Newmarket Till Aquitard:
Optimum grain packing with a calcite-rich cement

Why study Newmarket Till?

It is an important regional aquitard

Sharpe et al., 2015
Geophysical Properties, Newmarket Till

High-resolution digital laser scans of Newmarket Till cores from Oshawa reveal elevated densities of 2.28 – 2.40 g/cm³

Newmarket Till:
High velocity, similar to limestone (2.2-2.6 g/cm³)

Crow et al., 2017, CJES; 2017 SAGEEP
Why is Newmarket Till of High Density?

Newmarket Till is a stony, sandy, silty, clay-poor diamicton. It should not be that dense, nor an aquitard, given the high sand contents.

Newmarket Till - Knowledge

- Sand – silt – clay size distribution
- Geographic distribution
- Stratigraphic context
- Limited understanding of mineralogy, geochemistry

Source constituents that make up the Newmarket Till?
Why does Newmarket Till pretend it is a competent rock?
Cemented?
Optimum grain size for packing/over-consolidation?
Both processes?
Geographic Distribution

East of Niagara Escarpment. South of the Precambrian Shield. West of Frontenac axis.
Note 1: North facing escarpment at the Precambrian – Paleozoic inconformity (black dashed line)

Note 2: Dummer ‘moraine’; mapped as a separate unit from Newmarket Till
Sampling transect
Paleozoic Formations

- Alternating limestone and shale
- Wacke-grainstone + shale
- Lime mudstone (maarl)

Gull River Fm
Newmarket Till – Field Observations

- Typical red-brown shield till (~1 m)
- Newmarket till (~3-4 m)
- Newmarket till (~15 m)
- Newmarket till (~2 m) near unconformity

1 km
10 km
Dolostone with maarl interbeds

Bobcaygeon Fm (raft)

Gull River Fm
Pebbles in Newmarket Till

Paleozoics:
- Black limestone
- Grey limestone
- Green limestone
- White limestone
- Lithic limestone
- Dolostone
- Cement
- Cement + l’stone
- Pebbly sandstone
- Chert

Shield:
- fg gabbro
- mg gabbro
- red gabbro
- fg tonalite
- mg tonalite
- fg granitoid
- mg granitoid
- pegmatite
- schist

Provenance
% Paleozoic: % Shield
Percentage of Paleozoic Pebbles, 8-16 mm size fraction
1.) Optical mineralogy suggests little variability in one core

2.) Two provenance sources
   - **Shield:** qtz, K’spar, plagioclase + granitoid clasts
   - **Paleozoics:** calcite, dolomite + limestone clasts

3.) The intra-grain matrix is not resolvable optically
Newmarket Till
False color mineral maps

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Efficient comminution of mineral grains
Newmarket Till Aquitard: mineral grain size reduction via comminution

Hexagonal calcite plates
Newmarket Till Aquitard: **calcite** plates (cement)
Calcite-rich cement

- Multiple cement events?
- Syn-depositional?
- Post-depositional?
- Is all of Newmarket Till cemented?
- Or only specific areas geographically?
- Or specific horizons? NB - remember sonic log.
Localized Pressure Solution

Over-consolidation, very localized calcite cement precipitation
Sub-glacial calcite solution and precipitation due to pressure variation

Deposits formed by subglacial precipitation of CaCO$_3$ (Hallet, 1976, GSA Bulletin. Columbia Icefields, Alberta)

REGIONAL calcite solution and precipitation?

High Pressure (17 MPa, 2500 psi).

High CaCO$_3$ solubility in pore fluid

ICE SHEET

Newmarket Till

Cemented Newmarket Till

Very Low Pressure.
Low CaCO$_3$ solubility in pore fluid, calcite precipitation
XRD (clay+silt) – PW, Transect, Duffins Creek, Havelock
XRD (clay+silt)– PW, Transect, Duffins Creek, Havelock

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Purple Woods borehole: clay+silt fraction very homogenous mineralogy; clay fraction calcite-rich
Newmarket Till clay+silt fraction mineralogy generally similar, but SOME IMPORTANT DIFFERENCES

Gull River Fm (dolostone)

Purple Woods borehole: clay+silt fraction very homogenous mineralogy; clay fraction calcite-rich
Newmarket Till clay+silt fraction mineralogy generally similar, but SOME IMPORTANT DIFFERENCES
Newmarket Till, Conclusions:

1.) Fractal-like grain size distribution of comminuted minerals (down to <1 um)
   has led to optimum packing (= higher density)
2.) Over-consolidation effects due to ice sheet loading and calcite pressure solution
   and pressure shadow re-precipitation (= higher density)
3.) Calcite-rich cement precipitating from pore fluids: 2 events
   ‘Syn-depositional’ related to pressure solution (very localized, mm-scale)
   ‘Post-depositional’ related to ice sheet decay, pressure drop, over-saturation, precipitation.

Wider Applications?
“On the north campus of the University of Waterloo its (Catfish Creek Till) hardness made it suitable for diamond drill coring – the resulting core resembled concrete”

P.F. Karrow (1988), Catfish Creek Till, An Important glacial deposit in Southwestern Ontario
Thanks for listening