples are presented in Appendix F. The upper part of the till is, for the most part, massive to faintly stratified, with a silty clay to clayey silt matrix. Rare, thin sand layers also occur (W-89-13) (Figure 13, Appendix F). A drillhole within the Charing Cross Moraine (W-89-03) indicates that the till sequence is interrupted by glaciolacustrine sediments at a depth of 20 to 26 m below surface (Figure 24). The presence of this glaciolacustrine unit within the till may indicate a northerly retreat of the Huron lobe ice front from the Blenheim Moraine with a subsequent readvance to the Charing Cross Moraine. Where the till is found in association with glaciolacustrine sediments the succession of materials is better referred to as Tavistock Drift.

In the southern part of the map area 2 drillholes (W-89-02, and 05) intersected a clayey silt till above the Tavistock Till. This till is ascribed to the previously described Erie lobe Port Stanley Till. Physical and geochemical properties of these samples are presented in Appendix F.

Various thicknesses of fine-textured glaciolacustrine sediments were encountered above the tills in boreholes W-89-02,06,07,08,09,10, and 11. The thickest accumulations are found in boreholes 10 and 11, being up to 12 m thick. In all holes, the lower part of the glaciolacustrine unit was found to contain numerous mud pellets, rhythmites and thin diamicton flows. Upward in section, the rhythmites become cleaner. Borehole W-89-11 shows an overall coarsening upward sequence of rhythmites within which upward fining cosets occur. Individual couplets are thin (0.5 to 2.0 cm thick) with the finer-textured part being thicker than the coarser part. These rhythmites were deposited within the early glacial lakes that covered the area following retreat of the Huron and Erie lobe ice front(s).

Glaciolacustrine sands related to various lake stages of the Lake St. Clair and Erie basin cover the glaciolacustrine sediments in drillholes W-89-02,05,08,10, and 11.

GLACIAL HISTORY

Materials observed during mapping and sonic drilling of the Chatham-Wheatley area were deposited during Late Wisconsinan and Recent times, approximately 23 000 years BP to present. No pre-Late Wisconsinan deposits were encountered or have previously been reported from the area.

The oldest glacial sediment encountered was a clast-rich, compact, sandy silt to silty sand till lying immediately upon the Paleozoic bedrock. The till represents the Catfish Creek Till deposited during the Nissouri Stadial. Associated with this till are localized deposits of glaciofluvial sands and gravels and glaciolacustrine silts and sands. These sediments were most likely deposited in ice marginal environments during standstills of the retreating Nissouri

Stadial ice front(s). The buried aggregate deposit at Pinehurst was likely deposited at this time. It is unclear whether the Pinehurst deposit was deposited subaerially or subaquatically.

As the Catfish ice retreated during the Erie Interstadial, a series of high level glacial lakes occupied the Erie and Huron basins (Dreimanis 1969). Dreimanis (1958) termed this water body Lake Leverett and suggested it formed approximately 15 500 years BP, at the time of maximum ice retreat. Whether the Chatham-Wheatley area remained under water for all of the Erie Interstadial is unclear. However, evidence to suggest subaerial exposure, such as paleosol development, was not noted.

During the early part of the Port Bruce Stadial, southward advancing ice from the Lake Huron basin and ice advancing westward through the Lake Erie basin dammed outlets for Glacial Lake Leverett. A lake basin having high water levels existed at this time over the Chatham-Wheatley area. Clay-rich, massive to faintly stratified glaciolacustrine sediments were deposited throughout much of the map area, as indicated by their occurrence in many of the sonic drillholes. Thickest accumulations of this unit are present in the southern part of the map area where the bedrock surface elevation is lowest and hence where the lake basin was deepest.

Eventually, with further ice advance, the 2 ice lobes coalesced. Evidence suggests that initially, the Huron lobe was the dominant ice lobe of the 2 within the study area and deflected the Erie lobe ice southward. The ice pushed into Ohio and deposited till sheets and moraines (White 1982; Dreimanis and Goldthwait 1973 and Goldthwait et al. 1965). In the Chatham-Wheatley area deposition of the clayey silt- to silt-rich Tavistock Till by southward flowing ice occurred. The fine textured matrix of this till reflects incorporation of clay and silt-rich glaciolacustrine sediments derived from Glacial Lake Leverett. The basal part of this till is slightly coarser and less carbonate rich than the upper part, reflecting incorporation of local, carbonate-poor Kettle Point shale bedrock. The till is thickest in the southern part of the map area where bedrock surface elevation is lowest.

Later during the Port Bruce Stadial, ice flow from the Erie lobe increased while ice flow from the Huron lobe waned. Ice flow in the western part of the Lake Erie basin shifted westward (Fullerton 1986). The Erie lobe pushed into the southeastern and extreme southern margin of the area, depositing clayey silt rich, Port Stanley Till. This ice sheet appears to have overridden Huron lobe till south of Blenheim and Wheatley. Indications are that the Erie lobe did not push very far north and likely did not extend much further west than Wheatley. Morris (1994) has reported the presence of a hybrid Port Stanley-Tavistock till on Pelee Island and "p" forms on Pelee, East Sister and Middle islands that are likely related to this period of westward ice flow.

Gradually, as ice retreated from the western end of the Lake Erie basin the ice lobes began to separate. As the ice fronts retreated to the Blenheim area the Blenheim Moraine was deposited. This moraine is felt to be an interlobate deposit, however, evidence suggests that much of the moraine was constructed of sediments derived from the Huron ice lobe. Meltwaters generated at the ice fronts were forced to flow southwestward. Initially, the meltwaters eroded a large channel in the underlying sediments. The channel was subsequently infilled with an upward coarsening deltaic sequence of sands and gravels. This delta is exposed in the Lake Erie bluffs southwest of Blenheim.

Continued retreat of the Huron lobe ice front, punctuated by minor standstills or slight readvances, deposited the Charing Cross Moraine and the other minor moraines throughout the area.

As ice fronts retreated into the Erie and Huron basins, large glacial lakes fronted the glaciers. Fine-textured glaciolacustrine sediments of glacial lakes Maumee and Arkona were deposited throughout the area. Thickest sediment accumulations occur north of the Charing Cross Moraine and south of the Blenheim Moraine. Fluctuating, but overall falling, water levels finally exposed parts of the Chatham-Wheatley area during the time of glacial Lake Warren, approximately 12 800 years BP (Calkin and Feenstra 1985). Abandoned shorelines along, and a spit southwest of the Blenheim Moraine, mark the Lake Warren levels.

Lower levels of lakes Grassmere and Lundy are indicated by the presence of poorly-developed shorelines on the north flank of the Charing Cross Moraine and along the north shore of Lake Erie. During the Lundy stage, separate, distinct lakes developed in the Huron and St. Clair basins as water levels fell. During early Lake Algonquin time (12 400 to 12 200 years BP), a lake controlled by outlets at Windsor occupied the St. Clair basin. Deltaic sediments were deposited by the Thames River in this lake. The extensive sands near Chatham and finer-textured sediments immediately west of the city are representative of this delta.

Subsequent lowering of the lake waters to an unknown level probably exposed the entire Chatham-Wheatley land area. Exposure may not have been correlative in time with opening of the Kirkfield outlet and accompanying low water levels in the Huron basin. Instead, lowering of water level in the St. Clair basin could have occurred as an outlet barrier at Windsor was incised, allowing waters to drain southward into an Early Algonquin equivalent lake occupying the Erie basin.

A lake was re-established in the St. Clair and Erie basins at a much later time. Water level rose, either due to increased or re-established water flow through the Port Huron outlet during the early part of the Nipissing transgression, or as isostatic rebound uplifted outlets at Niagara causing water levels in the Erie basin to rise. Sandy shoreline features around Lake St. Clair at an elevation of 177 m may represent the main Nipissing stage in the basin.

Eventually water levels fell to the modern day levels in the St. Clair and Erie basins. The entire area was exposed, allowing soil development, erosion and eolian activity, which gave rise to the present day landscape.

Applied Quaternary Geology

AGRICULTURAL SOILS

Soils within the Chatham-Wheatley area are developed on Quaternary parent materials of Late Wisconsinan age. Deposits in the study area have been subjected to weathering since the lowering of glacial Lake Warren in the Erie basin some 12 800 years BP (Calkin and Feenstra 1985). The Blenheim Moraine was exposed first, followed by the remainder of the map area at lower elevations as water levels fell. Some areas, notably eolian modified sand plains south and east of Chatham and artificially drained areas west of Chatham, may have been subjected to weathering processes for only a few hundred years or less.

Soil maps for Kent and Essex Counties were prepared by the Ontario Agricultural College, Guelph in 1930 and 1949 respectively. The Ontario Centre for Soil Resource Evaluation has recently released updated soil maps for Kent County.

ECONOMIC GEOLOGY

Clay

A number of brick and drainage tile plants have existed in the Chatham-Wheatley area over the years (Guillet 1967). In 1965, 5 clay pits, belonging to 4 companies, were operating within the Chatham-Wheatley area. Plants were located at Tilbury (Central Tile Brick Corporation Limited), Chatham (Emig Clay Products Limited), Fletcher (Fletcher Tile Limited) and Stevenson (Hill Tile Limited). Products produced from the plants included, drain and structural tile and Roman and Standard brick and flue liners (Guillet 1967). At present, none of these plants remains in operation.

Sand and Gravel

Excavation for sand and gravel has occurred and is ongoing within some parts of the map area in surface glaciofluvial outwash, deltaic, abandoned beach and in some eolian dune sediments. The largest aggregate source in the area is a buried deposit located east of Chatham at Pinehurst. An aggregate inventory of Raleigh and Harwich Townships has recently been completed by the Ontario Geological Survey (1991).

At the time of investigation 20 active licences were held within the townships of Raleigh, Harwich and Romney. Records for an 11 year period (1974-1984) indicate that the average annual aggregate production for Raleigh and Harwich Townships was 101 000 tonnes and 680 000 tonnes respectively (R. Gorman, OGS, personal communication, 1989).

The other townships within the map area have only a few small sources of sand or gravel. These deposits are too small to be of economic value.

The area lacks adequate sources of high specification aggregate and as a result these materials must be imported. Much of this aggregate is supplied from the London and Windsor areas. Stone products have also been supplied from Manitoulin Island and Cayuga, Ontario and the United States.

Environmental Geology

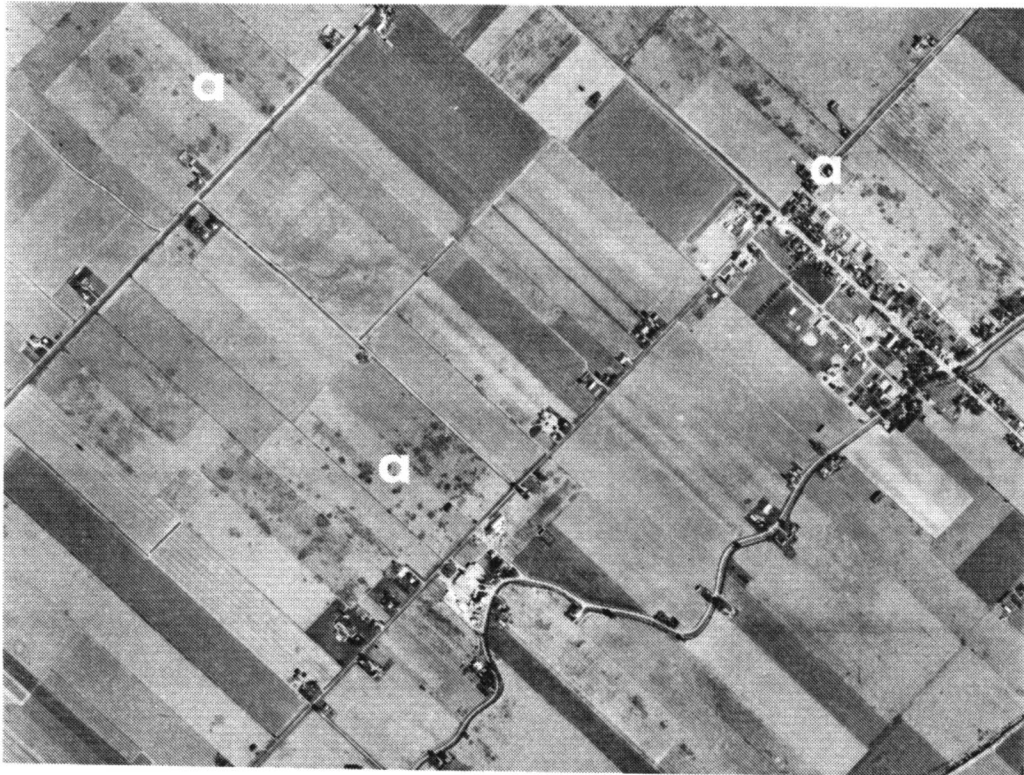
RADON GAS

In the past few years soil gas surveys in the northeastern states of the United States have indicated the presence of high radon gas levels in some areas. Radon gas results from the decay of uranium. In Ohio the principal geologic controls on uranium occurrence are black shales of Devonian and Mississippian age and surficial glacial deposits (Smith et al. 1989). The gas may accumulate in man-made structures that are poorly ventilated. In Ohio, studies suggest that the Late Devonian Ohio Formation shale may be a source of radon gas. The equivalent formation in Ontario is the Kettle Point shale.

The Ohio studies have also indicated that the primary control on radon gas concentration is the permeability of glacial materials. Other controls include the composition of glacial materials, including locally-derived black shales. Glacial controls usually override the effects of bedrock geology (Smith et al. 1989). The tills that overlie the Kettle Point shale in the Chatham-Wheatley area have characteristics which might concentrate radon gas. Studies should be conducted to investigate whether high radon levels are present in any public or private structures. Two studies on radon gas in southern Ontario have recently been completed by the Ontario Geological Survey (Tilsley et al. 1993a, Tilsley and Nicholls 1993b).

HYDROCARBON SEEPAGES(?)

The presence of peculiar dark, circular to semi-circular blotches on airphotographs (Photo 6) poses an interesting question as to their origin. It is hypothesized that these features represent areas of stressed vegetation due to the direct or indirect effects of hydrocarbons seeping to the surface from underlying bedrock. A number of observations support this suggestion, including: the blotches are found in areas of known oil and gas pools; in some areas, notably west of Chatham, linear "fields" of blotches were found to trend parallel with the strike of known faults in the area; blotches appear associated with certain types of vegetation but not with others, suggesting intolerance to hydrocarbon stress by some plants; and finally, Morris (OGS, personal communication, 1989) has noted circular oily deposits on the bedrock surface of the McGregor quarry at Amherstburg. If future investigation corroborates this hypothesis then a potentially valuable hydrocarbon exploration tool would be realized.



Photograph 6: Areas of suspected hydrocarbon seepage features (a).

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Appendix A. TEXTURE, CARBONATE, HEAVY MINERAL PROPERTIES

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE		SAND%	CALCITE%	DOLOMITE%	CARBONATE	TOTAL	CA/DOL	HEAVY MINERALS
	EASTING	NORTHING		CLAY%	SILT%							
w-631	413380	4691880	Tavistock Till	39	47	14	12.90	9.99	22.90	1.29	1.29	
w-637	415250	4693540	Tavistock Till	43	45	12	14.70	6.37	21.10	2.31	2.31	
w-687	397530	4681830	Tavistock Till	39	38	23	0.66	1.13	1.79	0.58	0.58	
w-694	401430	4684730	Tavistock Till	45	39	16	7.17	7.40	14.60	0.97	0.97	
w-696	402900	4683060	Tavistock Till	43	45	12	14.10	8.86	23.00	1.59	1.59	
w-702	398710	4680450	Tavistock Till	33	50	17	13.60	9.89	23.50	1.38	1.38	
w-710	400070	4680400	Tavistock Till	44	45	11	15.00	9.20	24.20	1.63	1.63	
w-714	403410	4682480	Tavistock Till	41	47	12	13.60	9.22	22.80	1.48	1.48	
w-715	404160	4681660	Tavistock Till	37	45	18	13.00	9.09	22.10	1.43	1.43	
w-723	377060	4677350	Tavistock Till	21	44	35	0.54	1.24	1.78	0.44	0.44	
w-724	378850	4677240	Tavistock Till	35	43	22	0.55	0.92	1.47	0.60	0.60	
w-725	380500	4677450	Tavistock Till	38	46	16	14.50	9.55	24.10	1.52	1.52	
w-17	375400	4675800	Tavistock Till	42	45	13	15.60	9.09	24.70	1.72	1.72	
w-29	379660	4672280	Tavistock Till	34	47	19	11.90	11.10	23.00	1.07	1.07	
w-99	380760	4666330	Tavistock Till	35	48	17	12.20	10.90	24.10	1.21	1.21	
w-101	381030	4665450	Tavistock Till	35	48	17	12.40	10.20	22.60	1.22	1.22	
w-120	382180	4665230	Tavistock Till	35	49	16	14.10	10.70	24.80	1.32	1.32	
w-124	384530	4665150	Tavistock Till	35	48	17	14.60	9.32	23.90	1.57	1.57	
w-250	389330	4670620	Tavistock Till	37	44	19	2.93	4.06	6.99	0.72	0.72	
w-271	387470	4666550	Tavistock Till	38	46	16	13.50	8.63	22.10	1.56	1.56	
w-279	383600	4677520	Tavistock Till	35	47	18	11.20	12.20	23.40	0.92	0.92	
w-286	386380	4678860	Tavistock Till	35	48	17	12.10	12.70	24.80	0.95	0.95	
w-302	387580	4675560	Tavistock Till	32	48	20	11.90	11.50	23.40	1.04	1.04	
w-308	384790	4675970	Tavistock Till	32	48	20	11.60	11.00	22.60	1.05	1.05	
w-331	391200	4674190	Tavistock Till	34	47	19	10.80	11.00	21.80	0.98	0.98	
w-336L	394320	4669310	Tavistock Till	34	47	19	10.80	11.40	22.20	0.95	0.95	
w-336U	394320	4669310	Tavistock Till	33	48	19	10.40	9.97	20.40	1.04	1.04	
w-350	392990	4669020	Tavistock Till	32	49	19	12.00	8.97	21.00	1.34	1.34	
w-352	397560	4672790	Tavistock Till	40	47	13	1.73	3.88	5.61	0.45	0.45	
w-403	402530	4677980	Tavistock Till	37	46	17	5.87	6.83	12.70	0.86	0.86	
w-412	407560	4677830	Tavistock Till	31	48	22	14.40	9.20	23.60	1.57	1.57	
w-424	408960	4681820	Tavistock Till	34	49	17	8.96	9.55	18.60	0.94	0.94	
w-432	411280	4681110	Tavistock Till	37	46	17	1.41	0.34	1.75	0.42	0.42	
w-435	417240	4680550	Tavistock Till	29	49	22	12.00	10.20	22.20	1.18	1.18	
w-442	413820	4683300	Tavistock Till	26	50	24	13.40	9.99	23.40	1.34	1.34	
w-446	415030	4682520	Tavistock Till	28	50	22	12.80	11.60	24.40	1.10	1.10	
w-525	413320	4685370	Tavistock Till	33	48	19	14.20	9.68	23.90	1.47	1.47	
w-576	407010	4682760	Tavistock Till	36	47	17	16.20	8.63	24.80	1.88	1.88	
w-578	409010	4683040	Tavistock Till	40	43	17	1.51	1.42	2.93	1.06	1.06	
w-602	412130	4687740	Tavistock Till	45	45	10	0.55	1.24	1.79	0.44	0.44	
w-610	417890	4690430	Tavistock Till	36	47	17	13.90	9.43	23.30	1.47	1.47	
w-619	412970	4688950	Tavistock Till	41	47	12	0.89	1.70	2.59	0.52	0.52	
w-645	417400	4691830	Tavistock Till	33	51	16	5.21	5.80	11.00	0.98	0.98	
PC-L	400300	4671800	Tavistock Till	32	48	20	13.10	11.80	24.90	1.11	1.11	
PC-10	400300	4671800	Tavistock Till	33	44	23	13.10	10.10	23.20	1.30	1.30	
PC-7	400300	4671800	Tavistock Till	29	47	24	13.40	10.10	23.50	1.33	1.33	
MEAN				35.57	46.59	17.87	10.26	8.20	18.46	1.16	1.16	
STD DEV				4.91	2.52	4.29	4.98	3.49	8.18	0.41	0.41	

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE		TOTAL CARBONATE	CAL/DOL RATIO	HEAVY MINERALS TOTAL %	MAGNETICS %	
	EASTING	NORTHING		CLAY%	SILT%					SAND%
BL-4	411600	4678400	Port Stanley Till	38	46	16	12.60	9.66	22.30	1.30
BL-5B	411600	4678400	Port Stanley Till	35	47	18	13.60	9.11	22.70	1.49
BL-5G	411600	4678400	Port Stanley Till	39	45	16	13.40	9.43	22.80	1.42
PA	397350	4670200	Port Stanley Till	33	47	20	11.20	10.30	21.50	1.09
w-506			Port Stanley Till	36	47	17	6.92	5.11	12.00	1.35
w-410	408300	4676920	Port Stanley Till	31	61	8	14.00	8.17	22.20	1.71
w-134	379550	4662710	Port Stanley Till	37	49	14	14.80	8.74	23.50	1.69
w-146T	376140	4661300	Port Stanley Till	38	47	15	15.60	7.71	23.30	2.02
w-164	382180	4662170	Port Stanley Till	38	47	15	14.60	8.19	22.80	1.78
w-233	376050	4660800	Port Stanley Till	40	44	16	0.55	1.24	1.79	0.44
w-237M	377820	4661110	Port Stanley Till	37	49	14	13.90	8.97	22.90	1.21
CC-T	386000	4662150	Port Stanley Till	38	46	16	13.30	8.74	22.00	1.52
TD-G	388300	4665900	Port Stanley Till	35	46	19	10.30	11.50	21.80	0.90
DR-G	408500	4676900	Port Stanley Till	30	49	21	11.90	10.90	22.80	1.09
DR-R	408500	4676900	Port Stanley Till	42	55	3	27.50	8.19	35.70	3.36
BL-G	411600	4678400	Port Stanley Till	30	45	25	14.10	9.99	24.10	1.41
BL-T	411600	4678400	Port Stanley Till	26	66	8	12.40	9.89	22.30	1.25
MEAN				35.47	49.17	15.35	12.98	8.58	21.56	1.47
STD DEV				4.07	5.80	5.06	5.03	2.30	6.44	0.59

SAMPLE	UTM COORDINATES		MATERIAL	CLAY%	SILT%	SAND%	CALCITE%	DOLOMITE%	TOTAL CARBONATE	CAL/DOL RATIO	HEAVY MINERALS TOTAL %	MAGNETICS %
	W-66	382180										
c-450lr	405850	4694850	Glaciolacustrine-Clay	56	38	6	13.40	6.66	20.10	2.01	0.07	8.97
ORR	439300	4702750	Glaciolacustrine-Clay	52	47	1	13.70	4.97	18.70	2.76	0.04	5.41
c3ab	376270	4683470	Glaciolacustrine-Clay	50	38	12	1.27	3.35	4.62	0.38	0.04	5.41
MEAN				54.50	40.25	5.25	9.55	5.94	15.51	1.57	0.05	7.20
STD DEV				3.84	3.90	4.32	5.02	2.01	6.31	0.90	0.02	1.78
TR-R	409000	9716100	Glaciolacustrine-Silt	40	55	5	11.60	12.00	23.60	0.97	0.04	6.67
BL-S	411600	4678400	Glaciolacustrine-Silt	40	50	10	17.30	8.30	25.60	2.08	0.01	7.14
c-446	417660	4700940	Glaciolacustrine-Silt	17	79	4	18.90	17.20	36.10	1.10	0.01	6.67
PH-1	414700	4697950	Glaciolacustrine-Silt	5	81	14	14.50	21.60	36.10	0.67	0.01	6.67
c-552	407530	4700730	Glaciolacustrine-Silt	35	47	18	9.81	7.48	17.30	1.31	0.01	6.67
c-115t	402280	4692080	Glaciolacustrine-Silt	1	96	3	10.40	24.50	34.90	0.42	0.03	13.33
c-140	393440	4700720	Glaciolacustrine-Silt	26	44	30	37.50	10.50	48.00	3.57	0.03	13.33
c-108	400290	4689030	Glaciolacustrine-Silt	18	79	3	0.00	3.85	3.85	0.85	0.04	6.67
c5at	379050	4683170	Glaciolacustrine-Silt	37	44	19	0.57	0.67	1.17	0.16	0.04	6.67
c-89	396910	4687700	Glaciolacustrine-Silt	32	67	1	0.68	4.38	5.06	0.16	0.04	6.67
c-385	408850	4705230	Glaciolacustrine-Silt	21	73	6	34.80	8.82	43.60	3.95	0.01	6.67
c-255	389290	4696250	Glaciolacustrine-Silt	22	68	18	3.94	11.00	14.90	0.36	0.01	6.67
c-572	403140	4698730	Glaciolacustrine-Silt	28	66	6	10.30	11.30	21.60	0.91	0.01	6.67
PH-2	414700	4697950	Glaciolacustrine-Silt	26	65	9	11.80	11.70	23.50	1.01	0.03	13.33
MEAN				24.86	65.29	10.43	14.01	10.95	25.49	1.34	0.02	8.45
STD DEV				11.55	15.16	8.00	10.86	6.33	13.47	1.13	0.01	2.82

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE			TOTAL CARBONATE	CAL/DOL RATIO	HEAVY MINERALS	
	EASTING	NORTHING		CLAY%	SILT%	SAND%			DOLOMITE%	CALCITE%
w-146S	376140	4661300	Glaciolacustrine-Sand	1	4	95				
w-159	382180	4661910	Glaciolacustrine-Sand	1	1	98				
w-186	380510	4660550	Glaciolacustrine-Sand	1	1	98				
w-452	415180	4682070	Glaciolacustrine-Sand	0	1	99				3.91
c-419t	410470	4703550	Glaciolacustrine-Sand	2	16	82				2.04
c-120b	383970	4706020	Glaciolacustrine-Sand	18	40	42				2.98
MEAN				3.83	10.50	85.67				0.16
STD DEV				6.36	14.22	20.37				0.11
PH-4	414700	4697950	Rhythmites	20	71	9	13.90	23.50	0.69	14.29
c-450Ur	405850	4694850	Rhythmites	17	82	1	18.00	23.90	0.33	
c-419b	410470	4685750	Rhythmites	23	75	2	15.10	29.80	0.97	
c-432	416272	4706710	Rhythmites	18	81	1	17.50	28.80	0.65	
c-68	388000	4689470	Rhythmites	19	72	9	15.80	30.00	0.90	0.07
c-143	398200	4705500	Rhythmites	31	61	8	14.60	25.60	0.75	1.04
c-115b	402280	4692080	Rhythmites	19	80	1	20.30	32.10	0.58	
MEAN				21.00	74.57	4.43	16.46	27.67	0.70	12.28
STD DEV				4.44	6.86	3.70	2.75	3.09	0.20	2.02
c-112	404200	4691070	Eolian sand	8	63	29				0.01
c-67	388150	4689280	Alluvium				14.10	27.10	1.08	
c-120t	383970	4706020	Alluvium				0.39	2.55	0.18	0.85
c3at	376270	4683470	Lacustrine sand				1.00	5.29	0.23	1.33

APPENDIX B. MAJOR ELEMENT GEOCHEMISTRY OF SAMPLES

SAMPLE	UTM COORDINATES EASTING NORTHING	MATERIAL	SiO2	Al2O3%	Fe2O3%	MgO%	CaO%	Na2O%	K2O%	TiO2%	P2O5%	MnO%	CO2%	%	LOI%	TOTAL%
w-631	413380	4691880	47.9	12.2	5.14	2.74	11.30	0.56	2.87	0.55	0.12	0.08	12.60	0.02	15.3	98.8
w-637	415250	4693540	48.9	13.0	5.51	2.22	11.00	0.66	3.15	0.59	0.15	0.12	11.40	0.02	14.2	99.5
w-687	397530	4681830	66.6	13.8	5.98	1.34	0.85	0.85	3.05	0.63	0.07	0.11	1.85	0.02	6.0	99.3
w-694	401430	4684730	54.2	13.7	5.14	2.36	7.24	0.53	3.07	0.62	0.12	0.07	7.65	0.02	11.5	98.6
w-696	402900	4683060	48.3	12.8	5.24	2.84	11.50	0.44	2.97	0.55	0.14	0.08	11.50	0.01	15.1	99.7
w-702	398710	4680450	48.3	11.8	4.87	3.98	11.80	0.53	2.93	0.55	0.12	0.08	13.20	0.02	14.4	99.3
w-710	400070	4680400	46.3	12.4	5.09	2.80	12.80	0.40	2.99	0.53	0.12	0.08	12.60	0.01	15.9	99.4
w-714	403410	4682480	47.8	12.4	4.81	2.88	11.40	0.53	3.08	0.60	0.14	0.07	12.20	0.05	14.7	98.4
w-715	404160	4681660	48.4	11.9	4.81	2.82	11.20	0.64	2.85	0.60	0.12	0.08	3.23	0.01	15.3	98.7
w-723	377060	4677350	73.1	11.3	3.51	0.96	1.01	1.18	2.18	0.53	0.06	0.04	1.41	0.01	5.0	98.9
w-724	378850	4677240	68.1	13.0	5.34	1.10	0.92	0.45	3.19	0.70	0.14	0.08	2.25	0.02	5.4	98.4
w-725	380500	4677450	47.8	11.8	4.70	3.03	11.60	0.77	2.91	0.51	0.14	0.06	13.60	0.05	15.3	98.6
w-17	375400	4675800	46.3	12.1	4.71	3.05	12.50	0.53	3.01	0.58	0.14	0.07	13.40	0.03	15.4	98.4
w-29	379660	4672280	49.5	11.7	4.88	3.08	10.80	0.59	2.89	0.55	0.11	0.07	13.40	0.06	14.8	99.0
w-99	380760	4666330	48.2	11.5	4.63	3.08	10.90	0.93	2.87	0.55	0.11	0.07	14.30	0.60	14.7	97.5
w-101	381030	4665450	49.2	11.7	4.80	3.10	10.50	0.55	2.88	0.52	0.10	0.07	11.90	0.03	14.6	98.0
w-120	382180	4665230	48.3	11.3	4.71	2.89	11.70	0.54	2.63	0.47	0.11	0.07	12.60	0.02	15.7	98.4
w-124	384530	4665150	48.6	11.4	4.60	2.71	11.80	0.66	2.71	0.55	0.15	0.07	12.10	0.05	14.9	98.2
w-250	389330	4670620	58.0	13.8	6.01	1.90	3.85	0.69	3.29	0.66	0.13	0.17	6.37	0.02	9.3	98.8
w-271	387470	4666550	48.6	12.1	4.87	3.11	11.20	0.84	2.95	0.53	0.15	0.07	13.20	0.43	14.3	98.5
w-279	383600	4677520	49.2	11.5	4.70	3.03	10.80	0.66	2.83	0.51	0.13	0.06	12.40	0.02	14.9	98.3
w-286	386380	4678860	47.6	11.3	4.76	3.12	11.90	0.88	2.83	0.51	0.14	0.07	14.70	0.63	15.2	98.3
w-302	387580	4675560	48.8	11.6	4.53	2.99	11.00	0.65	2.84	0.53	0.14	0.06	14.00	0.05	15.3	98.4
w-308	384790	4675970	50.2	11.8	4.61	2.91	10.80	0.67	2.88	0.57	0.10	0.06	12.60	0.04	14.8	99.4
w-331	391200	4674190	51.0	12.1	4.95	2.56	10.10	0.75	2.92	0.59	0.11	0.11	12.50	0.36	14.2	99.1
w-336L	394320	4669310	48.9	11.8	4.70	2.75	11.10	0.75	2.94	0.57	0.12	0.06	13.50	0.03	14.3	98.0
w-336U	394320	4669310	50.9	12.2	4.84	2.47	10.00	0.90	2.97	0.61	0.13	0.08	12.10	0.07	13.8	98.9
w-350	392990	4669020	50.1	12.1	4.67	2.83	1.04	0.74	2.92	0.53	0.13	0.06	13.00	0.02	14.5	99.0
w-352	397560	4672790	61.3	13.9	5.94	1.66	2.66	0.82	3.35	0.71	0.12	0.06	5.03	0.03	8.3	98.8
w-403	402530	4677980	55.3	13.5	5.80	2.26	5.65	0.59	3.22	0.60	0.13	0.11	8.55	0.02	11.1	98.3
w-412	407560	4677830	49.2	11.4	4.86	2.53	12.10	0.80	2.63	0.53	0.13	0.08	12.50	0.02	15.1	99.4
w-424	408960	4681820	51.2	12.5	5.58	2.30	8.90	0.70	3.01	0.55	0.13	0.10	11.60	0.02	13.5	98.5
w-432	411280	4681110	63.3	14.8	6.28	1.57	1.23	0.68	3.30	0.77	0.14	0.15	3.08	0.03	6.9	99.1
w-435	417240	4680550	50.1	11.5	4.85	2.89	10.30	0.69	2.75	0.49	0.11	0.07	13.00	0.02	14.6	98.4
w-442	413820	4683300	49.7	11.3	4.71	2.79	11.60	0.97	2.71	0.49	0.12	0.08	12.90	0.02	14.6	99.1
w-446	415030	4682520	48.2	11.3	4.52	2.93	12.20	0.80	2.80	0.50	0.11	0.07	14.20	0.39	14.9	98.3
w-525	413320	4685370	48.2	11.9	4.95	2.57	11.60	0.61	2.84	0.49	0.11	0.08	12.80	0.02	15.2	98.6
w-576	407010	4682760	47.3	11.7	4.95	2.72	12.30	0.53	2.84	0.51	0.12	0.06	13.50	0.03	15.9	98.9
w-578	409010	4683040	58.7	14.8	6.91	1.67	2.37	0.78	3.54	0.74	0.14	0.12	5.52	0.03	8.4	99.2
w-602	412130	4687740	63.7	14.9	6.38	1.58	1.01	0.83	3.41	0.71	0.12	0.08	2.03	0.02	6.6	99.3
w-610	417890	4690430	48.1	12.2	5.20	2.61	11.40	0.49	2.98	0.53	0.13	0.09	13.10	0.02	15.1	98.8
w-619	412970	4688950	61.0	15.3	6.82	1.55	1.43	0.43	3.59	0.77	0.15	0.20	3.48	0.03	7.7	98.9
w-645	417400	4691830	57.0	13.8	6.09	1.91	4.52	0.73	3.19	0.57	0.15	0.07	7.80	0.02	10.4	98.4
PC-L	400300	4671800	48.1	11.4	4.68	3.40	11.60	0.78	2.81	0.49	0.12	0.07	13.90	0.63	14.7	98.2
PC-10	400300	4671800	49.2	11.4	4.60	2.88	11.70	0.68	2.80	0.50	0.13	0.07	14.10	0.59	14.3	98.2
PC-7	400300	4671800	49.3	11.3	4.45	2.89	12.10	0.77	2.73	0.53	0.14	0.07	13.00	0.32	14.0	98.3
MEAN			52.17	12.37	5.10	2.55	8.85	0.67	2.96	0.57	0.12	0.08	10.56	0.11	13.05	98.71
STD DEV			6.43	1.11	0.66	0.63	4.12	0.16	0.25	0.08	0.02	0.03	4.08	0.18	3.19	0.47

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SAMPLE	UTM COORDINATES EASTING	UTM COORDINATES NORTHING	MATERIAL	SiO2%	Al2O3%	Fe2O3%	MgO%	CaO%	Na2O%	K2O%	TiO2%	P2O5%	MnO%	CO2%	S%	LOI%	TOTAL%
BL-4	411600	4678400	Port Stanley Till	49.0	12.0	4.78	3.28	10.90	0.58	2.89	0.55	0.12	0.07	13.30	0.40	14.2	98.4
BL-5B	411600	4678400	Port Stanley Till	49.6	11.9	4.75	2.90	11.10	0.72	2.79	0.55	0.12	0.08	11.70	0.05	14.0	98.5
BL-5G	411600	4678400	Port Stanley Till	48.8	12.1	4.84	3.20	11.30	0.60	2.88	0.54	0.12	0.07	13.30	0.41	14.1	98.6
PA	397350	4670200	Port Stanley Till	49.5	11.7	5.06	3.17	10.10	0.73	2.84	0.52	0.11	0.06	14.50	0.83	14.1	97.9
w-506	-----	-----	Port Stanley Till	55.9	13.7	5.51	1.93	6.46	0.64	3.10	0.63	0.14	0.08	6.91	0.02	10.3	98.4
w-410	408300	4676920	Port Stanley Till	48.3	12.3	4.62	3.12	11.70	0.81	3.04	0.50	0.13	0.07	11.90	0.29	13.8	98.4
w-134	379550	4662710	Port Stanley Till	48.9	11.9	4.86	2.99	11.70	0.68	2.89	0.57	0.14	0.07	11.60	0.18	14.7	99.4
w-146T	376140	4661300	Port Stanley Till	48.4	12.0	4.66	2.83	11.70	0.51	2.80	0.54	0.13	0.07	11.80	0.02	15.0	98.6
w-164	382180	4662170	Port Stanley Till	48.1	12.0	4.75	2.77	11.60	0.65	2.88	0.54	0.13	0.06	11.30	0.01	14.5	98.0
w-233	376050	4660800	Port Stanley Till	63.3	14.2	6.93	1.43	1.01	0.82	3.19	0.71	0.14	0.06	1.61	0.01	6.4	98.2
w-237M	377820	4661110	Port Stanley Till	48.8	12.2	4.65	2.77	11.50	0.74	2.99	0.61	0.12	0.08	12.60	0.04	14.6	99.1
CC-T	382800	4662150	Port Stanley Till	48.5	12.2	4.76	3.10	11.30	0.67	2.94	0.53	0.13	0.07	13.10	0.42	14.2	98.4
TD-G	388300	4665900	Port Stanley Till	50.5	11.8	4.65	3.39	9.74	0.56	2.88	0.50	0.10	0.06	14.30	0.51	13.9	98.1
DR-G	408500	4676900	Port Stanley Till	50.0	11.5	4.53	2.97	10.60	0.66	2.83	0.55	0.11	0.07	15.00	0.13	14.5	98.3
DR-R	408500	4676900	Port Stanley Till	40.9	9.9	4.16	3.23	17.60	0.77	2.60	0.54	0.14	0.08	4.08	0.04	18.5	98.5
BL-G	411600	4678400	Port Stanley Till	48.2	11.1	4.67	2.96	11.90	0.87	2.70	0.56	0.12	0.07	14.10	0.52	14.5	97.7
BL-T	411600	4678400	Port Stanley Till	51.2	10.5	4.48	3.45	11.00	0.94	2.52	0.53	0.15	0.08	12.00	0.27	13.4	98.3
MEAN				49.88	11.94	4.86	2.91	10.66	0.70	2.87	0.56	0.13	0.07	11.36	0.24	13.81	98.40
STD DEV				4.31	0.96	0.58	0.50	3.14	0.11	0.16	0.05	0.01	0.01	3.60	0.23	2.35	0.39

SAMPLE	UTM COORDINATES EASTING	UTM COORDINATES NORTHING	MATERIAL	SiO2%	Al2O3%	Fe2O3%	MgO%	CaO%	Na2O%	K2O%	TiO2%	P2O5%	MnO%	CO2%	S%	LOI%	TOTAL%
w-663	402140	4685940	Glaciolacustrine-Clay	46.2	15.4	5.62	2.83	9.46	0.36	3.84	0.65	0.14	0.08	10.30	0.02	14.0	98.6
TR-R	409000	4716000	Glaciolacustrine-Silt	48.8	12.2	4.89	3.52	10.90	0.85	2.99	0.57	0.13	0.07	11.50	0.12	13.6	98.3
BL-S	411600	4678400	Glaciolacustrine-Silt	46.5	12.0	4.62	2.81	12.90	0.95	2.97	0.56	0.15	0.08	12.30	0.22	14.6	98.1
w-146S	376140	4661300	Glaciolacustrine-Sand	85.2	6.7	1.20	0.20	0.83	1.16	1.40	0.26	0.04	0.02	0.69	0.01	1.5	98.5
w-159	382180	4661910	Glaciolacustrine-Sand	86.9	5.8	1.15	0.24	0.70	0.91	1.23	0.15	0.05	0.01	2.52	0.02	2.8	99.9
w-186	380510	4660550	Glaciolacustrine-Sand	86.1	5.7	1.36	0.32	0.74	0.91	1.28	0.19	0.04	0.03	2.49	0.01	2.8	99.5
w-452	415180	4682070	Glaciolacustrine-Sand	64.0	11.1	4.13	0.88	3.88	0.43	2.73	0.46	0.08	0.06	14.90	0.08	10.5	98.3

APPENDIX C: TRACE ELEMENT GEOCHEMISTRY OF SAMPLES

SAMPLE	UTM COORDINATES		MATERIAL	TRACE ELEMENT CONTENT (PPM)						
	EASTING	NORTHING		Fe PPM	Co PPM	Cr PPM	Cu PPM	Ni PPM	Pb PPM	Zn PPM
c-450lr	405850	4694850	Glaciolacustrine-Clay	2.20	15.00	79.00	26.00	46.00	17.00	81.00
ORR	439300	4702750	Glaciolacustrine-Clay	3.10	19.00	87.00	26.00	51.00	12.00	86.00
c3ab	376270	4683470	Glaciolacustrine-Clay	2.90	18.00	99.00	30.00	67.00	14.00	118.00
MEAN				2.73	17.33	88.33	27.33	54.67	14.33	95.00
STD DEV				0.39	1.70	8.22	1.89	8.96	2.05	16.39
c-446	417660	4700940	Glaciolacustrine-Silt	1.80	9.00	47.00	18.00	21.00	11.00	54.00
PH-1	414700	4697950	Glaciolacustrine-Silt	1.55	7.00	36.00	22.00	20.00	11.00	48.00
c-552	407530	4700940	Glaciolacustrine-Silt	3.10	16.00	78.00	20.00	36.00	12.00	84.00
c-115t	402280	4692080	Glaciolacustrine-Silt	1.80	6.00	51.00	13.00	14.00	10.00	43.00
c-140	493440	4700720	Glaciolacustrine-Silt	1.20	9.00	43.00	14.00	22.00	10.00	39.00
c-108	400290	4689030	Glaciolacustrine-Silt	2.70	14.00	67.00	25.00	37.00	13.00	83.00
c5at	379050	4683170	Glaciolacustrine-Silt	2.20	15.00	87.00	32.00	54.00	17.00	109.00
c-89	396910	4687700	Glaciolacustrine-Silt	2.20	18.00	73.00	31.00	50.00	14.00	87.00
c-385	408850	4705230	Glaciolacustrine-Silt	1.30	10.00	46.00	16.00	25.00	12.00	52.00
c-255	389290	4698730	Glaciolacustrine-Silt	2.40	11.00	58.00	20.00	28.00	19.00	58.00
c-572	405940	4698730	Glaciolacustrine-Silt	2.30	13.00	62.00	20.00	30.00	12.00	74.00
PH-2	414700	4697950	Glaciolacustrine-Silt	1.80	17.00	82.00	23.00	54.00	10.00	63.00
MEAN				2.03	12.08	60.83	21.17	32.58	12.58	66.17
STD DEV				0.54	3.82	15.98	5.71	13.19	2.72	20.33
c-120b	383970	4706020	Glaciolacustrine-Sand	3.50	17.00	82.00	23.00	43.00	11.00	85.00
PH-4	414700	4697950	Rhythmites	1.80	13.00	64.00	23.00	33.00	10.00	72.00
c-450ur	405850	4694850	Rhythmites	1.80	13.00	55.00	22.00	32.00	15.00	61.00
c-419b	410470	4703550	Rhythmites	2.30	11.00	55.00	21.00	29.00	15.00	62.00
c-432	411280	4681110	Rhythmites	2.40	11.00	50.00	23.00	27.00	12.00	61.00
c-68	388000	4689470	Rhythmites	1.90	9.00	53.00	16.00	27.00	10.00	58.00
c-143	398200	4705500	Rhythmites	1.40	14.00	61.00	23.00	30.00	26.00	68.00
c-115b	402280	4692080	Rhythmites	1.90	11.00	53.00	22.00	32.00	10.00	58.00
MEAN				1.93	11.71	55.86	21.43	30.00	14.00	62.86
STD DEV				0.31	1.58	4.55	2.32	2.27	5.32	4.85
c-67	388150	4689280	Alluvium	1.80	10.00	64.00	17.00	32.00	13.00	66.00
c-120t	383970	4706020	Alluvium	1.90	12.00	75.00	24.00	39.00	10.00	79.00
c3at	376270	4683470	Lacustrine Sand	1.70	9.00	54.00	21.00	37.00	10.00	60.00

Appendix D. GEOTECHNICAL PROPERTIES OF SAMPLES

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE			LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
	EASTING	NORTHING		CLAY%	SILT%	SAND%			
w-631	413380	4691880	Tavistock Till	39.00	47.00	14.00	35.00	19.00	16.00
w-637	415250	4693540	Tavistock Till	43.00	45.00	12.00	40.00	20.00	20.00
w-687	397530	4681830	Tavistock Till	39.00	38.00	23.00	41.00	19.00	22.00
w-694	401430	4684730	Tavistock Till	45.00	39.00	16.00	40.00	20.00	20.00
w-696	402900	4683060	Tavistock Till	43.00	45.00	12.00	37.00	19.00	18.00
w-702	398710	4680450	Tavistock Till	33.00	50.00	17.00	32.00	18.00	14.00
w-710	400070	4680400	Tavistock Till	44.00	45.00	11.00	37.00	20.00	17.00
w-714	403410	4682480	Tavistock Till	41.00	47.00	12.00	34.00	18.00	16.00
w-715	404160	4681660	Tavistock Till	37.00	45.00	18.00	32.00	18.00	14.00
w-723	377060	4677350	Tavistock Till	21.00	44.00	35.00	29.00	16.00	13.00
w-724	378850	4677240	Tavistock Till	35.00	43.00	22.00	36.00	19.00	17.00
w-725	380500	4677450	Tavistock Till	38.00	46.00	16.00	35.00	18.00	17.00
w-17	375400	4675800	Tavistock Till	42.00	45.00	13.00	36.00	18.00	18.00
w-29	379660	4672280	Tavistock Till	34.00	47.00	19.00	32.00	17.00	15.00
w-99	380760	4666330	Tavistock Till	35.00	48.00	17.00	30.00	16.00	14.00
w-101	381030	4665450	Tavistock Till	35.00	48.00	17.00	33.00	17.00	16.00
w-120	382180	4665230	Tavistock Till	35.00	49.00	16.00	33.00	18.00	15.00
w-124	384530	4665150	Tavistock Till	35.00	48.00	17.00	32.00	17.00	15.00
w-250	389330	4670620	Tavistock Till	37.00	44.00	19.00	39.00	21.00	18.00
w-271	387470	4666550	Tavistock Till	38.00	46.00	16.00	31.00	16.00	15.00
w-279	383600	4677520	Tavistock Till	35.00	47.00	18.00	31.00	17.00	14.00
w-286	386380	4678860	Tavistock Till	35.00	48.00	17.00	28.00	16.00	12.00
w-302	387580	4675560	Tavistock Till	32.00	48.00	20.00	31.00	17.00	14.00
w-308	384790	4675970	Tavistock Till	32.00	48.00	20.00	31.00	17.00	14.00
w-331	391200	4674190	Tavistock Till	34.00	47.00	19.00	34.00	18.00	16.00
w-336L	394320	4669310	Tavistock Till	34.00	47.00	19.00	30.00	16.00	14.00
w-336U	394320	4669310	Tavistock Till	33.00	48.00	19.00	32.00	18.00	14.00
w-350	392990	4669020	Tavistock Till	32.00	49.00	19.00	32.00	16.00	16.00
w-352	397560	4672790	Tavistock Till	40.00	47.00	13.00	42.00	21.00	21.00
w-403	402530	4677980	Tavistock Till	37.00	46.00	17.00	40.00	20.00	20.00
w-412	407560	4677830	Tavistock Till	31.00	48.00	22.00	32.00	17.00	15.00
w-424	408960	4681820	Tavistock Till	34.00	49.00	17.00	36.00	20.00	16.00
w-432	411280	4681110	Tavistock Till	37.00	46.00	17.00	41.00	22.00	19.00
w-435	417240	4680550	Tavistock Till	29.00	49.00	22.00	33.00	18.00	15.00
w-442	413820	4683300	Tavistock Till	26.00	50.00	24.00	29.00	16.00	13.00
w-446	415030	4682520	Tavistock Till	28.00	50.00	22.00	27.00	15.00	12.00
w-525	413320	4685370	Tavistock Till	33.00	48.00	19.00	33.00	17.00	16.00
w-576	407010	4682760	Tavistock Till	36.00	47.00	17.00	34.00	18.00	16.00
w-578	409010	4683040	Tavistock Till	40.00	43.00	17.00	43.00	22.00	21.00
w-602	412130	4687740	Tavistock Till	45.00	45.00	10.00	46.00	22.00	24.00
w-610	417890	4690430	Tavistock Till	36.00	47.00	17.00	34.00	18.00	16.00
w-619	412970	4688950	Tavistock Till	41.00	47.00	12.00	43.00	22.00	21.00
w-645	417400	4691830	Tavistock Till	33.00	51.00	16.00	41.00	21.00	20.00
PC-L	414700	4697950	Tavistock Till	32.00	48.00	20.00	28.00	15.00	13.00
PC-10	414700	4697950	Tavistock Till	33.00	44.00	23.00	27.00	15.00	12.00
PC-7	414700	4697950	Tavistock Till	29.00	47.00	24.00	26.00	14.00	12.00
MEAN				35.57	46.59	17.87	34.30	18.09	16.22
STD DEV				4.91	2.52	4.29	4.80	2.05	2.91

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE			LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
	EASTING	NORTHING		CLAY%	SILT%	SAND%			
BL-4	411600	4678400	Port Stanley Till	38.00	46.00	16.00	30.00	16.00	14.00
BL-5B	411600	4678400	Port Stanley Till	35.00	47.00	18.00	32.00	17.00	15.00
BL-5G	411600	4678400	Port Stanley Till	39.00	45.00	16.00	30.00	16.00	14.00
PA	397350	4670200	Port Stanley Till	33.00	47.00	20.00	27.00	15.00	12.00
w-506	-----	-----	Port Stanley Till	36.00	47.00	17.00	35.00	19.00	16.00
w-410	408300	4676920	Port Stanley Till	31.00	61.00	8.00	30.00	16.00	14.00
w-134	379550	4662710	Port Stanley Till	37.00	49.00	14.00	33.00	18.00	15.00
w-146T	376140	4661300	Port Stanley Till	38.00	47.00	15.00	34.00	18.00	16.00
w-164	382180	4662170	Port Stanley Till	38.00	47.00	15.00	33.00	18.00	15.00
w-233	376050	4660800	Port Stanley Till	40.00	44.00	16.00	-----	-----	-----
w-237M	377820	4661110	Port Stanley Till	37.00	49.00	14.00	34.00	18.00	16.00
CC-T	382600	4662150	Port Stanley Till	38.00	46.00	16.00	30.00	16.00	14.00
TD-G	388300	4665900	Port Stanley Till	35.00	46.00	19.00	28.00	16.00	12.00
DR-G	408500	4676900	Port Stanley Till	30.00	49.00	21.00	26.00	15.00	11.00
DR-R	408500	4676900	Port Stanley Till	42.00	55.00	3.00	29.00	16.00	13.00
BL-G	411600	4678400	Port Stanley Till	30.00	45.00	25.00	25.00	15.00	10.00
BL-T	411600	4678400	Port Stanley Till	26.00	66.00	8.00	25.00	14.00	11.00
MEAN				35.47	49.17	15.35	30.06	16.44	13.63
STD DEV				4.07	5.80	5.06	3.15	1.37	1.87

SAMPLE	UTM COORDINATES		MATERIAL	TEXTURE			LIQUID LIMIT	PLASTIC LIMIT	PLASTIC INDEX
	EASTING	NORTHING		CLAY%	SILT%	SAND%			
w-663	402140	4685940	Glaciolacustrine - Clay	60.00	38.00	2.00	49.00	22.00	27.00
c-450lr	405850	4694850	Glaciolacustrine - Clay	56.00	38.00	6.00	42.00	20.00	22.00
ORR	439300	4702750	Glaciolacustrine - Clay	52.00	47.00	1.00	48.00	26.00	22.00
c3ab	376270	4683470	Glaciolacustrine - Clay	50.00	38.00	12.00	—	—	—
MEAN				54.50	40.25	5.25	46.33	22.67	23.67
STD DEV				3.84	3.90	4.32	3.09	2.49	2.36
TR-R	409000	9716100	Glaciolacustrine - Silt	40.00	55.00	5.00	32.00	16.00	16.00
BL-S	411600	4678400	Glaciolacustrine - Silt	40.00	55.00	10.00	29.00	15.00	14.00
C-446	417660	4700940	Glaciolacustrine - Silt	17.00	79.00	4.00	25.00	17.00	8.00
c5at	379050	4683170	Glaciolacustrine - Silt	37.00	44.00	19.00	40.00	20.00	20.00
c-89	396910	4687700	Glaciolacustrine - Silt	32.00	67.00	1.00	37.00	19.00	18.00
c-385	408850	4704230	Glaciolacustrine - Silt	21.00	73.00	6.00	38.00	25.00	13.00
c-255	389290	4696230	Glaciolacustrine - Silt	22.00	68.00	18.00	29.00	17.00	12.00
PH-2	414700	4697950	Glaciolacustrine - Silt	26.00	65.00	9.00	27.00	18.00	9.00
MEAN				24.86	65.29	10.43	32.13	18.38	13.75
STD DEV				11.55	15.16	8.00	5.21	2.91	3.90
PH-4	414700	4697950	Rhythmites	20.00	71.00	9.00	33.00	20.00	13.00
c-450ur	405850	4694850	Rhythmites	17.00	82.00	1.00	24.00	18.00	6.00
c-419b	410470	4703550	Rhythmites	23.00	75.00	2.00	29.00	16.00	13.00
c-432	416270	4706710	Rhythmites	18.00	81.00	1.00	23.00	17.00	6.00
c-68	388000	4689470	Rhythmites	19.00	72.00	9.00	—	—	—
c-143	398200	4705500	Rhythmites	31.00	61.00	8.00	31.00	18.00	13.00
c-115b	402280	4692080	Rhythmites	19.00	80.00	1.00	25.00	17.00	8.00
MEAN				21.00	74.57	4.43	27.50	17.67	9.83
STD DEV				4.44	6.86	3.70	3.73	1.25	3.24

APPENDIX E: CLAY MINERALOGICAL ANALYSIS, SURFACE TILL SAMPLES

SAMPLE	UTM COORDINATES		MATERIAL	illite	chlorite	vermiculite	smectite	kaolinite	ill-smec
	EASTING	NORTHING							
PA	397350	4670200	Port Stanley Till	000		00		0	
DR-G	408500	4676900	Port Stanley Till	000	0	00		0	
DR-R	408500	4676900	Port Stanley Till	000	0	00		0	
BL-G	411600	4678400	Port Stanley Till	000	0	00		0	
w-237m	377820	4661110	Port Stanley Till	000	0	00	0	0	
w-17	375400	4675800	Tavistock Till	000	0	00	0	0	
w-29	379660	4672280	Tavistock Till	000	0	00	0	0	
w-99	380760	4666330	Tavistock Till	000	0	00	0	0	
w-308	384790	4675970	Tavistock Till	000	0	00	0	0	
w-331	391200	4674190	Tavistock Till	000		00		0	
w-336L	394320	4669310	Tavistock Till	000	0	00		0	
w-336U	394320	4669310	Tavistock Till	000	0	00		0	
w-352	397560	4672790	Tavistock Till	000	0	00		0	
w-432	411280	4681110	Tavistock Till	000	0	00		0	
w-578	409010	4683040	Tavistock Till	000	0	00		0	
w-619	412970	4688950	Tavistock Till	000	0	00		0	
w-687	397530	4681830	Tavistock Till	000		00		0	
w-694	401430	4684730	Tavistock Till	000	0	00		0	
w-714	403410	4682480	Tavistock Till	000	0	00		0	
w-715	404160	4681660	Tavistock Till	000	0	00		0	
w-724	378850	4677240	Tavistock Till	000		00		0	





















000 - Abundant 00 - Moderate 0 - Present

Appendix F. Sonic drillhole logs and data

Legend

Abbreviation	Translation
Pt. St	Port Stanley Till
Tav	Tavistock Till
CC	Catfish Creek Till
Diam	Diamicton
Glac	Glaciolacustrine
Gfluv	Glaciofluvial
Brk	Bedrock
Ill	Illite
Chl	Chlorite
Verm	Vermiculite
Smec	Smectite
Kaol	Kaolinite
Qtz	Quartz
Calc	Calcite

LEGEND

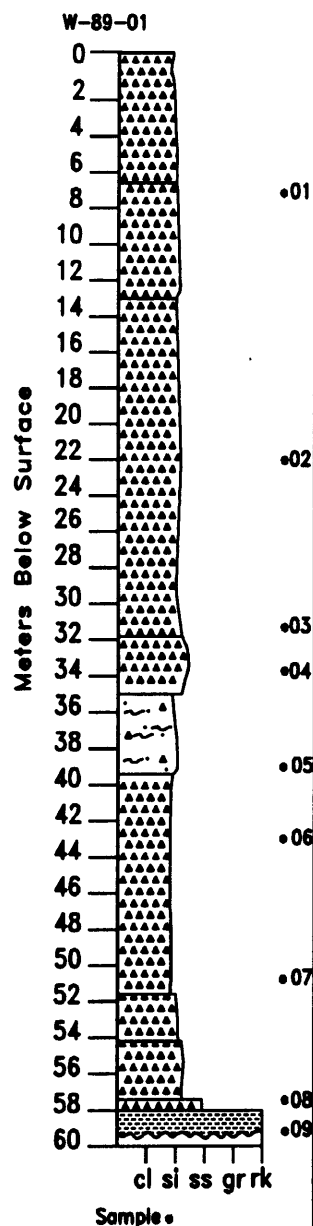
GRAVEL		STRATIFICATION		CLAY	cl
SAND		FAINT STRATIFICATION		SILT	sl
TILL AND/OR DIAMICTON		CONTORTED STRATIFICATION		SAND	ss
RIPPLE CROSS-LAMINATION		SHEARS		GRAVEL	gr
CLIMBING RIPPLES		FLOWS		AZIMUTH	
TROUGH CROSS-BEDDING		MUD PELLETS		till fabric	
LOW ANGLE CROSS-BEDDING		DISH STRUCTURES		paleocurrent	
FLAT BEDDED		PSEUDONODULES			
		DIAMICTON BALL			

Sonic Drillhole Number: W-89-01

Township: Raleigh Surface Elevation: 200.40 m

UTM Coordinates: E 410600 N 4680000

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-3.40 m - massive, grey brown, silty clay till, clasts common, black shale, limestone dominant, subangular to subrounded
- 3.40-4.40 m - massive, grey, silty clay till, as above, oxidized along vertical and horizontal cracks 3-4mm width
- 4.40-6.60 m - massive, grey, silty clay till
- 6.60-12.90 m - massive, grey, silty till, clasts; black shale, limestone dominant, up to 4 cm, subangular - subrounded, striated on one surface (top)
- 12.90-13.30 m - massive, dark grey, stony silty till, clasts subangular to subrounded, up to 7cm, black shale, limestone, rare granite, red shale
- 13.30-25.10 m - massive, grey, silty till, clasts subangular to subrounded, up to 8 cm, black shale, grey shale, limestone, faint fissility at bottom
- 25.10-31.90 m - massive, grey, silty till, clasts rare, black shale, limestone, subangular to subrounded, sharp lower contact
- 31.90-35.00 m - massive, grey, gritty, sandy silt till, clasts common, striated, up to 3 cm, black shale, limestone, subangular mostly
- 35.00-39.20 m - massive, smooth, grey, silty clay till, clasts rare, till has faint pinkish tinge in upper 50 cm, interbedded lower contact
- 39.20-51.60 m - massive, smooth, pink to grey, silty clay till, pink at top gradually changing to grey at bottom, clasts rare to common, small (<1cm) rare large clast up to 10 cm, mafic volcanic
- 51.60-54.20 m - massive, brownish grey, silty till, clasts rare, small, black shale, limestone, subangular-subrounded
- 54.20-57.40 m - massive, brownish grey, sandy silt till, coarsening with depth, sharp lower contact
- 57.40-58.00 m - massive, dense, stony sandy till, many grey green shale clasts
- 58.00+ m - bedrock, Hamilton Group, shale

W-89-01

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W-89-01-01	Tav	7.0	7.2
W-89-01-02	Tav	21.6	21.8
W-89-01-03	Tav	31.0	31.2
W-89-01-04	Tav	33.6	33.8
W-89-01-05	Tav	39.0	39.2
W-89-01-06	Tav	42.6	42.8
W-89-01-07	Tav	51.2	51.4
W-89-01-08	C C	57.6	57.8
W-89-01-09	B Rk-Shale	58.2	58.4

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
W-89-01-01	28	47	25	12.30	10.70	23.00	1.15
W-89-01-03	31	44	25	13.40	11.40	24.80	1.18
W-89-01-04	18	46	36	6.07	12.70	18.80	0.48
W-89-01-05	29	44	27	15.60	9.74	25.30	1.60
W-89-01-06	28	45	27	14.80	11.00	25.90	1.35
W-89-01-07	35	47	18	14.60	13.30	27.90	1.10
W-89-01-08	15	53	32	31.40	9.05	40.50	3.47

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W-89-01-01	3.36	13	72	32	40	10	82
W-89-01-03	3.20	13	67	28	36	11	72
W-89-01-04	3.49	14	64	37	46	11	98
W-89-01-05	3.31	13	64	29	31	11	74
W-89-01-06	3.29	12	64	28	28	-10	69
W-89-01-07	3.23	13	65	28	35	-10	70
W-89-01-08	2.35	11	53	24	30	10	49

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
3.44	7.14
2.56	7.32
1.95	7.14
5.22	8.93
2.55	6.25
3.14	8.25

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-01-01	ooo		oo		o				
W89-01-03	ooo		oo		o				
W89-01-04	ooo	o	oo						
W89-01-06	ooo		oo		o				
W89-01-06	ooo	o	oo						
W89-01-08	ooo	o	oo		o				

ooo-Abundant oo-Moderate o-Present

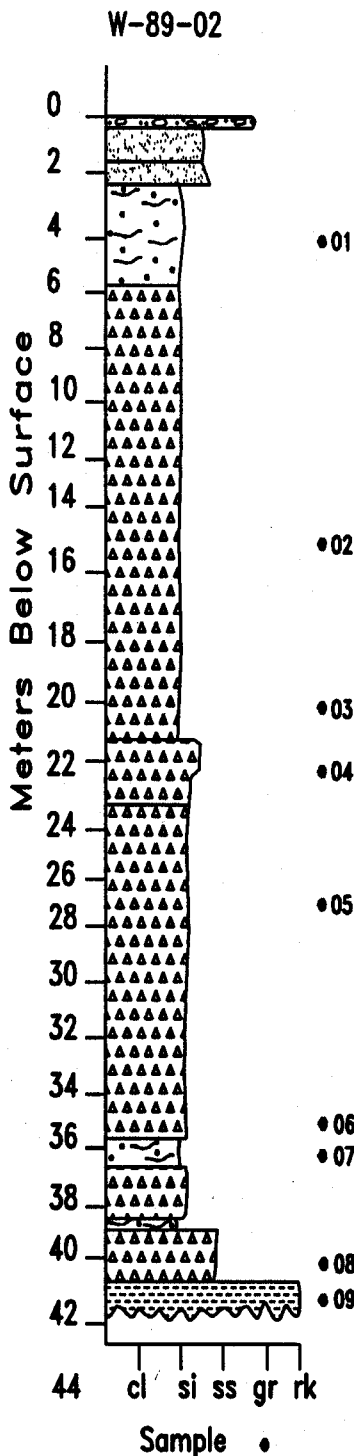
Sonic Drillhole Number: W-89-02

Township: Harwich

Surface Elevation: 189.0 m

UTM Coordinates: E 416300 N 4680850

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.40 m - road base
- 0.40-1.60 m - silty very fine sand, faint cross-lamination, thin organic matter stringers
- 1.60-2.40 m - well sorted fine sand, fining upward, weathered to 2.20 m
- 2.40-5.70 m - stratified silt to silty clay, reddish and whitish mud pellets common, thin (<1cm) reddish silty clay lenses, rare, small (<1.5cm) subangular to subrounded clast, clasts green shale, red shale, interbedded lower contact
- 5.70-21.50 m - massive, grey, silty till, clasts rare to common, small (<3cm), subangular to subrounded, black shale, green shale
- 21.50-23.00 m - massive, dense, grey, silty to silty sand till, clasts common, subangular to subrounded, black shale, limestone
- 23.00-23.45 m - massive, brownish grey, silty till, sharp lower contact
- 23.45-35.60 m - massive, dense, grey, silty to silty sand till, clasts common, up to 5cm, subrounded, striated, black shale
- 35.60-35.85 m - massive, grey, silty sand till, clasts common, subangular to subrounded, limestone, black shale, grey shale
- 35.85-36.00 m - interbedded, grey, silty sand till and pinkish brown, massive silty clay
- 36.00-36.40 m - massive to faintly stratified, pinkish, silty clay, reddish mud pellets common, reddish, thin (<0.5cm) silty clay lenses.
- 36.40-36.60 m - massive, pinkish brown, clayey silt diamicton, few small (<1cm) pebbles, black shale
- 36.60-38.25 m - massive, greyish brown, sandy silt till, clasts common, up to 4cm, black shale, limestone
- 38.25-38.50 m - massive to faintly stratified, pinkish clayey silt, reddish mud pellets, rare, small, rounded
- 38.50-40.40 m - massive, dense, brownish grey, stony, silty sand to sandy till, many clasts, subangular to subrounded, striated, black shale, limestone, lower 50 cm of till is saturated with oil
- 40.40+ m - bedrock, black shale, Kettle Point Formation

W-89-02

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W89-02-01	Glac	4.3	4.4
W89-02-02	Pt. St.	15.4	15.6
W89-02-03	Pt. St.	19.7	19.9
W89-02-04	Pt. St.	22.2	22.4
W89-02-05	Tav	27.4	27.6
W89-02-06	Tav	35.3	35.5
W89-02-07	Glac	36.1	36.3
W89-02-08	C C	39.9	40.1
W89-02-09	B Rk/Shale	40.5	40.6

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Do Ratio
W89-02-01	33	54	13	17.70	8.97	26.70	1.97
W89-02-02	33	46	21	12.90	12.50	25.40	1.03
W89-02-04	29	47	24	11.10	11.40	22.50	0.97
W89-02-05	28	46	26	10.50	12.90	23.40	0.81
W89-02-06	27	46	27	9.35	11.90	21.30	0.79
W89-02-07	36	51	13	12.80	10.30	23.10	1.24
W89-02-08	11	34	55	10.60	11.10	21.70	0.96

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W89-02-01	2.88	11	64	28	30	11	63
W89-02-02	3.35	12	70	31	35	12	71
W89-02-04	3.52	15	72	32	43	12	88
W89-02-05	3.45	13	71	31	43	13	81
W89-02-06	3.48	14	71	37	45	16	85
W89-02-07	3.20	11	63	30	29	13	70
W89-02-08	3.28	15	63	38	38	14	65

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
3.71	8.47
3.80	9.52
2.63	8.00
2.06	6.38
5.18	11.63
5.32	8.31

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-02-01	ooo	o	oo		o				
W89-02-02	ooo	o	oo		o				
W89-02-05	ooo	o	oo		o				
W89-02-06	ooo	o	oo		o				
W89-02-07	ooo	o	oo		o				
W89-02-08	ooo	o	oo						

ooo-Abundant oo-Moderate o-Present

W-89-02

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W89-02-01	Glac	4.3	4.4
W89-02-02	Pt. St.	15.4	15.6
W89-02-03	Pt. St.	19.7	19.9
W89-02-04	Pt. St.	22.2	22.4
W89-02-05	Tav	27.4	27.6
W89-02-06	Tav	35.3	35.5
W89-02-07	Glac	36.1	36.3
W89-02-08	C C	39.9	40.1
W89-02-09	B Rk/Shale	40.5	40.6

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Do Ratio
W89-02-01	33	54	13	17.70	8.97	26.70	1.97
W89-02-02	33	46	21	12.90	12.50	25.40	1.03
W89-02-04	29	47	24	11.10	11.40	22.50	0.97
W89-02-05	28	46	26	10.50	12.90	23.40	0.81
W89-02-06	27	46	27	9.35	11.90	21.30	0.79
W89-02-07	36	51	13	12.80	10.30	23.10	1.24
W89-02-08	11	34	55	10.60	11.10	21.70	0.96

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W89-02-01	2.88	11	64	28	30	11	63
W89-02-02	3.35	12	70	31	35	12	71
W89-02-04	3.52	15	72	32	43	12	88
W89-02-05	3.45	13	71	31	43	13	81
W89-02-06	3.48	14	71	37	45	16	85
W89-02-07	3.20	11	63	30	29	13	70
W89-02-08	3.28	15	63	38	38	14	65

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
3.71	8.47
3.80	9.52
2.63	8.00
2.06	6.38
5.18	11.63
5.32	8.31

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-02-01	ooo	o	oo		o				
W89-02-02	ooo	o	oo		o				
W89-02-05	ooo	o	oo		o				
W89-02-06	ooo	o	oo		o				
W89-02-07	ooo	o	oo		o				
W89-02-08	ooo	o	oo						

ooo-Abundant oo-Moderate o-Present

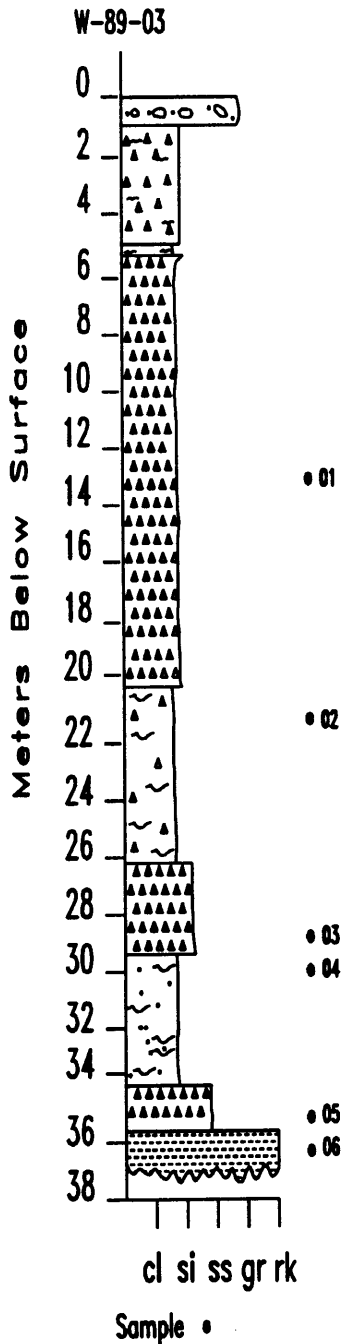
Sonic Drillhole Number: W-89-03

Township: Raleigh

Surface Elevation: 192.8 m

UTM Coordinates: E 401900 N 46802000

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.70 m - road base
- 0.70-5.05 m - massive, grey to yellowish grey (weathered), clayey silt till, clasts rare to common, small, up to 1.5 cm, black shale, crinoid stem
- 5.05-5.10 m - massive to stratified, clayey silt diamicton, rare whitish and reddish mud pellet, rare small (<1cm) clast
- 5.10-20.60 m - massive, grey, clayey silt to silty till, coarser at top gradually fining with depth, clasts common, up to 7 cm, subangular to subrounded, striated, larger with depth, black shale, limestone, brachiopod fossils, sharp lower contact
- 20.60-26.40 m - massive, pinkish grey, clayey silt till, rare, reddish, mud pellet, rare small clast, up to 1.5cm, subrounded, limestone, black shale, sharp sharp lower contact
- 26.40-29.70 m - massive, dense, grey, silty to sandy silt till, clasts common, up to 6 cm, black shale common, few limestone and rare felsic igneous
- 29.70-34.20 m - massive to faintly stratified, pinkish grey, clayey silt, reddish mud pellets common, rare whitish pellet, rare small (<1cm), subrounded clast, limestone, black shale, upper 1.0 m contains thin (<3cm) diamicton layers, lower contact is sharp
- 34.20-35.70 m - massive, dense, grey, stony silty sand to sandy till, clasts common, 10 cm plus, subangular to subrounded, black shale, limestone, till is oil saturated in lower 50 cm
- 35.70+ m - bedrock, black shale, Kettle Point Formation

W-89-03

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W-89-03-01	Tav	12.4	12.6
W-89-03-02	Tav	21.0	21.2
W-89-03-03	TAV	29.4	29.6
W-89-03-04	Glac/Tav	30.4	30.6
W-89-03-05	C C /Tav	35.0	35.2
W-89-03-06	B Rk/Shale	36.3	36.4

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
W-89-03-01	36	46	18	14.40	10.90	25.30	1.32
W-89-03-02	31	48	21	16.10	9.47	25.60	1.70
W-89-03-03	25	47	28	7.01	11.80	18.80	0.59
W-89-03-04	50	45	5	15.10	8.78	23.90	1.72
W-89-03-05	31	47	22	9.74	8.86	18.60	1.10

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W-89-03-01	3.08	13	70	28	37	11	77
W-89-03-02	3.15	13	66	30	32	11	61
W-89-03-03	3.42	14	66	37	46	15	105
W-89-03-04	3.02	13	71	28	33	13	19
W-89-03-05	3.76	15	74	32	42	13	75

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
3.24	9.09
4.10	8.82
2.25	7.32
3.79	8.99
1.80	3.13

Clay Mineralogy

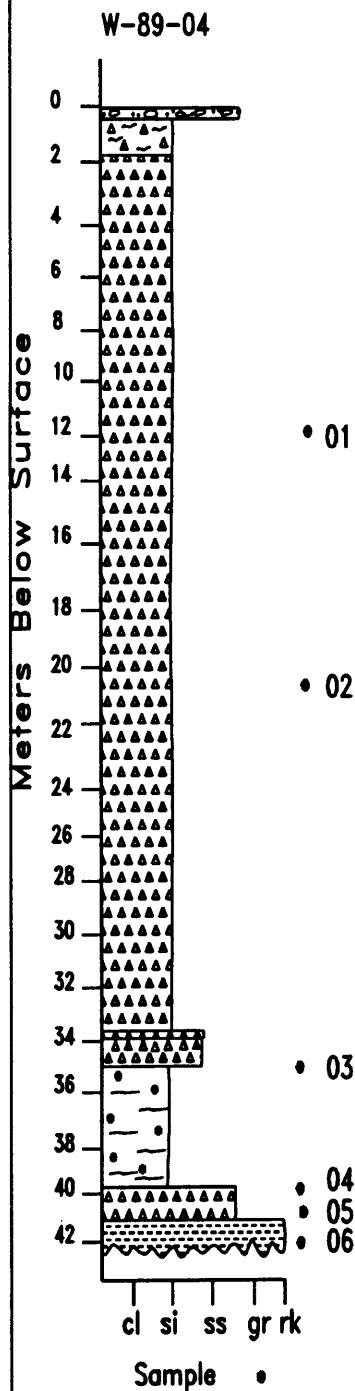
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-03-01	ooo	o	oo		o				
W89-03-02	ooo	o	oo		o				
W89-03-03	ooo	o			o				
W89-03-04	ooo	o	o		o				
W89-03-05	ooo	o	o		o				

ooo-Abundant oo-Moderate o-Present

Sonic Drillhole Number: W-89-04

Township: Tilbury East Surface Elevation: 184.8 m
 UTM Coordinates: E 385450 N 4676850

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

0.0-0.40 m - road base

0.40-1.60 m - massive, weathered, clayey silt till, has thin interbeds of stratified diamicton

1.60-1.70 m - faintly stratified clayey silt diamicton, contains few mud pellets, small clasts, black shale, red shale

1.70-10.50 m - massive grey, clayey silt till, clasts common, up to 4 cm, black shale, limestone, rare grey shale, red shale, striated

10.50-10.95 m - massive, grey, clayey silt till, rare small clast, limestone, black shale

10.95-33.25 m - massive, grey, clayey silt till, clasts rare, small (<1.5cm), limestone, black shale

33.25-33.50 m - faintly stratified, grey, clayey silt to silt diamicton, clasts rare, small, black shale, limestone, grey shale, interbedded lower contact

33.50-33.55 m - massive, dark grey, sandy silt till, clasts rare, black shale, sharp lower contact

33.55-33.60 m - faintly stratified, grey, clayey silt to silt diamicton, clasts rare, black shale

33.60-34.80 m - massive, grey, clayey silt diamicton, clasts very rare, black shale, grey shale

34.80-34.90 m - massive, grey, sandy silt till, clasts rare

34.90-35.80 m - massive, grey, clayey silt, clasts rare

35.80-39.80 m - massive to stratified, grey to pinkish, silty clay with thin interbeds of pinkish silt, sharp lower contact

39.80-41.60 m - massive, grey, dense, stony silty sand to sand till, clasts common, large, many (>10 cm), limestone, grey shale, black shale

41.60+ m - bedrock, greenish grey shale, Hamilton Group

W-89-04

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W-89-04-01	Tav	12.0	12.2
W-89-04-02	Tav	20.8	21.0
W-89-04-03	Glac	35.3	35.5
W-89-04-04	C C	40.0	40.1
W-89-04-05	C C	41.3	41.5
W-89-04-06	B Rk/Shale	41.9	42.0

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
W-89-04-01	33	45	22	11.10	11.00	22.10	1.01
W-89-04-02	31	44	25	9.82	12.00	21.80	0.82
W-89-04-03	36	44	20	8.71	10.50	18.20	0.83
W-89-04-04	20	40	40	14.90	9.99	24.80	1.49

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W-89-04-01	3.29	14	74	31	41	11	85
W-89-04-02	3.38	13	73	31	42	13	108
W-89-04-03	4.47	14	76	33	44	13	109
W-89-04-04	3.18	16	80	28	44	-10	70

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
1.71	4.17
2.16	8.45
1.96	7.55
4.05	8.46

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-04-01	ooo	o	o		o				
W89-04-02	ooo	o	o		o				
W89-04-03	ooo	oo			o				
W89-04-04	ooo	oo			o				

ooo-Abundant oo-Moderate o-Present

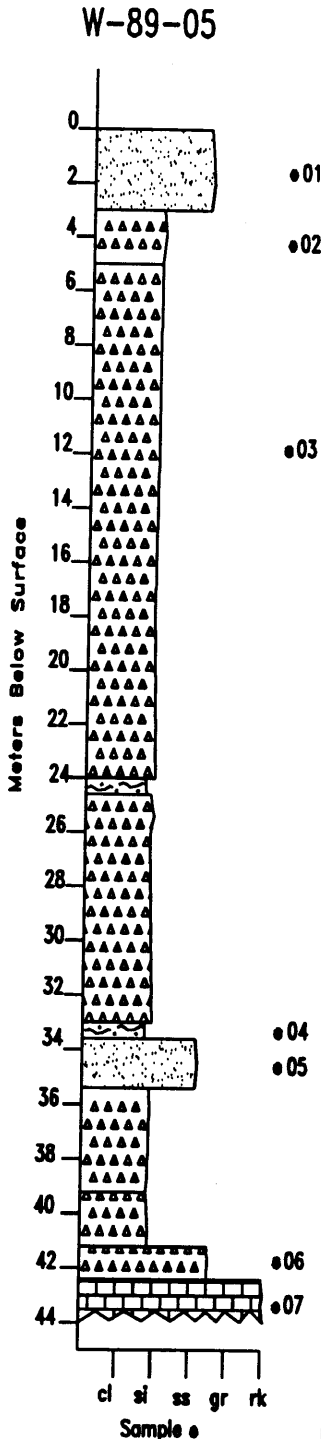
Sonic Drillhole Number: W-89-05

Township: Romney

Surface Elevation: 185.1 m

UTM Coordinates: E 382200 N 4661850

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.10 m - road base
- 0.10-3.10 m - faintly laminated, well sorted, medium to coarse, yellowish brown sand, sharp lower contact
- 3.10-5.10 m - massive, grey, dense, clayey silt till, breaks along horizontal planes into thin plates, clasts common, subangular to subrounded, striated, black shale, grey shale, rare red shale, igneous
- 5.10-24.00 m - massive, grey, soft, clayey silt till, clasts rare to common, small (<3cm), black shale, grey shale, rare red shale, mafic igneous, granite
- 24.00-24.60 m - massive, grey, clayey silt to silt till interbedded with faintly stratified, pinkish, silty clay
- 24.60-32.93 m - massive, grey, soft, clayey silt till, clasts very rare, small, black shale, grey shale
- 32.93-33.00 m - massive, grey, spongy, silty till
- 33.00-33.45 m - massive to faintly stratified, grey, silty clay, reddish mud pellets common, concentrated in lower 15 cm, clasts rare, small(<1cm), black shale, red shale
- 33.45-33.55 m - massive, pinkish, soft, silty clay, rare small, black shale, grey shale
- 33.55-33.60 m - stratified, pinkish, silty clay, reddish mud pellets common, clasts rare, red shale, black shale
- 33.60-35.40 m - well sorted, medium to coarse, yellowish sand, no shells evident, sharp upper and lower contacts
- 35.40-39.10 m - massive, pinkish to greyish, silty clay diamicton, clasts rare, black shale, red shale, abrupt colour change at lower contact
- 39.10-41.30 m - massive, grey, soft, silty clay diamicton, clasts rare, black shale, limestone, grey shale
- 41.30-42.50 m - massive, grey, dense, very hard, stony silty sand to sand till, clasts common, large, many >10 cm, subangular to subrounded, limestone, black shale
- 42.50+ m - bedrock, greyish brown limestone, Dundee Formation

W-89-05		Sample Intervals:	
Sample	Material	Sample Interval (m)	
		=====	=====
		UPPER	LOWER
W-89-05-01	Glac	2.0	2.1
W-89-05-02	Pt. St.	4.1	4.2
W-89-05-03	Pt. St.?	11.8	12.0
W-89-05-04	Glac	33.2	33.4
W-89-05-05	Glac	34.0	34.2
W-89-05-06	C C	42.0	42.2
W-89-05-07	B RK/Limestone	42.5	42.6

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
=====							
W-89-05-02	38	47	15	14.00	8.97	23.00	1.58
W-89-05-03	37	47	16	12.30	9.22	21.50	1.33
W-89-05-04	28	54	18	14.20	9.43	23.60	1.51
W-89-05-05	1	5	94				
W-89-05-06	14	48	38	19.50	12.00	31.50	1.63

Element Analysis							
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
=====							
W-89-05-02	3.34	13	69	30	34	11	76
W-89-05-03	3.51	13	75	33	39	19	85
W-89-05-04	2.86	12	61	32	29	14	69
W-89-05-05							
W-89-05-06	2.37	9	52	27	23	-10	56

Heavy Mineral Separation	
Heavy Minerals	Magnetic Fraction
=====	
3.79	8.96
2.79	8.62
3.55	11.30
1.42	3.65
4.83	8.65

Clay Mineralogy									
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
=====									
W89-05-02	ooo	oo			o				
W89-05-03	ooo	oo			o				
W89-05-04	ooo	o	o						
W89-05-06	ooo	oo			o				

ooo-Abundant oo-Moderate o-Present

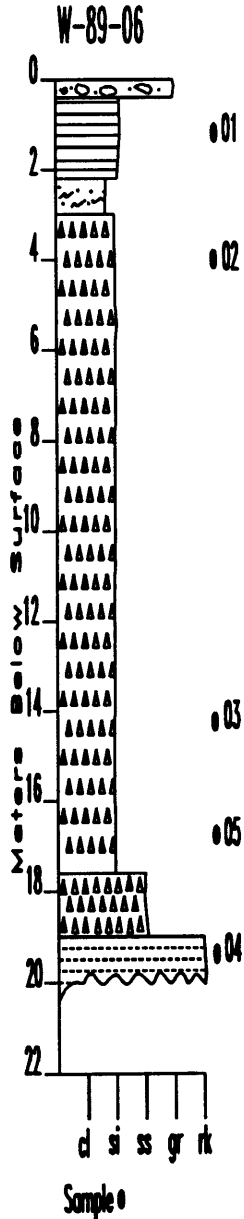
Sonic Drillhole Number: W-89-06

Township: Raleigh

Surface Elevation: 182.0 m

UTM Coordinates: E 401750 N 4688350

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.60 m - road base
- 0.60-2.30 m - faintly laminated, mottled, greenish brown, silty very fine sand, rare shell, gradational lower contact
- 2.30-2.80 m - faintly stratified, sandy silt, with thin interbeds of pebbly clayey silt diamicton, gradational lower contact
- 2.80-5.70 m - massive, grey, clayey silt till, clasts common, subangular to subrounded, striated, black shale, limestone
- 5.70-6.25 m - massive, grey, stony, clayey, silt till, clasts very common, striated, up to 8 cm, black shale, limestone
- 6.25-14.65 m - massive, grey, clayey silt till, clasts common, subangular to subrounded, faintly striated, black shale, limestone
- 14.65-17.80 m - massive, grey, clayey silt till, clasts rare, black shale, limestone
- 17.80-19.10 m - massive, grey, stony silty till, very stony 18.0-18.6m, clasts subangular to subrounded, limestone, black shale
- 19.10+ m - bedrock, black shale, Kettle Point Formation

W-89-06

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		UPPER	LOWER
W-89-06-01	Glac	1.2	1.4
W-89-06-02	Tav	4.0	4.1
W-89-06-03	Tav	14.4	14.6
W-89-06-04	B Rk/Shale	19.3	19.5
W-89-06-05	C C	17.0	17.2

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
W-89-06-01	28	62	10	0.43	0.90	1.33	0.43
W-89-06-02	30	45	25	13.10	11.40	24.50	1.15
W-89-06-03	33	45	22	12.00	11.40	23.40	1.05
W-89-06-05	29	40	31	12.40	11.30	23.70	1.10

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W-89-06-01	3.17	13	86	26	41	22	119
W-89-06-02	3.17	12	70	29	39	13	80
W-89-06-03	3.10	13	73	30	40	11	83
W-89-06-05	3.53	13	74	31	43	13	85

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
1.80	2.08
2.42	7.46
2.03	8.33
2.52	6.17

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-06-01	ooo						o		
W89-06-02	ooo	o	o		o				
W89-06-03	ooo	o	o		o				
W89-06-05	ooo	o							

ooo-Abundant oo-Moderate o-Present

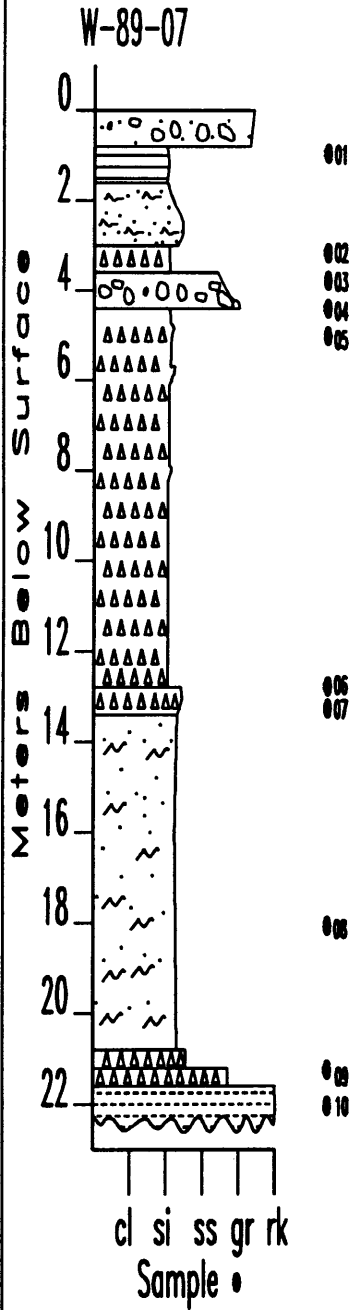
Sonic Drillhole Number: W-89-07

Township: Harwich

Surface Elevation: 185.2 m

UTM Coordinates: E 411200 N 4692800

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

0.0-0.80 m - road base

0.80-2.10 m - faintly laminated, mottled, silt to sandy silt, rare small pebble present, gradational lower contact

2.10-2.95 m - faintly stratified, mottled, clayey silt to sandy silt, small clasts common, subrounded to rounded

2.95-3.40 m - massive, grey, gritty, clayey silt to sandy silt till, exhibits upward fining, clasts common, small (<2cm), limestone, black shale

3.40-3.50 m - massive, poorly sorted silty, pebbly gravel, matrix of silty fine sand, clasts subrounded to rounded, up to 2 cm in diameter

3.50-3.60 m - faintly laminated, clayey silt

3.60-3.90 m - poorly sorted clayey-sandy gravel to sandy gravel, fining up sequence, clasts subrounded to rounded, size at base up to 6 cm

3.90-4.00 m - faintly stratified, pebbly silt, clasts subrounded

4.00-4.10 m - massive, poorly sorted, sandy gravel, clasts subrounded to rounded

4.10-4.20 m - massive, grey, silty sand till, clasts common, small (<3cm), limestone, black shale

4.20-4.40 m - massive, grey, silty till, clasts rare

4.40-7.90 m - massive, grey, clayey silt till, clasts rare to common, small (<1.5cm), limestone, black shale, faintly striated, upper 50cm breaks along horizontal planes into thin plates

7.90-10.95 m - massive, grey, clayey silt till, clasts very common, small (<2cm), limestone, black shale

10.95-11.60 m - massive, grey, clayey silt till, clasts rare, small (<1cm), limestone, black shale

11.60-12.90 m - massive, dark grey, clayey silt till, spongy, clasts rare to common, small (<2cm), limestone, black shale

12.90-13.15 m - massive, grey, soft, very fine sandy silt till, clasts rare, small (<1cm)

13.15-13.40 m - massive, grey, sandy silt till, clasts common, subangular to rounded, small (<3cm), limestone, black shale, rare granite

13.40-21.05 m - massive, grey, soft, very fine sandy silt, clasts very rare, black shale, gradational lower contact

21.05-21.20 m - massive, grey, sandy silt till, clasts common, subrounded to rounded, black shale, limestone

21.20-21.25 m - massive, poorly sorted sandy gravel, clasts subrounded to rounded, limestone, black shale

21.25-21.30 m - massive, well sorted, yellowish brown, medium sand

21.30-21.40 m - massive, grey, dense, stony sandy till, clasts common, limestone, black shale

21.40+ m - bedrock, black shale, Kettle Point Formation

W-89-07

Sample Intervals:

Sample	Material	Sample Interval (m below surface)	
		=====	=====
		UPPER	LOWER
W-89-07-01	Glac	1.4	1.6
W-89-07-02	Tav	3.3	3.4
W-89-07-03	Gfluv	3.7	3.9
W-89-07-04	Gfluv	4.1	4.2
W-89-07-05	Tav	5.1	5.2
W-89-07-06	Tav	12.8	12.9
W-89-07-07	Tav	12.9	13.1
W-89-07-08	Glac	18.0	18.2
W-89-07-09	Gfluv	21.3	21.4
W-89-07-10	B Rk/Shale	22.0	22.1

Texture (-2mm) & Carbonate Content (-0.074mm)

Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Do Ratio
=====							
W-89-07-01	43	46	11	0.66	1.13	1.79	0.58
W-89-07-02	24	45	31	13.80	11.90	25.70	1.16
W-89-07-04							
W-89-07-05	29	51	20	8.65	12.20	20.90	0.71
W-89-07-06	43	49	8	14.30	11.00	25.30	1.30
W-89-07-07	40	48	12	14.40	10.50	24.90	1.37
W-89-07-08	45	50	5	17.50	8.97	26.50	1.95

Element Analysis

Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
=====							
W-89-07-01	4.50	14	92	42	44	17	125
W-89-07-02	3.30	13	66	30	38	14	80
W-89-07-04							
W-89-07-05	3.50	14	74	33	43	14	88
W-89-07-06	3.33	12	72	28	35	13	77
W-89-07-07	3.43	13	75	30	38	15	81
W-89-07-08	3.51	12	72	28	34	12	75

Heavy Mineral Separation

Heavy Minerals	Magnetic Fraction
=====	
2.41	3.70
3.11	4.95
2.58	4.35
2.50	10.71
2.34	6.06
2.62	8.82

Clay Mineralogy

Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
=====									
W89-07-01	ooo		oo						
W89-07-02	ooo	o	o						
W89-07-05	ooo	o	o		o				
W89-07-06	ooo	o	o		o				
W89-07-07	ooo	o	o		o				
W89-07-08	ooo	o	o		o				

ooo-Abundant oo-Moderate o-Present

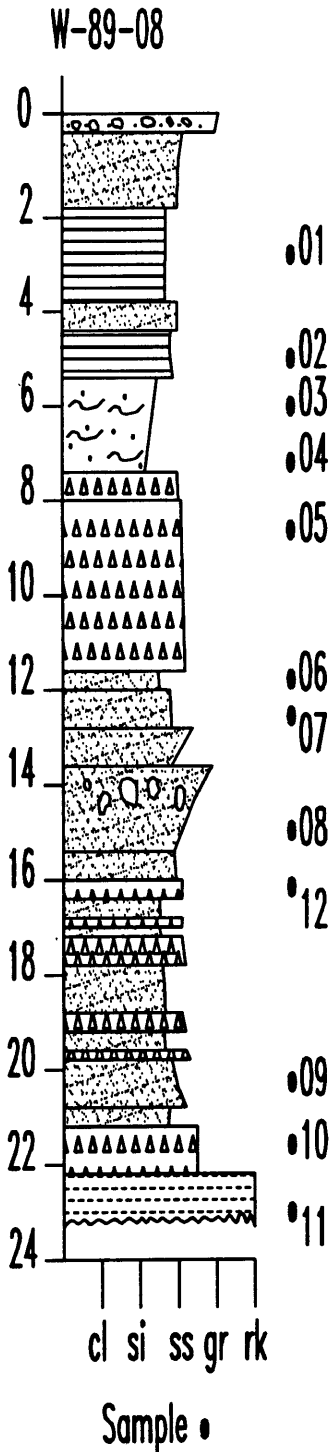
Sonic Drillhole Number: W-89-08

Township: Harwich

Surface Elevation: 188.6 m

UTM Coordinates: E 413650 N 4697750

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

0.0-0.20	m	- gravelly sand, road base
0.20-1.72	m	- faintly laminated silty fine sand, mottled, thin organic matter lenses, root remnants
1.72-3.32	m	- silty very fine sand-clayey silt rhythmites, couplets 0.1-0.3 cm thick, sharp lower contact
3.32-3.42	m	- faintly laminated clayey silt, clasts free
3.42-3.92	m	- silty very fine sand-clayey silt rhythmites, couplets 0.1-0.3 cm thick, sharp lower contact
3.92-4.40	m	- well sorted, fine-medium, yellowish brown sand, faintly laminated (parallel)
4.40-4.52	m	- well sorted, fine-medium, yellowish brown sand, faint cross-lamination, sharp lower contact
4.52-5.56	m	- silty fine sand-clayey silt rhythmites, couplets 0.3-0.5 cm thick, coarser part of couplet 0.1-0.3 cm thick, clast free, gradational lower contact
5.56-7.06	m	- massive to faintly laminated clayey silt to silty clay becoming finer with depth, reddish mud pellets common becoming abundant near bottom, sharp lower contact
7.06-7.96	m	- dense, massive, grey, silty till, clasts common, black shale, limestone dominant, up to 3 cm, subangular to subrounded
7.96-8.26	m	- soft, massive, grey, silty till, clast rare to common
8.26-11.51	m	- dense, massive, grey, silt to sandy silt till, coarser at base, faint shear planes? at base, clasts common, small < 3cm, black shale, limestone, rare igneous, sharp lower contact
11.51-11.96	m	- interbedded fine sand and silty very fine sand, beds < 1cm thick
11.96-12.80	m	- well sorted, light yellowish brown, fine sand, faint cross-lamination
12.80-13.60	m	- coarsening up sequence very fine sand to fine-medium sand, faintly laminated, sharp lower contact
13.60-15.40	m	- coarsening up sequence very fine sand to sandy pebbly gravel, lower sand faintly laminated, sharp lower contact
15.40-15.50	m	- pebbly, silty sand till, small rounded clasts evident, < 1cm, sharp contacts
15.50-15.90	m	- well sorted, light yellowish brown, medium sand
15.90-16.05	m	- very fine sand and clayey silt rhythmites, couplets 1.0-2.0 cm thick
16.05-16.45	m	- sandy, massive grey till, black shale, limestone, clasts, common, sharp contacts
16.45-16.65	m	- massive silt-very fine sand, faint lamination, compact, sharp contacts
16.65-16.75	m	- pebbly, massive, sandy till
16.75-17.15	m	- massive silt-very fine sand, brownish, faint lamination, compact, common, limestone, black shale
17.15-17.65	m	- sandy to silty sand, massive, grey, till, clasts common, limestone, black shale
17.65-18.85	m	- massive silt-very fine sand, light brown, faint lamination, compact
18.85-19.00	m	- pebbly, massive, silty sand till
19.00-19.05	m	- dense, massive, brownish silt
19.45-19.85	m	- pebbly, massive, silty sand till
19.85-20.05	m	- fine sand-clayey silt rhythmites, couplets 1.0-2.0 cm thick
20.05-20.20	m	- well sorted, light brown, fine sand, faint laminae
20.20-20.70	m	- dense, massive, very fine sand-silt, thin, very fine sand layers (1mm) in upper 15 cm
20.70-20.85	m	- pebbly, massive, silty sand till
20.85-21.05	m	- dense, massive, light brown silt
21.05-22.10	m	- dense, massive, light grey, stony sandy till
22.10	m	- bedrock, Kettle Point Formation, black shale

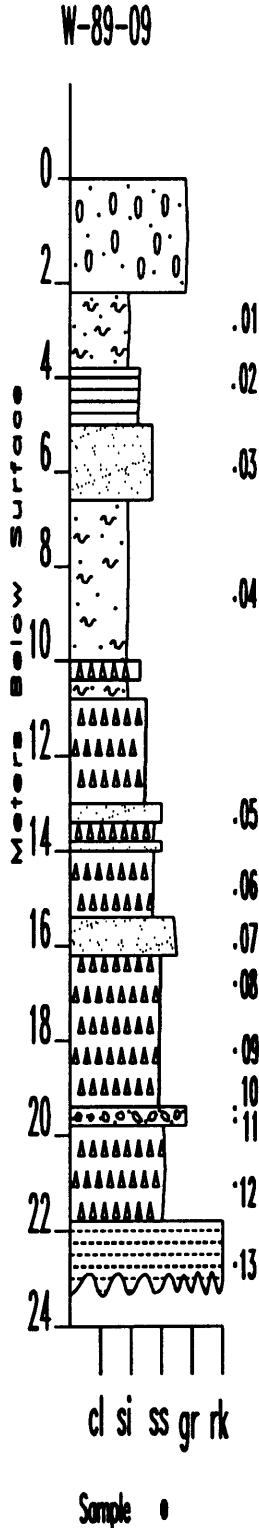
Sonic Drillhole Number: W-89-09

Township: Harwich

Surface Elevation: 184.5 m

UTM Coordinates: E 411250 N 4702350

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-2.50 m - road base and fill
- 2.50-3.89 m - faintly laminated, grey, clayey silt, no clasts, sharp lower contact
- 3.89-5.00 m - laminated, grey, sandy silt, no clasts, sharp lower contact
- 5.00-6.95 m - faintly laminated, well sorted, brownish grey, fine sand, sharp lower contact
- 6.95-7.95 m - faintly stratified, greyish, clayey silt, reddish mud pellets common
- 7.95-10.05 m - massive, pinkish, soft, silty clay, rare reddish mud pellet, rare small (<1cm) clast
- 10.05-10.15 m - faintly stratified, greyish, silty clay, reddish mud pellets common
- 10.15-10.30 m - massive, dark grey, gritty sandy silt diamicton, clasts common, black shale, limestone
- 10.30-10.80 m - massive, smooth, grey, silty clay, clasts very rare, small (<1cm), black shale
- 10.80-12.00 m - massive, silty sand diamicton, clasts rare to common, subangular to subrounded, small (<2cm), limestone, black shale
- 12.00-13.25 m - massive, grey, dense, fissile, stony silty sand till, clasts subangular to subrounded, limestone, black shale
- 13.25-13.45 m - massive, moderately well sorted fine to very coarse sand, rare, rounded, limestone pebble
- 13.45-13.90 m - massive, grey, dense, stony silty sand till, clasts subangular to subrounded, limestone, black shale
- 13.90-14.05 m - massive, well sorted, medium sand
- 14.05-15.45 m - massive, grey, dense, stony silty sand till, clasts subangular to rounded, limestone, black shale
- 15.45-16.45 m - massive, well sorted coarse-very coarse sand, some pebbles, rounded, black shale
- 16.45-19.05 m - massive, grey, silty sand till, denser at bottom breaks into thin plates, clasts common, up to 10 cm, striated
- 19.05-19.45 m - massive, grey, very dense, stony silty sand till, many clasts, 10 cm+
- 19.45-19.65 m - massive, sandy pebbly gravel, pebbles up to 1 cm, well rounded
- 19.65-19.75 m - massive, poorly sorted, sandy gravel, clasts up to 3 cm exhibits fining up sequence
- 19.75-19.90 m - massive, poorly sorted, pebbly sand, fining up sequence
- 19.90-21.90 m - massive, grey, stony-sandy till, many clasts, subangular to subrounded, limestone, black shale
- 21.90+ m - bedrock, black shale, Kettle Point Formation

W-89-09 Sample Intervals:							
Sample	Material	Sample Interval (m below surface)		Sample	Material	Sample Interval (m below surface)	
		=====	=====			=====	=====
		UPPER	LOWER			UPPER	LOWER
W-89-09-01	Glac	3.0	3.1	W-89-09-08	Tav	16.7	16.9
W-89-09-02	Glac	4.2	4.3	W-89-09-09	Tav?	18.0	18.2
W-89-09-03	Glac	6.0	6.1	W-89-09-10	Gfluv	19.6	19.7
W-89-09-04	Glac	9.0	9.2	W-89-09-11	Gfluv	19.8	19.9
W-89-09-05	Glac	13.3	13.4	W-89-09-12	C C	21.0	21.2
W-89-09-06	Tav	14.9	15.0	W-89-09-13	B RK/Shale	22.0	22.1
W-89-09-07	Glac	16.0	16.1				

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio

W-89-09-01	25	74	1	14.40	14.90	29.30	0.97
W-89-09-03	17	82	1				
W-89-09-04	66	33	1	22.00	6.64	28.60	3.44
W-89-09-05	2	4	94				
W-89-09-06	17	41	42	14.50	12.00	26.50	1.21
W-89-09-07	4	11	85				
W-89-09-09	16	45	39	20.00	10.60	30.60	1.87
W-89-09-11	4	21	75				
W-89-09-12	10	40	50	15.10	22.60	37.70	0.67

Element Analysis								Heavy Mineral Separation	
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm	Heavy Minerals	Magnetic Fraction
-----								-----	
W-89-09-01	2.81	11	55	28	29	14	69		
W-89-09-03									
W-89-09-04	3.56	15	81	27	37	-10	78		
W-89-09-05								4.02	4.58
W-89-09-06	3.21	13	82	33	41	11	72	3.72	7.28
W-89-09-07								1.63	5.30
W-89-09-09	2.82	11	60	28	31	10	58	5.31	8.22
W-89-09-11								4.84	6.88
W-89-09-12	2.23	9	39	58	20	-10	52	4.66	8.26

Clay Mineralogy									
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC

W89-09-01	ooo	o				o	o		
W89-09-04	ooo		oo			o			
W89-09-06	ooo	o				o			
W89-09-09	ooo	oo							

ooo-Abundant oo-Moderate o-Present

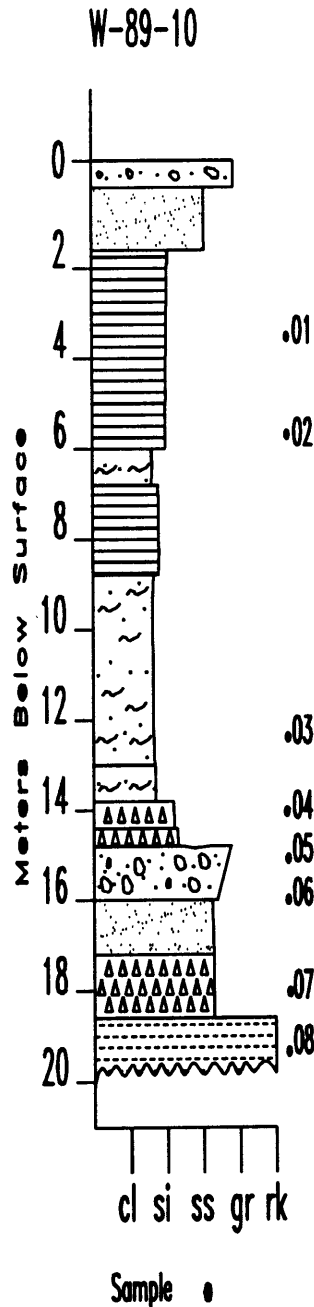
Sonic Drillhole Number: W-89-10

Township: CHATHAM

Surface Elevation: 183.5 m

UTM Coordinates: E 404500 N 4704800

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.40 m - road base
- 0.40-1.60 m - faintly laminated, mottled, clayey silt
- 1.60-1.90 m - massive, well sorted, fine to medium sand, sharp lower contact
- 1.90-6.15 m - rhythmically bedded clayey silt and very fine sand, couplets 0.5 - 1.0 cm at top becoming thicker with depth to 1.0 -2.0 cm, finer layer of couplet much thicker than coarser layer, thin (0.3 cm) organic matter lens at 4.4 m
- 6.15-6.45 m - massive, grey, smooth, silty clay
- 6.45-6.70 m - rhythmically bedded silty clay and very fine sand, couplets 0.5 - 1.0 cm thick, fine layer thicker than coarser layer
- 6.70-6.95 m - massive, grey, smooth, silty clay
- 6.95-8.80 m - rhythmically bedded clayey silt and silt, couplets are thin (0.5cm), bedding becomes indistinct at depth, finer layer thicker than coarser layer
- 8.80-12.85 m - indistinctly bedded, pinkish silty clay, lower contact is gradational
- 12.85-13.10 m - faintly stratified, pinkish, silty clay, reddish mud pellets common
- 13.10-13.17 m - rhythmically bedded clayey silt and silt, pinkish, couplets 0.5 cm thick
- 13.17-13.42 m - faintly stratified, pinkish, silty clay to silt, exhibits upward fining, reddish mud pellets common, sharp upper contact, gradational lower contact
- 13.42-13.82 m - massive to faintly stratified, pinkish, sandy clay, reddish mud pellets common
- 13.82-13.90 m - massive, brownish grey, silty sand till, clasts rare to common, small
- 13.90-14.45 m - massive, grey, silty sand till, clasts common, small, subangular to subrounded
- 14.45-14.52 m - faintly stratified, soft, clayey silt
- 14.52-14.82 m - massive, grey, silty sand till, clasts common, subangular to subrounded, black shale, limestone
- 14.82-15.12 m - faintly laminated, poorly sorted, pebbly sand
- 15.12-15.27 m - massive, poorly sorted, sandy gravel, clasts rounded, up to 3 cm
- 15.27-15.60 m - massive, poorly sorted, pebbly sand
- 15.60-16.15 m - massive, well sorted, medium to coarse sand, rare pebble sized clast, rounded
- 16.15-16.30 m - faintly laminated, greyish, sandy silt
- 16.30-17.10 m - faintly laminated, well sorted, medium to coarse sand, rare pebble, subangular to rounded, limestone, black shale
- 17.10-18.60 m - massive, hard, stony silty sand till, clasts common, subangular to subrounded, limestone, black shale
- 18.60+ m - bedrock, black shale, Kettle Point Formation

W-89-10		Sample Intervals:	
Sample	Material	Sample Interval (m below surface)	
		=====	
		UPPER	LOWER
W-89-10-01	Glac	3.6	3.7
W-89-10-02	Glac	5.9	6.0
W-89-10-03	Glac	12.6	12.8
W-89-10-04	Tav	14.2	14.4
W-89-10-05	Gfluv	15.1	15.2
W-89-10-06	Gfluv	16.0	16.1
W-89-10-07	C C	17.9	18.1
W-89-10-08	B RK/Shale	18.7	18.8

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio
=====							
W-89-10-01	33	46	1	14.00	14.10	28.10	0.99
W-89-10-02	28	71	1	11.90	17.80	29.70	0.67
W-89-10-03	69	30	1	24.60	7.00	31.60	3.51
W-89-10-04	15	51	34	6.60	11.40	18.00	0.58
W-89-10-05	5	30	65				
W-89-10-06	2	9	89				
W-89-10-07	11	37	52	12.40	13.30	25.70	0.93

Element Analysis							
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
=====							
W-89-10-01	2.79	12	57	28	30	13	71
W-89-10-02	2.47	10	45	25	22	11	61
W-89-10-03	3.57	13	72	28	33	11	79
W-89-10-04	3.50	13	63	38	49	13	100
W-89-10-05							
W-89-10-06							
W-89-10-07	3.15	13	65	36	41	11	67

Heavy Mineral Separation	
Heavy Minerals	Magnetic Fraction
=====	
1.86	7.69
4.98	9.45
5.02	6.25
5.69	3.89

Clay Mineralogy										
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC	
=====										
W89-10-01	ooo	oo								o
W89-10-03	ooo	oo								o
W89-10-04	ooo		oo		o					
W89-10-07	ooo	o								o

ooo-Abundant oo-Moderate o-Present

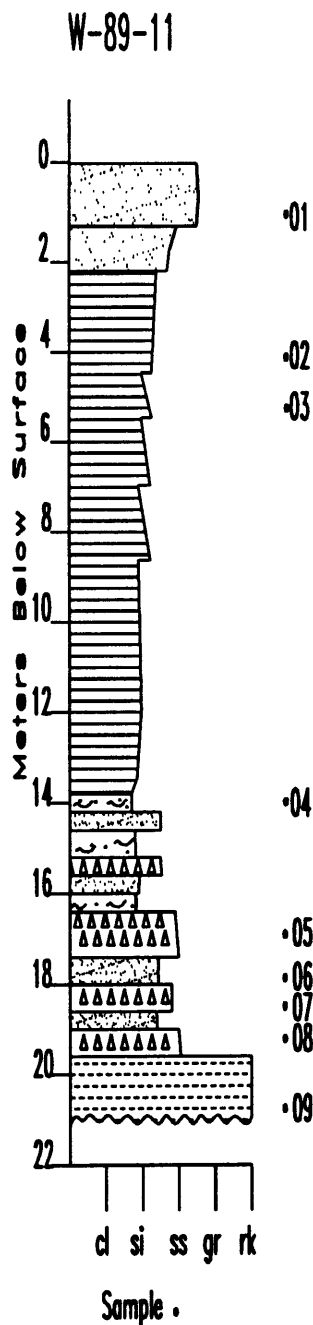
Sonic Drillhole Number: W-89-11

Township: Dover

Surface Elevation: 179.0 m

UTM Coordinates: E 388000 N 4692450

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.20 m - road base
- 0.20-1.25 m - faintly laminated, dark grey black, well sorted, medium to coarse sand, many small disseminated organic matter fragments, whitish mottles
- 1.25-2.30 m - faintly laminated, grey, mottled, silty fine sand to medium sand, fining with depth, sharp lower contact
- 2.30-4.40 m - rhythmically bedded silty very fine sand and clayey silt, couplets 0.5 - 0.8 cm thick, finer layer thicker than coarser
- 4.40-5.60 m - rhythmically bedded fining up sequence, at bottom couplets are 1.5 - 2.0 cm thick, composed of a thick clayey silt layer and a thin silty very fine sand layer, couplets at top are 0.5 cm thick and comprise a thick silty clay layer and thin silty layer
- 5.60-6.80 m - rhythmically bedded, fining up sequence, as above
- 6.80-8.50 m - rhythmically bedded silty clay and silt, couplets 0.5 cm thick, finer layer thicker than coarser layer
- 8.50-14.00 m - rhythmically bedded silty clay and silt, couplets thin, 0.2 - 0.5 cm at top and become thinner at bottom, 0.2 cm, couplets also become indistinct at bottom
- 14.00-14.10 m - faintly stratified, greyish, silty clay, reddish mud pellets common, gradational upper contact
- 14.10-14.20 m - massive, smooth, greyish, silty clay, rare small rounded pebble
- 14.20-14.60 m - faintly stratified, greyish, silty clay, reddish mud pellets common, rare, thin sand lens
- 14.60-14.75 m - massive, poorly sorted, silty sand
- 14.75-15.15 m - massive, clayey silt, rare pebble, rare reddish mud pellet
- 15.15-15.45 m - faintly stratified, greyish, clayey silt, reddish mud pellets common, rare, small pebble
- 15.45-15.60 m - massive, dark grey, silty sand till
- 15.60-16.00 m - massive to faintly stratified, grey, sandy silt, rare, reddish mud pellet
- 16.00-16.20 m - faintly stratified, poorly sorted silty sand
- 16.20-16.50 m - faintly stratified, clayey silt, rare reddish mud pellet, rare small pebble, sharp lower contact
- 16.50-17.55 m - massive, dense, grey, sandy till, clasts common, small (<3cm), limestone, black shale
- 17.55-18.00 m - massive, well sorted, fine sand
- 18.00-18.25 m - massive, grey, spongy, silty sand
- 18.25-18.80 m - massive, grey, silty sand till, clasts rare to common, small (<2cm)
- 18.80-18.95 m - faintly laminated, greyish brown, silty very fine sand
- 18.95-19.20 m - massive, dense, greyish brown silt, breaks into thin plates, rare small pebble
- 19.20-19.40 m - massive silty sand till, clasts common, small (<2cm)
- 19.40-19.90 m - massive, dense, grey, stony silty sand till, clasts common, subangular to subrounded, limestone, black shale
- 19.90+ m - bedrock, black shale, Kettle Point Formation

W-89-11		Sample Intervals:	
Sample	Material	Sample Interval (m below surface)	
		=====	
		UPPER	LOWER
W-89-11-01	Glac	0.8	1.0
W-89-11-02	Glac	4.1	4.2
W-89-11-03	Glac	5.3	5.4
W-89-11-04	Glac	14.1	14.2
W-89-11-05	Tav	16.9	17.1
W-89-11-06	Glac	17.8	17.9
W-89-11-07	Glac	18.8	18.9
W-89-11-08	C C	19.7	19.8
W-89-11-09	B RK/Shale	20.0	20.1

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio

W-89-11-01	7	58	35				
W-89-11-03	38	61	1	12.40	18.30	30.70	0.68
W-89-11-04	46	50	4	5.78	13.50	19.30	0.43
W-89-11-05	23	51	26	13.30	13.20	26.50	1.01
W-89-11-06	4	36	60				
W-89-11-08	14	60	26	13.90	14.60	28.50	0.95

Element Analysis							
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm

W-89-11-01							
W-89-11-03	2.55	10	52	24	26	10	58
W-89-11-04	3.39	13	79	29	37	10	78
W-89-11-05	3.23	12	67	29	39	11	83
W-89-11-06							
W-89-11-08	2.92	13	57	35	41	14	117

Heavy Mineral Separation	
Heavy Minerals	Magnetic Fraction

0.54	37.50
2.60	10.53
2.06	6.15
0.64	7.69
4.40	7.69

Clay Mineralogy									
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC

W89-11-03	ooo	o	oo		o				
W89-11-04	ooo		oo		o				
W89-11-05	ooo	o	o		o				
W89-11-08	ooo	o	o		o				

ooo-Abundant oo-Moderate o-Present

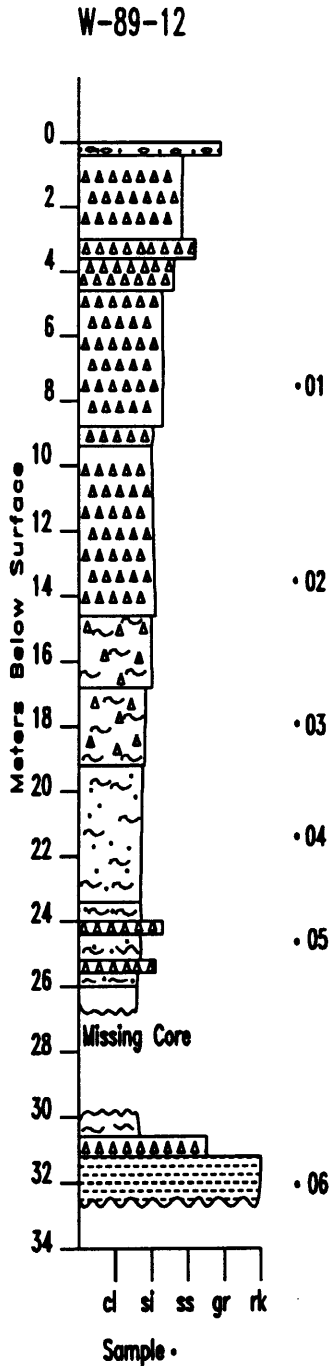
Sonic Drillhole Number: W-89-12

Township: Raleigh

Surface Elevation: 183.8 m

UTM Coordinates: E 398050 N 46831000

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.4 m - road base
- 0.4-3.30 m - weathered, massive, yellowish grey, sandy silt till, clasts common, small (<2cm), subangular to subrounded, black shale, limestone, breaks into thin plates
- 3.30-3.60 m - weathered, massive, silty sand till, clasts common
- 3.60-4.70 m - massive, grey, sandy silt till, clasts rare to common, small (<2cm), limestone, black shale, weathered along vertical and horizontal fractures
- 4.70-8.80 m - massive, grey, hard, sandy silt to silt till, clasts rare to common, black shale, limestone, rare igneous
- 8.80-9.15 m - massive, grey, spongy, silt diamicton, clasts rare to common, angular to subangular, black shale, limestone
- 9.15-9.20 m - massive, pinkish, sandy silt diamicton, clasts rare
- 9.20-14.45 m - massive to weakly fissile, grey, silty till, clasts common, small(<3 cm), black shale, limestone, brachiopod fossils
- 14.45-16.75 m - massive, grey, soft, spongy, clayey silt till, clasts rare, small, subangular to rounded, black shale
- 16.75-19.15 m - massive, dark grey, clayey silt till, clasts rare to common, black shale
- 19.15-23.35 m - massive, smooth, soft, silty clay to clayey silt, only rare small pebble near top, reddish mud pellets common at bottom
- 23.35-23.70 m - massive, smooth, grey, silty clay, reddish mud pellets common
- 23.70-23.80 m - massive, dark grey, sandy silt diamicton, clasts common, small, black shale, limestone
- 23.80-24.15 m - massive, smooth, grey, silty clay, reddish mud pellets common
- 24.30-25.40 m - massive, smooth, pinkish, silty clay
- 25.40-25.50 m - massive, dark grey, sandy silt diamicton, clasts common, small
- 25.50-25.80 m - massive, smooth, pinkish, silty clay
- 25.80-30.60 m - lost core
- 30.60-31.10 m - massive, dense, grey, stony silty sand till, clasts common, subangular to subrounded, limestone, grey shale, black shale
- 31.10+ m - bedrock, greenish grey shale, Hamilton Group

W-89-12		Sample Intervals:	
Sample	Material	Sample Interval (m below surface)	
		-----	-----
		UPPER	LOWER
W-89-12-01	Tav	7.8	7.9
W-89-12-02	Tav	13.8	14.0
W-89-12-03	Tav	17.9	18.0
W-89-12-04	Glac	21.1	21.2
W-89-12-05	Glac	24.9	25.1
W-89-12-06	B Rk/Shale	31.6	31.7

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Dol Ratio

W-89-12-01	33	49	18	14.20	10.70	24.90	1.33
W-89-12-03	32	47	21	10.40	11.40	21.80	0.91
W-89-12-04	29	60	11	14.30	10.80	25.10	1.32
W-89-12-05	21	66	13	16.40	11.40	27.80	1.44

Element Analysis							
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm

W-89-12-01	3.48	13	72	29	37	11	76
W-89-12-03	3.53	13	74	30	42	10	87
W-89-12-04	3.25	13	64	29	34	11	70
W-89-12-05	2.99	11	55	29	30	-10	74

Heavy Mineral Separation	
Heavy Minerals	Magnetic Fraction

2.90	10.53
2.37	7.46
2.29	9.09
1.98	11.11

Clay Mineralogy									
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC

W89-12-01	ooo	o	o		o		o		
W89-12-03	ooo				o		oo		
W89-12-04	ooo	oo			o				
W89-12-05	ooo	oo			o				

ooo-Abundant oo-Moderate o-Present

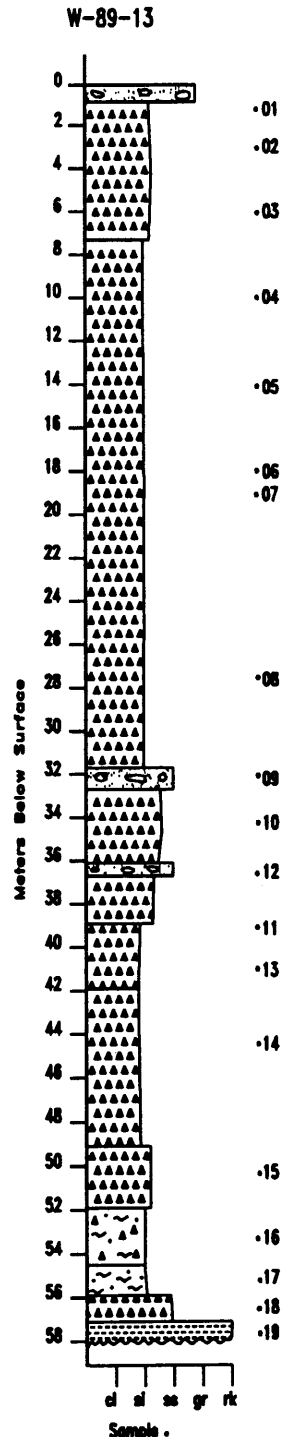
Sonic Drillhole Number: W-89-13

Township: Raleigh

Surface Elevation: 204.0 m

UTM Coordinates: E 407950 N 4677350

Graphic Log:



Descriptive Log:

Ground Surface - Datum 0 m

- 0.0-0.20 m - road base
- 0.20-0.50 m - massive, poorly sorted gravelly sand
- 0.50-2.30 m - massive, hard, brownish grey, sandy silt till, clasts common, up to 3 cm, subangular, striated, limestone, black shale, mafic and felsic igneous
- 2.30-4.40 m - massive, grey, sandy silt till, breaks into thin plates, clasts common, small (<2 cm), black shale, limestone, rare red shale, igneous
- 4.40-6.80 m - massive, brownish grey, sandy silt till, clasts black shale and limestone common
- 6.80-7.10 m - massive, brownish grey, stony sandy silt till, many clasts, subangular to subrounded, up to 12 cm, quartzite, metavolcanics, limestone
- 7.10-10.90 m - massive, brownish grey, sandy silt till, clasts rare to common, striated, black shale, limestone, rare igneous, red shale, dolostone
- 10.90-15.40 m - massive, brownish grey to grey, sandy silt to silt till, clasts common, small (<2 cm), limestone, black shale
- 15.40-18.40 m - massive, stiff, grey, sandy silt till, clasts common, small (<2 cm), striated, black shale, limestone
- 18.40-18.60 m - massive, grey, sandy silt till, as above, but breaks into thin plates
- 18.60-27.40 m - massive, stiff, grey, sandy silt till, clasts rare to common, subangular to subrounded, striated, limestone, black shale, rare red shale, oolitic limestone
- 27.40-30.70 m - massive, grey, soft, sandy silt diamicton, clasts rare, black shale, limestone
- 30.70-31.50 m - massive, soft, spongy, grey, sandy silt, rare small clast
- 31.50-32.20 m - massive, very poorly sorted, pebbly-silty sand, clasts rounded, limestone, black shale
- 32.20-35.90 m - massive, grey, sandy silt to silty sand till, clasts rare, small (<2 cm), striated, limestone, black shale
- 35.90-36.30 m - massive, moderately well sorted pebbly sand, pebbles rounded, limestone, black shale
- 36.30-37.50 m - massive, grey, silty sand till, few clasts, black shale, limestone
- 37.50-41.50 m - massive, grey, clayey silt till, clasts rare, limestone, black shale, sharp lower contact
- 41.50-48.85 m - massive, soft, pinkish, clayey silt till, clasts rare to common, black shale, limestone, rare red shale, chert, matrix colour changes to grey with depth
- 48.85-51.05 m - massive, dark grey, sandy silt till, clasts common, up to 3 cm, subangular to subrounded, black shale, limestone, rare chert, brachiopod, sharp lower contact
- 51.05-54.25 m - massive, soft, spongy, grey, silty very fine sand, pebbles rare, black shale, limestone, red shale, reddish mud pellets at bottom, gradational lower contact
- 54.25-55.81 m - massive, soft, pinkish, silty clay, rare small pebble, black shale, limestone
- 55.81-56.90 m - massive, dense, grey, stony sandy till, clasts common, large, up to 20 cm, subangular to subrounded
- 56.90+ m - bedrock, greenish grey shale, Hamilton Group

W-89-13		Sample Intervals:					
Sample	Material	Sample Interval (m)		Sample	Material	Sample Interval (m)	
		UPPER	LOWER			UPPER	LOWER
W-89-13-01	Tav	1.1	1.2	W-89-13-10	Tav	34.1	34.2
W-89-13-02	Tav	2.8	3.0	W-89-13-11	Tav	39.1	39.2
W-89-13-03	Tav	5.8	5.9	W-89-13-12	Glac	36.0	36.1
W-89-13-04	Tav	9.8	9.9	W-89-13-13	Tav	41.1	41.3
W-89-13-05	Tav	13.9	14.0	W-89-13-14	Tav	44.6	44.8
W-89-13-06	Tav	17.9	18.0	W-89-13-15	Tav	50.0	50.1
W-89-13-07	Tav	18.5	18.6	W-89-13-16	Glac	52.8	53.0
W-89-13-08	Tav	27.3	27.4	W-89-13-17	Glac	55.0	55.1
W-89-13-09	Glac	32.1	32.2	W-89-13-18	C C	56.2	56.4
				W-89-13-19	B Rk/Shale	57.1	57.2

Texture (-2mm) & Carbonate Content (-0.074mm)							
Sample	Clay (%)	Silt (%)	Sand (%)	Calcite (%)	Dolomite (%)	Total Carbonate	Cal/Do Ratio
W-89-13-02	30	48	22	14.20	9.86	23.90	1.47
W-89-13-05	31	47	22	11.80	11.10	22.90	1.06
W-89-13-08	33	47	20	14.40	8.42	22.80	1.71
W-89-13-09	34	47	19				
W-89-13-10	33	45	22	12.50	10.80	23.30	1.16
W-89-13-11	33	47	20	10.60	11.00	21.60	0.96
W-89-13-14	30	45	25	13.10	11.60	24.70	1.13
W-89-13-15	30	46	24	12.00	11.00	23.00	1.09
W-89-13-16	35	46	19	9.15	11.30	20.50	0.81
W-89-13-17	45	42	13	12.00	9.57	21.60	1.25
W-89-13-18	21	47	32	21.60	10.20	31.80	2.12

Element Analysis							
Sample	Fe (%)	Co ppm	Cr ppm	Cu ppm	Ni ppm	Pb ppm	Zn ppm
W-89-13-02	3.50	13	70	30	37	10	81
W-89-13-05	3.49	13	74	30	42	10	84
W-89-13-08	3.45	14	74	30	42	11	86
W-89-13-09							
W-89-13-10	3.68	13	70	28	40	10	83
W-89-13-11	3.57	15	77	30	45	11	89
W-89-13-14	3.32	13	64	28	32	10	75
W-89-13-15	3.32	14	77	32	45	12	91
W-89-13-16	3.79	14	75	32	43	12	91
W-89-13-17	3.33	15	76	29	38	11	83
W-89-13-18	3.63	12	69	28	36	11	66

Heavy Mineral Separation	
Heavy Minerals	Magnetic Fraction
3.50	6.94
2.89	7.32
2.70	9.66
2.95	11.29
2.67	7.58
1.87	8.70
4.78	9.21
2.54	7.04
2.42	7.84
3.27	9.09
4.12	8.33

Clay Mineralogy									
Sample	ILL	CHL	VERM	SMEC	KAOL	ILL-SMEC	ILL-VERM	QTZ	CALC
W89-13-02	ooo		oo		o				
W89-13-05	ooo	o	o		o				
W89-13-08	ooo	oo			o				
W89-13-10	ooo	o	oo		o				
W89-13-11	ooo	o			o		o		
W89-13-14	ooo		oo		o				
W89-13-15	ooo		o		o				
W89-13-16	ooo	o	o		o				
W89-13-17	ooo	o	o		o				
W89-13-18	ooo	o	o		o				

ooo-Abundant oo-Moderate o-Present

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

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

OTHER USEFUL CONVERSION FACTORS

	<i>Multiplied by</i>	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

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

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LEGEND

- PHANEROZOIC
CENOZOIC
QUATERNARY
RECENT
15 Fill: earth and rock fill, concrete rubble
14 Organic deposits: peat and muck, marshland areas with open water
13 Modern beaches: includes sand and gravelly sand
12 Modern alluvium: young stream deposits; clay, silt, sand and muck
11 Eolian deposits: poorly developed dunes, fine to medium sand
10 Lacustrine deposits: beach, bar and nearshore deposits; silty sand and sand
PLEISTOCENE
LATE WISCONSINAN
9 Older Alluvium: fluvial sediments; clay, silt and sand
8a predominantly clay and silt
8b predominantly sand
8 Glaciolacustrine deposits: deltaic; bars, sand plains; silty sand and sand; overlain by:
8a modern alluvium: clay and silt
7 Glaciolacustrine deposits: beach, bar and nearshore deposits; sand and sandy gravel
6 Glaciolacustrine deposits: clayey silt, silt and silty sand, with organic matter fragments, shells; overlain by:
6a glaciolacustrine silty sand and sand
6b lacustrine silty sand and sand
5 Glaciolacustrine deposits: rhythmites, clayey silt and silty sand; overlain by:
5a glaciolacustrine clayey silt, silt and silty sand (unit 6)
5b glaciolacustrine silty sand and sand (unit 8)
4 Glaciolacustrine deposits: stratified to massive, silty clay to silt; overlain by:
4a glaciolacustrine rhythmites, clayey silt and silty sand (unit 5)
4b glaciolacustrine silty sand and sand (unit 8)
4c glaciolacustrine clayey silt, silt and silty sand (unit 6)
3 Glaciofluvial deposits: deltaic, sand and sandy gravel
2 Erie lobe till; Port Stanley, clayey silt; overlain by:
2a glaciolacustrine silty clay to silt (unit 4)
2b glaciolacustrine silty sand and sand (unit 8)
1 Huron lobe till; Tavistock equivalent, clayey silt to silt; overlain by:
1a glaciolacustrine silty clay to silt (unit 4)
1b glaciolacustrine silty sand and sand (unit 8)

*The legend and symbols apply to map P.3337 and map P.3338; all units may not be present on this sheet.

SYMBOLS

- Trend of moraine crest
Hummocky topography
Abandoned shoreline feature
Abandoned fluvial terrace escarpment
Dunes

SOURCES OF INFORMATION

This map is based on information taken from the National Topographic System map sheet number 40 J/8 Her Majesty the Queen in Right of Canada with permission of Energy, Mines and Resources Canada.

Airphotos from the Ontario Ministry of Natural Resources. Metric conversion factor: 1 foot = 0.3048 m

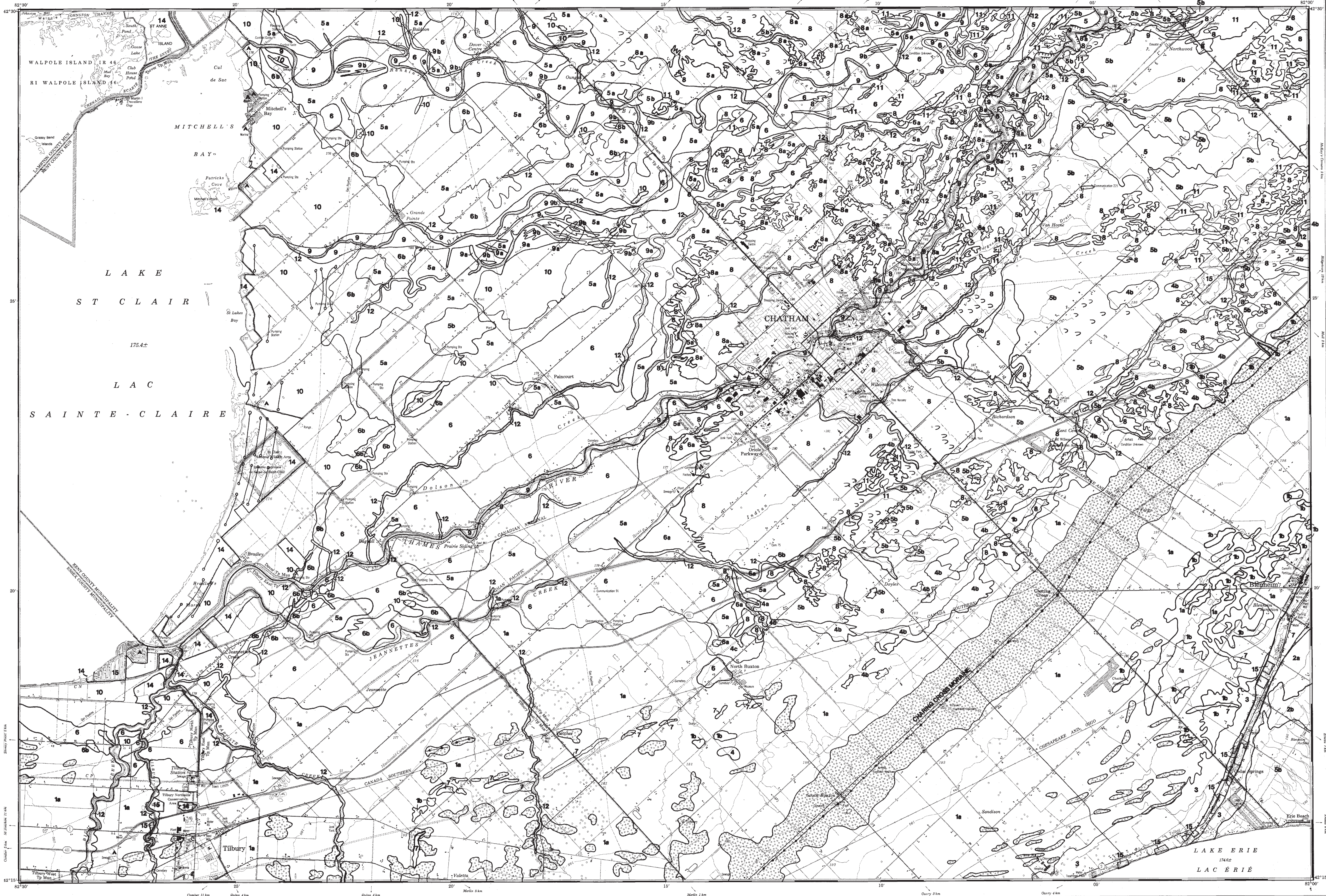
CREDITS

Geology by R.I. Kelly, 1988, 1989. Additional field observations by E.V. Sado.

To enable the rapid dissemination of information, this map has not received a technical edit. Discrepancies may occur for which the Ontario Geological Survey does not assume liability. Users should verify critical information.

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Information from this map may be quoted if credit is given. It is recommended that reference be made in the following form: Kelly, R.I., 1995. Quaternary Geology, Chatham area, southern Ontario. Ontario Geological Survey, Preliminary Map P.3337, scale 1:50 000.



CHATHAM ONTARIO Scale 1:50 000 Echelle 1:50 000. Includes conversion scales for elevations (Metres 20 to 100, Feet 100 to 300), contour interval (10 metres), and symbols for roads, railroads, and other features. Includes the Ontario Geological Survey logo and contact information.

