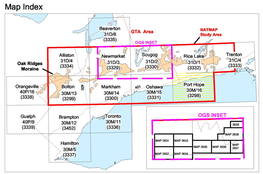
Natural Resources Canada / Ressources naturelles Canada
Canada
GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA
NATMAP CARTNAT
Canada's National Geoscience Mapping Program / La Programme national de cartographie géoscientifique au Canada
Ministry of Northern Development and Mines / Ontario

Surficial Geology of the Port Hope Area, NTS 30M/16, southern Ontario

Scale 1:50 000

Map Index



Oak Ridges Moraine NATMAP Project
Surficial Geology Series

Recommended citation:
Brennand, T. A., 1997: Surficial Geology of the Port Hope Area, NTS 30M/16, southern Ontario; Geological Survey of Canada, Open File 3298, Scale 1:50 000.

Open File
Dossier Public
3298
Geological Survey of Canada
Commission géologique du Canada
1997

Where to obtain the publications:
Bookstore, Geological Survey of Canada
601 Booth Street, Ottawa, Ontario, K1A 0E8
ph.: 613-995-4342
Email: gsc_bookstore@gsc.nrcan.gc.ca
GSC Bookstore Web Site:
http://www.nrcan.gc.ca/gsc/gsclpubs/publish.html

Ontario Geological Survey Publications
Mineral Resources Information Centre
M2-17 Macdonald Block
900 Bay St.
Toronto, Ontario M7A 1C3
Toll-free long distance: 1-800-665-4480

INTRODUCTION

NATMAP Oak Ridges Moraine Map series

Port Hope is one in a series of 15 digital 1:50,000 maps summarizing the glacial and postglacial deposits of the Oak Ridges Moraine (ORM) and Greater Toronto Area (GTA) (index map). The series is sponsored by the National Mapping Program (NATMAP) of the Geological Survey of Canada in collaboration with the Ontario Geological Survey (OGS). These maps complement a series of 1:20,000 geology maps covering the central area of the ORM, published by OGS. The OGS is also publishing two 1:50,000 sheets (Scugog and Newmarket) using map detail and the expanded legend of the1:20,000 series. A 1:200,000 scale compilation map of the 1:50,000 maps completes the series (Sharpe et al, 1997).

Objectives and Content

The objective of the map series is to synthesize the geology of the ORM study area as a basis for environmental analysis, particularly hydrogeology. Each map consists of 4 coloured panels:
1) title block, series introduction and regional setting, 2) thematic maps, 3) legend, symbols and geology map, and 4) reference material: map notes, stratigraphic table and series bibliography. The layout is designed to allow folds between the first three panels and to allow the main map and legend to be cut off for field use.

Thematic maps and other features

A thematic map series complements the surficial geology map by providing at a common scale:
1) field site locations and Voronoi polygons of sediment descriptions (Fig.3);
2) geologic map (Fig.4) for comparison with other thematic maps;
3) digital elevation model (DEM) (Fig.5) to allow visualization of relief / terrain elements that shows the pattern and control on drift distribution;
4) bedrock topography map with bedrock geology overlay (Fig. 6);
5) sediment thickness map that shows variation in sediment thickness (Fig. 7).

Each map is supplemented with map notes, an explanation of the key geologic terms related to the map unit sequence (stratigraphy) and age relationships, and a series bibliography. The digital map files will be released as part of a CD-ROM data release.

Data sources and structure

The nine maps within the NATMAP area all include new field work complemented by archival field data; combined, most maps have > 1,000 data points. The six maps outside NATMAP and within the GTA (location map) have been re-mapped with a minimum of new field work but include re-assessed archival data. All maps are structured in a Geographic Information System (GIS) with supporting data in a relational database (Russell et al., 1996). This format permits map feature enhancement and analysis (e.g. thematic map series, Figs. 3-7). Surficial geology forms the first layer of a set of regional themes in the area, where Quaternary sediment thickness reaches approximately 200 m. The relational database allows for the digital map files to be easily updated as new data are added.

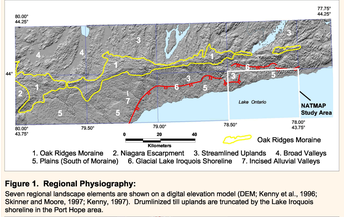


Figure 1. Regional Physiography:
Seven regional landscape elements are shown on a digital elevation model (DEM; Kenny et al., 1996; Skinner and Moore, 1997; Kenny, 1997). Drumlinized till uplands are truncated by the Lake Iroquois shoreline in the Port Hope area.

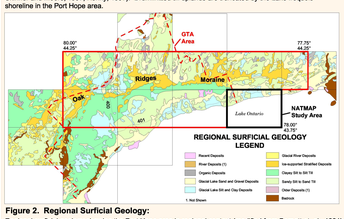


Figure 2. Regional Surficial Geology:
Regional surficial geology showing the Port Hope area in regional context (modified from Barnett et. al., 1991). Newmarket Till is exposed south of the Oak Ridges Moraine in the Port Hope area. The map legend is the same as that for the main map.

THEMATIC MAPS

Figure 3 Legend: Sediment Codes

10	Fill	8	Clay	6	Sand	4	Silty-clay diamicton	2	Sand diamicton
9	Organics	7	Silt	5	Gravel	3	Sandy-silt diamicton	1	Bedrock

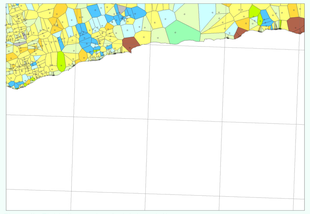


Figure 3. Field sites and material description:
Field sites located at the centre of polygons (Voronoi plot) describe the sediment found (at 1 m depth) and used as ground control for air photo interpretation of the Quaternary geology map. Fieldwork was carried out in the summers of 1993-1995 by Brennand and assistants.

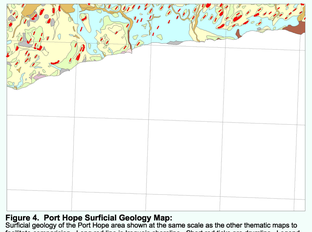


Figure 4. Port Hope Surficial Geology Map:
Surficial geology of the Port Hope area shown at the same scale as the other thematic maps to facilitate comparison. Long red line is Iroquois shoreline. Short red ticks are drumlins. Legend is same as main map.

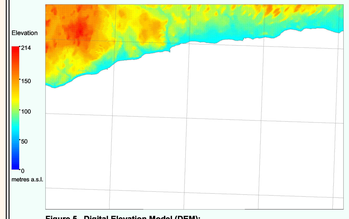


Figure 5. Digital Elevation Model (DEM):
DEM (hill-shaded, colour gradient) of the Port Hope area. Readily visible are the NE-SW oriented drumlins in the northeast and the Ganaraska River valley at Port Hope which separates a local till upland (unit 3f) from offshore glacial lake sediments (unit 7).

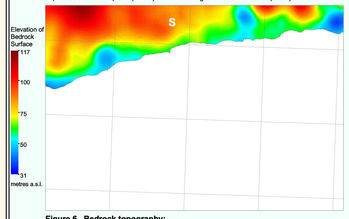


Figure 6. Bedrock topography:
The bedrock elevation decreases southeastward toward Lake Ontario, and the surface is dissected by several valleys (from Brennand et. al., 1997). Simcoe Group (S) limestone underlies the area (Sanford and Baer, 1981).

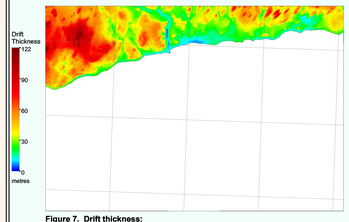


Figure 7. Drift thickness:
The thickest drift occurs in the northern and western parts of the area (from Russell et. al., 1997).

LEGEND

SURFICIAL GEOLOGY OF THE GREATER TORONTO / NATMAP AREA

QUATERNARY PERIOD(~last 2 million years)

11 — **Recent Deposits:sand, gravel and diamicton:** 1 - 3 m thick; includes wind-derived, landslide, slope, groundwater sapping, lakeshore deposits and fill

10 — **River Deposits: sand and gravel**
a. gravel, sand, silt, clay, muck; 1-2 m thick; occurs on modern floodplains
b. gravel, sand, silt, clay; 1-8 m thick; forms river deltas and terraces of early post-glacial age

9 — **Organic Deposits:peat, muck and marl,**1-7 m thick; occurs in wetlands

8 — **Glacial Lake Deposits[1]: sand and gravel** (minor diamicton)
a. sand and silty sand, 1 to >50 m thick; occurs in basin lows and nearshore flats
b. gravely sand and gravel, 1-5 m thick; raised shorelines or bars

7 — **Glacial Lake Deposits[1]: silt and clay,** massive to laminated
a. silt and clay interbedded with diamicton and some lone stones, 1 –10 m thick; occurs in basins
b. silt and clay; 1-5 m thick; laminations deformed in basin fills

6 — **Glacial River Deposits[2]: sand and gravel** (minor diamicton)
a. sand; 1-15 m thick; occurs as eskers, valley fills and terraces
b. gravel; 1-15 m thick; occurs as eskers, valley fills and terraces

5 — **Moraine Deposits: fine sand to gravel**
a. fine sand, some gravel, minor silt, clay and diamicton; 1-50 m thick; rhythmic beds common
b. medium to coarse sand and gravel and diamicton; 1-20 m thick; channels common
(a and b occur in disorganized hills, depressions and eskers)

4 — **Glacial Deposits (till):clayey silt to silt,** 1-2% stone content; 1 -15 m thick; occurs in till or lake plains often with interbedded fine sand, silt and clay
a. Wilfrid‡ / Kettleby[3]
b. Halton
c. Tavistock

3 — **Glacial Deposits (till): sandy silt to sand,** > 3% stone content; stratified interbeds; 1-50 m thick; forms uplands
d. Wentworth
e. Port Stanley
f. Newmarket/northern[4]Bowmanville

2 — **Lower (drift) Deposits[5]: till, fine-medium sand, and laminated silt and clay,** 1-50 m thick; exposed in bluffs
g. Upper Thorncliffe Formation / Clarke beds; **h.** Seminary / Meadowcliffe / Bondhead tills;
i. Lower Thorncliffe Formation / Clarke beds; **j.** Sunnybrook / Port Hope fill; **k.** Scarborough Formation;
l. Don Formation; **m.** York Till; **n.**[6] Stratified sediment, dominantly sand; **o.**[6] Stratified sediment, dominantly silt and clay

Unconformity _____ (interval with no deposits and/or major erosion)

PALEOZOIC (rocks >400 million years in this area)

1 — **Bedrock: limy mudrock and clastic sedimentary rock**
a. bedrock-drift complex
b. clastic (sandstone or shale)
c. carbonate

1. Peel/Schomberg ponds above, Lake Iroquois/Algonquin below raised shorelines
2. Subglacial and/or proglacial outwash
3. Wildfield south of ORM and Kettleby north of ORM; sub units in units 2-4 are listed in stratigraphic order: a-o
4. Northern till is used to indicate a source area to the north; it may have several age assignments (cf. White, 1975)
5. Most units not present as surface units on 1:50,000 maps
6. Age unknown.

Note: The legend is not strictly stratigraphic; attached stratigraphic table explains age relationships and regional terminology. Not all map units appear on each map.

SYMBOLS

- Geological boundary (approximate)
- Drumlin or fluting
- Esker, direction of flow known
- Trend of moraine crest
- Kettle
- Ice-contact slope
- Small ridges
- Area of hummocky topography
- Area of sand dunes (eolian)
- Base of terraced escarpment (fluvial, glaciofluvial)
- Meltwater flow direction
- Channels
- Base of lake-cut escarpment (abandoned shoreliuf)
- Raised shoreline (projected)
- Crest of abandoned beach bar or spit
- Brow of landslide or zone of groundwater sapping
- Sand and gravel pit
- Borehole (GSC/OGS)
- Fill

Note: all symbols may not appear on this map.

NTS LEGEND

North American Datum 1983
Universal Transverse Mercator Grid - Zone 17

- Lakes and rivers
- Streams
- Contour lines (interval 10m)
- Roads (any type)
- Railway lines
- Greater Toronto Area boundary

Note: Selected listing.

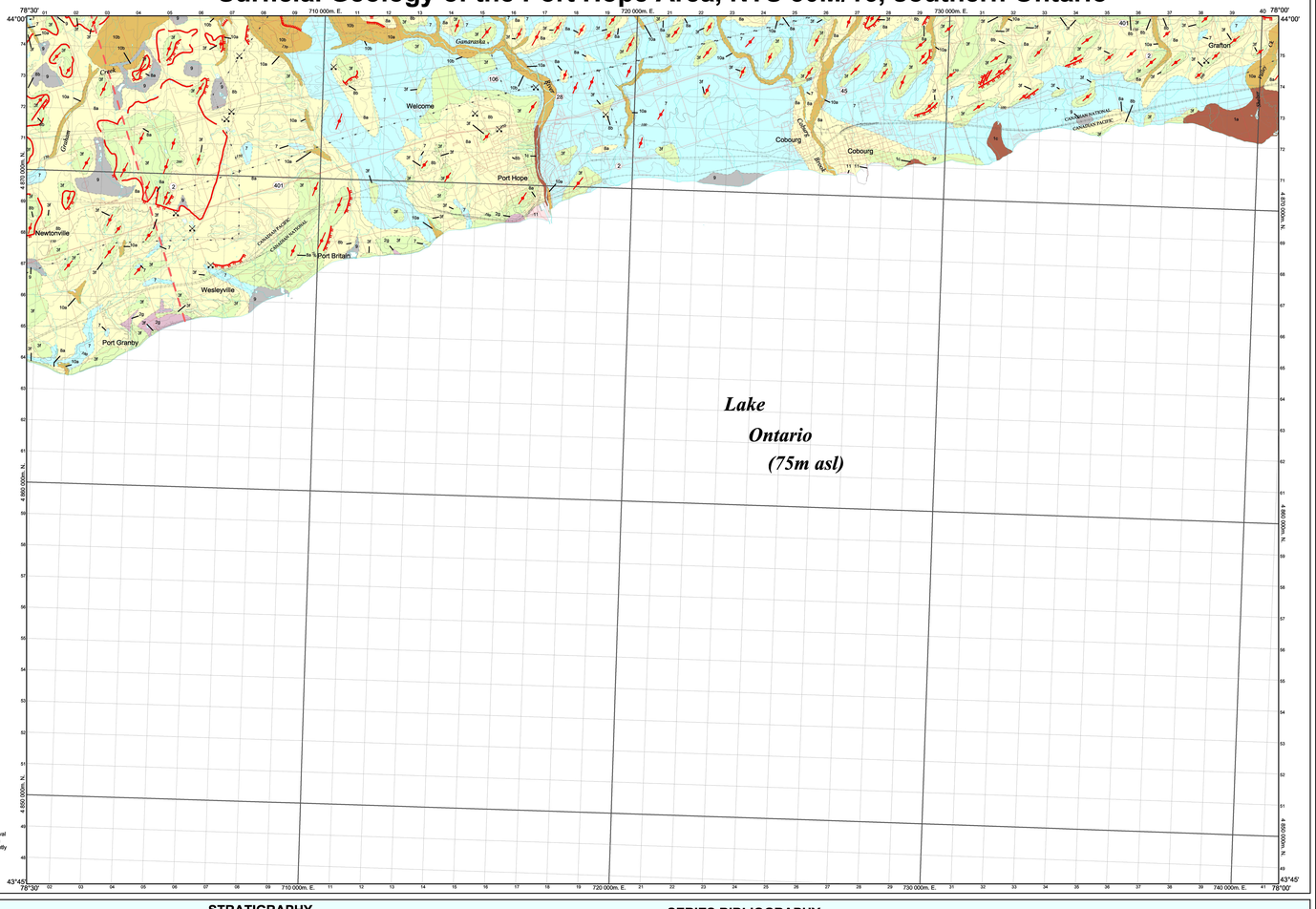
Scale 1:50,000 Échelle
0 1000 2000 3000 4000 5000
Mètres Mètres

MAP PRODUCTION

This map has been produced from interpretation of 1:30,000 scale black and white aerial photographs. Individual geological map units have been identified on the basis of landform, surface texture, tonal contrasts and elevation relationships. This interpretation has been verified with both archival and project ground control data (Figure 3). Line work was transferred from photographs to a 1:50,000 NTS topographic map and subsequently to a registered chronoflex base. The chronoflex base was scanned and registered to a NAD 83 Datum in Mapinfo. The raster line work was subsequently digitized and an attributed vector file built.

RECOMMENDED CITATION:
Brennand T. A., 1997: Surficial Geology of the Port Hope Area, NTS 30M/16, southern Ontario; Geological Survey of Canada, Open File 3298, Scale 1:50 000.

Surficial Geology of the Port Hope Area, NTS 30M/16, southern Ontario



MAP NOTES

This surficial geology map synthesizes topographic and sediment information, and presents the areal distribution of sediments at 1 m depth in the Port Hope area. Sediment type and stratigraphy is compiled from field sites (blue dots), drill holes, gravel pits, and shovel, auger and probe holes; Fig. 3), geotechnical boreholes (Brennand et al., 1995; Russell et al., 1996) and other data. Fieldwork was undertaken during the summers of 1993-1995 by Brennand, assisted by T. Shaw and J. Ross. Gravenor (1957) published the previous surficial geology map of the area.

Physiography and Landforms:

The Port Hope area is divided into two physiographic regions by the Lake Iroquois shoreline and raised beaches (Fig. 1). In the northwest, drumlinized till plains are dominated by Bowmanville till and draped by glaciolacustrine sediments, are truncated by the Iroquois shoreline (Fig. 5). These drumlins likely record a catastrophically-released subglacial meltwater erosional event directed toward the south-southwest (Shaw and Gilbert, 1990) or they record an ice erosion event. The southern margin of a fluted glacial delta is present in the northeast (Gravenor, 1957). The remainder of the area is the low-relief Lake Iroquois plain. This plain is covered by glacial lake sediments which in-fill the underlying surface leaving the tops of SSW-oriented drumlins as till islands. Both regions are dissected by creeks that have their headwaters in the Oak Ridges Moraine or drumlinized uplands to the north and discharge into Lake Ontario (Fig. 5).

Bedrock Geology, Topography and Drift Thickness:

Bedrock is exposed only along the Lake Ontario shoreline east of Cobourg, and along the Ganaraska River (Carson, 1979). Middle Ordovician, Simcoe or Trenton Group (Lindsay Formation) limestone mostly subcrops below Quaternary drift (Sanford and Baer, 1981). The bedrock surface slopes gently southeastward toward Lake Ontario, but exhibits several southeast-oriented bedrock valleys (Holden et al., 1993b). The Ganaraska River appears to follow one of these bedrock valleys. Drift thickness is highly variable, being controlled by bedrock topography and post-depositional erosion. In general, drift thickness decreases toward the southeast (Fig. 7).

Quaternary Geology:

Older Deposits:

The oldest exposed sediments are the clayey Port Hope till and the glaciolacustrine sands, silts and clays of the Clarke beds, identified in exposures along the Lake Ontario bluffs (e.g. Brookfield et al., 1982.) Only the Clarke beds (unit 2g) are mapped at the land surface, at the shore around Port Hope and east of Port Granby. The Clarke beds were deposited in a proglacial lake, prior to the main Lake Wisconsinan ice advance responsible for much of the surficial geology in the Port Hope area.

Till:

The main Late Wisconsinan ice readvanced from the north depositing a stony (> 5% pebbles) silty sand to sandy silt diamicton, locally known as the Bowmanville till (unit 3f; Brookfield et al., 1982). This till functions as a regional aquitard and is up to 10m thick at the Lake Ontario bluffs. Carbonate and Precambrian (igneous and metamorphic) pebbles are dominant in this till, and it exhibits a wide range of sedimentary styles from lodgement to shear structures to debris flow. The Bowmanville till is in the same stratigraphic position and has similar characteristics to the Newmarket Till north of the Oak Ridges Moraine; extending below the Oak Ridges Moraine, these tills are likely correlative (Gwyn, 1970; Barnett et al., 1991; Sharpe et al., 1994, 1996). The main Late Wisconsinan ice that deposited the Bowmanville till retreated northward, separating from downwasting ice in the Lake Ontario basin.

Glacial Lake Deposits:

As the ice downwasted and retreated out of the Lake Ontario basin, Glacial Lake Iroquois was impounded within the basin to a level of ~165-170 m asl in this area. At its margin, this lake eroded into the till uplands, and longshore currents reworked their sediments into gravelly beaches and baymouth bars. Nearshore deposits are dominantly sand and gravel (unit 8). Offshore deposits occur in topographic lows (Fig.5) that coincide with bedrock lows, and include massive to laminated silt and clay (unit 7). Elsewhere in the offshore zone, wave-washed Bowmanville till is exposed. It is likely that stronger currents in these slightly elevated positions prevented deposition of fine-grained lake sediments. Post-Iroquois, lower lake levels (80-150 masl) are locally recorded by wave-eroded scarps (washing limits), gravel beaches and nearshore sands.

Organic, River and Recent Deposits:

Holocene organics (unit 9) have accumulated in poorly drained hollows and wetlands, but are only mapped where their depth exceeds 1 m. Rivers discharged water to Lake Iroquois, dissecting the landscape and depositing sediment on their floodplains or as a delta into Lake Iroquois. As lake level fell these rivers incised leaving raised river and delta terraces (unit 10b) and creating new floodplains (unit 10a). Recent deposits (unit 11) include a thin veneer of wind-blown sand over much of the area (not shown on map), Lake Ontario beach, baymouth bars and spits, and fill.

STRATIGRAPHY

Explanation of stratigraphic terms in the ORM NATMAP area

	Stratigraphic unit* (youngest on top)		Map units	Explanation / description[2] (reference to stratigraphic name)
Quaternary				Period covering last 2 million years of glacial climates
Recent				Last 10,000 years following glacial climates
	Lake and aeolian deposits	11		Deposits along shore of modern lake
	Alluvium	10a		Sediment deposits by modern rivers in Recent time
	Organic deposits	9		Plant and animal matter accumulated in wetlands
	Older alluvium	10b		Sediment deposited by rivers in terraces and deltas during glacial melt
Pleistocene				Time of advance and retreat of large ice sheets (2 million to ~10 000 years ago)
	Glacial Lake Iroquois / Algonquin deposits	7, 8		Two of the largest postglacial lakes in Lake Ontario / Lake Huron basins
	Glacial Lake Peel / Schomberg deposits	7, 8		Series of lake beds deposited against the ORM as the glacier blocked drainage (commonly >100m asl)
	Glaciofluvial deposits	6		Deposits of high-energy streams or currents issuing from a glacier; may form cores of ORM
	Wildfield / Kettleby[3] till a	4a		Interbedded with lake deposits and flanks the ORM (White, 1975; Barnett et al, 1991)
	Halton Till / (Bouchette till)[3]	4b		Thick, interbedded till and lake deposits, in Humber Valley; thins to the east (Karrow, 1956)
	Oak Ridges Moraine sediments	5		Thick, mostly glacial lake deposits, resting on eroded Newmarket Till or lower beds (Chapman and Putnam, 1943; Barnett, 1995)
	Wentworth[3] upper Leaside till	3f		May grade upward into Halton Till (Karrow, 1959); Leaside, Kamiros, 1967)
	Port Stanley / Tavistock till	3e/4c		Port Stanley: Lake Ontario derived till; Tavistock: Lake Huron derived till (Karrow, 1971)
Unconformity				Major erosional episode marked by drumlin formation and channel cutting and scouring; channels produced by subglacial drainage (cf. Barnett, 1990)
	Newmarket / lower Leaside / Bowmanville till	3f		Thick regional till extending beneath the ORM from Lake Ontario to Lake Simcoe (Dwyn and DiLabio, 1973; Sharpe et al., 1994)
	Upper Thorncliffe Formation / (Clarke beds)[4]	2g		Deltaic? flex beds at Scarborough / Bowmanville bluffs (sandy/silt/clay) (Karrow, 1967; Singer, 1974)
	Seminary / Meadowcliffe / (Bondhead) till	2h		Thin lenses separating Thorncliffe and Clarke beds at lake bluffs (clayey, silty till; low stone content) (Karrow, 1967)
	Lower Thorncliffe Formation / (Clarke beds)	2i		Series of lake beds found at Scarborough or Bowmanville bluffs; ~ 30-50,000 years old (Terasmae, 1960; Eyles and Clark, 1988)
	Sunnybrook till / [Port Hope till]	2j		Forms a regional till sheet and marker bed (clay till with very few stones) (Karrow, 1967; Brookfield et al., 1992)
	Scarborough Formation	2k		Interglacial (>50° C), lake beds (~122 m asl at Toronto; ~90,000 y BP (clay and sand beds) (Karrow, 1967; Kelly and Martini, 1986)
	Don Formation	2l		Warm-climate (>2° C), raised lake beds with interglacial fossils (sand, silt) (Karrow, 1967)
	York Till	2m		Dense, sandy till from glacial interval prior to last major warm period (Karrow, 1967)
	Older sand?	2n		Unifferentiated stratified sediment, dominantly sand, some pebbles
	Older clay, silt [6]	2o		Unifferentiated stratified sediment, dominantly silt and clay
Unconformity				Long interval with no deposits and/or major erosion
Paleozoic				Period covering~ 230 - 570 million years ago, (Liberty, 1969)
	Bedrock	1		Ancient marine rocks
	a. Bedrock-drift complex	1a		Map unit with thin (<1m) cover of glacial deposits on bedrock.
	b. Clastic (sandstone or shale)	1b		Rocks made from grains of sediment cemented together; e.g. Georgian Bay/Queenston shale
	c. Carbonate	1c		Limestone and dolostone rocks; found respectively east and west of the Niagara Escarpment

1. See Barnett et al. (1991) for stratigraphic scheme of southern Ontario
2. Lithology of older drift is described
3. Wildfield occurs south of ORM; Kettleby occurs north of ORM
4. Till is mixed sediment (sand, silt, clay, stone) deposited by glaciers; till, lower case, indicates local name
5. Units in square brackets refer to names for strata found east of Oshawa (Brookfield et. al., 1992)
6. May correlate with Newmarket Till; Wentworth may have been deposited from retreat phase of "Newmarket ice"

7. Erosional episodes may also be present between and within some units e.g. boulder pavements
8. Unit 2 comprises "lower drift" in regional stratigraphic synthesis (Sharpe etc al., 1996)
9. Uncertain age designation

SERIES BIBLIOGRAPHY

Barnett, P. J.
1991: Surficial radiocarbon dates in Quaternary geology and geomorphology, Quaternary Research, Ontario, Canada; in Radiocarbon dating, Geological Survey of Canada, Paper 91-2, p. 151-170.
1992: Quaternary geology of the Timiskaming (NTS 31M/9,10) and Temiscaming (NTS 31L/12,13) areas, Ontario and Quebec; Ontario Geological Survey, Open File Report 5821, 280 p.
1995: Quaternary geology of the Sudbury area, Ontario; Ontario Geological Survey, Open File Report 5929, 280 p.
Barnett, P. J. and Hinzman, D.F.
1993: Geological Investigations in the Oak Ridges Moraine area, parts of Scugog, Manvers and Cartwright Townships, Durham and Ontario Municipalities, Ontario; in Summary of Fieldwork and Other Activities 1993, Ontario Geological Survey, Miscellaneous Paper 162, p. 155-161.
Barnett, P. J. 1995: Geology of the Oak Ridges Moraine area, parts of Peterborough and Victoria counties and Durham and York Regional Municipalities, Ontario; in Summary of Fieldwork and Other Activities 1995, Ontario Geological Survey, Miscellaneous Paper 164, p. 177-183.
Barnett, P. J. 1996: Geology of the Oak Ridges Moraine area, parts of Peterborough and Victoria counties and Durham and York Regional Municipalities, Ontario; in Summary of Fieldwork and Other Activities 1996, Ontario Geological Survey, Miscellaneous Paper 164, p. 177-183.
Barnett P.J.
1997a: Quaternary Geology of the Claremont area; Ontario Geological Survey, Map 2554, scale 1:20,000. Geology 1983, 1994, 1995.
Barnett P.J.
1997b: Quaternary Geology of the Entwistle area; Ontario Geological Survey, Map 2636, scale 1:20,000. Geology 1983, 1994.
Barnett P.J.
1997c: Quaternary Geology of the Kendal area; Ontario Geological Survey, Map 2637, scale 1:20,000. Geology 1983, 1994.
Barnett, P.J.
1997d: Quaternary Geology of the Bethany area; Ontario Geological Survey, Map 2638, scale 1:20,000. Geology 1983, 1994.
Barnett P.J.
1997e: Quaternary Geology of the Beaverton area; Ontario Geological Survey, Map 2639, scale 1:20,000. Geology 1983, 1994.
Barnett, P.J.
1997f: Quaternary Geology of the Port Perry area; southern Ontario; Ontario Geological Survey, Map 2656, scale 1:20,000.
Barnett, P.J.
1997g: Quaternary Geology of the Uxbridge area; Ontario Geological Survey, Map 2657, scale 1:20,000. Geology 1983, 1994, 1995.
Barnett, P.J.
1997h: Quaternary Geology of the Mt. Albert area; Ontario Geological Survey, Map 2931, scale 1:20,000. Geology 1983, 1994, 1995.
Barnett, P.J.
1997i: Quaternary Geology of the Sharpe Lake area; Ontario Geological Survey, Map 2932, scale 1:20,000. Geology 1983, 1994.
Barnett, P.J.
1997j: Quaternary Geology of the Sturgeon Lake area; Ontario Geological Survey, Map 2933, scale 1:20,000. Geology 1983, 1994.
Barnett, P.J.
1997k: Surficial Geology of the Newmarket area, NTS 31D/5, southern Ontario; Geological Survey of Canada, Open File 3335, scale 1:50,000.
Barnett, P.J.
1997l: Surficial Geology of the Port Perry area, NTS 31D/12, southern Ontario; Geological Survey of Canada, Open File 3336, scale 1:50,000.
Barnett, P.J.
1997m: Surficial Geology of the Lindsay-Peterborough, Ontario, Victoria, Peterborough, Durham and Northumberland counties, Ontario; Geological Survey of Canada, Memoir 288, 60 p. scale 1:126,720.
Barnett, P.J.
1997n: Quaternary Geology and granular resources of the central and eastern parts of the Peterborough-Lindsay area, southern Ontario; Ontario Geological Survey, Open File Report (Victoria and Clarke Townships), southern Ontario, Ontario Division of Mines, Geological Branch, Open File Report 5176.
Barnett, P.J.
1997o: Quaternary geology of the Newcastle area; southern Ontario; Ontario Division of Mines, Preliminary Map P846, scale 1:50,000.
Barnett, P.J.
1997p: Quaternary geology of the Alliston area; southern Ontario; Ontario Division of Mines, Preliminary Map P847, scale 1:50,000. Geology, 1983.
Barnett, P.J.
1998: Industrial Mineral Resources of the Manilla-Newmarket area; Ontario Department of Mines, Industrial Mineral Report 54, 41 p.
Barnett, P.J.
1999: Quaternary geology of the Hamilton area; Ontario Department of Mines, Geological Series No. 5.
Karrow, P.F.
1956: Pleistocene geology of the Scarborough area; Ontario Department of Mines, Maps 2009, 2077, scale 1:63,360.
Karrow, P.F.
1970: Pleistocene geology of the Thornhill area; Ontario Department of Mines, Industrial Mineral Report 30, Maps P274, P275, scale 1:31,680.
Karrow, P.F.
1971: Quaternary geology of the Stratford-Conestogo area; Ontario; Geological Survey of Canada, Paper 70-34, 17p.
Karrow, P.F.
1974: Till stratigraphy in parts of southwestern Ontario; Geological Society of America Bulletin, v. 85, p. 779-786.
Kelly, R. and Martini, P.
1986: Interglacial and Interstadial lacustrine deposits of the Scarborough Formation, Ontario, Canada; Sedimental Geology, v. 47, p. 27-52.
Kenny, F. M.
1997: A stereoscopic enhanced Digital Elevation Model of the Oak Ridges Moraine area; southern Ontario; Geological Survey of Canada and Ontario Ministry of Natural Resources, Geological Survey of Canada, Open File 3423, scale 1:200,000.
Kenny, F. M. and Hinzman, D. F.
1996: Digital Elevation Model in environmental geoscience, Oak Ridges Moraine, southern Ontario; in Current Research, 1996-E; Geological Survey of Canada, p. 201-208.
Liberty, B. A.
1969: Preliminary map, Oshawa, Ontario and Durham Counties, Ontario; Geological Survey of Canada, Paper 63-17.
Liberty, B. A.
1970: Rice Lake-Port Hope and Trenton Map area; Geological Survey of Canada Paper 69-14, 4 p.
Liberty, B. A.
1969: Paleozoic geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 305.
Carson, D.M.
1979: Surficial geology of the Rice Lake - Port Hope area, southern Ontario; Ontario Geological Survey, Preliminary Map P. 2338, scale 1:50,000.
Chapman, L. J. and Putnam, D.F.
1943: The topography of southern Ontario; Transactions of the Royal Society of Canada, v. 37, p. 33-41.
Chapman, L. J. and Putnam, D.F.
1984: The Physiography of southern Ontario; Third Edition; Ontario Geological Survey, Special Volume 2, 270 p.
Coleman, A. P.
1941: The Pleistocene of the Toronto region; Ontario Department of Mines Report v. XLI, part 1, Map no. 42g, scale 1:63,360.
Cowan, W.R. and Sharpe, D.R.
1973: Quaternary Geology of Orangeville, southern Ontario; Ontario Division of Mines, Map 2336, scale 1:50,000.
Deane, R. E.
1950: Pleistocene geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 255, 108 p.
Eyles, N. and Clark, B.
1988: Seismic stratigraphy and ice scouring in a late Pleistocene glacial lake, Ontario; Geological Society of America Bulletin, v. 100, p. 793-809.
Gorrell, G.E.
1997: Surficial Geology of the Trenton Area, NTS 31G/4, southern Ontario; Geological Survey of Canada, Open File 3333, scale 1:50,000.
Gorrell, G.E.
1997: Surficial Geology of the Rice Lake Area, NTS 31G/1, southern Ontario; Geological Survey of Canada, Open File 3332, scale 1:50,000.
Gravenor, C. P.
1954: Glacial geology - Scugog, Durham, Ontario and Victoria counties; Geological Survey of Canada, preliminary map 53-31, scale 1:63,000.
Gravenor, C. P.
1957: Surficial geology of the Lindsay-Peterborough, Ontario, Victoria, Peterborough, Durham and Northumberland counties, Ontario; Geological Survey of Canada, Memoir 288, 60 p. scale 1:126,720.
Grieve, D.W.
1978: Quaternary Geology and granular resources of the central and eastern parts of the Peterborough-Lindsay area, southern Ontario; Ontario Geological Survey, Open File Report (Victoria and Clarke Townships), southern Ontario, Ontario Division of Mines, Geological Branch, Open File Report 5176.
Grieve, D.W. and Gorrell, G.E.
1979: Quaternary geology of the Newcastle area; southern Ontario; Ontario Division of Mines, Preliminary Map P846, scale 1:50,000.
Grieve, D.W.
1980: Quaternary geology of the Alliston area; southern Ontario; Ontario Division of Mines, Preliminary Map P847, scale 1:50,000. Geology, 1983.
Hewitt, D. F.
1964: Industrial Mineral Resources of the Manilla-Newmarket area; Ontario Department of Mines, Industrial Mineral Report 24, 41 p.
Karrow, P.F.
1956: Pleistocene geology of the Scarborough area; Ontario Department of Mines, Maps 2009, 2077, scale 1:63,360.
Karrow, P.F.
1967: Pleistocene geology of the Toronto area; Ontario Department of Mines, Maps 2183, 2184, scale 1:63,360.
Karrow, P.F.
1968: Pleistocene geology of the Guelph area; Ontario Department of Mines, Maps 2249, 2250, scale 1:63,360.
Karrow, P.F.
1971: Quaternary geology of the Stratford-Conestogo area; Ontario; Geological Survey of Canada, Paper 70-34, 17p.
Karrow, P.F.
1974: Till stratigraphy in parts of southwestern Ontario; Geological Society of America Bulletin, v. 85, p. 779-786.
Kelly, R. and Martini, P.
1986: Interglacial and Interstadial lacustrine deposits of the Scarborough Formation, Ontario, Canada; Sedimental Geology, v. 47, p. 27-52.
Kenny, F. M.
1997: A stereoscopic enhanced Digital Elevation Model of the Oak Ridges Moraine area; southern Ontario; Geological Survey of Canada and Ontario Ministry of Natural Resources, Geological Survey of Canada, Open File 3423, scale 1:200,000.
Kenny, F. M. and Hinzman, D. F.
1996: Digital Elevation Model in environmental geoscience, Oak Ridges Moraine, southern Ontario; in Current Research, 1996-E; Geological Survey of Canada, p. 201-208.
Liberty, B. A.
1969: Preliminary map, Oshawa, Ontario and Durham Counties, Ontario; Geological Survey of Canada, Paper 63-17.
Liberty, B. A.
1970: Rice Lake-Port Hope and Trenton Map area; Geological Survey of Canada Paper 69-14, 4 p.
Liberty, B. A.
1969: Paleozoic geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 305.
Ledyard, J.O. and Mitrychuk, M.
1984: Quaternary Geology of the Trenton-Cobourg area; southern Ontario; Ontario Geological Survey, Map P2580. Geological Series-Preliminary Map, scale 1:50,000.
Mirynych, O.N.
1976: Surficial Geology of the Trenton and Presqu'ile areas; Ontario; Geological Survey of Canada, Open File Report 340.
Pugin, L. and Pullan, S.E.
1997: Seismic stratigraphy and history in glacial sediments with shallow land-based extents in Lake Huron; Annals of Glaciology, v. 22, p. 176-182.
Russell, H.A.J.
1997: Surficial Geology of the Alliston Area, NTS 31G/4, southern Ontario; Geological Survey of Canada, Open File 3334, scale 1:50,000.
Russell, H.A.J. and Brennand, T.A.
1997: Surficial Geology of the Bolton Area, NTS 30M/13, southern Ontario; Geological Survey of Canada, Open File 3335, scale 1:50,000.
Russell, H.A.J., Brennand, T.A. and Sharpe, D.R.
1997: Regional geoscience database for the Oak Ridges Moraine project; southern Ontario; in Current Research 1997- E; Geological Survey of Canada, p. 191-200.
Russell, H.A.J., Sharpe, D.R., Barnett, P.J. and Kenny, F.M.
1997: Digital Thickness of the Greater Toronto and Oak Ridges Moraine Area NATMAP areas; southern Ontario; Geological Survey of Canada, Open File 2892, scale 1:200,000.
Sharpe, D.R. and Barnett, P.J.
1997: Surficial Geology of southern Ontario; Geological Survey of Canada, southern Ontario sheet 32-3, Tobermory, scale 1:1,000,000.
Sharpe, D.R.
1997: Quaternary geology of Toronto and surrounding area; Ontario Geological Survey, Map 2, 2004, scale 1:100,000.
Sharpe, D.R. and Gorrell, G.E.
1997: The internal structure of glacial landforms; an example from the Halton till plain, Scarborough Bluffs, Ontario, Scenes, Vol.17, pp. 19-26.
Sharpe, D.R. and Pugin, L.
1997: Surficial Geology of the Markham Area, NTS 30M/14, southern Ontario; Geological Survey of Canada, Open File 3337, scale 1:50,000.
Sharpe, D.R., Dyke, L.D.,