

A Standardized Mapping Nomenclature for Permafrost and Thermokarst Features



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INTRODUCTION

Building on the Thermokarst Mapping Collective [1] model and recent fine-scale permafrost mapping by the Geological Surveys of Canada (GSC) and the Northwest Territories Geological Survey (NTGS) along infrastructure corridors [2-4], we propose to develop nomenclature and symbology for describing and depicting permafrost landform characteristics on large-scale (1:10,000) surficial and permafrost maps.

This effort aims to augment the Standardized Science Language of the Geological Survey of Canada's surficial geology data model [5] by developing the tools to identify, document, and depict a wide range of mappable permafrost characteristics for enhancing Community Permafrost Mapping products.

The GSC data model facilitated production of standardized surficial geology maps at a scale of 1:100,000 [5]. At the community-level scale (1:10,000), permafrost features can be identified, contributing to more informative mapping products. However, the current nomenclature, (i.e. GSC or BC/Yukon Classification system [5-6]) lacks the diversity of landforms that occur across permafrost regions and indicate thaw sensitivity of the terrain.

By developing permafrost and thermokarst landform modifiers and symbologies that can be linked to surficial mapping units (Figure 1), we establish tools that improve information and enhance visualizations of permafrost mapping products. We propose a collaborative approach to leverage the breadth of expertise in the permafrost and surficial geology mapping communities.

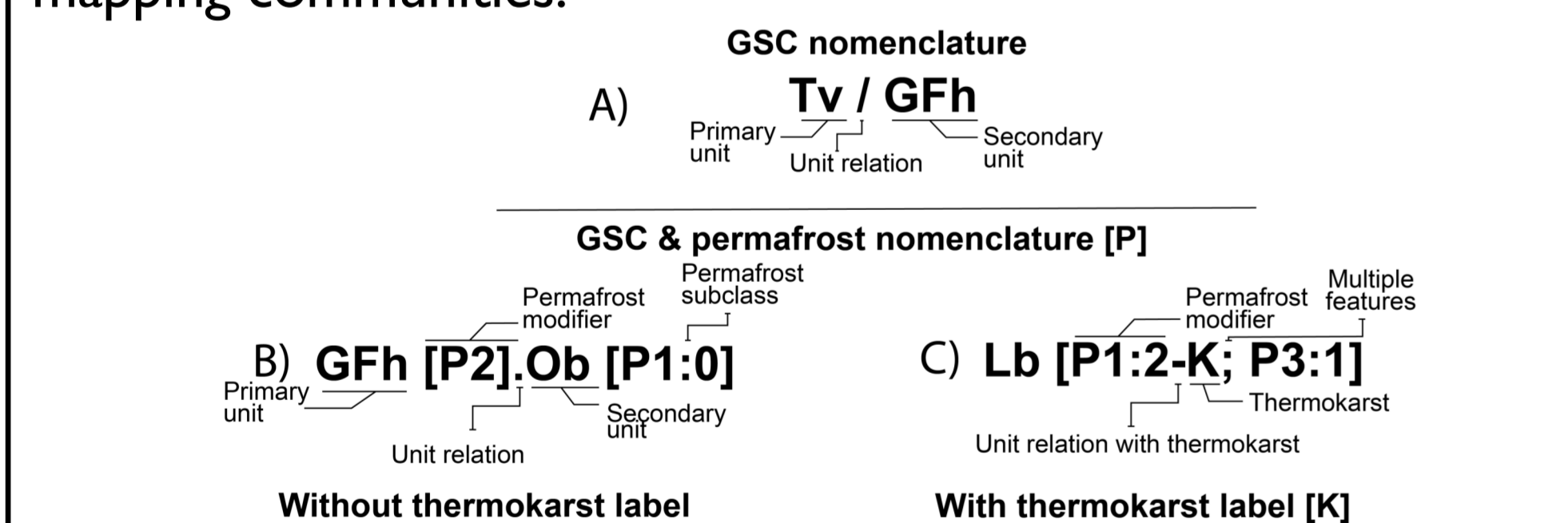


Figure 1: Schematic representation of terrain unit classification with permafrost nomenclature. (A) Standard GSC classification: "Tv — till veneer" represents the primary terrain unit, with "Tv" indicating a stratigraphic relationship where "Tv" overlies a glaciofluvial hummocky terrain "GFh". (B) Detailed classification with permafrost nomenclature [P]: "GFh" represents the primary unit, modified by the permafrost indicator "P2 — Involved terrain". The secondary unit "Ob" is an organic blanket terrain with undifferentiated ice-wedge polygons [P1:0]. Colon ":" indicates a subclass modifier. "." indicates that units within the polygon are found in equal proportion. (C) Permafrost nomenclature with thermokarst indicator [K]. This example indicates that the units is a lacustrine basin (Lb) with degrading (thermokarst -K) high-centered ice-wedge polygon network [P1:2] and collapsed Pingo [P3:1]. Semi-colon ";" indicates multiple features within one unit. This notation system enables detailed mapping of geomorphological and permafrost features with insight on particular types of thermokarst processes.

We plan to implement the mapping protocols within a GIS framework (point, polyline, and polygon) and test the nomenclature and symbologies by mapping around NWT communities in different permafrost settings. These preliminary results will provide a basis for expert review and methods improvement (Figures 2-3 & Table 1).

PROPOSED STANDARDIZED PERMAFROST MAPPING NOMENCLATURE AND SYMBOLOGY

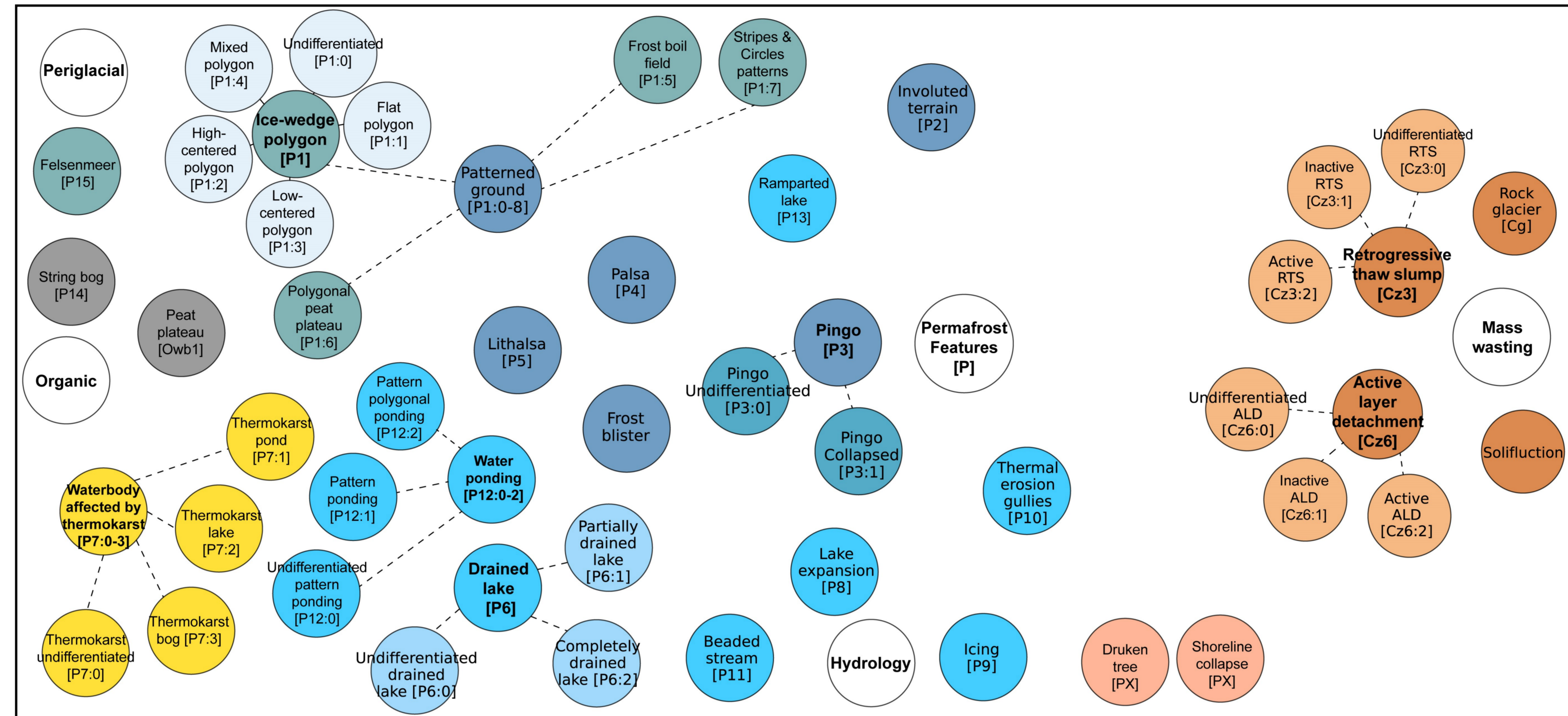


Figure 2: Permafrost nomenclature [P]. Classification of permafrost and thermokarst landforms. Permafrost and thermokarst landforms are assigned a Modifier number, which can be divided into subclasses. Subclasses are designed using a sequential number following the colon ":". See Figures 4 and 5 for examples.

Features	Nomenclature	Thermokarst	Category
1 Patterned ground	[P1:0-8]	K	Periglacial
2 Ice-wedge polygon	[P1:0-4]	K	Patterned ground
3 Undifferentiated	[P1:0]	K	Ice-wedge polygon
4 Flat polygon	[P1:1]	K	Ice-wedge polygon
5 High-centered polygon	[P1:2]	K	Ice-wedge polygon
6 Low-centered polygon	[P1:3]	K	Ice-wedge polygon
7 Mixed polygon	[P1:4]	K	Ice-wedge polygon
8 Frost boil field	[P1:5]	K	Patterned ground
9 Polygonal peat plateau	[P1:6]	K	Patterned ground
10 Stripes & Circles patterns	[P1:7]	K	Patterned ground
11 Felsenmeer	[P1:5]	K	Patterned ground
12 Involved terrain	[P2]	K	Periglacial
13 Frost blister	[Symbol]	K	Periglacial
14 Pingo	[P3]	K	Periglacial
15 Pingo - Undifferentiated	[P3:0]	K	Pingo
16 Pingo - Collapsed	[P3:1]	K	Pingo
17 Palsa	[P4]	K	Periglacial
18 Lithalsa	[P5]	K	Periglacial
19 String bog	[P14]	K	Organic
20 Peat plateau	[Owb1]	K	Organic
21 Drained lake	[P6:0-2]	K	Hydrology
22 Undifferentiated drained lake	[P6:0]	K	Drained lake
23 Partially drained lake	[P6:1]	K	Drained lake
24 Completely drained lake	[P6:2]	K	Drained lake
25 Undifferentiated thermokarst	[P7:0]	K	Waterbody with thermokarst
26 Thermokarst pond	[P7:1]	K	Waterbody with thermokarst
27 Thermokarst lake	[P7:2]	K	Waterbody with thermokarst
28 Thermokarst bog	[P7:3]	K	Waterbody with thermokarst
29 Lake expansion	[P8]	K	Hydrology
30 Icing	[P9]	K	Hydrology
31 Thermal erosion gullies	[P10]	K	Hydrology
32 Beaded stream	[P11]	K	Hydrology
33 Pattern ponding	[P12:0]	K	Hydrology
34 Undifferentiated Pattern ponding	[P12:0]	K	Hydrology
35 Pattern ponding	[P12:1]	K	Hydrology
36 Pattern polygonal ponding	[P12:2]	K	Hydrology
37 Drunken tree	[Indicator?]	K	Hydrology
38 Shoreline collapse	[Indicator?]	K	Hydrology
39 Ramparted lake	[P13]	K	Hydrology
40 Rock glacier	[Cg]	K	Mass Wasting
41 Active layer detachment (ALD)	[Cz6]	K	Mass Wasting
42 Undifferentiated ALD	[Cz6:0]	K	Mass Wasting
43 Inactive ALD	[Cz6:1]	K	Mass Wasting
44 Active ALD	[Cz6:2]	K	Mass Wasting
45 Retrogressive thaw slump (RTS)	[Cz3]	K	Mass Wasting
46 Undifferentiated RTS	[Cz3:0]	K	Mass Wasting
47 Inactive RTS	[Cz3:1]	K	Mass Wasting
48 Active RTS	[Cz3:2]	K	Mass Wasting
49 Solifluction	[Symbol]	K	Mass Wasting

Table 1: Permafrost [P] nomenclature table. Categories and lists of periglacial, mass-wasting, and hydrological features, including their subclasses and associated nomenclature numbers. Each subclass is color-coded based on Figure 2.

GSC Symbology

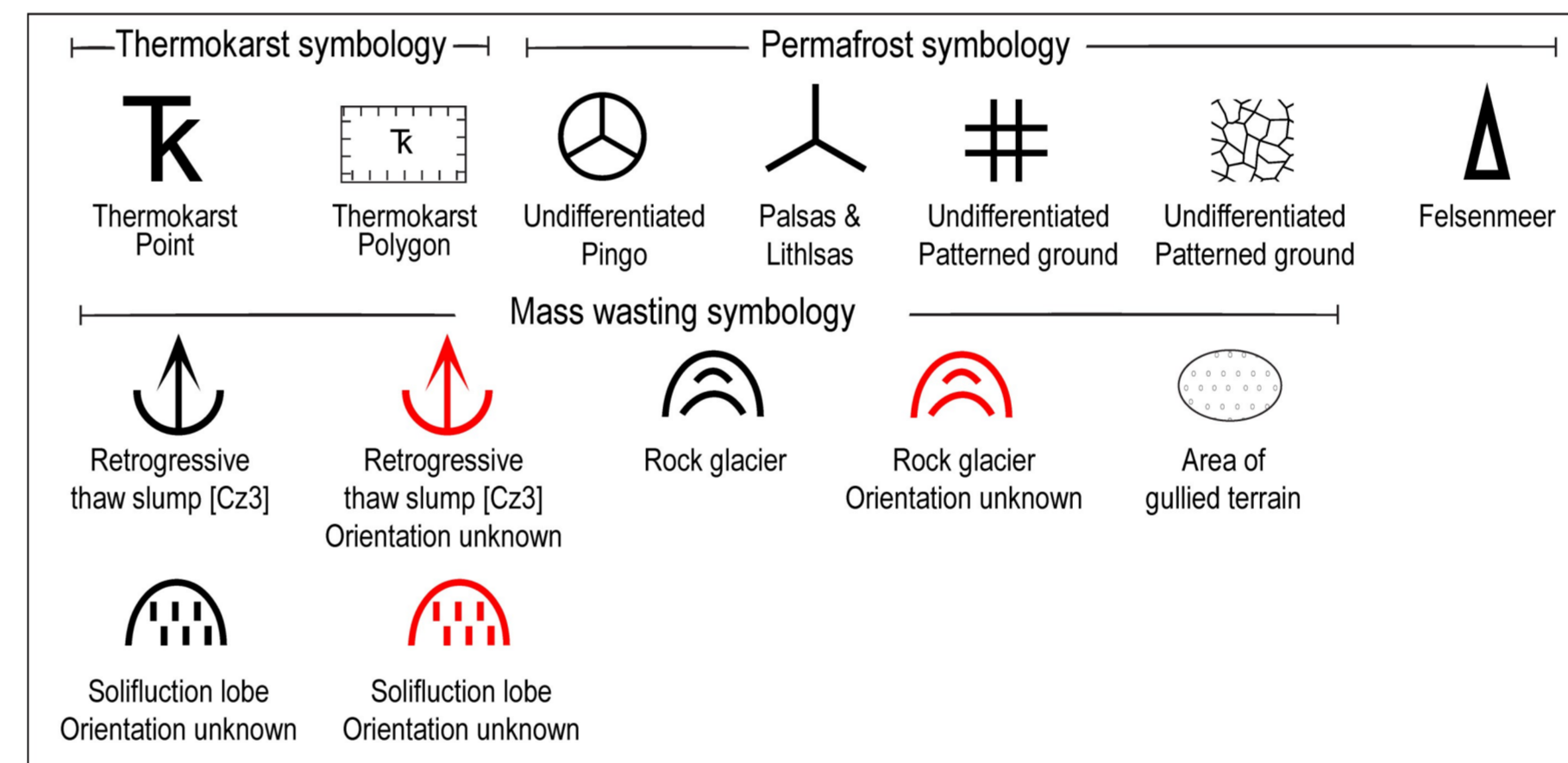


Figure 3: Existing GSC permafrost, thermokarst and mass wasting symbology [5].

- Features are divided into three categories: Hydrology, Mass Wasting, and Periglacial.
- The letter "P" is associated with permafrost features throughout the classification.
- Brackets [P] are used to indicate permafrost-specific nomenclature. They are used after the Primary, Secondary unit or both.
- Subclasses are devised using a sequential number following Colon ":".
- "-K" represents permafrost degradation within a unit. For example, a thick marine deposit covered by lithalsas and affected by thermokarst ponds would be labelled Mb [P5-K;P7:1]. However, a code must be developed to identify the type of degradation occurring within the unit.

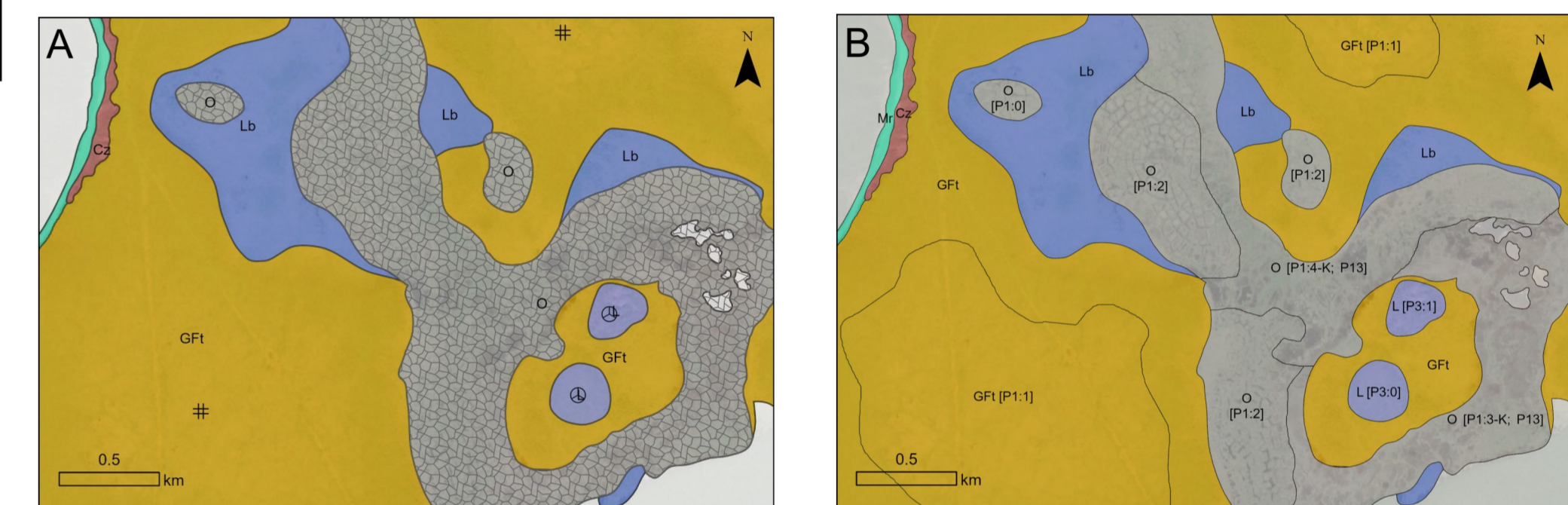


Figure 4: A) GSC standardized nomenclature with units and symbols. B) Proposed standardized permafrost nomenclature with surficial geology units, permafrost [P] and thermokarst modifiers [-K] and subclasses [:].

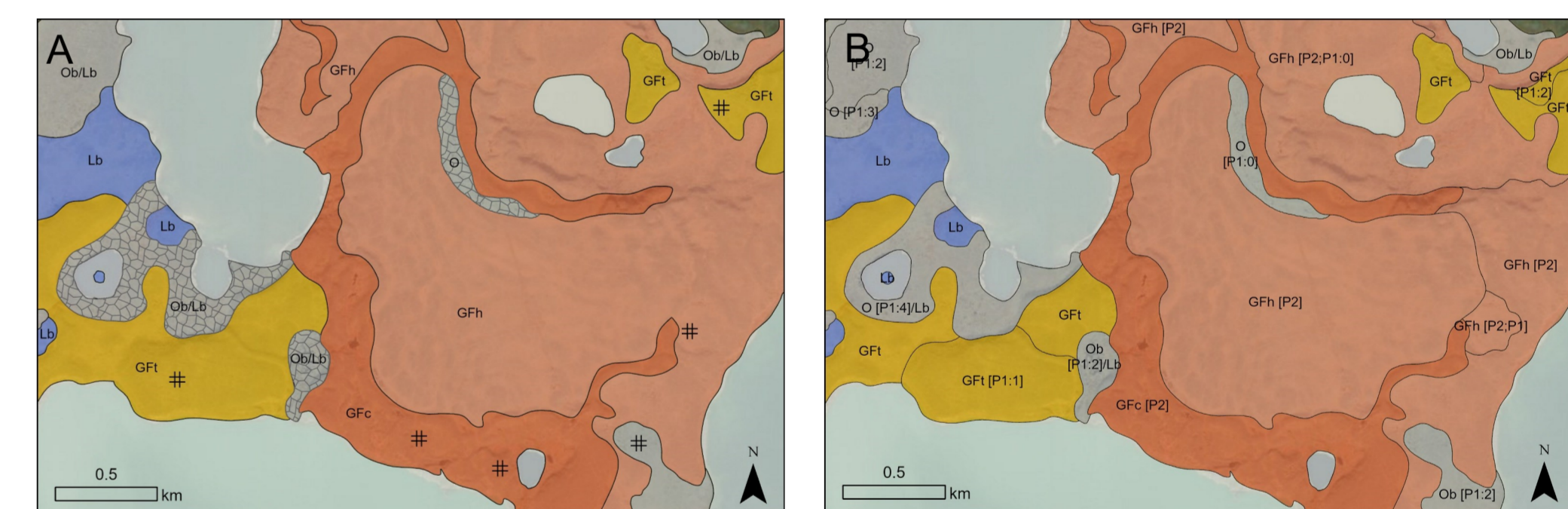


Figure 5: A) GSC standardized nomenclature with units and symbols. B) Involved terrain [P2] near Tuktoyaktuk are common in hummocky glaciofluvial (GFh) terrain and host ground ice. This indicator also reveals valuable information regarding ground ice distribution.

Key Challenges and Actions

- **Lack of available letters from the GSC nomenclature:** Ensuring clarity and usability of the nomenclature.
- **Temporality of permafrost mapping:** Develop a method to capture and represent temporal changes in permafrost features (i.e. active or Inactive landslide).
- **Review GSC classification:** Review and augment existing GSC classification by identifying missing elements. Example: including active-layer detachment as Cz6.
- **Define modifiers representation:** Establish criteria for representing thermokarst [K] better as a modifiers, as a features, but also as an indicator (i.e. drunken trees or shoreline collapse) (Figure 1 & Figures 4-5).
- **Define adaptability to different scales:** Define how the nomenclature can be adapted to different spatial scales while maintaining clarity and effective communication.
- **Consult, test, and Standardize nomenclature:** Form a committee of GIS specialists, permafrost scientists, and surficial geologist experts to refine and improve the nomenclature & apply the updated nomenclature to case studies.

We are actively seeking participants to contribute to this project. Please contact me at Alexandre_Chiasson@gov.nt.ca if you would like to be a member of the committee.

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Any additional suggestions to further improve this nomenclature are most welcome.