NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Overview of the GEM2 Glacial Synthesis Project in mainland Nunavut

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Outline of presentation

- Project framework

  Rationale, Objectives, Outcomes, Regional context

- Sector 1 compilation

  Nomenclature, field work, compilation

- Till provenance studies

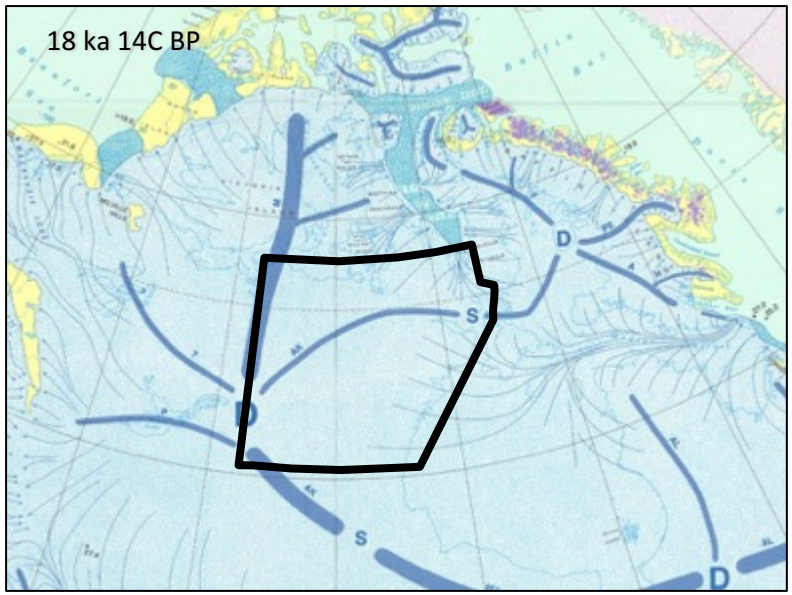
  Dubawnt Lake Ice Stream, Keewatin Ice Divide

- Summary

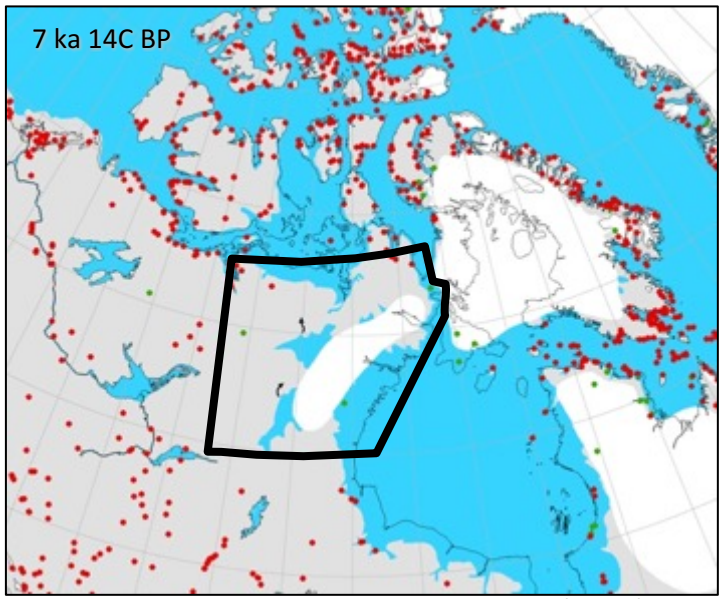
Rationale

Glacial Synthesis Project

- Core region of the LIS heavily covered by glacial sediments
- Complex glacial history with evidence for multiple glaciations, dynamic glacial systems and changing basal ice thermal regimes
- Poorly constrained relative/absolute chronology of glacial events
- Current compilations of glacial features are incomplete and/or generalized and models of paleo-ice sheet evolution are outdated



Dyke and Prest, 1987



From Dyke et al., 2003

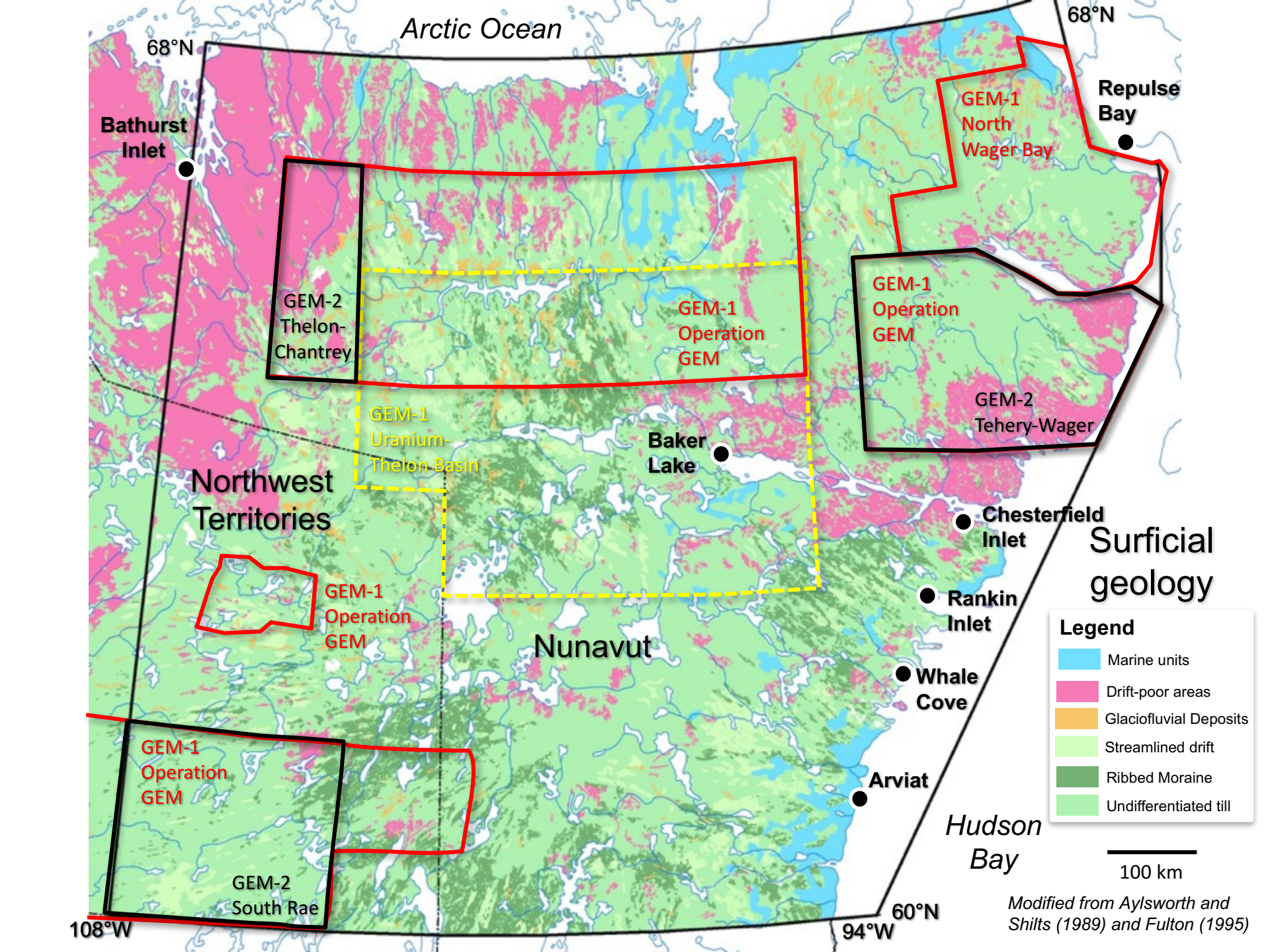
Objectives

Glacial Synthesis Project

- Provide a new digital compilation of glacial landforms and interpretation of glacial landscapes by integrating published and recent map compilations, field observations and interpretations from high-resolution DEM and imagery
- Update the glacial history of mainland Nunavut and NWT
- Examine the effect of the complex glacial history on nature of drift composition and glacial dispersal characteristics in the various identified glacial landscapes

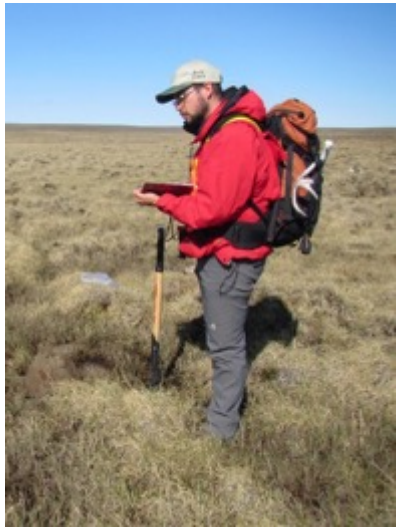
Outcomes

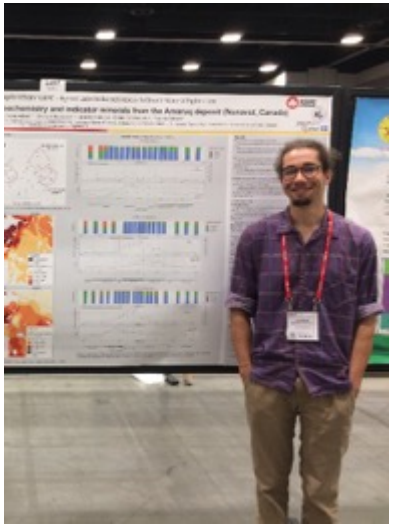
- Provide a regional framework to improve mineral exploration models for interpreting sources of anomalies in surface materials directly deposited by glacial ice (till, boulders) or derived from glacial sediments (esker, stream and lake sediments, etc.).

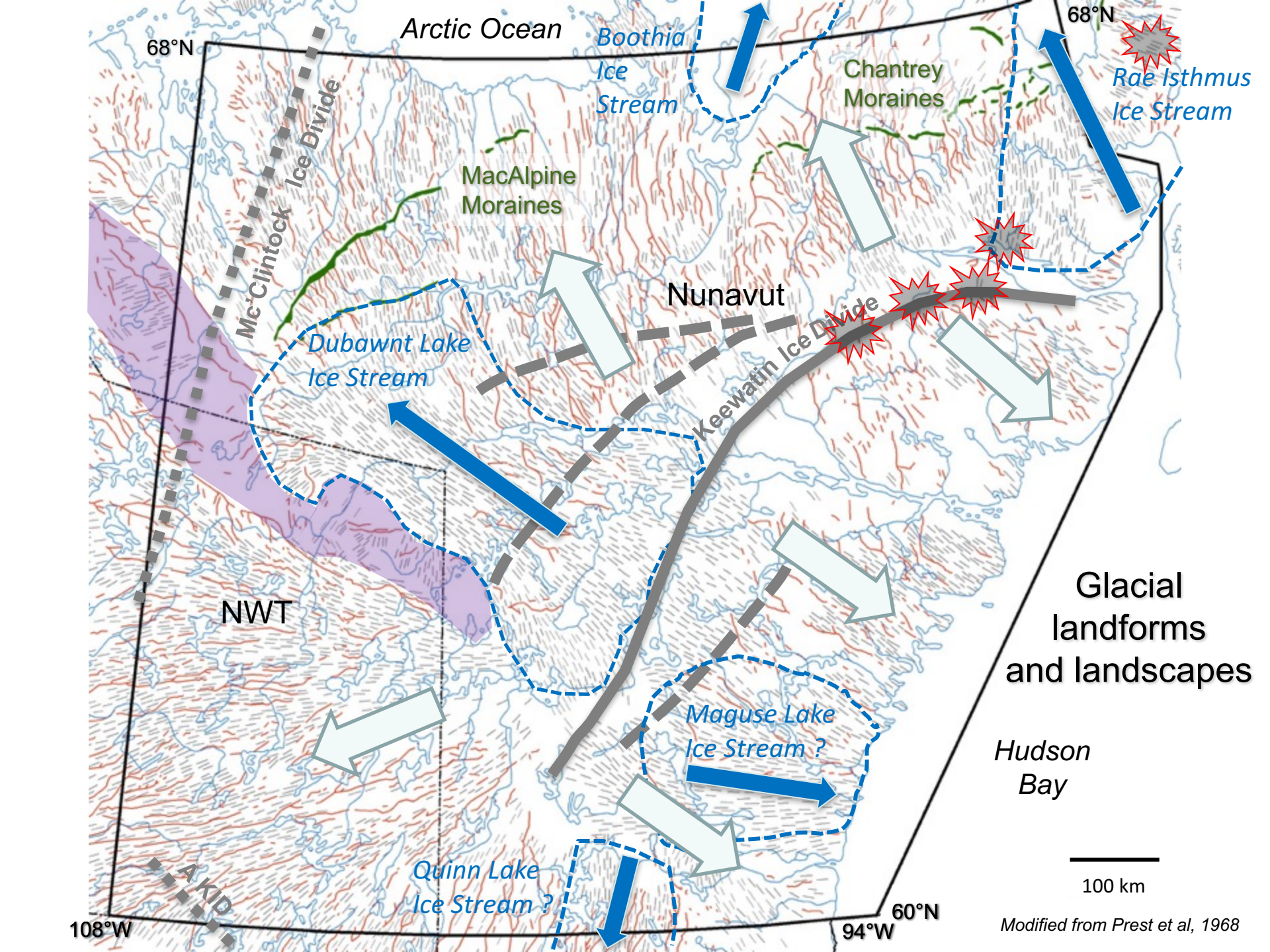

Arctic Ocean
68°N
68°N
Bathurst Inlet
Repulse Bay
GEM-1 North Wager Bay
GEM-2 Thelon-Chantrey
GEM-1 Operation GEM
GEM-1 Operation GEM
GEM-2 Tehery-Wager
GEM-1 Uranium-Thelon Basin
Baker Lake
Northwest Territories
Chesterfield Inlet
Surficial geology
GEM-1 Operation GEM
Rankin Inlet
Nunavut
Whale Cove
Legend
Marine units
Drift-poor areas
Glaciofluvial Deposits
Streamlined drift
Ribbed Moraine
Undifferentiated till
GEM-1 Operation GEM
Arviat
Hudson Bay
GEM-2 South Rae
100 km
108°W
94°W
60°N
Modified from Aylsworth and Shilts (1989) and Fulton (1995)

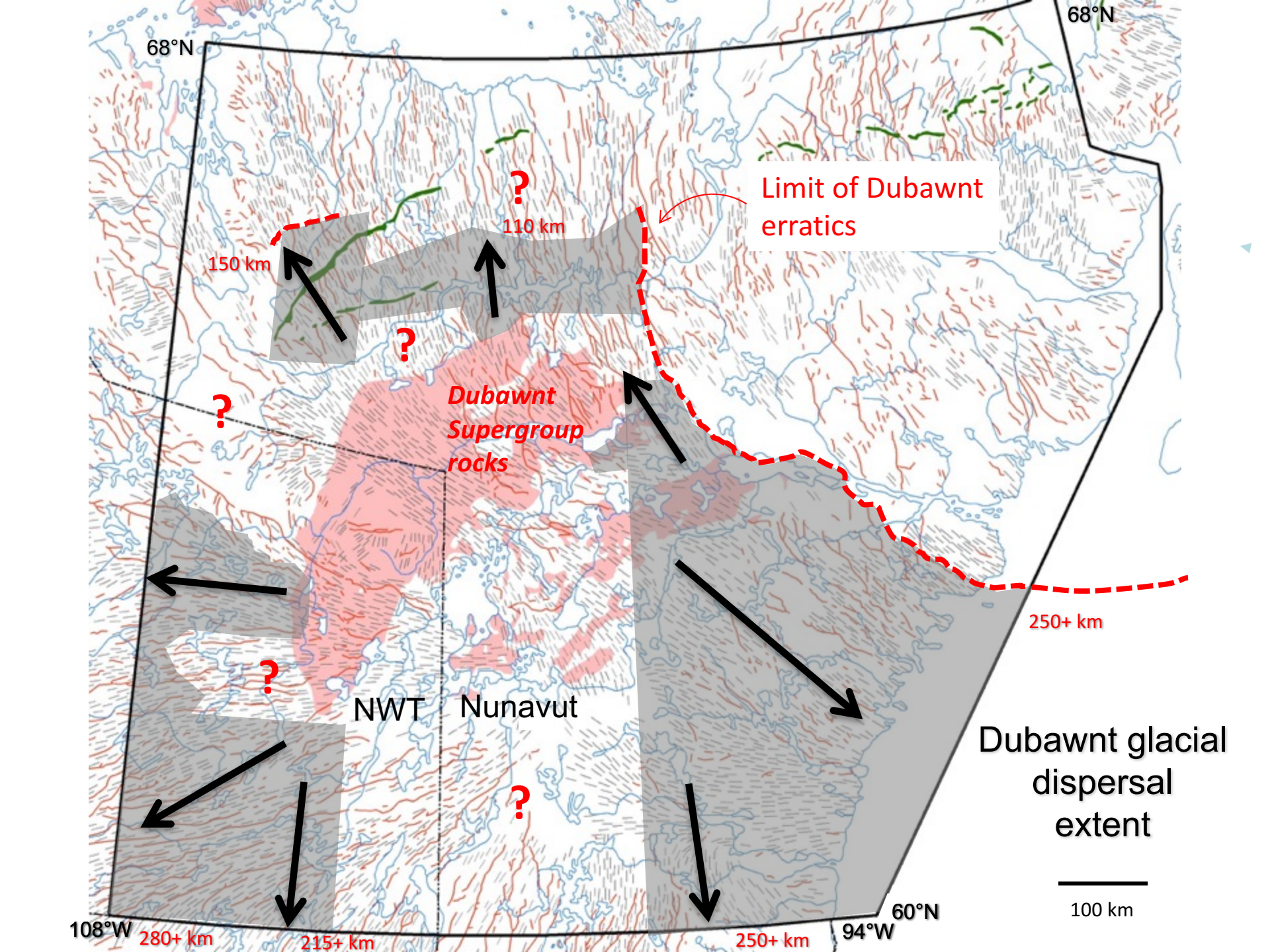
MSc Thesis in GEM1 & GEM2

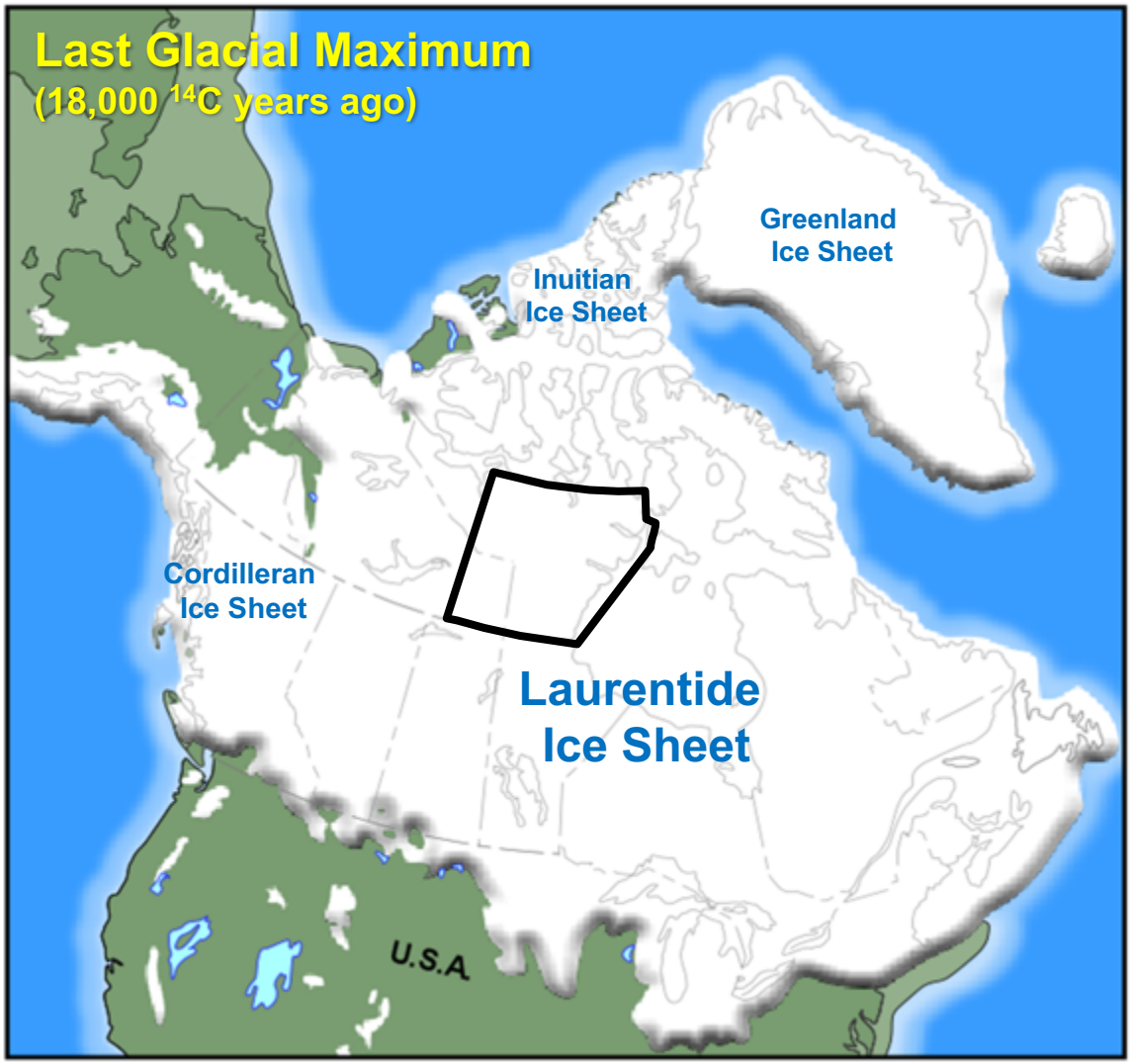
1. RPM Surficial Materials Repulse Bay Area (Ulanna Wityk - U. Waterloo 2014)
2. Signature of Kiggavik U Deposit in till (Scott Robinson – Queen's U 2015)
3. RPM Surficial Materials Wager Bay Area (Justin Byatt – U New Brunswick 2017)
4. Marine extent, chronology and impact on till composition (Iyse Randour– UQAM 2018)
5. Glacial geology near Amaruq (Nicolas Boulianne-Verschelden – Laval U)
6. Signature of Amaruq Au deposit in proximal till (Victor De Bronac de Vazelhes - Laval U)
7. Signature of Amaruq Au deposit in distal till (Alexandre Mendizabal - Laval U)




Arctic Ocean
68°N
68°N
Boothia
Ice
Stream
Chantrey
Moraines
Rae Isthmus
Ice Stream
MacAlpine
Moraines
Mc Clintock Ice Divide
Nunavut
Dubawnt Lake
Ice Stream
Keewatin Ice Divide
NWT
Maguse Lake
Ice Stream ?
Quinn Lake
Ice Stream ?
AKD
108°W
94°W
60°N
Hudson
Bay
Glacial
landforms
and landscapes
100 km
Modified from Prest et al, 1968


68°N
68°N
Limit of Dubawnt erratics
110 km
150 km
?
?
?
Dubawnt Supergroup rocks
250+ km
?
NWT
Nunavut
?
Dubawnt glacial dispersal extent
100 km
108°W
280+ km
215+ km
250+ km
94°W
60°N



(adapted from Dyke et al., 2003)

Key scientific questions

1) what is the flow direction, sequence and degree of overprinting of shifting glacial and deglacial events in a core region of the LIS;

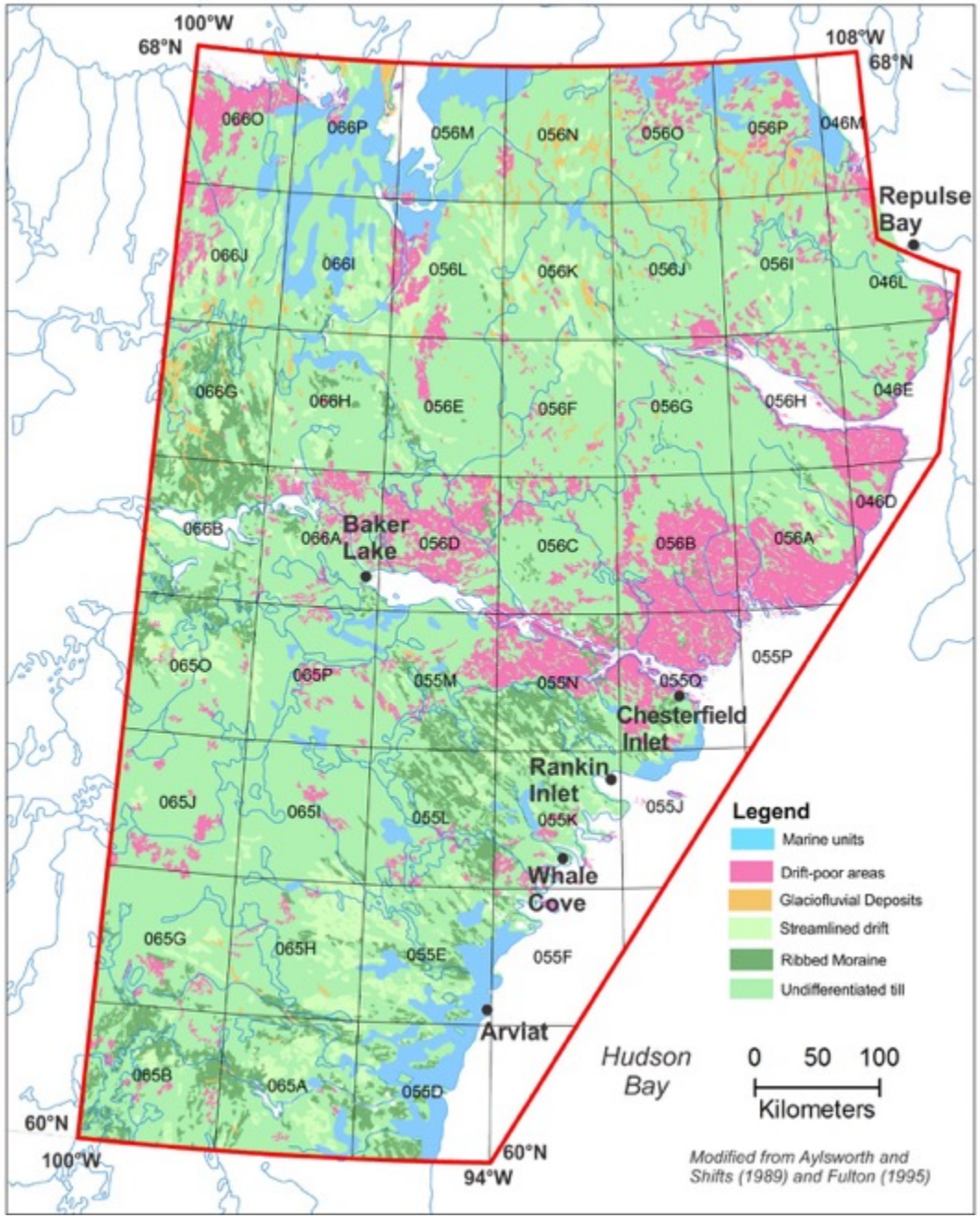
2) what is the extent and nature of early glacial landscapes that may have escaped younger glaciation(s) under non-erosive ice regimes (ice divides and/or cold-based); and,

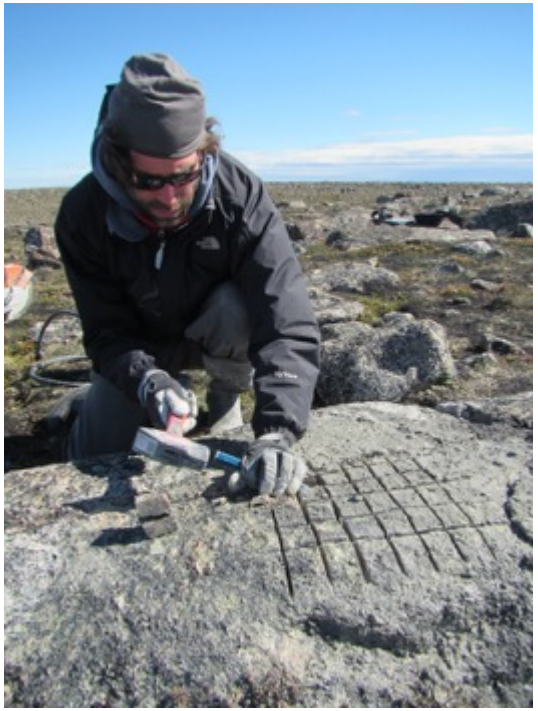
3) what is the net effect of the glacial history on the nature of glacial dispersal patterns, i.e. palimpsest, recycled and/or inherited surface sediment composition.

Sector 1 compilation

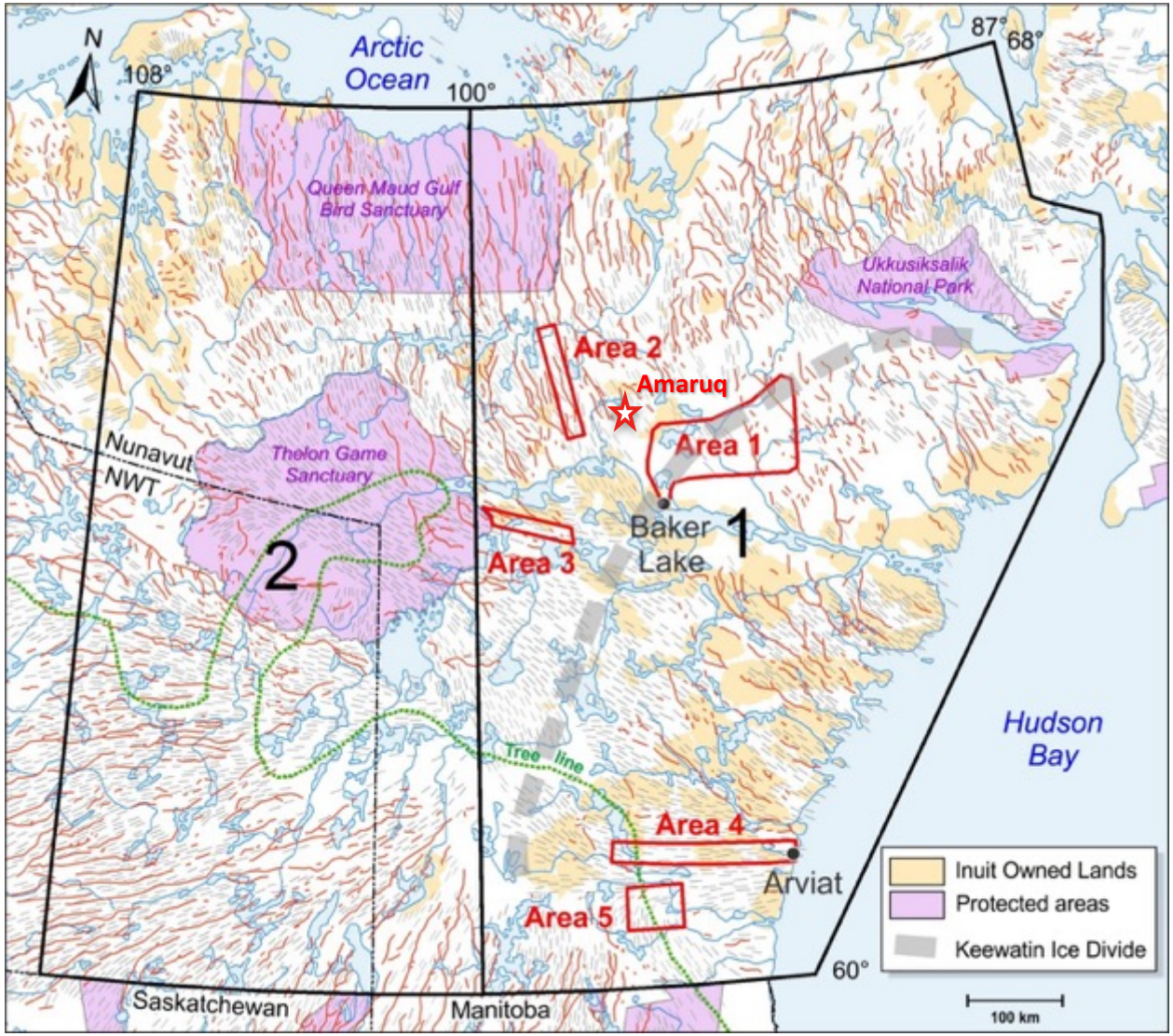
43 complete/partial 1:250K NTS map sheets

1) Targeted field work
2) Nomenclature of glacial features
3) Glacial features compilation





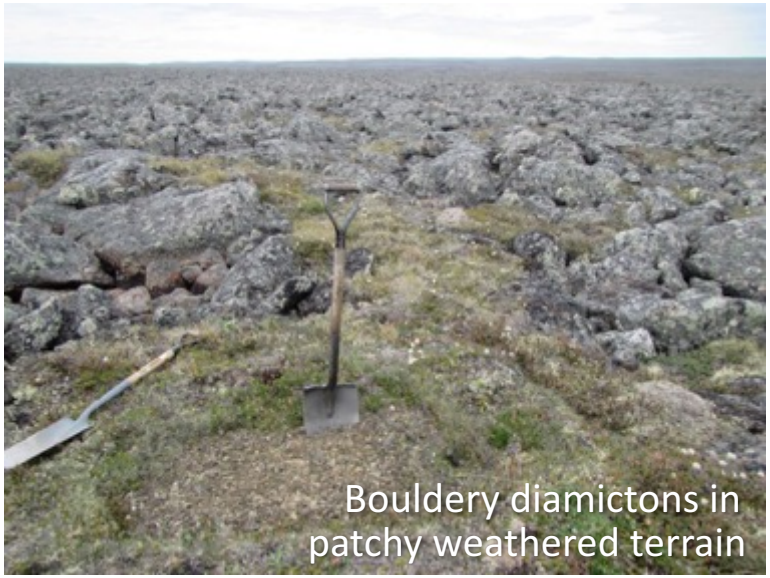
1) Targeted field work (5 selected areas in 2017)



From McMartin et al, 2017; GSC OF 8320

- Engagement activities prior to field work in Baker Lake and Arviat
- Hiring of 2 local field assistants
- Surficial geology observations at 92 stations, including ice-flow indicator measurements (n=35 stations) and detailed marine limit elevation measurements (5)
- 16 geochronological samples (TCN & IRSL); 38 regional till samples for geochemistry, HMC, pebble lithology); 8 till samples for TCN; 4 bedrock samples from Dubawnt Supergroup for lithogeochemistry
- Submission of 15 samples for TCN from GEM2 framework mapping areas
- Continued field work as part of 2 MSc thesis at Amaruq

Keewatin Ice Divide: Areas 1 and 5



From McMartin et al, 2017; GSC OF 8320

- Nature of terrain examined
- Relative chronology of ice-flow events determined
- Four sites sampled to evaluate relative erosion rates and/or deglaciation ages (TCN)

Results

- Landscape varies from intermediate cold-based NE of Baker Lake to a warm-based, erosive glacial landscape further south
- Evidence for a significant migration and change in orientation of central axis of ice divide

Ice-stream landscapes: Areas 2, 3 and 4

- Nature of terrain examined
- Till samples collected along 3 transects to characterize glacial transport
- Relative chronology of ice-flow events determined
- Four sites sampled to evaluate deglaciation ages (TCN)

Results

- Evidence for long-range glacial transport (>30 km)
- Relative chronology of striations indicates complex ice-flow events prior to ice streaming events

From McMartin et al, 2017; GSC OF 8320

2) Nomenclature of glacial features

❑ POLYGONS: end moraine deposits, glaciofluvial ice-contact deposits

❑ LINES: subglacial meltwater corridors, meltwater channels (major, minor, lateral, iceberg scour, moraine ridge (major, minor), De Geer moraine, ice stream margin, ice-contact scarp, esker ridge (sense known, unknown), glacially streamlined landform, crag-and-tail landform, limit of inundation (marine, glacial lake), beach crest (marine, glacial lake), spillway, visible till plume direction (carbonate, non-carbonate)

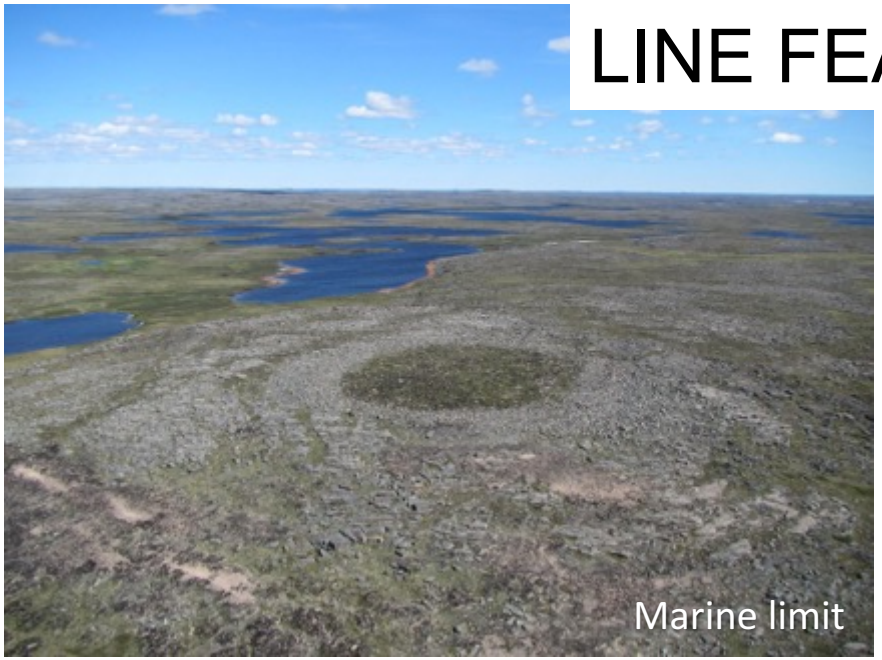
❑ POINTS: ice-contact delta (marine, glaciolacustrine), kame, kettle

- FIELD OBSERVATIONS: station (ground, remote), surface earth material, ice-flow indicator (roche moutonnée, striations), sample (till, bedrock, age dating material), photograph

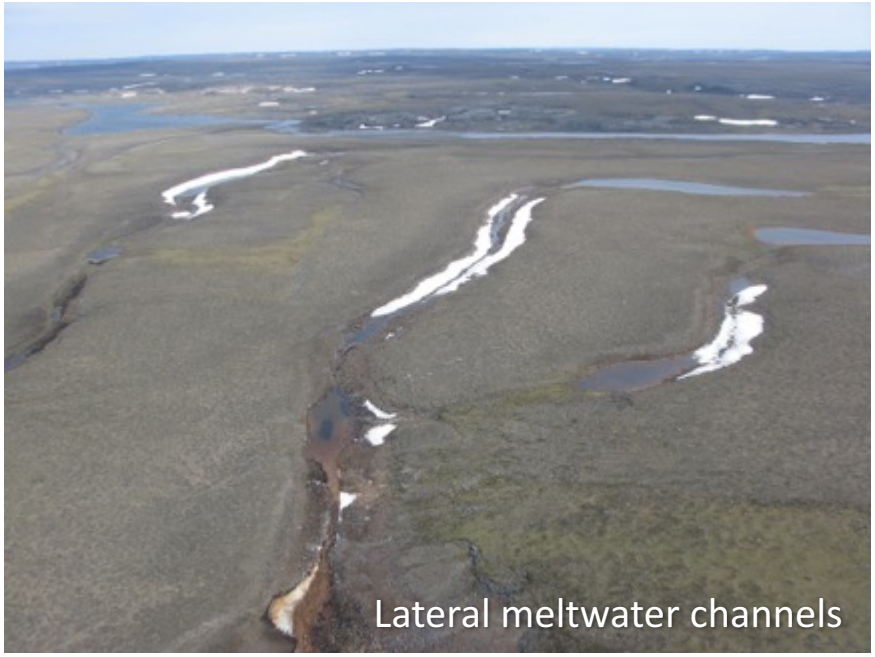
- ANALYTICAL RESULTS: sample composition, sample age

- OVERLAY FEATURES (interpreted): ice divide central axis, ice divide zone, ice-flow direction, ice stream landscape, palimpsest landscape, relict cold-based terrain (full, intermediate), deglacial cold-based, relict warm-based

LINE FEATURES

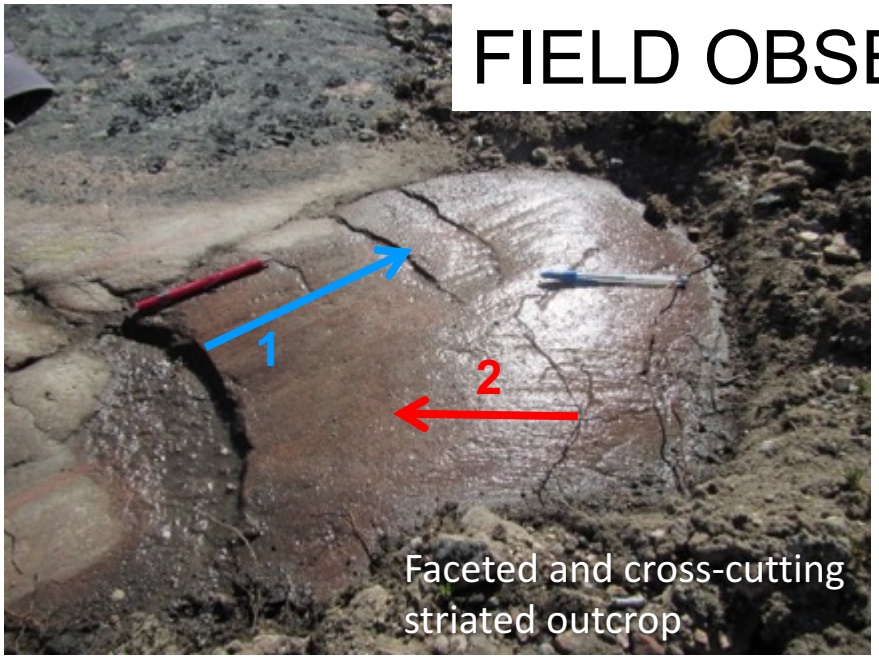

Marine limit


Esker ridge


Lateral meltwater channels


Crag-and-tail landforms

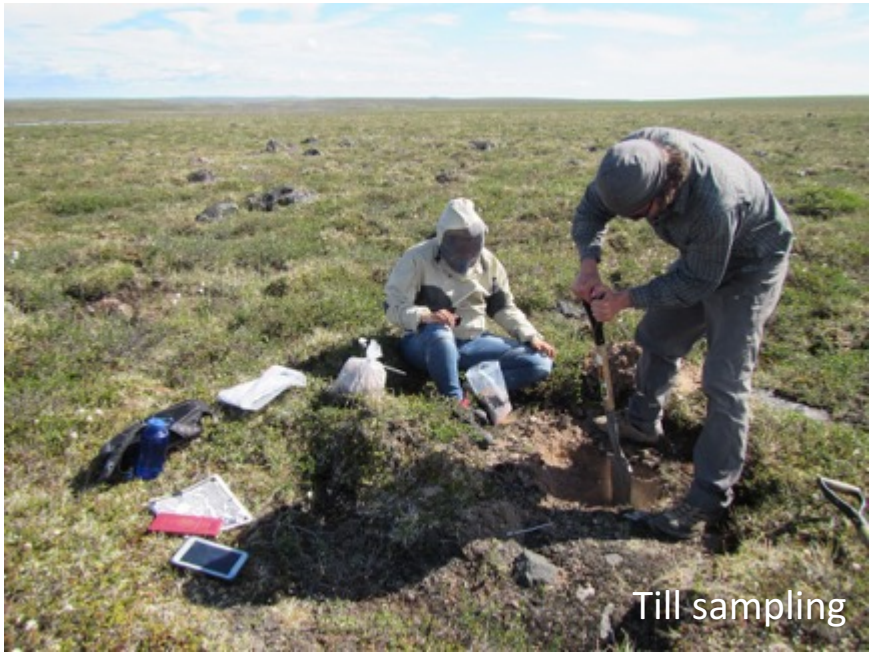
FIELD OBSERVATIONS



Faceted and cross-cutting striated outcrop

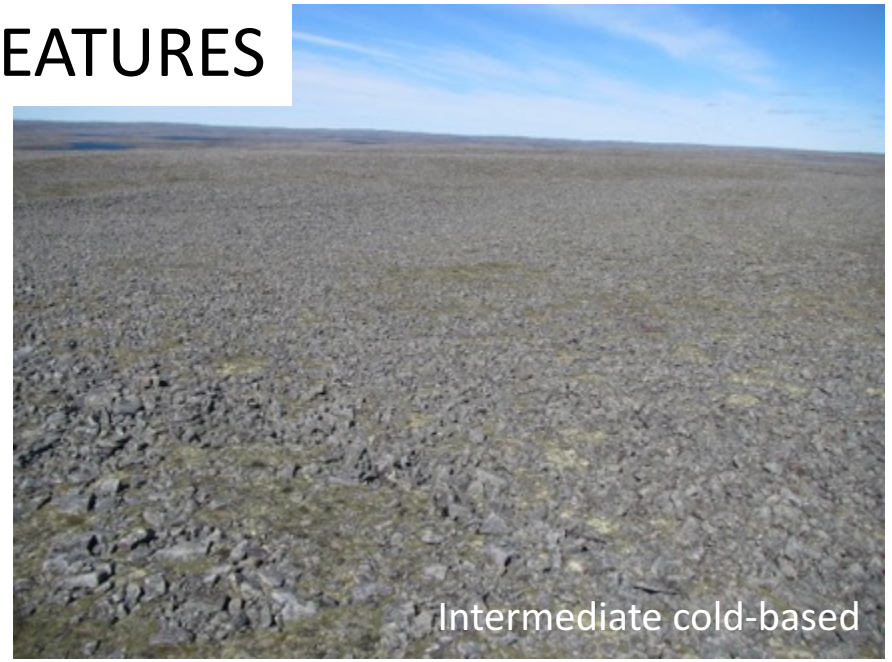

TCN sampling


IRSL sampling


Till sampling

OVERLAY FEATURES

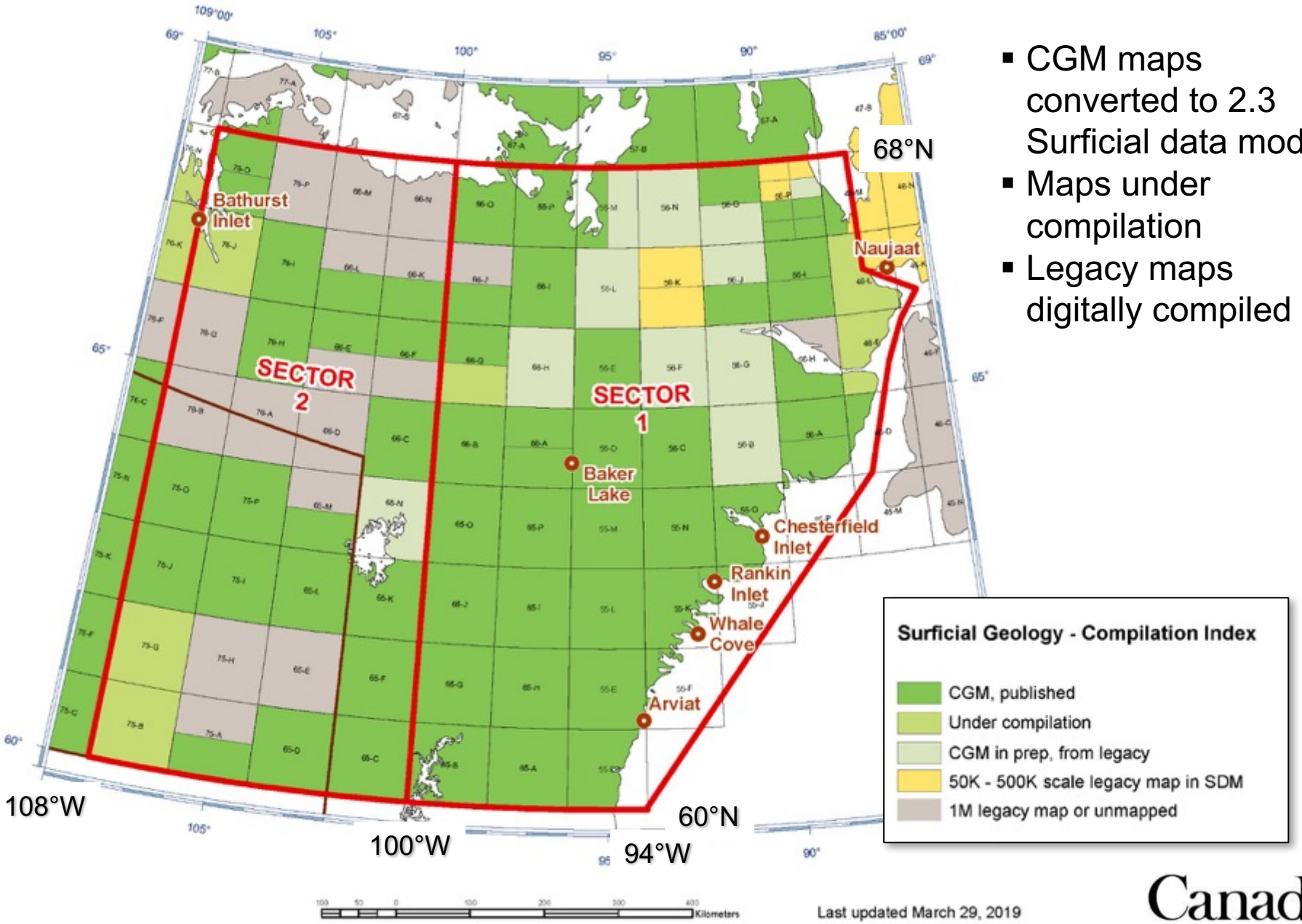

Full cold-based


Intermediate cold-based


Ice stream landscape


Deep linear erosion

3) Glacial features compilation

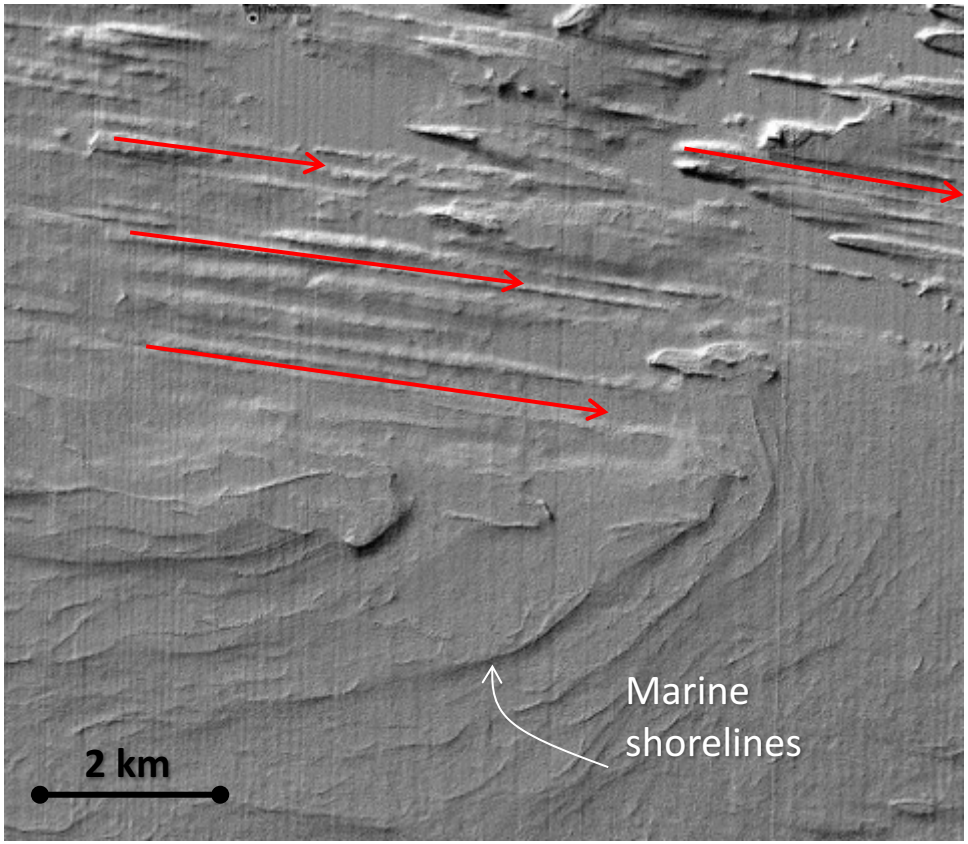


- CGM maps converted to 2.3 Surficial data model
- Maps under compilation
- Legacy maps digitally compiled

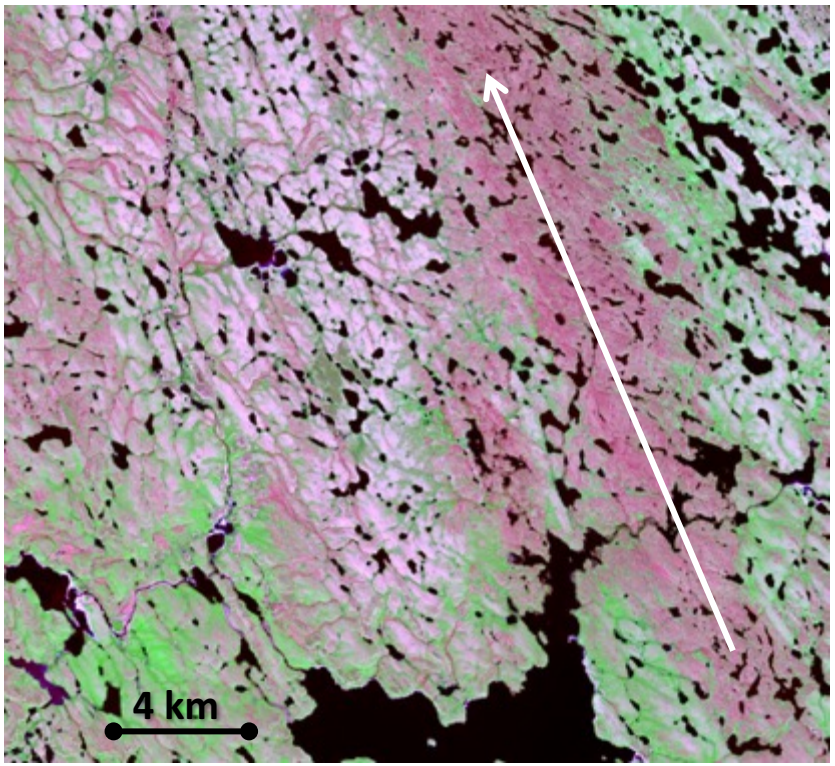
Last updated March 29, 2019

Canada

ArcticDEM
(5 m resolution)



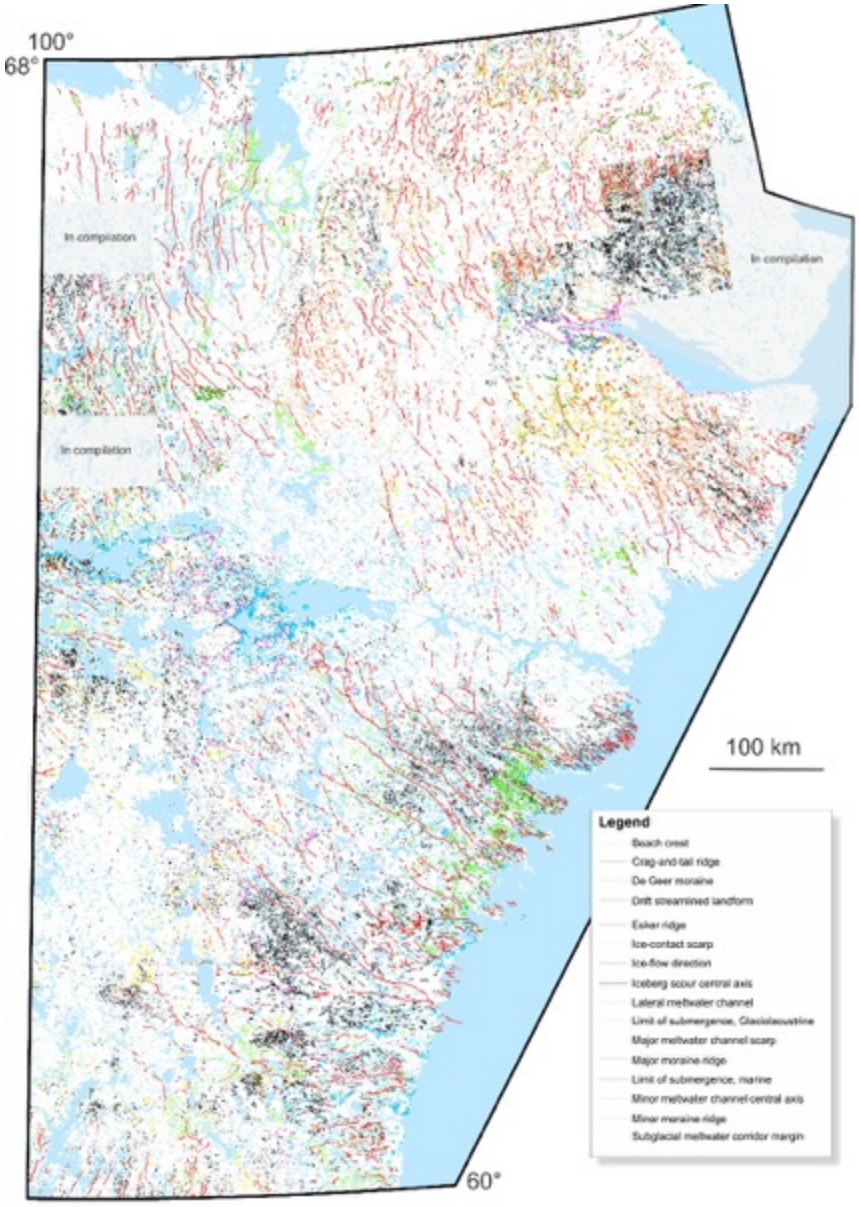
Landsat 8
(30 m resolution)



Bands 754

Compilation – Sector 1

LINE FEATURES



Metadata structure

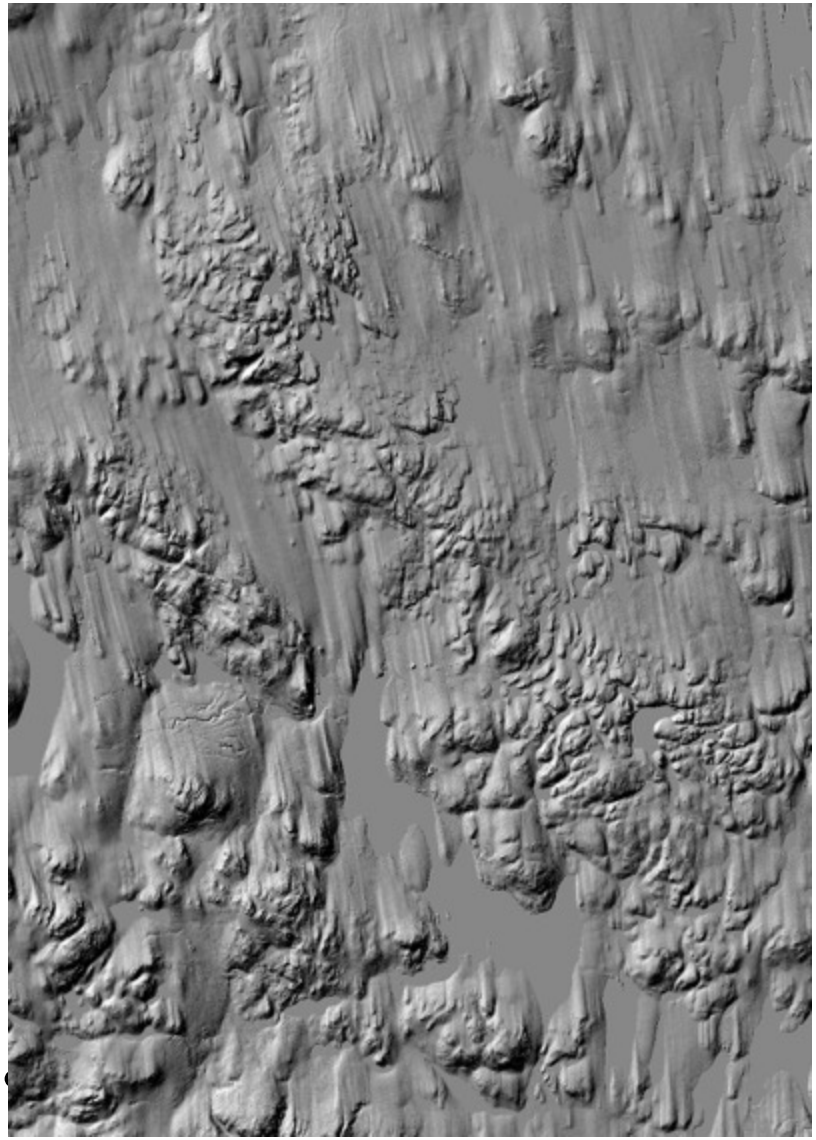
- simplified shape files
- individual features mapped to scale
- information stored in GIS attribute tables:
  - Feature type and sub-type
  - Data source
  - Original interpretation
  - Remarks on re-interpretation (mapper, date, nature: error, duplication, shift, addition)

N = 126,606

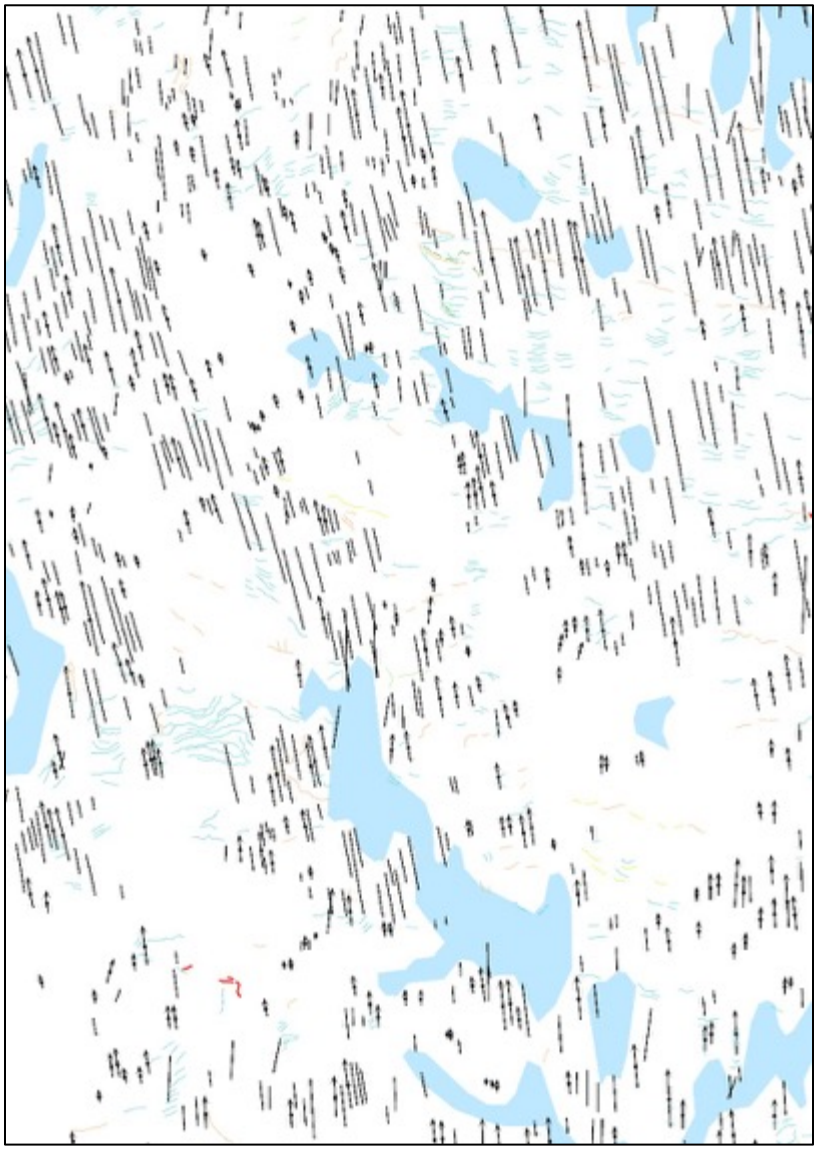
Feature Type	Feature Type Subset	Count (Sector 1)
Line features		Total = 126,606
Subglacial meltwater corridor margins		983
Major meltwater channel scarp		5459
Minor meltwater channel central axis	Sense: Known, Unknown	9507
Lateral meltwater channel central axis	Lateral up hill left, right	2025
Iceberg scour central axis		16
Major moraine ridge		1336
Minor moraine ridge		13295
De Geer moraine		5554
Ice-contact scarp		147
Esker ridge	Sense: Known, Unknown	14061
Streamlined landform	Sense: Known, Unspecified	30686
Crag-and-tail landform		9155
Ice-flow direction (in glacial trough)		87
Limit of submergence	Glaciolacustrine, Marine	1419
Beach crest	Marine, Glaciolacustrine	27921

Compilation – Sector 1

LINE FEATURES



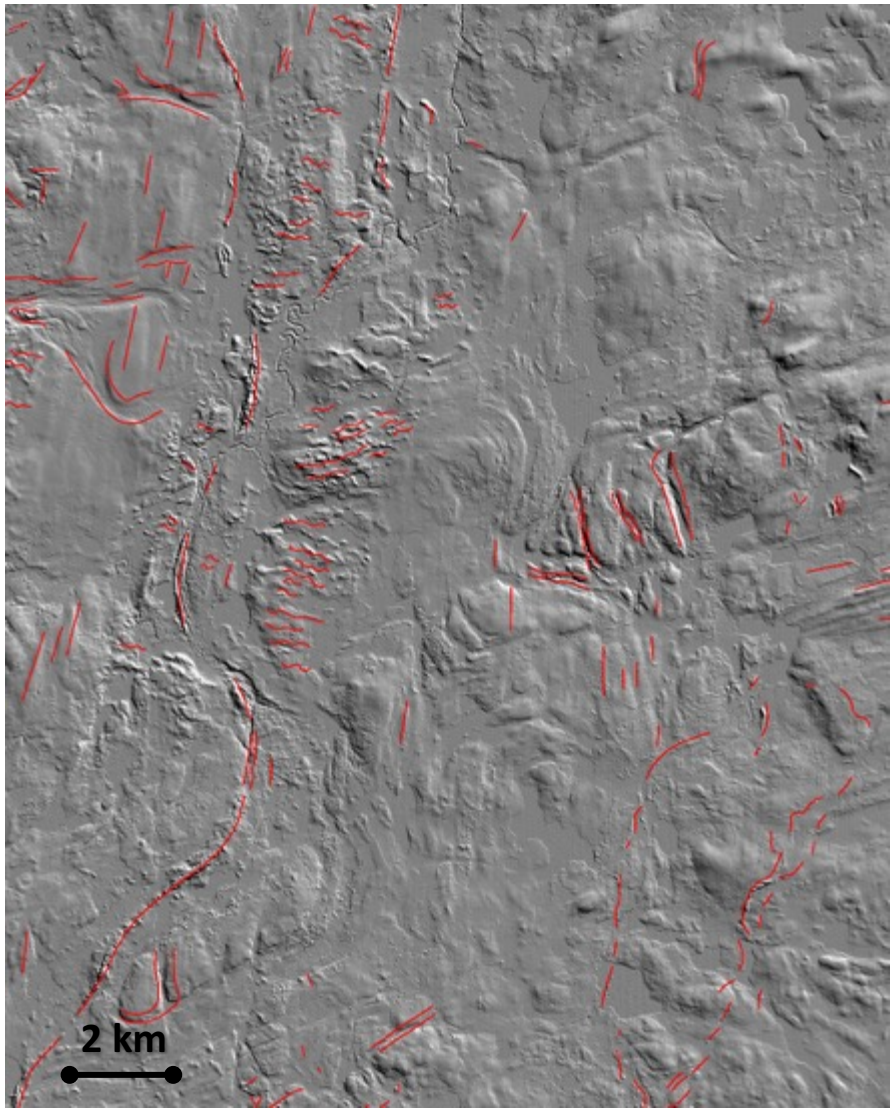
ArcticDEM



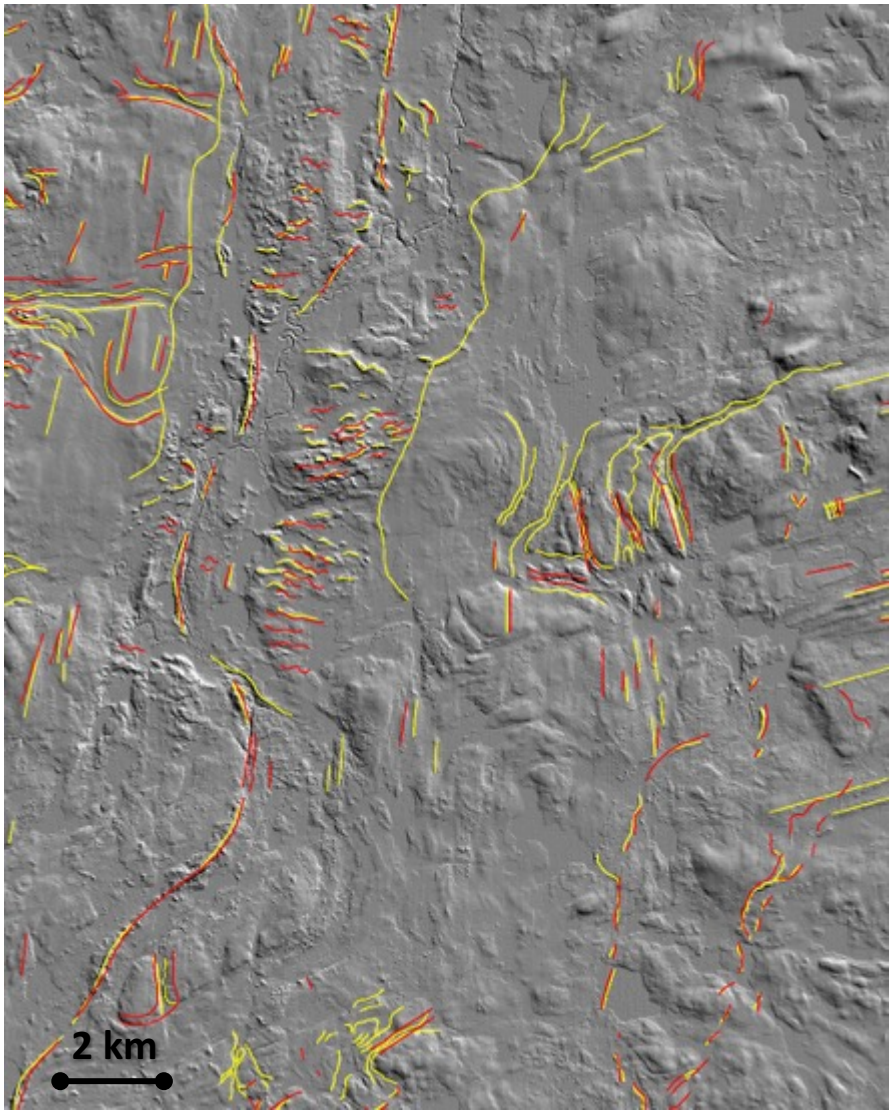
McMartin et al., 2017, CGM map 294

Compilation – Sector 1

LINE FEATURES



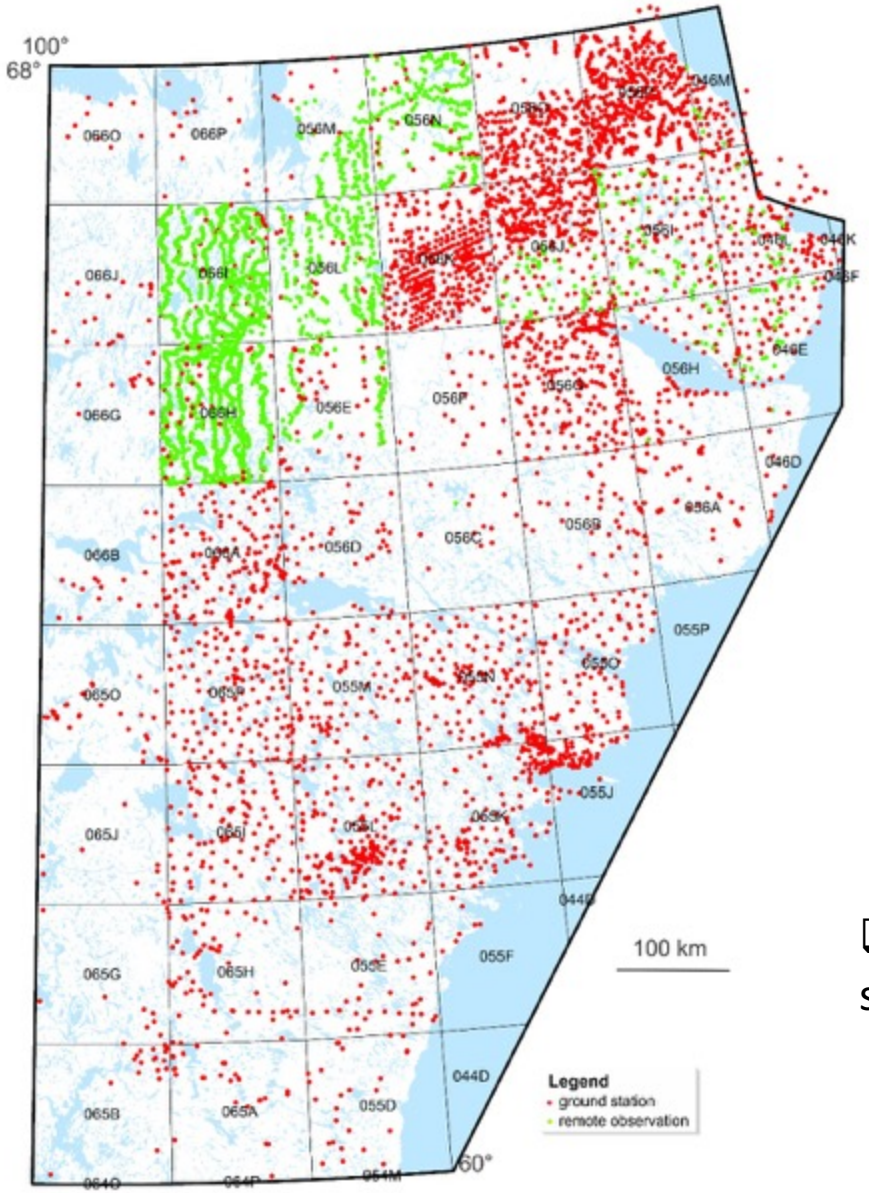
Features from original GSC map



New map

Compilation – Sector 1

FIELD OBSERVATIONS



Metadata structure

- simplified shape files
- individual field observations linked to Station ID
- information stored in GIS attribute tables:
  - Station ID
  - Visit date
  - Observation type
  - Map sheet
  - Legend value
  - Notes
  - Source

N = 5028 ground stations;
2301 remote observations

❑ surface earth materials, ice-flow indicators, samples, photographs

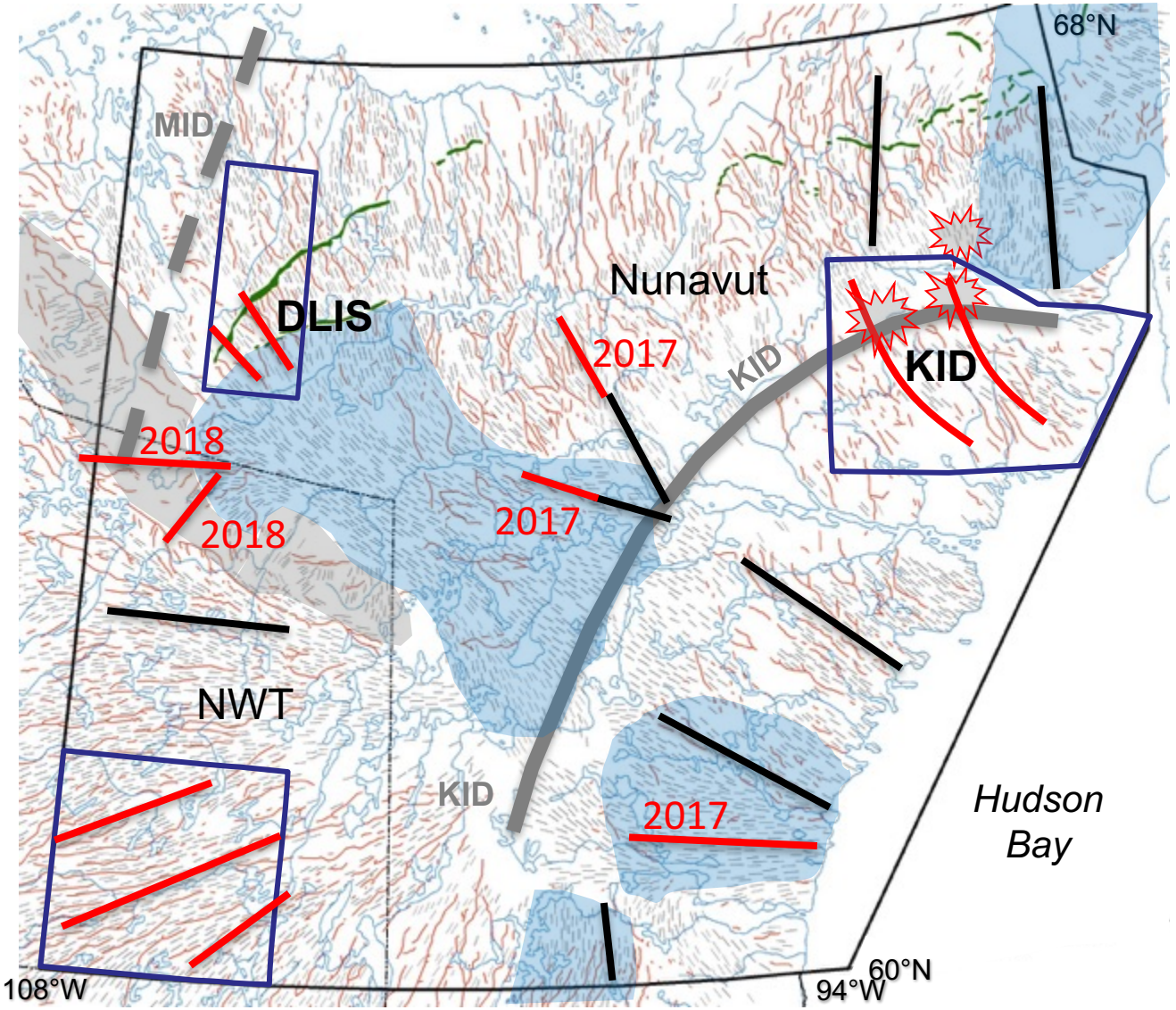
Final product – Sector 1 compilation

- ✓ A scalable map with accompanying database of glacial features and landforms (individually identified)
- ✓ A generalized map of glacial features using GEOSCALER software
- ✓ A field database including ground and remote stations with field observations, ice-flow measurements and/or glacial sediment samples
- ✓ An interpretation of glacial landscapes (georeferenced overlays)
- ✓ A bibliography of all published sources
- ✓ A nomenclature of the map features

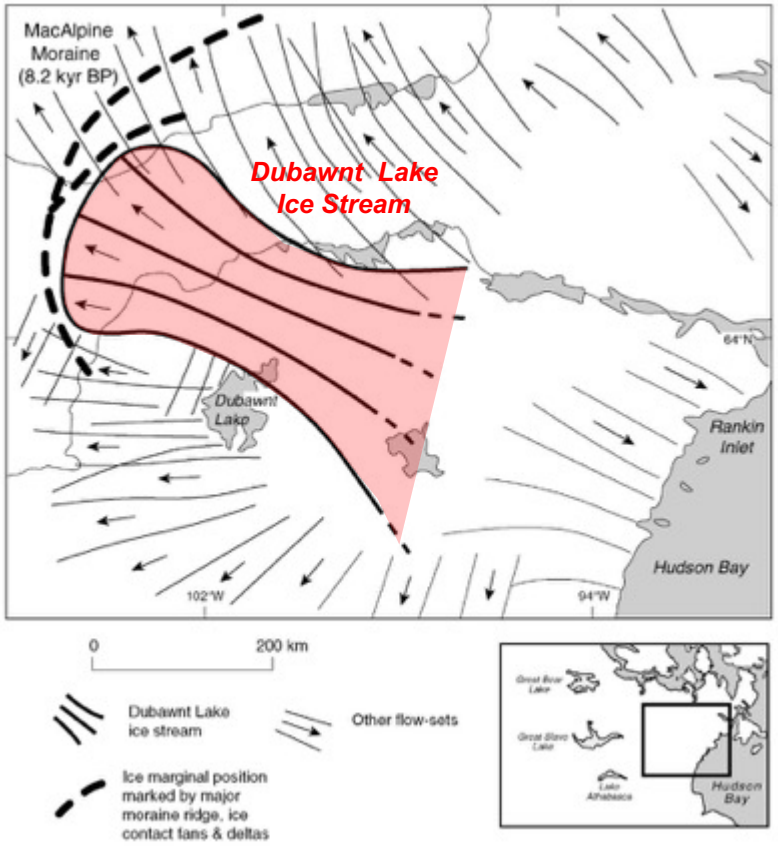
❑ Updated glacial history : a contribution to the GEM Surficial Synthesis

Till provenance studies along selected transects

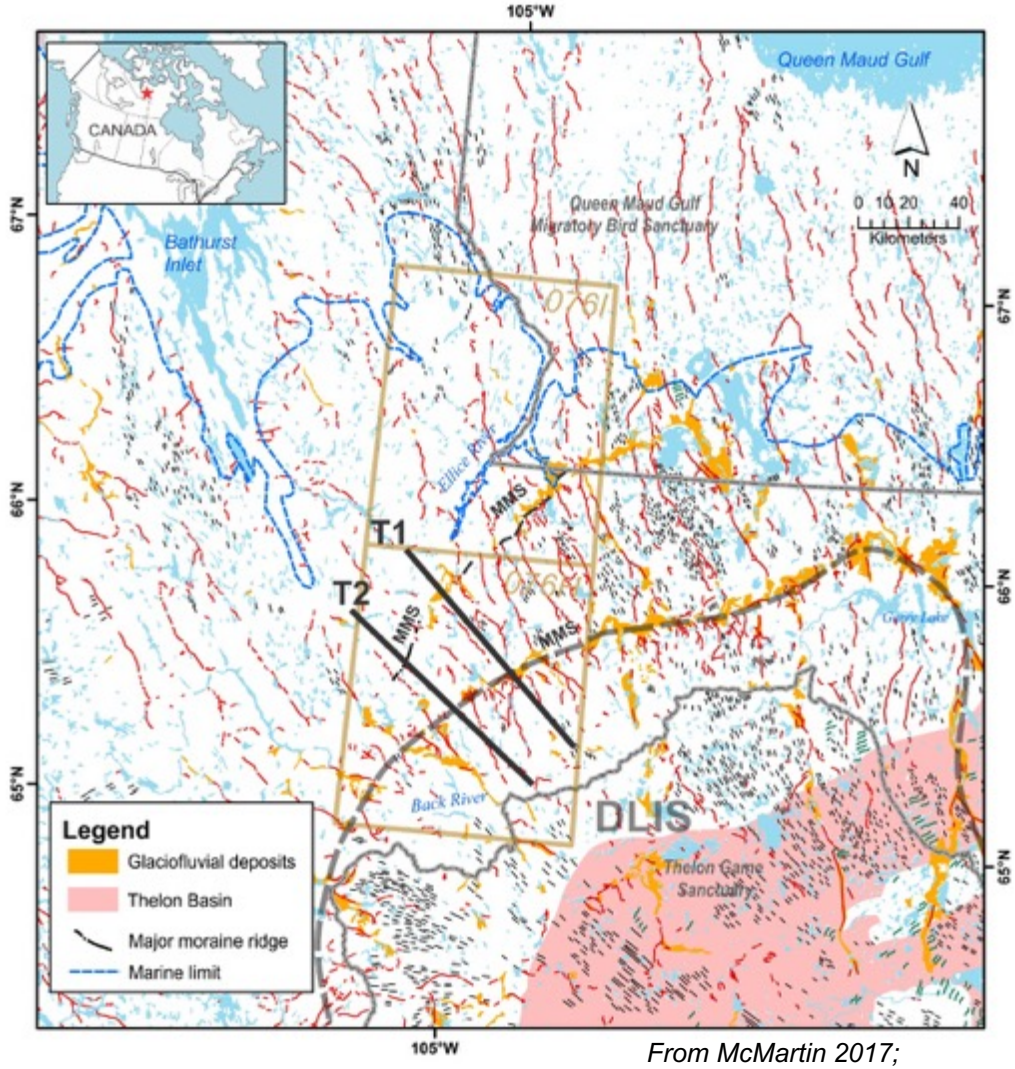
Objective: Characterize regional glacial transport using key glacial sediment composition datasets from archived/published and new samples in various glacial landscapes



Transect study: terminus of DLIS



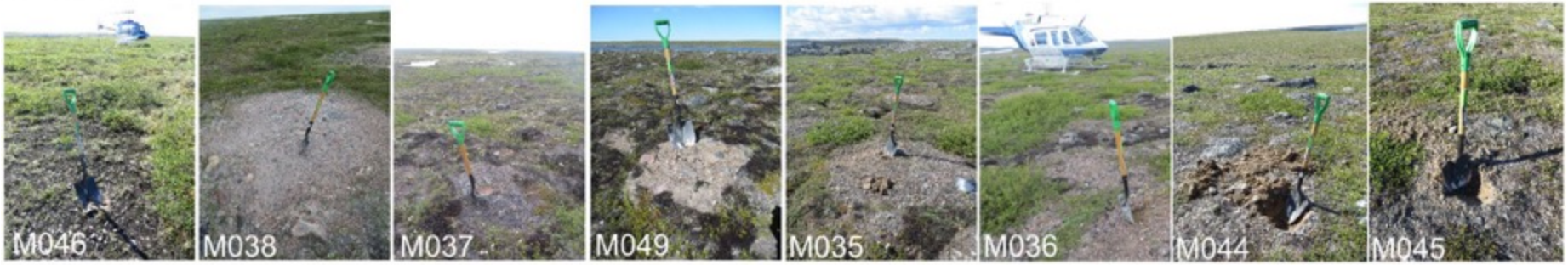
From Stokes & Clark, Boreas 2003



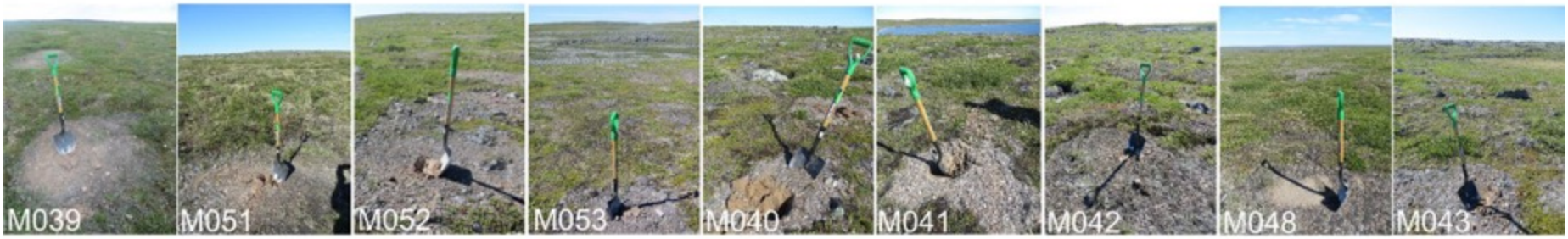
From McMartin 2017;
GSC Current Research paper

Transect study: terminus of DLIS

A: Transect 1

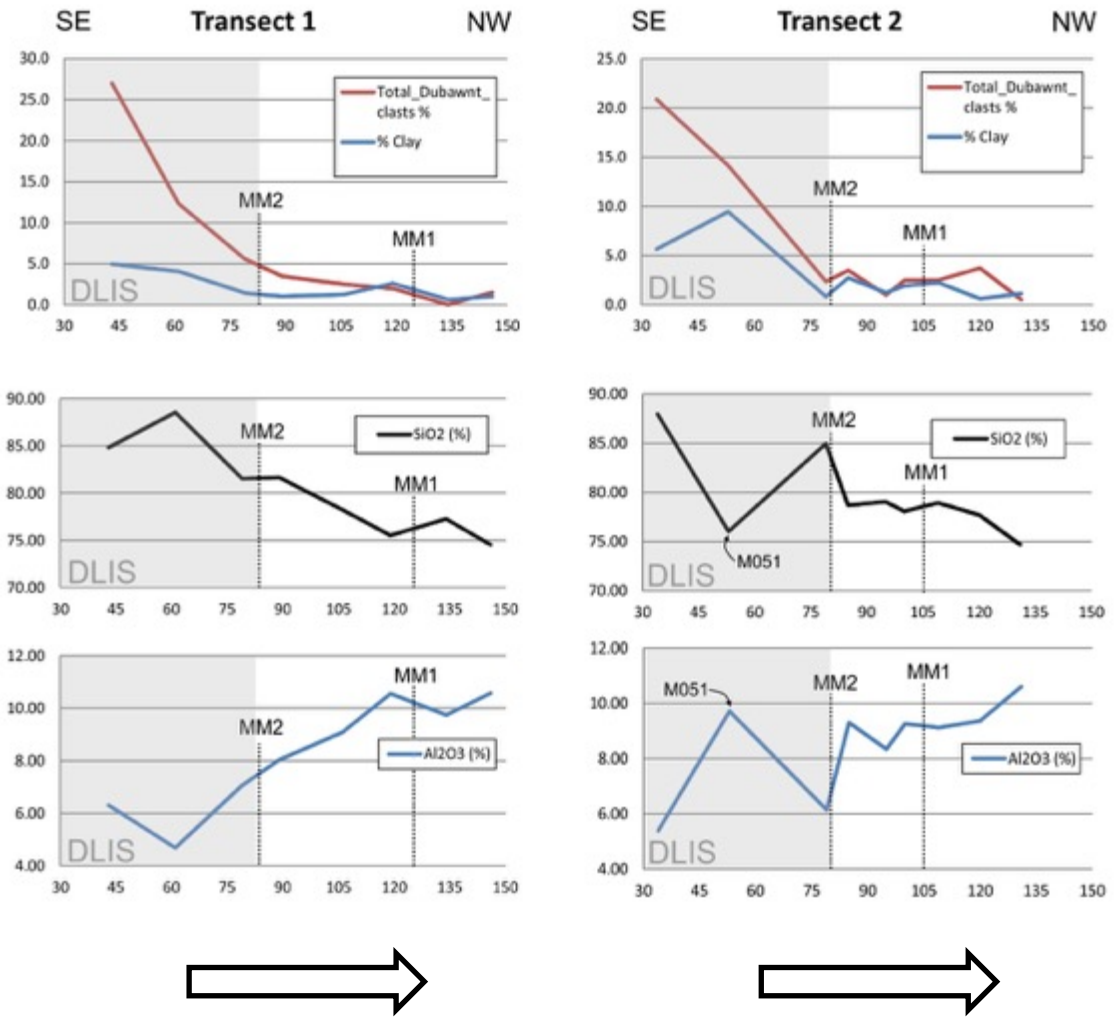


B: Transect 2



From McMartin 2017;
GSC Current Research paper

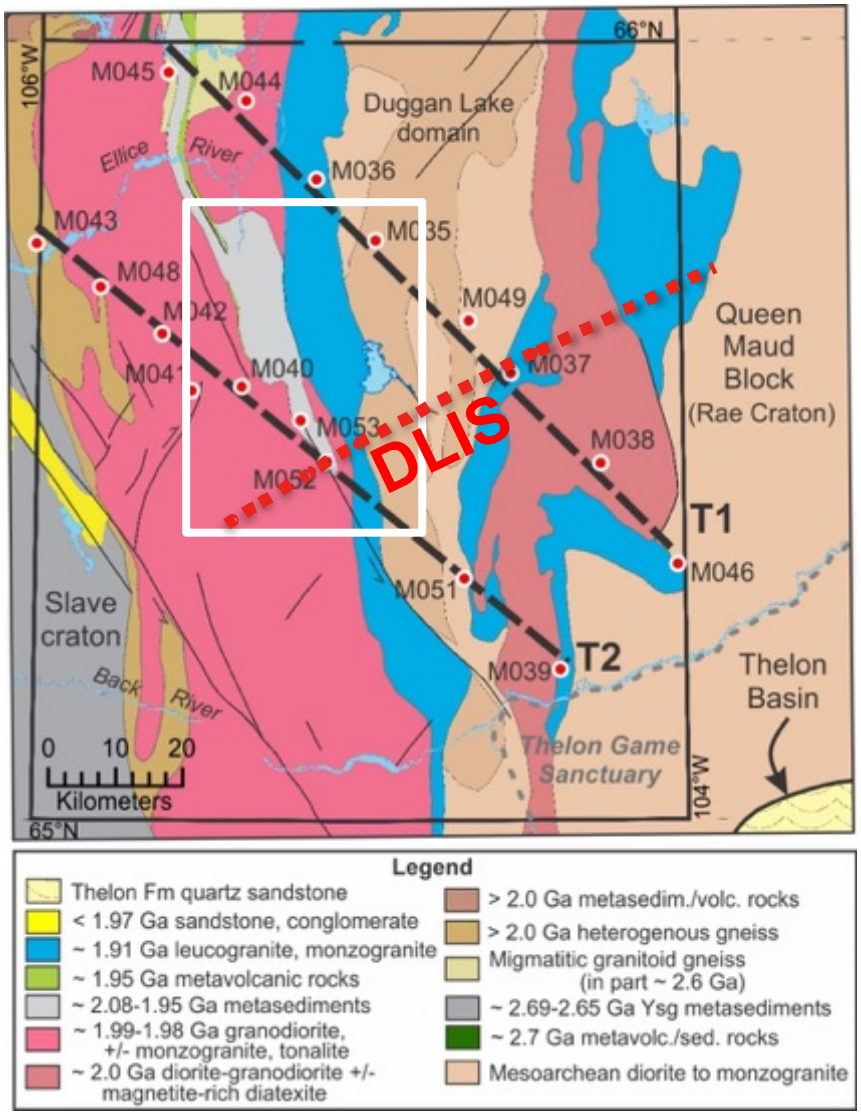
Transect study: terminus of DLIS



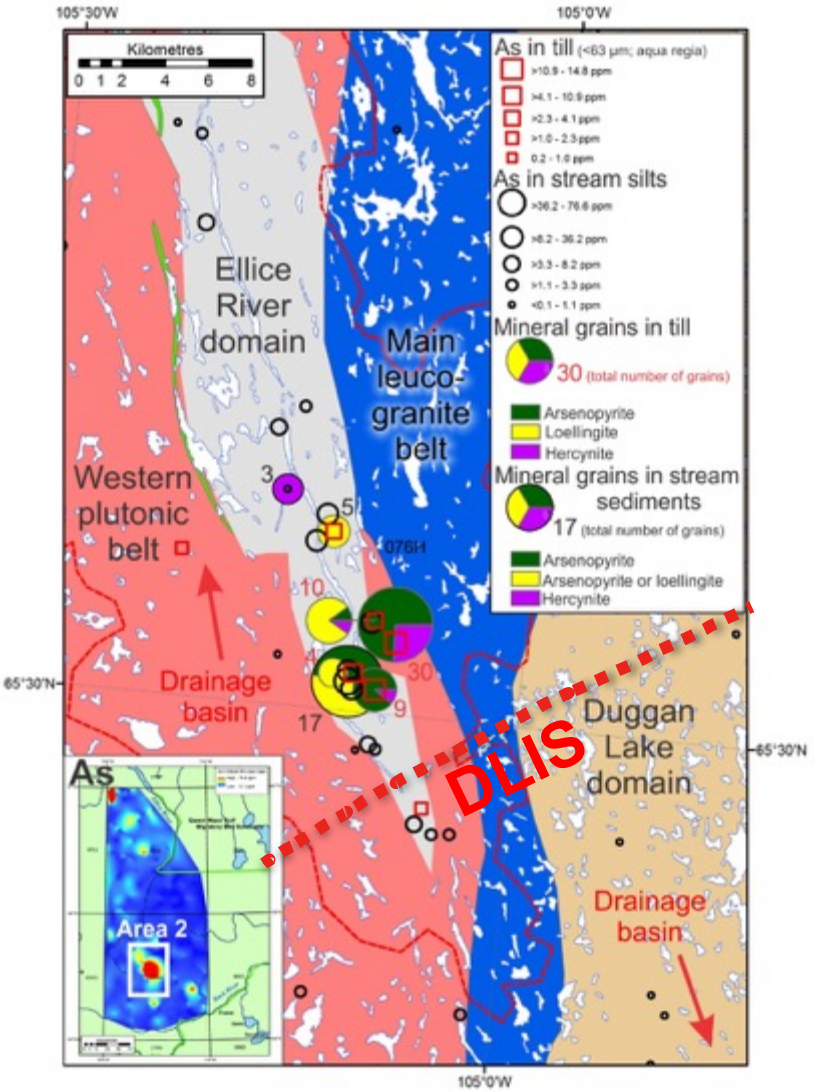
- Till over the DLIS is distally derived: relatively enriched in Thelon quartz-rich sst, clay content and SiO2, and depleted in most trace and major elements
- The effects of long-range glacial transport of metal-poor Dubawnt debris over the DLIS supresses the geochemical signature of the local bedrock

From McMartin 2017; GSC Current Research paper

Transect study: terminus of DLIS

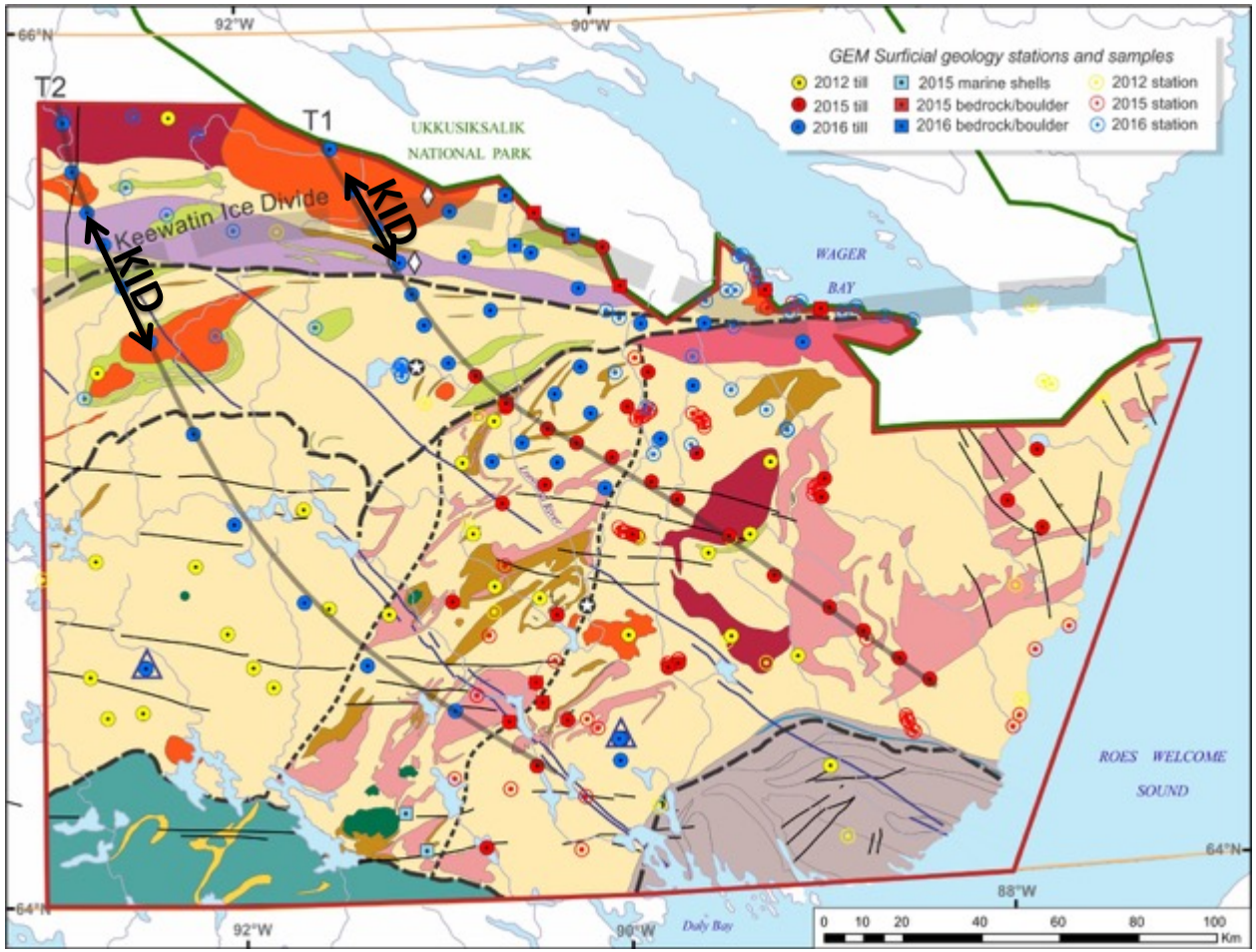


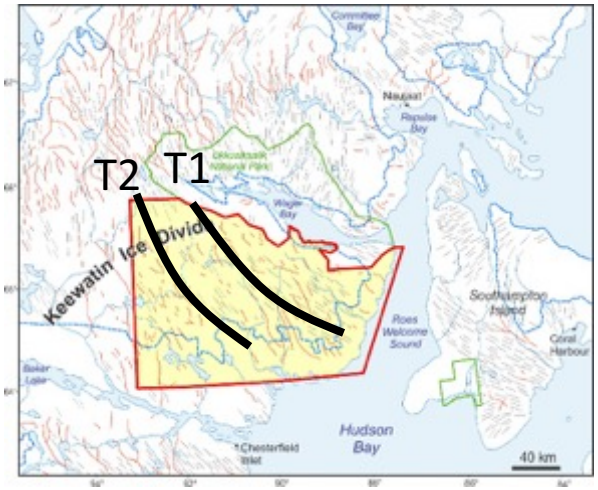
From McMartin 2017; GSC Current Research paper



From McCurdy and McMartin 2017; GSC OF 8302

Transect study: Keewatin Ice Divide

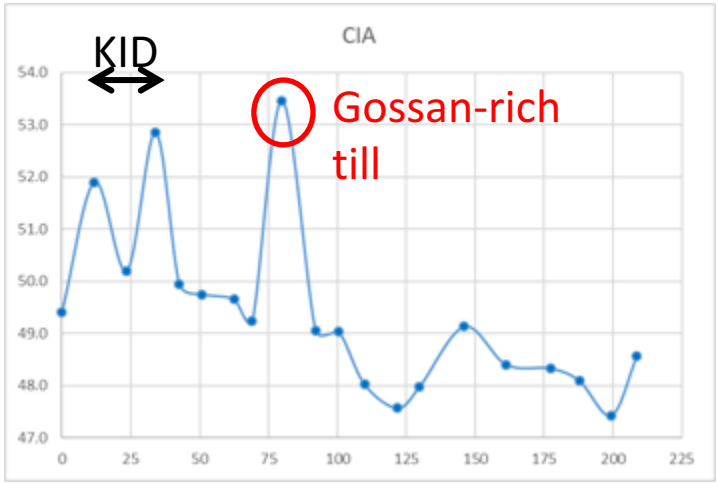




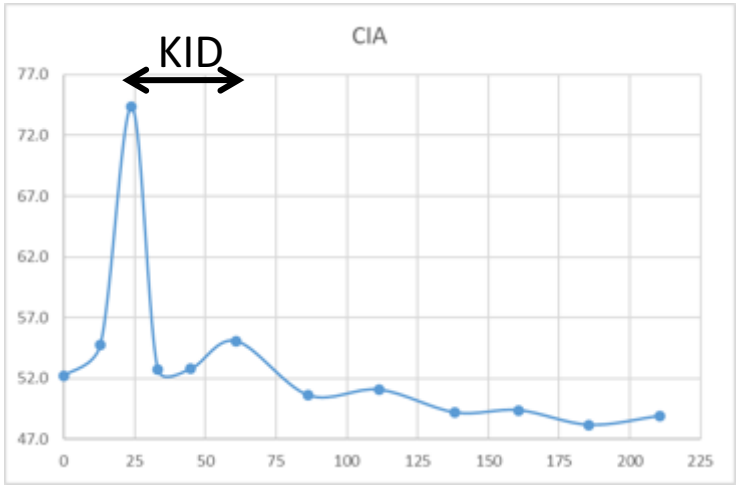
From McMartin et al., in press; GSC OF 8563

Transect study: Keewatin Ice Divide

T1



T2



KID zone:

- Deeply weathered terrain with alternating weathered bedrock and diamictons, boulder fields and felsenmeer
- Bouldery sandy and immature tills with relatively high clay contents
- Clay mineralogy by XRD indicates high proportions of secondary mixed-layer clay minerals and high proportions of amorphous Fe-oxides

➢ Relict weathered landscape preserved under low-erosive, cold-based ice

Summary

- A new digital compilation of glacial features will be soon available for an area covering ~400,000 km^2 in the Keewatin Sector of the Laurentide Ice Sheet (LIS) in mainland Nunavut. The new compilation integrates published surficial geology maps, recent field-based mapping and new mapping interpretations using ArcticDEM and LANDSAT8 imagery.
- The data will be integrated over broad regions, and together with recent framework mapping supported by relative and absolute chronologies, will allow interpretation of glacial landscapes and modelling of past glacial histories.
- Glacial sediment composition collected in targeted areas will help evaluate glacial transport in areas of complex ice-flow dynamics and changing basal ice thermal regimes.

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Thanks to:

GEM2, PCSP, NRCan Research Affiliate Program, SINED
Hamlet of Baker Lake and Arviat & Baker Lake HTO
Baker Lake Lodge, EPLS

Qujannamiik/Quana