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Form and Sedimentary Fill of Tunnel Channels Beneath the Oak Ridges Moraine, Southern Ontario: the Holland Marsh-King City Channel System

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INTRODUCTION

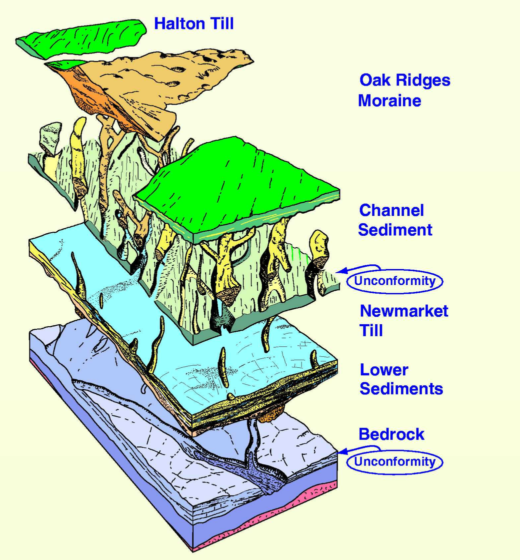


Fig.1: Conceptual regional geological model of the Oak Ridges Moraine (ORM) and Greater Toronto Area (GTA). The 3-D geological framework consists of six regional sediment packages and 2 unconformities (Sharpe et al. 1996)

- Regionally unconformities occur on bedrock and truncate the upper surface of drumlinized Newmarket Till.
- One element of the regional unconformity are tunnel channels

Introduction

- The Oak Ridges Moraine (ORM) is a significant regional aquifer complex (Turner 1977)
- The structure and texture of ORM sediment are important in assessing its hydrogeological function (Howard et al., 1997)
- Seismic surveys are the most cost effective technique to define stratal geometry. This technique is particularly effective for locating buried channels (Pugin et al. 1999)
- Regional strata in the GTA are presented in a stratigraphic framework (Fig.1). A network of tunnel channels that crop out north of, and underlie the ORM are a central element of the stratigraphic framework (Sharpe et al. 1997). Buried channels beneath the ORM are infilled by initial ORM deposits (Fig.1,2)
- The location, size, shape, continuity and infill sediment of channels is central to understanding their hydrogeological function (Fig.3-11). The hydrogeological function of the channel network has important implications for water resource and land-use planning as growth occurs in the GTA. For example, channels have been demonstrated to control leakance locally to confined lower deposit aquifers of the Scarborough and Thorncliffe formations (Desbarats et al. 2000)

Regional Channel Network

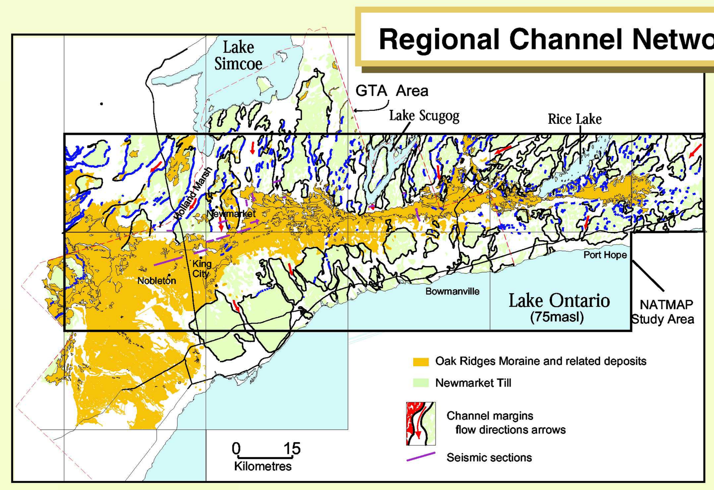


Fig. 2: Location of GTA study area and regional channel network. Channel network is clearly visible as valley system north of the ORM

Hydrogeology

- Hydraulic conductivity values of ORM sediment range from 10^{-2} to 10^{-6} ms^{-1} (Fenco MacLaren 1994)
- For comparison hydraulic conductivity values of Newmarket Till are 10^{-9} to 10^{-11}, however vertical flow is locally fracture controlled (Gerber and Howard 1996)
- Channel fills are locally complex and coarse gravel aquifers may be discontinuous. Aquifers in lower channel fills may be hydraulically connected laterally to lower deposit aquifers (Fig.1)

Objective

- There is a need to improve the understanding of channel sediment distribution and channel erosion and sedimentation. This poster provides an overview of part of one channel system based on the study of seismic, continuous core and the ORM borehole derived 3-D data model

Geological Setting

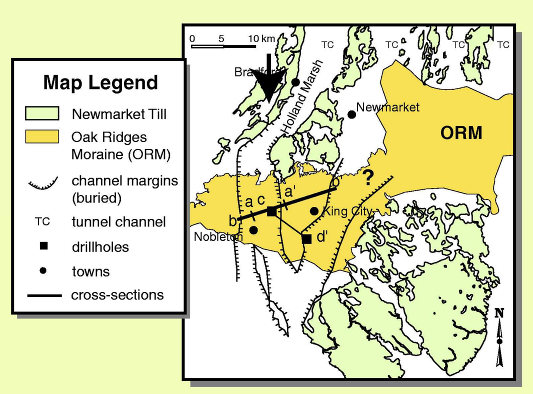


Fig.3: Location of studied channels

- Holland Marsh-King City tunnel channel system and data sets. Perspective view shown by Fig.4 is indicated by arrow
- Location of buried channels is interpreted from seismic profiles, boreholes, and regional stratigraphic surfaces

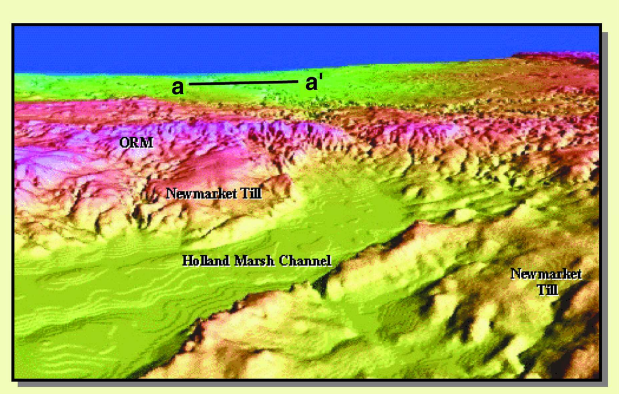


Fig.4: Terrain model - perspective view

- Large channel (Holland Marsh) eroded through drumlinized Newmarket Till
- Downflow Holland Marsh channel is infilled and buried by Oak Ridges Moraine (ORM) sediment
- a-a' is location of east-west seismic profile (Fig.5)

CHANNEL FORM & SEDIMENT FILL

Channel Form

- A surface channel network has been mapped using remote sensing, terrain models and field surveys (Fig. 2, Barnett et al., 1998)
- The erosional base of channels and drumlinized Newmarket Till form part of a regional, erosion surface, an unconformity (marker horizon, Fig.5)
- Large channels are 4-5 km wide, 30-40 km long and up to ~170 m deep and locally extend to bedrock (Fig.5 &6)
- Channels are steep-walled, over-deepened, and display undulating bases and asymmetric cross-sections (Pugin et al.1999)
- Shallow channels ornament drumlinized Newmarket interfluves
- Deep channels commonly have eroded through Newmarket Till, truncating lower deposits of Thorncliffe and Scarborough formations and intercepting bedrock (Fig.5)
- Channels are generally shallower and broader toward their southern, downflow end

Seismic Profile and Interpretation

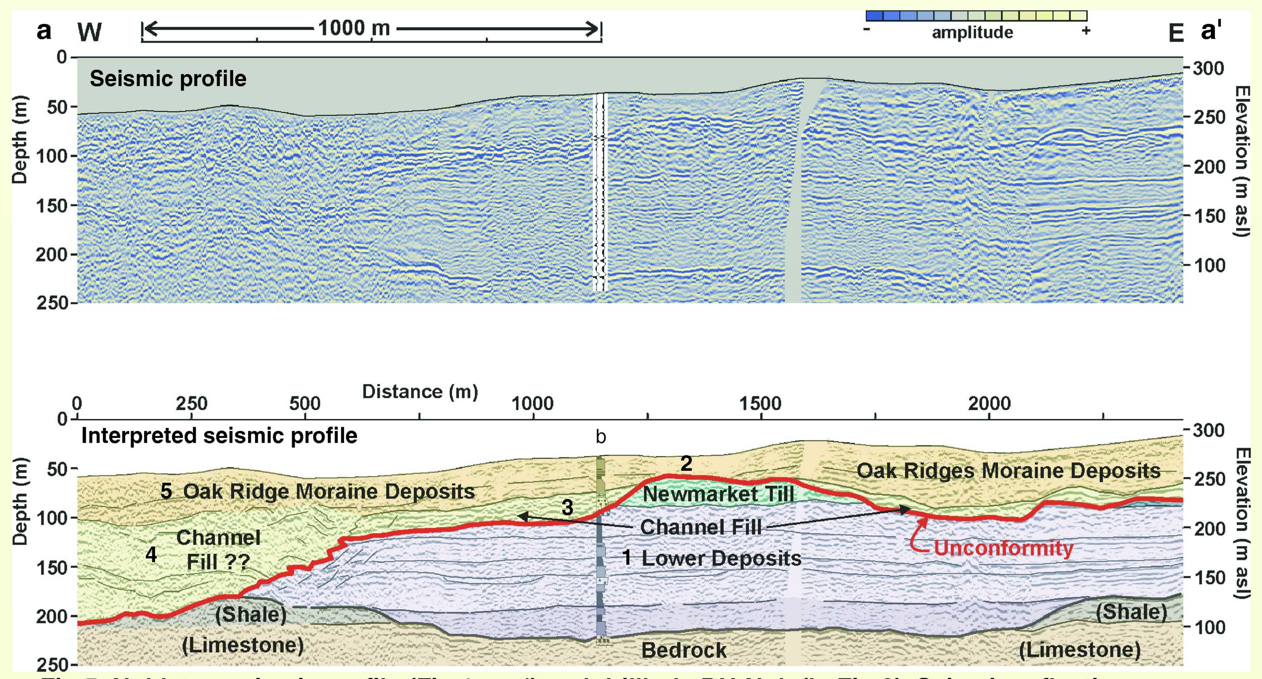


Fig.5: Nobleton seismic profile (Fig.1; a-a') and drillhole DH-Nob (b, Fig.3). Seismic reflections are produced by velocity contrasts related to grain size, density, and structure in the sediment

The following are of note on the seismic section

1. Stratified lower deposits ofScarborough and Thorncliffe formations
2. Interpreted erosional surface (unconformity marked in red) defining the channel which truncates lower deposits(1) and Newmarket Till. Locally this surface extends to bedrock
3. Hummocky reflections are interpreted as gravel channel deposits (Fig.7)
4. Chaotic reflections are interpreted as masive or poorly stratified sand and silt (Fig. 11)
5. Overlying (ORM) sediment has a variable reflection signature, including; subparallel, discontinuous to continuous; chaotic; and transparent character

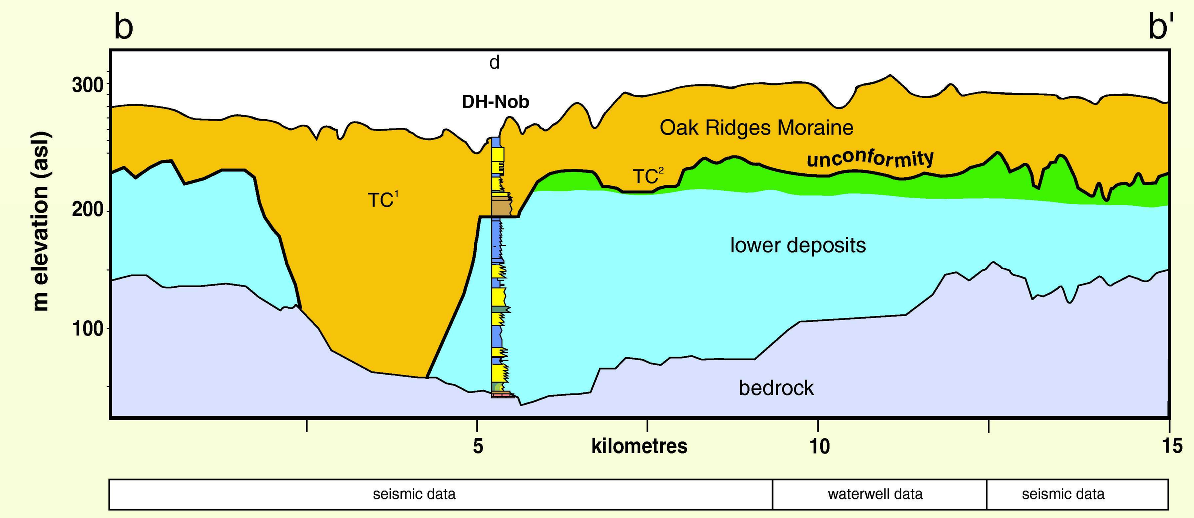


Fig. 6: Cross-section b - b' (Fig.3) perpendicular to channel axis showing a deep channel and adjacent shallow channels underlain by Newmarket Til

- Deeper channels (TC) extend to bedrock and are up to ~5 km wide and 170 m deep
- Interfluve (Newmarket Till and lower deposits) to right of the deep channel has a number of shallow channels < 30 m deep and < 3 km wide. In addition the interflueve surface is drumlinized

Channel Sediment

- Channel sediment are up to ~150 m thick, and consist of gravel, sand, silt, and minor clay (Russell et al. 1998)
- 30-50 m thick successions of predominantly massive sand may extend along channels for several kilometres
- Gravel is most likely to occur at the base of channels directly above the regional unconformity. 20 m thick gravel deposits have been intercepted in DH-Nob (Fig. 6, Russell and Pullan 1998)
- Upper channel fills are commonly dominated by fine sand, silt and clay (Fig. 7)

Gravel Facies

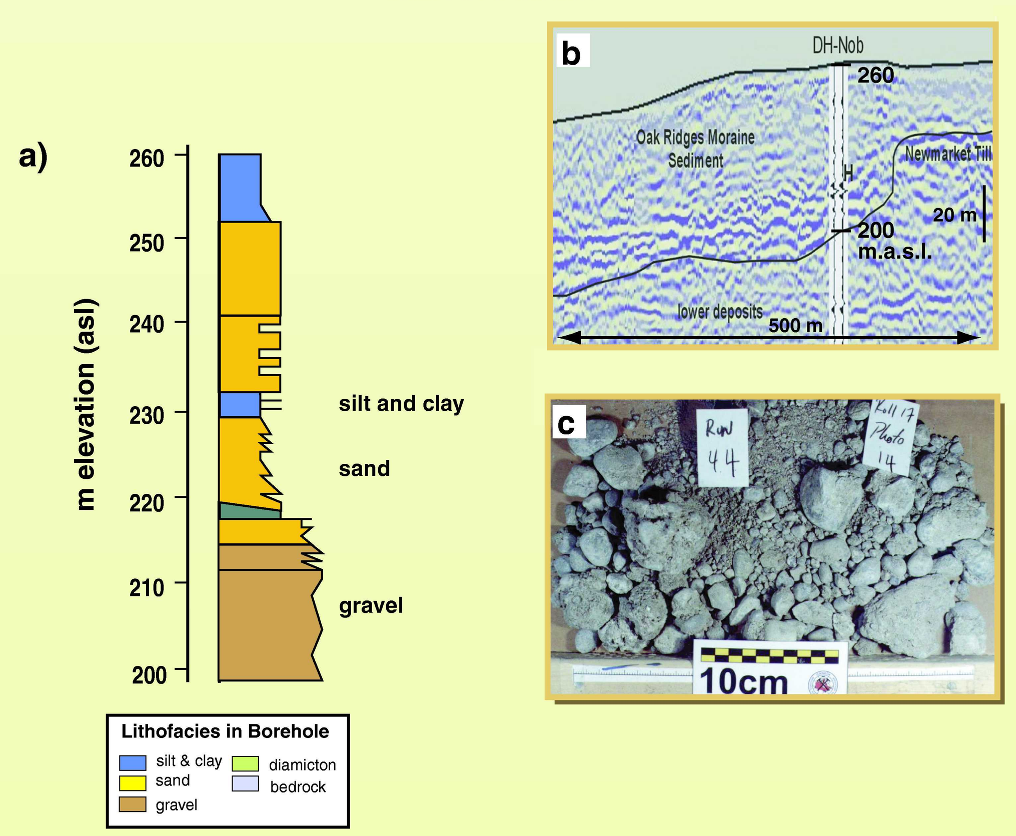


Fig.7: Nobleton core log (c, Fig.3) of channel and overlying ORM sediment (a), related seismic reflections (b), gravel (c)

- Subhorizontal, hummocky reflectors correlate with gravel (Fig.6) and are interpreted as 4-5 m high bedforms
- Less than 20 % core recovery within the ~20 m thick gravel interval prevented detailed lithofacies descriptions

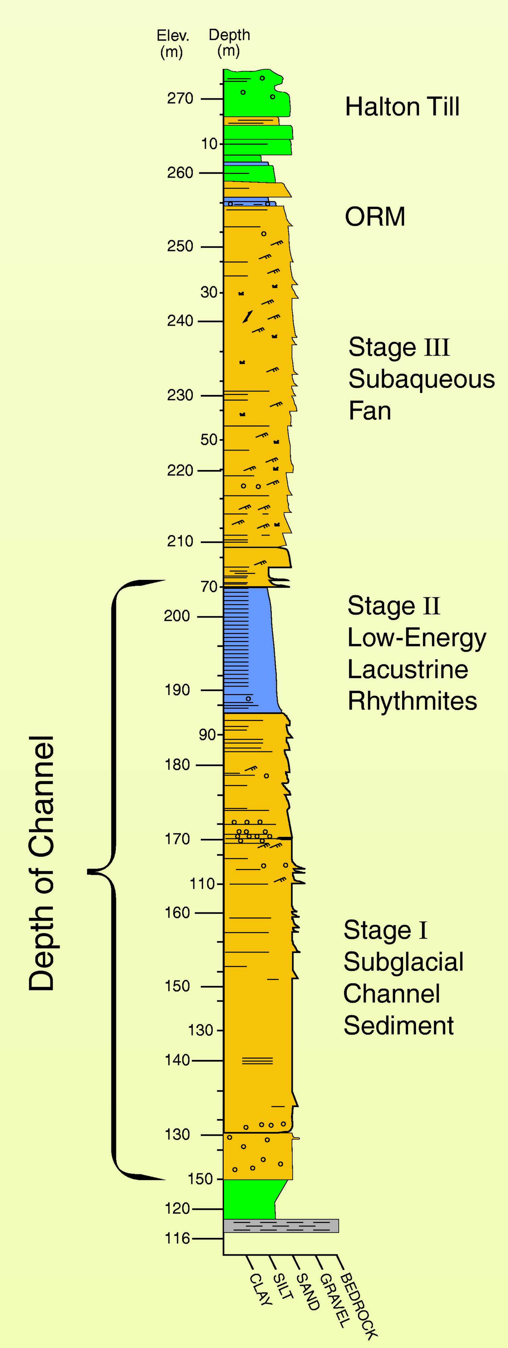


Fig.8: Core log of sediment at DH-V-158 (d' Fig.3)

Sand Facies

core | outcrop

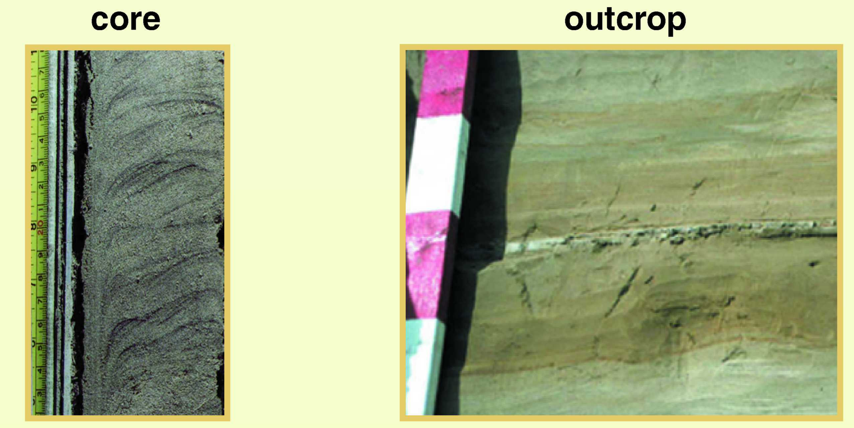


Fig.9: Cross-laminated sand with clay laminae interpteted as subaqueous fan sediment (stage III, Fig.7)

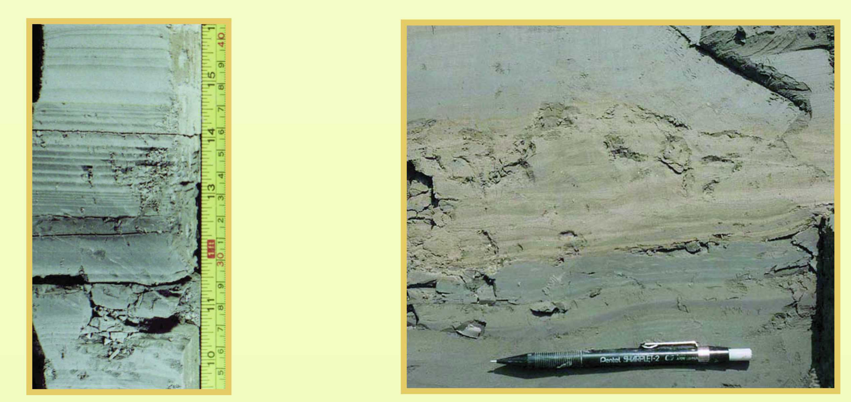


Fig.10: Graded, fine sand, silt, clay interpreted as annual rhythmites deposited in a low-energy, glacial-lacustrine environment (stage II)

Fig.11: Massive and graded sand interpreted to indicate rapid sedimentation from hyperconcentrated flows (stage I)

Erosional and Depositional Model

a)

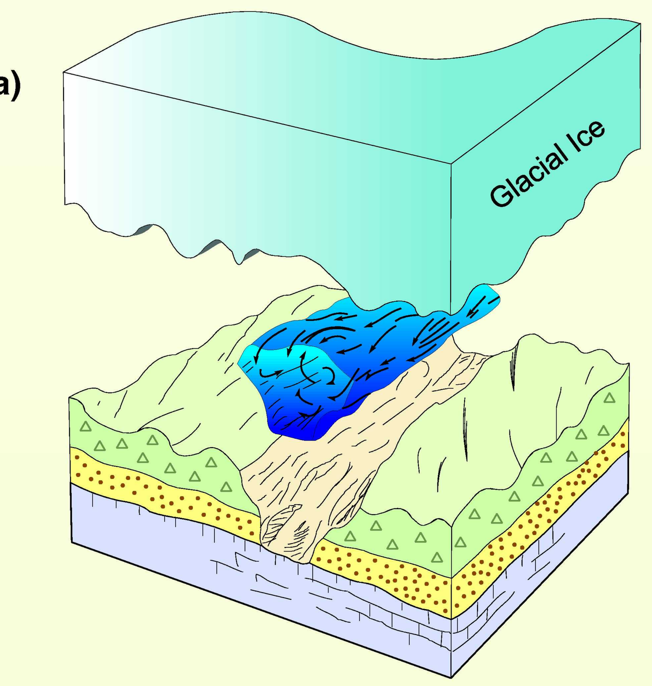
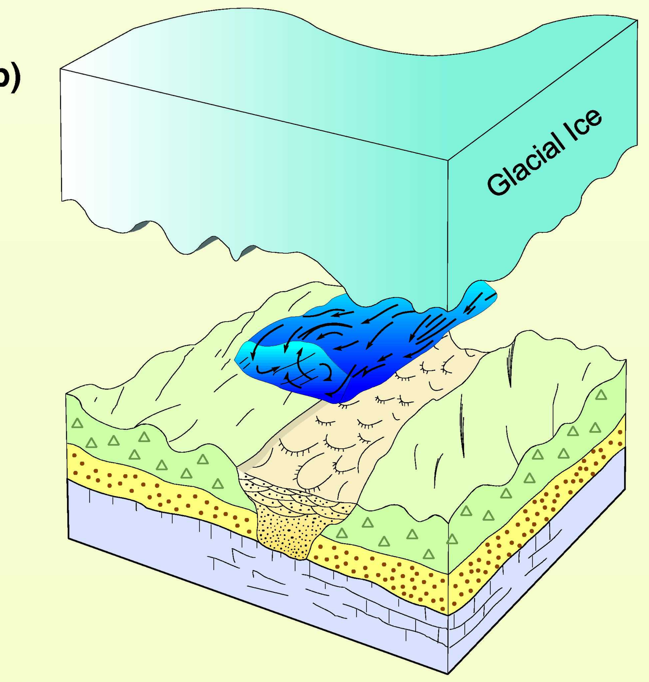


Fig.12:
a) Subglacial erosion by pressurised episodic jokulhlaup (outbreak flood) discharge (e.g. Brennand and Shaw 1994)

b)



b) Rapid subglacial sedimentation from waning jokulhlaup (outbreak flood) discharge (e.g. Barnett et al. 1998)

- Channel fill sedimentation is locally stage I in the formation of the Oak Ridges Moraine. This gradational transition from stage I to stage II is clear in core from site DH-V-158 (Fig. 11)

Summary

- Channels are interpreted to be of subglacial origin (tunnel channels) based on landform evidence, relationship to the erosional unconformity, on the undulatory longitudinal profiles and sediment lithofacies found within the channels
- Channels fills are predominantly fine sand, with secondary amounts of gravel and silt-clay
- The location, geometry, continuity, and composition of buried channels is central to understanding their hydrogeological function

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