Permafrost Mapping at the Community Scale — Initial Results from the Community of Tulita, Northwest Territories

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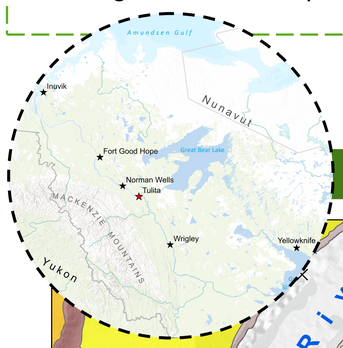
Introduction

Increases in air and ground temperatures have resulted in warming and thawing of permafrost, placing northern communities at risk from the effects of permafrost degradation. In 2021, the Northwest Territories Geological Survey supported the **P**ermafrost **Ar**ctic**h**ives **S**cience Laboratory (PACS labs, University of Alberta) to update surficial geology mapping at a community scale for communities in the Sahtu region. This initial project focuses on mapping surficial geology, permafrost thickness and ground ice conditions for the Hamlet of Tulita in the Sahtu Region of the NWT.

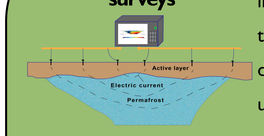
The objective of this project is to provide a comprehensive geotechnical characterization of permafrost conditions in the Sahtu communities. These maps will help communities make the necessary adaptations and decisions to mitigate the effects of permafrost degradation in their communities.



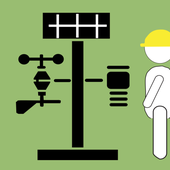
Methodology

1 Fieldwork and permafrost characterisation

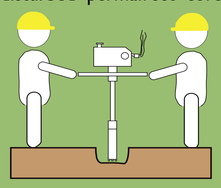
Electrical tomography surveys



Fieldwork investigations involving electrical resistivity tomography surveys (ERT), drilling with recovery of undisturbed permafrost cores,



Installation of monitoring stations

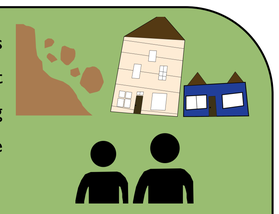


Permafrost coring

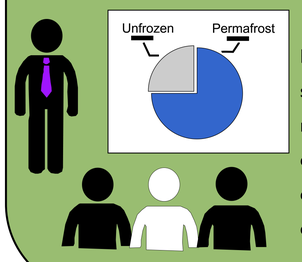
soil sampling and installation of two ground temperature monitoring stations (< 3m).

2 Collaboration with local knowledge holders

Meetings with the community's stakeholders to discuss about geohazards and thawing permafrost issues in the community;

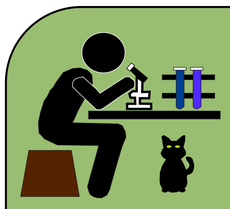


Observations of natural hazards



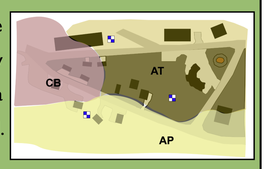
Researches and geotechnical studies, including expert reports related to construction projects, was collected, analyzed, and combined to our maps.

3 Permafrost and geotechnical analyses



Field observations and laboratory data were compiled in a GIS to produce surficial geology and permafrost conditions maps.

Create new maps at a community scale (1:10,000) with newly acquired field data using Allard et al. (2020)'s classification.



Surficial geology and permafrost conditions maps

Results: The Case of Tulita

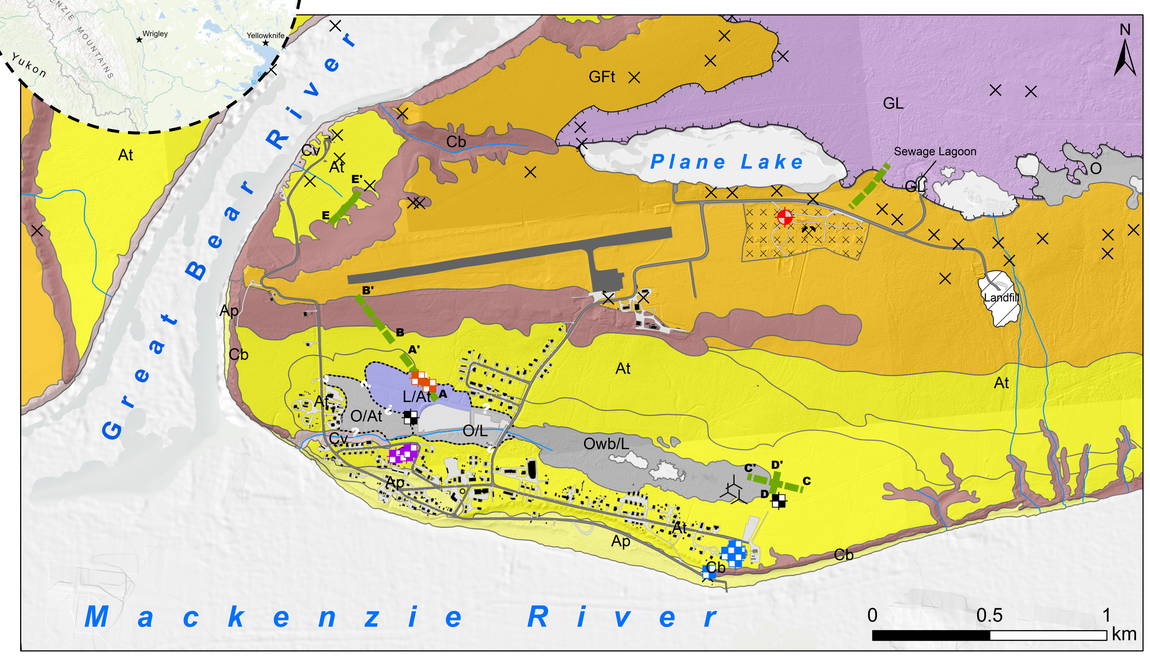


Figure 1: Surficial geology in the hamlet of Tulita

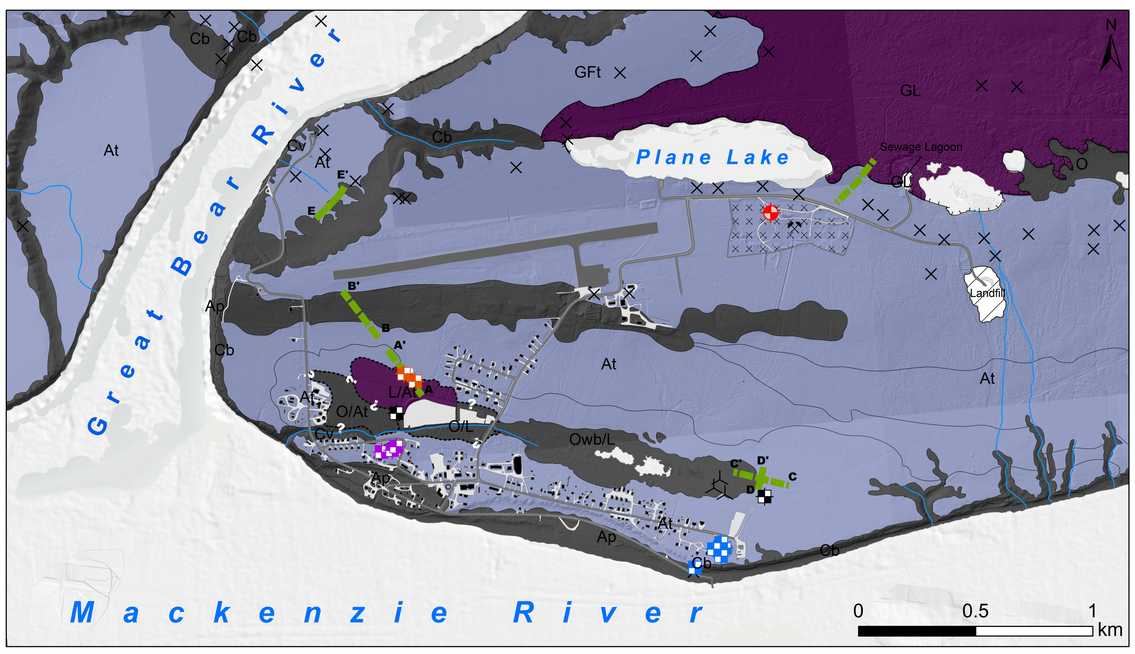


Figure 2: Permafrost conditions in the hamlet of Tulita

LEGEND

Surficial deposits
- Ap: Alluvial sediments - Floodplain
- At: Alluvial sediments - Terraced
- Cb: Colluvial - Blanket
- Cv: Colluvial - Veneer
- GFt: Glaciofluvial sediments - Terraced
- GL: Glaciolacustrine sediments - Undifferentiated
- L: Lacustrine sediments - Undifferentiated
- O: Organic deposits - Undifferentiated
- Owb: Organic deposits - Bog deposits

Hydrography
- River
- Lake/Mackenzie River

Permafrost conditions
- Thick layer of sand and gravel. Likely ice-poor deposit.
- Ice-rich lacustrine or glaciolacustrine deposits. Evidence of thermokarst
- Current floodplain, thick organic matter deposit (Ice-rich sediments).

Geomorphologic features

Ponctual
- Palsa or lithalsa
- Quarry (Sand pit)

Linear
- Geological boundary (confidence concealed)

Polygon
- Quarry
- Thermokarst depression

Road network and Infrastructure
- Local Streets
- Runways/Airstrips
- Sidewalks/Streets/Parking
- Building
- Landfill
- Tank Farm
- Winter Road

Intrusmentations

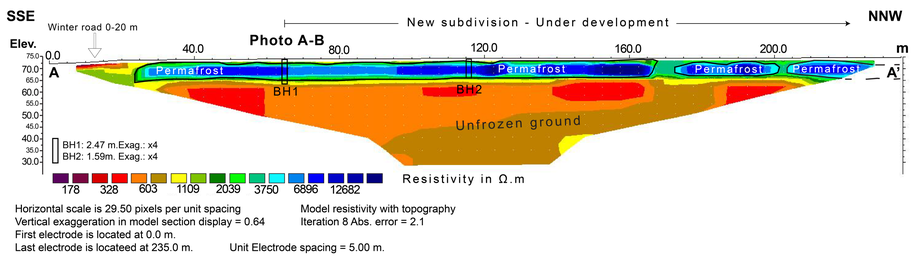
Boreholes
- Tetra Tech - 2011
- Tetra Tech - 2017
- Pacs Labs - 2022
- Ground monitoring stations
- Borehole (Mackenzie pipeline proj.)
- ERT Survey - 2022

PHOTO A

PHOTO B

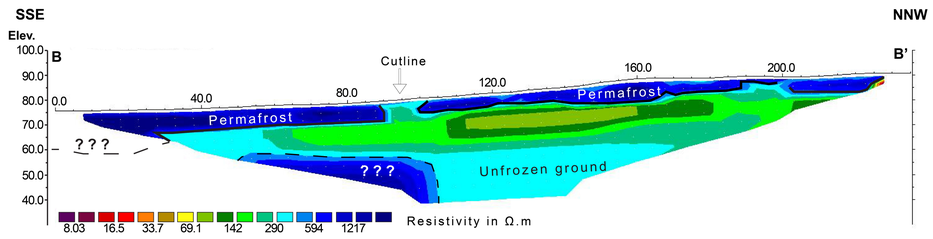
PHOTO C

Electrical Resistivity Interpretation



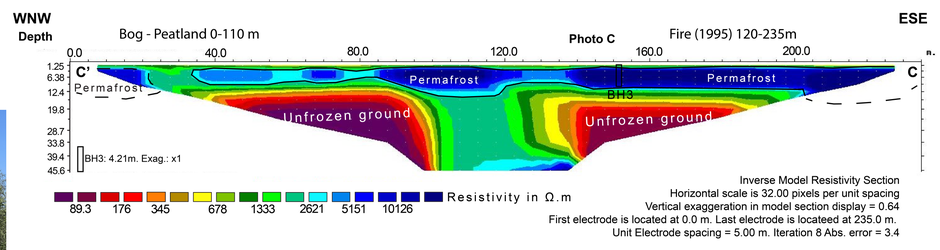
Horizontal scale is 29.50 pixels per unit spacing
Vertical exaggeration in model section display = 0.64
First electrode is located at 0.0 m.
Last electrode is locateed at 235.0 m.
Model resistivity with topography
Iteration 8 Abs. error = 2.1
Unit Electrode spacing = 5.00 m.

Figure 3: ERT profile across the new subdivision near the baseball field. Ice-rich permafrost have been located in this area (photo A and B)



Horizontal scale is 29.50 pixels per unit spacing
Vertical exaggeration in model section display = 0.68
First electrode is located at 0.0 m.
Last electrode is locateed at 235.0 m.
Model resistivity with topography
Iteration 8 Abs. error = 1.3
Unit Electrode spacing = 5.00 m.

Figure 4: South-facing colluvium deposit hosting permafrost (~5m thick) near the new subdivision.



Inverse Model Resistivity Section
Horizontal scale is 32.00 pixels per unit spacing
Vertical exaggeration in model section display = 0.64
First electrode is located at 0.0 m. Last electrode is locateed at 235.0 m.
Unit Electrode spacing = 5.00 m. Iteration 8 Abs. error = 3.4

Figure 5: ERT profile along the winter road near the tank Farm. Left section cross a bog.

Discussion & Next Steps

- This work highlights the need for high quality surficial geology and permafrost maps to support community land use planning.
- ERT interpretation profile allow rapid depth of permafrost estimated and lateral continuity of estimates. Results indicate that permafrost is generally thin around the community (~10-15m) and that the community of Tulita is mostly built on ice-poor sandy alluvial terraces (Fig. 1-5).
- Drilling in the new subdivision outlined a lacustrine deposit on an alluvial terrace (L/At) which locally hosts ice-rich permafrost, posing a potential risk of permafrost degradation and thaw settlement (Fig. 3-4).
- Surprisingly, this area's abundant ground ice shows little surface expression of past thermokarst highlighting the hidden hazards that permafrost can present within communities (Photo A & B).
- Difficulty in delineating and interpreting coarse sediments, which may have resistivity values similar to fine sediments in warm permafrost (Fig. 3-5).
- We will present those maps to the community later this year for feedback and engagement with local knowledge holders, and follow up with additional mapping and community engagement in 2023.

References

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Collaborators

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