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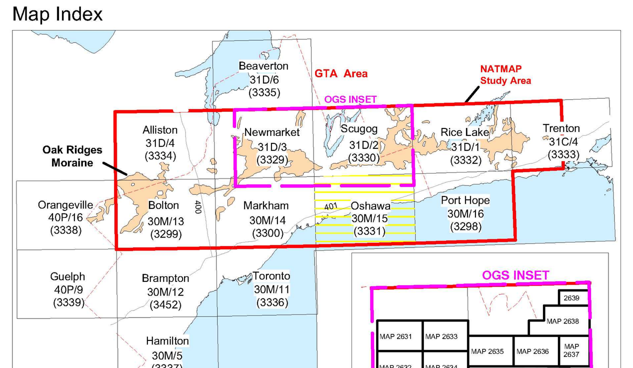
Surficial Geology of the Oshawa Area, NTS 30M/15, southern Ontario

Scale 1:50 000

Map Index



Oak Ridges Moraine NATMAP Project
Surficial Geology Series

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INTRODUCTION

NATMAP Oak Ridges Moraine Map series

Oshawa 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.

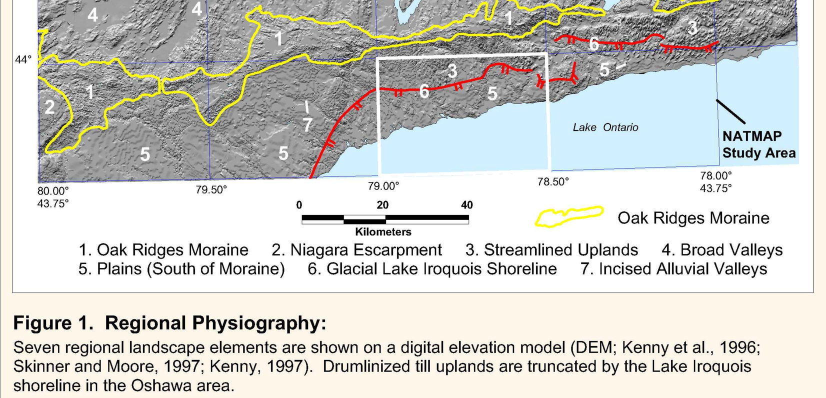


Figure 1. Regional Physiography:
Seven regional landscape elements are shown on a digital elevation model (DEM; Kenny et al., 1996; Skinner and Moore, 1997; Kenny, 1997). Drumlinized till uplands are truncated by the Lake Iroquois shoreline in the Oshawa area.

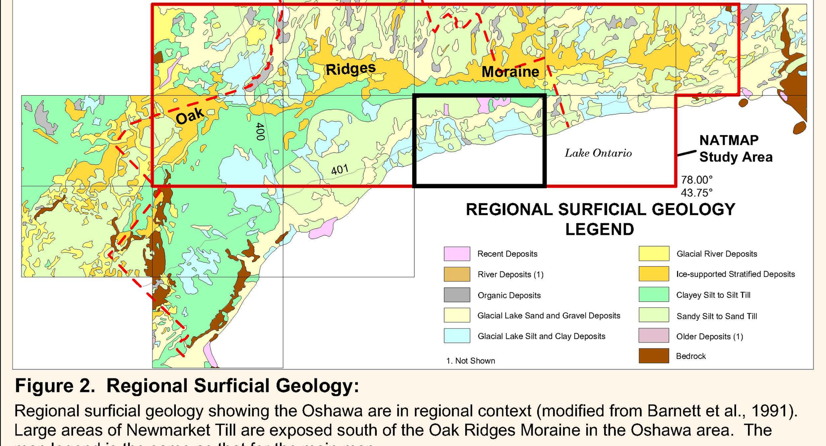


Figure 2. Regional Surficial Geology:
Regional surficial geology showing the Oshawa are in regional context (modified from Barnett et al., 1991). Large areas of Newmarket Till are exposed south of the Oak Ridges Moraine in the Oshawa area. The map legend is the same as that for the main map.

THEMATIC MAPS

Figure 3 Legend: Sediment Codes

Code	Material	Code	Material	Code	Material	Code	Material	Code	Material
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

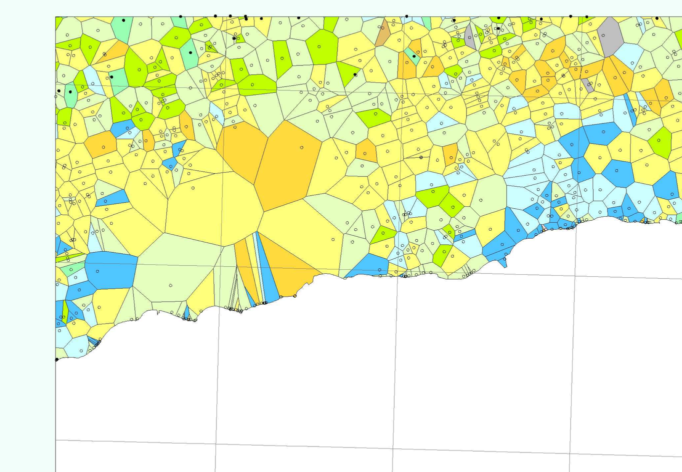


Figure 3. Field sites and material description:
Field sites located at the centre of polygons (Voronoi plot) describe the sediment found (at 1 m depth) and used as ground control for air photo interpretation of the surficial geology map. Fieldwork was carried out in the summers of 1993 - 1995 by Brennand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

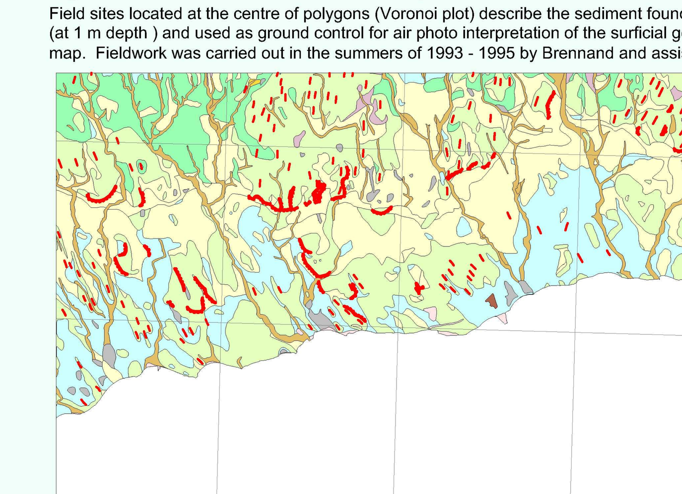


Figure 4. Oshawa surficial geology map:
Surficial geology map of Oshawa area shown at the same scale as the other thematic maps to facilitate comparison. Long red line is Iroquois shoreline. Short red ticks are drumlins. Legend is same as main map.

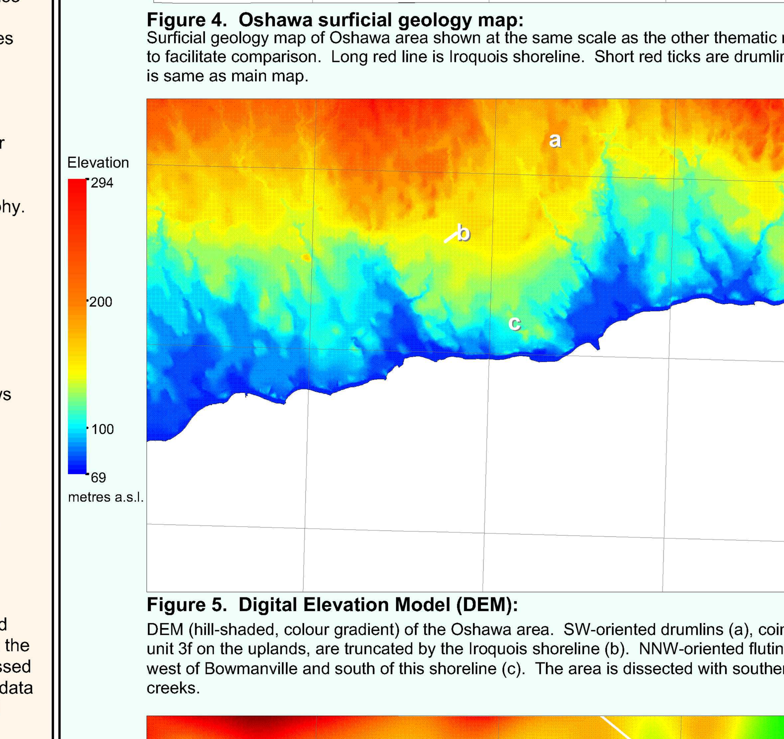


Figure 5. Digital Elevation Model (DEM):
DEM (hill-shaded, colour gradient) of the Oshawa area. SW-oriented drumlins (a), coincident with unit 3f on the uplands, are truncated by the Iroquois shoreline (b). NNW-oriented flutings occur west of Bowmanville and south of this shoreline (c). The area is dissected with southerly flowing creeks.

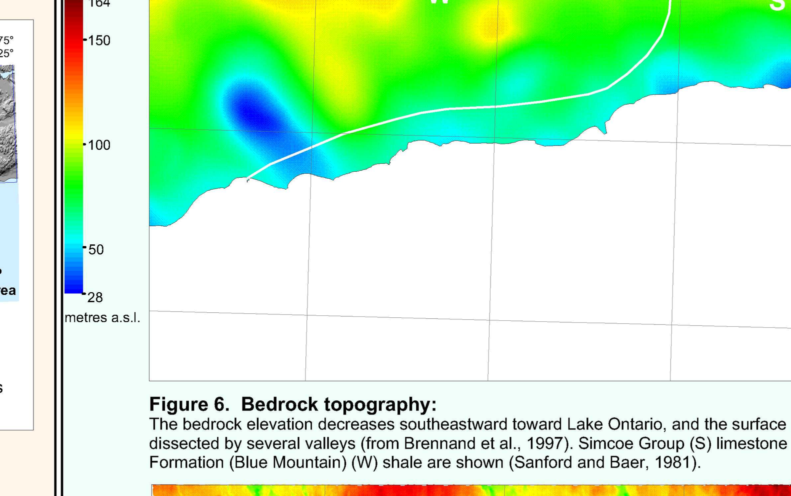


Figure 6. Bedrock topography:
The bedrock elevation decreases southeastward toward Lake Ontario, and the surface is dissected by several valleys (from Brennand et al., 1997). Simcoe Group (S) limestone and Whitby Formation (Blue Mountain) (W) shale are shown (Sanford and Baer, 1981).

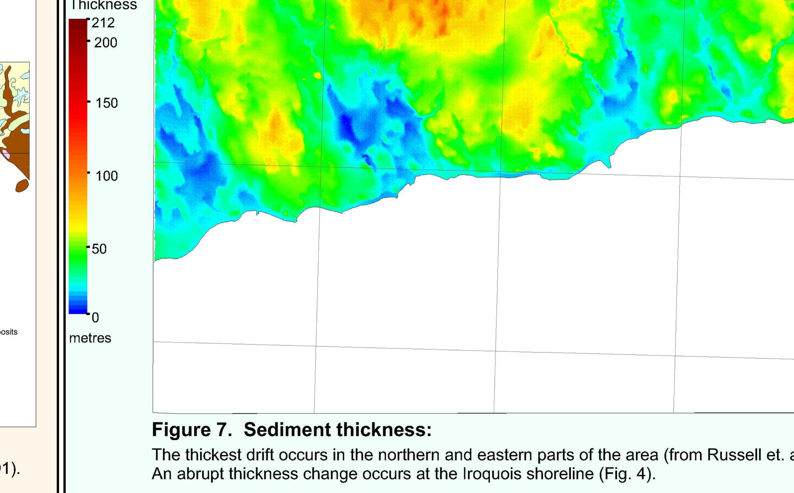


Figure 7. Sediment thickness:
The thickest drift occurs in the northern and eastern parts of the area (from Russell et. al., 1997). An abrupt thickness change occurs at the Iroquois shoreline (Fig. 4).

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.** Wildfield / 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 till; **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)	Small ridges	Base of lake-cut escarpment (abandoned shorebluff)
Drumlin or fluting	Area of hummocky topography	Raised shoreline (projected)
Esker, direction of flow known	Area of sand dunes (eolian)	Crest of abandoned beach bar or spit
Trend of moraine crest	Base of terraced escarpment (fluvial, glaciofluvial)	Brow of landslide or zone of groundwater sapping
Kettle	Meltwater flow direction	Sand and gravel pit
Ice-contact slope	Channels	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	Contour lines (interval 10m)	Railway lines
Streams	Roads (any type)	Greater Toronto Area boundary

Note: Selected listing.

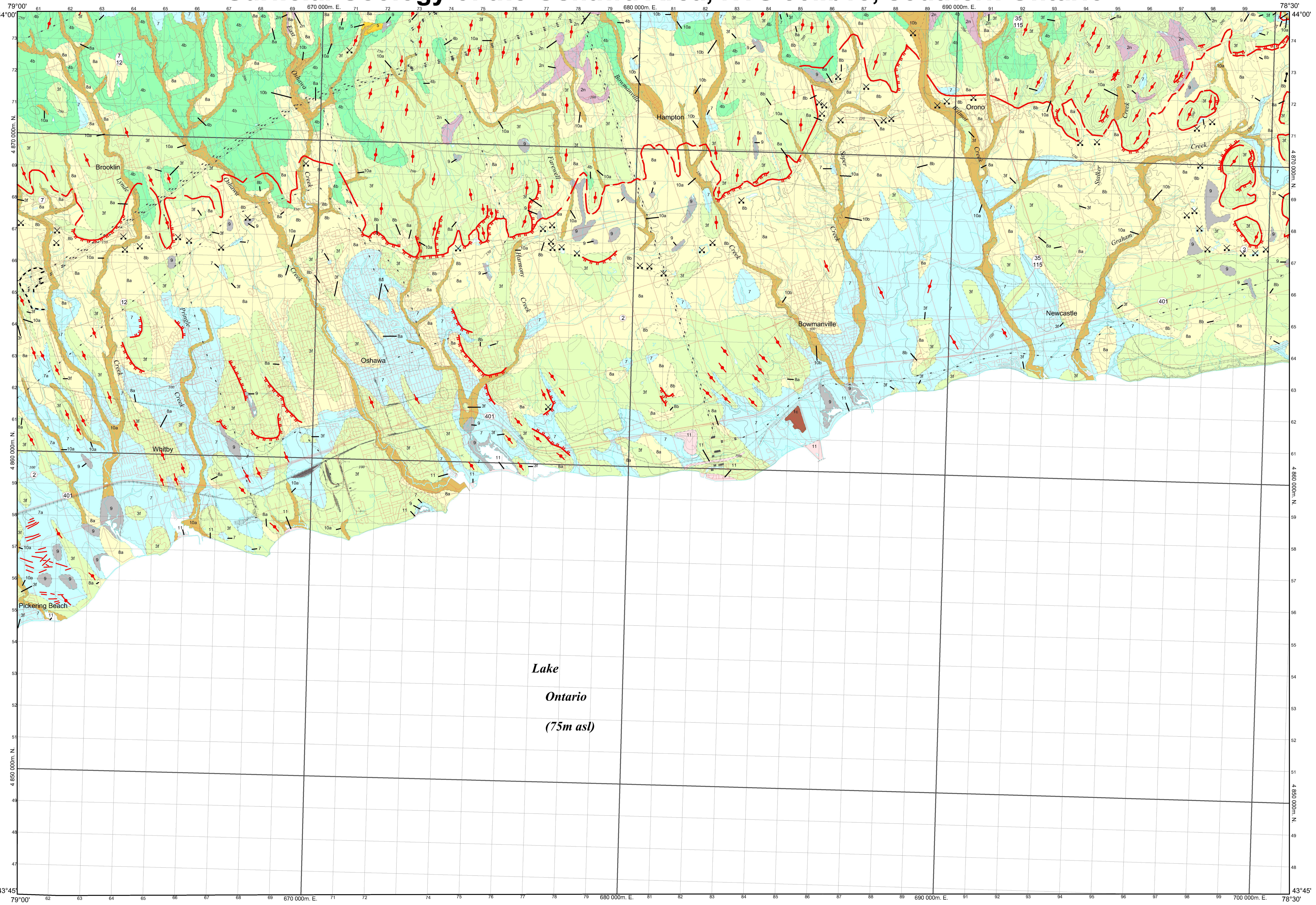
Scale 1:50,000 Échelle
0 1000 2000 3000 4000 5000
Metres Mètres

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 Oshawa Area, NTS 30M/15, southern Ontario; Geological Survey of Canada, Open File 3331, Scale 1:50 000.

Surficial Geology of the Oshawa Area, NTS 30M/15, southern Ontario



MAP NOTES

This surficial geology map synthesizes topgraphic and sediment information, and presents the areal distribution of sediments at 1 m depth in the Oshawa area. Sediment type and stratigraphy is compiled from field sites (lake and river bluffs, gravel pits, and shovel, auger and probe holes; Fig.3; Brennand, 1994) and other data (Brennand, 1997c). Fieldwork was undertaken by Brennand during the summers of 1993-1995, assisted by T. Shaw and J. Ross. Gravenor (1957) published the previous surficial geology map of the area.

Physiography and Landforms:

The Oshawa area is divided into two physiographic regions by the Lake Iroquois shoreline and raised beaches. To the south, is the low-relief, wave-washed Iroquois Lake Plain (Fig. 1), which exhibits NW-NNW oriented flutings. These flutings record an erosional event.

In the north, drumlinized and gullied uplands, underlain by tills and draped by glaciolacustrine sediments, are truncated by the Iroquois shoreline (Fig. 1). These drumlins record an earlier erosional event directed toward the SSW. The agent for both erosional events was either glacial erosion or catastrophically-released subglacial meltwater (Shaw and Gilbert, 1990).

Both regions are dissected by creeks that have their headwaters in the Oak Ridges Moraine or drumlinized uplands to the north (Fig. 2), and discharge into Lake Ontario. These creeks are not necessarily controlled by bedrock valleys (Fig. 6).

Bedrock Geology, Topography and Drift Thickness:

Bedrock is only exposed along Oshawa and Lynde Creeks (Liberty, 1953). Bedrock mostly subcrops below Quaternary drift; Upper Ordovician, Whitby (Blue Mountain) Formation shales overlie Middle Ordovician, Simcoe or Trenton Group limestones (Fig. 6);Sanford and Baer, 1981). The bedrock surface slopes gently southeastward toward Lake Ontario, but exhibits several SE-oriented bedrock valleys (Fig. 6; Holden et al., 1993a), likely tributaries of the ancient Laurentian channel (Spencer, 1881). Drift thickness is highly variable (~0-200 m), being controlled by bedrock topography and post-depositional erosion. In general, drift thickness decreases toward Lake Ontario (Fig.7), but an abrupt change in thickness is visible at the Iroquois shoreline, reflecting the erosional activity of the glacial lake.

Quaternary Geology:
Older Deposits:

The oldest exposed deposits are the glaciolacustrine sands, silts and clays of the Clarke beds, identified in exposures along the Lake Ontario bluffs where the drift is thicker in the east (e.g. Brookfield et al., 1982). These sediments were deposited in a proglacial lake, prior to the main Late Wisconsinan ice advance, the latter being responsible for much of the surficial geology of the Oshawa area.

Locally, north of the Iroquois shoreline, river incision and gullying have exposed sand and gravel (unit 2n) below the Bowmanville till (unit 3f). The age and correlation of these older sands and gravels are unknown.

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 exceeds 50 m in places, and functions as a regional aquitard. Carbonate and Precambrian (igneous and metamorphic) pebbles are dominant in this till, but locally-derived shale fragments can be preserved rendering the till matrix silty to clayey. The till exhibits a wide range of sedimentary styles from lodgement to shear structures to debris flows. Locally, the Bowmanville till includes lenticular sand and silt packages up to 15 m thick (Brookfield et al., 1982). These record subaqueous fans which may have been deposited subglacially. 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, 1976; 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.

Whereas the Bowmanville till is the only surficial till south of the Iroquois shoreline, it is partially buried by Halton drift (unit 4b) north of the shoreline. Regionally, Halton drift onlaps the southern flank of the Oak Ridges Moraine to its north (Fig.2). Toward the end of the Late Wisconsinan, ice melted back into Lake Ontario and its margin fluctuated, depositing this interstratified package of glaciolacustrine and glaciofluvial sediments and silty diamicton. The lateral extent and continuity of Halton drift increases westward, locally draping drumlinized uplands cut into Bowmanville till, and infilling valleys and basins in this surface.

Glacial Lake Deposits:

As deglaciation progressed water became ponded against the southward receding ice margin. The Peel Ponds are recorded by deposits of sand, silt and clay in basins on the drumlinized uplands.

As the ice retreated out of the Lake Ontario basin, Glacial Lake Iroquois was impounded within the basin to a level of ~160 m asl in this area. At its margin, this lake eroded into the till uplands, and longshore currents reworked their sediments into gravely beaches, baymouth bars, spits and recurved spits. Nearshore deposits are dominatly sand and gravel (unit 8). Offshore deposits occur in topographic lows (Fig.5) that coincide with bedrock lows (Fig.6), 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 (100-145 m asl) are locally recorded by sand spits and gravel beaches.

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 glacial landscape and depositing sediment on their floodplains. As lake level fell, these rivers incised further leaving raised terraces (unit 10b) and creating new floodplains (unit 10a). While much of the area is covered with a thin veneer of wind-blown sand, east of Orono nearshore sands were locally reworked into sand dunes when the area was deforested for a short time. Other recent deposits (unit 11) include the Lake Ontario beach, baymouth bars, spits and recurved spits, in addition to fill.

STRATIGRAPHY

Explanation of stratigraphic terms in the ORM NATMAP area

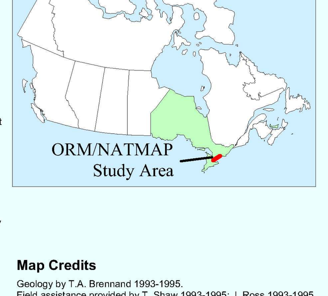
	Stratigraphic unit[1] (youngest on top)	Map units	Explanation / description[2] (reference to stratigraphic name)
Quaternary			Period covering last 2 million years of glacial climates
Recent			Last 10,000 years following glacial climates
	Lake and aeolian deposits	11	Deposits along shore of modern lake
	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 >180m asl)
	Glaciofluvial deposits	6	Deposits of high-energy streams or currents issuing from a glacier; may form core of ORM
	Wildfield / Kettleby[3] tills[4]	4a	Interbedded with lake deposits and flanks the ORM (White, 1975; Barnett et al, 1991)
	Halton Till / [Bouchette till][5]	4b	Thick, interbedded till and lake deposits, in Humber Valley; thins to the east (Karrow, 1959)
	Oak Ridges Moraine sediments	5	Thick, mainly glacial lake deposits, resting on eroded Newmarket Till or lower beds (Chapman and Putnam, 1943; Barnett, 1995)
	Wentworth[6]/ upper Leaside tills	3d	May grade upward into HaltonTill (Karrow, 1959; Leaside, Karrow, 1967)
	Port Stanley / Tavistock tills	3e/4c	Port Stanley: Lake Ontario derived till; Tavistock: Lake Huron derived till (Karrow, 1971)
Unconformity	Major erosional [7]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 (Gwyn and DiLabio, 1973; Sharpe et al., 1994)
	Upper Thorncliffe Formation / [Clarke beds] [8]	2g	Deltaic? /fan beds at Scarborough / Bowmanville bluffs (sand/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	Sandy to clayey 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., 1982)
	Scarborough Formation	2k	Cool-climate (-5° C), lake beds (~122 m asl at bluffs) ~90,000 y BP (clay and sand beds) (Karrow, 1967; Kelly and Martini, 1986)
	Don Formation	2l	Warm-climate (+3° 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[9]	2n	Undifferentiated stratified sediment, dominantly sand, some pebbles
	Older clay, silt[9]	2o	Undifferentiated 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., 1982)
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 et. al., 1996)
9. Uncertain age designation

SERIES BIBLIOGRAPHY

Barnett, P.J.
1990: Tunnel valleys: evidence of catastrophic release of meltwater, central-southern Ontario, Canada; in Abstracts with programs, northeast section, Geological Society of America, Syracuse, New York, p. 3.
Barnett, P.J.
1993: Geological Investigations in the Oak Ridges Moraine area, parts of Scugog, Manvers and Newcastle Township Municipalities and Oshawa Municipality, Ontario; in Summary of Fieldwork and Other Activities 1993; Ontario Geological Survey, Miscellaneous Paper 162, p. 158-159.
Barnett, P.J.
1994: 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 1994; Ontario Geological Survey, Miscellaneous Paper 163, p. 155-160.
Barnett, P.J.
1995: Geology of the Oak Ridges Moraine area, parts of Peterborough and Victoria counties and and Durham and York Regional Municipalities, Ontario; in Summary of Fieldwork and Other Activities 1995; Ontario Geological Survey, Miscellaneous Paper 164, p. 177-182.
Barnett P.J.
1996a: Quaternary Geology of the Claremont area; Ontario Geological Survey, Map 2634, scale 1:20,000. Geology 1993, 1994, 1995.
Barnett P.J.
1996b: Quaternary Geology of the Enniskillen area; Ontario Geological Survey, Map 2636, scale 1:20,000. Geology 1993, 1994.
Barnett P.J.
1996c: Quaternary Geology of the Kendal area; Ontario Geological Survey, Map 2637, scale 1:20,000. Geology 1993, 1994.
Barnett, P.J.
1996d: Quaternary Geology of the Bethany area; Ontario Geological Survey, Map 2638, scale 1:20,000, Geology 1993, 1994.
Barnett, P.J.
1996e: Quaternary Geology of the Brunswick area; Ontario Geological Survey, Map 2639, scale 1:20,000, Geology 1993, 1994.
Barnett, P.J.
1997: Surficial Geology of the Scugog Area, NTS 31D/2, southern Ontario; Geological Survey of Canada, Open File 3330, scale 1:50,000.
Barnett, P. J., and Henderson, L.A.
1995: Quaternary Geology of the Port Perry area; southern Ontario; Ontario Geological Survey, Map 2635, scale 1:20,000.
Barnett, P.J., and Dodge, J.E.P.
1996: Quaternary Geology of the Uxbridge area; Ontario Geological Survey, Map 2633, scale 1:20,000, Geology 1993, 1994, 1995.
Barnett, P.J., and McRae, M.K.
1996a: Quaternary Geology of the Mt. Albert area; Ontario Geological Survey, Map 2631, scale 1:20,000, Geology 1993, 1994, 1995.
Barnett, P.J., and McRae, M.K.
1996b: Quaternary Geology of the Stouffville area; Ontario Geological Survey, Map 2632, scale 1:20,000, Geology 1993, 1994.
Barnett, P.J. and Gwyn, Q.H.J.
1997: Surficial Geology of the Newmarket Area, NTS 31D/3, southern Ontario; Geological Survey of Canada, Open File 3329, scale 1:50,000.
Barnett, P.J., Henry, A.P. and Cowan, W.R.
1991: Quaternary geology of Ontario, southern sheet; Ontario Geological Survey, Map 2556 scale 1:1,000,000.
Barnett, P.J., Dodge, J.E.P. and Henderson, L.A.
1996: Quaternary Geology, Scugog area; Ontario Geological Survey, Map 2644, scale 1:50,000.
Boyce, J.J., Eyles, N. and Pugin, A.
1995: Seismic reflection, borehole and outcrop geometry of Late Wisconsin tills at a proposed landfill near Toronto; Canadian Journal of Earth Sciences, v. 32, p.1331-1349.
Brennand, T.A.,
1994: Preliminary surficial geology site attributes, Oshawa area, Ontario (NTS) 30M/15); Geological Survey of Canada, Open File 2877, 1 sheet, scale 1:50,000.
Brennand, T.A.
1997a: Surficial Geology of the Port Hope Area, NTS 30M/16, southern Ontario; Geological Survey of Canada, Open File 3298, scale 1:50,000.
Brennand, T.A.
1997b: Surficial Geology of the Oshawa Area, NTS 30M/15, southern Ontario; Geological Survey of Canada, Open File 3331, scale 1:50,000.
Brennand, T.A.
1997c: Urban Geology Note: Oshawa Ontario; Geological Association of Canada, Special Paper 42: Urban Geology of Canadian Cities (in press).
Brennand, T.A., Hinton, M. and Sharpe, D.R.
1995: Terrestrial Quaternary geologic and hydrogeologic framework - Port Hope Region (Oshawa-Cobourg); in Regional Geology and Tectonic Setting of Lake Ontario Region. Compiler, D.R. Sharpe. Geological Survey of Canada, Open File Report 3114.
Brennand, T.A., Moore, A., Logan, C., Kenny, F., Russell, H.A.J., Sharpe, D.R., and Barnett, P.J.
1997: Bedrock Topography of the Greater Toronto and Oak Ridges Moraine NATMAP areas, southern Ontario; Geological Survey of Canada Open File 3419, scale 1:200,000.
Brookfield, M.E., Gwyn, Q.H.J., and Martini, I.P.
1982: Quaternary sequences along the north shore of Lake Ontario: Oshawa-Port Hope, Canadian Journal of Earth Sciences, v. 19, p. 1836-1850.
Carson, D.M.
1979: Paleozoic 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 Putman, D.F.
1943: The moraines of southern Ontario; Transactions of the Royal Society of Canada, v. 37., p. 33-41.
Chapman, L.J., and Putman, D.F.
1984: The Physiography of southern Ontario, Third Edition; Ontario Geological Survey, Special Volume 2, 270 p.
Coleman, A.P.
1932: The Pleistocene of the Toronto region; Ontario Department of Mines Report V. XLI, part 7, 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 2326, scale 1:50,000.
Deane, R.E.
1950: Pleistocene geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 256, 108 p.
Eyles, N. and Clarke, B.,
1988: Storm-influenced delta and ice scouring in a late Pleistocene glacial lake, Geological Society of America Bulletin, v. 100, p. 793-809.
Gorrell, G.
1997: Surficial Geology of the Trenton Area, NTS 31C/4, southern Ontario; Geological Survey of Canada, Open File 3333, scale 1:50,000.
Gorrell, G., and Brennand, T.A.
1997: Surficial Geology of the Rice Lake Area, NTS 31D/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 53-26, scale 1:63,500.
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.
Gwyn, Q.H.J.
1976: Quaternary Geology and granular resources of the central and eastern parts of the regional municipality of Durham (parts of Reach, Whitby, East Whitby, Cartwright, Darlington and Clarke Townships) southern Ontario. Ontario Division of Mines Geological Branch, Open File Report 5176.
Gwyn, Q.H.J. and DiLabio, R.N.W.
1973: Quaternary geology of the Newmarket area; southern Ontario; Ontario Division of Mines, Preliminary Map P836, scale 1:50,000.
Gwyn, Q.H.J. and White, S.
1973: Quaternary geology of the Alliston area; southern Ontario; Ontario Division of Mines, Preliminary Map P835, Geological series, scale 1:50,000. Geology, 1972.
Hewitt, D.F.
1969: Industrial Mineral Resources of the Markham-Newmarket area; Ontario Department of Mines, Industrial Minerals Report 24, 41 p.
Karrow, P.F.
1959: Pleistocene geology of the Hamilton area; Ontario Department of Mines, Geological Circular No. 8.
Karrow, P.F.
1967: Pleistocene geology of the Scarborough area; Ontario Department of Mines, Maps 2076, 2077, scale 1:50,000.
Karrow, P.F.
1970: Pleistocene geology of the Thornhill area; Ontario Department of Mines, Industrial Minerals Report 23; Maps, P244, P574, scale 1:31,180.
Karrow, P.F.
1971: Quaternary geology of the Stratford-Conestoga area; Ontario; Geological Survey of Canada Paper 70-34, 11p.
Karrow, P.F.
1974: Till statigraphy in parts of southwestern Ontario; Geological Society of America Bulletin, v. 85, p. 761-768.
Kelly, R. and Martini, P.
1986: Pleistocene glaciolacustrine deposits of the Scarborough Formation, Ontario, Canada. Sedimentary Geology, v. 47, p. 27-52.
Kenny, F.M.
1997: A chromostereo enhanced Digital Elevation Model of the Oak Ridges Moraine area; southern Ontario; Geological Survey of Canada and Ontario Ministry of Natural Resources, Geologoical Survey of Canada, Open File 3423, scale 1:200,000.
Kenny, F.M., Russell, H.A.J., Hinton, M.J., and Brennand, T.A.
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.
1953: Preliminary map, Oshawa, Ontario and Durham Counties, Ontario; Geological Survey of Canada, Paper 53-18.
Liberty, B.A.
1960: Rice Lake-Port Hope and Trenton Map areas; Geological Survey of Canada Paper 60-14, 4 p.
Liberty, B.A.
1969: Paleozoic geology of the Lake Simcoe District, Ontario; Geological Survey of Canada, Memoir 355.
Leyland, J.G. and Mihychuk, M.
1984: Quaternary Geology of the Trenton-Consecon area; southern Ontario; Ontario Geological Survey, Map P2586. Geological Series-Preliminary Map, scale 1:50,000.
Mirynech, E.
1978: Surficial Geology of the Trenton and Presqu'ile areas; Ontario: Geological Survey of Canada, Open File Report 545.
Pugin, A., Pullan, S.E., and Sharpe, D.R.
1996: Observations of tunnel channels in glacial sediments with shallow land-based seismic reflection; Annals of Glaciology, v. 22, p. 176-180.
Russell, H.A.J. and Dumas, S.
1997: Surficial Geology of the Alliston Area, NTS 31D/4, southern Ontario; Geological Survey of Canada, Open File 3334, scale 1:50,000.
Russell, H.A.J. and White, O.L.
1997: Surficial Geology of the Bolton Area, NTS 30M/13, southern Ontario; Geological Survey of Canada, Open File 3299, scale 1:50,000.
Russell, H.A.J., Logan,C., Brennand,T.A., Hinton, M.J., and Sharpe, D.R.
1996: Regional geoscience database for the Oak Ridges Moraine project; southern Ontario; in Current Research 1996 - E; Geological Survey of Canada p. 191-200.
Russell, H.A.J., Moore, A., Logan, C., Kenny, F., Brennand, T.A., Sharpe, D.R. and Barnett, P.J.
1997: Sediment Thickness of the Greater Toronto and Oak Ridges Moraine NATMAP areas; southern Ontario; Geological Survey of Canada, Open File 2892, scale 1:200,000.
Sanford, B.V. and Baer, A.J.
1981: Geological map of southern Ontario; Geological Survey of Canada, southern Ontario sheet 30 S, 1335A, scale 1:1,000,000.
Sharpe, D.R.
1980: Quaternary geology of Toronto and surrounding area; Ontario Geological Survey, Map P. 2204, scale 1:100,000.
Sharpe, D.R.
1988: The internal structure of glacial landforms: an example from the Halton till plain, Scarborough Bluffs, Ontario, Boreas, Vol.17, pp. 15-26.
Sharpe, D.R. and Barnett, P.J.
1997: Surficial Geology of the Markham Area, NTS 30M/14, southern Ontario; Geological Survey of Canada, Open File 3300, scale 1:50,000.
Sharpe, D.R., Barnett, P.J., Dyke, L.D., Howard, K.W.F., Hunter, G.T., Gerber, R.E., Paterson, J. and Pullan, S.E.
1994: Quaternary geology and hydrogeology of the Oak Ridges Moraine area; Geological Association of Canada Mineralogical Association of Canada, Joint Annual Meeting, Field Trip A7; Guidebook, 32 p.
Sharpe, D.R., Dyke, L.D., Hinton, M.J., Pullan, S.E., Russell, H.A.J., Brennand, T.A., Barnett, P.J. and Pugin, A.
1996: Groundwater prospects in the Oak Ridges Moraine area; southern Ontario: application of regional geological models; in Current Research 1996 - E; Geological Survey of Canada p. 181-190.
Sharpe, D.R., Barnett, P.J., Brennand, T.A., Finley, D., Gorrell, G. and Russell, H.A.
1997: Surficial geology of the Greater Toronto and Oak Ridges Moraine areas; compilation map sheet; Geological Survey of Canada, Open File 3062, scale 1:200,000.
Shaw, J., and Gilbert, R.
1990: Evidence for large-scale subglacial meltwater flood events in southern Ontario and northern New York State; Geology, v. 18, p. 1169-1172.
Skinner, H., and Moore, A.
1997: A Digital Elevation Model of the Oak Ridges Moraine, southern Ontario, Geological Survey of Canada Open File 3297.
Singer, S.
1974: A hydrological study along the north shore of Lake Ontario in the Bowmanville-Newcastle area; Ontario Ministry of Environment, Water Resources Report 5d, 72 p.
Spencer, J.W.
1881: Discovery of the preglacial outlet of the basin of Lake Erie into that of Lake Ontario, Canadian Naturalist (New series), v. 10, p. 65-79.
Taylor, F.B.
1913: Moraines north of Toronto; Ontario Bureau of Mines, Annual Report 22, p. 256-260.
Terasmae, J.
1960: Contributions to Palnology No. 2, Part 2. A Palnological study of Pleistocene interglacial beds at Toronto, Ontario. Geological Survey of Canada, Bulletin 56, 47 p.
Watt, A.K.
1957: Pleistocene geology and groundwater resources of the Township of North York, York County; Ontario Department of Mines, Annual Report 1955, v. 64 pt. 7, 64 p. scale 1:31,180.
Watt, A.K.
1968: Pleistocene geology and groundwater resources of the Township of Etobicoke; Ontario Department of Mines, Geological Report 59, 50 p., scale 1:31,180.
White, O.L.
1973: Quaternary Geology of the Bolton area, southern Ontario; Ontario Division of Mines, Map 2275, scale 1:63,360.
White, O.L.
1975: Quaternary Geology of the Bolton area; Ontario Geological Survey Report 117, 119 p.

Note: not all references apply to all maps in the series.



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