# The Buried Laurentian Valley, southern Ontario: Character, Sedimentary Fill, and Hydrogeological Setting in the Nobleton – King City area.

Natural Resources Canada / Ressources naturelles Canada
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## The Buried Laurentian Valley, southern Ontario: Character, Sedimentary Fill, and Hydrogeological Setting in the Nobleton – King City area.

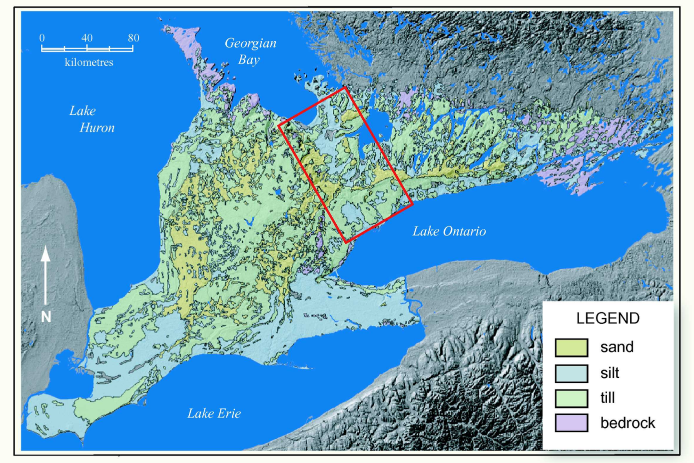


**Figure 1.** Generalized geology of southern Ontario and location of the Laurentian Valley study area east of the Niagara Escarpment. Geology simplified from Barnett et al., 1991.

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## Introduction

- Buried valleys have been investigated in southern Ontario since the 1880's.
- Buried valleys contain locally significant groundwater resources; yet, no study of buried valleys in southern Ontario adequately constrains aquifer characteristics, reserves, or flow paths.
- Spencer (1890) identified the Laurentian Valley by using water well records.
- More than 100 years later, there is no clear idea of the geometry, extent, and sedimentary fill of the valley that connected Georgian Bay to Lake Ontario.
- Development of well-constrained geological models for buried valleys is relevant to modelling groundwater fluxes in valleys ~30 km x 100 km with sediment fills ~100-200 m deep.
- The poster summarizes current knowledge on geometry and fill of the Laurentian Valley to identify data gaps for research and assessment of buried valley aquifers.
- The poster presents a series of maps of the valley setting, landscape, bedrock topography, geology, and sediment thickness.
- Details include: high-resolution seismic reflection data, sediment architecture / nested scale of valleys, and, stratigraphic / sedimentological context from two drill cores in the Nobleton – King City area.

## Regional Stratigraphic Setting

- The lithostratigraphic framework of the study area (Karrow, 1967) has been reinterpreted using basin analysis principles and event stratigraphic concepts (Figs. 2; Barnett et al., 1998).
- A key result is the mapping of a regional unconformity that is defined by drumlinized Newmarket Till and tunnel channels (Barnett et al., 1998; Sharpe et al., 2004).
- To map the regional stratigraphy using archival data, the lithostratigraphic framework has been simplified to five principal units.
- They are, stratigraphically upward: 1) Paleozoic bedrock, 2) Lower sediment, 3) Newmarket Till, 4) Oak Ridges Moraine and channel sediment, and 5) Halton Till. Lower sediment (LS) comprises 10 poorly exposed formations representing middle Wisconsinan and older sediment (Fig. 2) described mainly from Scarborough Bluffs (Karrow, 1967; Eyles et al., 1985; Sharpe et al., 1996; 1997).

## Stratigraphic and Geological Model

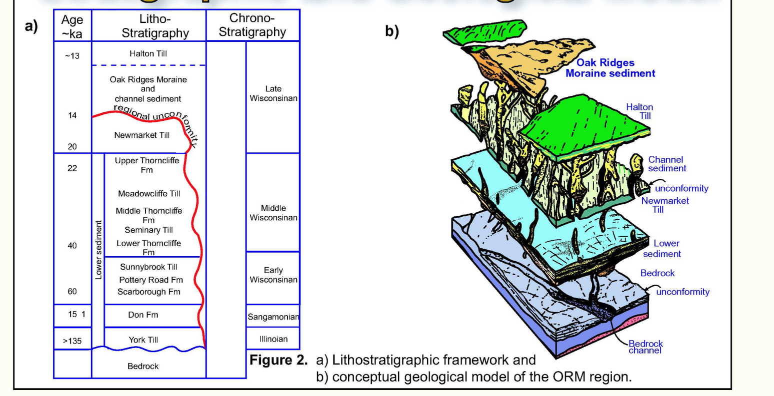



**Figure 2.** a) Lithostratigraphic framework and b) conceptual geological model of the ORM region.

## Data and Topography

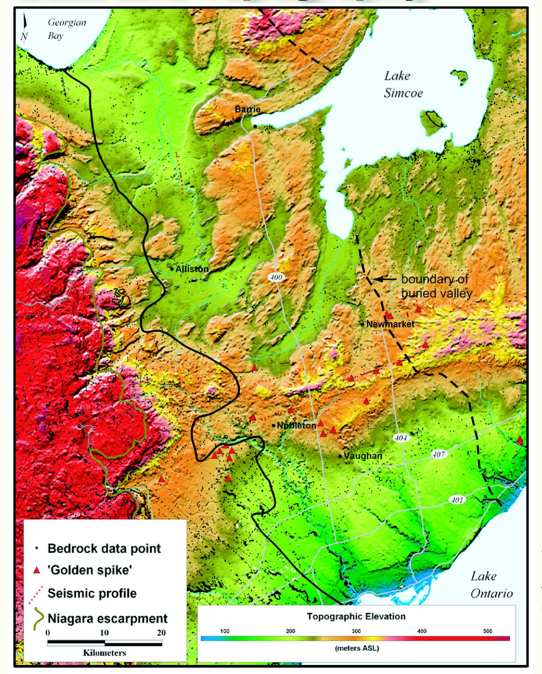



**Figure 3.** Topographic DEM from Georgian Bay to Lake Ontario with MOE water well data and high-quality control data.

## Bedrock Topography

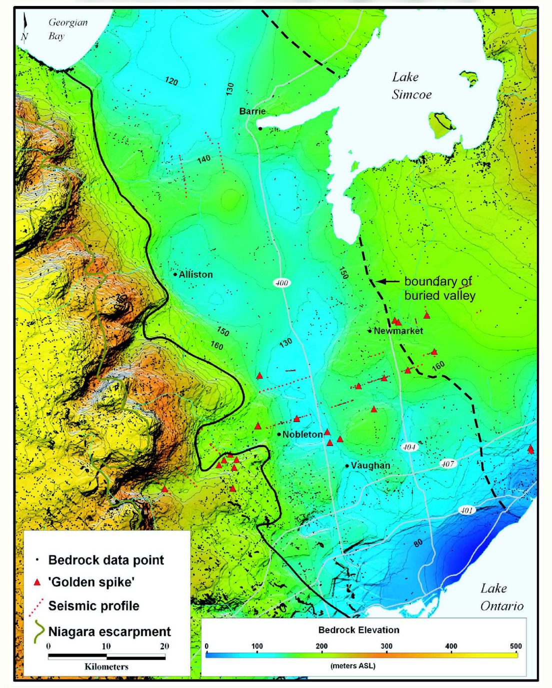



**Figure 4.** Bedrock elevation DEM of the buried Laurentian valley extent from Georgian Bay to Lake Ontario. Valley is ~3000 km$^2$.

## Bedrock Geology

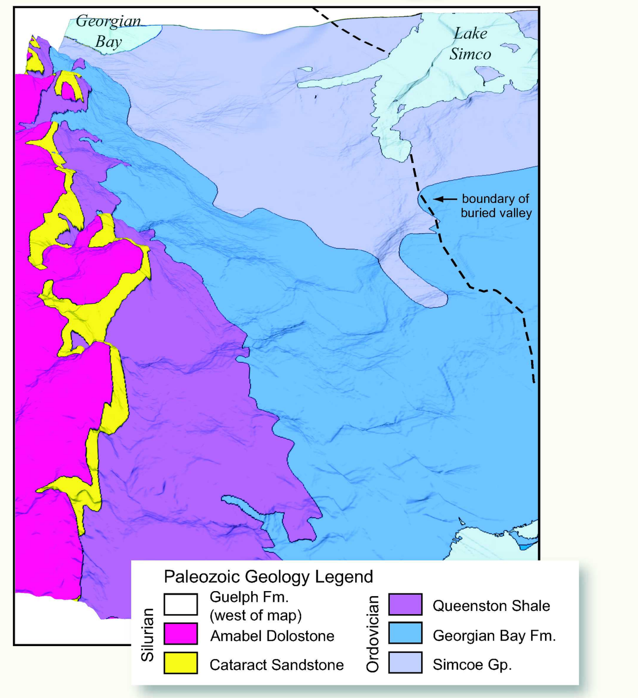



**Figure 5.** Bedrock geology draped on perspective-view of bedrock elevation DEM. Laurentian valley is eroded into Georgian Bay Fm and Simcoe Gp shale and limestone. Geology is from Ontario Geological Survey (1993). Base does not match other maps.

## Sediment Thickness

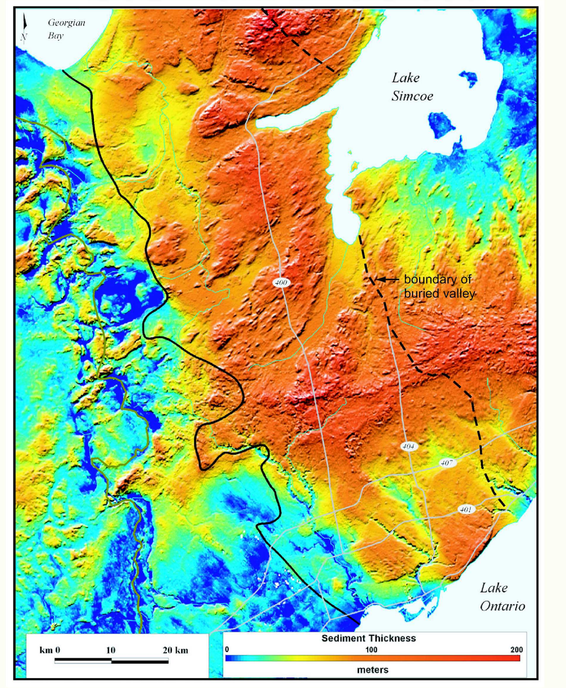



**Figure 6a.** Sediment thickness map of the buried valley fill. Map is derived from subtraction of bedrock surface elevation DEM from modern topographic DEM elevation. Thickest sediment occurs west of Lake Simcoe and beneath Oak Ridges Moraine (east of Nobleton).

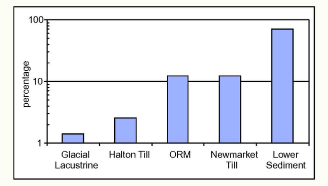



**Figure 6b.** Histogram of stratigraphic units that fill the southern 60% of the valley. Note most fill is classed as Lower sediment.

## Surficial Geology

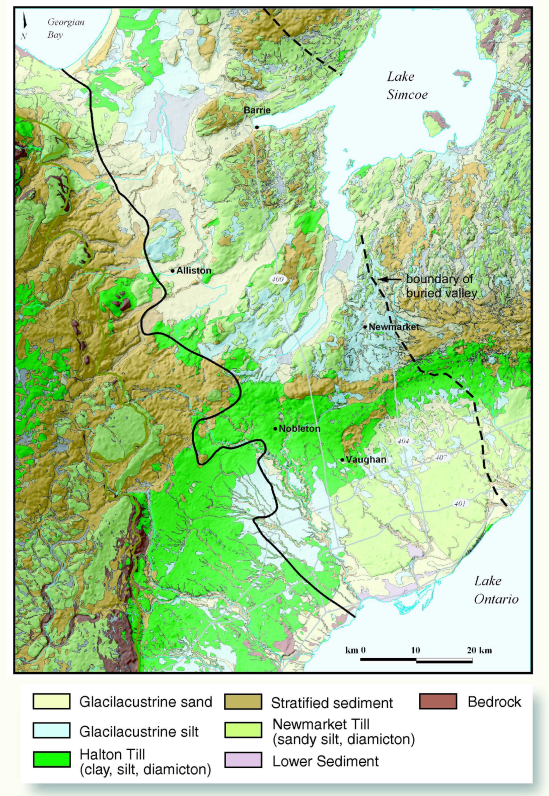



**Figure 7.** Surficial geology draped on the topographic DEM. Geology from Ontario Geological Survey (2003).

## Glacilacustrine Sediment

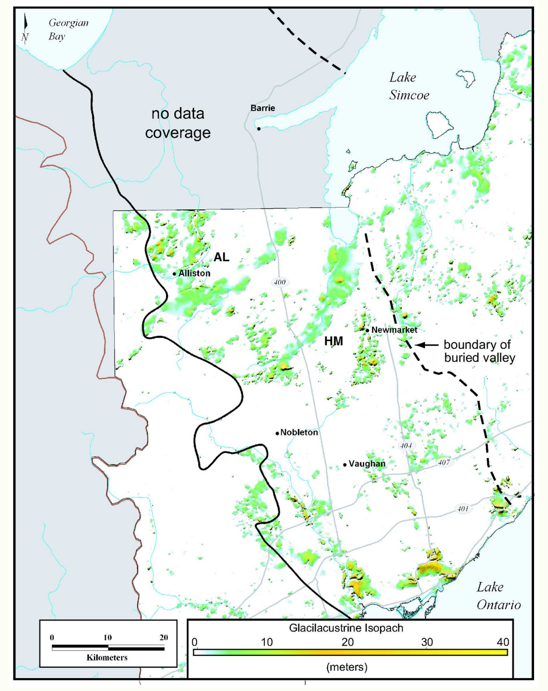



**Figure 8.** Glacilacustrine stratigraphic unit isopach is thickest in the Holland Marsh (HM) and Alliston lowland (AL) areas (from Logan et al., 2005). This is likely glacial Lake Algonquin sediment.

## Halton Till

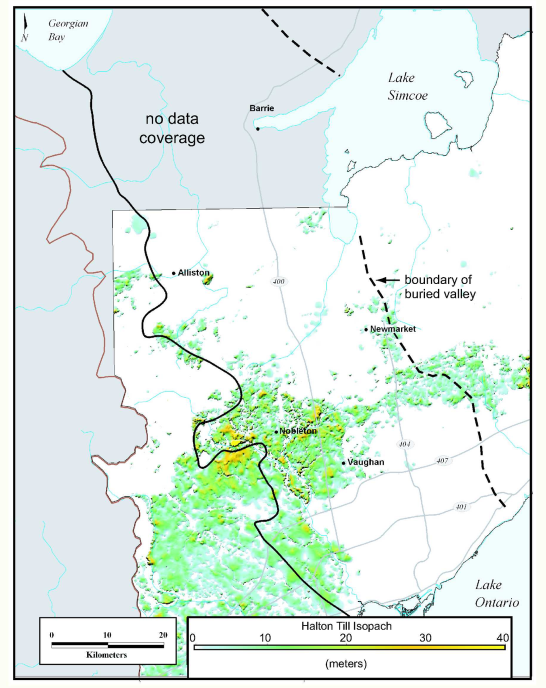



**Figure 9.** Halton Till stratigraphic unit isopach is thickest to the east and west of Nobleton (from Logan et al., 2005). This unit forms a leaky aquitard that locally yields water for domestic use.

## ORM Sediment

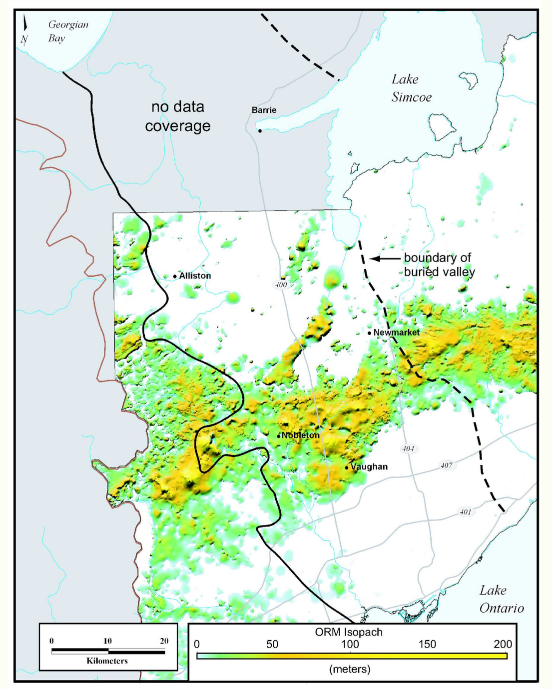



**Figure 10.** Oak Ridges Moraine stratigraphic isopach is thickest in an E-W belt crosscutting the Laurentian valley (from Logan et al., 2005). This unit can extend to bedrock (see Fig. 13 and 15) along tunnel channels. It is a prime exploration target for municipal water supplies (see Sharpe et al. 1996).

## Newmarket Till

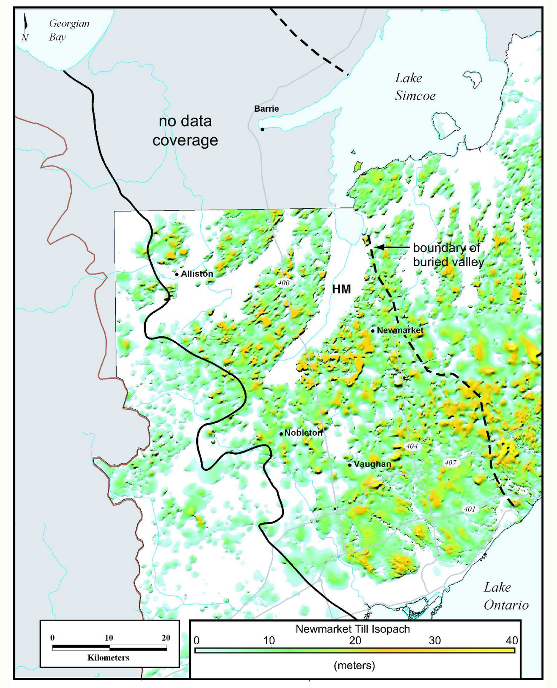



**Figure 11.** Newmarket Till stratigraphic isopach has variable thickness within uplands adjacent to Holland Marsh and along highway 400 (From Logan et al., 2005). Newmarket Till is absent along tunnel valleys such as Holland Marsh. This unit is very dense and forms a regional aquitard (Gerber and Howard, 1996).

## Lower Sediment

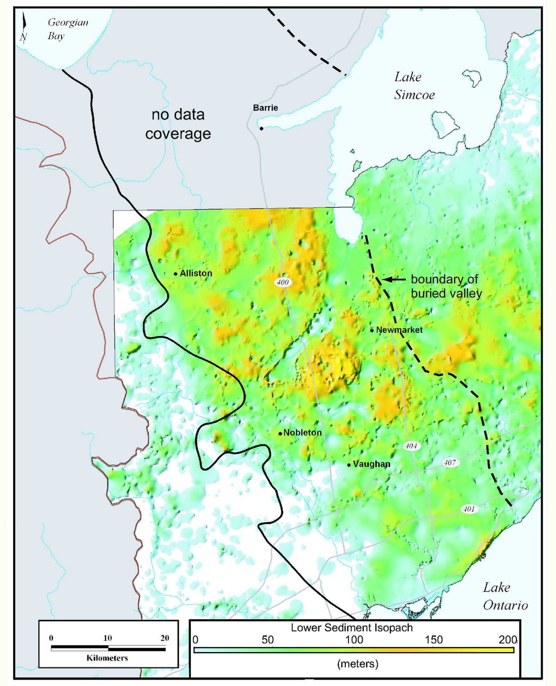
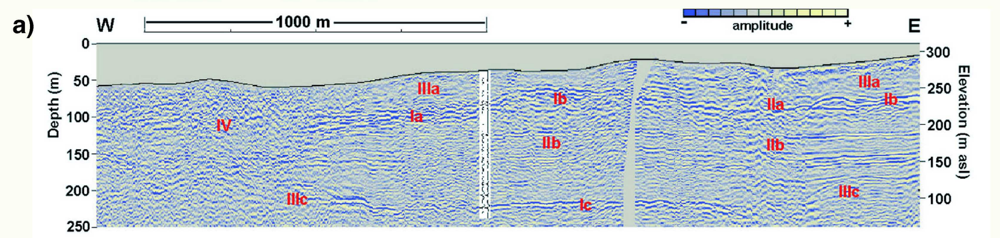


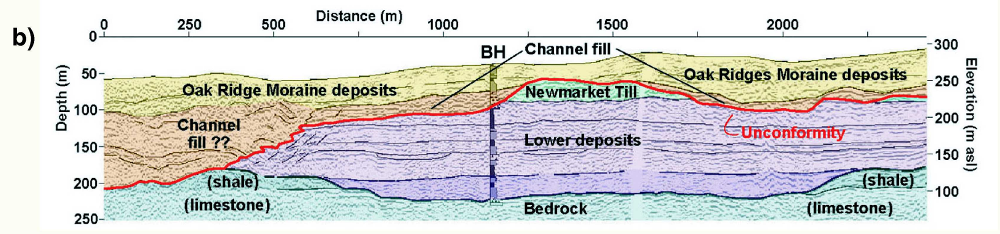

**Figure 12.** Lower sediment stratigraphic isopach is the most extensive and volumetrically important fill of the valley (From Logan et al., 2005). It hosts the Alliston and Young Street aquifers. Water quality can be affected by high dissolved carbon, likely from organics in the Scarborough Formation (see Aravena and Wassenaar, 1993).

## Seismic Stratigraphy

### Nobleton Transect



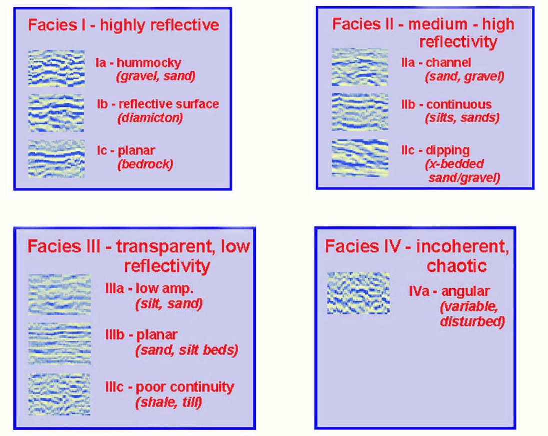

- Note differences between continuous, horizontal medium-amplitude reflectors of IIb (Thorncliffe and Scarborough fms) and less coherent signal of IV (channel sediment). Ic is strong bedrock reflector.




- Seismic data records a regional unconformity similar to that mapped at the surface north of the Oak Ridges Moraine (Sharpe et al., 2004). Geometry of the unconformity is shown schematically in figure 15.

**Figure 13.** A 3 km long portion of a seismic reflection profile collected in the Nobleton area. a) Plotted by seismic amplitude (Pugin et al. 1999; see index to labels and seismic facies in figure 14). b) Interpretation of profile shows tunnel channel cut to bedrock and well-stratified Lower sediment.

## Seismic Facies




- Seismic facies (I – IV) are defined primarily on reflection amplitude
- Subfacies (a-c) are defined based on differences of reflector continuity and geometry
- Verified seismic facies provide a framework for interpretation of new seismic reflection data.

**Figure 14.** Illustration of seismic facies labelled on figure 13a and summary description (modified from Pugin et al., 1999).

## Sediment Architecture of nested valleys

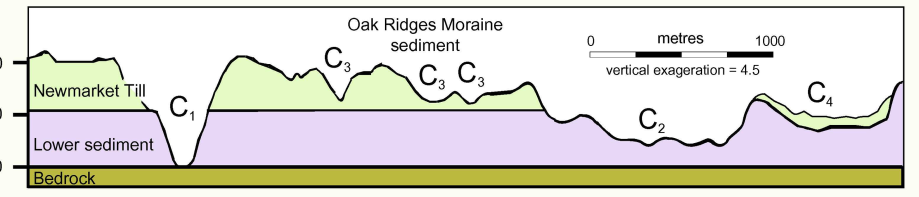



**Figure 15.** Stratigraphic architecture of the regional unconformity synthesized from seismic reflection data (Russell et al. 2003). Channels eroded into thick sediment result in a complex valley fill with nested channel geometries. Only channels of class C1 to C3 have been recognized in Laurentian Valley sediment.

| Characteristic | C1 | C2 | C3 |
|---|---|---|---|
| Substrate | LS or bedrock | LS or bedrock | Newmarket |
| Length (km) | > 40 | < 25 km | < 10 |
| Width (km, <) | 7 | 3 | 3 |
| Depth (m, <) | 175 | 100 | 30 |
| Width/depth (<) | 47 | 23 | 29 |
| Surface relief (m, <) | 50 | 50 | 20 |
| Side-wall slopes (°, <) | 20 | 15 | 10 |
| Orientation | NNE_SSW | N-S; NNE-SSW | N-S |
| Antecedent topography | probable | no | no |
| Islands | very few | common | common |
| Branching | low | moderate | moderate |

Table 1. Characteristics of sediment hosted tunnel valleys in the GTA (modified from Russell et al., 2003).

## Stratigraphic and Sediment Character

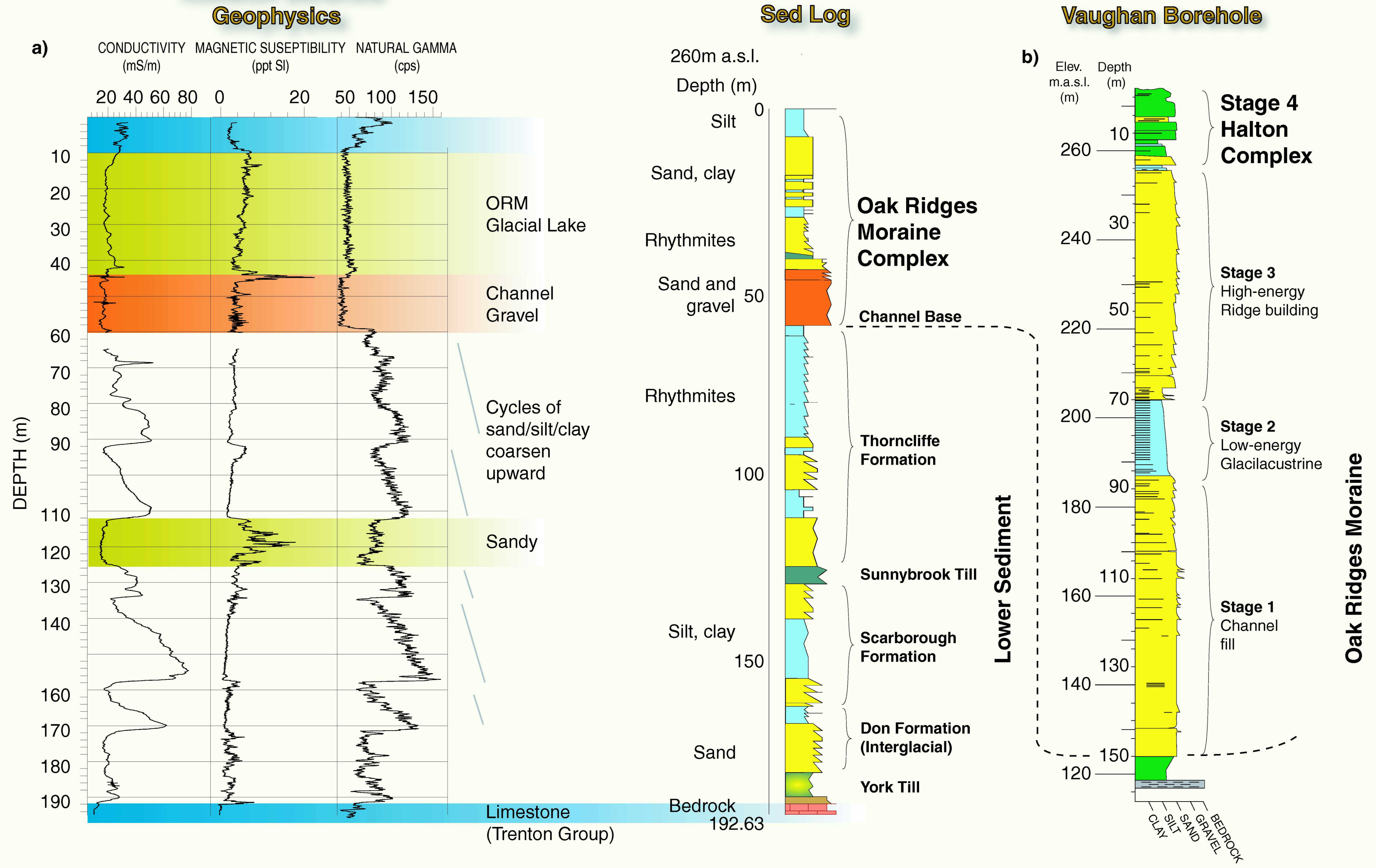



**Figure 16.** Sediment from the Nobleton and Vaughan show contrasting valley successions: a) Nobleton borehole geophysics and sediment logs show a type C2 channel floored by lower sediment (Fig. 15). The valley fill succession consists of Lower sediment truncated by the Late Wisconsinan regional unconformity (Fig. 2) overlain by tunnel channel sediment. Note inclined signatures on geophysical logs for Lower sediment compared to vertical signature for ORM sediment. b) Vaughan borehole sediment log from within a type C1 or C2 channel eroded nearly to bedrock (Fig 15). The regional unconformity extends to within 2 m of bedrock and the overlying 150 m succession is correlatable with Oak Ridges Moraine and Halton sediment.

## Hydrogeological Implication

**Aquifers:** Valley fill aquifers occur in a number of stratigraphic units, and have a variety of depositional settings. Individual stratigraphic units vary greatly in sediment composition, and consequently hydraulic properties. Horizontal and vertical facies changes within stratigraphic units highlight complex aquifer geometry and character.

**Aquitards:** Newmarket Till is a regional aquitard exposed at the surface north of the ORM and continues beneath the moraine. Several types of fine-grained sediment form less continuous and stratigraphically complex aquitard units.

**Vertical Connectivity:** The nested channel architecture within channel fill enhances vertical connectivity along tunnel valleys. Tunnel valleys may have shallow fine-grained lacustrine fills; however, modern rivers have eroded shallow aquitards, thus providing a direct connection to deeper aquifers.

Two main valley architectures and fills have been shown in figure 13 (seismic profile)

1. Sediment-hosted valley fills, or fills in tunnel channels (Vaughan borehole ie. C1 channels)
2. Older valley fill sediment layer not cut deeply by sediment-hosted channels (Nobleton ie. C3 channels)

Three scenerios are shown below: A) no valley; B) valley with coarse fill, and C) valley with coarse-fine fill.

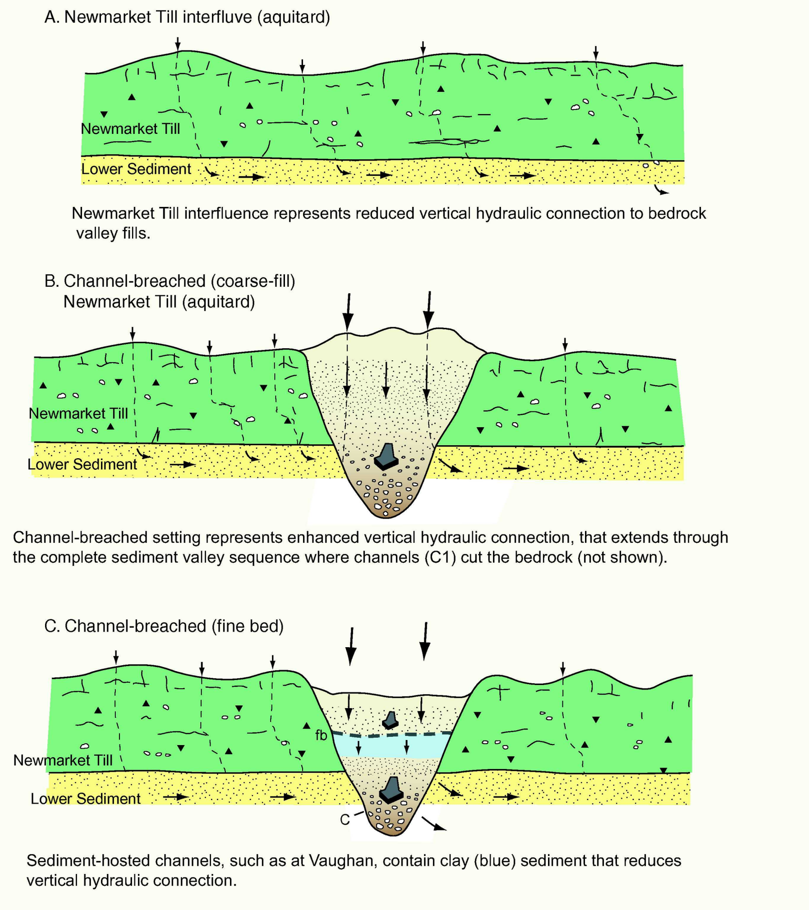



**Figure 17.** Conceptual model of three scenarios of valley fill marked by the presence or absence of Newmarket Till: a) unbreached aquitard, b) channel breach of Newmarket Till (coarse fill), c) channel breach of Newmarket Till (fine bed). For details and 2-D scenario flow modeling see Sharpe et al. (2002).

## Summary

- Laurentian valley is an ~3000 km$^2$ buried valley filled by a complex succession of sediment.
- Significant regional aquifers are hosted within the Laurentian valley, yet little is known of aquifer geometry and heterogeneity in this setting.
- Lower sediment (e.g. Alliston Aquifer) and tunnel channel aquifers (e.g. Nobleton) occur within the Laurentian valley.
- Improved knowledge and management of these aquifers require collection of new sedimentological data that can yield detailed information on aquifer extent and hydraulic properties.

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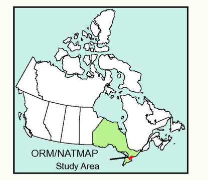


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