Surficial Geology of the Greater Toronto and Oak Ridges Moraine Area, Southern Ontario

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Ministry of Northern Development and Mines, Ontario

NATMAP CARTNAT
Canada's National Geoscience Mapping Program
Le Programme national de cartographie géoscientifique du Canada

Surficial Geology of the Greater Toronto and Oak Ridges Moraine Area, Southern Ontario

Scale 1:200 000

Map Index

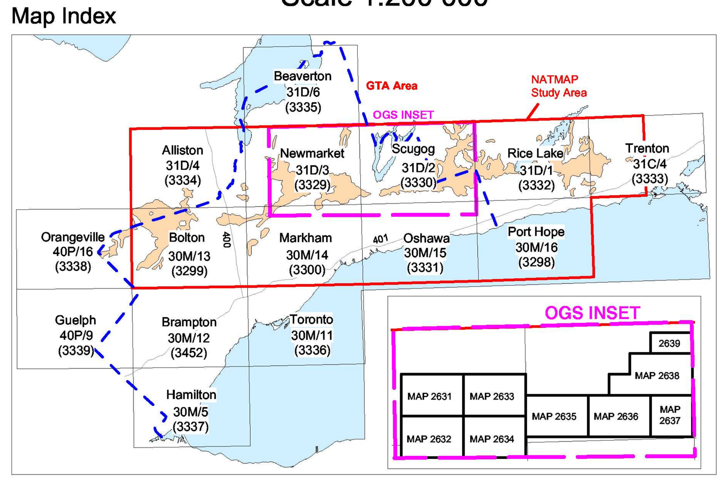

Figure 1. Location and index map for Oak Ridges Moraine NATMAP Area

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INTRODUCTION

A regional, 1:200 000 scale, surficial geology map of the Oak Ridges Moraine (ORM) and Greater Toronto Area (GTA) summarizes a new series of 15 digital 1:50, 000 maps for the area (Fig. 1). Mapping was initiated in response to a number of earth and environmental management issues identified during resource planning by the Ontario government, particularly the Ministry of Natural Resources. The regional mapping was sponsored by the National Mapping Program (NATMAP) of the Geological Survey of Canada Canada in collaboration with the Ontario Geological Survey (OGS) and a number of other provincial and municipal agencies and local groups. This regional map also incorporates data from a series of 9 new OGS, 1:20,000 geology maps covering the central area of the ORM.

Objective and Content

The regional map synthesizes the geology of the ORM-GTA study area as a basis for terrain evaluation, regional planning, resource management and environmental analysis, particularly hydrogeology and water resource assessment. The mapping provides uniform geological data across the region as required for standardized resource evaluation. The map provides a basis for understanding the proposing a regional surficial geology of the area in three dimensions and for conceptual geologic model (Sharpe et al., 1996; Fig. 4). A regional cross-section shows how the map view can be extended to provide a view of the subsurface (Fig. 3). Map notes briefly describe the geological context, topography, drift thickness, landforms, sedimentary units of the area. A companion article (Sharpe et al., in press) provides documentation of the progress of geological mapping, developing concepts, history and a regional geologic synthesis of the GTA.

Related maps products

The regional map is georeferenced, at 1:200,000 scale, to a number of other maps that complement this geological synthesis: 1) a hill-shaded digital elevation model (Skinner and Moore, 1996; Fig 2), 2) a chromo-depth digital elevation model (DEM; Kenny, 1997), 3) bedrock topography (Brennand et al., 1997), 4) drift sediment thickness (Russell et al., 1997), and 5) regional map of potential springs (Dyke et al., 1997). Other related map data e.g. LANDSAT, land use, vegetation, etc., will be available to compare with this geological summary (e.g. Kenny 1997). The map is also linked by a sediment coding scheme to >100,000 water well, geotechnical and geologic field records across the area. Digital map files will be released as part of a CD-ROM data release in late 1998.

Data sources and structure

The nine new maps within the NATMAP study area (Fig. 1) are based on new field work complemented by archival field data; combined most maps have > 1,000 field sites. The six maps outside the NATMAP area (Fig. 1) have been re-mapped with a minimum of new fieldwork but include re-assessed archival data and a simple common legend. The summary map here retains the linework, legend, and many of the symbols of the 1:50, 000 map series. Channels, drumlins and moraine forms are highlighted while more local features were omitted. The 15 maps are structured in a Geographic Information System (GIS) with supporting data in a relational database (e.g. Russell, et al. 1996). This format permits map feature enhancement and analysis. Surficial geology is the first layer of a set of regional themes in the area, where sediment thickness reaches ~ 200 m.

Acknowledgments

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Credit Valley Regional Conservation Authority,
Metro Toronto Regional Conservation Authority,
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Ministry of Northern Development and Mines,
Ontario Ministry of Environment and Energy (MOEE),
Ontario Ministry of Natural Resources (MNR),
Queen's University,
Regional Municipalities of Peel and York,
University of Ottawa.

Map Credits

Northwood Geoscience Ltd.
RASCL Consultants Ltd.

Map Base

Base source: Geomatics Canada Digital Topographic Base 1:50 000 (water features) and 1:250 000 (roads & contours)

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 contrast and elevation relationships. This interpretation has been verified with both archival and project ground control data. Line work was transfered 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 attribute vector file built.

RECOMMENDED CITATION:

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Hill-shaded Digital Elevation Model

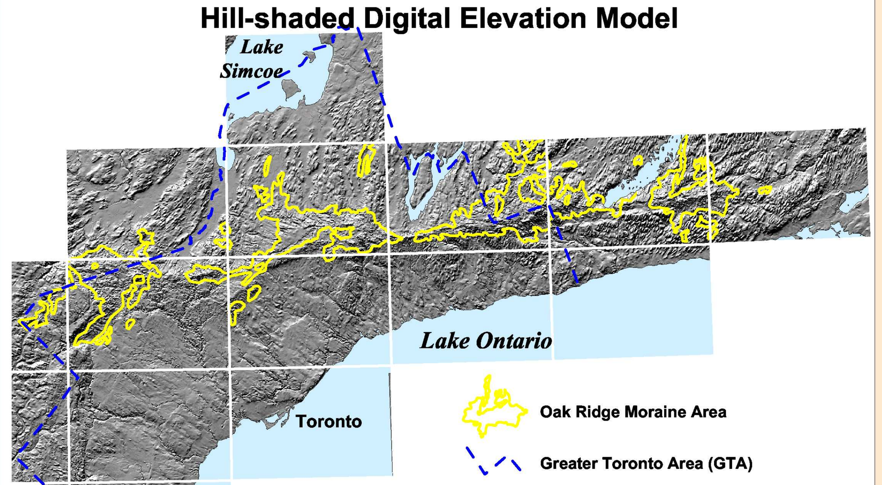
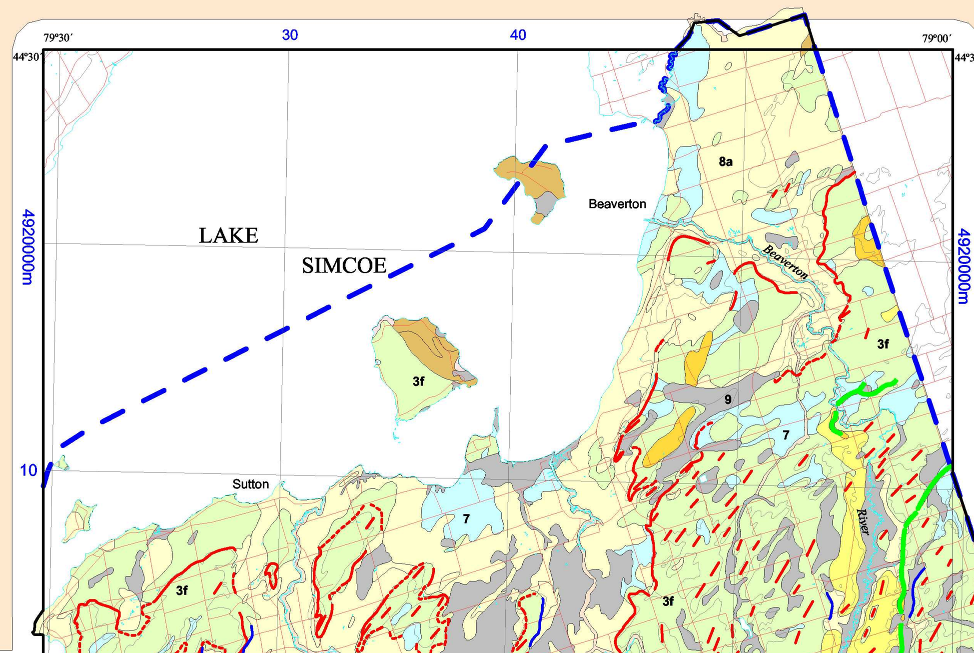
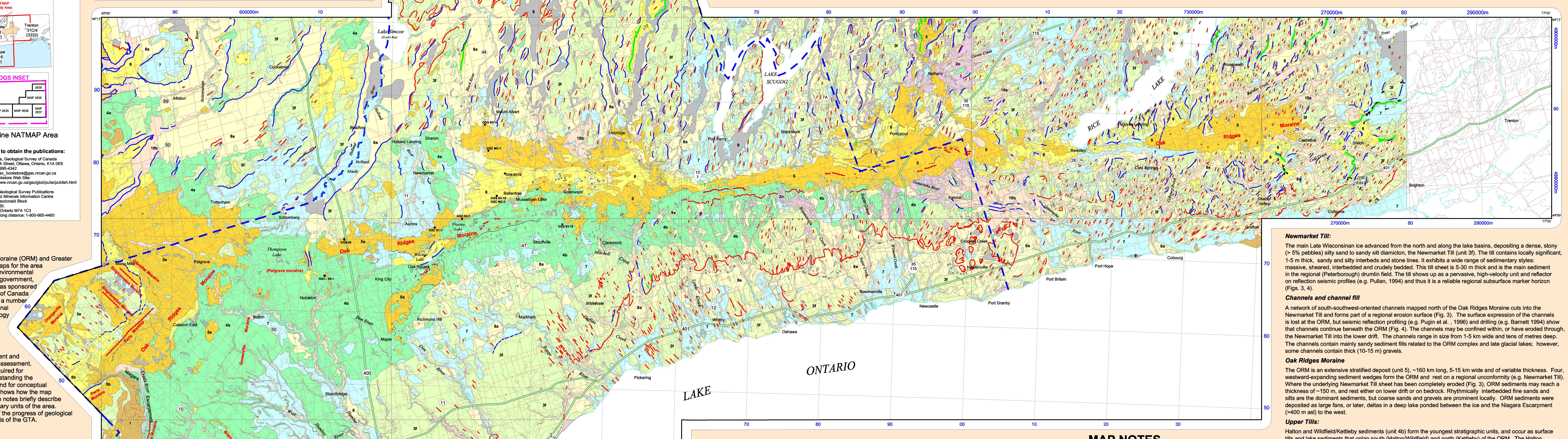
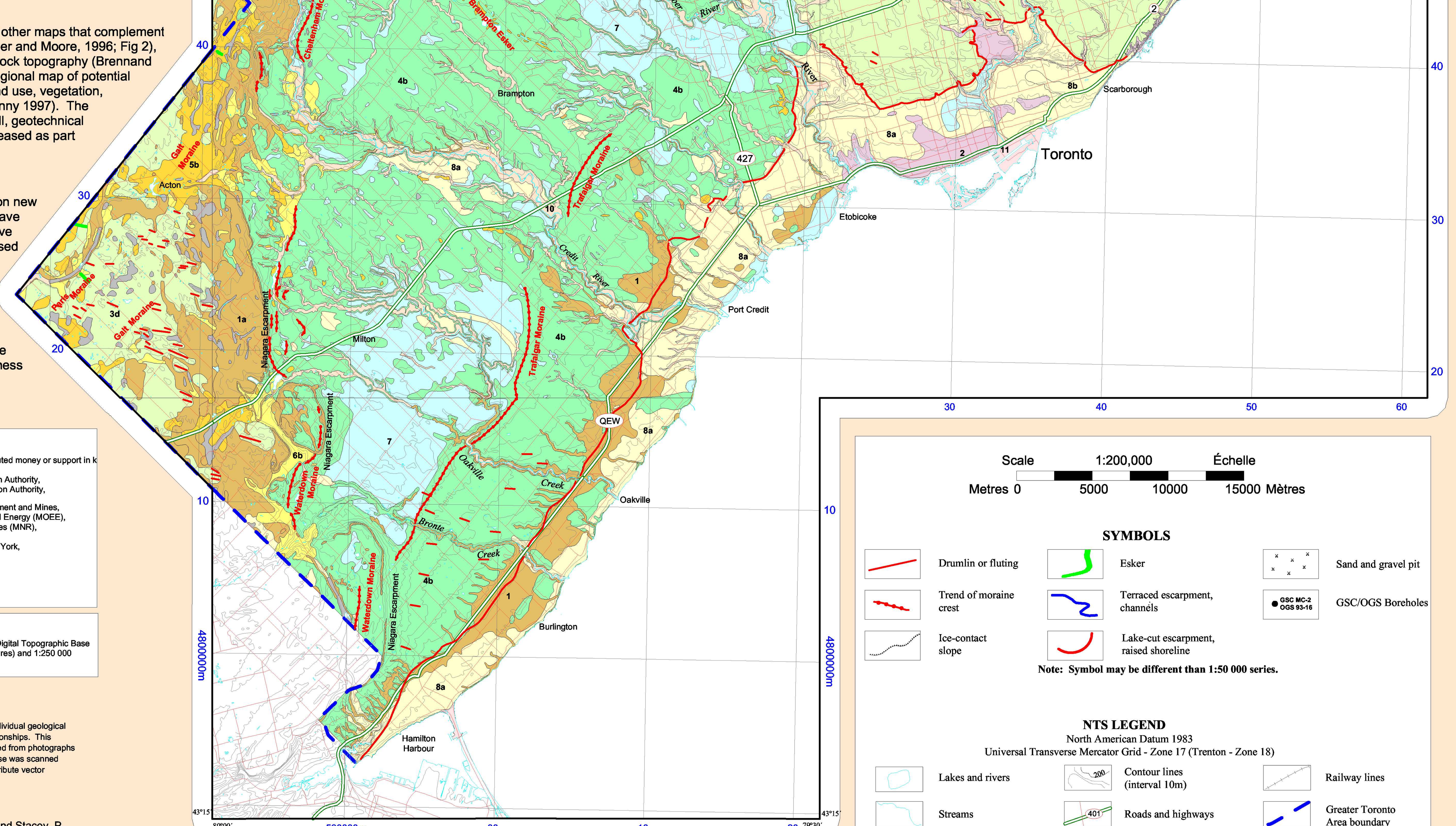


Figure 2. Hill-shaded, digital elevation model (DEM) of the GTA area showing terrain and landform character. Major physiographic features of the area can be viewed and compared with the map units (Skinner and Moore, 1997).







Geologic Cross-section (Newmarket - Scarborough Bluffs)

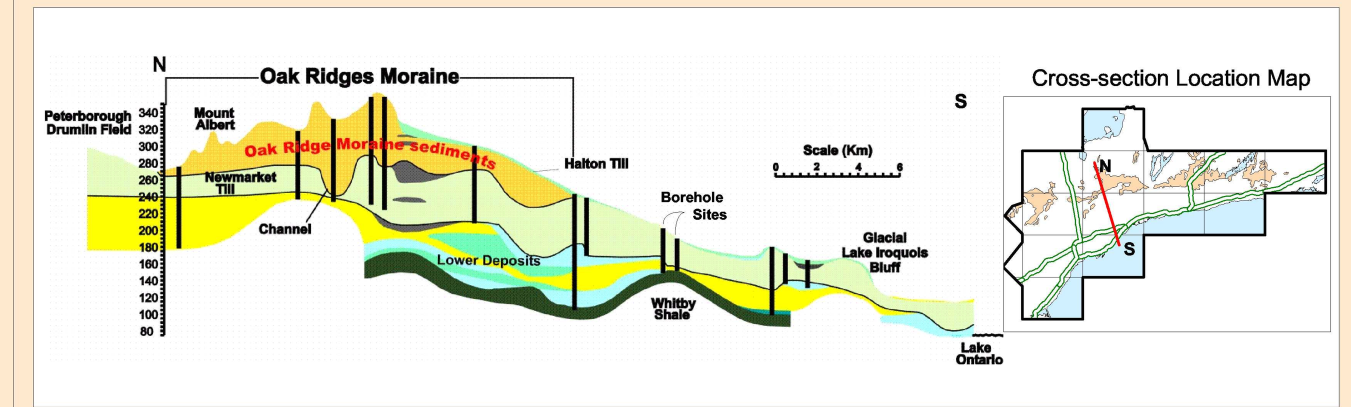
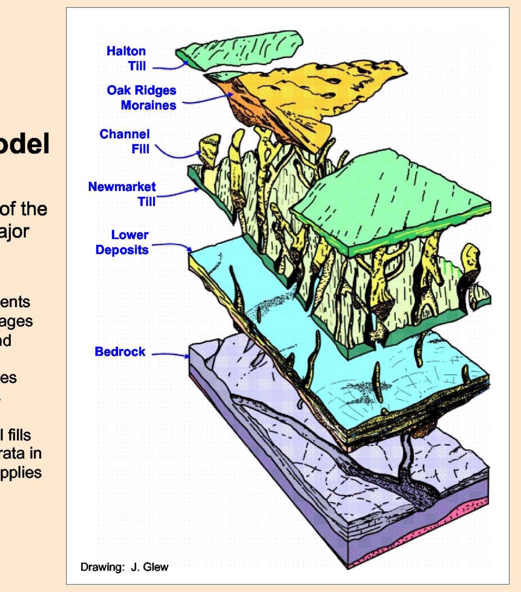


Figure 3. Geologic cross-section from Scarborough Bluffs to Newmarket. Newmarket Till forms a regional marker bed and aquitard separating lower deposits from the ORM (from Sharpe et al 1994).

Oak Ridges Moraine Conceptual Geologic Model

Figure 4. Conceptual geologic model of the GTA area showing the six major stratigraphic elements.

A conceptual geologic model of the area presents six geologic elements; four sedimentary packages and two major erosional surfaces (bedrock and Newmarket channels). All four stratigraphic packages (Lower Drift, Newmarket, Oak Ridges Moraine & Channel Fill and Halton) packages contain aquifer and non-aquifer (aquitard) sediments. The ORM and related (?) channel fills and lower drift are the major water-bearing strata in the ORM and GTA region. This model best applies to a central N-S corridor (Figure 3).



LEGEND

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 /Bowmanville

2 Lower (drift) Deposits: 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.** Stratified sediment, dominantly sand; **o.** 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

Note: The legend is not strictly stratigraphic.

Scale 1:200,000 Échelle

Metres 0 5000 10000 15000 Mètres

SYMBOLS

Drumlin or fluting	Esker	Sand and gravel pit
Trend of moraine crest	Terraced escarpment, channels	GSC/OGS Boreholes (GSC MC-2, OGS 93-16)
Ice-contact slope	Lake-cut escarpment, raised shoreline	

Note: Symbol may be different than 1:50 000 series.

NTS LEGEND

North American Datum 1983
Universal Transverse Mercator Grid - Zone 17 (Trenton - Zone 18)

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

Note: Selected listing.

MAP NOTES

The surficial sediments in the GTA require a simple, consistent and well documented regional style of mapping for users to efficiently apply the map data to earth resource issues. To that end, this map integrates geological and geophysical data to characterize the sediment properties and stratigraphy across the GTA. Integration of this data allows for the successful development of conceptual and predictive sediment models across the area (Fig. 4). These notes briefly review the regional geology and developing concepts in the GTA. An accompanying paper (Sharpe et al., in press) will describe these themes in more detail and provide further map documentation and full referencing.

Geologic mapping in the Greater Toronto area started in the mid 1800's (e.g. Hinde, Coleman , Talyor and others; Karrow, 1967). The Ontario Geological Survey has recently compiled a 1: 1,000,000 scale map of southern Ontario that includes the GTA (Barnett et al., 1991).

Bedrock geology, topography and drift thickness

The surficial sediments shown on this map rest on relatively flat-lying Paleozoic rocks of the St. Lawrence Lowlands, which underlie southern Ontario and Lake Ontario. These strata are underlain and bounded on the north by Precambrian rocks of the Canadian Shield. In the GTA, bedrock (unit 1) outcrops along the Niagara Escarpment and in some of the creeks close to Lake Ontario. Ordovician limestones, shales, sandstones and silurian dolostone subcrop across the area. The bedrock surface slopes gently southwestward toward Lake Ontario. Bedrock is cut by valleys trending eastward from the Niagara Escarpment and trending SE (e.g. Laurentian valley). Bedrock topography (Brennand et al., 1997) and drift thickness are both highly variable (0- 200 m; Russell et al., 1997).

The region can be divided into seven main physiographic areas that are significant to understanding the regional geology (Skinner and Moore, 1997; Fig. 2): i) Niagara Escarpment, ii) Oak Ridge Moraine (ORM) iii) drumlin uplands, iv) channels, v) plains, vi) Lake Iroquois shoreline, and, vii) river valleys. The Niagara Escarpment forms a topographic barrier that affected ice and meltwater flow during formation of the ORM. The ORM meets the escarpment at >400 m asl and erosional channels were cut where high lakes drained. Drumlin uplands forming the Peterborough drumlin field occur north and south of the moraine with little change in drumlin long-axis orientation. These drumlins show continuity in topography and form and appear to underlie the ORM (Fig. 3). Large flat-floored valleys (channels) are eroded into the drumlin uplands north of the moraine and apparently end at the moraine (e.g. Holland Marsh). The Oak Ridges Moraine, a raised, east-west drainage divide extends from east of Rice Lake to the Niagara Escarpment. The moraine forms a hummocky, kettled, complex of glaciofluvial - glaciolacustrine sediment. A broad, gently sloping plain, composed of lake deposits borders the area south of the ORM. Lake Iroquois shoreline cuts across this plain at elevations that range from ~110 m asl near Hamilton to ~140 m asl at the east margin of the area.

Surficial geology

The map legend provides a simple 11-unit classification based on sediment textures (sand, silt, clay and gravel), landform and origin. The deposits are grouped by origin (e.g. river, glacial lake etc.) except the unclassified lower drift. The major sediment packages are tied to a developing regional geologic model (e.g. Sharpe et al., 1996) that highlights 6 principal stratigraphic elements (Fig. 4).

Lower (drift) Deposits:

The oldest exposed sediments in the region are found along Lake Ontario (Scarborough Bluffs) and river valleys leading from the lake (e.g. Karrow, 1967). These sediments (unit 2) are mainly glacial lake sand, silt and clay, deposited prior to or as the main Late Wisconsinan ice advanced. They also include York Till from the previous, Illinoian glaciation, and warm-climate Don Formation interglacial beds. Lower deposits include distinctive fossils and wood that define them as important marker beds in regional investigations and correlation (Figs. 3, 4). Uncorrelated beds of silts and sands appear to be widespread below a regional till (Newmarket) in both the subsurface seismic data and in outcrop adjacent to the ORM between Lake Scugog and Rice Lake (unit 2n and 2m).

Newmarket Till:

The main Late Wisconsinan ice advanced from the north and along the lake basins, depositing a dense, stony (> 5% pebbles) silty sand to sandy silt diamicton, the Newmarket Till (unit 3f). The till contains locally significant, 1-5 m thick, sandy and silty interbeds and stone lines. It exhibits a wide range of sedimentary styles: massive, sheared, interbedded and crudely bedded. This till sheet is 5-30 m thick and is the main sediment in the regional (Peterborough) drumlin field. The till shows up as a pervasive, high-velocity unit and reflector on reflection seismic profiles (e.g. Pullan, 1994) and thus it is a reliable regional subsurface marker horizon (Figs. 3, 4).

Channels and channel fill

A network of south-southwest-oriented channels mapped north of the Oak Ridges Moraine cuts into the Newmarket Till and forms part of a regional erosion surface (Fig. 3). The surface expression of the channels is lost at the ORM, but seismic reflection profiling (e.g. Pugin et al. , 1996) and drilling (e.g. Barnett 1994) show that channels continue beneath the ORM (Fig. 4). The channels may be confined within, or have eroded through, the Newmarket Till into the lower drift. The channels range in size from 1-5 km wide and tens of metres deep. The channels contain mainly sandy sediment fills related to the ORM complex and late glacial lakes; however, some channels contain thick (10-15 m) gravels.

Oak Ridges Moraine

The ORM is an extensive stratified deposit (unit 5), ~160 km long, 5-15 km wide and of variable thickness. Four, westward-expanding sediment wedges form the ORM and rest on a regional unconformity (e.g. Newmarket Till). Where the underlying Newmarket Till sheet has been completely eroded (Fig. 3), ORM sediments may reach a thickness of ~150 m, and rest either on lower drift or on bedrock. Rhythmically interbedded fine sands and silts are the dominant sediments, but coarse sands and gravels are prominent locally. ORM sediments were deposited as large fans, or later, deltas in a deep lake ponded between the ice and the Niagara Escarpment (>400 m asl) to the west.

Upper Tills:

Halton and Wildfield/Kettleby sediments (unit 4b) form the youngest stratigraphic units, and occur as surface tills and lake sediments that onlap south (Halton/Wildfield) and north (Kettleby) of the ORM. The Halton sediment complex is thickest in the Humber Valley and thins towards the north and east. The sediment is dominantly a clayey silt to silt till with interbedded sand and silt. The extent of Halton sediment has been redefined east of the Humber watershed to a narrow unit onlapping the Oak Ridges Moraine from Oak Ridges to Claremont to Kendal.

Glacial Lake Deposits:

Glacial lake deposits (unit 7 and 8) are widespread in the area. Thin deposits of sand, silt and clay are found related to a series of lake levels: from 280 m asl to 245-260 (Algonquin,), to 130 m asl (Iroquois). Glacial Lake Iroquois and Algonquin re-worked sediments into gravely beaches, baymouth bars, and spits; sand and gravel (unit 8); silt and clay (unit 7).

Recent Slope, Organic, and River Deposits:

Immediately following deglaciation and lowering of post-glacial lakes, slope erosion was active. This produced deep gullies from runoff and landslides from groundwater piping. Holocene organics (unit 9) accumulated in poorly drained hollows and kettles producing wetlands. As water levels fell to Lake Ontario levels, rivers incised deeper, leaving raised terraces (unit 10b) and creating new floodplains (unit 10a).

Hydrogeologic considerations

The geologic model (Fig. 4) provides at least four sedimentary units or subsurface structures that are potential aquifer targets: 1) extensive Oak Ridges Moraine sediments exposed at the surface; 2) tunnel channels structures that cut into or through the Newmarket Till and that are filled by ORM sediments; 3) extensive sands within the lower deposits; and 4) lower sediments filling valleys on the bedrock surface. The location of aquifer beds depends primarily on the type and distribution of depositional facies (e.g. gravel). Therefore, lateral and vertical sediment (facies) changes within the map units can be more important than the generalized stratigraphy as a guide for defining productive aquifers and other hydrostratigraphic units Sharpe et al., 1996).

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An accompanying article (Sharpe et al., in press) provides a more complete explanation and references of GTA mapping.

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