Geological Sampling Best Practices: Soils, Tills, Bedrock and Mineralization

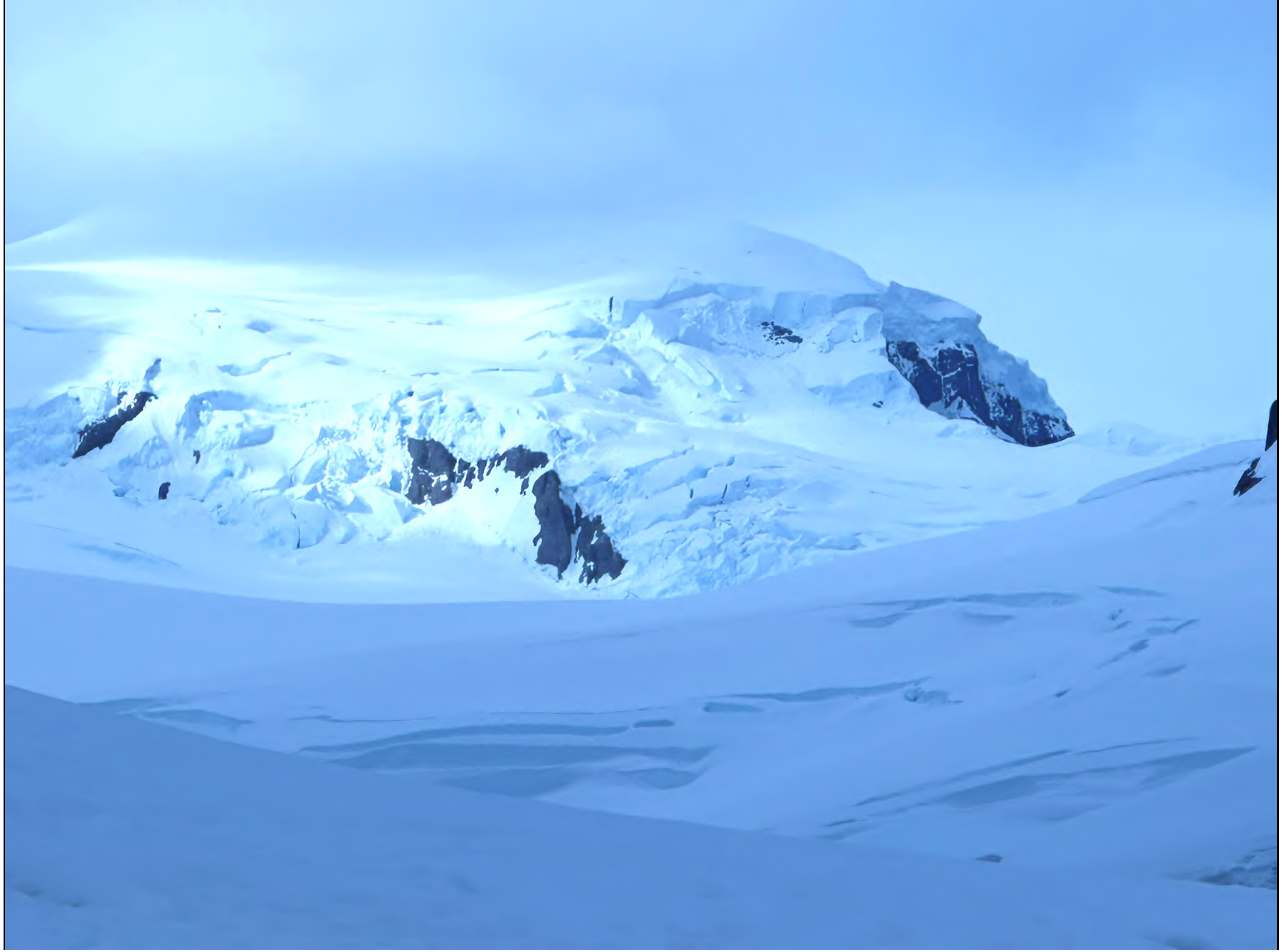
November 5th, 2024

Jennifer Organ, Greg Sparkes, Rebecca Stirling, Tim van Nostrand

Contributions: Heather Campbell and Hamish Sandeman

Outline

1. Introduction to glaciation
   - Glacial erosion in Newfoundland and Labrador
2. Glaciation of Newfoundland and Labrador
   - Glacial deposition
   - Other glacial and non-glacial processes
   - Soils
   - Glacial dispersal
3. Designing a sampling program
   - General sampling patterns
   - Setting up a grid
   - Case studies
4. Sampling strategies
   - Till vs soil
   - Sample size
   - Sample methods
   - Sample equipment
   - Site selection
   - Sampling best practices
     - Labelling and note taking
5. Bedrock sampling
6. Sampling mineralization



Glaciology background

1a. Glacier formation

1b. Erosion

1c. Landscape transformation

1d. Transport

1e. Deposits

1f. Meltwater

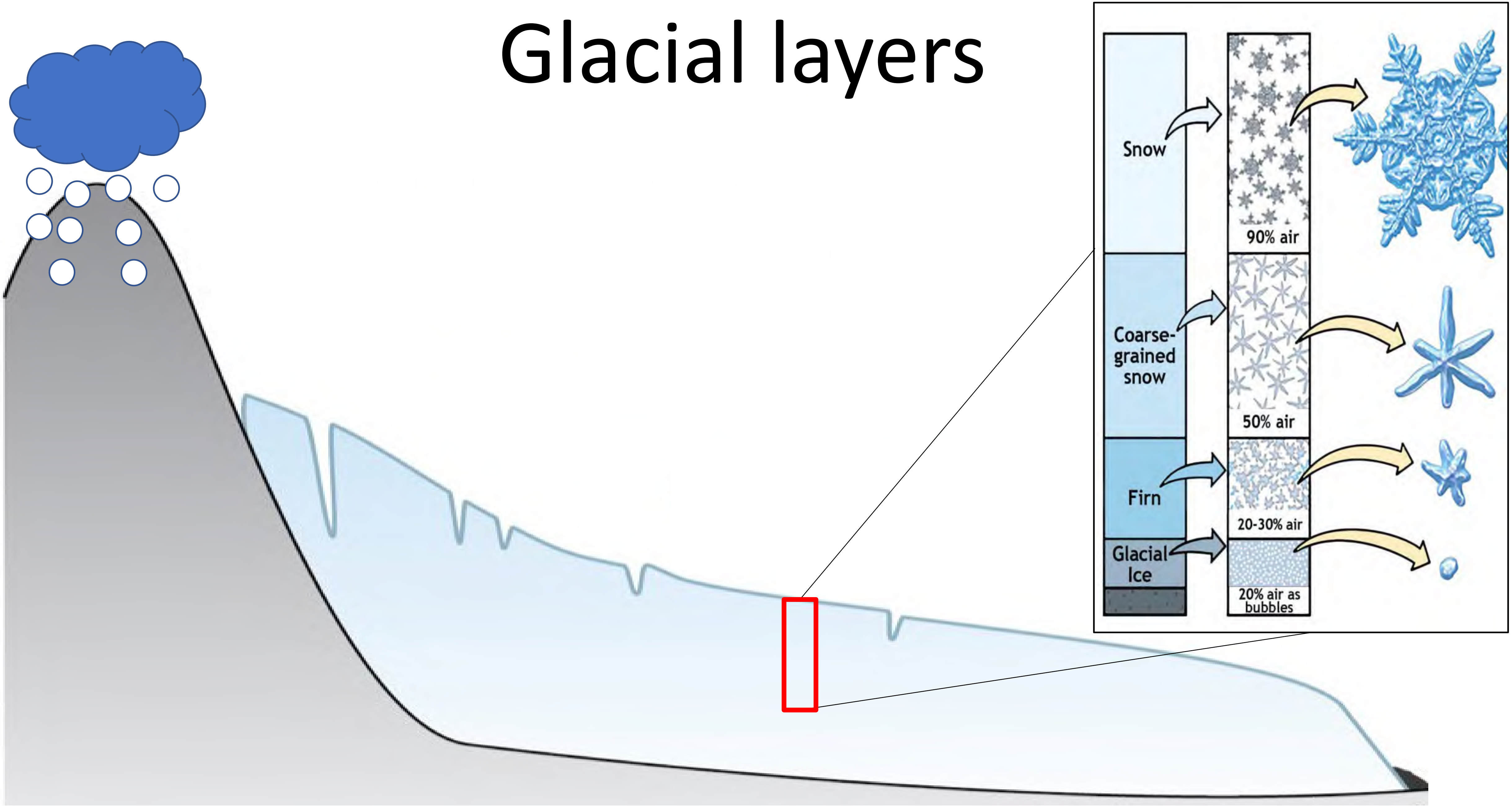
1g. Legacy

Mountain glaciers

Continental glaciers

(Ice sheets)

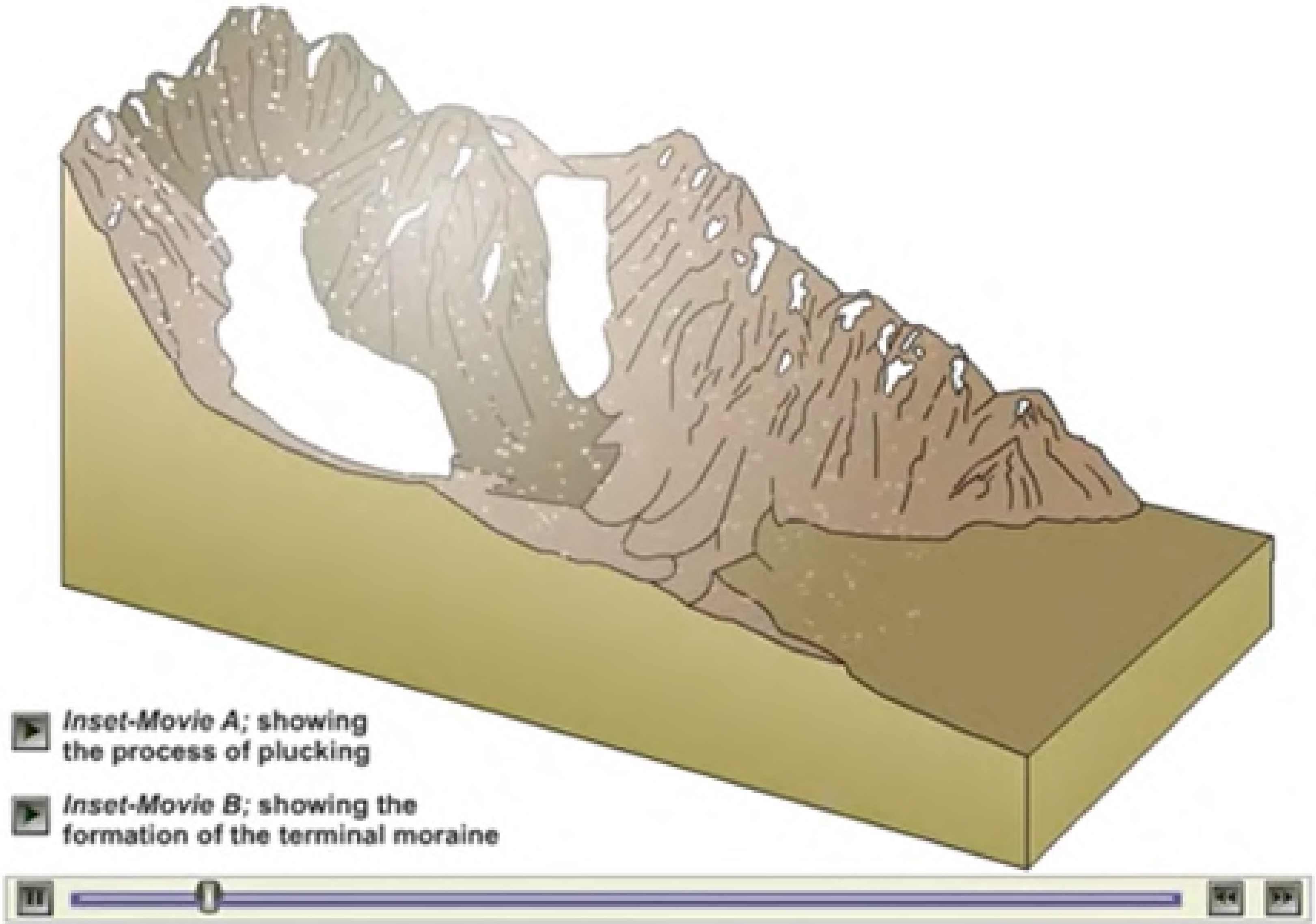
Glacial layers



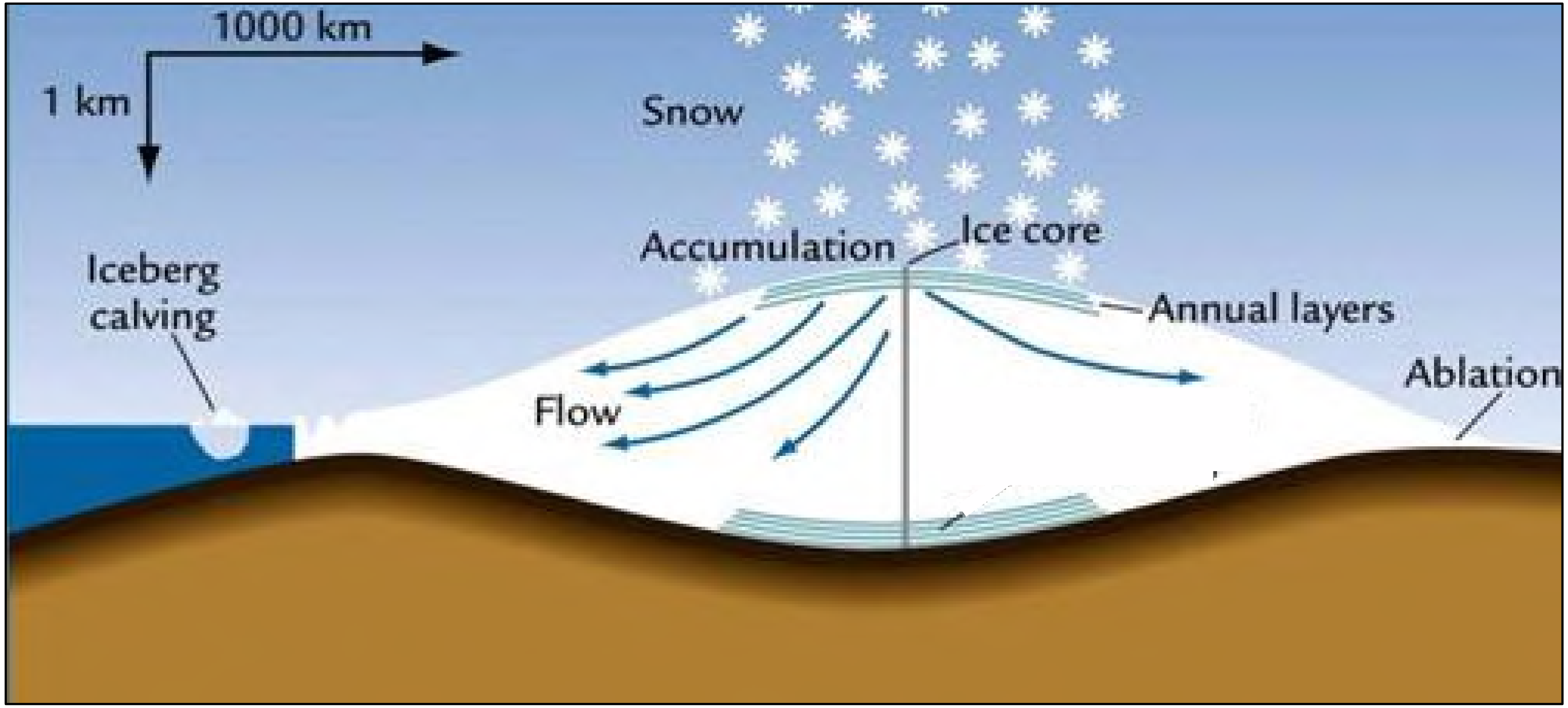
1a. Formation

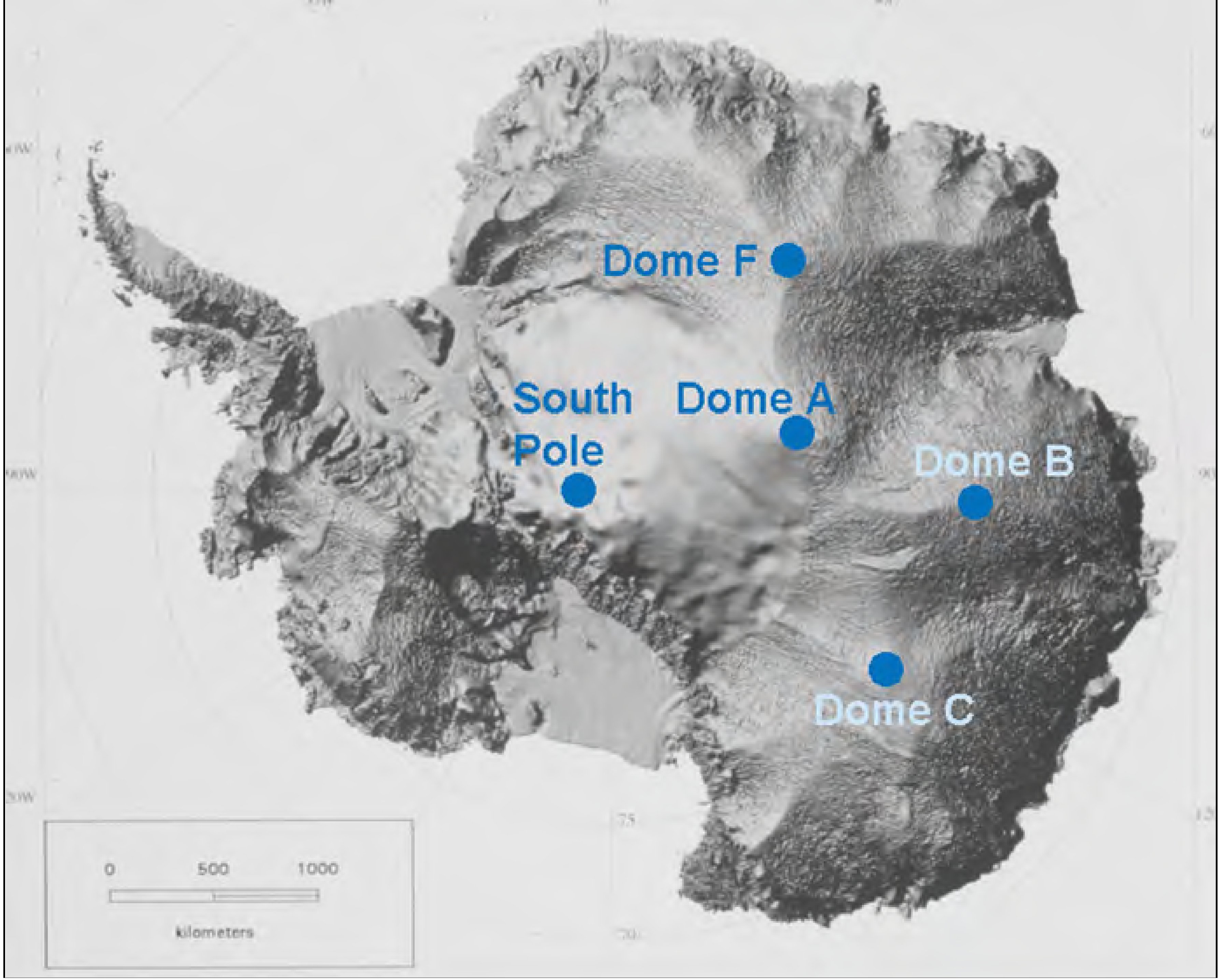
Modified from AntarcticGlaciers.org

Glacier advance



Ice sheet formation



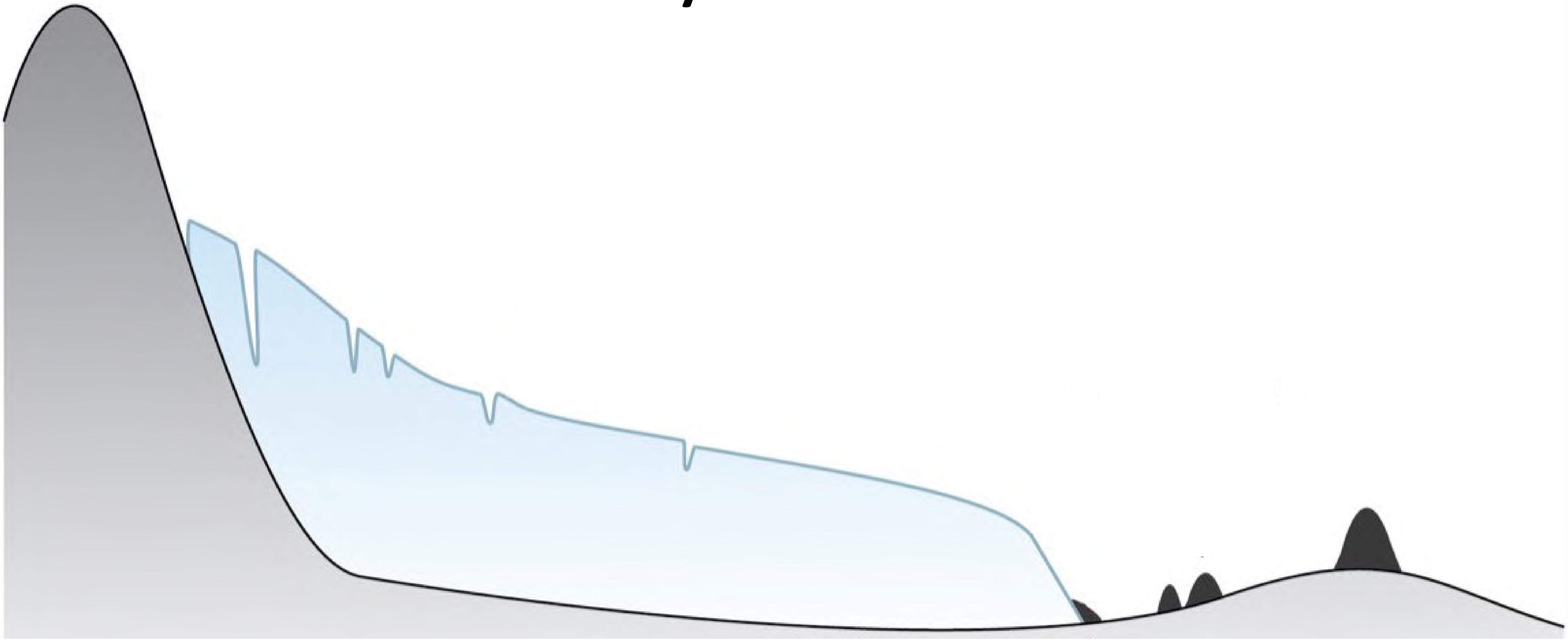


1a. Formation

1a. Formation

Shaw et al. (2006)

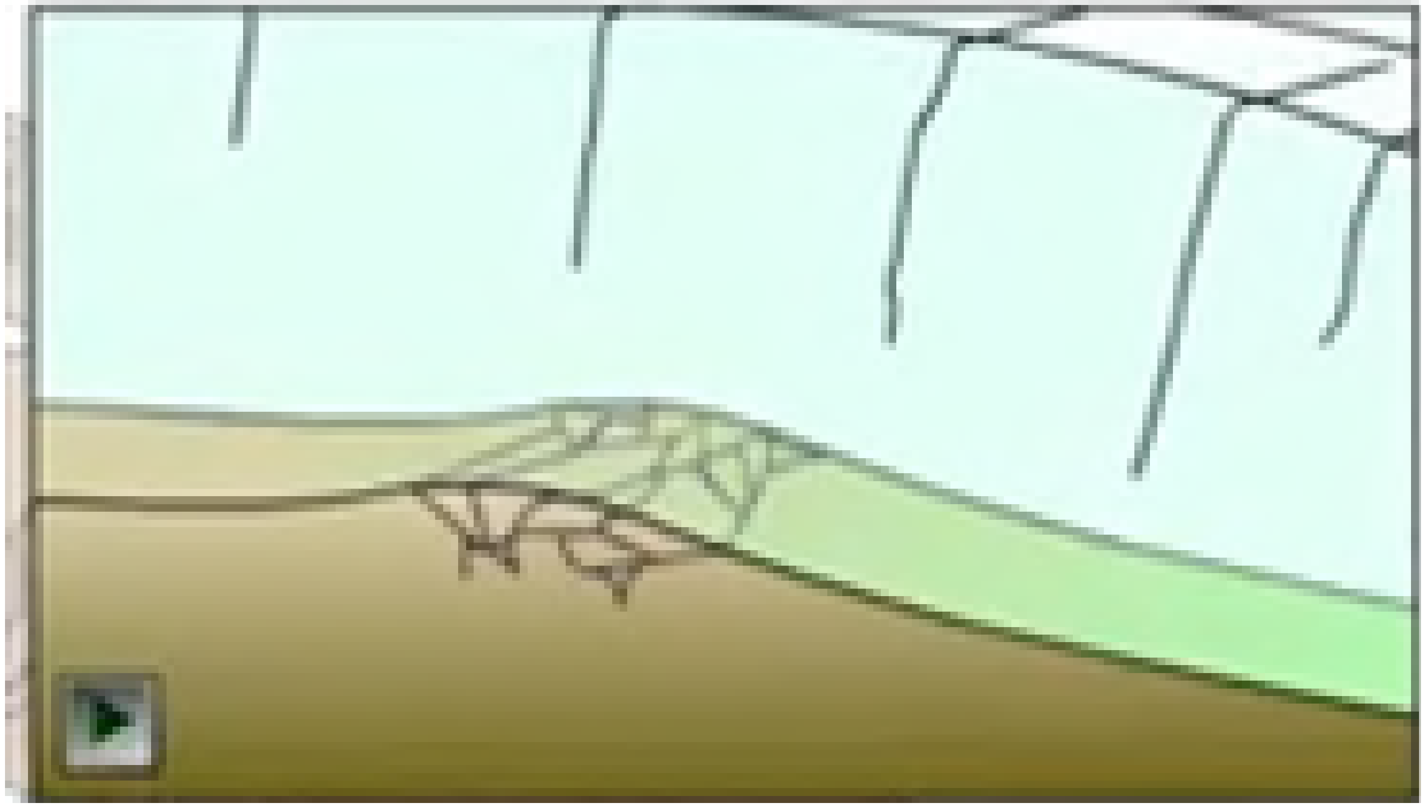
Dynamic



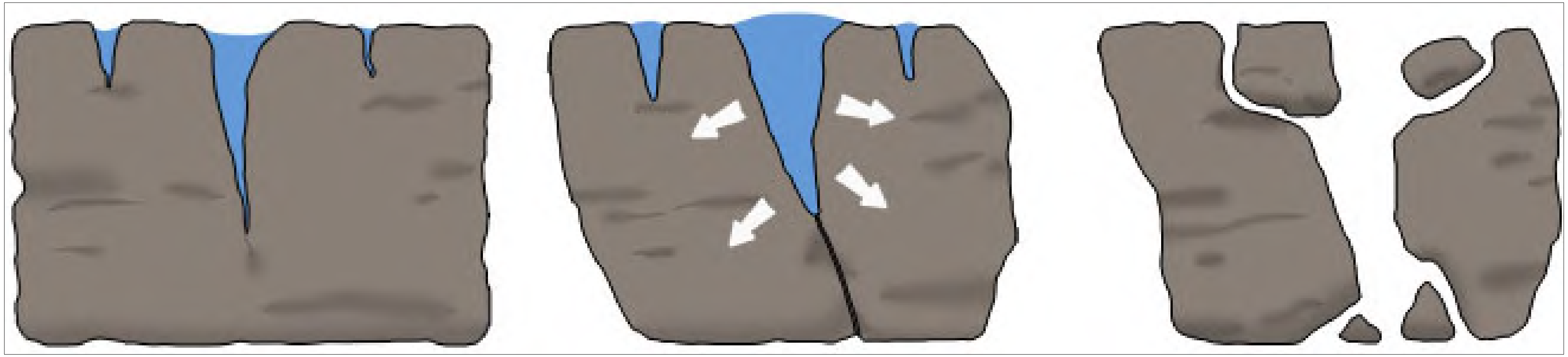
1a. Formation

Modified from AntarcticGlaciers.org

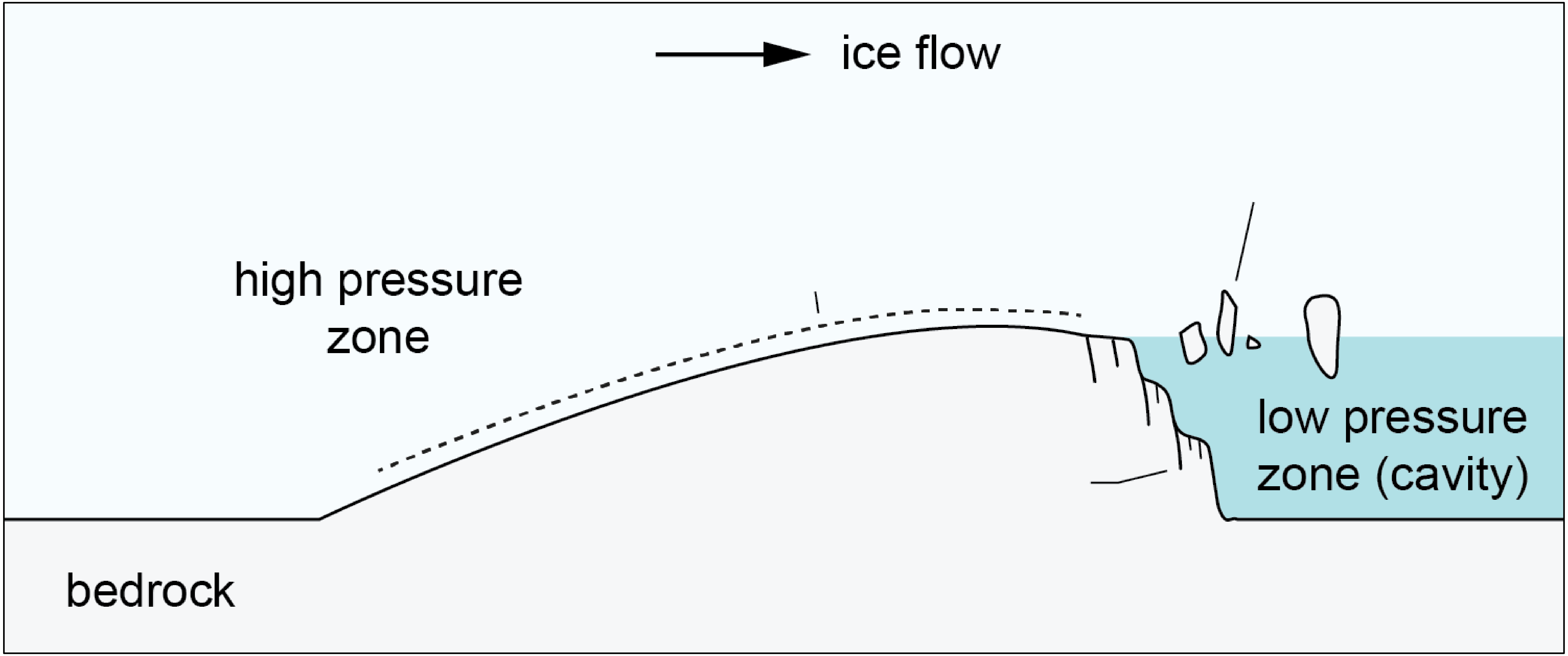
Plucking



Freeze-thaw

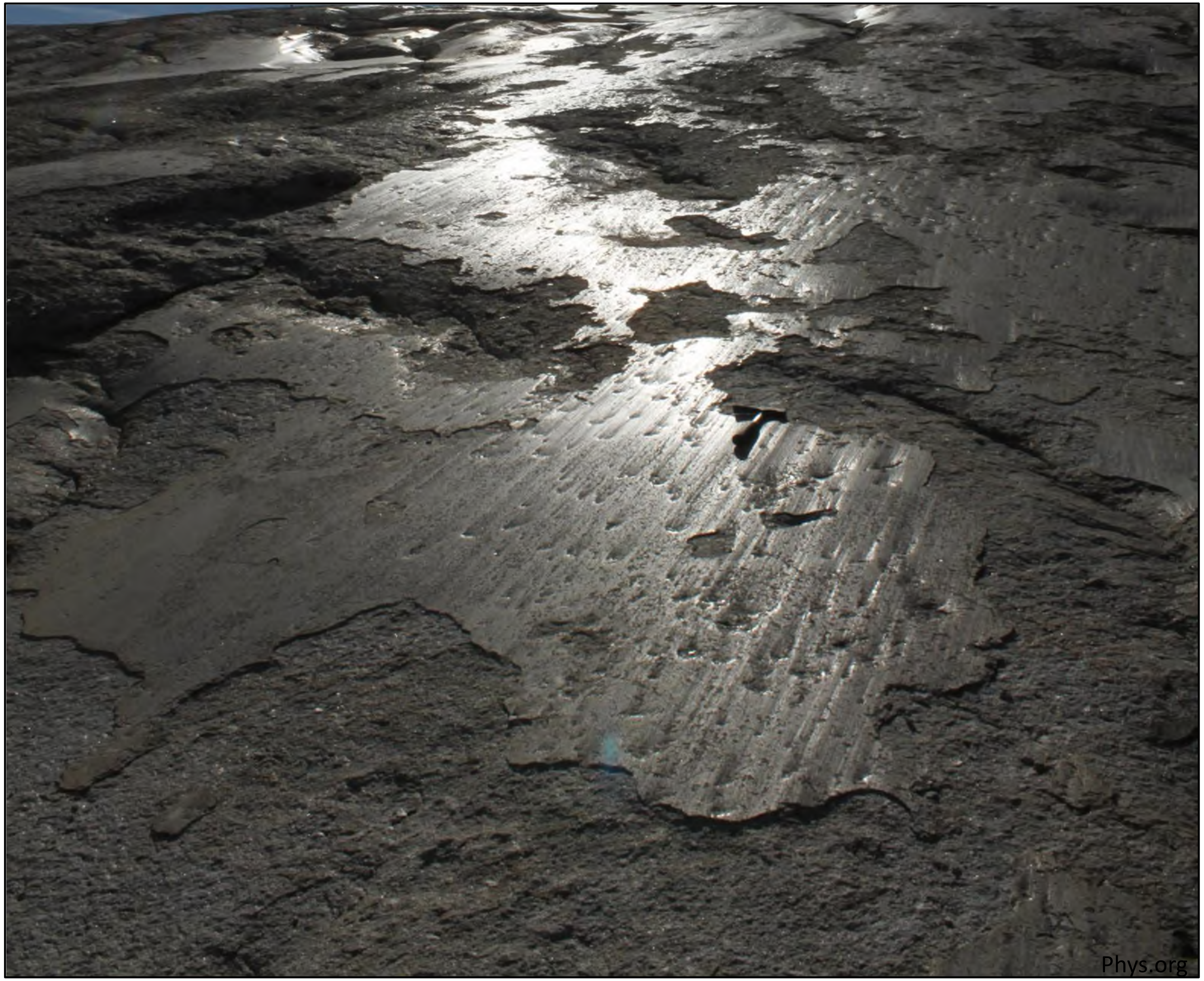


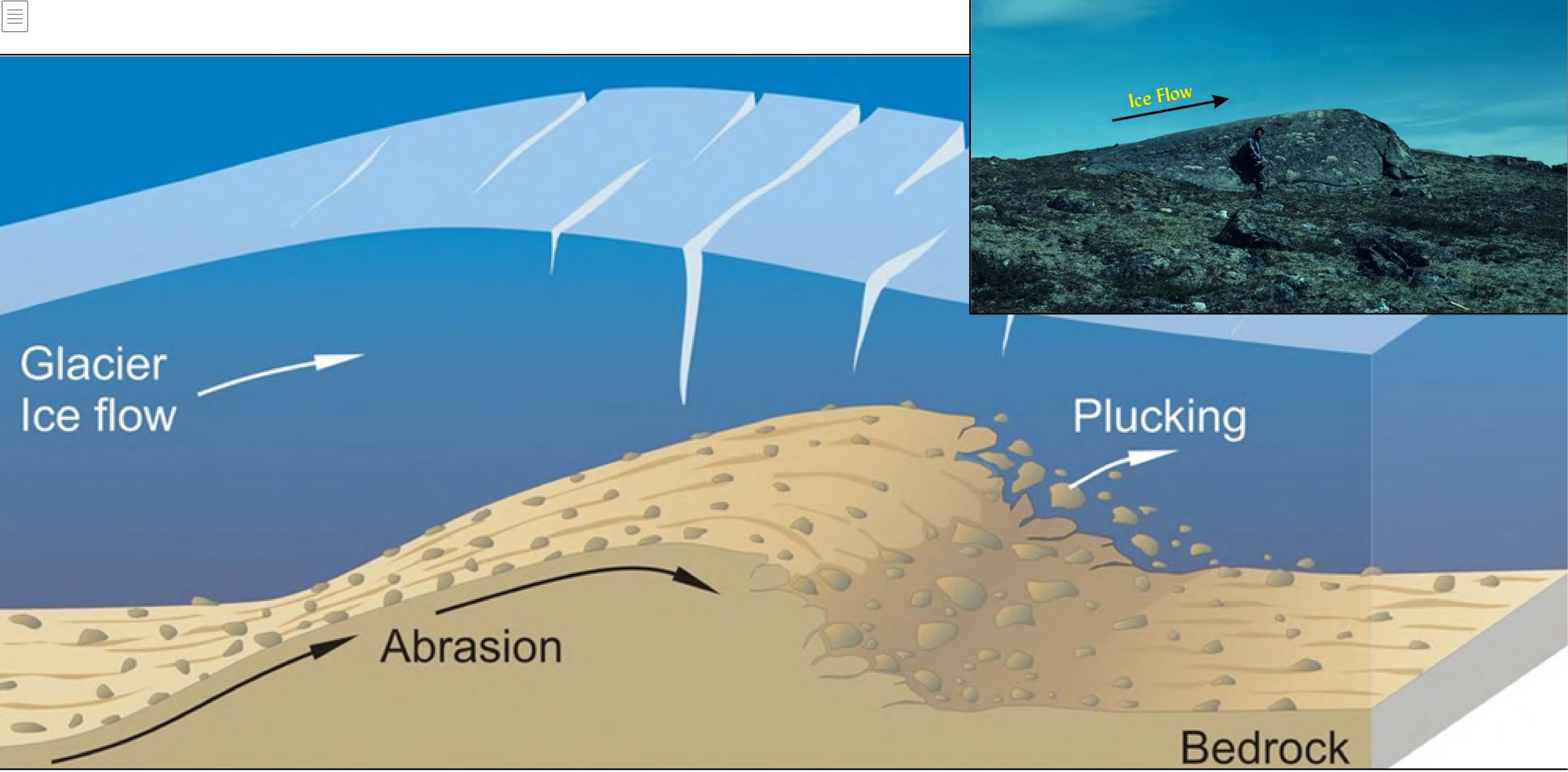
Plucking



Bendle (2020)

Abrasion

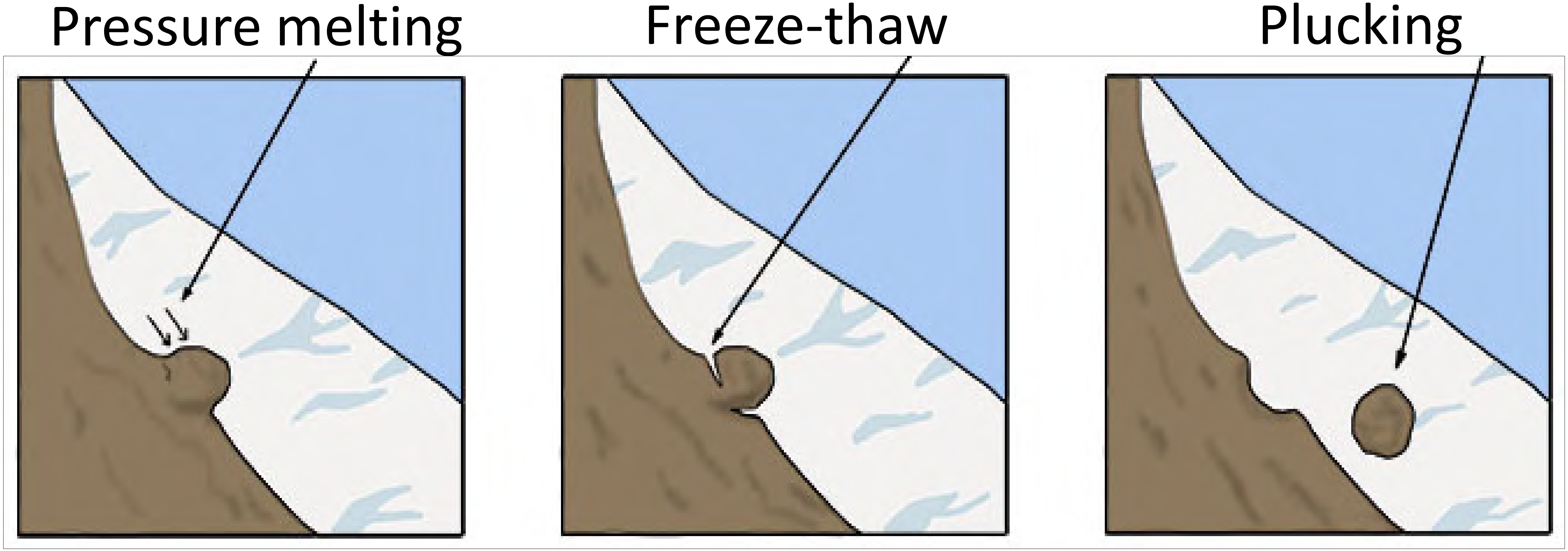




Stoss

Lee

Plucking



Scale of glacial erosion features

Large-scale: e.g., fjords

Western Brook Pond Source GSNL

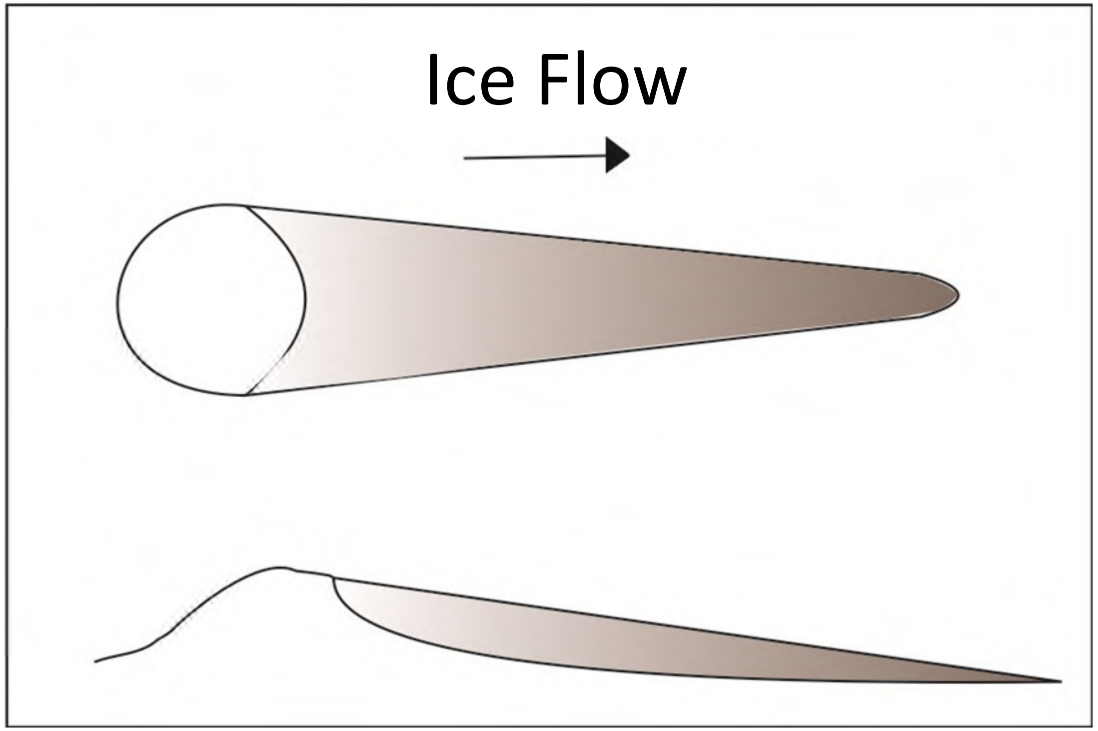
Medium-scale: e.g., rôche moutonées

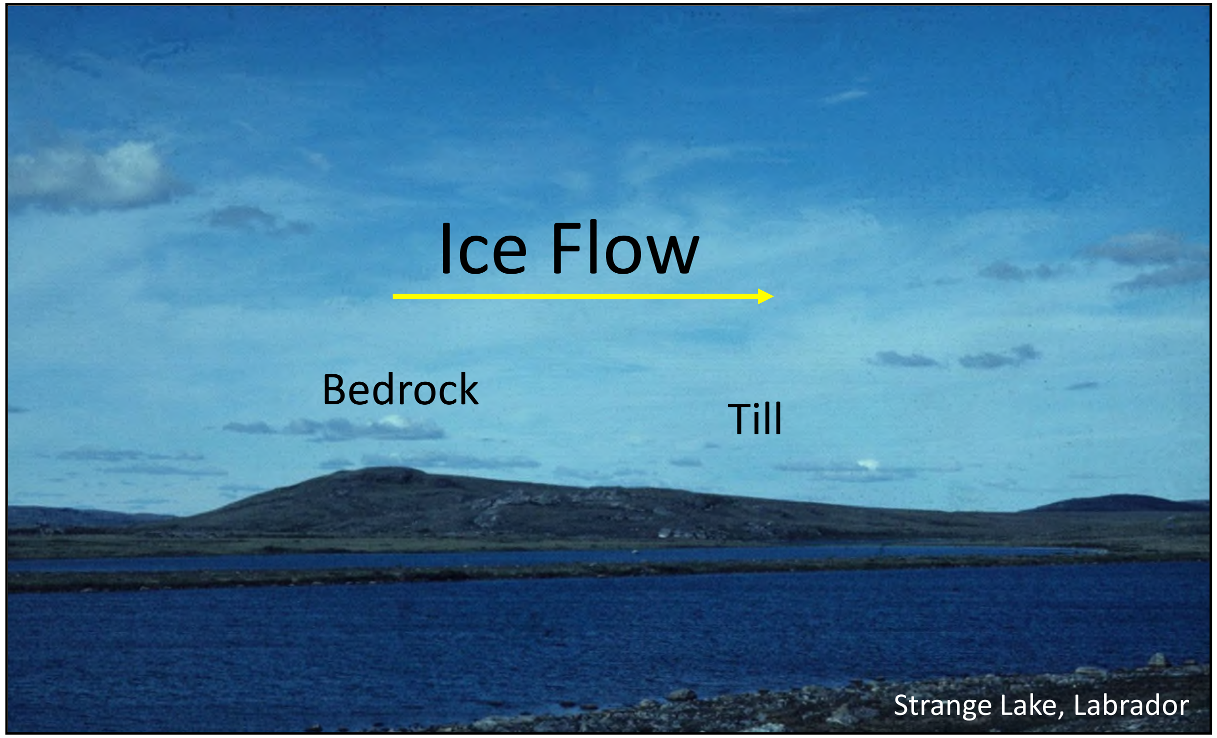
Rôche moutonnée, Burgeo Highway Source GSNL

Small-scale: e.g., striae

Glacial grooves and striae, Hawke's Bay
Source GSNL

Medium scale: crag and tail features





Source GSNL

1b. Erosion

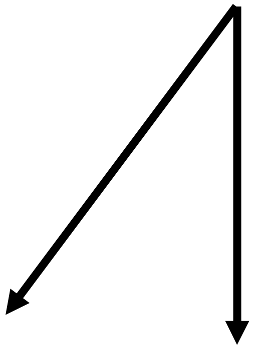
Medium scale: rôche moutonnée

Rôche moutonnée, Strange Lake

Source GSNL

heartofavalonia.org/glacial-processes

Small scale: ice-flow indicators



1b. Erosion

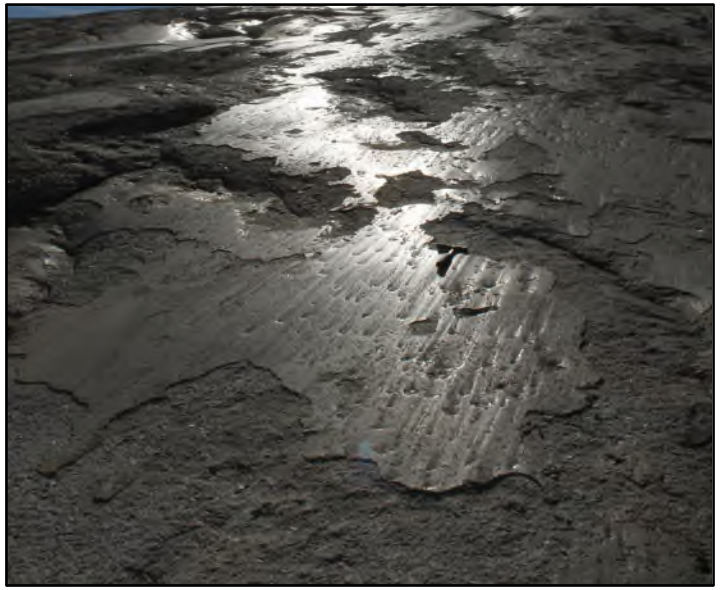
Types of small-scale ice-flow indicators

- Striae
- Grooves
- Rat-tail striae
- Nailhead striae
- Chatter marks
- Crescentic gouges
- Lunate fractures
- Sichelwannen (water)

Where to find small scale features?

- On the top of stoss and lee landform
- Bedrock that looks moulded or polished
- Feels smooth
- Veins (quartz -beware of the twinning)

Source GSNL



May have to clean off….

Source GSNL

Source J.S. Organ

1b. Erosion

Water and sun

Source GSNL

Source GSNL

Grooves

Northern Peninsula

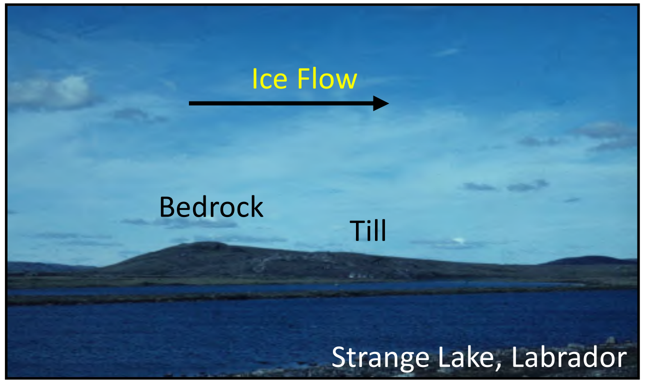
Source GSNL

1b. Erosion

Determining direction

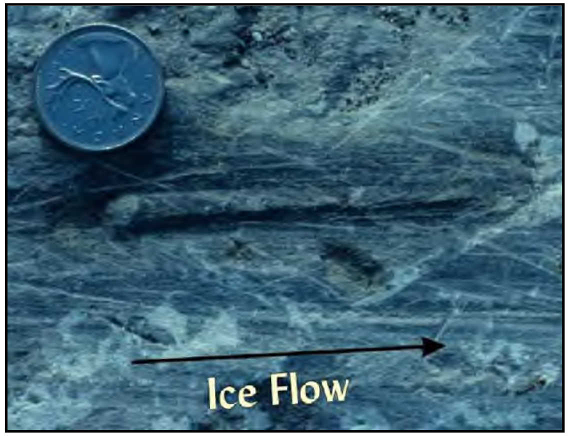
Medium scale features:
Stoss and lee shapes

Source GSNL



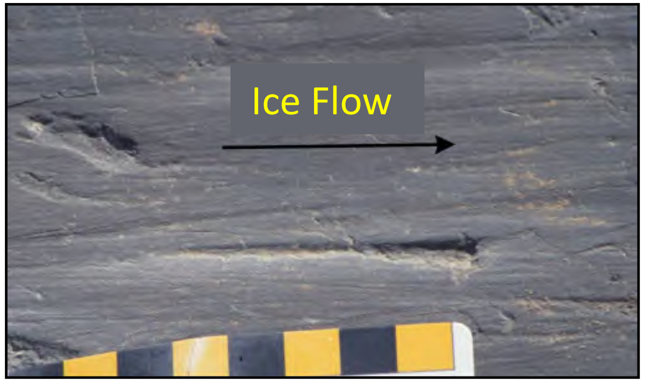
Source GSNL

Small scale features:
Rat-tail striae
Nailhead striae
Abrasion



Source GSNL

Rat-tail striae



Source GSNL

Nailhead striae

Measuring striae

- Select a horizontal surface wherever possible
- Using compass, measure orientation of striae (bidirectional e.g., 90-270)
- Explore outcrop – see if there is variation
- Look for stoss and lee shapes or crag and tail features to determine and record the 'down-ice' direction

Source GSNL

North of Ashuapun, Labrador

Melody Lake, Central Mineral Belt, Labrador

Source GSNL

Crosscutting relationships

novascotia.ca/natr/meb/fieldtrip/stop11

1b. Erosion

Superposition of indicators on streamlined landforms

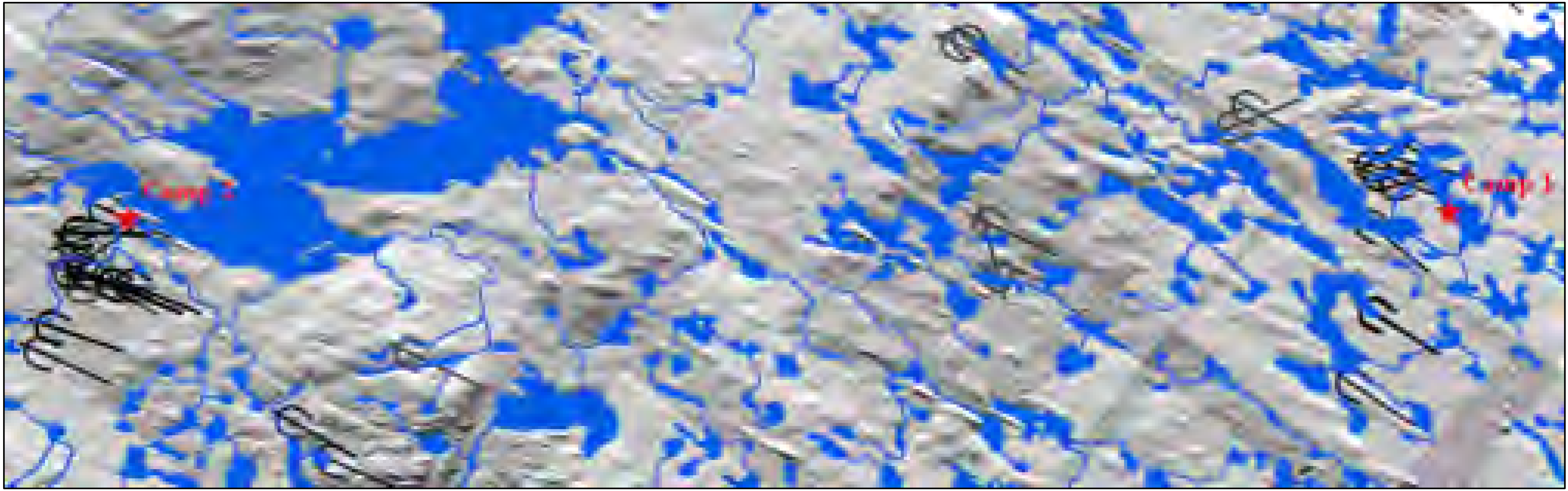
Source GSNL

1b. Erosion

Mapping erosion features

1b. Erosion

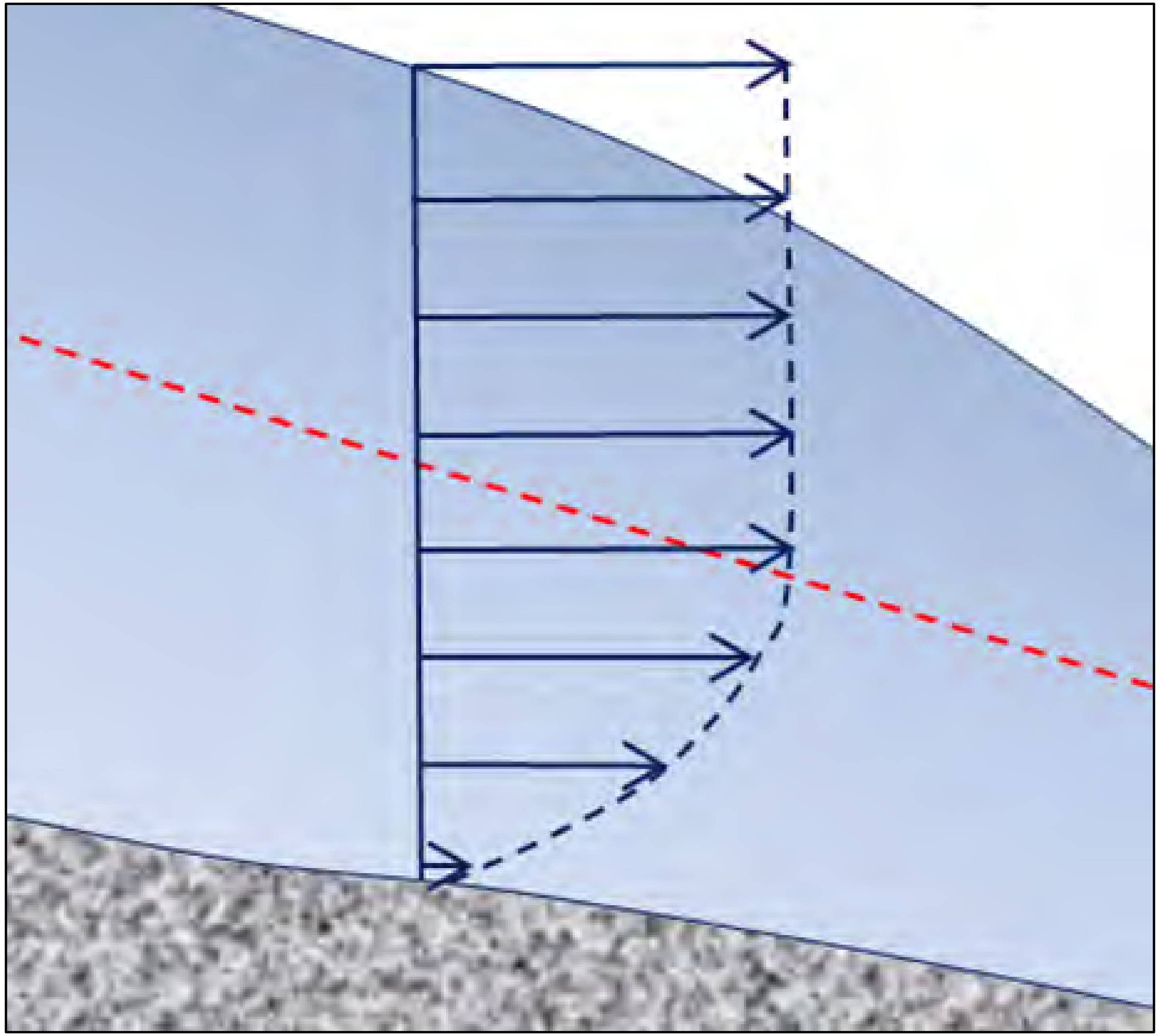
Ice flow across a landscape



1b. Erosion

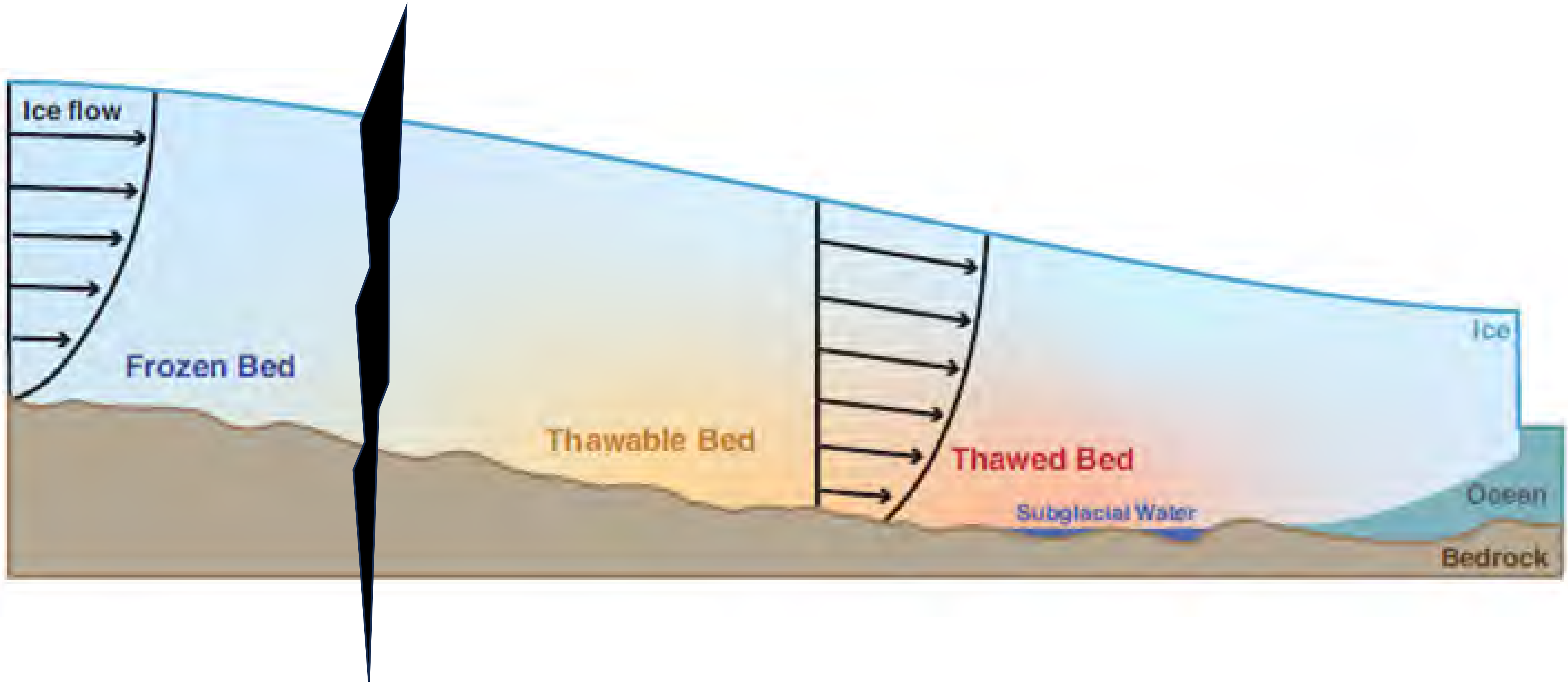

BBC

Glacier movement (ice flow)



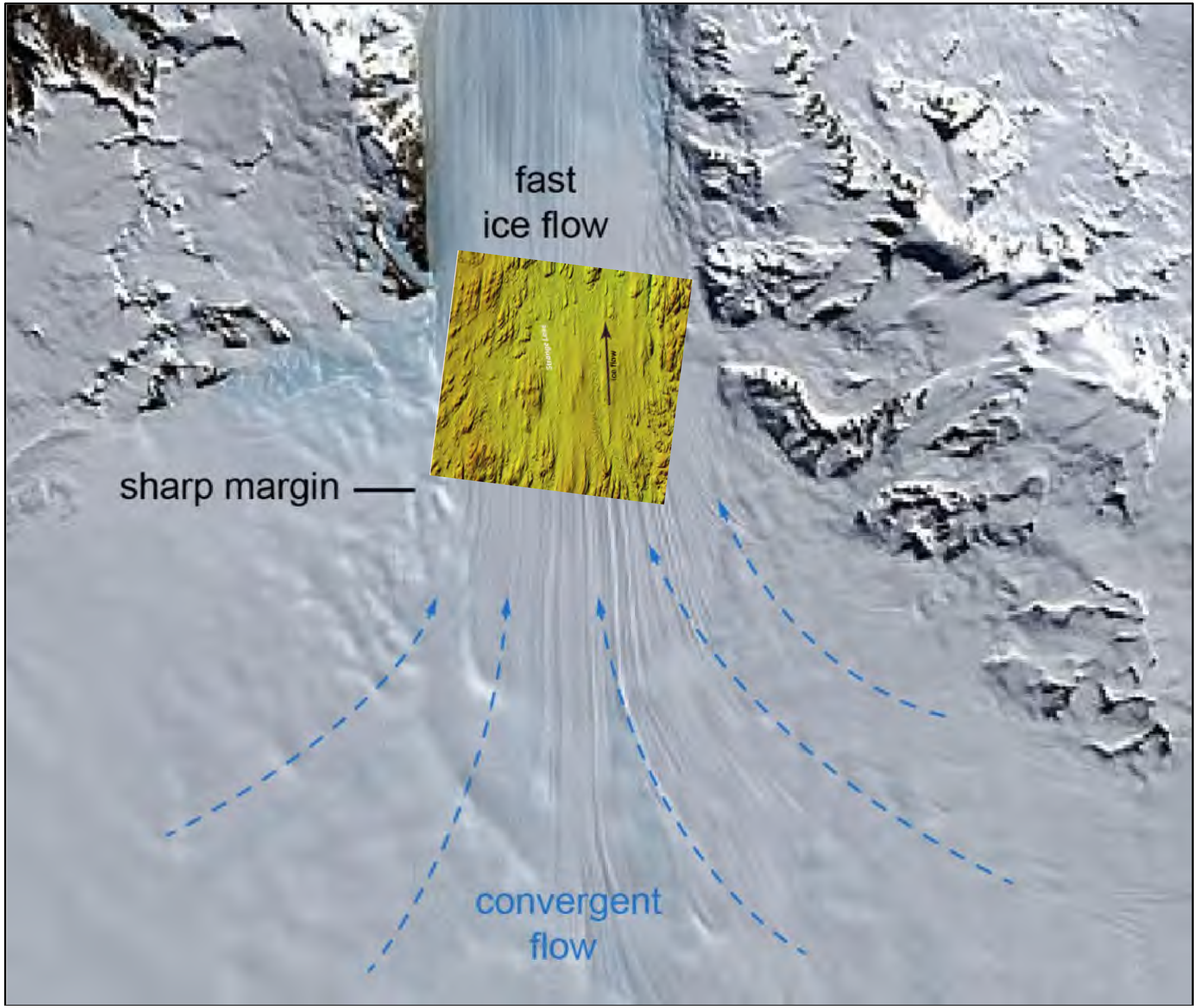
Modified by Earle (2017)

Cold vs warm based glaciers



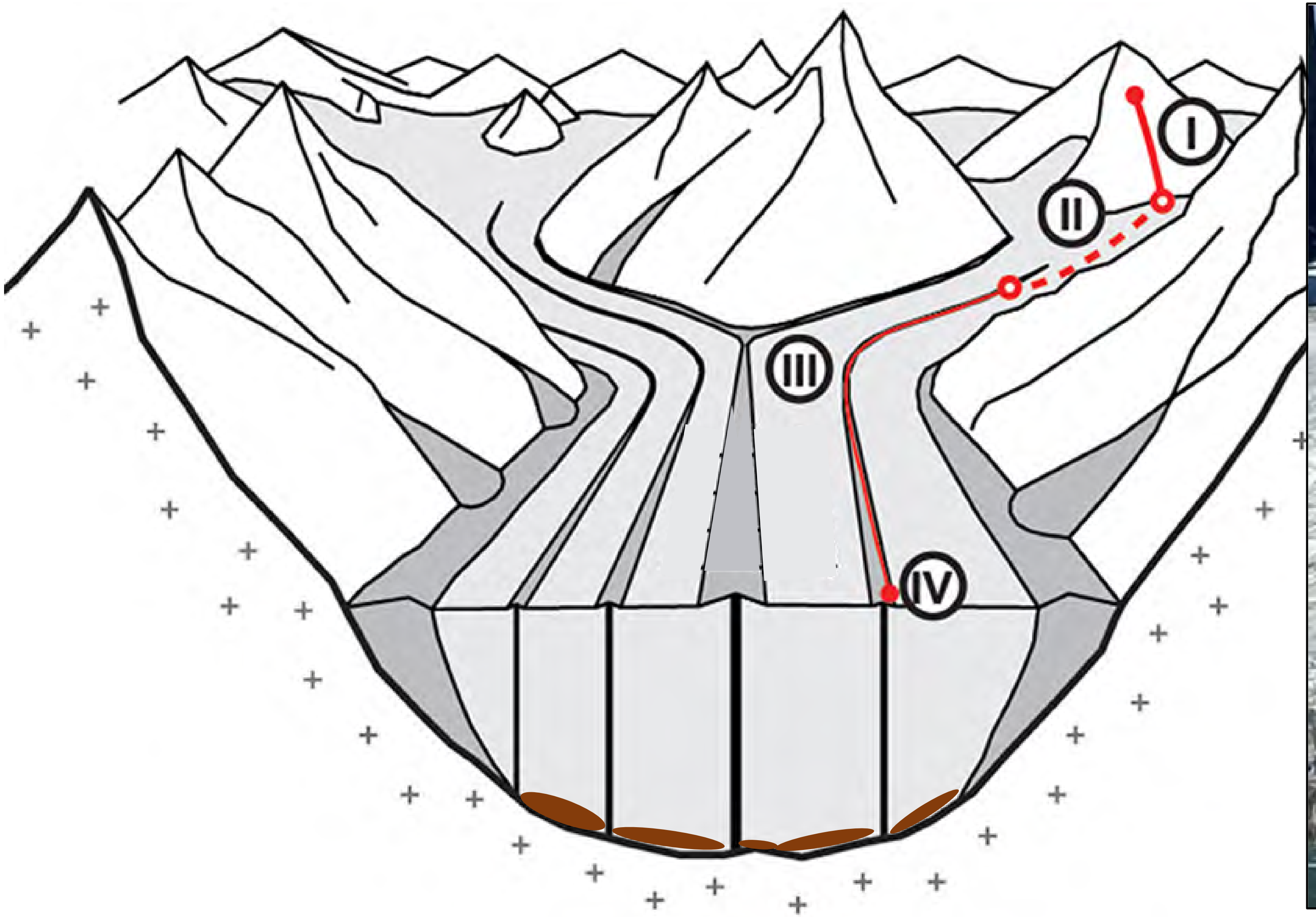
Dawson et al. (2022)

Ice stream



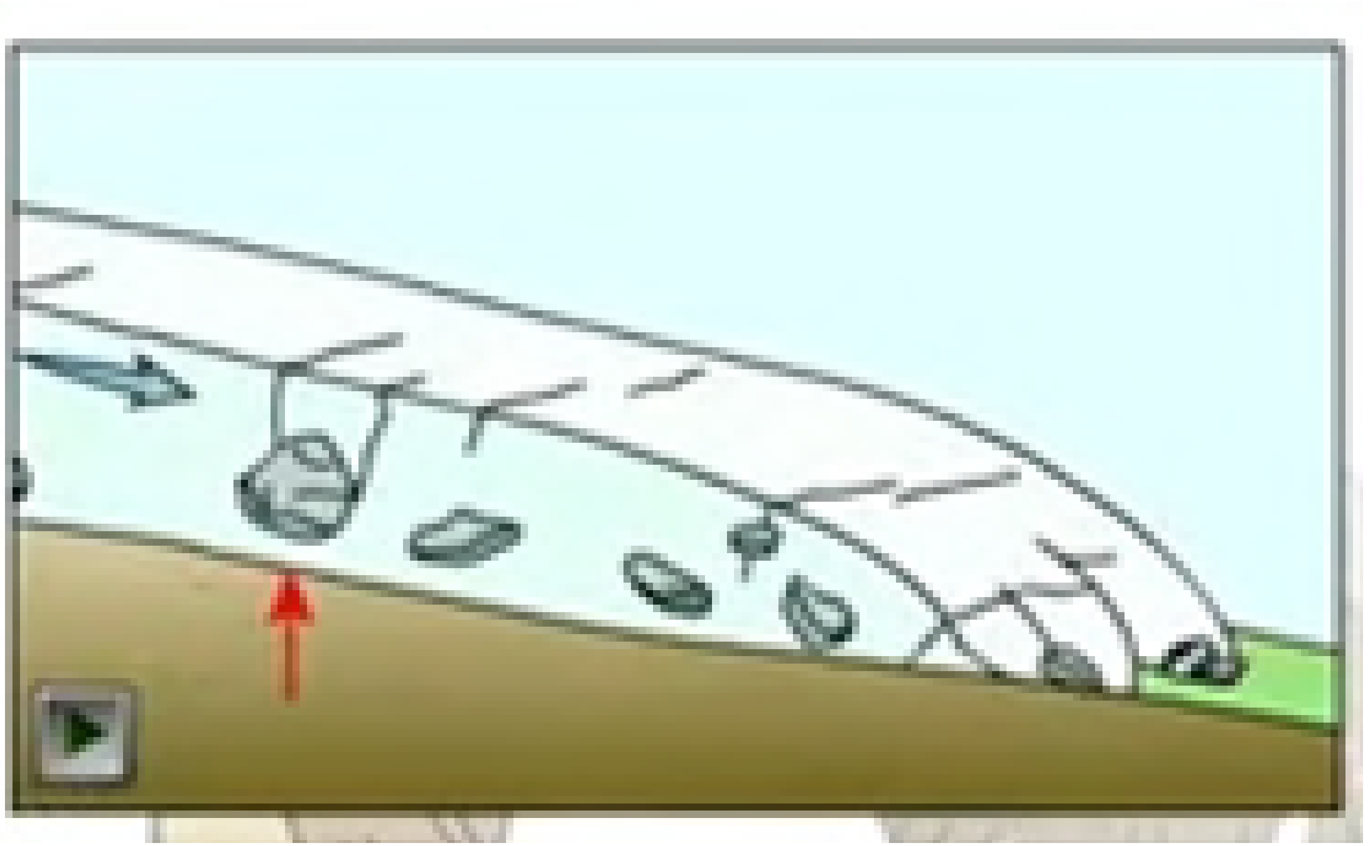
NASA image modified by Brendle (2020)

Transport of rock fragments in ice

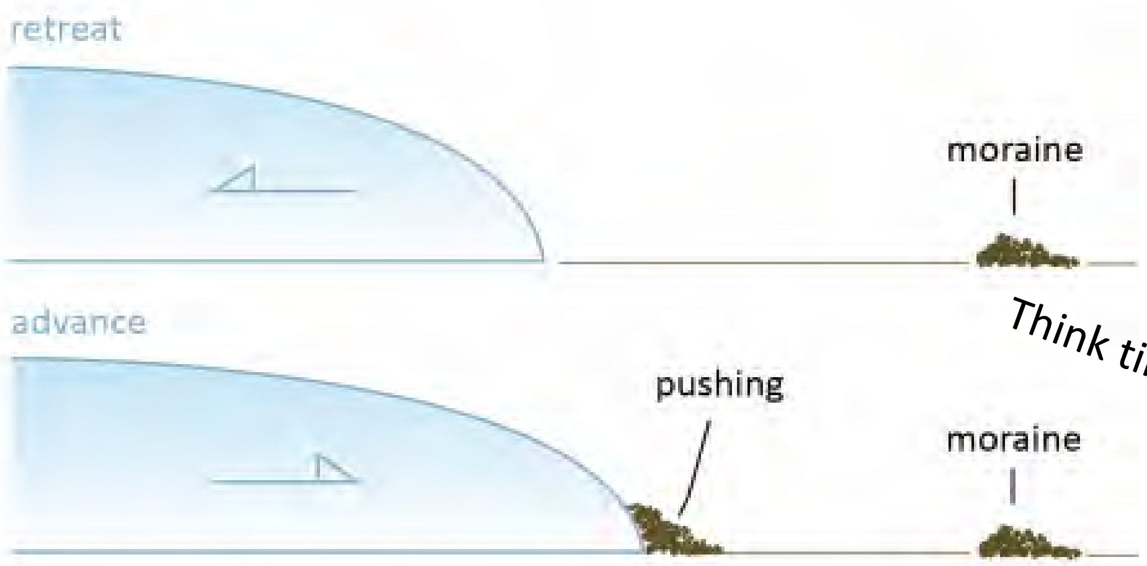


Cross-section modified from Scherler and Egholm, 2020

Transport of rock fragments in ice

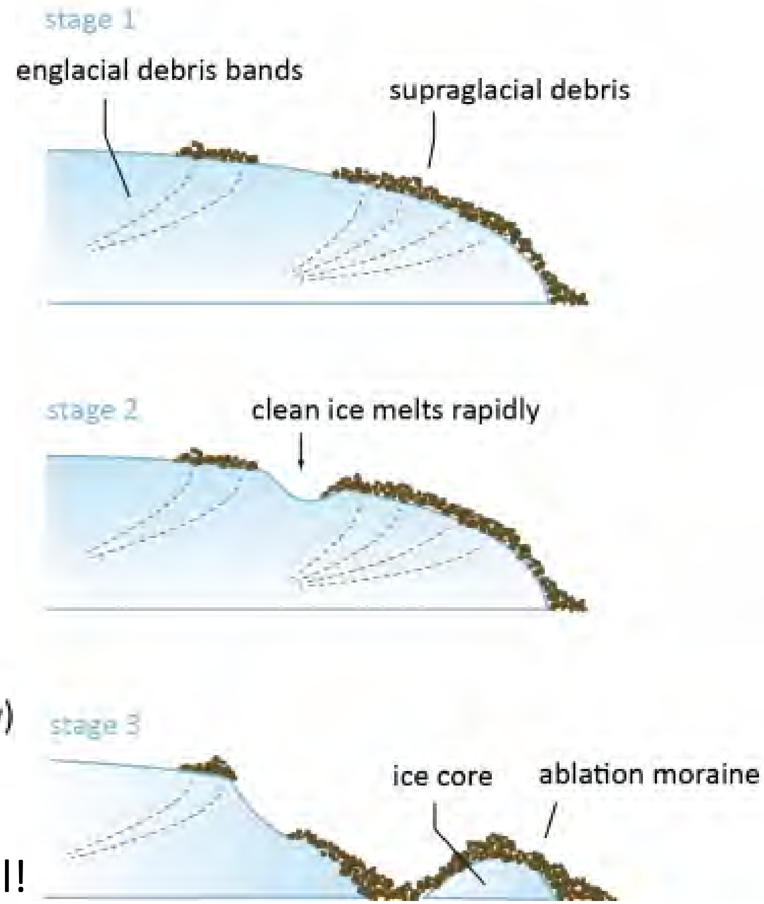


Push moraine

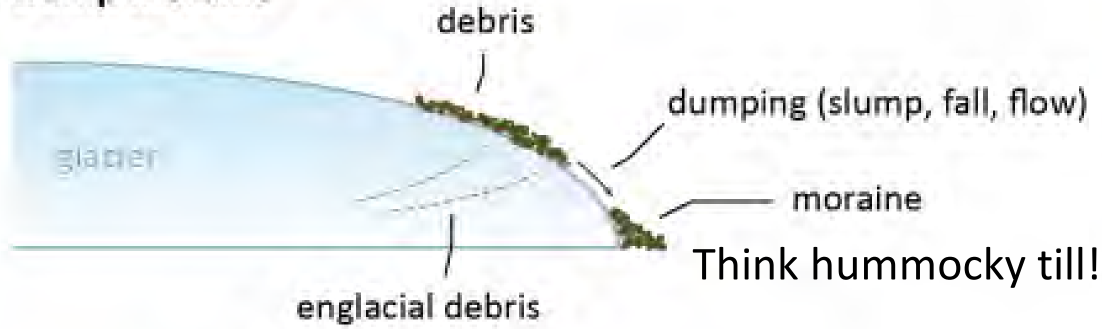


Think till ridges!

Ablation moraine



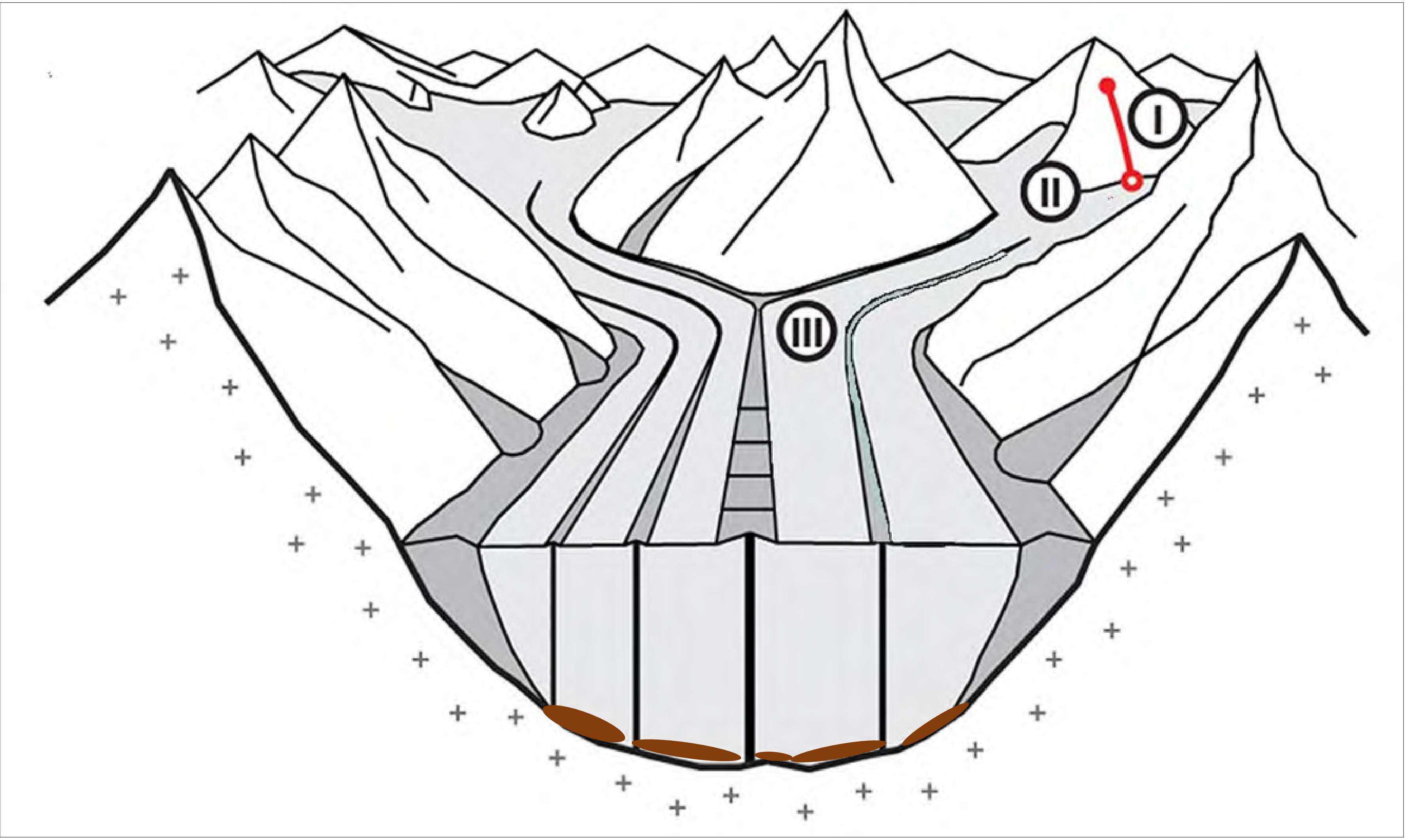
Dump moraine



Think hummocky till!

Bendle (2020)

Glacial till

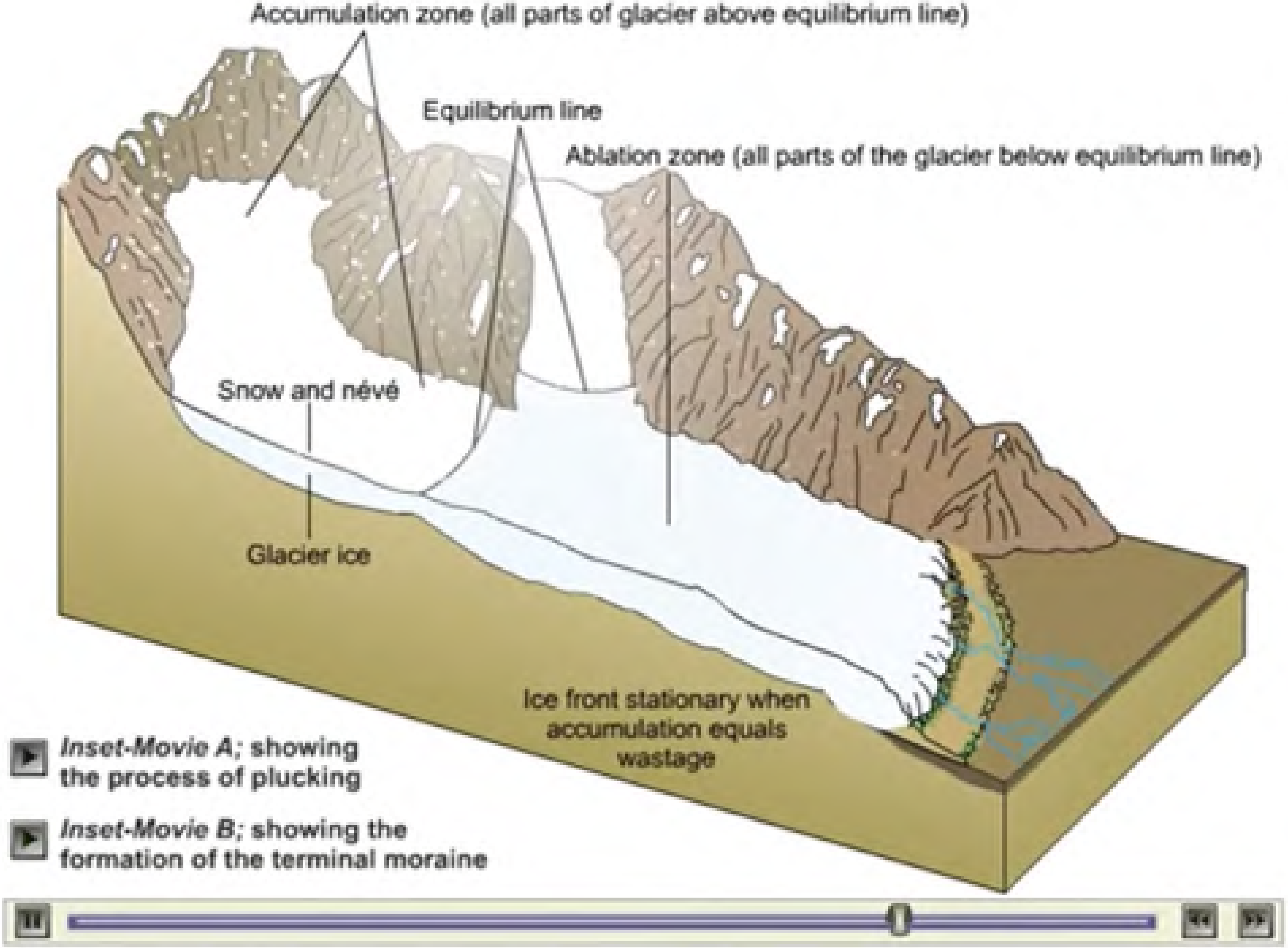


Transport:
Lateral moraine
Medial moraine
End (terminal) moraine

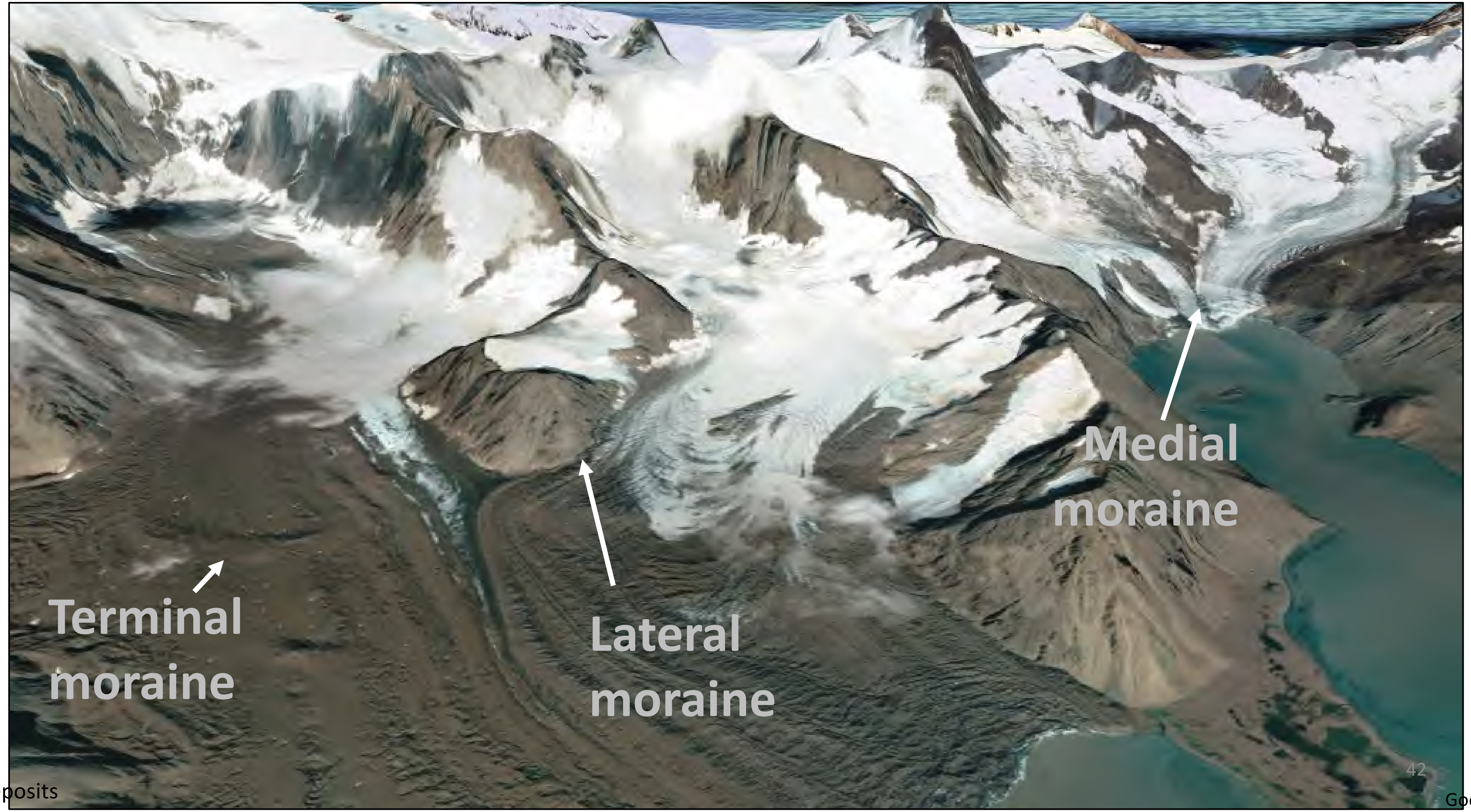
Subglacial till

First derivative of bedrock!

Glacier retreat



Glacial deposits



Google Earth

Crevasses

Photo by: Yves Adams

Cracks within glacier formed from stress: ice moving at different rates

This happens at:

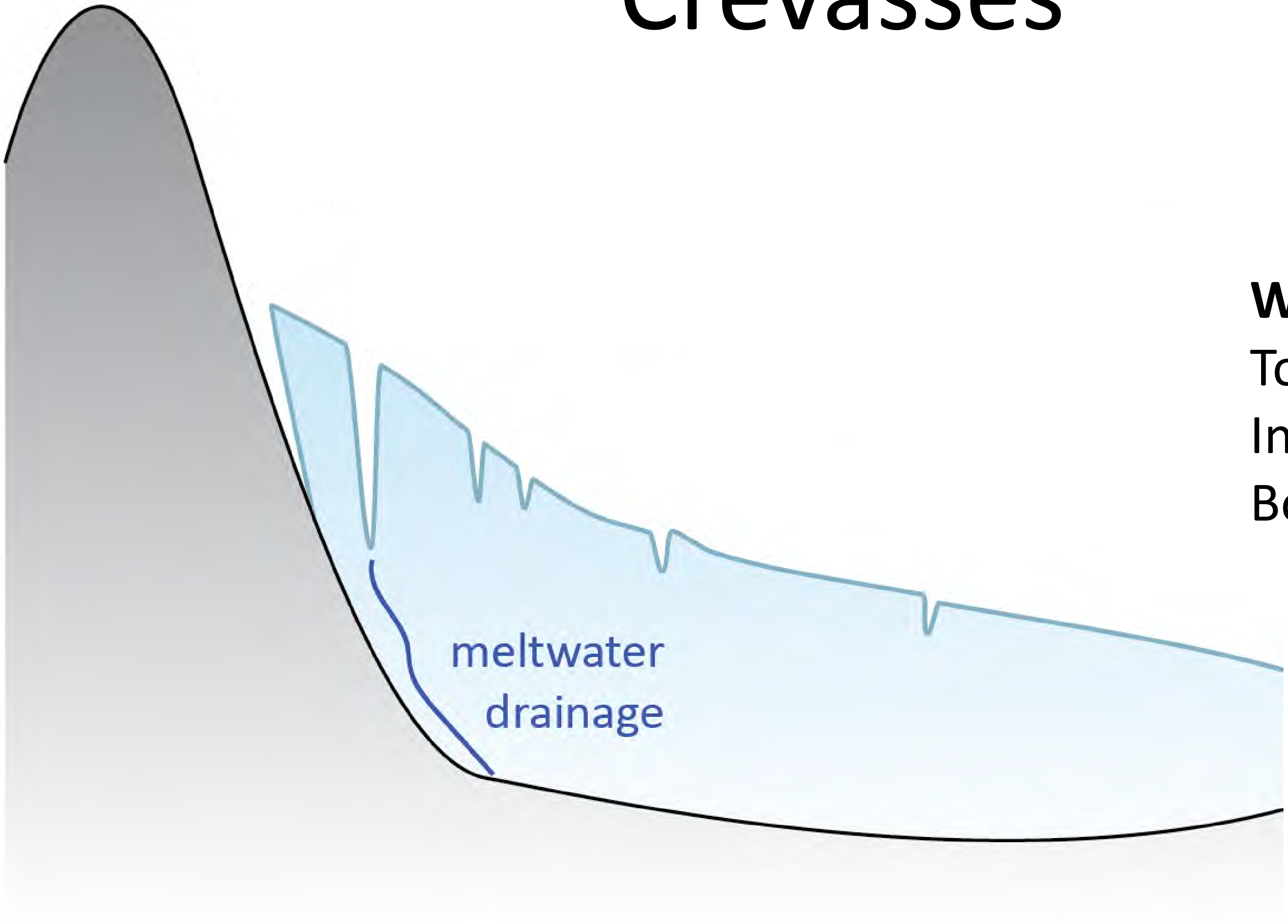
-bumps in the mountain

-space to flatten out

-base of a glacier

-tidewater flexes

Crevasses

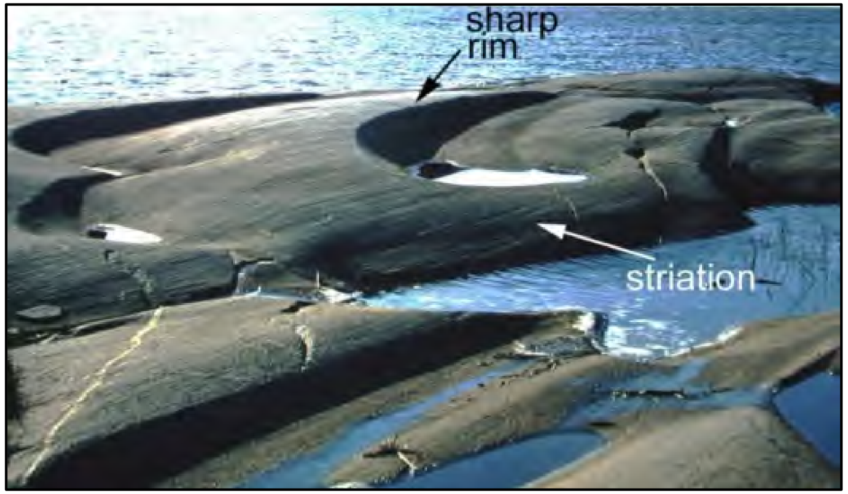


Water transport:
Top - supraglacial
Inside - englacial
Bottom - subglacial

Modified from AntarcticGlaciers.org

Glacial meltwater erosion

- Susceptibility of bedrock involved (weaknesses)
- Amount of water and velocity
- level of turbulent flow
- Quantity of sediment in transport
- Form Sichelwannen, p-forms



Shaw et al. (2020)

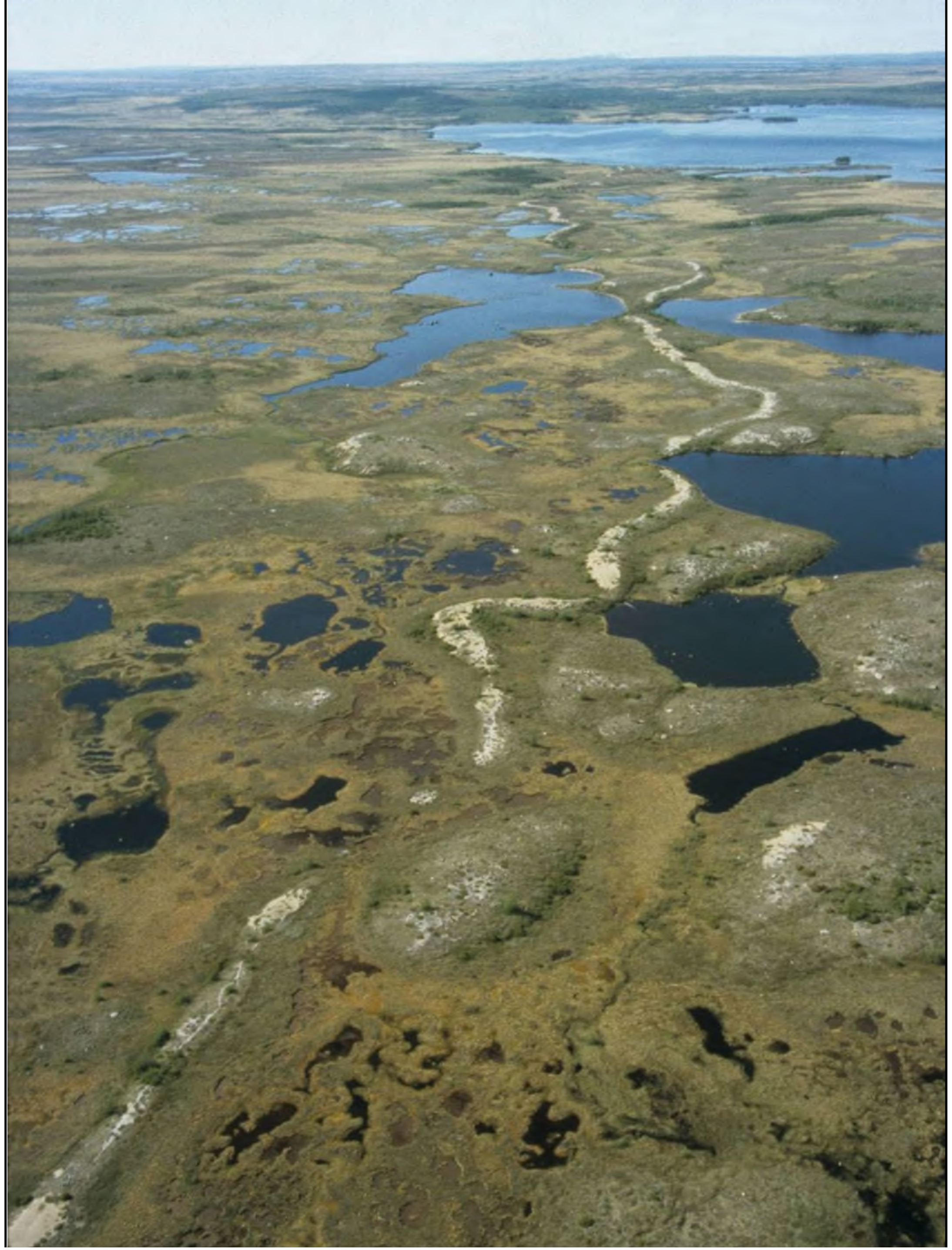
Mullgeology.net/pforms

Glacier drainage


Shilts (2014)


Shilts (2014)

Eskers



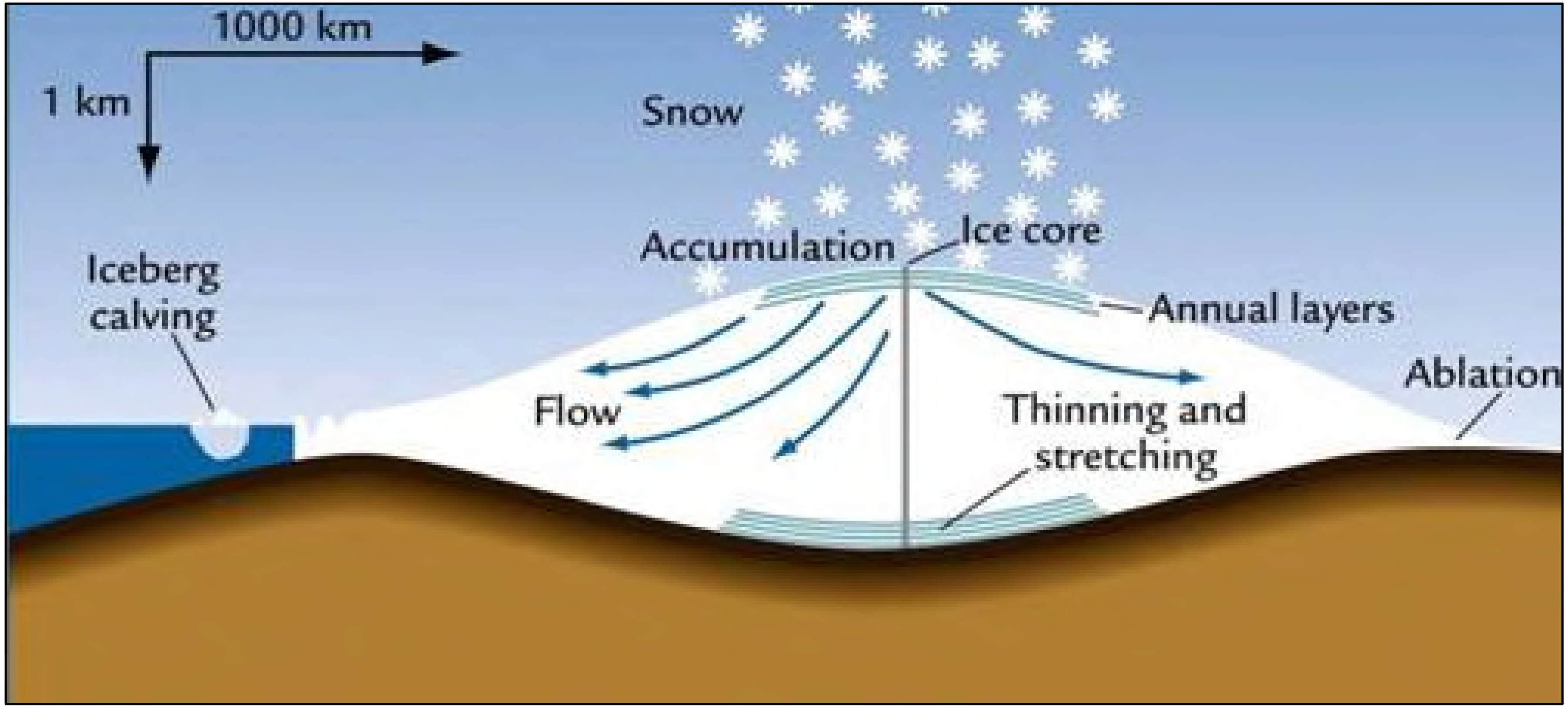
Eskers

1f. Meltwater

Source GSNL

Raised beaches

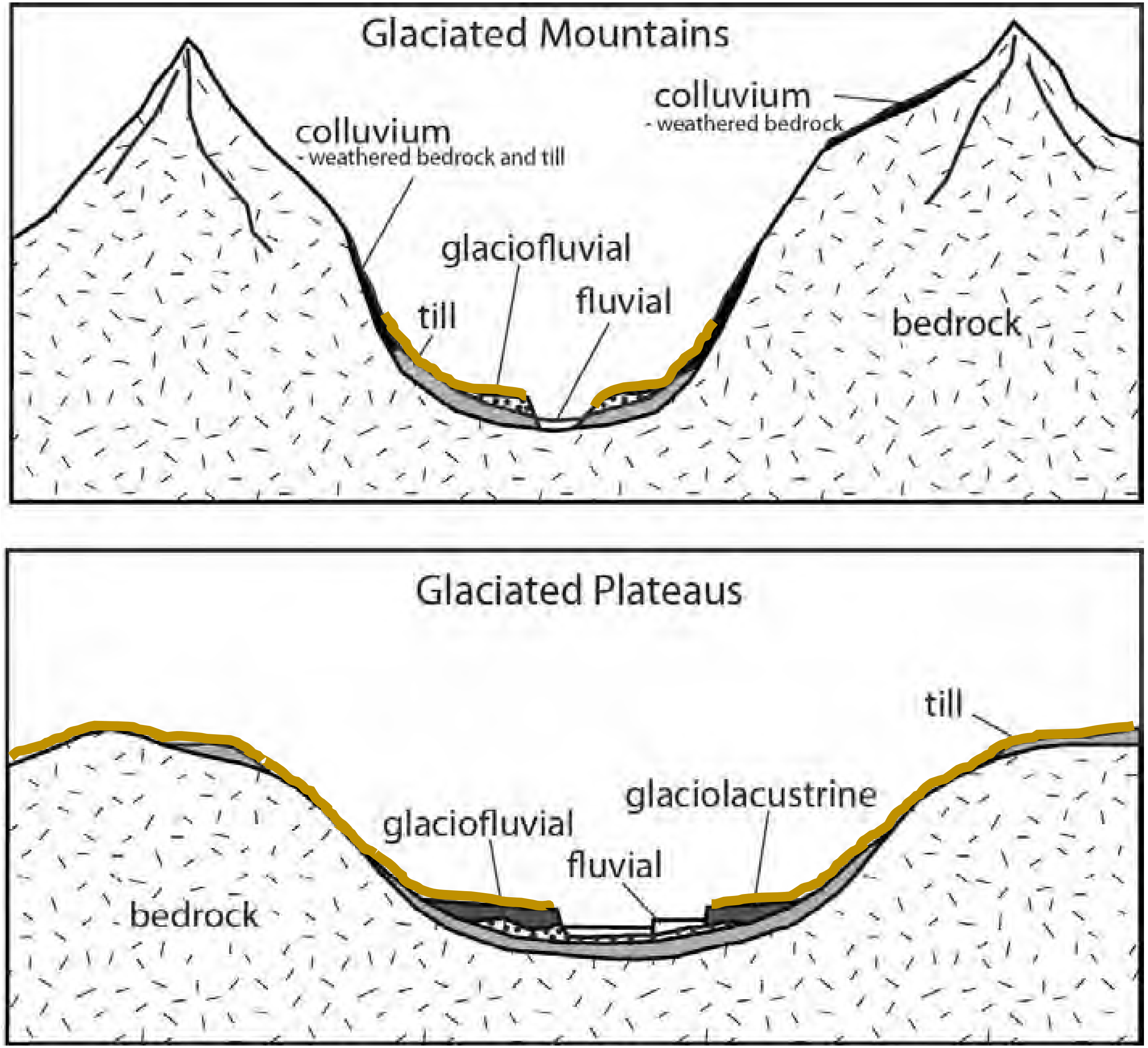
Heavy


1000 km
1 km
Snow
Iceberg
calving
Accumulation
Ice core
Annual layers
Ablation
Flow
Thinning and
stretching

Isostatic rebound

Raised beaches

Beauregard (2013)

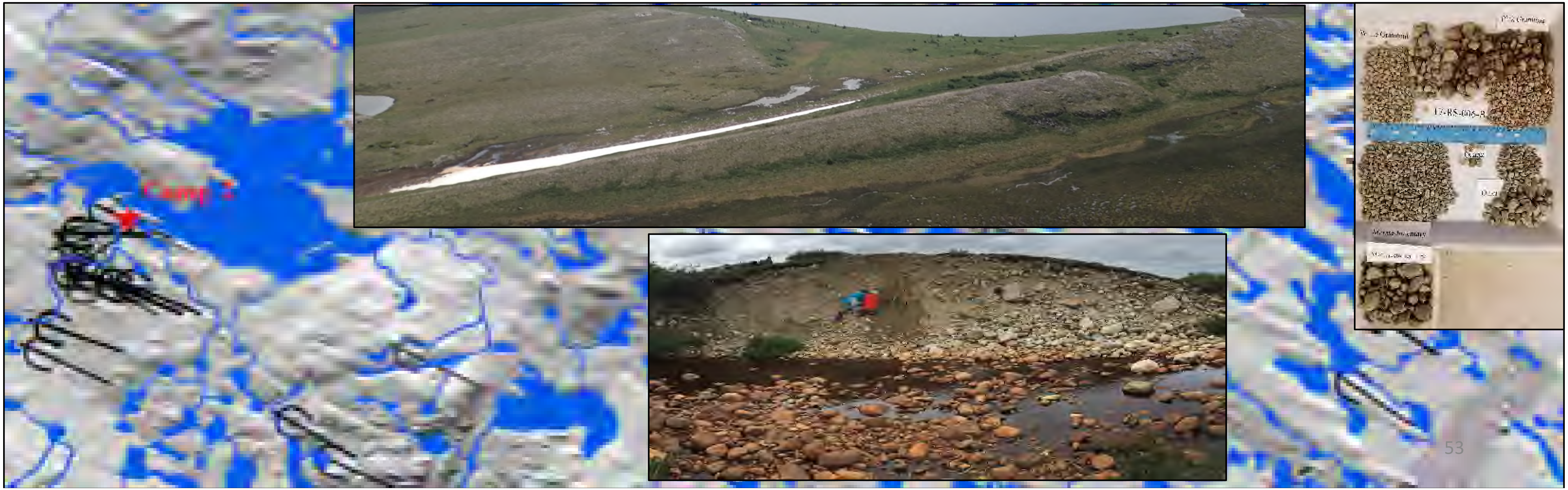


Soil!

1g. Legacy

Modified from YGS (2007)


Greenland, J.Briner


Camp 2

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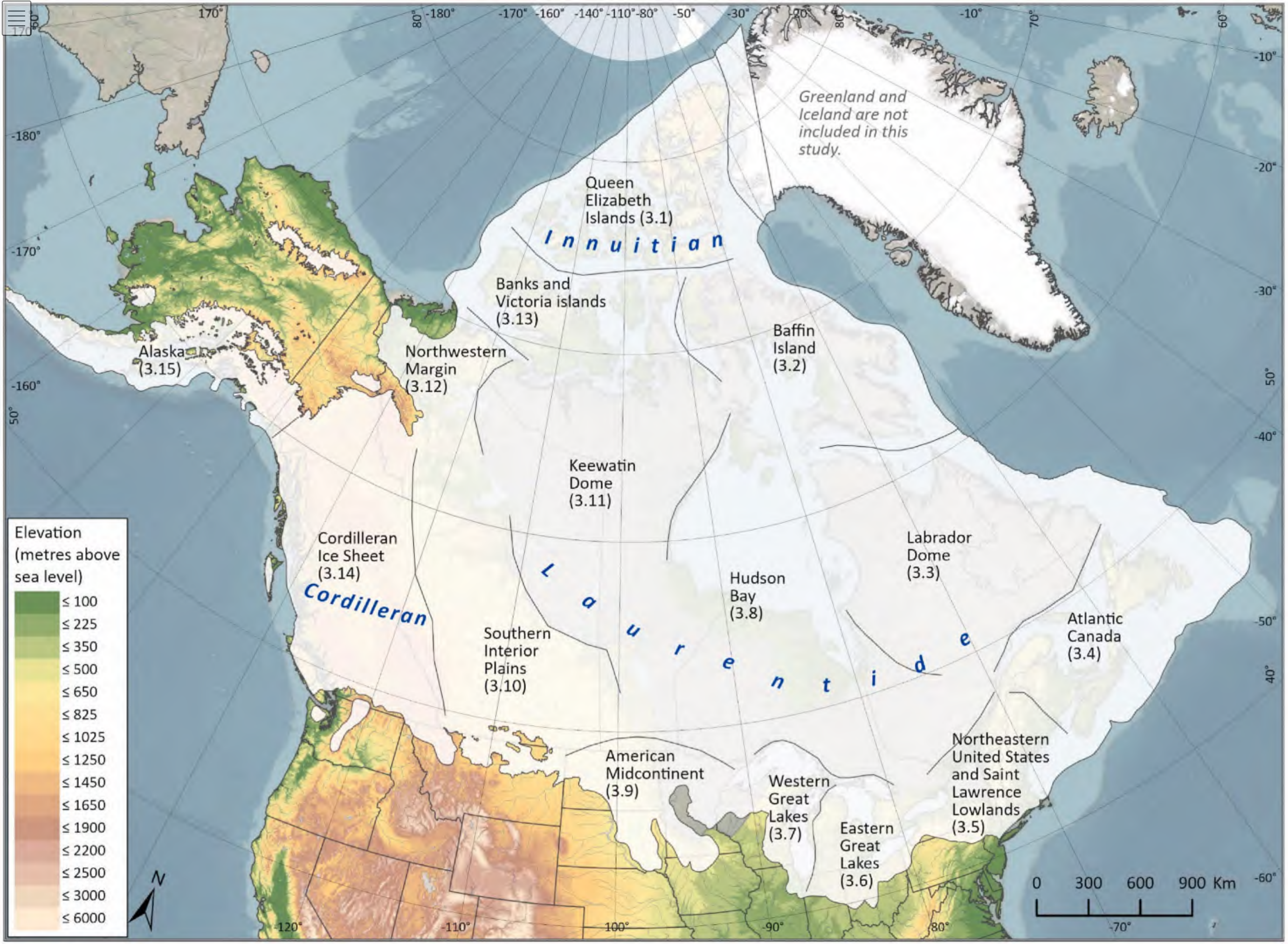

Earth-Science Reviews
Volume 224, January 2022, 103875

Evolution of the Laurentide and Innuitian ice sheets prior to the Last Glacial Maximum (115 ka to 25 ka)

April S. Dalton [a,b], Chris R. Stokes [a], Christine L. Batchelor [c]

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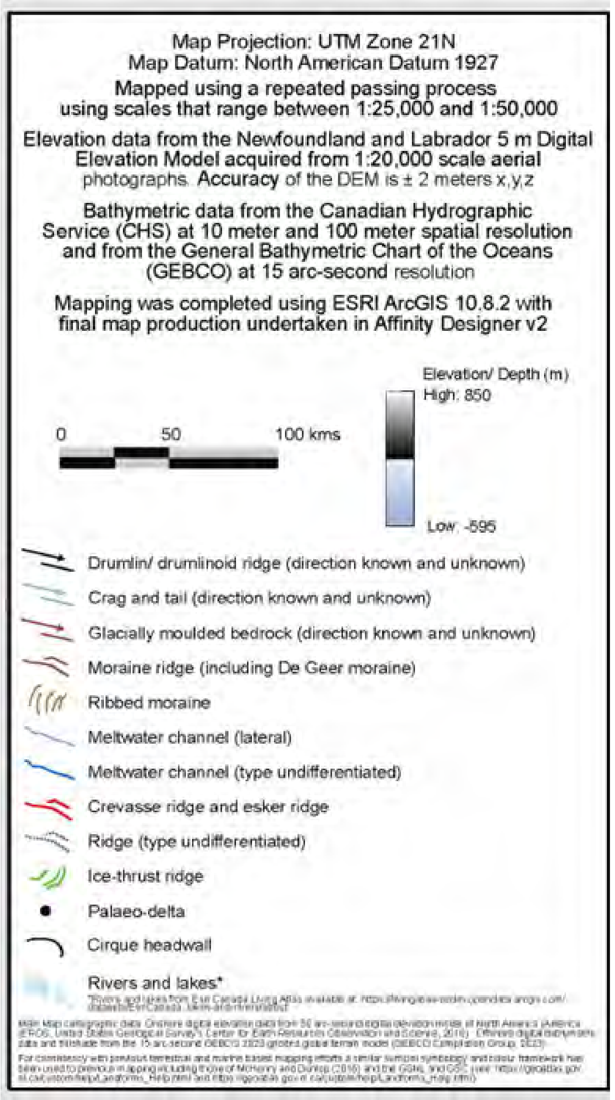
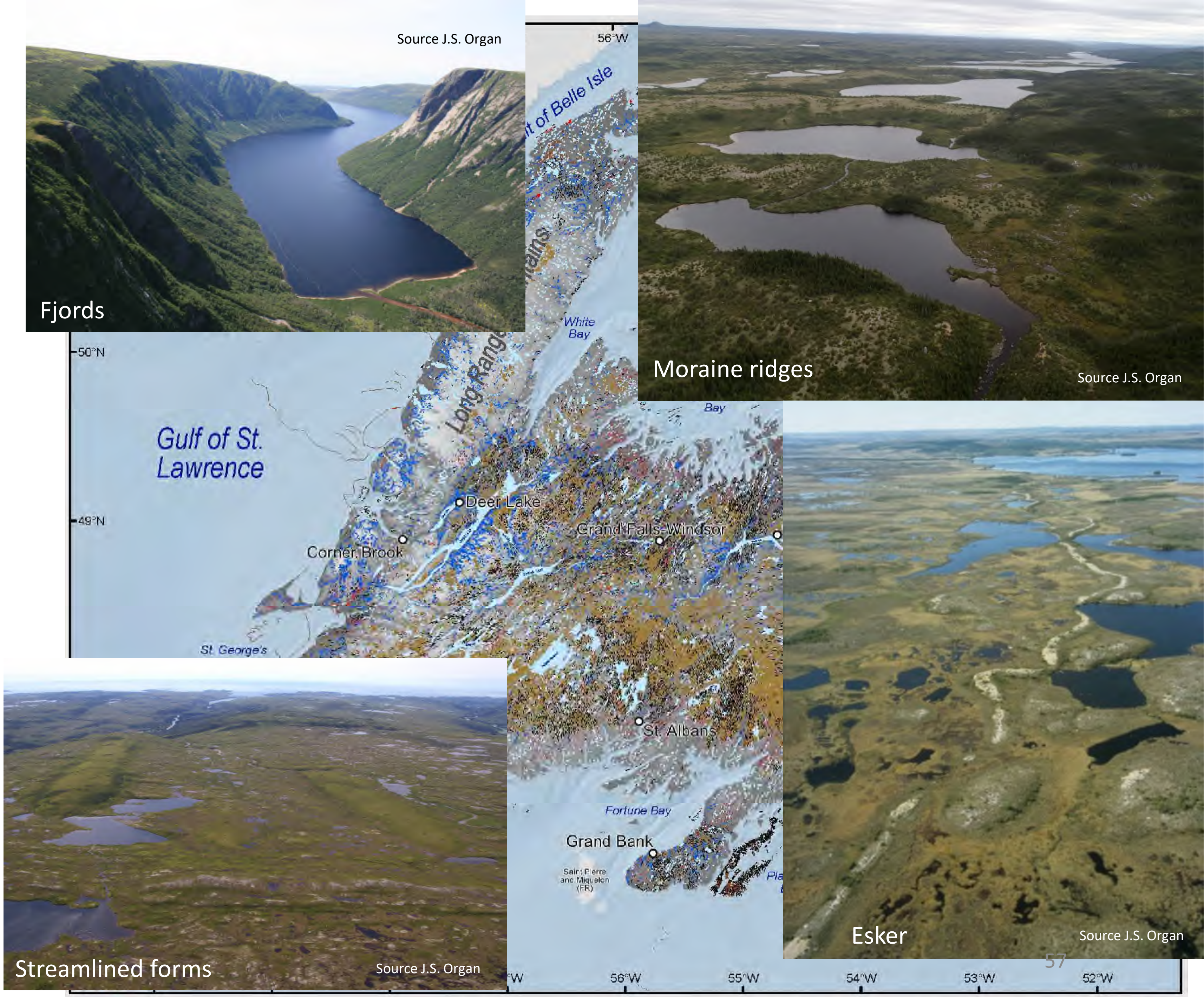
2. Glaciation of Newfoundland and Labrador

13ka (c. 14.8 ka cal BP) (Shaw et al., 2006)

12ka (c. 14 ka cal BP) (Shaw et al., 2006)

Glacial Geomorphology of Newfoundland





Journal of Maps, Volume 20, 2024 – Issue 1
https://doi.org/10.1080/17445647.2024.2386296

Glacial deposition

- Unsorted unstratified sediment is often referred to as a diamicton
- When deposited by ice = Till

Yoho Valley, British Columbia

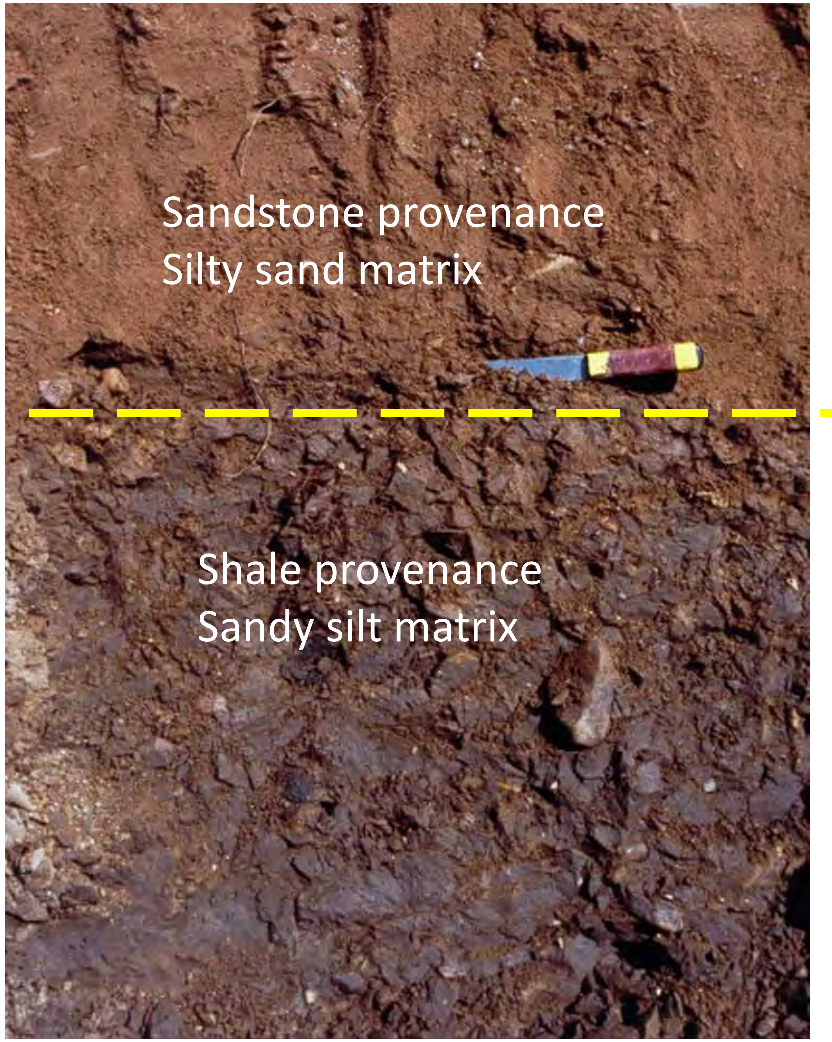
Till characteristics

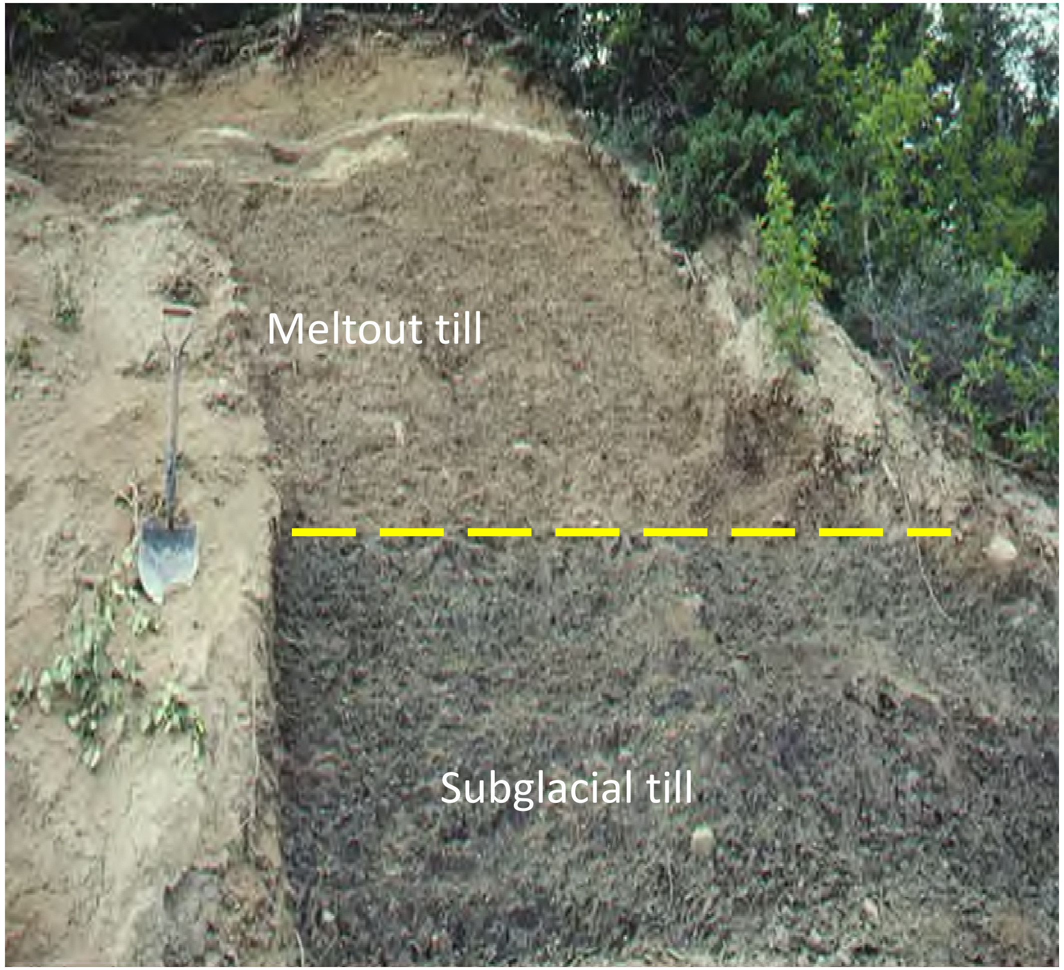
- Poorly sorted mixture of sediment
  - clay to boulders
- Matrix-supported (silt/clay/sand)
  - Silty sand/sand silt typical on the Island
- Clasts: local to far travelled (e.g., exotic)
- Clast shape: angular to subrounded
- Fabric: common orientation of pebbles
- Striated and faceted clasts

Striated and faceted clasts

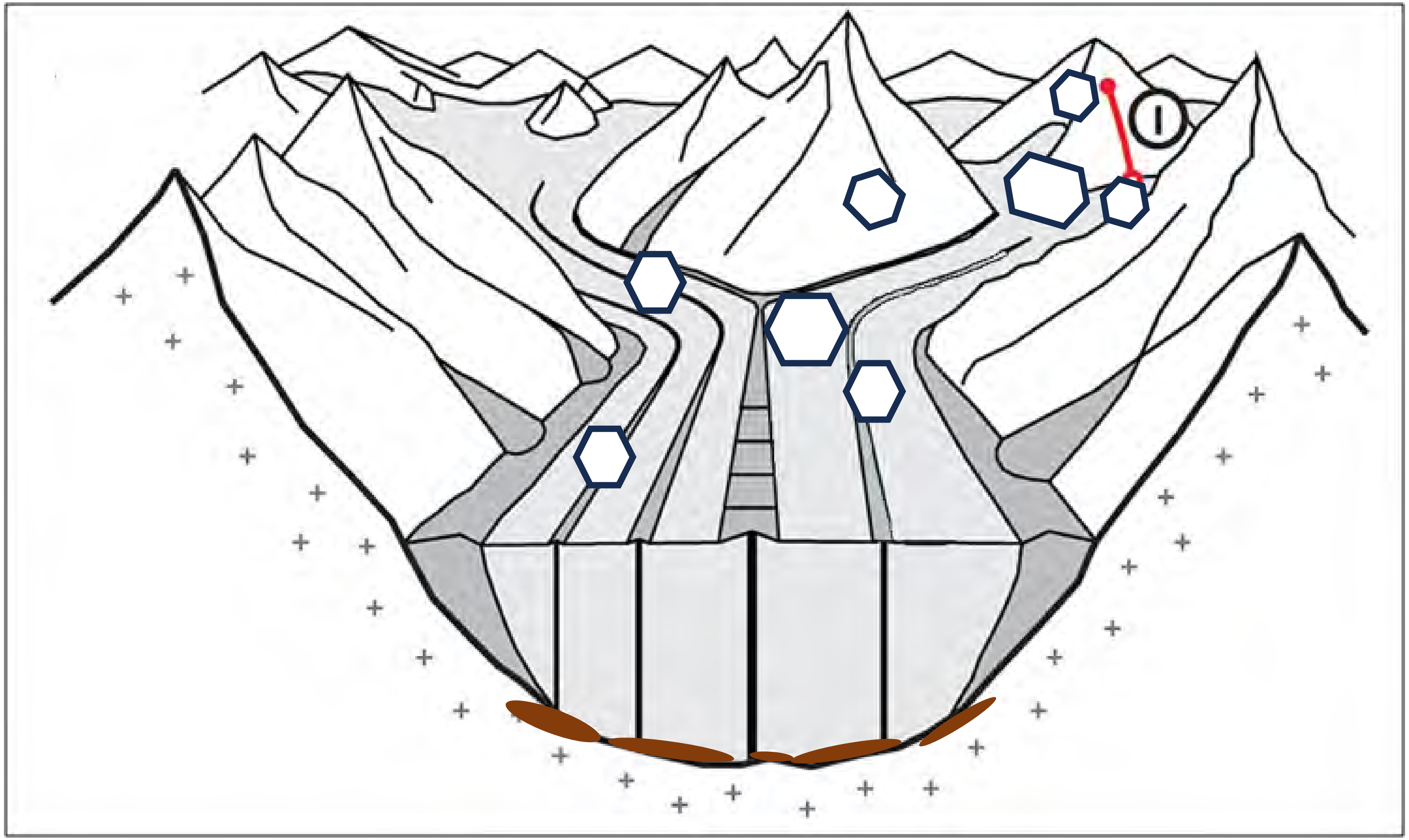
(Barrett et al., 2005)

Variable till textures





Supraglacial till vs subglacial till



Subglacial

- Material deposited at the base of the ice (usually locally derived)
- Compact to over-consolidated (hard to dig)
- Matrix-supported, massive (structure less)
  - High silt-clay content
- Moderate to strong fissility
- Striated and faceted clasts
- Subangular to subrounded clasts
- Deposited by actively flowing ice

Source GSNL

Source J.S. Organ

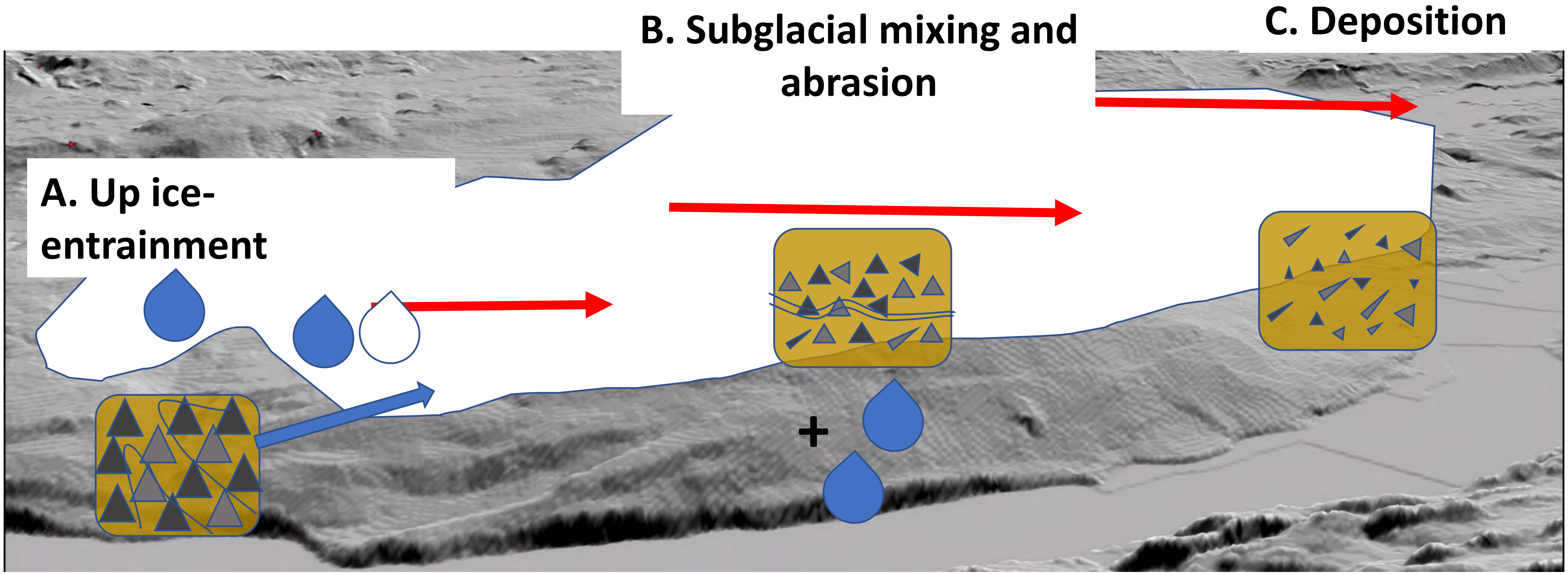
Compact

Fissile

Source J.S. Organ

2a. Glacial Deposition

Subglacial till formation



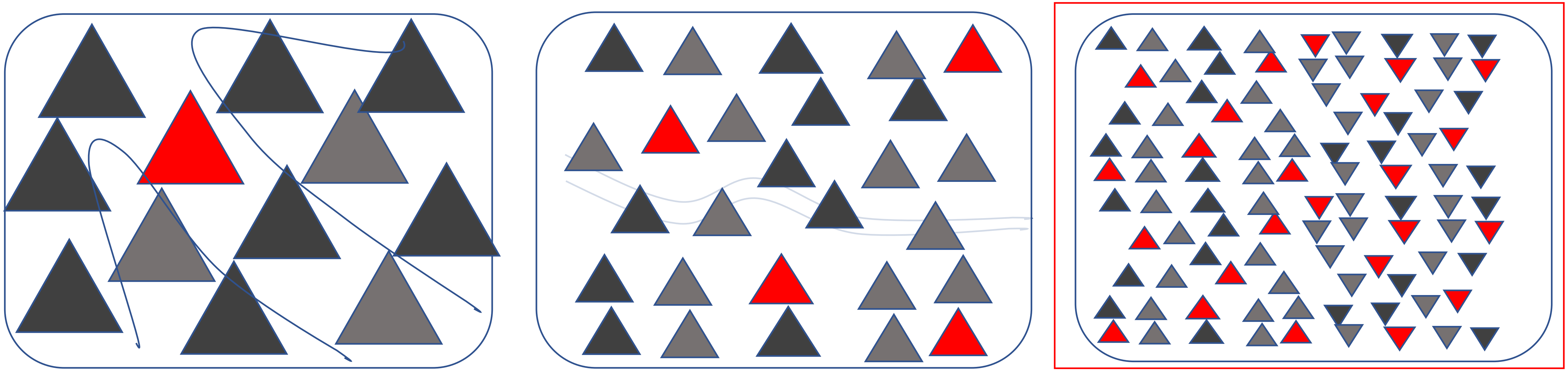
- Subglacially formed diamicton = till
- Best sample material (<0.063mm fraction) - consists of broken up bedrock
- Identified generally by higher silt + clay, higher compaction, angular material

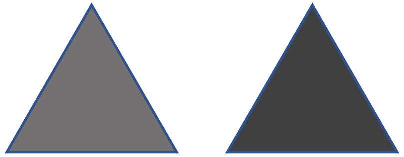
(Slide courtesy of Heather Campbell)

B. Comminution

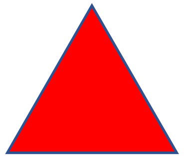
Coarse-Grained
(nearer to bedrock source)

Finer –Grained
(further from bedrock source)





- **Unmineralized**



- **Mineralized**

Finer-grained material (<0.063 mm)=more mineralized bits=higher probability of detection in a single sample

(Slide courtesy of Heather Campbell)

Indicative Material for Tracing To Source-Boulders/Cobbles/Pebbles

Bedrock Source → **Near Source** → **Farther from source**

Source-distinctive net textured diorite (Mount Peyton)

Faceted boulder several kms northeast of Mount Peyton

Subrounded cobble > 10s of km northeast of Mount Peyton

(Slide courtesy of Heather Campbell. Photo and rock identification courtesy of Hamish Sandeman)

Supraglacial till

- Composed of material deposited within or on top of glacial ice
- Loose, not compact
- Massive to crudely stratified
- Lenses of gravel or sorted material
- Soft sediment deformation
- Matrix or clast-supported
- Striated clasts less abundant
- More distally derived material

Source J.S. Organ

Till veneer (Tv)

- < 1.5 m thick
- Commonly overlies bedrock

Source J.S. Organ

Source J.S. Organ

Till blanket (Tb)

- >1.5 m thick
- Masks underlying topography

Source J.S. Organ

The Topsails

Source J.S. Organ

North Shore of Beothuk Lake

Multiple Tills

Near Pasadena

Source GSNL

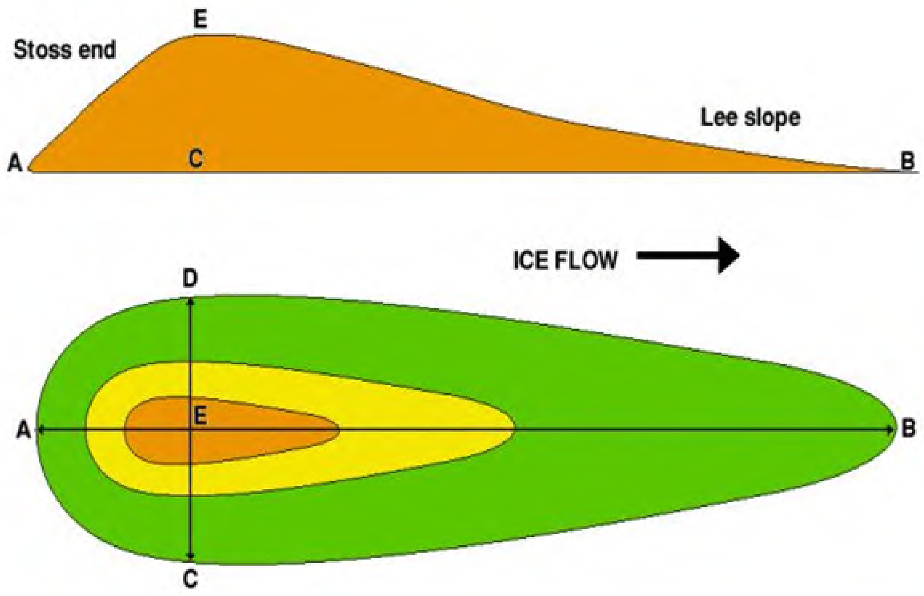
Source J.S. Organ

Beothuk Lake

Source J.S. Organ

Hampton

Drumlins (Tl)



http://www.geography-site.co.uk/pages/physical/glaciers/drum.html

Source GSNL

Northeast of Sarah Lake, Labrador

Streamlined forms

Source J.S. Organ

Streamlined form - Southwest coast

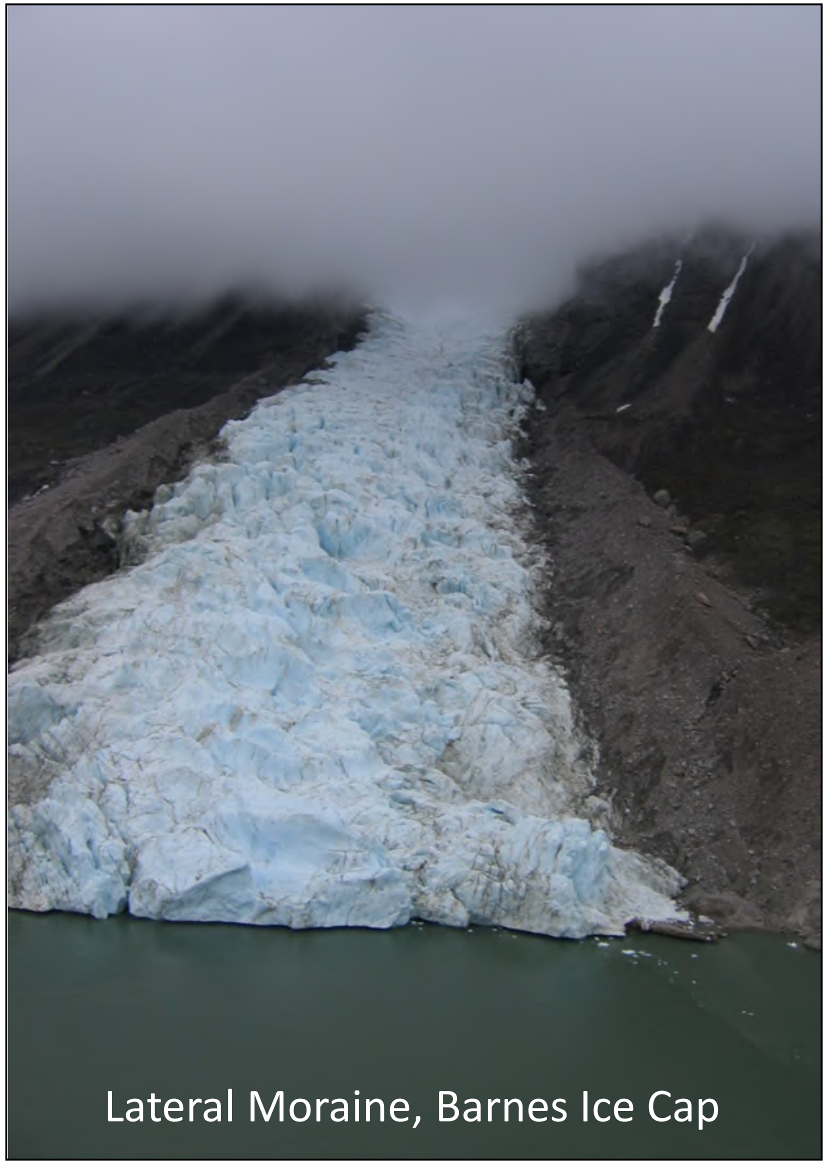
Source GSNL

Crag and tail – West of Pants Lake, Labrador

Moraines (Tr)

End Moraine, Barnes Ice Cap

Source D. Utting



Lateral Moraine, Barnes Ice Cap

Source D. Utting

Moraines

- Cross-valley moraines
- De Geer moraines
- Perpendicular to ice-flow

Source J.S. Organ

Rogen Moraine

- Irregular ridges
- Not useful for determining Ice-flow

Ocean Pond, Avalon
Source GSNL

Till hummocks (Th):

Hummocky Terrain – Noel Paul's Brook

Source J.S. Organ

Hummocky Terrain - Meelpaeg Lake

Source J.S. Organ

Sediment deposited by other processes

- Glaciofluvial – meltwater
- Marine/Lacustrine – standing water (ocean & Lakes)
- Fluvial – modern river systems
- Aeolian – wind
- Colluvium – gravity-driven slope processes

Sediment deposited by other processes

- Glaciofluvial – meltwater
- Fluvial – modern river systems
- Marine/Lacustrine – standing water (ocean & Lakes)
- Aeolian – wind
- Colluvium – gravity-driven slope processes

Glaciofluvial

- Sands and gravels
- Deposited by glacial meltwater
- Can be sorted
- Little to no silt clay
- Clasts more rounded

Gravel deposit – Exploits River

Source J.S. Organ

Glaciofluvial

Source J.S. Organ

Source J.S. Organ

Esker Complex, Sheffield Lake

Esker Ridge, West of Clarenville

Marine & Lacustrine

- Fine sand/silt/clay
- Suspension settling
- Standing water
- Very well-sorted
- Clasts rare - dropstones

Glaciofluvial sands and marine clay, Porcupine Strand
Source J.S. Organ

Drop stone
Source GSNL

Marine clay, Springdale
Source J.S. Organ

Fluvial

- Modern deposits overlie till
- Sands and gravels
- Sorted
- Clasts more rounded

Aeolian

- Fine sand
- Very well-sorted

Parabolic dunes, SE of Harp Lake, Labrador
Source GSNL

Coastal dunes, Cape Freels
Source GSNL

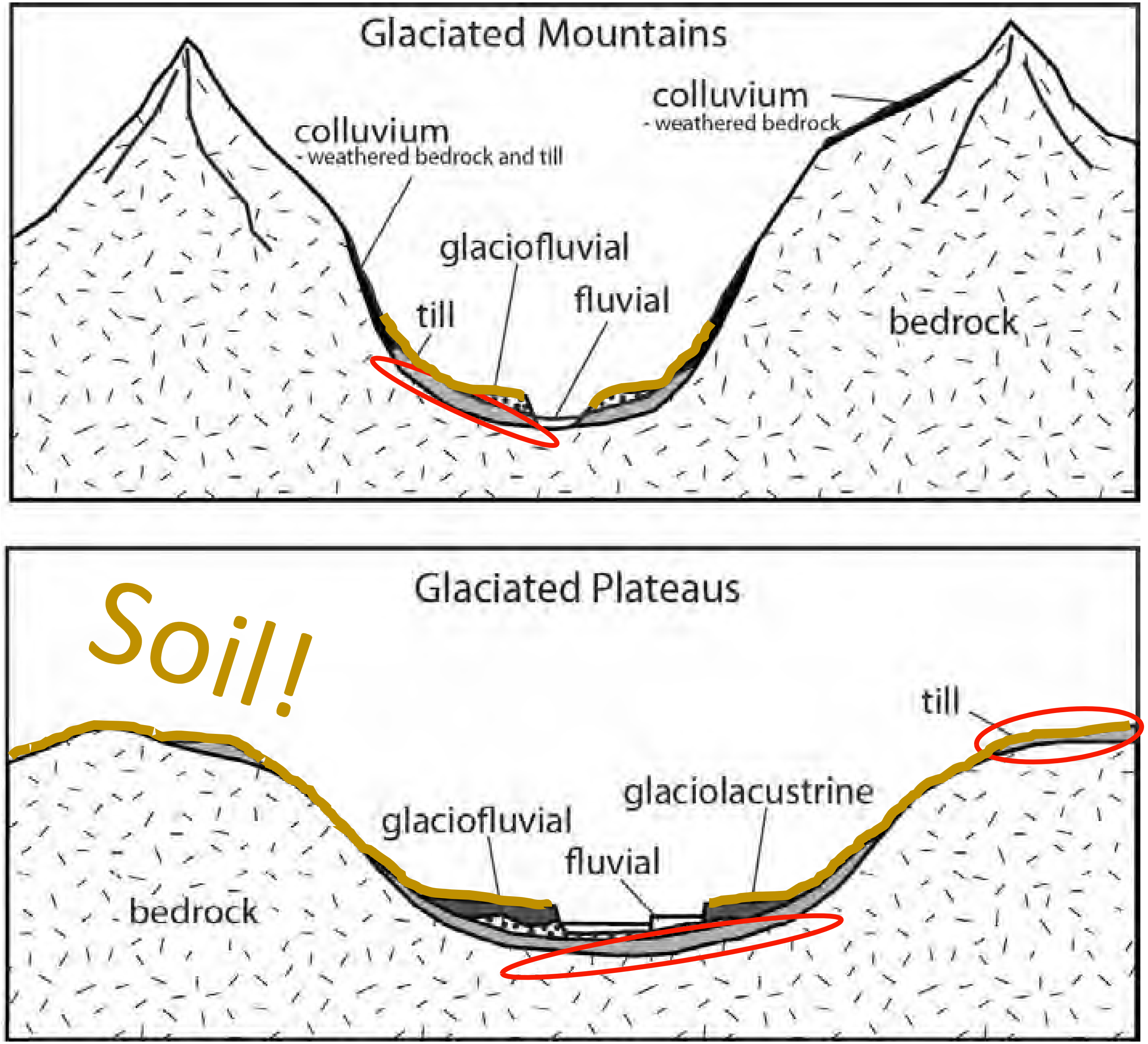
Colluvium

- Steep slope
- Very angular clasts
- Sorting, some bedding

Colluvium, Gros Morne Mountain
Source J.S. Organ

Sample material

- Make sure you are sampling till (first derivative of bedrock)
- Subglacial till is the best material to sample for your mineral exploration program



Yukon Geological Survey, 2007

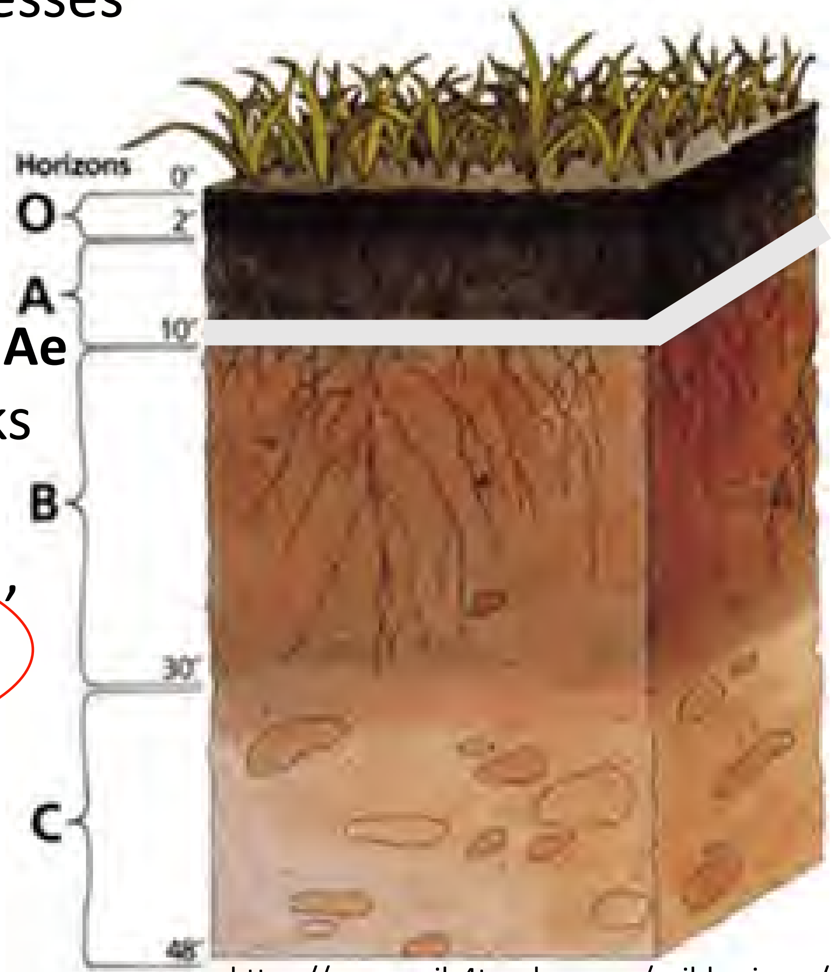
Soils

- Mixture of organic matter and underlying sediment
- Forms through chemical and physical weathering processes
- Has different horizons:

O – organic matter
A – horizon: organic-rich material near surface
Ae – horizon: leached grey horizon (looks ashy)
B - horizon: chemical/physical alteration, enriched in Al or Fe-Mn oxides (gives orangey - brown color)

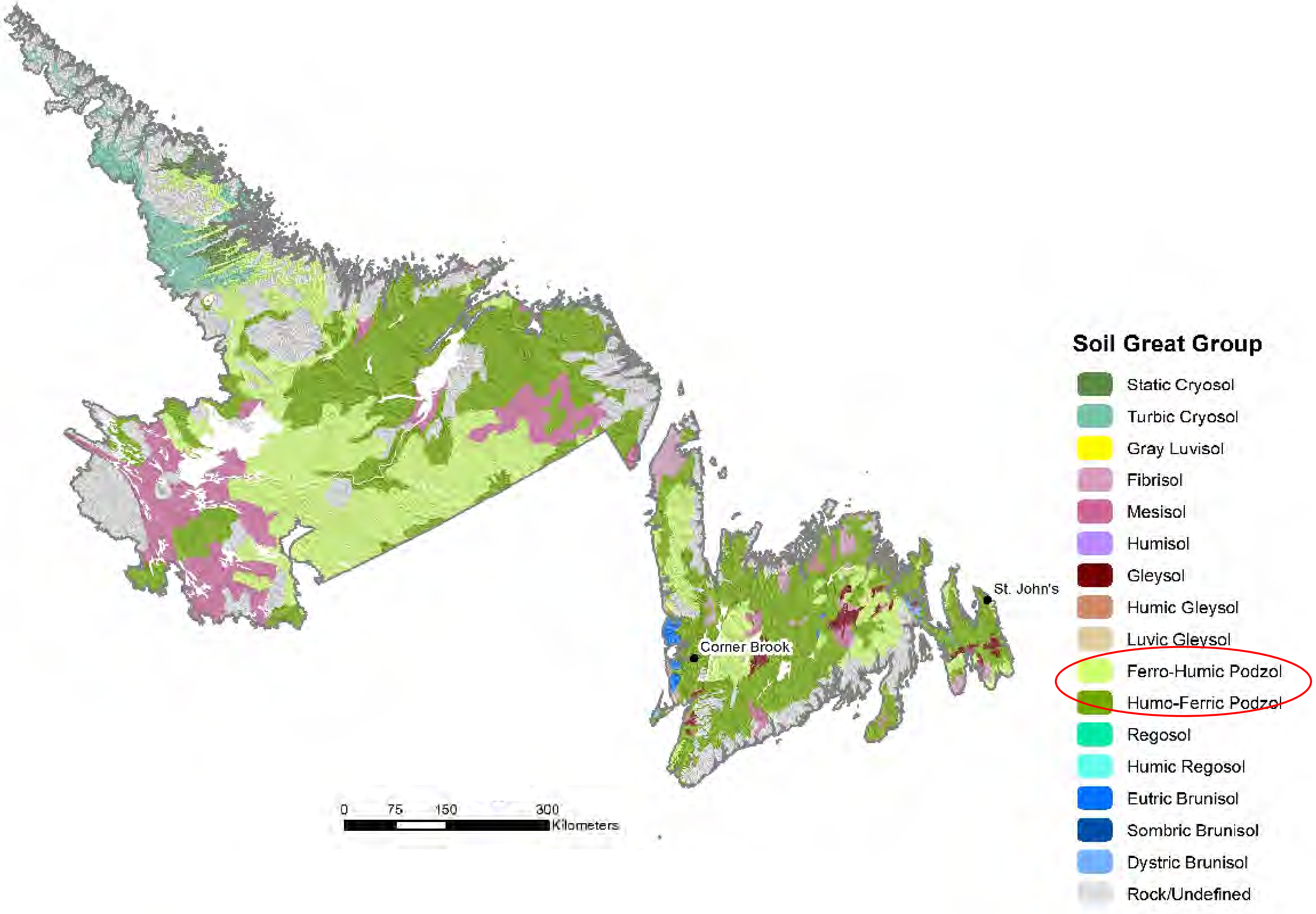
C – horizon: unaltered parent material

Mineral exploration (weathered parent material)



https://www.soils4teachers.org/soil-horizons/

Soils

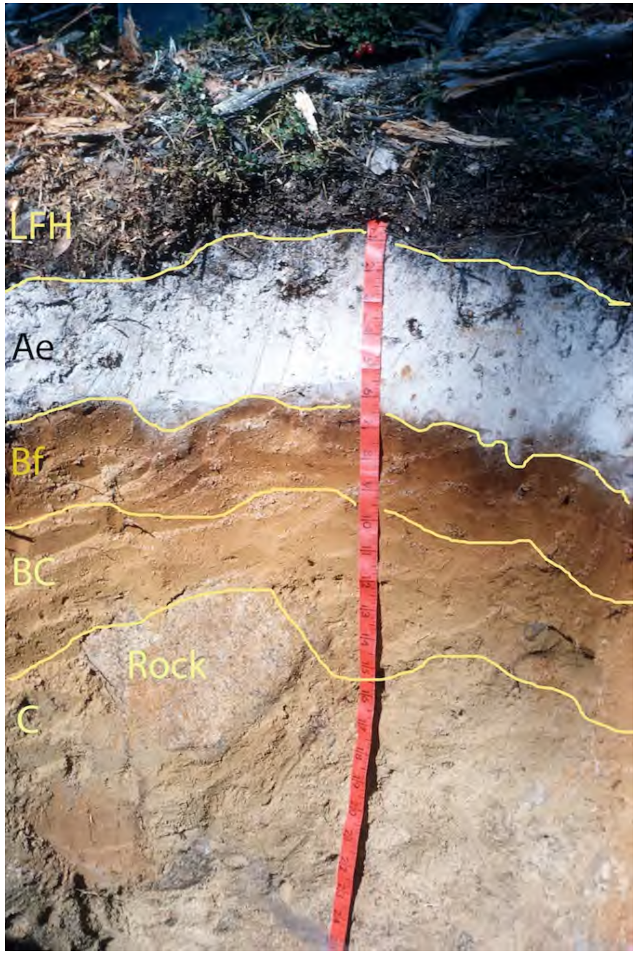


[Soils of the Atlantic Provinces – Digging into Canadian Soils (usask.ca)]

Soil development

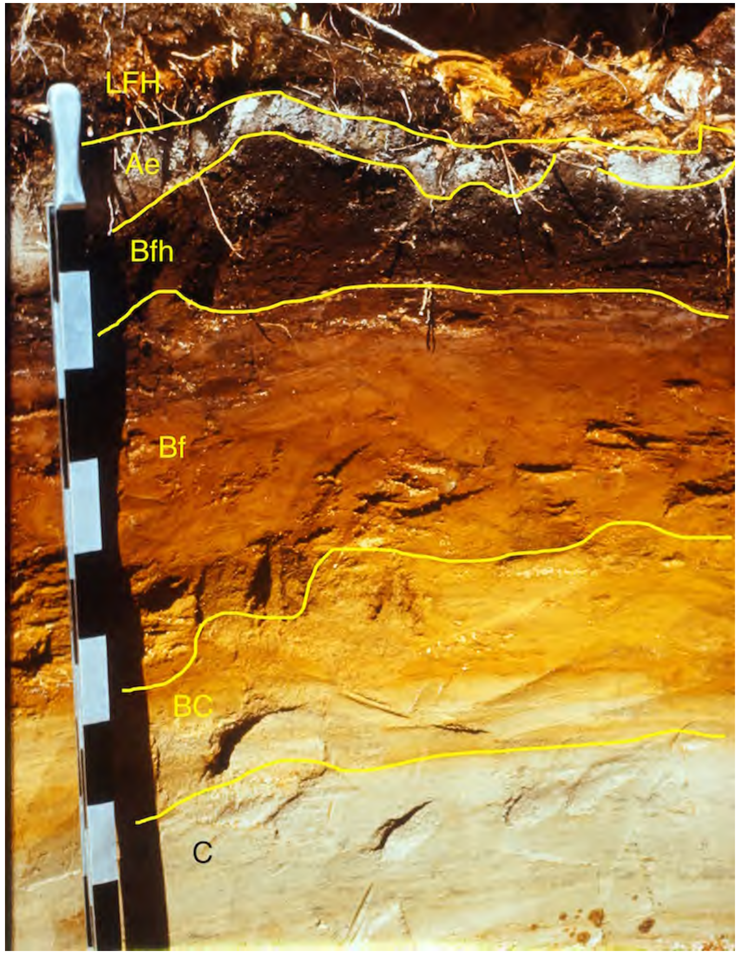
Humo-Ferric Podzol

- Typically drier
- Lacks a well-developed B horizon with organic material
- Thick Ae (grey layer)
- Bf horizon with iron deposition (gives color)



Ferro-Humic Podzol

- Ae horizon typically thin
- B horizon divided into two diagnostic horizons:
  - Bfh – enriched in iron (f) and organic matter (h)
  - Bf – enriched in only iron



https://soilsofcanada.ca/imagery-collection/podzols.php

Soil development – is variable

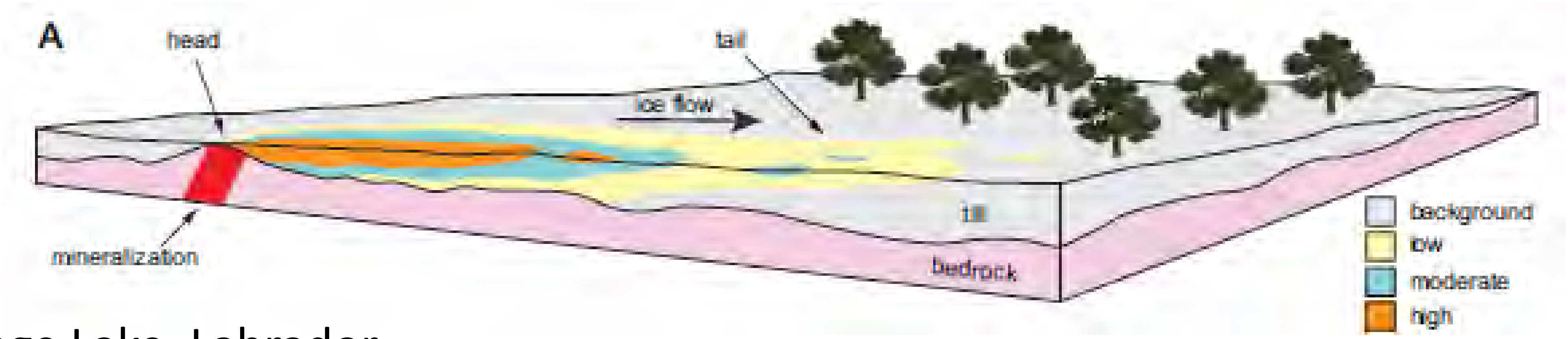
How to find mineral deposits?

- Look at dispersal of till using:
  - Mineralized boulder tracing
  - Till geochemistry
- Use ice-flow history to trace back to source

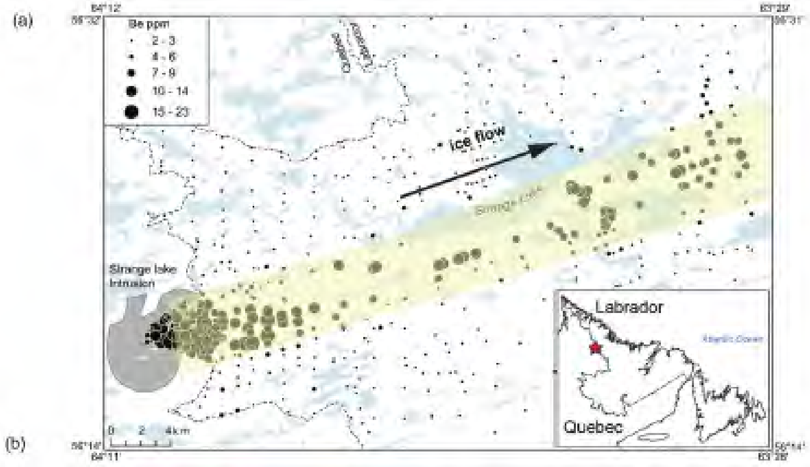
Source GSNL

Dispersal - surface expression

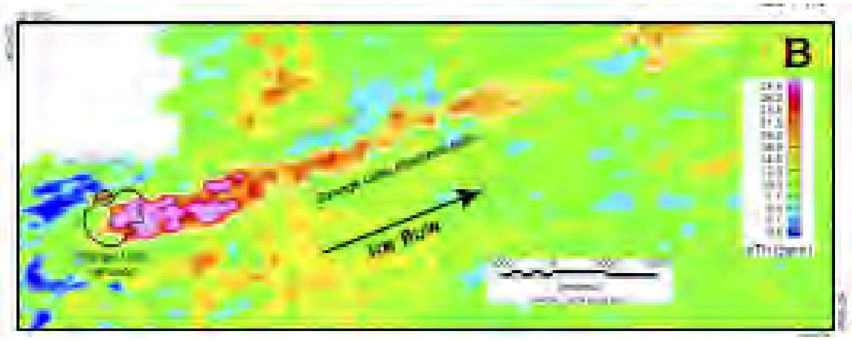
Single source - ribbon-shaped dispersal train (McClenaghan et al., 2020)



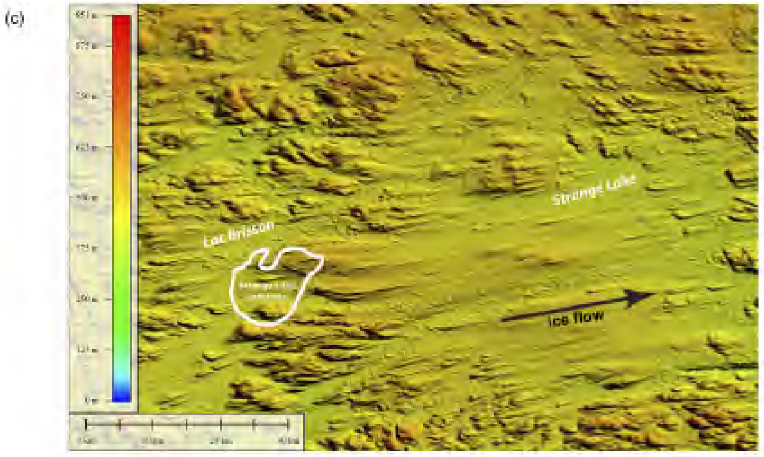
Strange Lake, Labrador



Dispersal of Beryllium content <0.063mm fraction



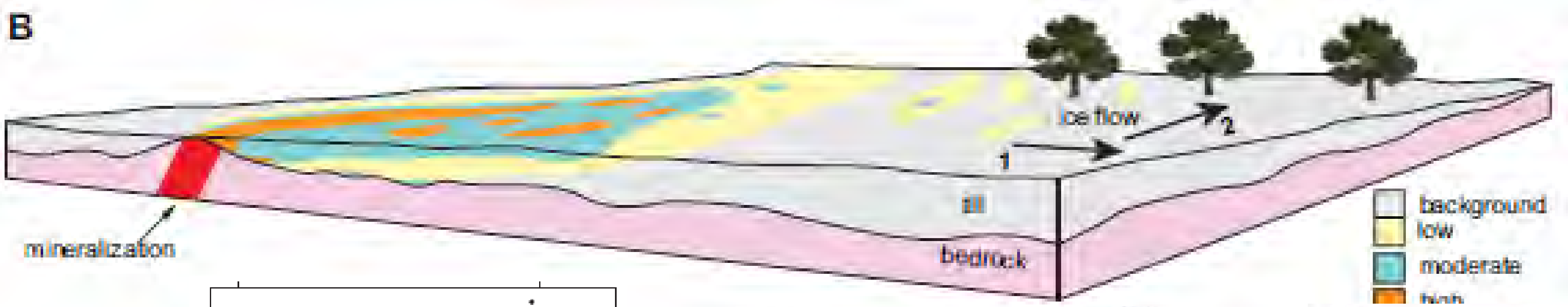
Airborne gamma-ray signature – e Th values



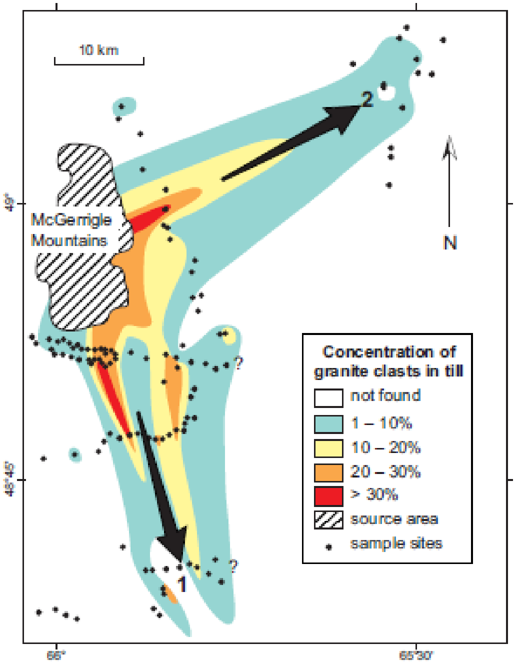
SRTM – mega scale streamlined forms

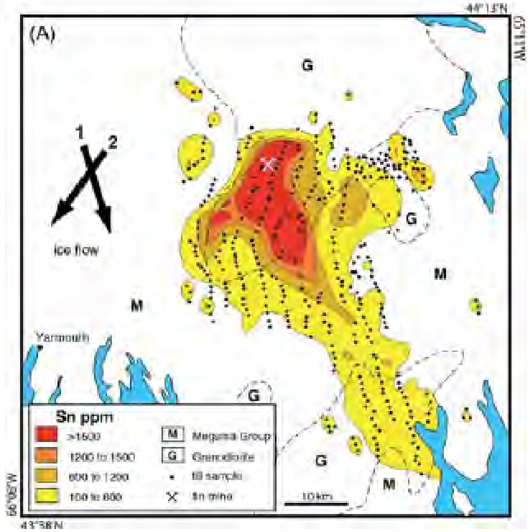
Dispersal- surface expression

Single source – palimpsest dispersal two ice-flow phases (McClenaghan et al., 2020)

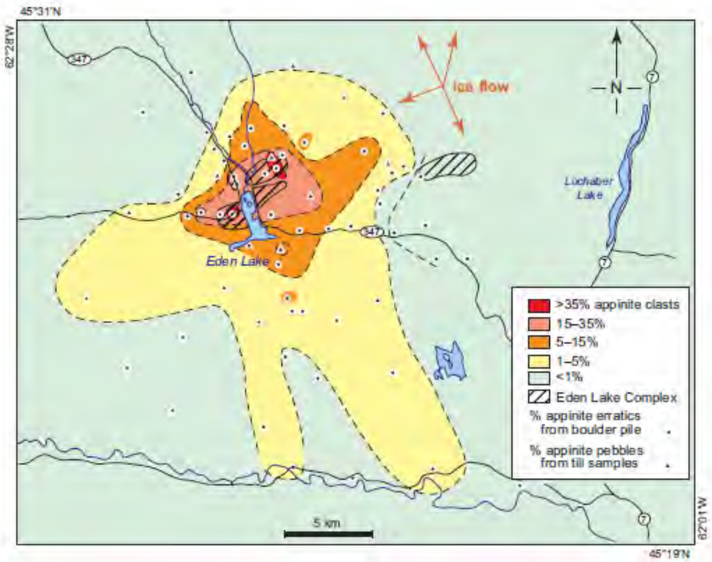


McGerrigle Mountains, Quebec: Bilobate dispersal





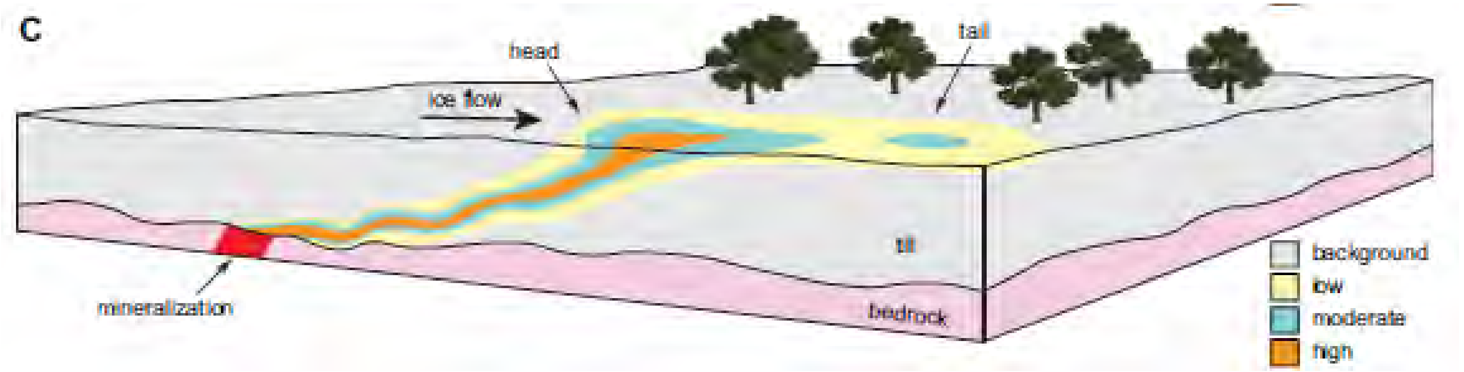
East Kemptville, NS: Fan-shaped dispersal -multi phases of flow McClenaghan and Paulen, 2018)



Edan Lake, Nova Scotia: Multi-lobed dispersal pattern

Dispersal- surface expression

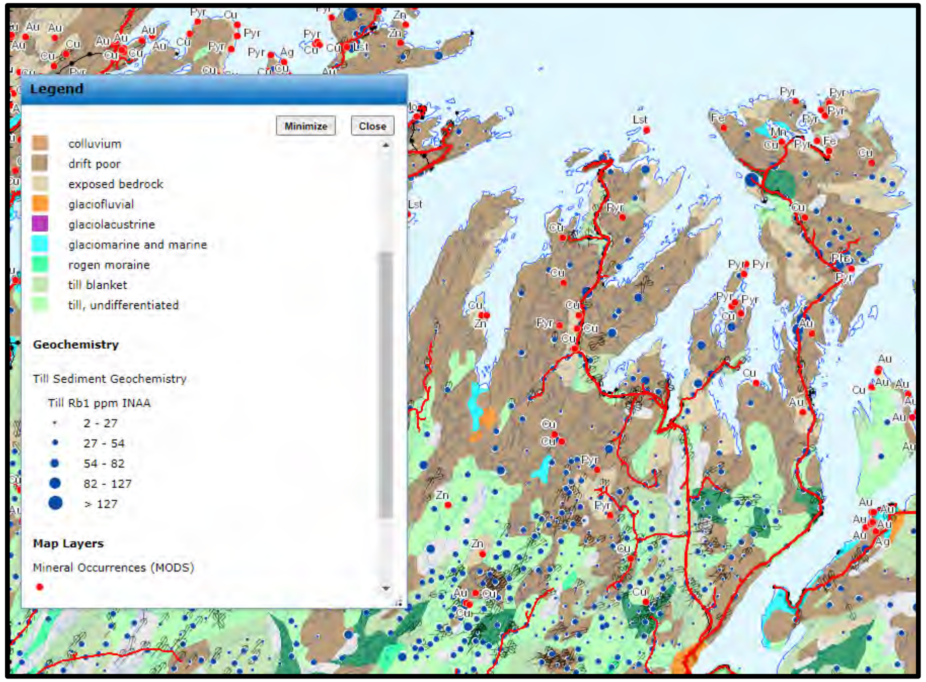
Single source – thick till (McClenaghan et al., 2020)



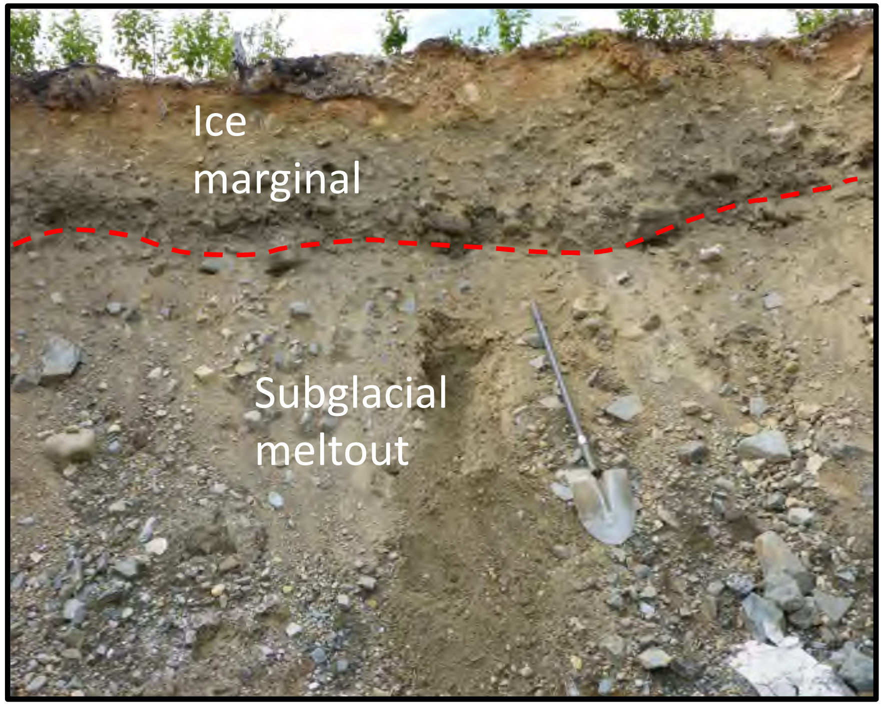
- In thick till dispersal plume can be kms – 100s of kms down-ice from source

- Dispersal plume further altered with additional flows

Complications (obscuring of dispersal trains)



1.Erosion of till layers and deposition of marine sediment.



2.Ice marginal fan deposits (subangular gravel, pebbles and cobbles) overlying a loosely consolidated diamicton (subglacial meltout till?)

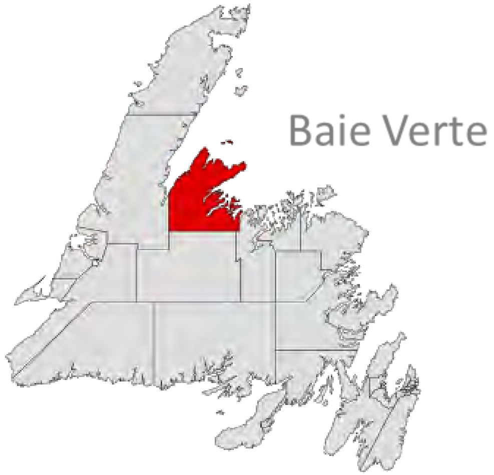
- Till can be eroded and modified by post-glacial processes (e.g., marine incursion)
  - Marine limit – defined by highest beaches or deltas, varies depending on part of the province
- Till can be obscured by glacial (e.g. supraglacial) and post-glacial deposition
- Other materials are not suitable for sampling as they are farther from the source, and they are diluted by other processes (e.g. the geochemical anomalies indicative of the source are obscured or non-existent)

(Slide courtesy of Heather Campbell)

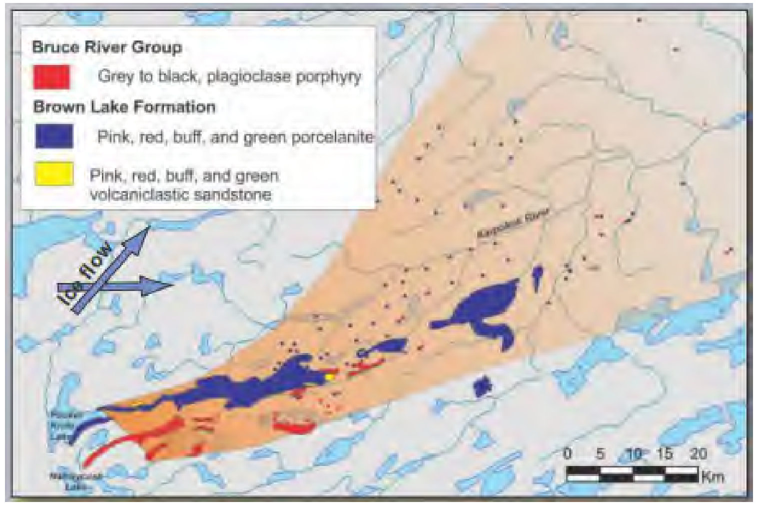
Designing sampling program

- What is the objective?

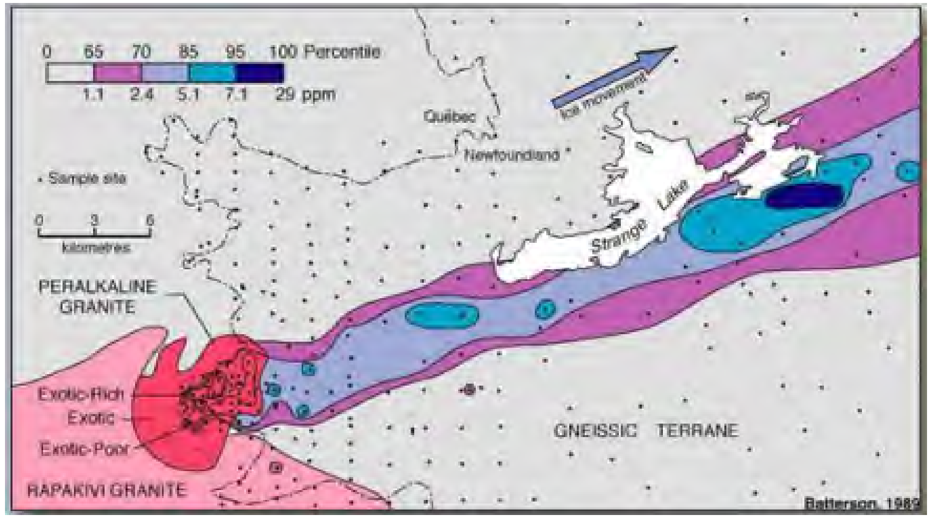
Geological Survey’s objectives include:



Characterize the regional till geochemical signature of an area (McClenaghan et al., 2020)



Document glacial dispersal using a specific bedrock lithology (McClenaghan et al., 2020)



Document glacial dispersal from a mineral deposit (McClenaghan et al., 2020).

When should you conduct a till sampling program?

- Following up
  - On mineralized boulders – unknown source
  - Bedrock anomaly identified but little bedrock exposure
    - Looking for additional bedrock sources
  - On anomalies found in previous sampling program

- New area
  - little work has been completed (greenfield property)
    - Narrowing scope

Designing sample program

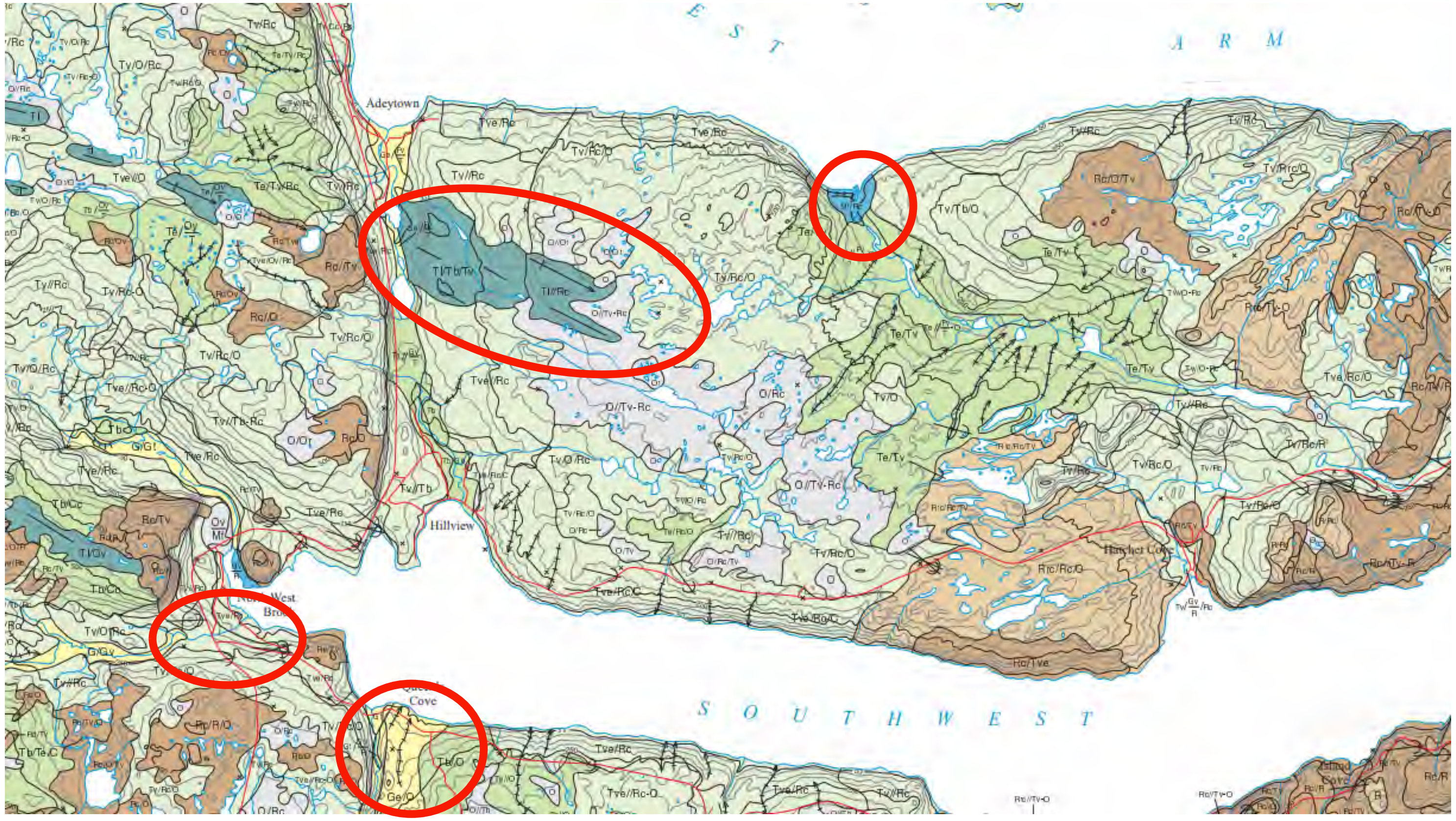
- What is the objective?
- What is the scale of the program?
  - Is this reconnaissance vs follow-up
    - greenfield vs brownfield
- What are you looking for? (e.g., Au matrix geochemistry vs. HMC)
- What's the budget? Remember to budget for duplicate samples (QA/QC)
- How much time?
- Accessibility?
  - Truck vs helicopter vs boat
- What work has been done?

Before designing a sampling program do your homework:

- Distribution and thickness of glacial deposits (color)
- Glacial landforms
- Regional ice-flow patterns
- Secondary processes affecting till (marine, lacustrine)
- Glacial stratigraphy

(McClenaghan et al., 2020)

- Resources:
  - Geoscience Atlas
  - Surficial maps
  - Open Files
  - Current Research Articles
  - Assessment reports
  - Other scientific literature

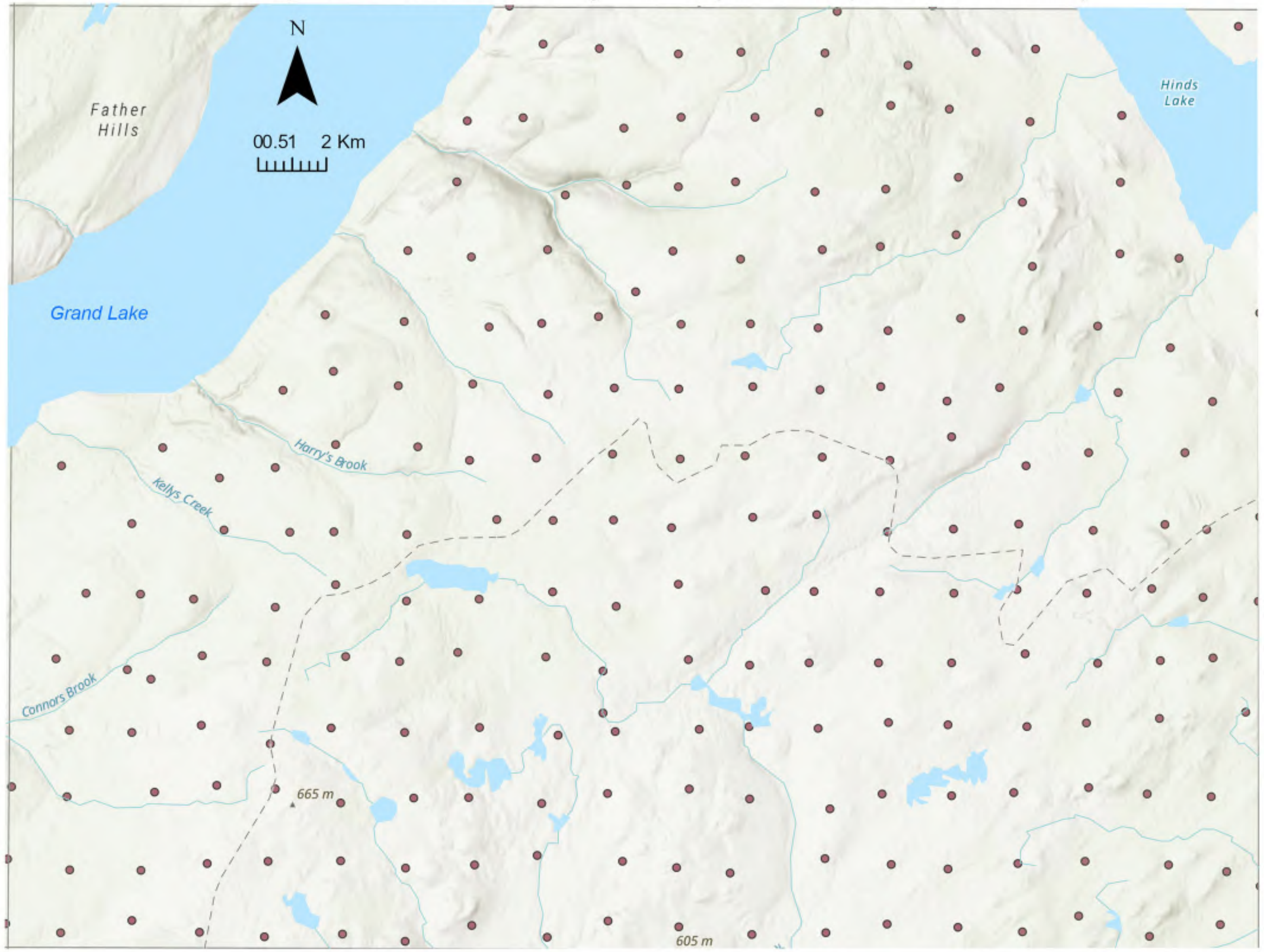


General sampling patterns

- Grid sampling:
  - Where ice-flow directions are not known
  - Where there are multiple ice-flow directions

McClenaghan et al., 2020

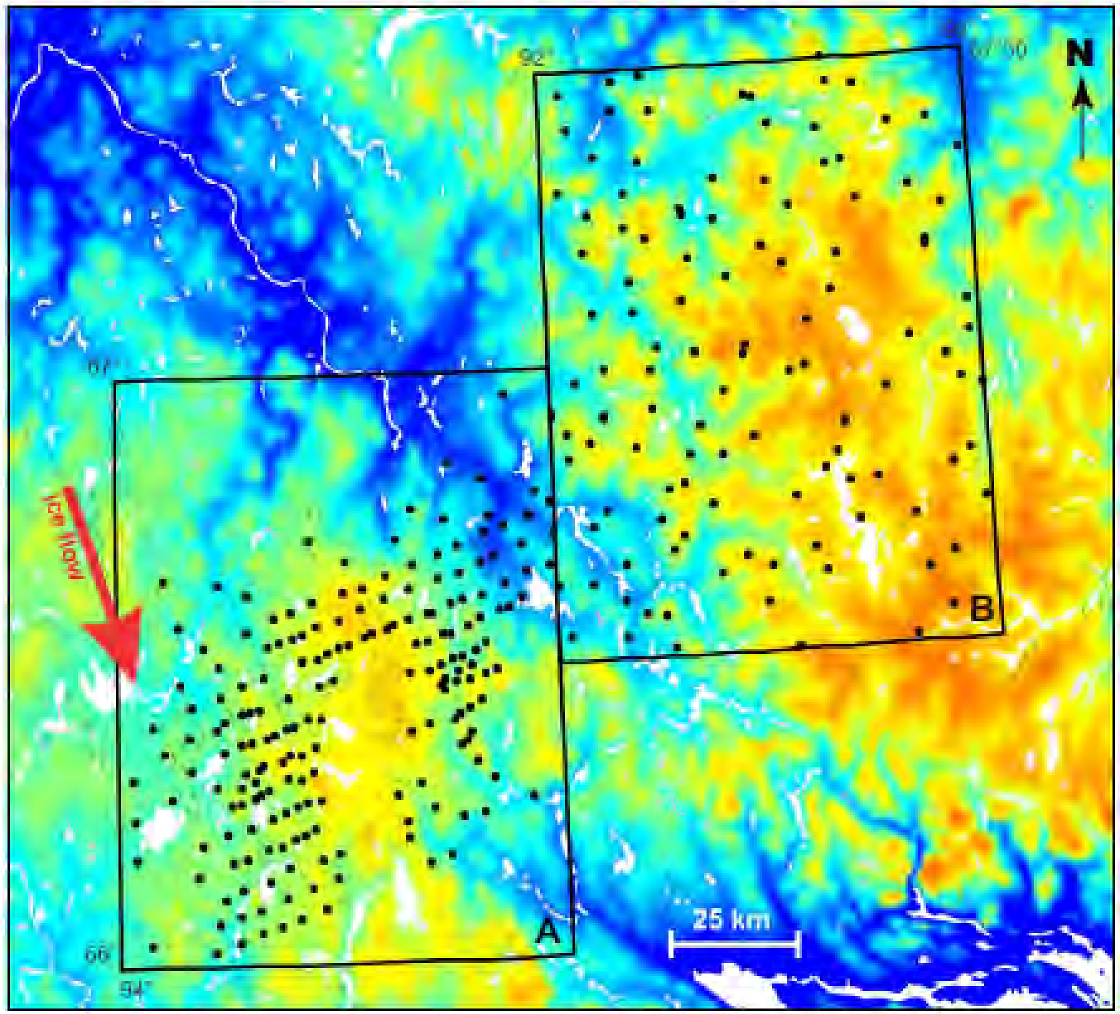
Till Sample Locations - Rainy Lake (NTS map sheet 12A/14)



Esri, NASA, NGA, USGS, Esri Canada, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, NRCan,

General sampling patterns

- Line sampling perpendicular to ice flow

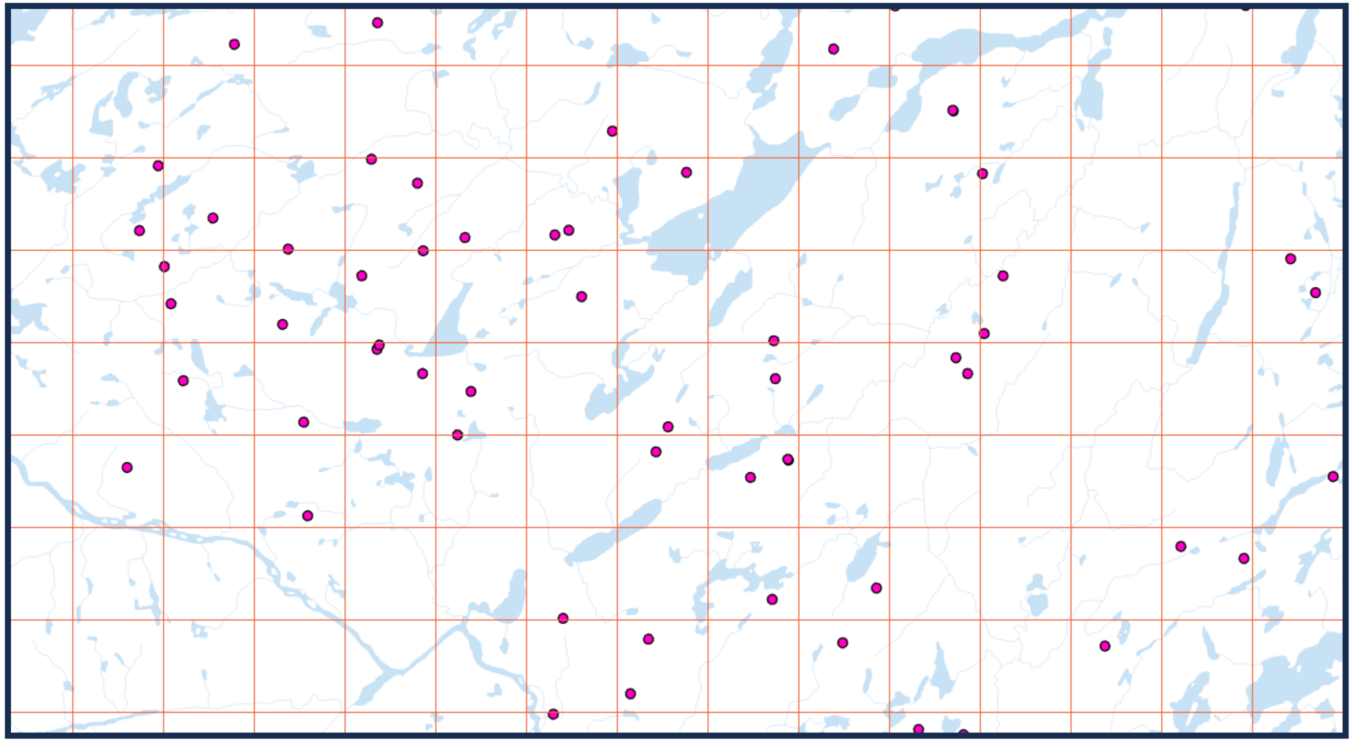


(Committee Bay, Nunavut; McClenaghan et al., 2020)

General sampling patterns

- Random sampling spacing:
  - Availability of access and resources
  - Availability of preferred sampling material

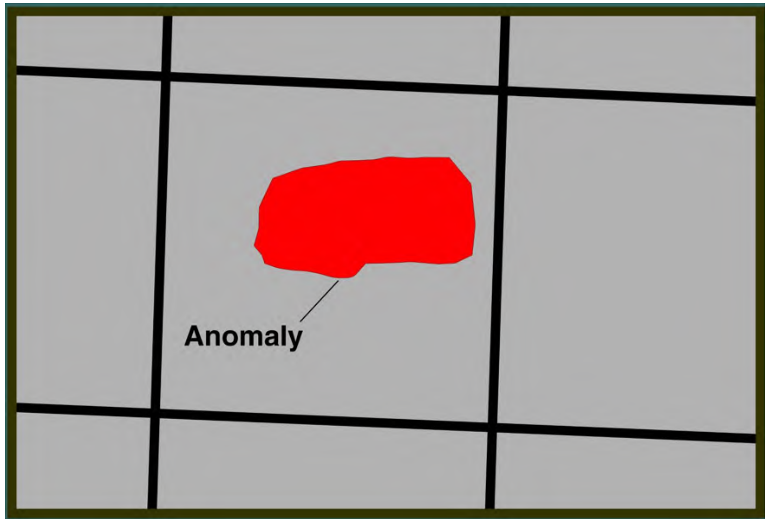
    (Subglacial Till)
  - Use when you have a good understanding of landforms and till morphology
  - Use when mineralization is well understood



Grid 4 km – Random sample distribution

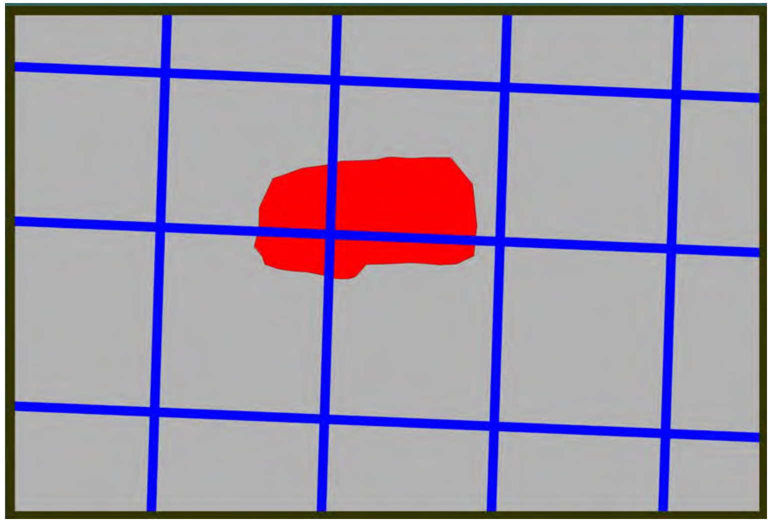
Why do grids matter?

4 km sampling grid



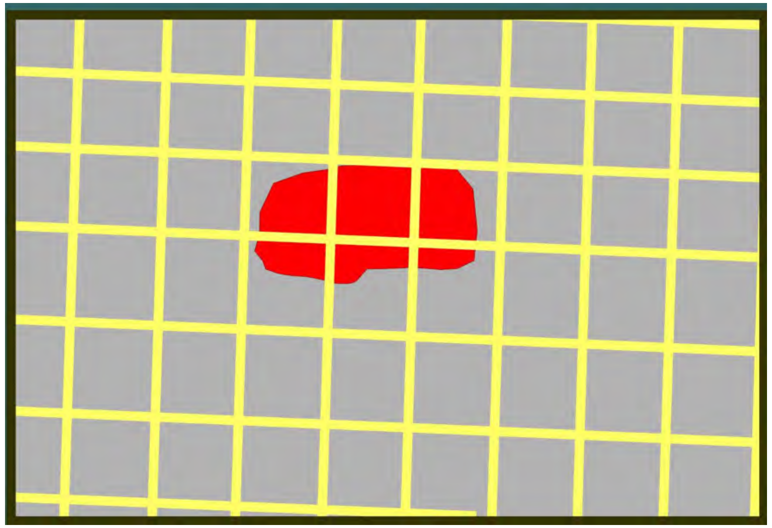
No Hits

2 km sampling grid



Single Hit

1 km sampling grid



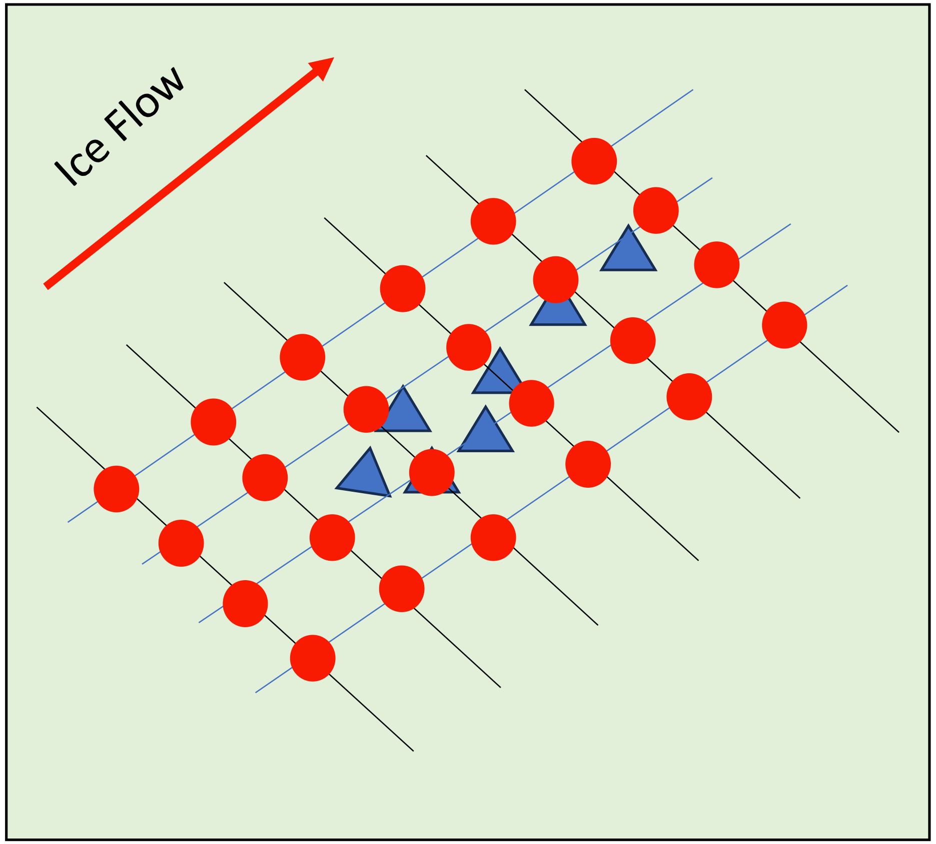
Multiple Hits

How To Set Up A Grid

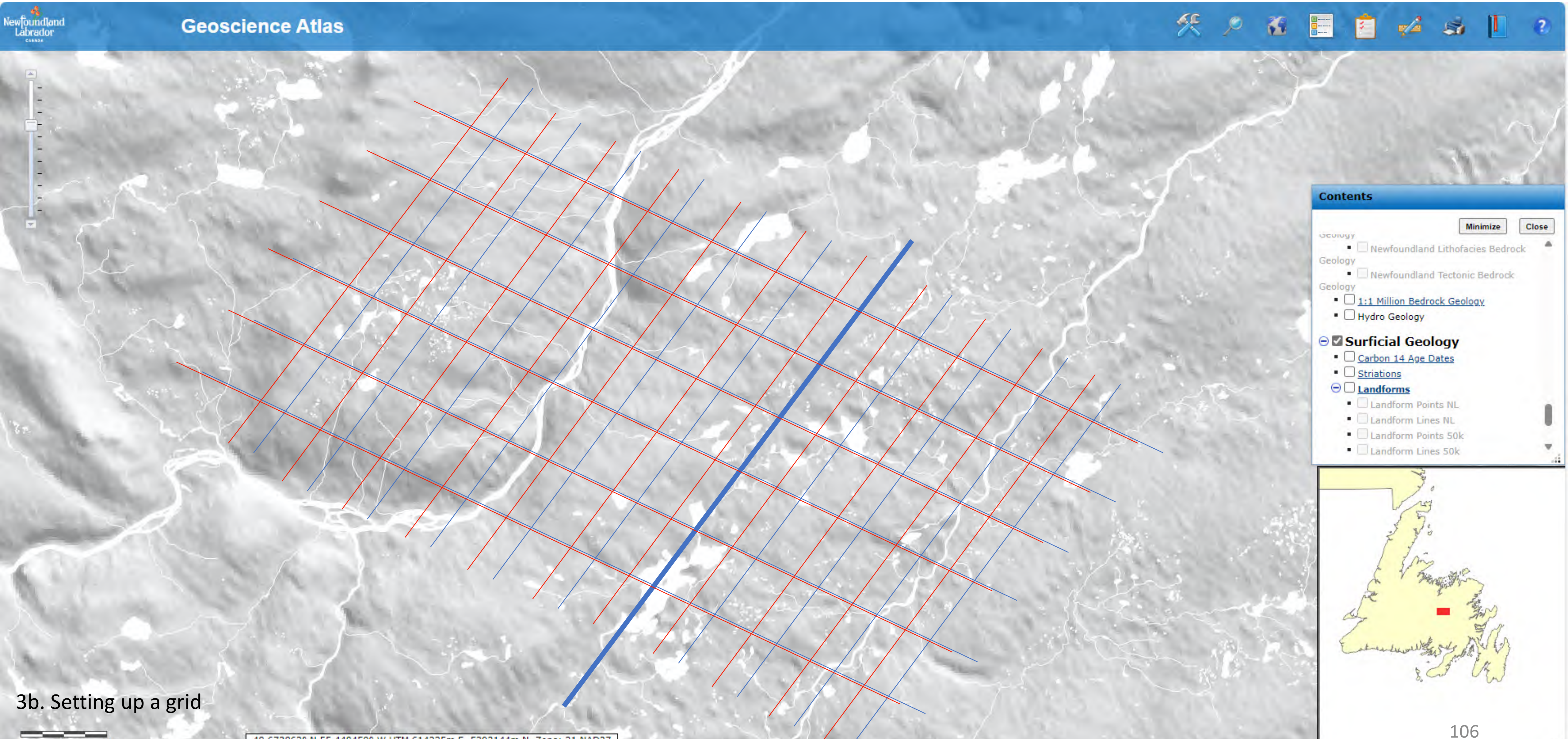
- Do you know the ice-flow direction(s)?
  - YES
    - Set up lines perpendicular to ice flow
    - Might not match the grid set up for bedrock (i.e along strike)

- Determine your line spacing (50 m, 100 m, 200 m)
  - Select grid origin point based on what makes sense for area
    - Minimize coverage over bogs, ravines, and water bodies
- Determine your sample density and spacing
  - Based on budget and previous work completed

Setting up a grid – mineralized boulders

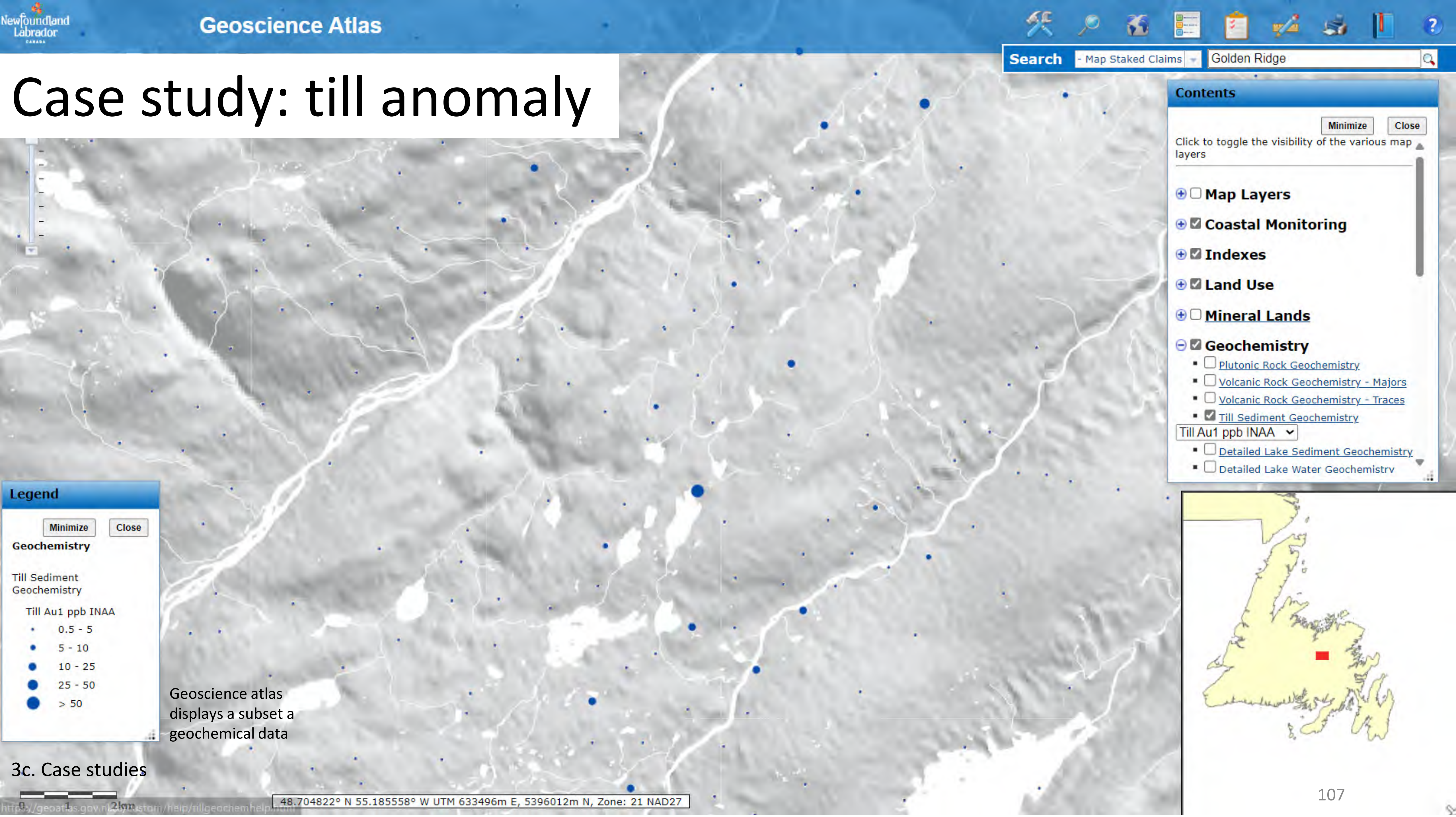


Setting up a grid



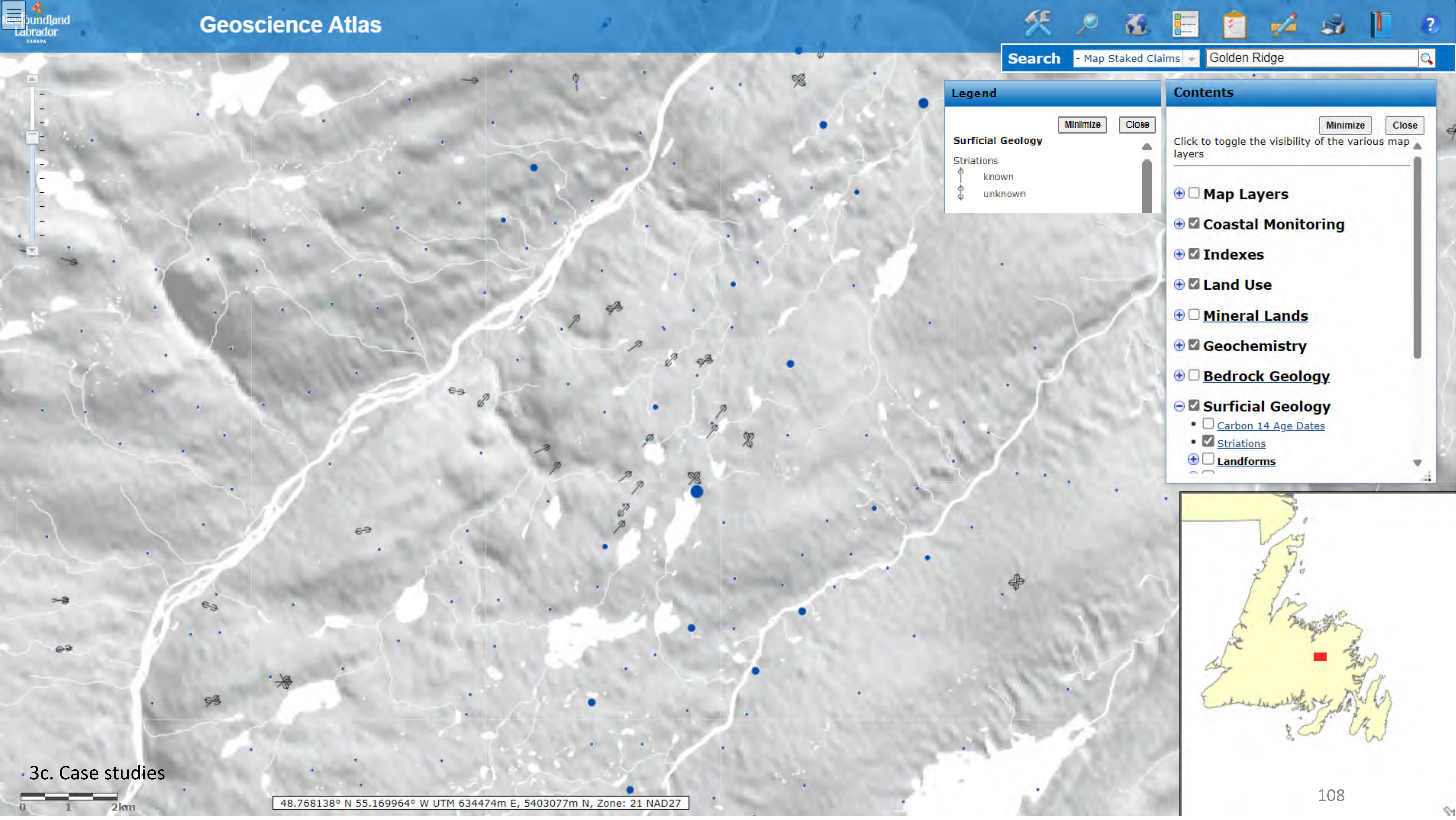
3b. Setting up a grid

Case study: till anomaly



Geoscience atlas displays a subset a geochemical data

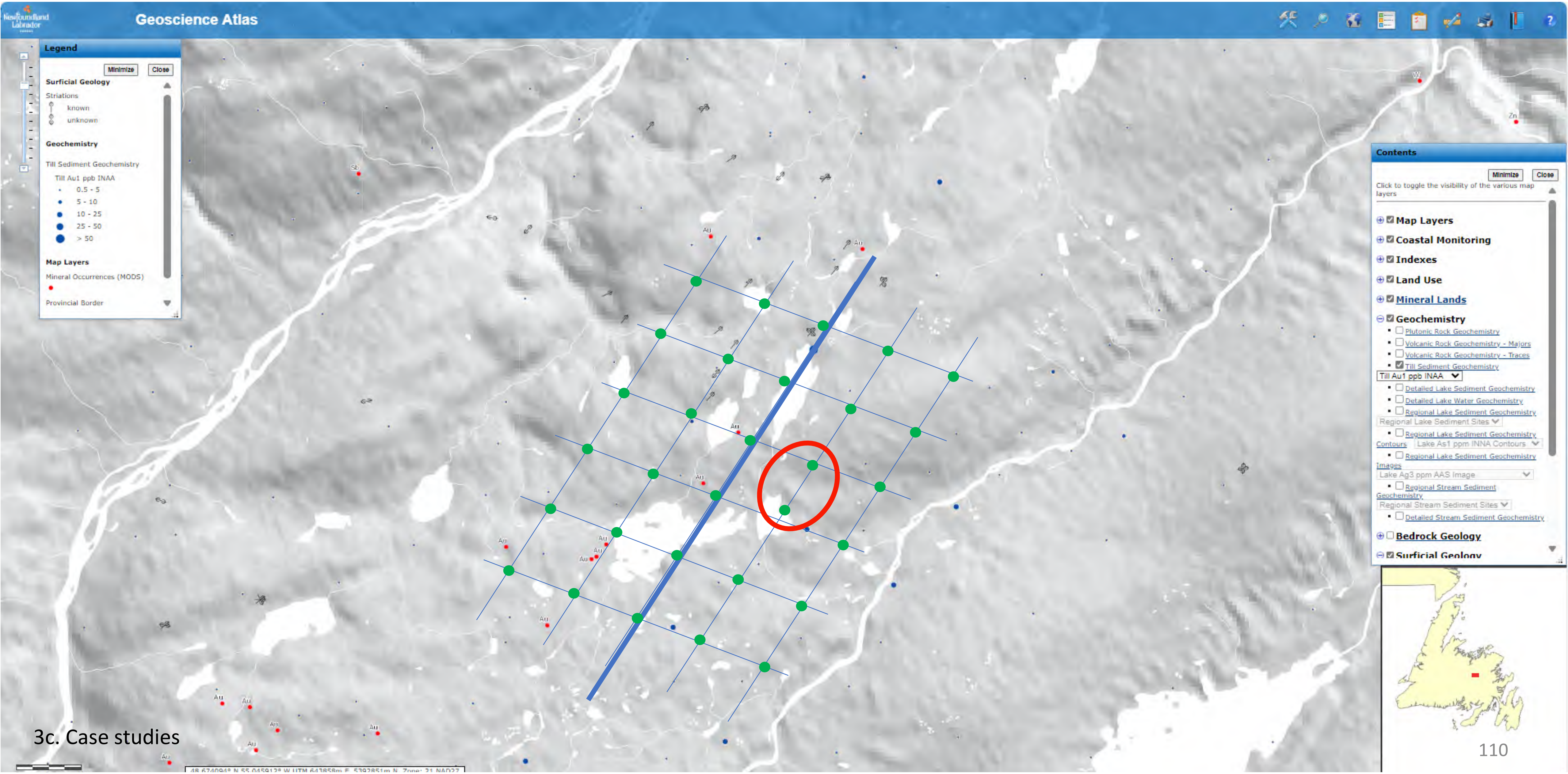
3c. Case studies



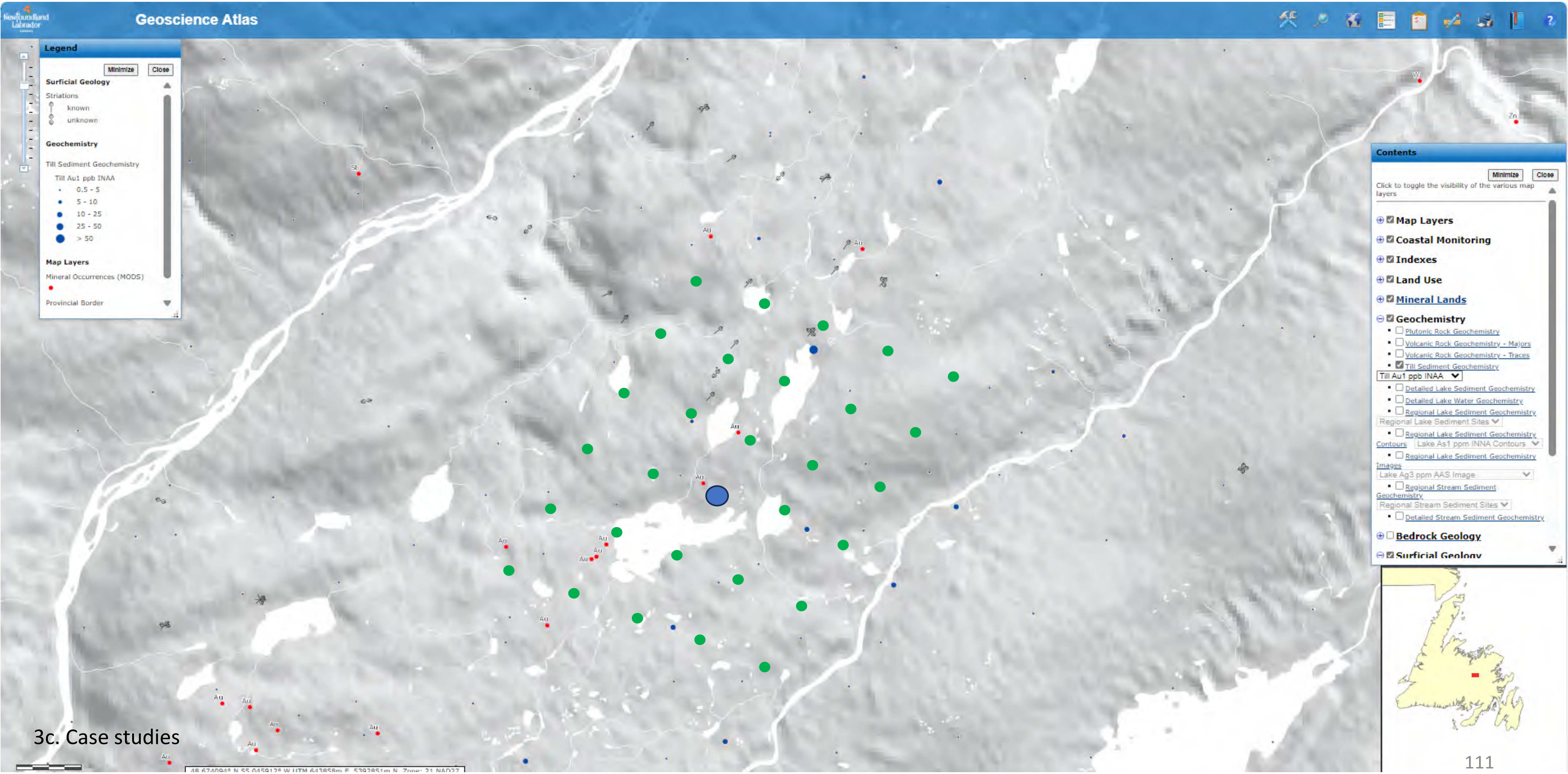
3c. Case studies

Case study: till anomaly – where is the till?

Placing a grid

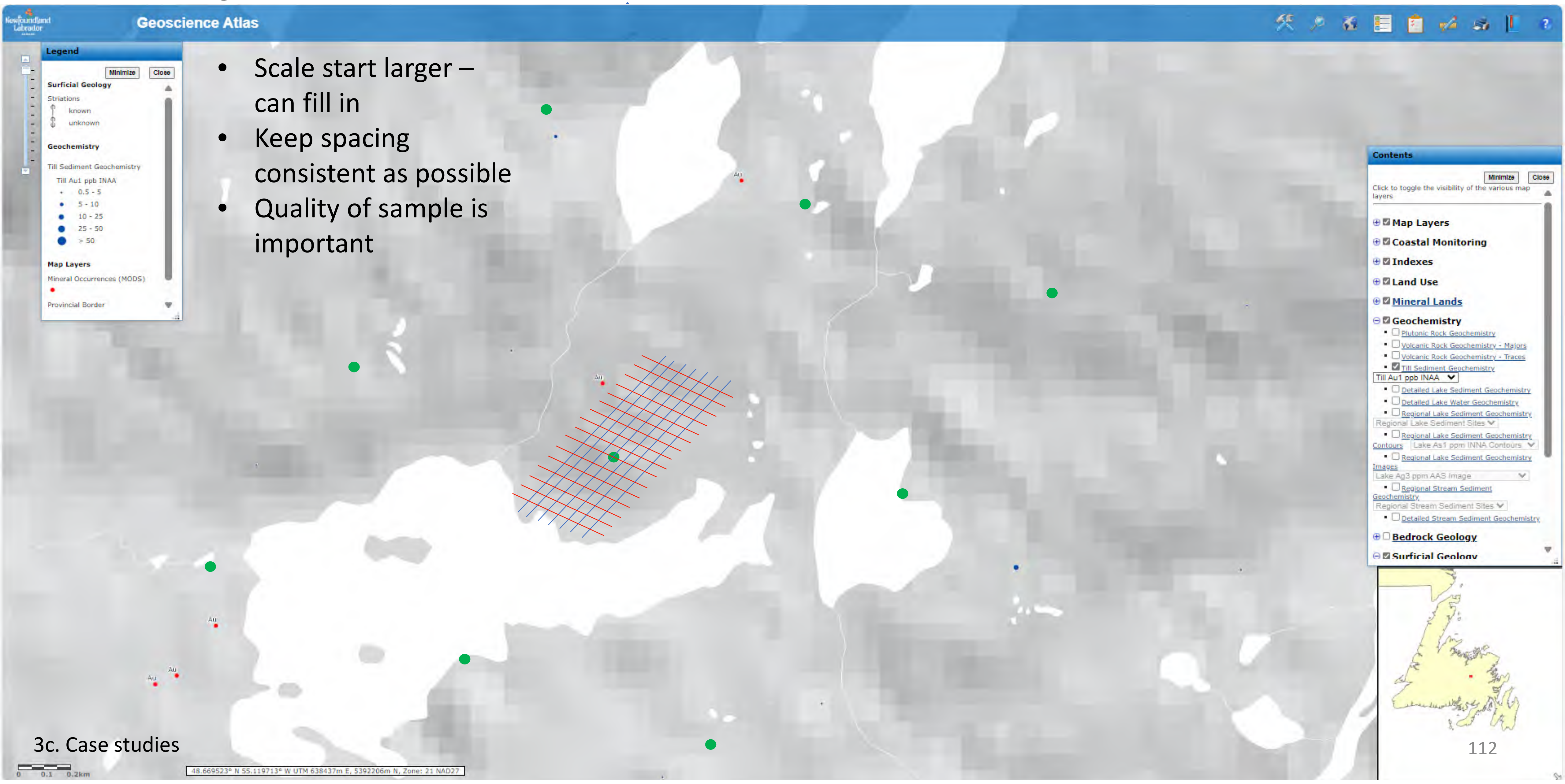


Placing a grid

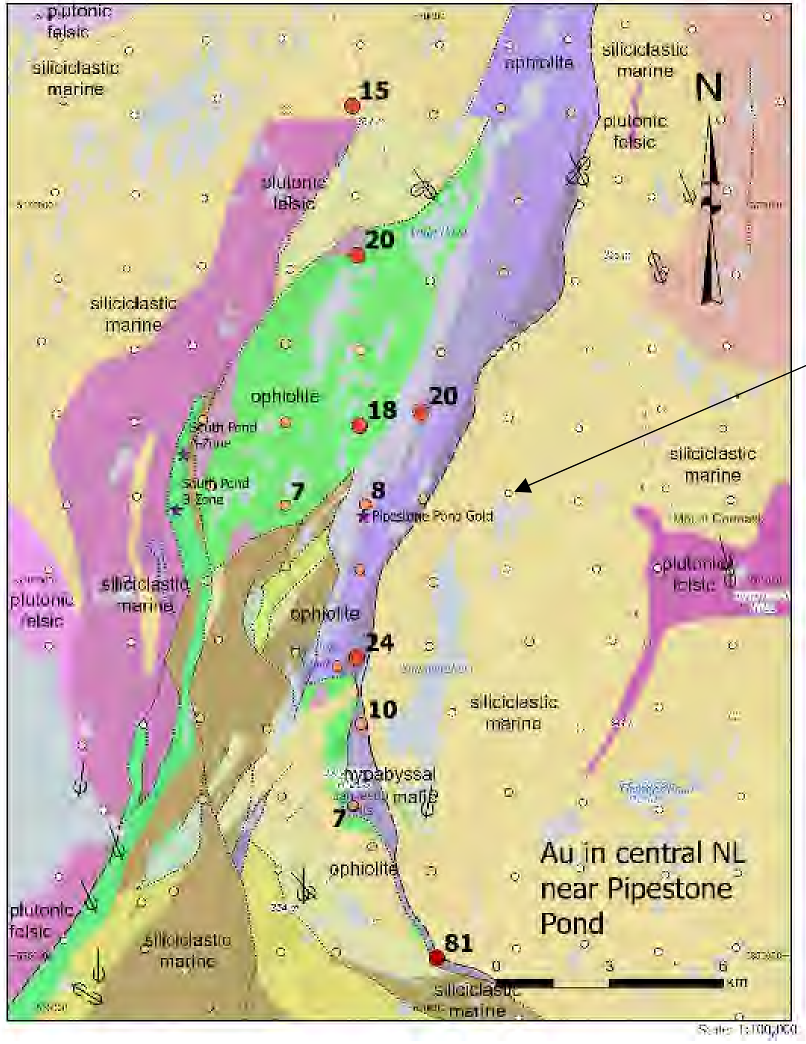


Placing a Grid

- Scale start larger – can fill in
- Keep spacing consistent as possible
- Quality of sample is important

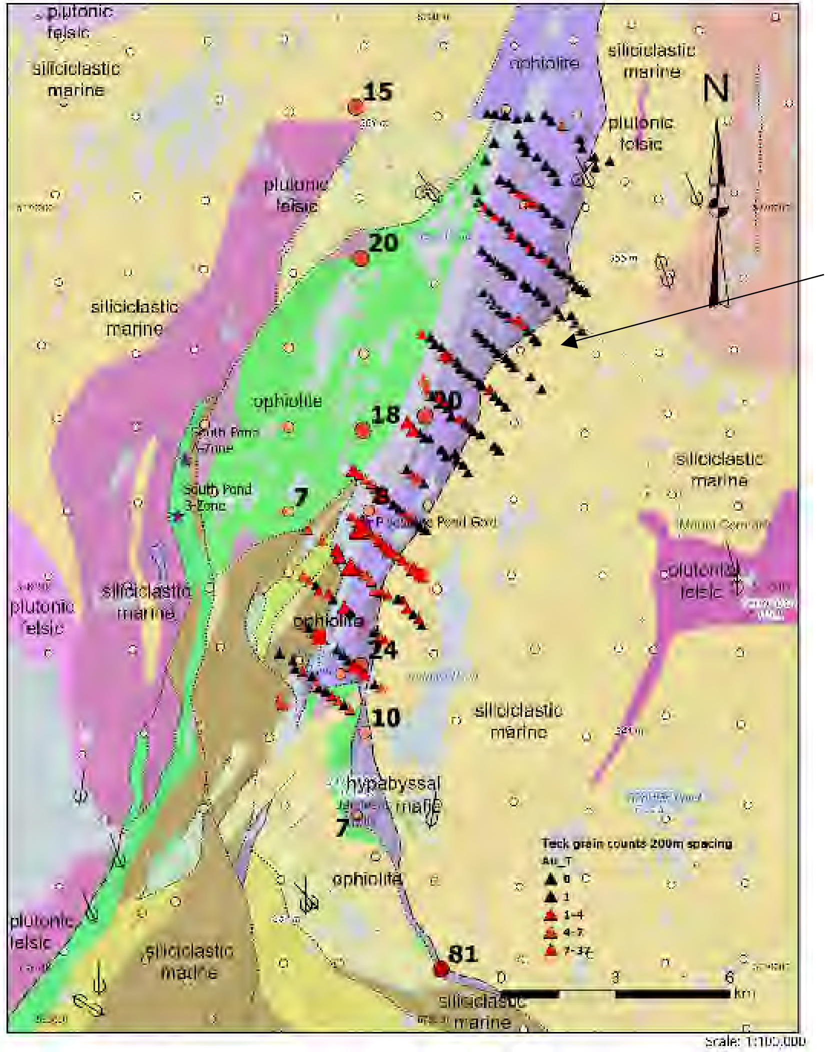


Complications (more than one source along ice flow)



Au (ppb) geochemical anomalies in till on a 2 km grid (GSNL)

Newfoundland and Labrador Geological Survey. "Till Geochemistry." Newfoundland and Labrador GeoScience Atlas OnLine. Last update: (March, 2024). https://geoatlas.gov.nl.ca/ . [9/13/2024].



Resolution of possible source areas (red) using 200 m sample grid through follow-up property scale sampling by industry (Teck, 1990)

From Teck 1990, Assessment Report- NFLD 12A/08 579: John Clarke

- There can be more than one bedrock source for anomalies along the path of glacial transport
- Sampling at a higher density, and using grain morphology can define a smaller source area

(Slide courtesy of Heather Campbell)


Break

Outline

1. Introduction to glaciation
   - Glacial erosion in Newfoundland and Labrador
2. Glaciation of Newfoundland and Labrador
   - Glacial deposition
   - Other glacial and non-glacial processes
   - Soils
   - Glacial dispersal
3. Designing a sampling program
   - General sampling patterns
   - Setting up a grid
   - Case studies
4. Sampling strategies
   - Till vs soil
   - Sample size
   - Sample methods
   - Sample equipment
   - Site selection
   - Sampling best practices
     - Labelling and note taking
5. Bedrock sampling
6. Sampling mineralization

Sampling Strategies

- Quality Assurance/ Quality Control (QA/QC)
- Sample material type
- Soil vs Till Sampling
- Sampling size
- Sampling methods
  (auger / hand dug / backhoe)
- Sampling equipment
- Site selection
- Sampling best practices


Source J.S. Organ


Source J.S. Organ

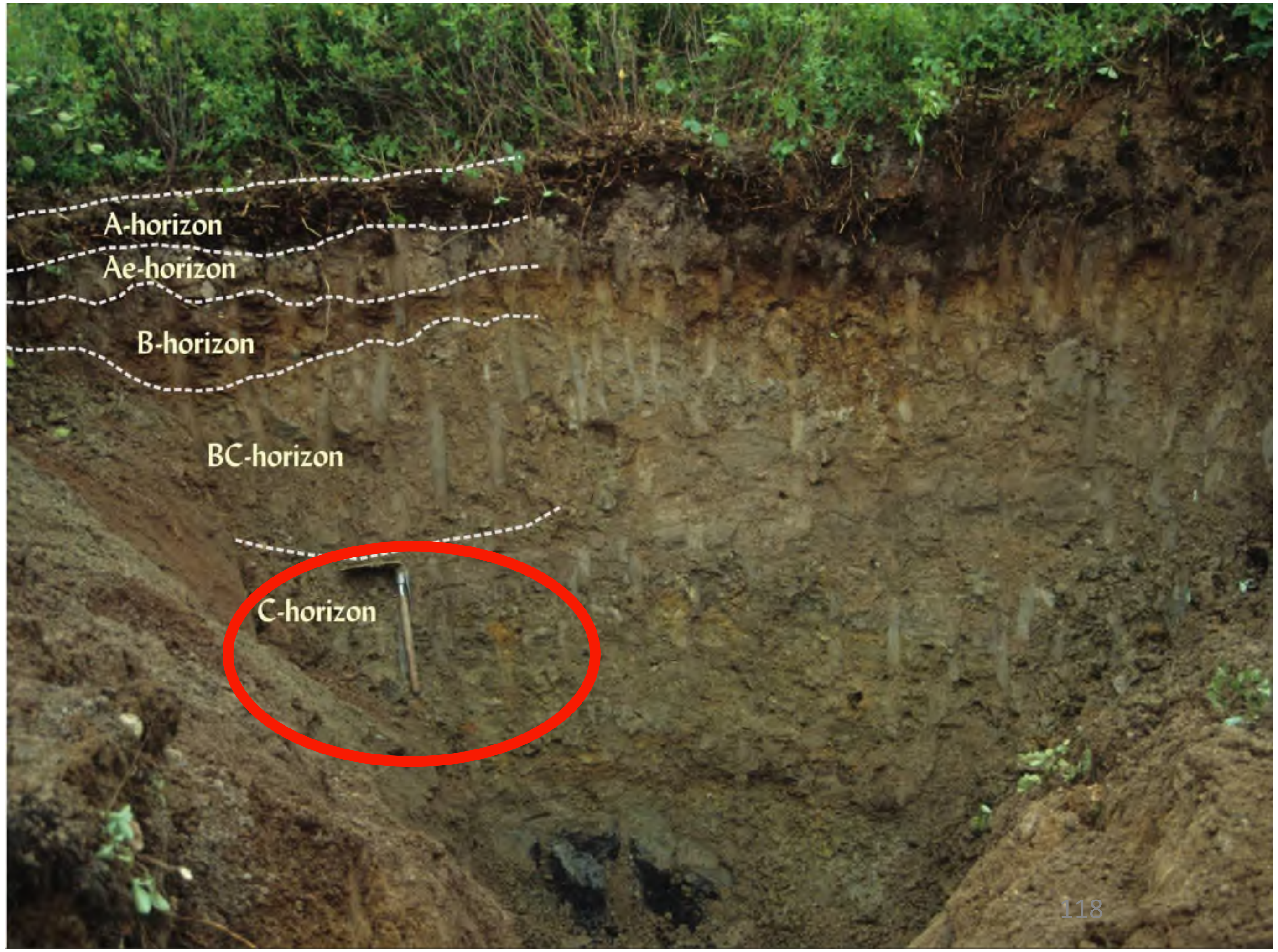
Quality Assurance/Quality Control

- Poor sample collection = poor data and interpretations
- Budget for analysis of QA/QC samples
- Field duplicates – separate holes 2 m from each other
- Collect one field duplicate every 15-20 samples
  - Fewer samples (e.g., 25 samples = 2 duplicates)
- Laboratory blind standards, blanks and duplicates as per NI 43-101 as necessary
- Sample security – making sure no samples are lost or tampered with

Sample material type

Soil development

- A – horizon: organic-rich material near surface
- Ae – horizon: leached grey horizon
- B - horizon: chemical/physical alteration, enriched in Al or Fe-Mn oxides (gives orangey - brown color)
- C – horizon: unaltered parent material

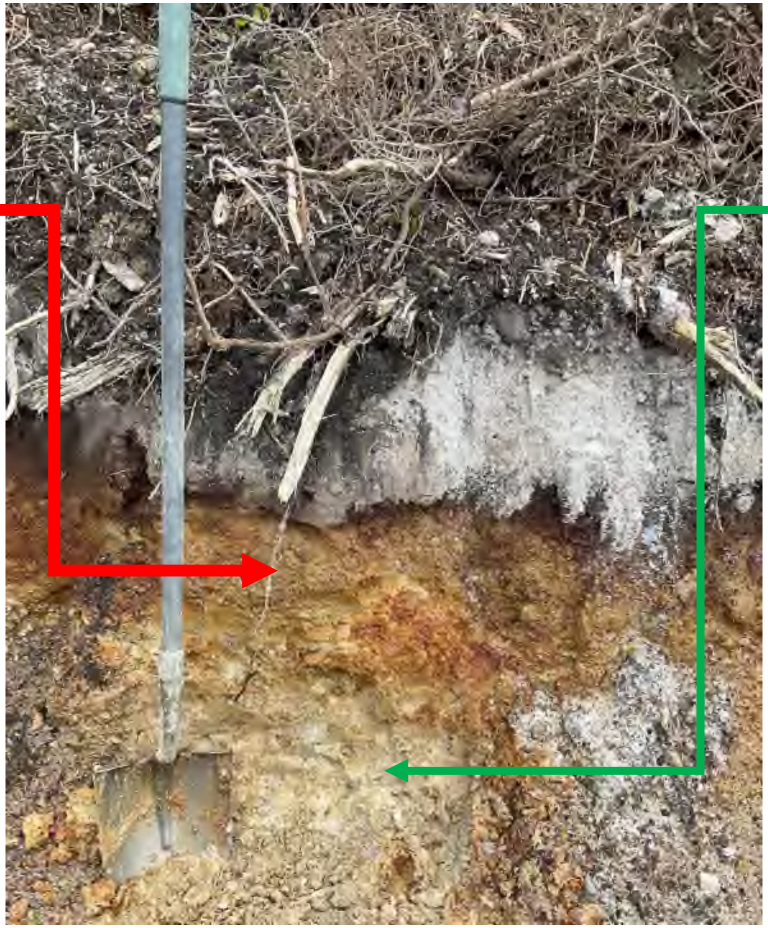


Soil sampling vs Till sampling

- Sampling **B** horizon
  - Oxidized layer
- Variable down to 50 cm
- Easier to sample
- Represents soil forming processes (alteration)

Thick soil development (>70 cm)
Limited time and staff

Less representative of the bedrock than till



BE CONSISTANT

- Sampling **C** horizon
  - Unaltered Parent material
- Commonly 50-70 cm deep
- Harder to sample
- **Yields better geochemical results**

Till preferred
Follow up sampling from B horizons

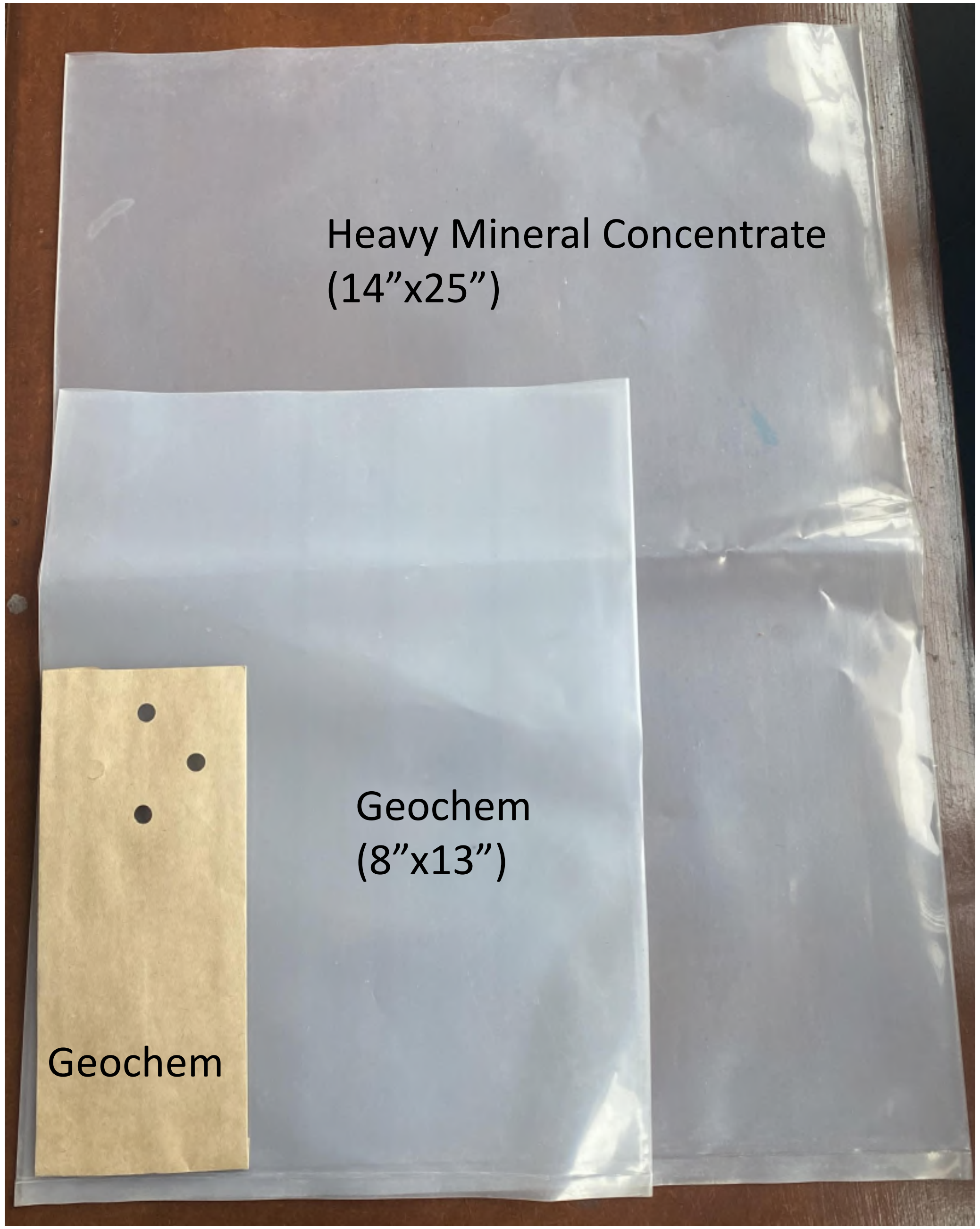
Sample size determination

- What is the purpose of the project?
- What commodity?
  - Geochem matrix 1-5 kg
  - Heavy Mineral Concentrate (HMC) – 10-15 kg
- Budget?
- Depends on amount of clay and silt in sample material
  - Coarser (e.g. sandy till) requires more material Geochem & HMC
  - Finer (e.g. clay rich till) requires more material for HMC (20-40 kg)

Larger samples cost more $$ to analyze and ship

But

Larger samples = greater probability of capturing mineralized debris



Sampling methods

Dutch Auger

- Best for:
  - Quick identification of till prior to digging hole
  - Works will in clast-poor till
  - Under bogs
- Small diameter hole
  - Hard to see what you are sampling
- Brings up 15 cm of sediment at a time
- Could have contamination from B horizon

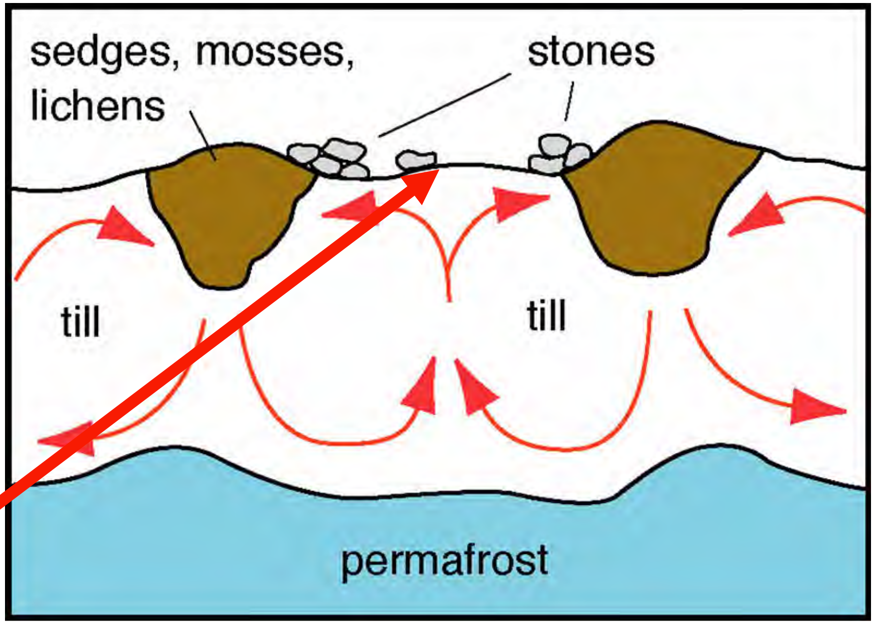
Sampling methods

Hand excavation:

Test pit

Sampling methods

Hand excavation: Mudboils



Sample Here

Sampling methods

Road cuts

Source J.S. Organ

Sampling Methods

Steam Cuts

Sampling Methods

Trenching

Do not get in a trench without proper safety protocols

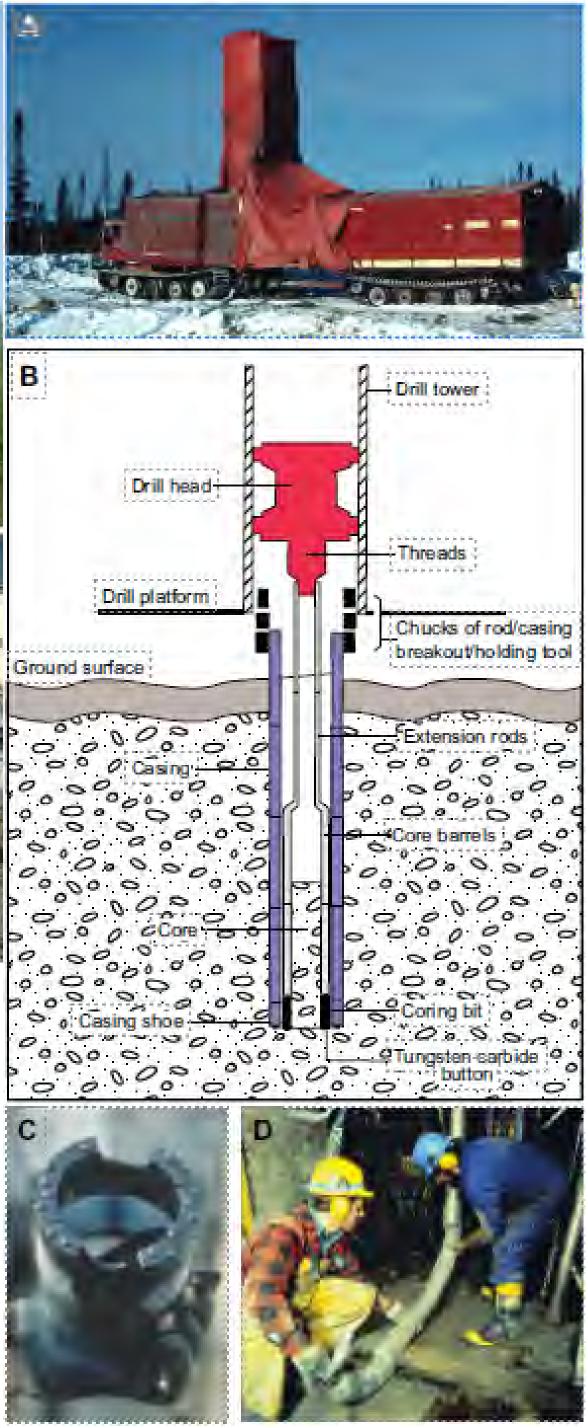
Source J.S. Organ

Sampling methods: Getting deeper…

Portable Drills (<10 m)

Power Augers (1-100 m)

Mud Rotary Drill (10-300 m)



Rotasonic Drills (10-125 m)

- Method dependent on the clast content of the till
- Some methods retain core of sediment

More information see McClenaghan et al., 2020

Sampling equipment

- Shovel (galvanized coatings/paint removed)
- Geotul, grub hoe
- Pruners
- Fish scale – determining weight of sample
- Flagging tape
- Electrical tape, zip-ties
- Measuring tape
- Sample bags (Kraft paper bag for 1kg, plastic 6 mil (8”x13”) for 3-5kg sample)
- Plastic bags and buckets for 10-15 kg HMC samples
- Scale card
- Camera

Site selection

- Areas where you think there is till
  - Consult surficial maps
    - Green areas
    - Beware that areas of Te and Th may have less silt = less suitable
  - In the field look for till characteristics
    - Poorly sorted (fines to cobble/boulders)
    - Silt rich
    - Striated and/or faceted clasts

Clip from Sweet Bay (2C/05) Surficial Map

Site selection

- Avoid areas that are disturbed (garbage, drill sites) or too close to roads
- Contamination potential for samples

Site selection - look for:

Source J.S. Organ

Streamlined form - Southwest coast

Source GSNL

Crag and tail – West of Pants Lake, Labrador

Site selection - look for:

Source J.S. Organ

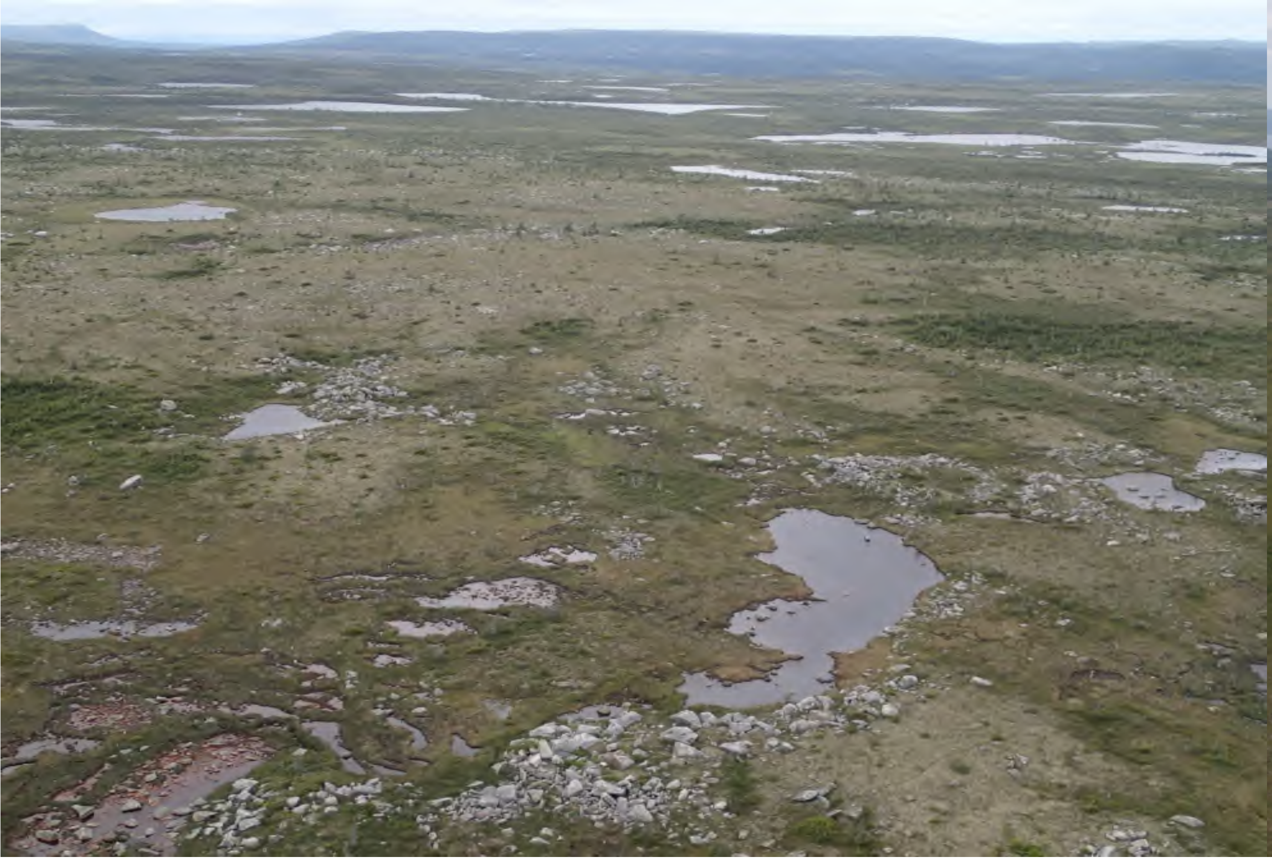
Till Veneer - Southwest NL

Source J.S. Organ

Till Veneer – North of Burgeo

Look in the lees of bedrock highs for till

Site selection - look for:



Source J.S. Organ

Undulating terrain - Topsails

Source J.S. Organ

Till blanket Sheffield Lake

Site Selection – Not Great:

Hummocky Terrain – Noel Paul's Brook

Source J.S. Organ

Hummocky Terrain - Meelpaeg Lake

Source J.S. Organ

Site selection - review

Table 3. Overview of potential till sample sites with respect to till thickness and glacial landforms.

GSNL* Mapping Label	Terrain types	Provenance	Preferred sampling site	Comments	Selected publications
Tv	Till veneer (till <2 m thick)	Predominantly local debris	Well drained, top of slope, flat area, *or* Down-ice side of outcrops	Generally best terrain for sampling locally derived debris if till is thick enough (>60–cm) to collect C-horizon soil	Paulen et al., 2013; Kelley et al., 2019
Tb	Till blanket or till plain (till >2 m thick)	Variable; generally has significant proportion of local debris	Well drained, top of slope, flat area	Typically, the proportion of local debris increases with depth with the greatest percentage just above the bedrock surface	McMartin, 2000; Averill, 2017; Kelley et al., 2019
	Crag-and-tail, Precrag landform		Stoss slope of crag if till is present, otherwise along top of tail	Precrag: tail or rampart formed on the up-ice side of the crag Caution: small-scale crag-and-tails can resemble resemble lee-side deposits; *see* below	Crag-and-tail: McMartin et al., 2015 Precrag: Haavisto-Hyvärinen et al., 1989; Haavisto-Hyvärinen, 1997
	Lee-side deposit		Down-ice side of outcrop at top of slope	Cavity-fill deposits beside and down-ice of out-crops; sediments, or portions of, have undergone some degree of meltwater sorting, i.e., fines removed	McMartin et al., 1996
Th	Hummocky moraine – undulating, gentle relief		Well drained, top of slope, flat area	Till composition similar to till plain	Eyles et al., 1999; McMartin et al., 2006; Evans et al., 2014
	Ice-pressed landforms: ridges, hills		Top of and between ridges	Basal debris and/or previously deposited sedi-ments squeezed up into cavities (e.g. basal crevasse fills)	Sharp, 1985; Kleman, 1988; Evans et al., 2014, 2016, 2019
Tr	Rogen moraine, ribbed moraine	Surface till is local; core (lower till) can have higher proportion of distal debris	Crest of ridge	Multiple theories on genesis; each type of ridged moraine may be linked to a specific depositional environment, thus will affect how the fill results are interpreted; limited studies suggest the surface deposit is more locally derived	Sarala and Neonen, 2005; Knudsen et al., 2006; Möller, 2006, 2010; Sarala and Peuraniemi, 2007; Trommelen et al., 2014

(McClenaghan et al., 2020)

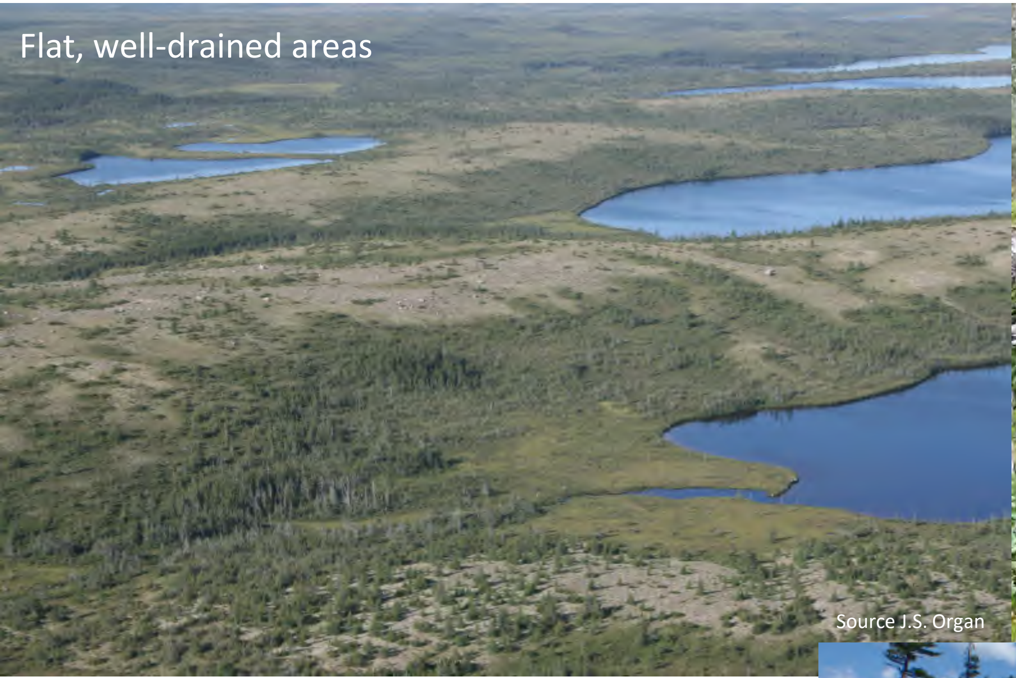
Site selection – review:

(Table 3 continued, from McClenaghan et al., 2020)

GSNL* Mapping Label	Terrain types	Provenance	Preferred sampling site	Comments	Selected publications
Tl	Drumlin, streamlined ridge	Variable with higher proportion of distal debris	Top of landform, up-ice end	Multiple theories on genesis: surface till often more locally derived; internal composition of drumlins is variable	Stea and Brown, 1989; Campbell, 2007; Plouffe et al., 2011; Stokes et al., 2013b; Evans et al., 2015; Möller and Dowling, 2016; McMartin, 2017; Menzies et al., 2018
Tl	Mega-scale glacial lineations (MSGL)	Variable with higher proportion of distal debris	Top of ridge	Generally located in ice stream; typically fast-flowing, long-distance transport	Clark, 1993; Ross et al., 2009; Ó Cofaigh, et al., 2013; Stokes et al., 2013a
Th-Gh	Hummocky moraine "kame and kettle"		Between knobs but <u>not</u> in kettles (sorted sediments)	Ice contact deposit; mixture of sand gravel and till; variable sorting; meltout, flow and dump deposits **Caution: sampling not recommended**	
Tr	Moraine ridge: recessional, push, minor end, De Geer	Variable, mixed provenances	Top of ridge; where matrix is present	Debris flow, dump, ploughed and meltout debris; in a montane setting, these can provide a regional indication of the mineral potential in the source region of the ice	Day et al., 1987; Evenson and Clinch, 1987
Tr	Lateral moraine		Top of ridge; where matrix is present	Restricted to valley glaciers/montane terrain; prospect following moraine up-ice; *see* comment for moraine ridge	Day et al., 1987; Evenson and Clinch, 1987
Tr	Medial moraine		Top of ridge; where matrix is present	Rare; restricted to valley glaciers/montane terrain; prospect following moraine up-ice; *see* comment for moraine ridge	Day et al., 1987; Evenson and Clinch, 1987
	Thrust moraine (glacial tectonite)		NA	Glaciotectonic ice thrust ridges; plucked, folded and/or stacked sequences **Caution: not recommended for sampling due to deposit complexity**	Evans, 2018
	Subglacial meltwater corridors		Crest of mound or ridge if composed of diamicton	Deposits of hummocks and ridges with variable composition and genesis: sand, sand and gravel, and till **Caution: sample till, not ice-contact deposits**	Utting et al., 2009; Haiblen, 2017; Peterson and Johnson, 2018; Peterson et al., 2018

GSNL* = Geological Survey of Newfoundland Labrador

Site selection – On the ground:



Sampling how to…

Make sure your tools are CLEAN!

Avoid contamination

- Remove jewelry (rings, bracelets, metal watches)
- Gloves off while sampling
- Hands are clean
- Check tool wear

(McClenaghan et al., 2020)

Digging a till pit

- Dig a hole 50-70 cm in diameter
  - Use pruners to cut roots
  - Remove vegetation mat
- Remove clasts

Digging a till pit

- May have to move if stuck by large roots or boulders

Digging a till pit

- Dig past 'B' Horizon if unsure (0.5-1 m)

Source J.S. Organ

Source J.S. Organ

Sample collection from mudboils

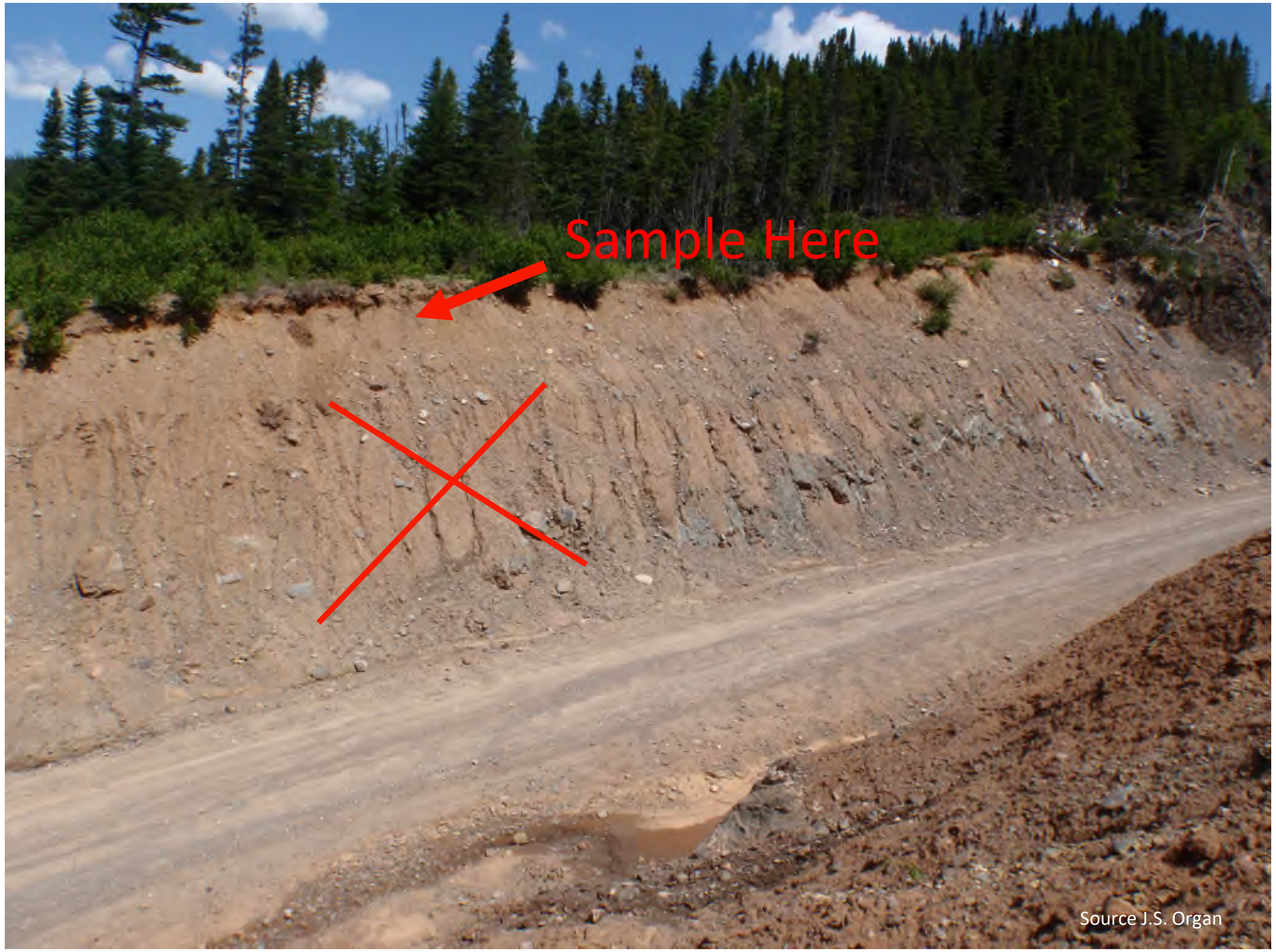
Sampling from sections

Choose a place:

- Where you can see the soil horizons
- The steepest part of the section (avoid slumped material)
- Dig back into section, until you get to unaltered material
- Be aware of contamination

Source J.S. Organ

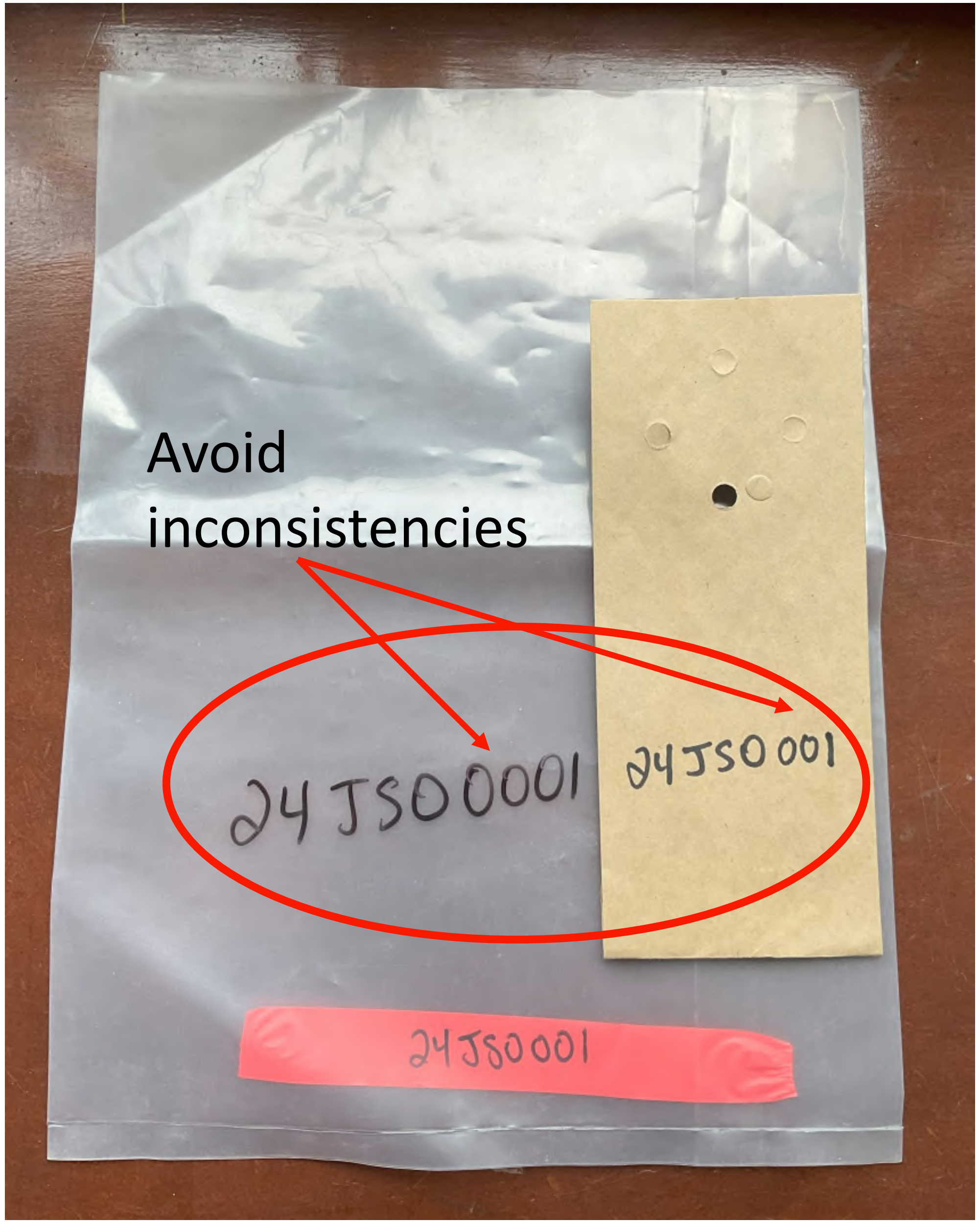
Where do you sample when you have a thick till?



- Do not sample where there are rills or slumped material
- Top – where you can see soil horizon (undisturbed)
- Detailed section sampling
  - Sample at regular intervals up (vertically) the section to create profile
  - Could have differences geochemically between top and bottom (closest to bedrock)
  - Top and bottom may not reflect the same ice flow

Sample collection

- Label bag – sample number should be a **unique ID**
  - 24JSO0001 (year, initials, number)
  - Be consistent with labeling
    - Double check bag numbers
  - Label both sides of the bag
    - Be mindful of where you label
    - Plastic bag: place labelled flagging tape in the bag



Source J.S. Organ

Sample collection

- Place sediment matrix in bag
  - Remove clasts (>2cm)
  - Remove **all** of the B horizon/organics
    before putting sediment in bag
  - Avoid any “rotten clasts” and oxidation

Source J.S. Organ

Source J.S. Organ

Sample collection

Securely close bag

- Brown bag fill to holes, fold properly
- Plastic bag
    - Twist bag
        - Wrap electrical tape around at base

        Or

        - Use zip tie
    - Fold tail of bag over
    - Tape tail

If there is water present:

DO NOT REMOVE

it contains suspended silt/clay

Source J.S. Organ

Record

- Site information:
  - Date
  - Site and sample number
  - Coordinates and datum (UTM NAD 27 vs Lat Long)
  - Elevation

- Sample Information:
  - Type of sample site: test pit, ditch, section, trench
  - Type of sample being collected: Geochem matrix, HMC, texture, bedrock, boulder
  - Horizon sampled (B, BC, C)
  - Depth of horizon
  - **Sample Quality: good, ok, poor**

Record

- Sample Description:
  - Material type (soil, till, glaciofluvial, pebbles, bedrock)
  - Matrix type (e.g., silty sand, sandy silt)
  - Matrix vs clast-supported
  - Clast type, shape, size, mineralization
  - Is bedrock seen? What depth?
  - Structures: bedding, faults, rip-up clasts etc.
  - Multiple units: thickness and contact type with units above and below (e.g., erosional, graduation, undulating)
- Photos of site, hole, with visible sample ID

What is next? Think about….

- Analytical lab and methods (e.g. Au+34 on <0.063mm)
  - Shipping costs
  - Consider saving pulps for further analysis
- Spatial interpretation….how do the results compare to ice flow?
  - Do they make sense? Do they define an “anomaly”?
- Reporting requirements
  - Assessment Report - if prospecting completed on mineral license
  - Prospector Assistance Grant – Final Report
- Does follow up sampling need to be completed?
- Do results warrant promoting property for option

Questions

Resources:

- Benn, D., and Evans, D.J.A. 2010. Glaciers and Glaciation, 2nd edition. Routledge, London. 816 pages. https://doi.org/10.4324/9780203785010
- Brushett, D., 2014: Prospecting under cover: Using knowledge of glacial processes in Mineral Exploration. Notes to accompany CIM Short Course, November 5, 2014. Geological Survey of Newfoundland and Labrador.
- Geoscience Atlas - https://geoatlas.gov.nl.ca/Default.htm
- McClenaghan, M.B., W.A., Spirito, Plouffe, A., McMartin, I., Campbell, J.E., Paulen, R.C., Garrett, R.G., Hall, G.E.M., Pelchat, P., Gauthier, M.S. 2020: Geological Survey of Canada till sampling and analytical protocols: from field to archive, 2020 update. Geological Survey of Canada, Open File 8591. 73 Pages.
- McClenaghan, M.B., Paulen, R.C. 2018: Chapter 20: Application of till mineralogy and geochemistry to mineral exploration *In* Past Glacial Environments, edited by Menzies, J., and van der Meer, J.J.M. Elsevier. Amsterdam. Pages 689-751.
- Norris, S.L., Organ, J.S., Dyke, A.S., Neligan, T. Stanton, C.C., Strickland, K., and Gosse, J.C. 2024. Glacial geomorphology of Newfoundland, Canada. Journal of Maps, Vol 20, No.1, 2386296. 14 pages. https://doi.org/10.1080/17445647.2024.2386296
- Shaw, J., Piper, D.J.W., Fader, G.B., King, E.L., Todd, B.J., Bell, T., Batterson, M.J. and Liverman, D.G.E. 2006: A conceptual model of the deglaciation of Atlantic Canada. Quaternary Science Reviews, Volume 25, pages 2059-2081.

Handout for notebook:

Source J.S. Organ

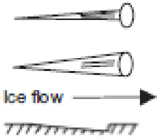
CIM Newfoundland & ICM Labrador Branch

2024 Prospector Short Course: Geological Sampling Best Practices

Ice-flow:

- Striae and grooves are bidirectional
- Nailhead and rat tail striae show ice-flow direction
- Cross-cutting relationships provide age relationships
- Look in the lee (down ice side of outcrop) for older striae
- Record oldest striae as 1, younger = 2, youngest = 3
- Use water and sunlight to see better and photograph

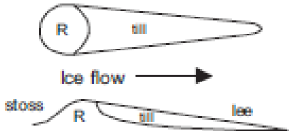
Nailhead striae



Rat tail striae

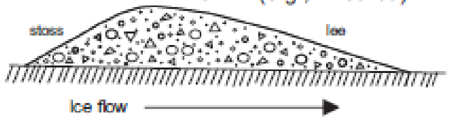
Subglacial Landforms:

Crag and tail

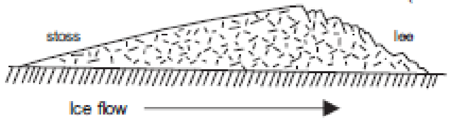


Till moraines (ridges) form perpendicular to ice flow

Drumlin (e.g., till cored)



Rôche moutonnée (rock)



Till Characteristics:

- Poorly-sorted mixture of sediment (clay to boulders)
- High silt and clay content (matrix-supported)
- Contains clasts that are:
  - local and transported far distances (e.g. exotic clasts)
  - striated and/or faceted clasts and angular to subround
- Deposited in contact with glacial ice (1st derivative of bedrock)

Subglacial Till:

- All characteristics above and
- Compact (hard to dig)
- Fissile (matrix crumbles along planes of weakness)
- Deposited at base of the ice - reflects actively flowing ice

Source J.S. Organ

Supraglacial Till:

- Poorly-sorted
- Contains silt and clay (usually less than subglacial till)
- Composed of material transported on top or within the ice
- Clasts transported far distances (e.g. exotic clasts)
- Loose, not compact
- Fewer striated faceted clasts
- Deposited by ice melting in place, meltwater may alter sediment (remove silt and clay content)

Sampling:

- C-horizon is best to sample
- Be consistent in sampling medium, note inconsistencies
- Use consistent, consecutive labeling system
- Insert QA/QC - field and lab duplicates (e.g. 1 in 10 or 1 in 20)
- Clean tools between sites

RECORD

Site information:

- Date
- Site and sample number
- Coordinates, elevation and datum (UTM Nad 27 vs Lat Long)

Sample Information:

- Type of sample site: test pit, ditch, section, trench
- Type of sample being collected: geochem, HMC, bedrock
- Soil Horizon sampled (B, BC, C) be consistent
- Depth of horizon
- **Sample quality: excellent, good, ok, poor**

Sample Description:

- Material type (soil, till, glaciofluvial, pebbles, boulders, bedrock)
- Matrix texture (e.g., silty sand, sandy silt)
- Matrix vs clast supported (>40% clasts)
- Clast type, shape, size, mineralization
- Is bedrock seen? What depth?
- Structures: bedding, faults, rip up clasts etc.
- Multiple units: thickness and contact type with units above and below (e.g. erosional, gradational, undulating)
- Photos of site, hole, sample bag with sample ID visible