Initial Investigations of Degrading Dendritic Peat Plateaus in the Central Mackenzie Valley, Northwest Territories

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BACKGROUND & INTRODUCTION

In the discontinuous permafrost zone, thermokarst lakes and thermal erosion are widespread and common permafrost thaw-related phenomena. Thermokarst features are indicative of thaw sensitive permafrost terrain and can lead to reduced ground stability and changes in landscape and drainage configuration.

Peatland permafrost features, including peat plateaus and palsas, are particularly vulnerable to thaw in response to global warming because frozen organic materials consolidate when thawed and typically overly ice-rich mineral deposits. Peat plateaus dissected by dendritic fluvial and fen networks are common landforms in the central Mackenzie Valley, Northwest Territories. These networks tend to be associated with gradually sloping terrain (up to ~3m per km) and develop primarily on moraines and glaciolacustrine sediments, hosting segregated ground ice. To our knowledge, no studies have been conducted on the origin of dendritic peat plateau networks.

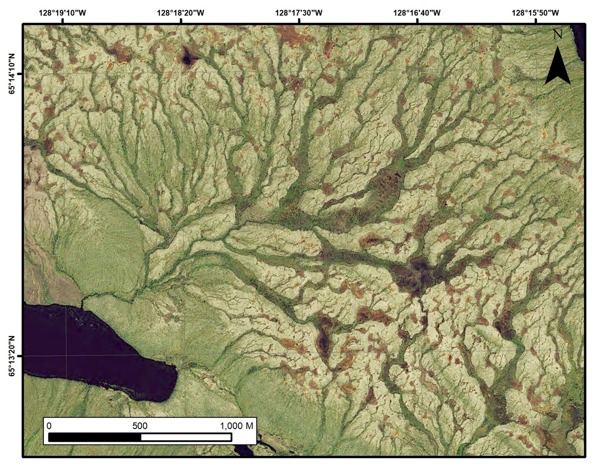


Fig. 1: Area of interest. Satellite imagery of degrading dendritic peat plateau near Mackenzie Mountains.

The central Mackenzie Valley is characterized by discontinuous permafrost with low to medium ice content. Electrical resistivity tomography surveys, borehole records, and other field investigations were carried out to describe morphology and permafrost conditions associated with dendritic peat plateau networks.

Objectives: Provide a model of dendritic peat plateau evolution from their initial configuration, and to better understand the origin of this particular landform.

Question: What is actually driving this thermokarst landform? Is ground ice thaw? Or are these particular landforms that form in sloping peat plateaus?

METHODOLOGY

1 Fieldwork

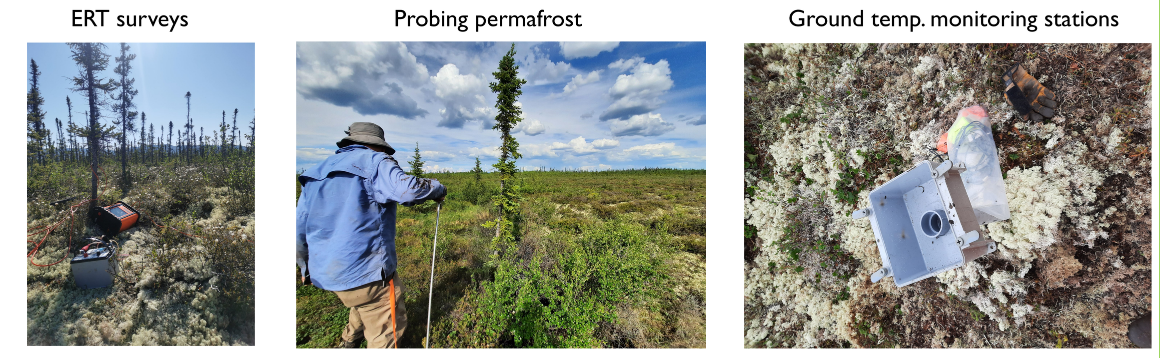
- Fieldwork investigations involving drilling with recovery of undisturbed permafrost cores, electrical resistivity tomography surveys (ERT) and installation of three climate stations (< 3m).

Field observations — Permafrost coring

2 Permafrost characterization and DC electrical resistivity tomography

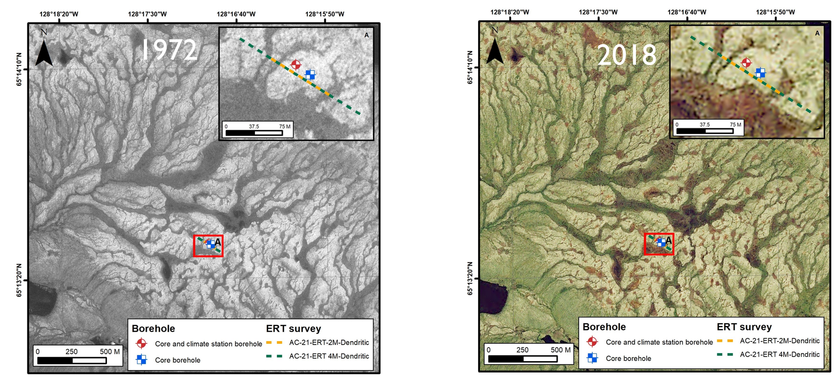
- ABEM Terrameter LS 2, Wenner and dipole-dipole configuration using RES2DINV software.
- Electrode spacings were 1, 2, 4 or 8m. Profile lengths varied between 48, 96, 192 or 384m.
- A 1-meter probe was used along the ERT transect to verify thaw depths.
- Three ground temperature stations, using GeoPrecision loggers, were installed at two different peat plateaus sites dissected by the fen channels.

ERT surveys — Probing permafrost — Ground temp. monitoring stations



3 Landform mapping and spatio-temporal analysis (remote-sensing)

- Aim for systematically quantifying peatland morphological characteristics, to better understand how this climate sensitive element of the permafrost landscape varies,
- High-resolution SPOT 6/7 1.5 m resolution imagery from 2018 and aerial photographs from 1972 acquisition (2400 dpi resolution and a scale of 1:35,000).
- Assessment of the degree of thermokarst expansion within peat plateau (65° 13.478'N, 128°16.984'W).
- Fine-scale peat plateaus mapping (1:1000) to asses the rate of thermokarst expansion.
- Grid cell mapping method (50x50m) to determine the proportion of the area affected by thermokarst within the cells.



LANDSCAPE EVOLUTION (1970-2018)

1972 — 2018

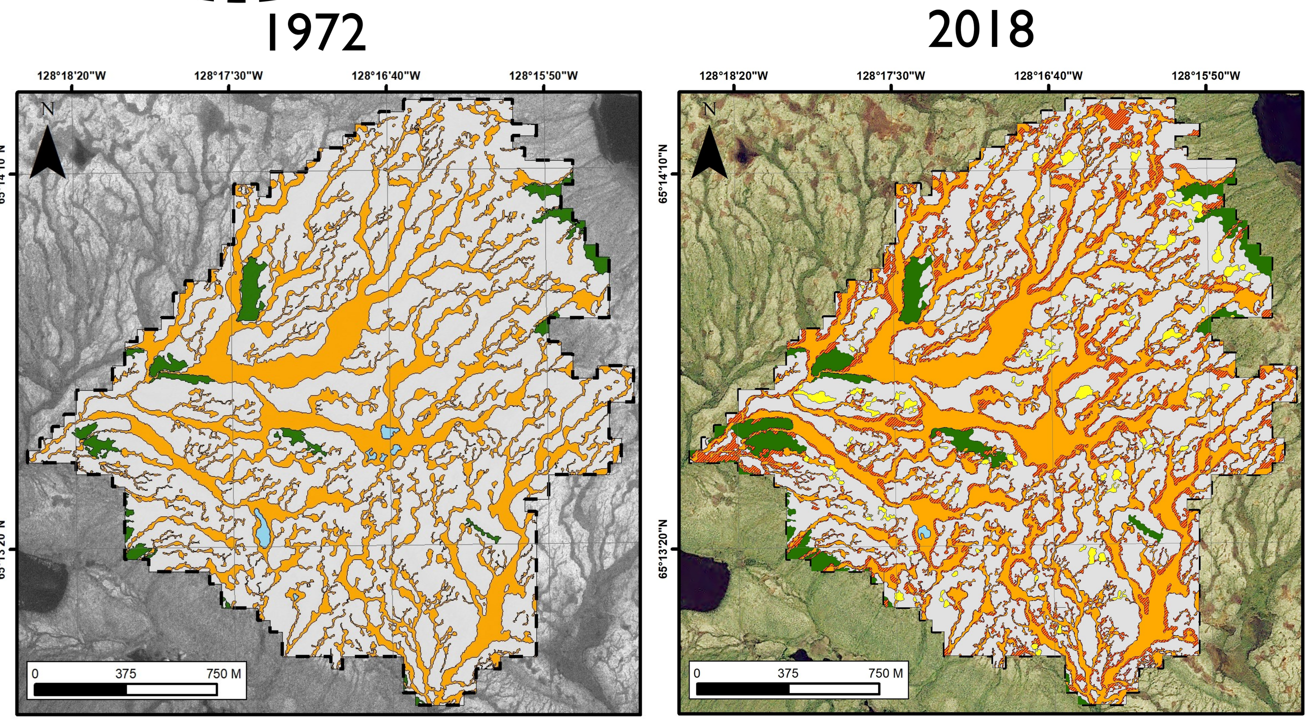


Fig. 2: Landform mapping of the dendritic peat plateau. The image on the left shows the extent of the fen network in 1972. The image on the right shows the same area in 2018.

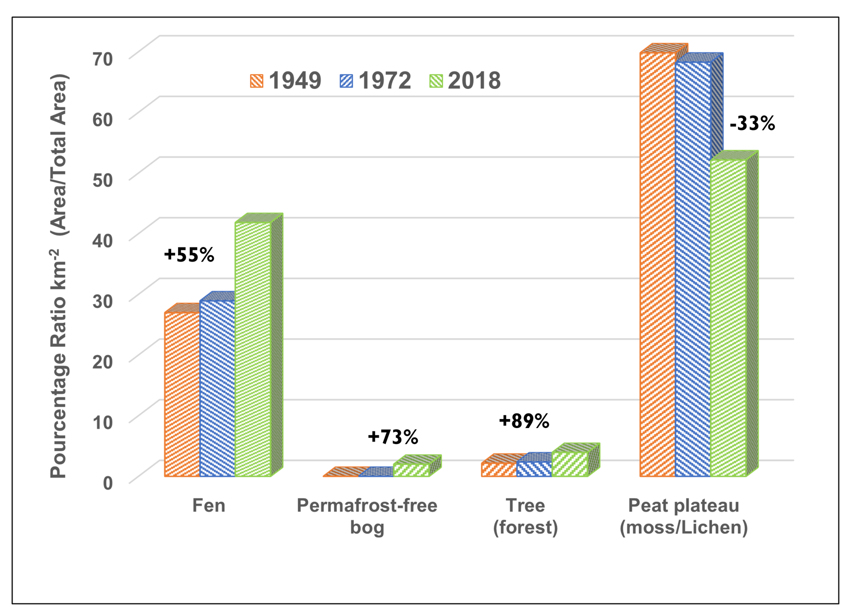


Fig. 3: Proportion of the analyzed area covered by four different classes for 1949*, 1972 and 2018.

*The 1949 mapping could not be displayed in the poster.

1972 — 2018

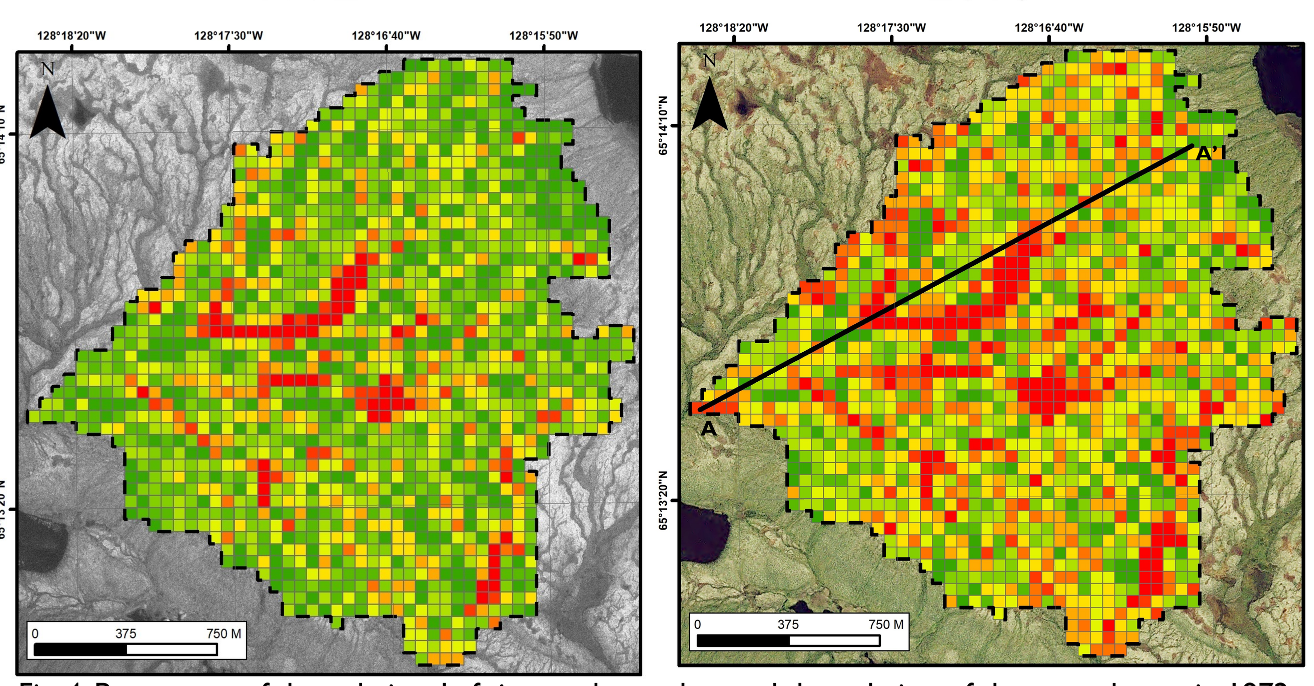


Fig. 4: Percentage of degradation. Left image shows the total degradation of the peat plateau in 1972. Right image shows the same area in 2018.

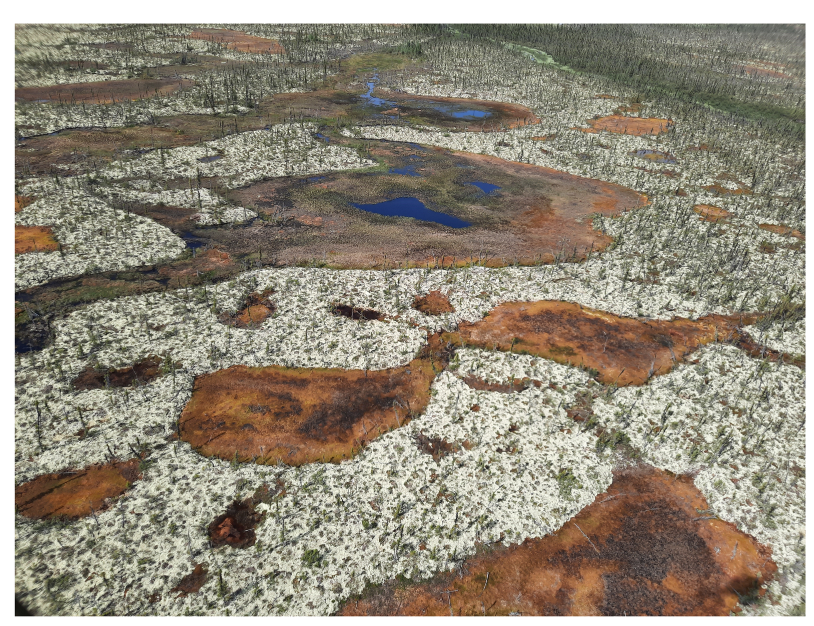


Fig. 5: Degrading peat plateau. Fens and bogs are present within the dendritic peat plateau.

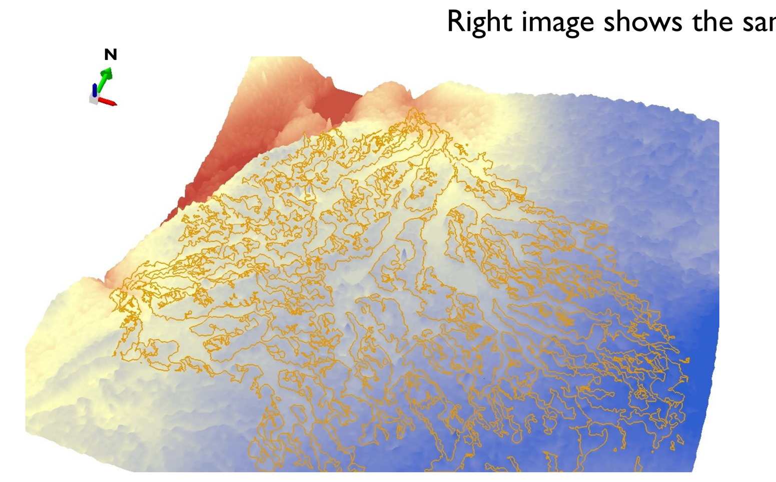


Fig. 6: 3D model of the dendritic peat plateau. Orange lines delimitate the fen network. V. exageration x26.

LEGEND

Dendritic Peat Plateau Network — Mapping symbology
- Water (ponds)
- Fen
- Permafrost-free bog
- Forest (Trees)
- Peat plateau
- New fen area in 2018
- Mapping outline

Gridcell Peat Plateau — Percentage (50x50m)
- 0 - 8
- 9 - 17
- 18 - 25
- 26 - 33
- 34 - 42
- 43 - 52
- 53 - 64
- 65 - 77
- 78 - 90
- 91 - 100

Other elements — Instrumentation and Borehole
- Climate Station and Borehole
- Borehole

DC Electrical Resistivity Tomography — Survey
- AC-21-ERT-2M-Dendritic
- AC-21-ERT 4M-Dendritic

Topographic profile
- Profile line

Digital Surface Model (2m) — Elevation
- High : 393.94 m
- Low : 368.79 m
- Fen limit

Scan me for more results

ELECTRICAL RESISTIVITY INTERPRETATION

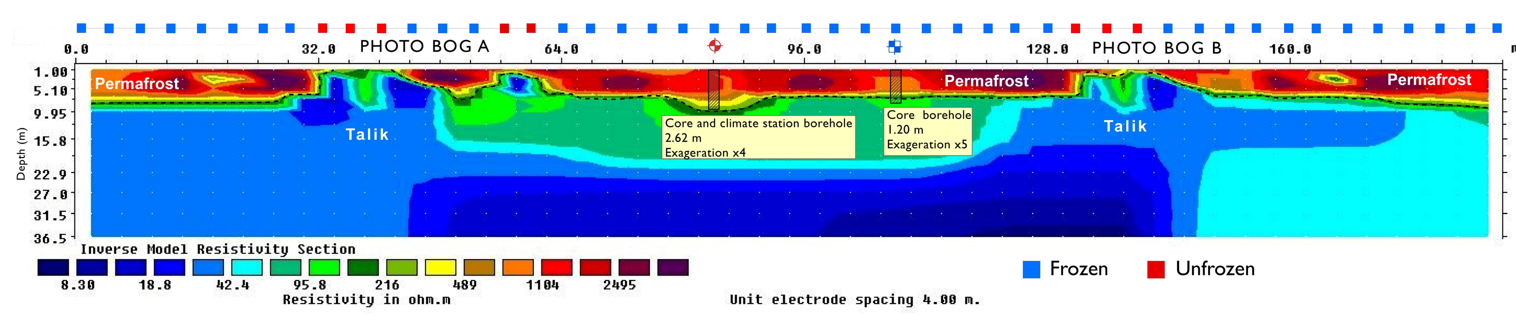


Photo bog A

Fig. 7: ERT profile (AC-21-ERT-4M-Dendritic) from the peat plateau, dashed black line represents the inferred base of permafrost. Transect line is indicated in the maps of the *Landscape evolution* (Methodology section).

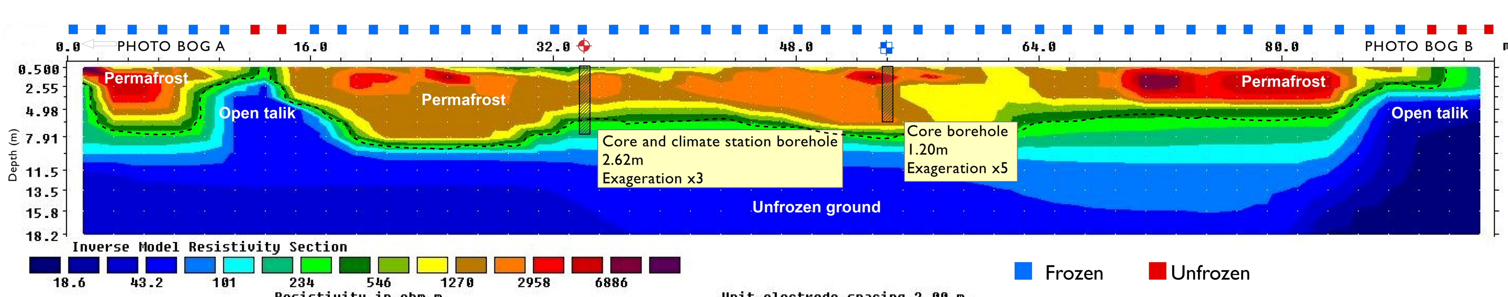


Photo bog B

Fig. 8: ERT profile (AC-21-ERT-2M-Dendritic) from the peat plateau, dashed black line represents the inferred base of permafrost. Transect line is indicated in the maps of the *Landscape evolution* (Methodology section).

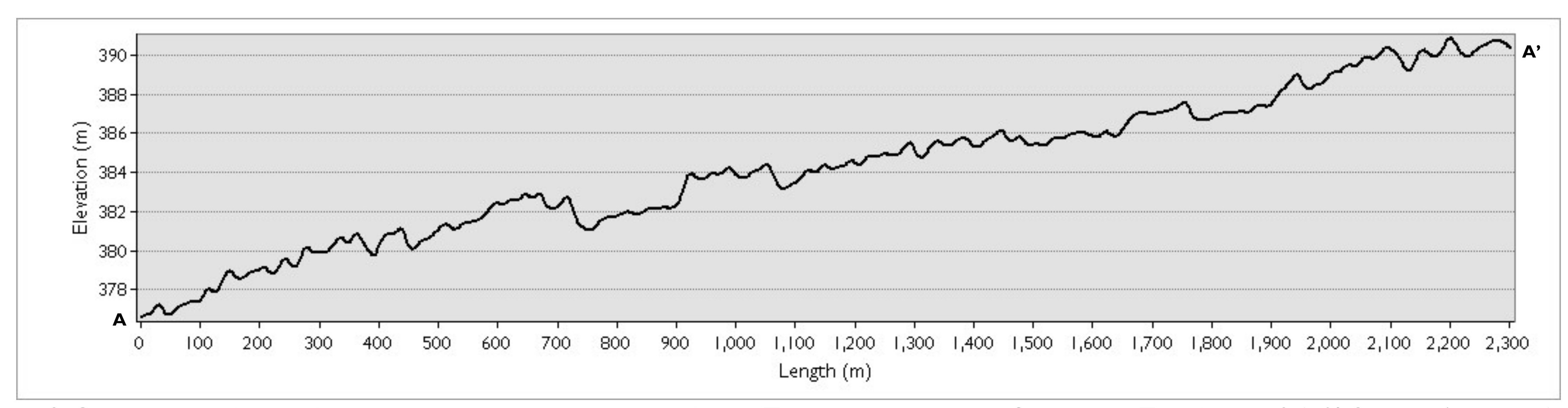


Fig. 9: Cross-sectional view along the degrading dendritic peat plateau. The gradient is up to ~3m per km. The slope is 0.65%. See Fig. 4 and Fig. 6.

SUMMARY & FUTURE WORK

- Fine-scale mapping (1:1,000) allows us to determinate that ~55% of the peat plateau has degraded over ~75 years (Fig. 2-5).
- Electrical resistivity tomography profiles indicate that permafrost is typically thin in these areas (5-12m), and through-going taliks forming the channel network are common, and increase in frequency downslope (Fig. 6-9).
- Field investigation of peat plateaus in 2021 showed that peat thicknesses were ~2m with structureless pore ice, that was overlaying several metres of ice-rich diamict or glaciolacustrine sediments (Fig 7-8).
- The ERT results allow us to determine that peat plateaus degradation is driven by thermal erosion of the plateau edges from the ice-rich diamict deposit underlying the peat deposit, but also by the formation of ponds and drainage in the peat plateaus (Fig. 7-9).
- We hypothesize that these are slowly expanding thaw networks, likely driven by basal permafrost thaw near taliks, and expansion of fens along margins.

Future Work

- Interpretation of a set of aerial photographies from the 1950s and comparison with the 1970s and 2018 imageries for another peat plateau site.
- Comparison of airborne-electromagnetic (AEM) and ERT data will aid in identifying high resistivity ground (i.e permafrost).
- Cryostratigraphic analyses of permafrost cores that will provide an estimation of the ground ice content and ground stability.
- Thermal dynamic modelling from our climate stations to document the peat plateaus degradation.

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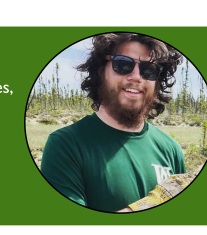

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