UNIVERSITY OF TORONTO AT SCARBOROUGH

EESC31 GLACIAL SEDIMENTOLOGY AND STRATIGRAPHY

FALL 2013

Lectures: Wednesdays 2-5 Room BV264

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Q: Why do you need to know about glaciers and their deposits?

A: Because in a northern country such as Canada, glaciation has profoundly affected our landscapes, dictated much of our recent geological history and also the initial peopling of North America. Glaciers still survive in the Rockies (supplying rapidly-dwindling water to the Prairies) and in the High Arctic. Much of the north is 'permafrozen' i.e., underlain by frozen ground much of which was inherited from the ice age. Canada is truly a 'glacial' country. Engineering and construction activity, mineral exploration in the far north, environmental investigations, soil science, and hydrogeological work all require a firm knowledge of glacial deposits. Mining, oil exploration and infrastructure development in Canada's far north all have to deal with the issue of permanently frozen ground ('permafrost') that is now degrading in warmer climates.

Ice sheets as much as 3 km thick have covered our country many times in the past 2 million years during what is termed the Pleistocene epoch. The latest (the 'Laurentide ice sheet') only left the Toronto area as recently as 12,000 years ago. Canada's landscapes and surface sediments have been profoundly modified; much of Southern Ontario is a fossil glacial landscape no different from that found at the margins of modern ice sheets in Iceland. Moreover, ancient pre-Pleistocene glaciations occurred several times in Earth history at about 2.4 Ga (Huronian glaciation), between 750 and 545 Ma (Neoproterozoic), at 440 Ma (Late Ordovician) and between 350 and 250 Ma (Late Paleozoic). The origins of several of these are controversial e.g., the Neoproterozoic 'Snowball Earth' which has been linked by some to the 'Cambrian explosion' of complex metazoans some 550 million years ago.

The peak warmth of the last interglacial (a time period called the 'Sangamon') occurred just after 110,000 years ago and the Laurentide Ice Sheet began to grow shortly thereafter at the beginning of the Wisconsin glaciation. One of the best records of its growth and demise anywhere in North America is found right here in Southern Ontario at Scarborough Bluffs and in the Dion Valley Brickyard which we shall visit on September 18th. These deposits contain key information on past global climate changes. The Great Lake basins are the direct result of large-scale glacial erosion. Huge changes have taken place in flora and fauna as a consequence of glaciation; modern humans evolved in East Africa about 200,000 years ago, crossed into North America from Asia at a time of lowered sea level and finally migrated into Southern Ontario just as it was being exposed by retreat of the ice sheet about 12,000 years ago. If natural rhythms have not been disturbed too much by human activity Canada will find itself once again, under ice.

Course content

This course consists of lectures and field trips. It will review the cause of glaciations and their geological and geomorphological effects paying especial regard to the lengthy record of past glacial and interglacial climates preserved in southern Ontario. By the end of this course you will be able to recognize the principal glacial sediments and landforms across Canada using a variety of methods.

Teaching method

The course is based on a weekly three-hour class except for Reading Week. Each week will consist of a short (10 minute) in-class test (simple definitions etc.,) based on the previous week's lecture material which will be marked in class. There are six of these and designed to keep you on top of material and

determine whether you will need to drop the course by November 18th (see below). I will then lecture for approximately 2 hours during which time questions and discussions are invited *at any time*.

We will circulate every week by email a pdf of a key paper (or papers). Please read this material and come prepared to the next week's class to comment on the value of the material (both positive and negative) in hour 3 and its significance in understanding the glacial history of Canada. The content of each paper will be included in the test material the following week and will be on the final exam. *I have assigned a maximum of 10 marks for your contributions to discussion over the course of the semester.*

Note: Lectures are also available as WebOption Lecturecasts when posted.

Fieldwork

There will be a one day *compulsory* field excursion by bus to Scarborough Bluffs, Duffins Creek, East Point and the Don Valley Brick Yard on September 18th.

There will also be a two-day *voluntary* field trip in late September or early October to Parry Sound for a show and tell on geophysical methods of exploring the geology of glacial sediments. I will circulate a sign up list and itinerary shortly.

By the end of the course you will know:

1) How glaciers and ice sheets form and flow.
2) How sediments are produced and deposited in various glacial environments on land (terrestrial environments) and in the sea (glaciomarine environments).

3) The glacial geologic history of Canada and Ontario over the past 2 million years.

4) Cold climate but non-glacial environments (e.g., periglacial processes and deposits).

5) The timing and causes of glaciations in the remote past.

6) How applied investigations (e.g., geophysics, groundwater, terrain mapping, waste disposal, mineral exploration etc) are conducted in glaciated areas.

Why this course is important

This course satisfies the glacial geology requirement for the Association of Professional Geoscientists of Ontario.

Course Outline and topics

Week 1: **4th September: Overview**

Glacial sedimentology: Glacial processes and deposits.

Glaciology: the science of how glaciers form (mass-balance and flow, deformation, sliding); the science of *glaciology;* wet-based *vs.* dry-based ice masses.

Paleoclimatology: Why do glaciations occur and what controls their frequency?

Basic reading for course: Eyles and Eyles (2010) 'Glacial facies models.' I would also ask you to use the web site Planetrocks.ca developed with Richard Gao and Shane Sookhan which contains much information on glacial landforms and deposits across Ontario.

Week 2: **11thSeptember**

How glaciers deposit sediments on land ('terrestrial glacial deposits) and brief intro to next week's field trip

Discussion paper: Dyke et al. (2002) Laurentide Ice Sheet growth

Week 3: **18th September**

Compulsory all-day fieldtrip: Glacial deposits of the GTA
Test 1 'in-bus' on weeks 1 and 2 material

Week 4: **25th September**

Terrestrial glacial processes and deposits (con't)
Test 2 on week 3 field trip material
Discussion papers: Eyles (2012) and Eyles and Eyles (2010): pp.73-90.

End September: date to be announced voluntary Field Trip:

Demonstration of marine and land-based geophysical methods used for exploring glacial and postglacial sediments at Parry Sound and Georgian Bay.

Week 5: **2nd October**

How glaciers deposit sediment in the ocean ('glaciomarine deposits')
Test 3 on Week 4 material
Discussion paper: Eyles and Eyles (2010), pp. 92-100

Week 6: **9th October**

Cold-climate, non-glacial processes ('periglacial') in areas of permanently-frozen ground ('permafrost') i.e., Canada's North.
Discussion paper: Eyles and Eyles (2010), pp. 90-92.

Week 7: **16 October: No class: Reading Week**

Week 8: **23rd October**

Applied aspects of glacial sediments: geophysical exploration, waste management, hydrogeology, mineral exploration, environmental and geotechnical investigations in glaciated terrains.
Guest speakers:
Dr. Niko Putkinen: Geological Survey of Finland
Tom Meulendyk, M.Sc., UTSC
Test 4 on week 6 material

Discussion paper: tba

Week 9: 30th October
Ms. Kirsten Kennedy: Ancient glaciers: Neoproterozoic glacial sedimentology, tectonics and copper in the Congo
Test 5 on week 8 material
Discussion paper: tba

Week 10: **6th November**
Ancient glaciers of the last 2800 million years and global change

Week 11: **13 November**
Test 6 on weeks 9 and 10 material
Class presentations begin

Monday November 18th: Last day to drop F courses without penalty

Week 12: **20th November**
Class presentations continued.

Week 13: **27th November last class**
Final class presentations and Final Exam revision session

Final Exam: The Final exam is 3 hours long and consists of 6 questions consisting of a mixture of short essay-type answers and simple definitions of basic terms.

Marking schedule and assignments

1)Individually (or in groups of 3 people *max*) you will research for a brief in-class PowerPoint presentation during weeks 11-13 *either* one of the topics shown below, *or* the glacial geology and history of any area of Canada ***or*** any topic selected by yourselves. **30 marks**

Note: Each group must register and get approval for their topic with NE and no two groups can do the same topic *so decide early*.

You will be required to submit a one-page abstract to the class ahead of your presentation.

2) 6 multiple-choice in-class tests (5 marks each): **30 marks**

3) Contribution to in-class discussions **10 marks**

4) Final exam: **30 marks**

Note: There will be NO re-writes for missed tests: weekly tests cannot be retaken. If you miss a test without a Doctor's note and appropriate UTSC documentation you will be assigned a mark of zero.

Accessibility Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations especially on the field trip, please approach me and/or the AccessAbility Services Office *as soon as possible*. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff (located in S302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or ability@utsc.utoronto.ca.

Plagiarism Cheating of any kind is not tolerated and will be reported to the Chair and Dean immediately.

Possible poster topics (you are free to suggest others)

1. Origin and global climatic significance of Heinrich events
2. Causes of the medieval warm period
3. The origins and effects of the Little Ice Age
4. Mineral exploration in glaciated terrains
5. Origin of fiords
6. Postglacial lake levels in the Great Lakes
7. Postglacial changes in global sea level
8. Human migration into North America
9. Himalayan Uplift hypothesis for Pleistocene glaciations
10. Human evolution and climate in East Africa
11. Submarine permafrost
12. Permafrost thawing under modern day climate warming
13. Glaciation on Mars
14. Snowball Earth
15. Glaciotectonic processes and structures
16. The Laurentide Ice Sheet: formation and decay
17. Origin of the overdeepened Great lake bedrock basins
18. Preglacial drainage in the Great Lakes region
19. Glacial landsystems as a means of classifying glaciated terrains
20. Karst
21. The sedimentary and biological record of the last interglacial at Toronto
22. Eskers; types and depositional processes
23. Sedimentation in glacial lakes and typical facies
24. Glaciomarine environments
25. Glaciers of Alberta (or British Columbia, Yukon, Alaska etc.)
26. Periglacial processes and structures
27. Geology and wine in the Niagara Peninsula
28. NAMOC
29. Drumlin fields of Ontario; where are they and how did they form?
30. How does till form and how is it deposited?
31. Mid Pleistocene Transition:
32. Human migration into North America:
33. Drumlins
34. Permafrost
36. Ice streams in the Laurentide (or any modern) ice sheet
37. Till-forming processes

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Office Hours:12-2 on Wednesdays in Room SY 205 immediately before lecture.