Glacial systems

Depositional models

Glacial environments

- Valley glaciers, ice caps, ice sheets, ice shelves and icebergs, sea ice, lake ice, ground ice (permafrost)
  - Ice affects both terrestrial and marine depositional environments
    - glacial environments: subglacial, supraglacial
    - proglacial sub-environments: glacifluvial, glacilacustrine, glacimarine, eolian
- During major glaciations, ice shelves and even grounded ice advanced across continental shelves and influenced deep marine environments
  - Significant global sea level fluctuations
    - Complex coastal evolution
- Earliest known glaciers: ~2.8 billion yrs ago
- Major glaciations during the Quaternary (last 2.6 Ma)

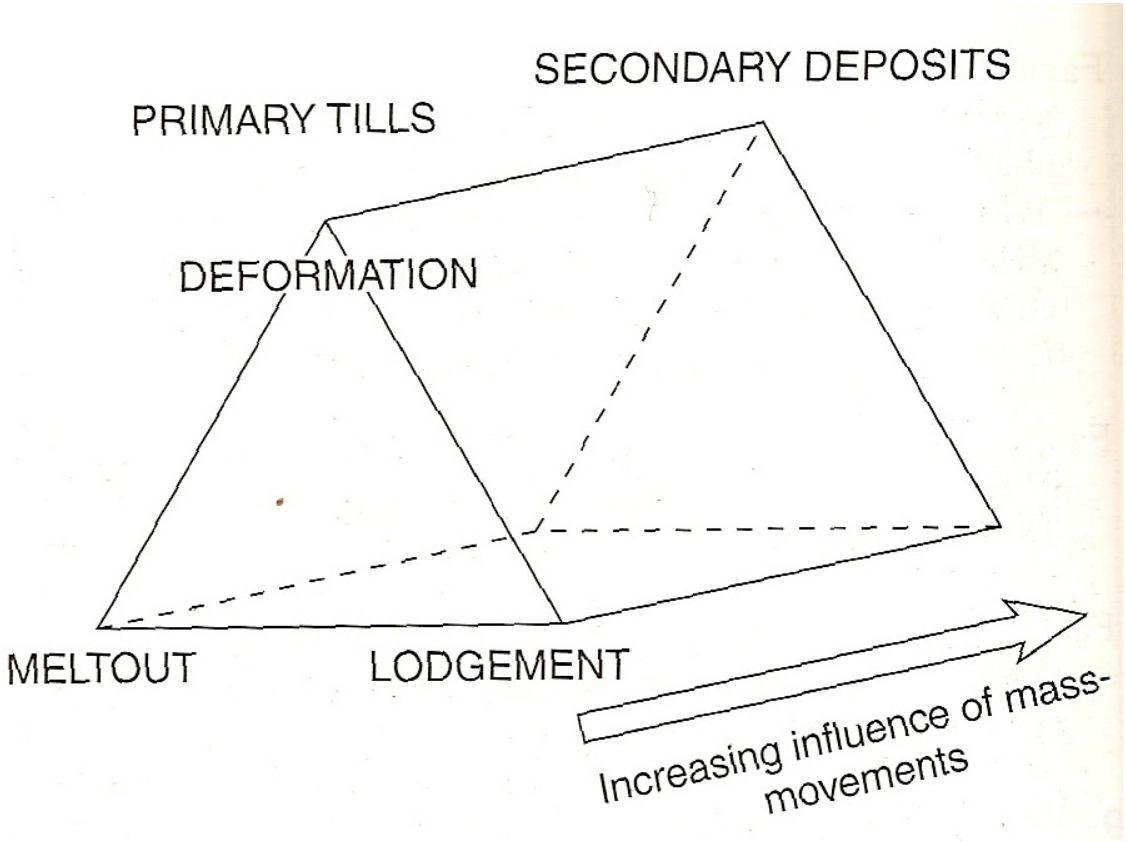
Important applications

- Northern regions such as Canada
  - Glacial sediments underlie many urban centers
    - Groundwater resources and protection of supply
    - Waste disposal sites
    - Aggregate resources
  - Mineral exploration
    - Composition of glacial sediments covering ore deposits
  - Shallow gas trapped in Pleistocene sediments
  - Oil, coal and gas in older glacial strata (e.g. Brazil, Australia, India)

Today's learning objectives

- Recognize key sediment characteristics (facies) that are diagnostic of glacial influence (direct and indirect)
- Appreciate a variety of sub-environments
  - Summary of key sedimentary features
  - Typical facies successions
  - Typical sediment-landsystems
- Consider pre-enrolling in 440!! ☺

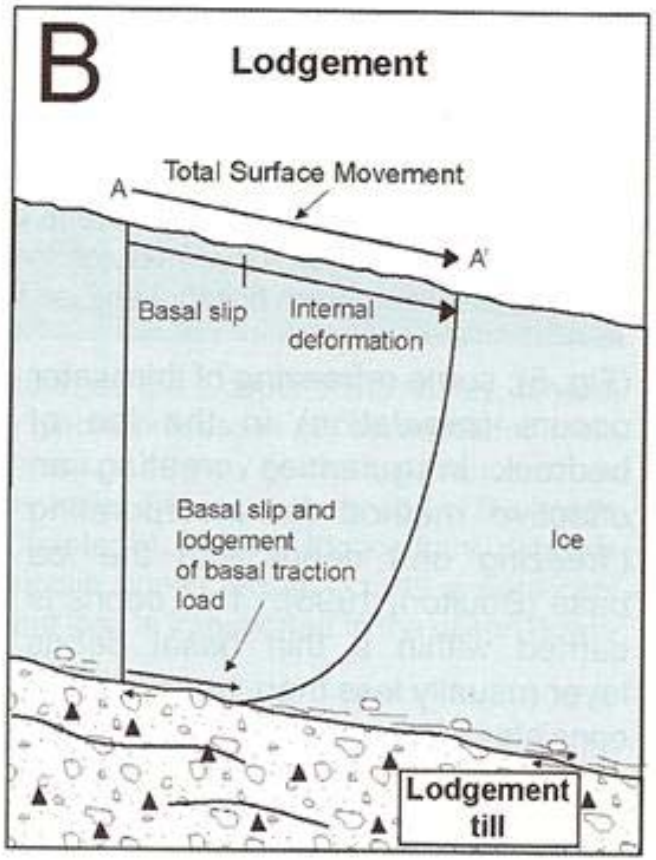
Glaciogenic deposits

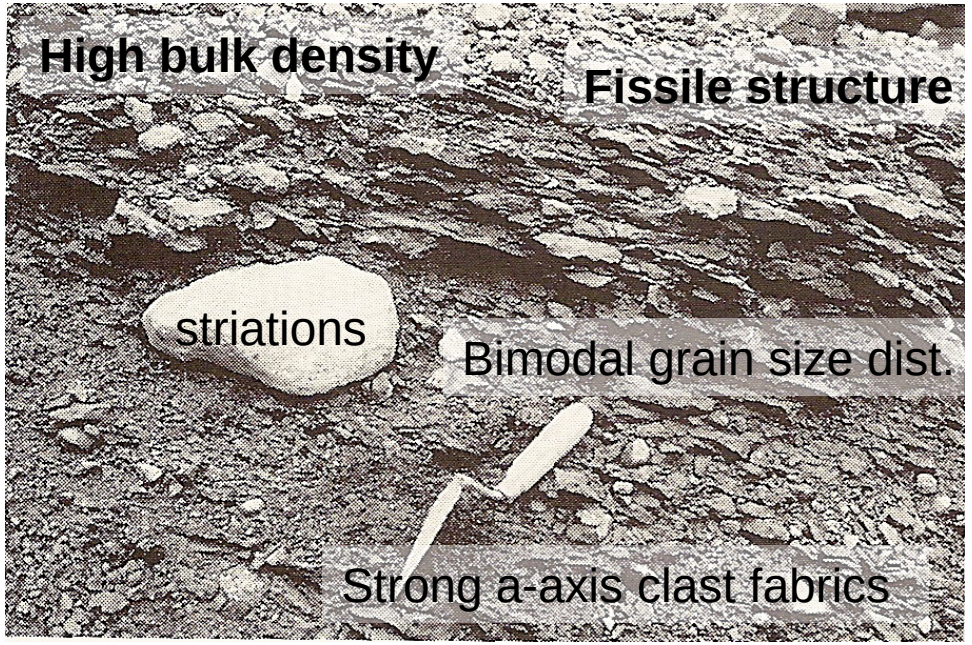


Lodgement till: Direct deposition from sliding ice by frictional processes
Melt-out till: Deposition due to melting of stagnant (or slowly moving) ice
Deformation till: deposition from the base of subglacial deforming layer
Flow till: Deposition by gravity processes

Lodgement till

- Deposition by plastering of glacial debris from a sliding glacier sole by mechanical processes

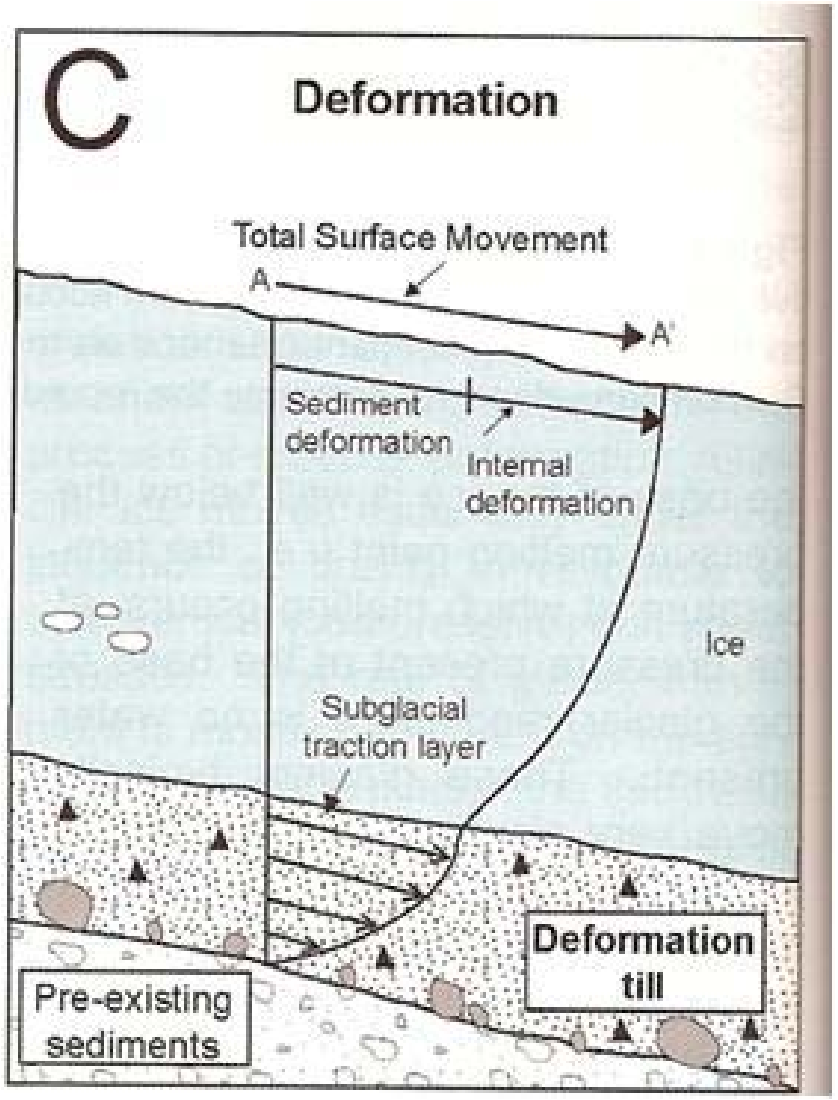




(Benn and Evans (1998)

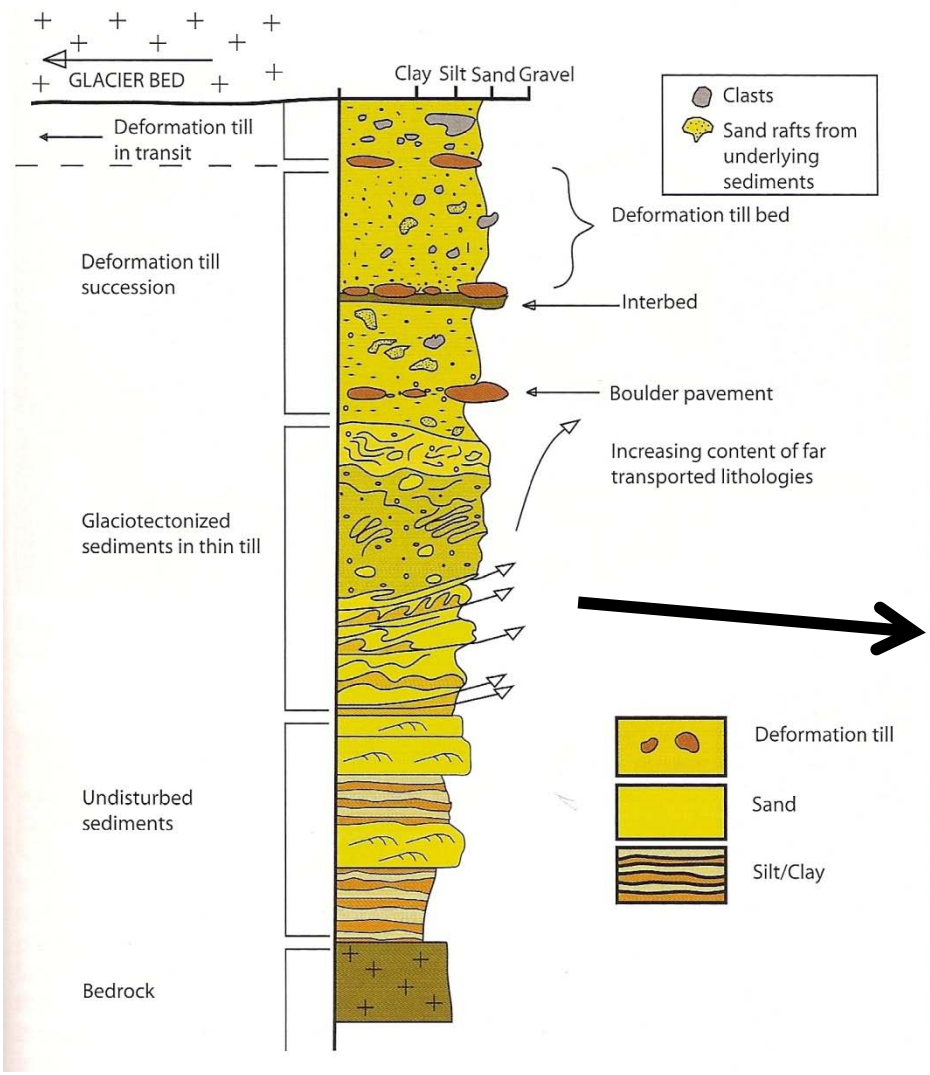
Deformation till

- More complete desaggregation and homogenization by shearing
  - Destruction of pre-existing structures
    - Difficult to identify...
  - Deformed inclusions
    - e.g. folded pods of sand or soft rock
    - More abundant at the base...



Glacitectonite

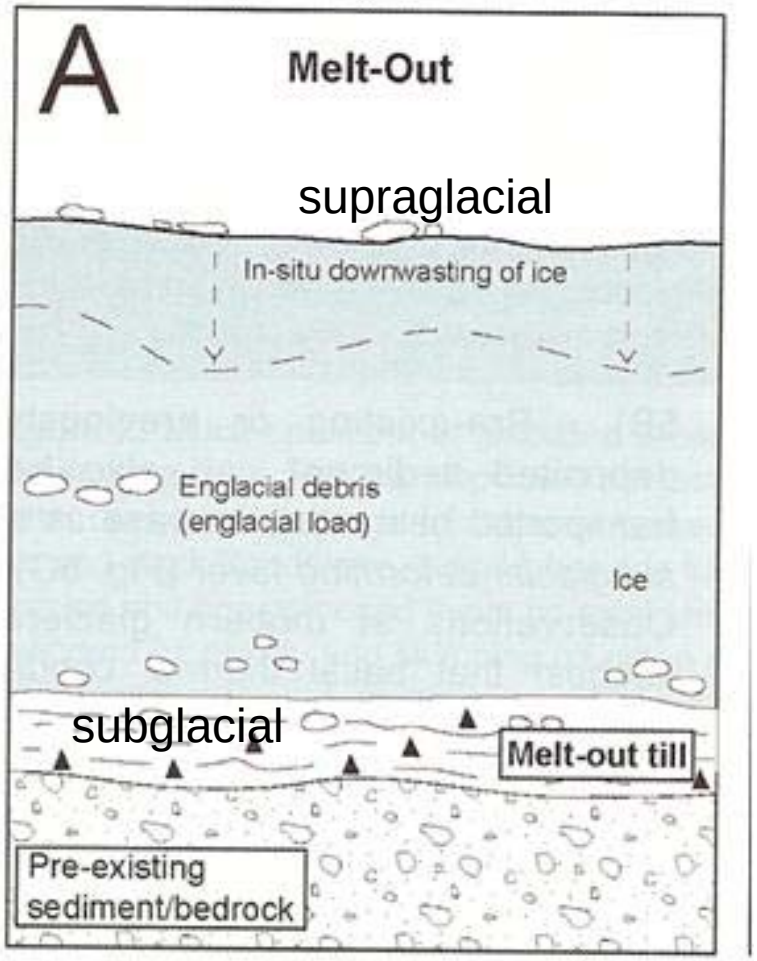
- Subglacially sheared rocks and sediments
- Some primary structures are visible
  - Lamination
  - Xs-bedding



Eyles and Eyles (2010): Facies Models 4

(Benn and Evans (1998)

Melt-out till



Petawawa, ON

Taylor Glacier, Antarctica

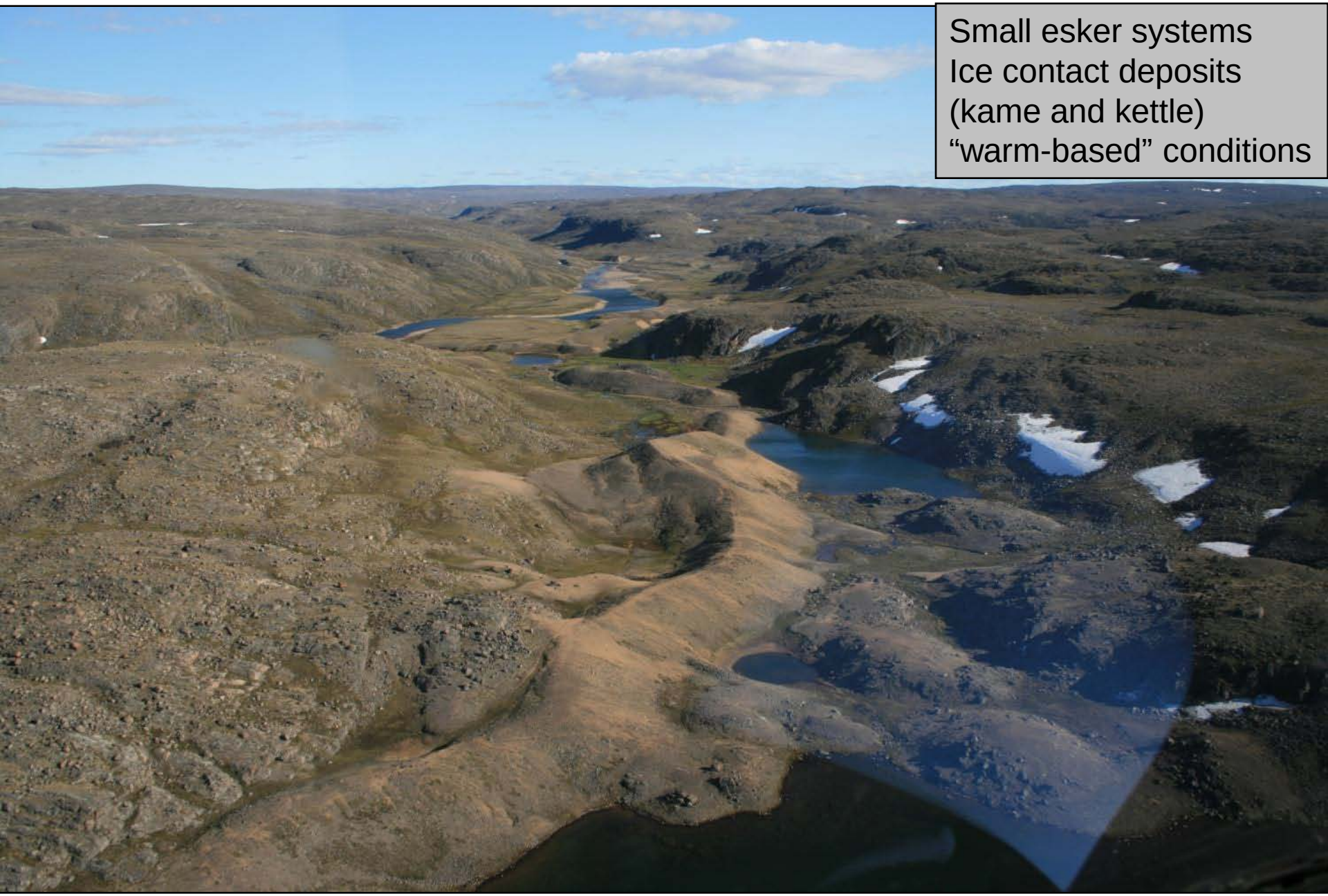
Glacial landforms - Drumlins...

James Bay area

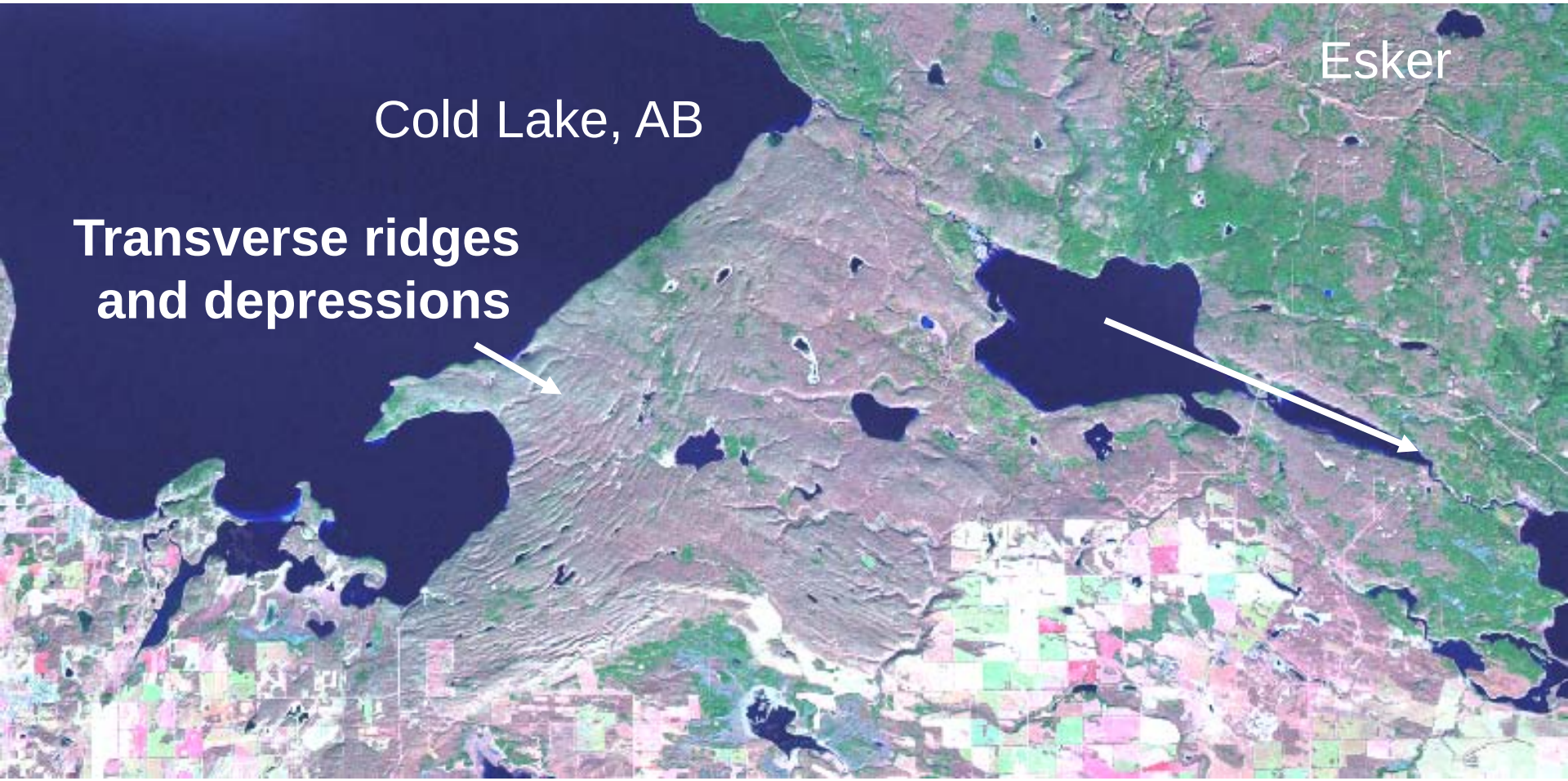
Eskers

Glaciofluvial in origin (meltwater): ice conduits fill with sediments, which later leave a positive sinuous sand/gravel ridge on the land

James Bay area


Small esker systems
Ice contact deposits
(kame and kettle)
“warm-based” conditions

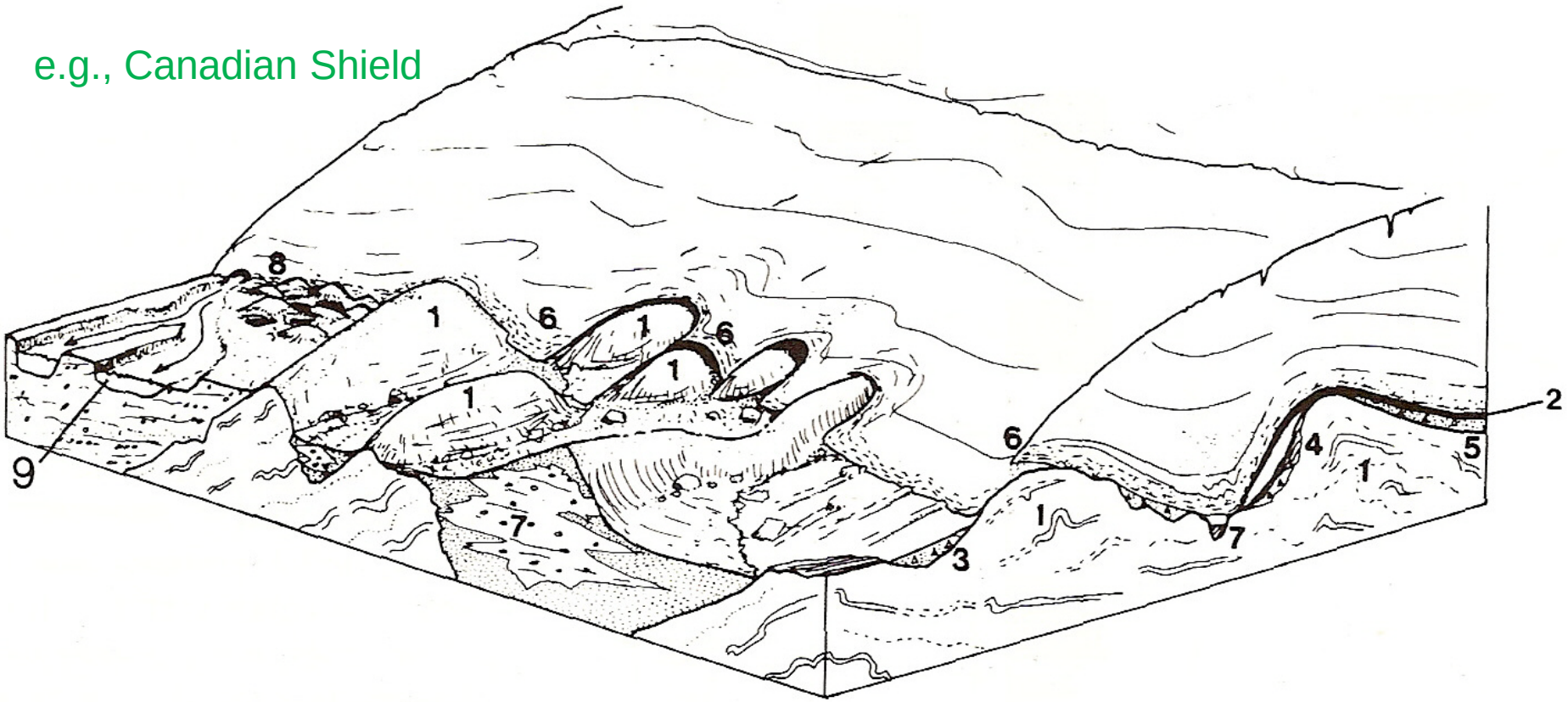
The subglacial system...



Landsat image

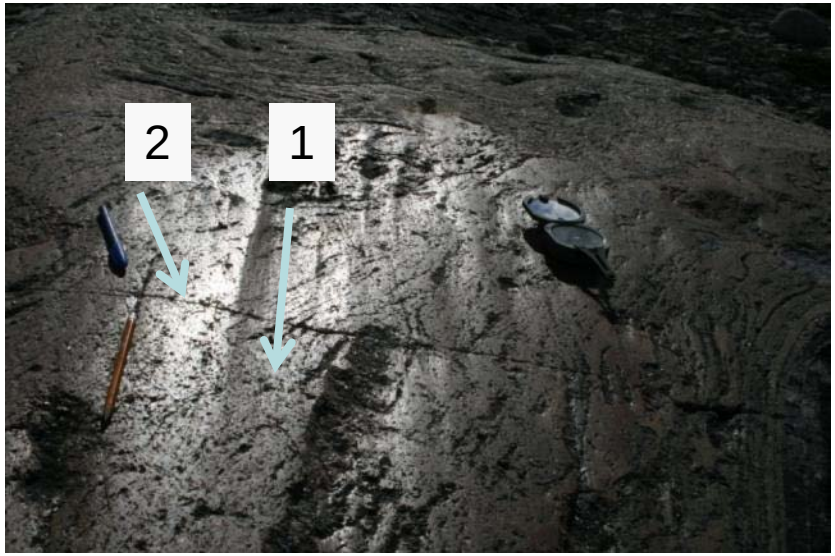
Subglacial landsystem – Hard rock

e.g., Canadian Shield

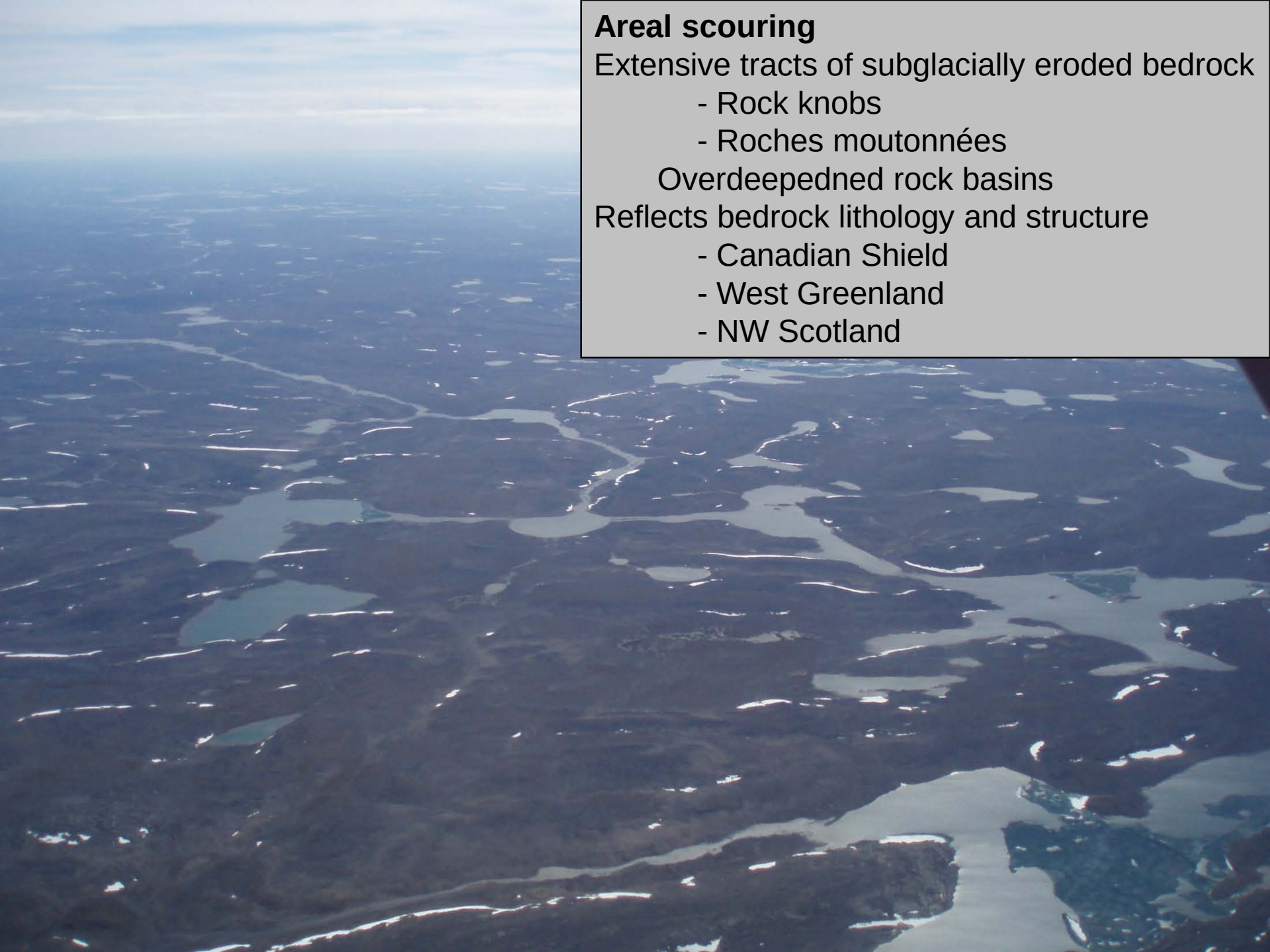


1. Streamlined rock knobs
2. Basal debris
3. Lodgement till on low relief rock surface
4. Lee-side cavity fill
5. Basal melt-out till
6. Supraglacial melt-out
7. Subglacial esker
8. Hummocky or kettled outwash surface
9. Proglacial fluvial system

Micro-scale erosional marks



Meso-scale erosional forms



Areal scouring

Extensive tracts of subglacially eroded bedrock

- Rock knobs
- Roches moutonnées

Overdeepedned rock basins

Reflects bedrock lithology and structure

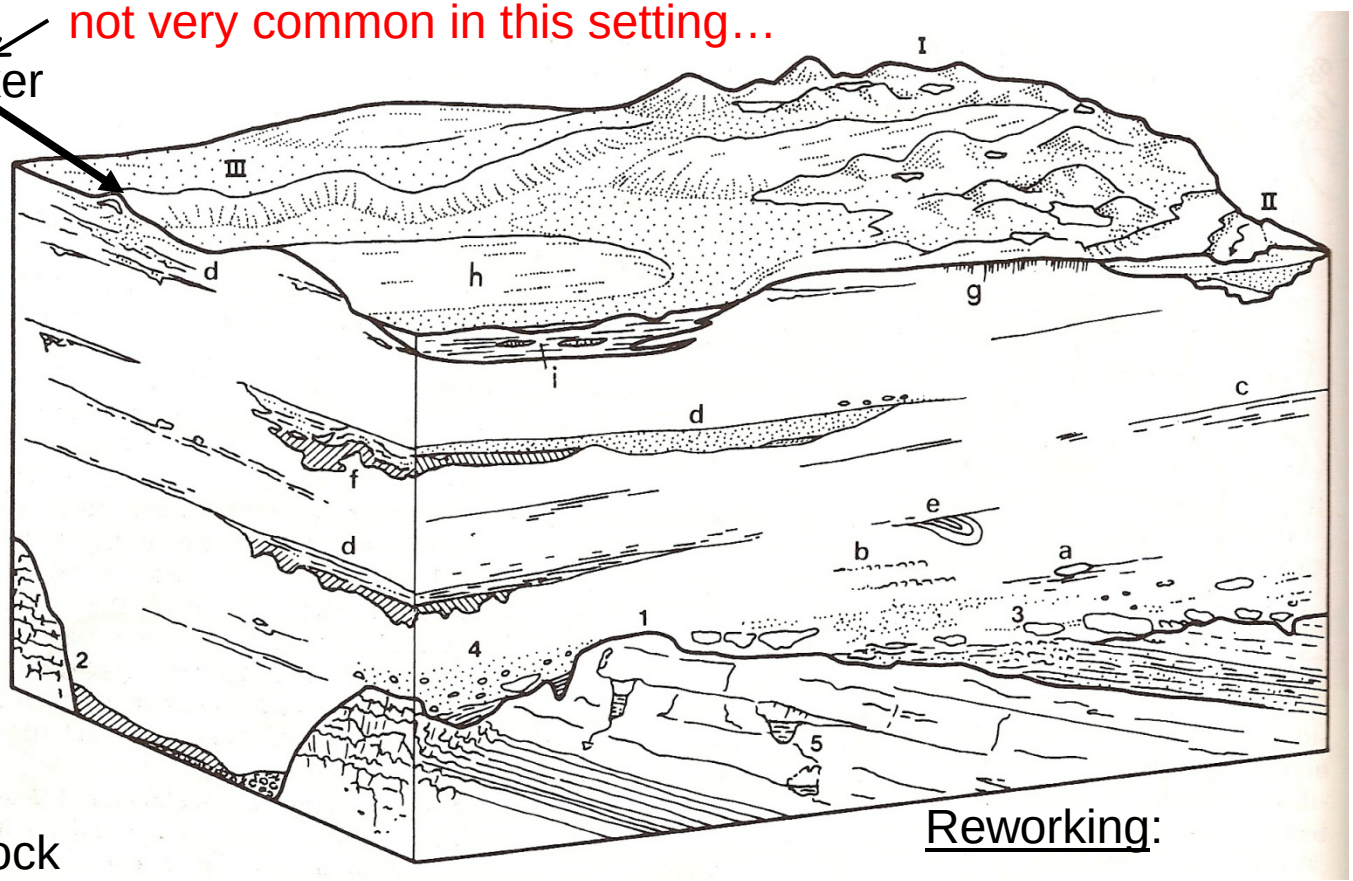
- Canadian Shield
- West Greenland
- NW Scotland

Subglacial landsystem – Soft rock

not very common in this setting…

Esker

Canadian
Prairies
Southern Ontario

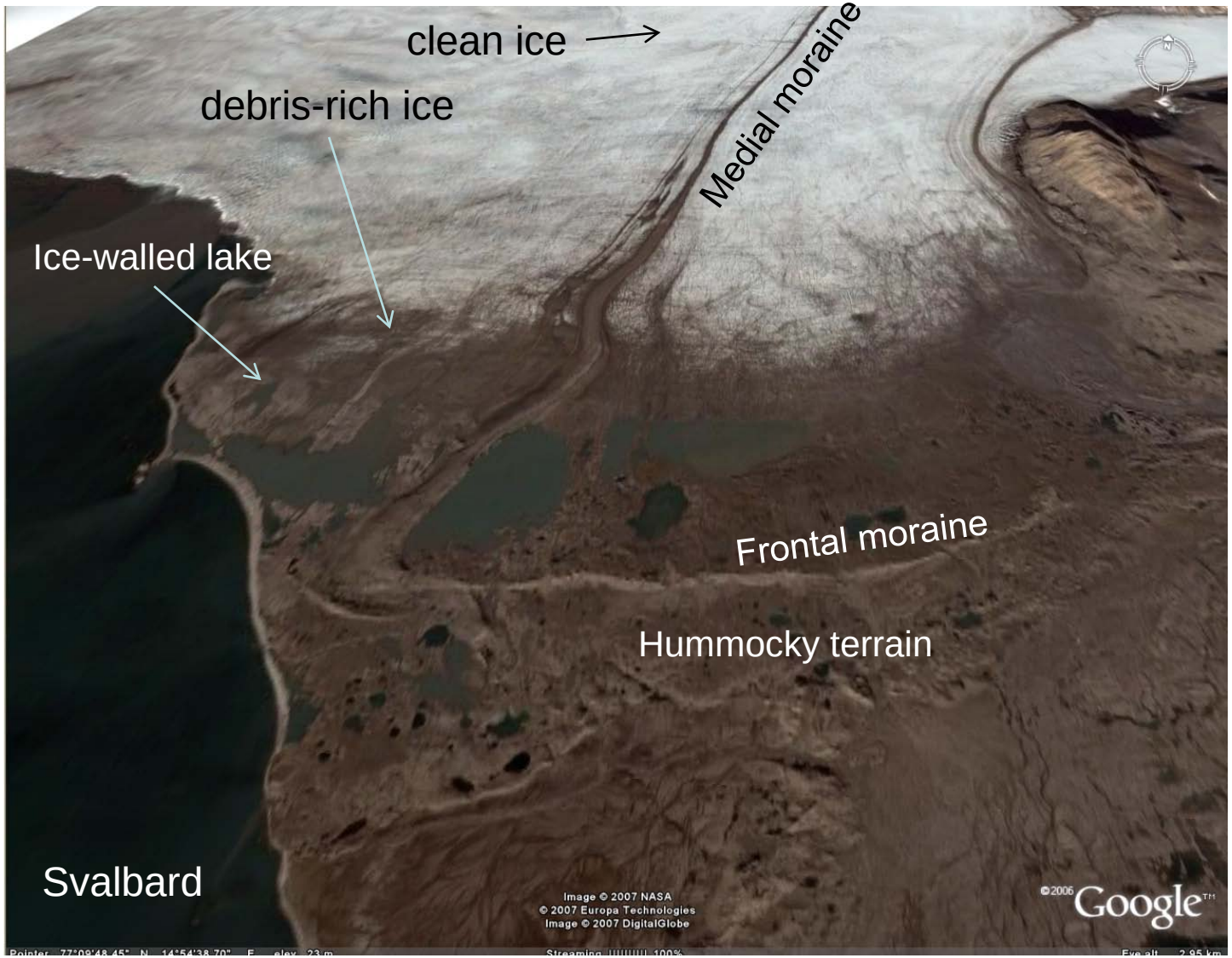


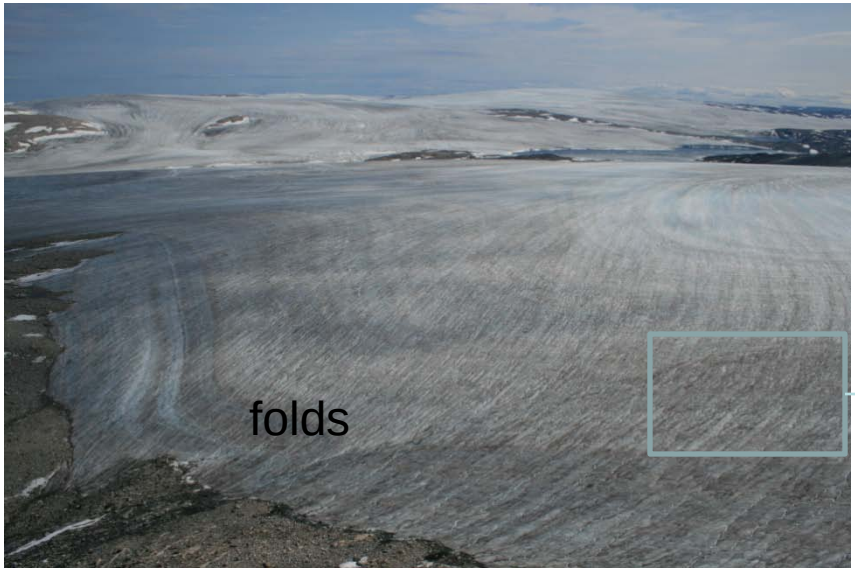
1. Striated bedrock
2. Buried valley and associated fill
3. Glaciotectonized bedrock
4. Lowermost till (local lithologies; lee-side cavity fills)
5. Cold-water karst

<u>Reworking</u>:

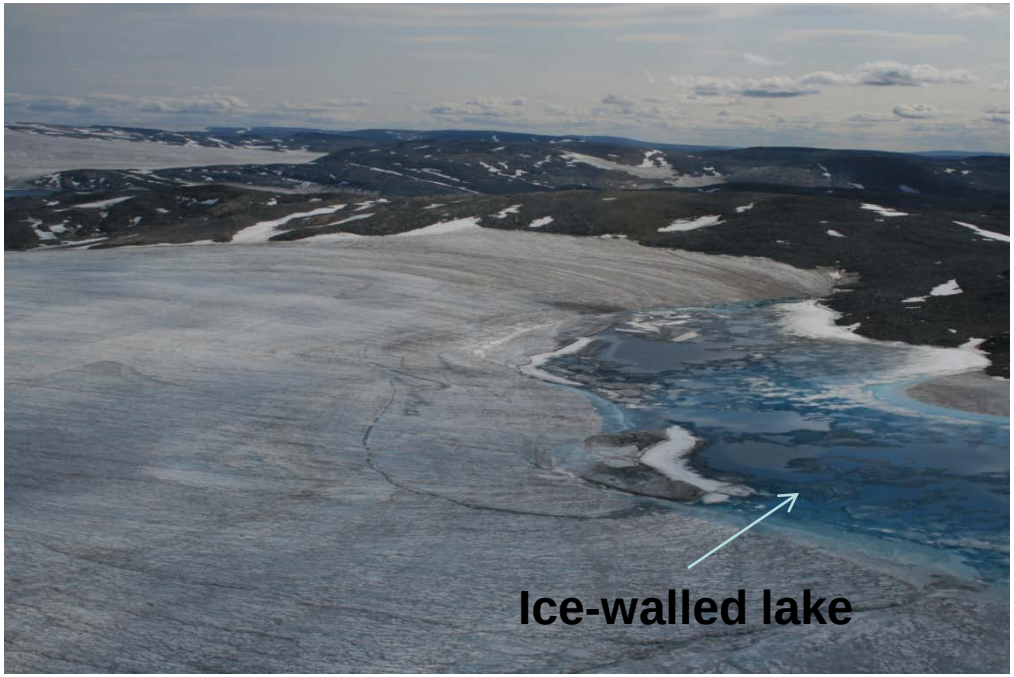
I. Hummocky kame and kettle topo.
II. Outwash

Supraglacial/ice-marginal associations

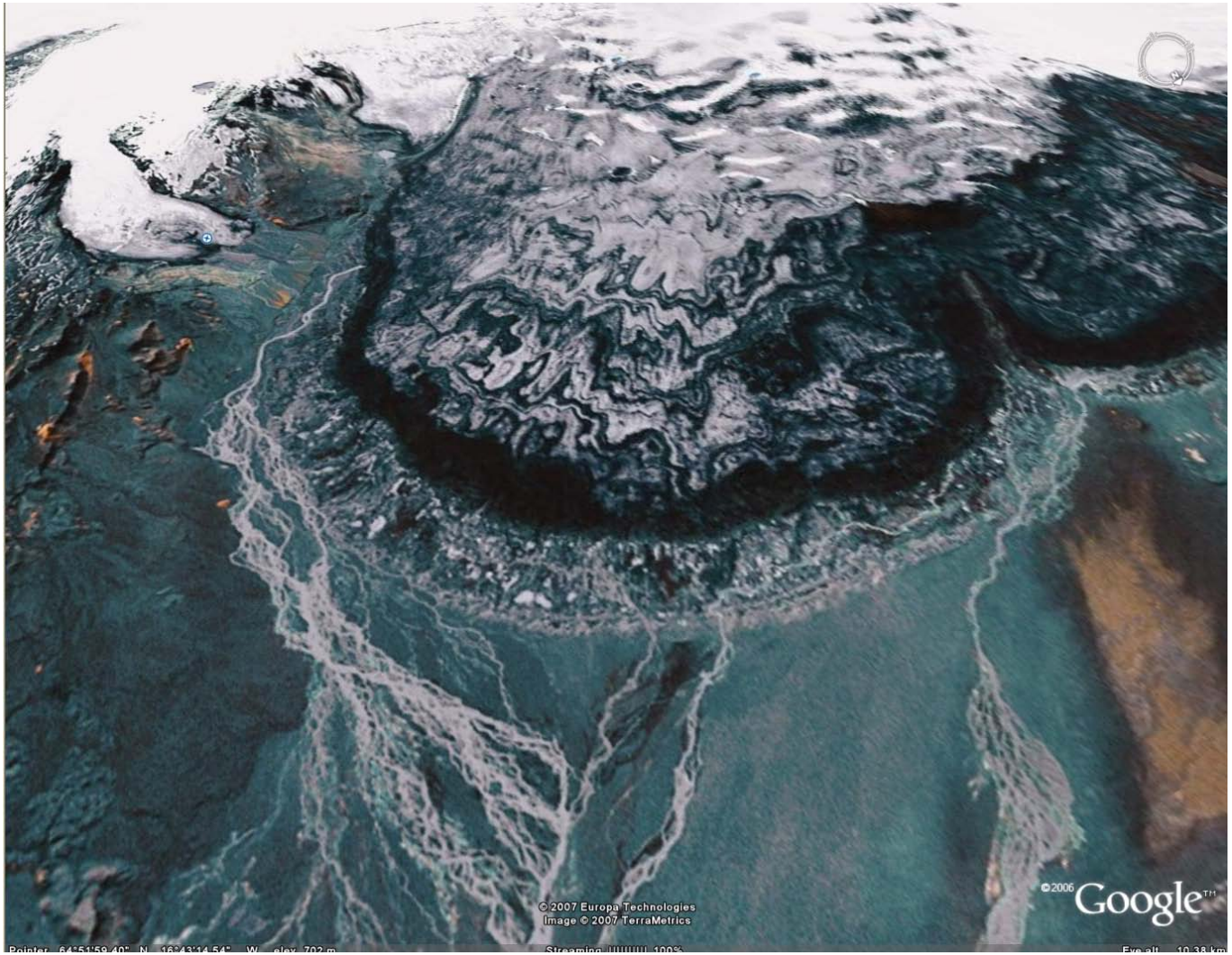



folds


Supraglacial streams

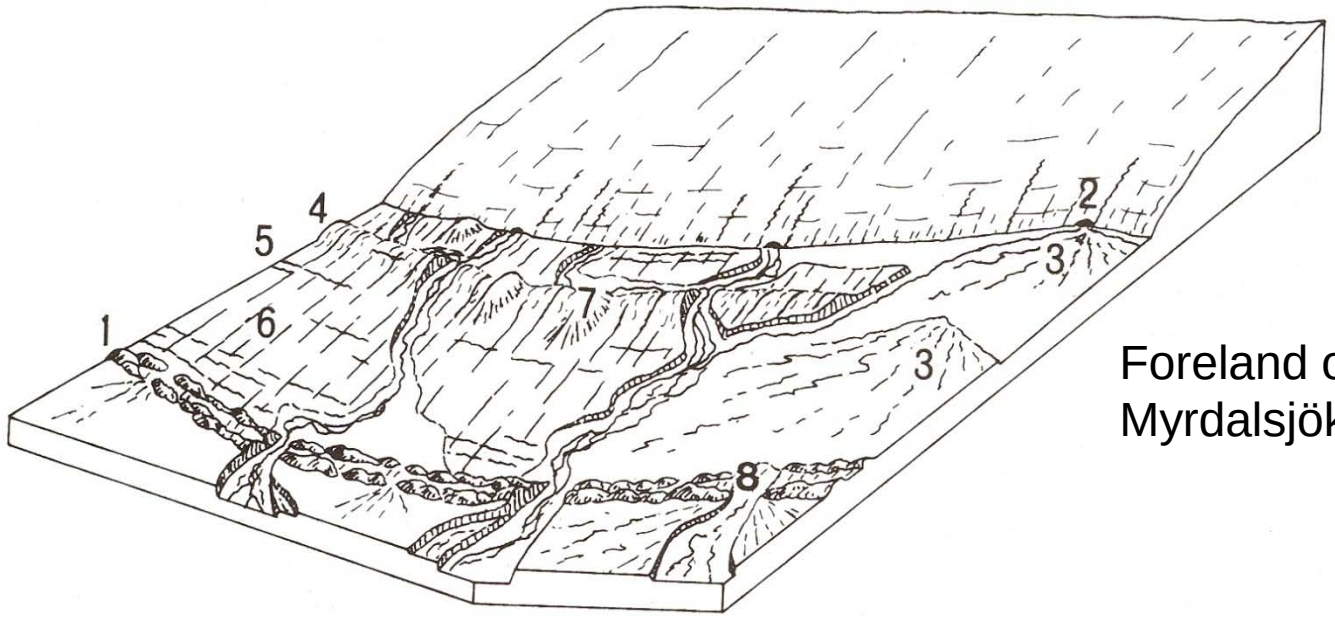

Ice-walled lake

Supraglacial/ice-marginal associations



Iceland

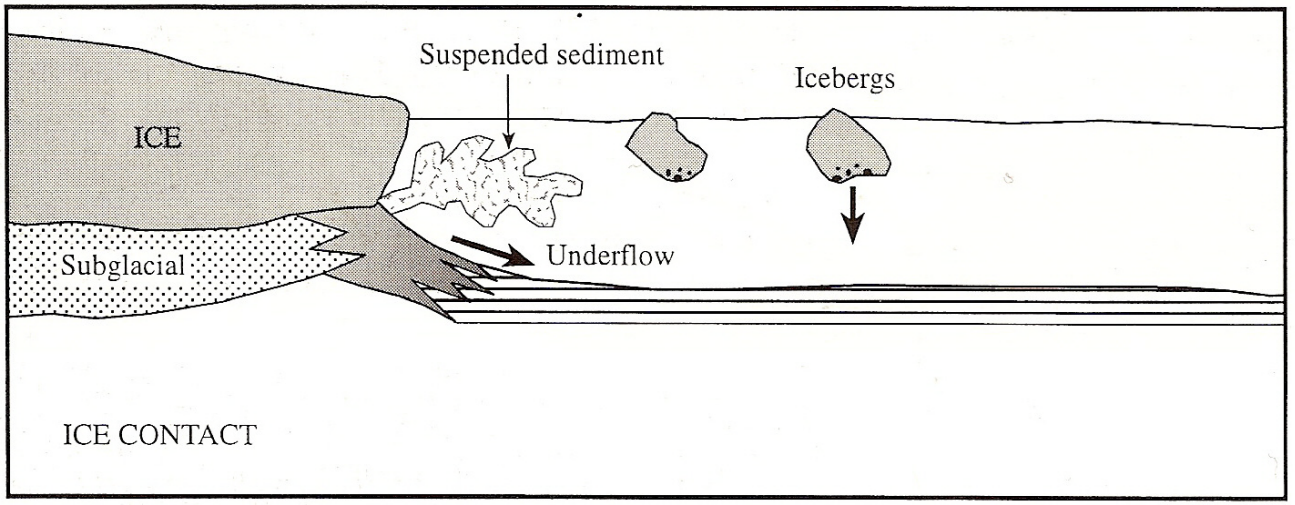
Landsystem model

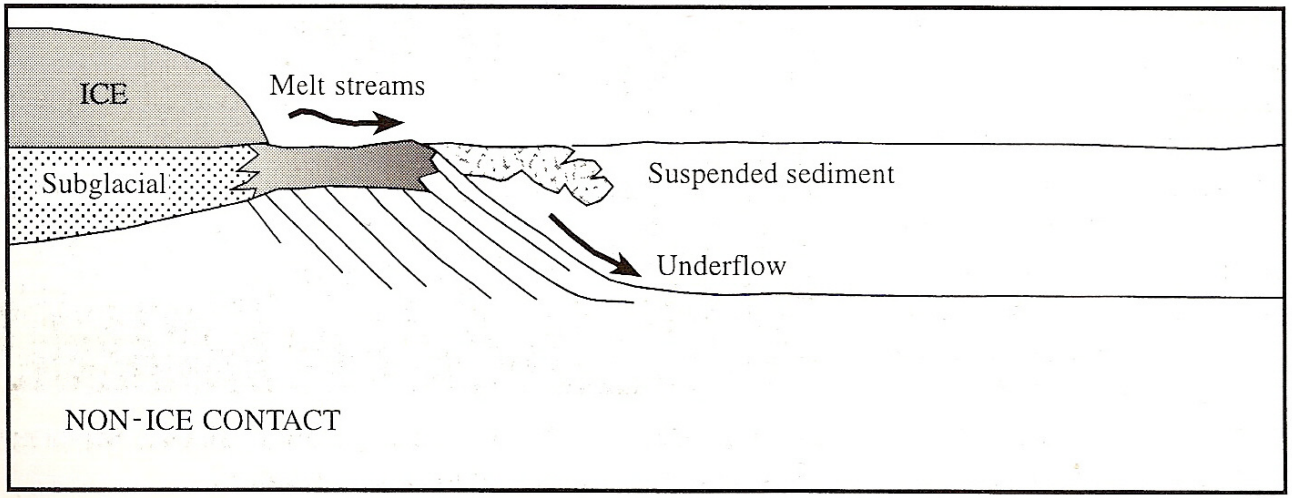


Foreland of
Myrdalsjökull, Iceland

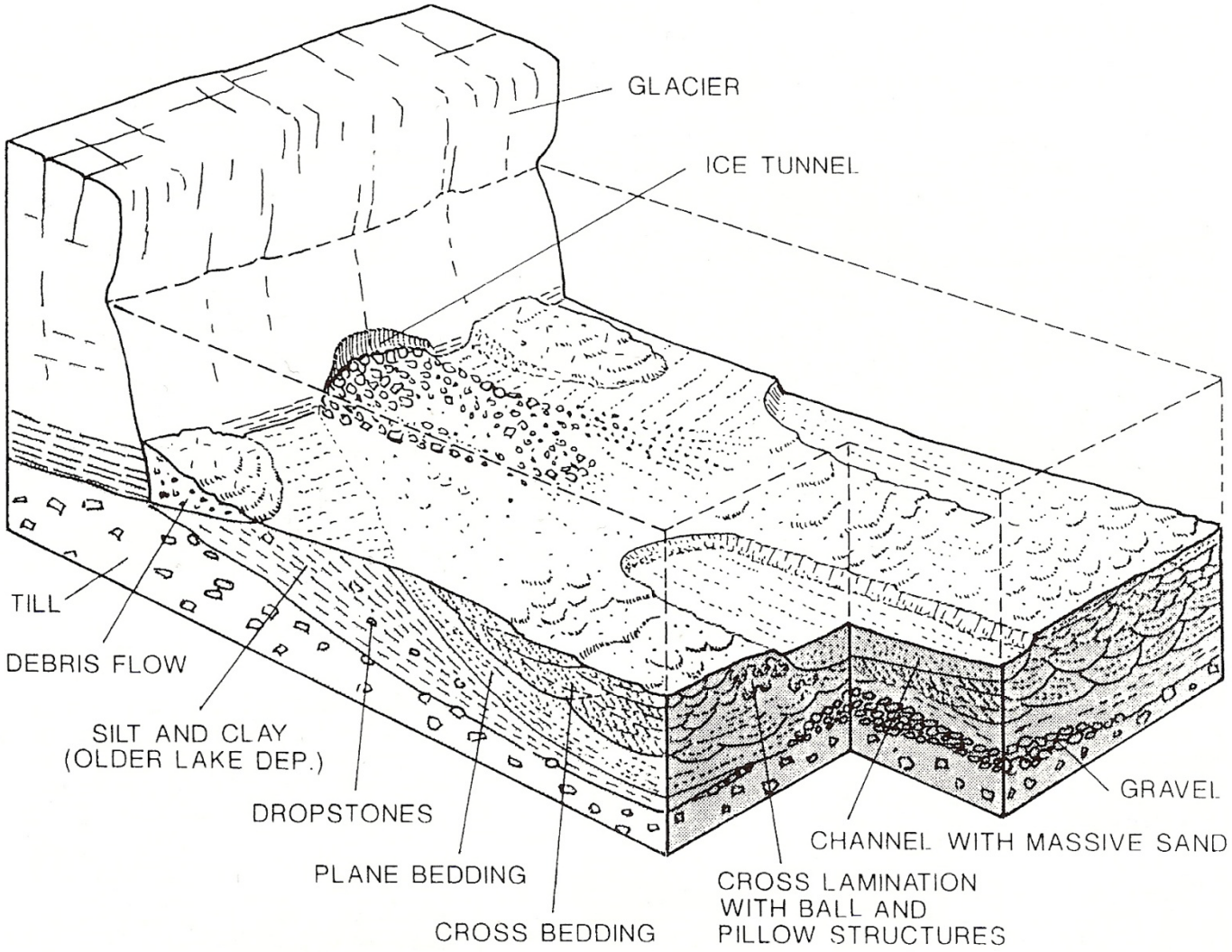
1. Outermost push moraine (Little Ice Age; 16th – 19th century)
2. Ice cave and stream outlet
3. Outwash fan (multi-stage)
4. Old push moraine
5. Annual push moraines
6. Small flutings
7. Drumlinized moraine
8. Proglacial outwash (Little Ice Age max.)

Glaciolacustrine depositional system



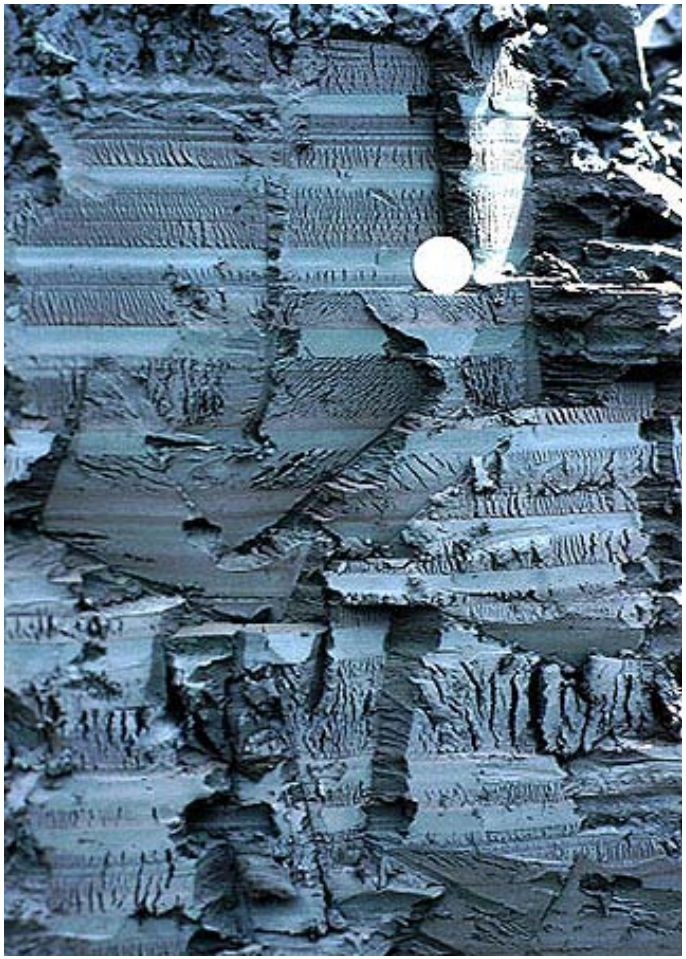


Subaqueous outwash fan



Glaciolacustrine sediments

Intermediate distance to ice margin



More distal facies

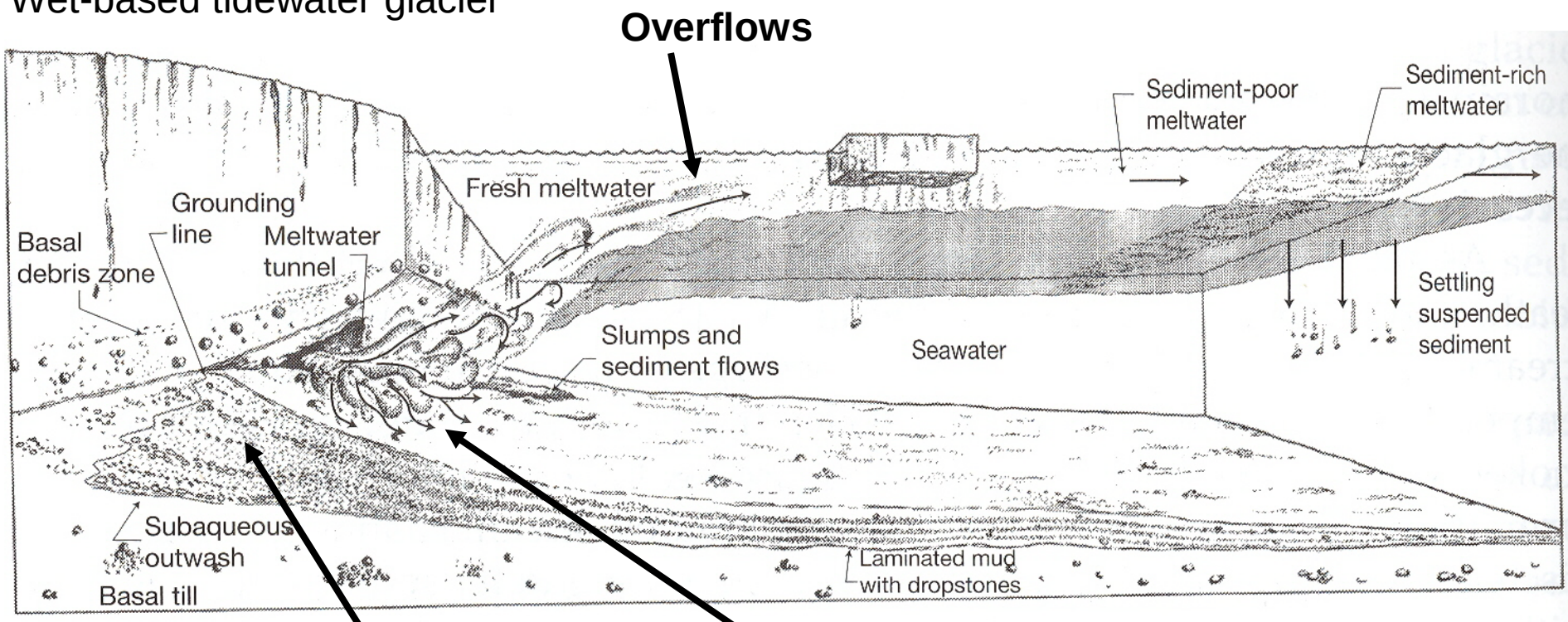
Glaciomarine systems tract

- Continental shelf settings
- Continental slopes and fiords

  - Ice-proximal settings (glacial processes dominate)
  - Ice distal settings (marine processes dominate)
  - Climate
    - Temperate oceanic env. (large sed. volumes)
    - Polar areas (sediment-starved settings)
      - Chemical and biogenic deposition are important

Proximal subaqueous sedimentation

Wet-based tidewater glacier



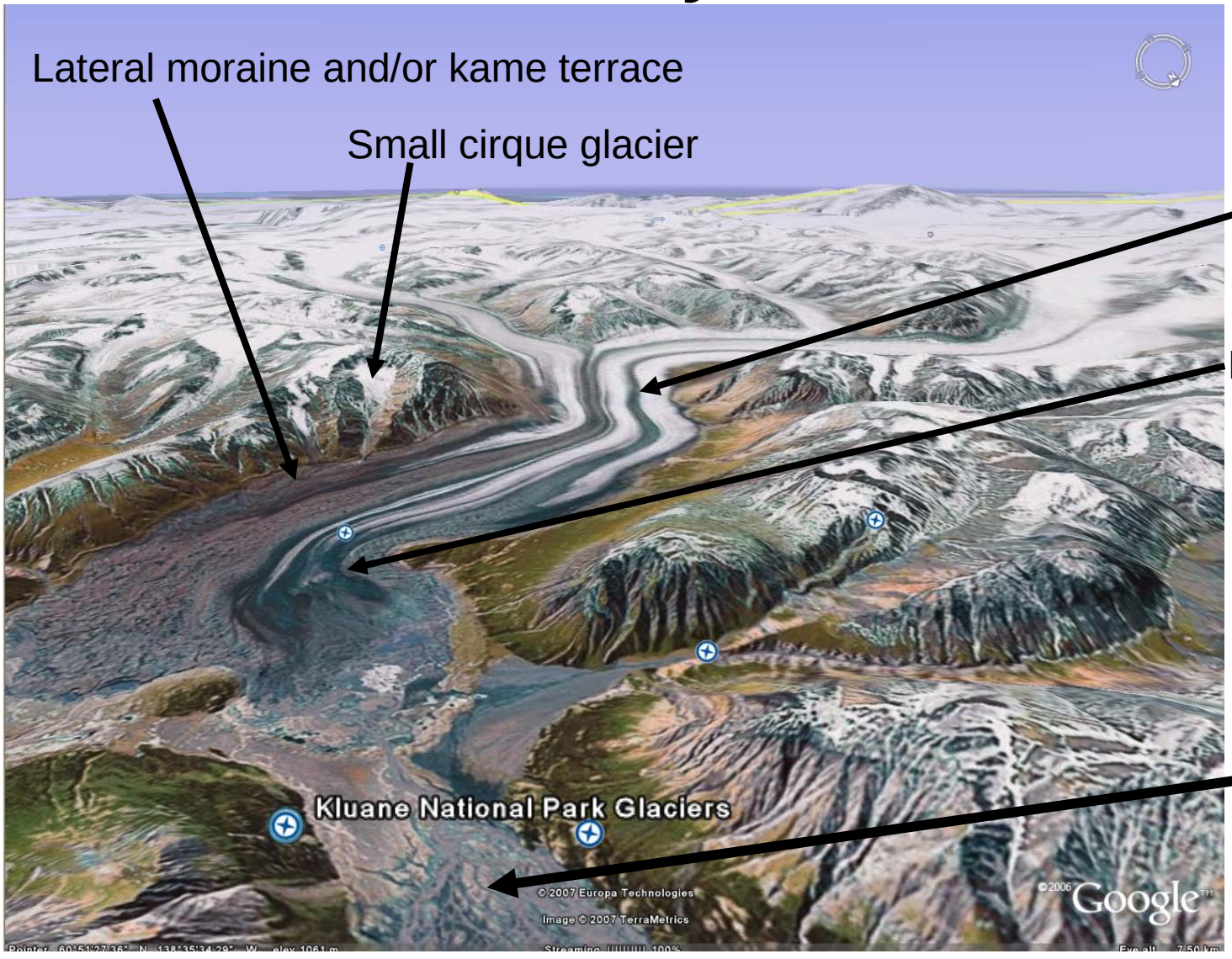
Grounding-line fan deposit

Debris-flow-dominated fan (proximal)

Grade distally into **turbidites**

Strong **underflow** currents

Glaciated valley depositional system

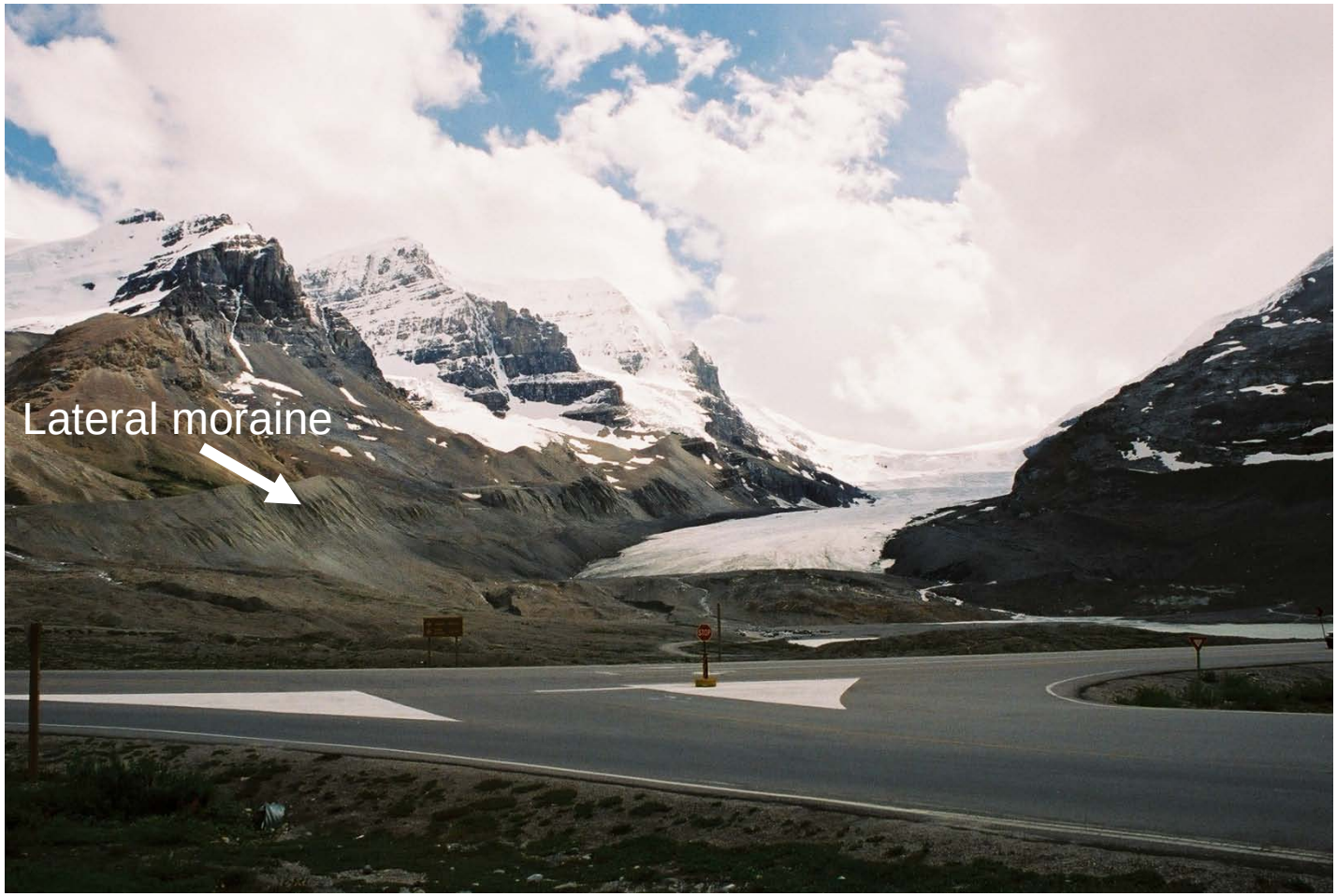


Medial moraine

Debris-covered ice

Braided-river system

Columbia Icefield



AB

Old cirques


Mt Washington observatory
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- Exercise
  - Associate each section with its setting (using the numbers from 1 to 8) and give a name for each setting.