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The effects of permafrost thaw on organic matter quality and availability along a hill slope in northeastern Siberia

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Introduction:

Climate warming and permafrost thaw in northeastern Siberia are expected to remobilize previously trapped OC, thereby changing the quantity and quality of organic matter (OM) transported through watersheds and to biologically available pools. However, Arctic watersheds are dynamic, and hill slopes can largely influence the movement and distribution of OM through the active layer (seasonal thawed soils), resulting in soil horizons that differ in both the quality and availability of OM across the landscape.

The objective of this study is to examine the distribution, quality, and availability of OM in active layer soils and permafrost along a hill slope.

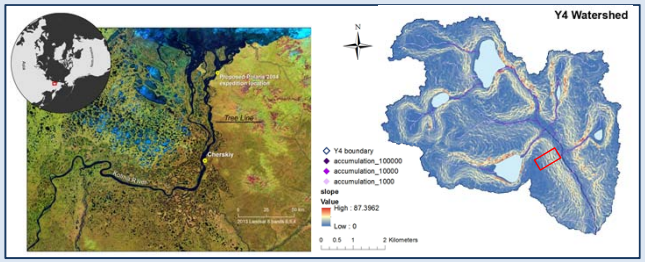

Figure 1. (left) Location of Cherskiy and the Northeast Science station on the Kolyma River, Siberia. (right). Map of the Y4 watershed showing landscape slope surrounding major hydrologic flow paths. Stream vectors and the surrounding slopes were quantified in GIS using a digital elevation model and the number of pixels draining into stream networks (1000--100000 being moderate--high flow accumulation). The hill slope used for this study is outlined in the red box. Map produced by Mr. Gregory Fiske, WHRC.

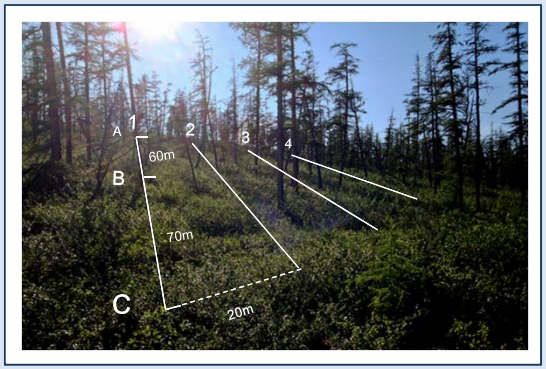

Figure 2. Picture of the study site with a sketch of the hill slope zones (A-uphill; B-middle (mid); C-downhill) and four replicate transects. Organic and thawed mineral soils, and permafrost (at ~1m depth) were sampled from 12 points along the hill slope. Vegetation was largely dominated by larch trees, low shrubs, moss, grass, and lichen during the sampling period (late July, 2014).

Methods:

- Dissolved organic carbon (DOC), total dissolved nitrogen (TDN), and the fraction of biodegradable DOC (%DOC Loss)[2] were measured on water extracts of organic and mineral soils, and permafrost sampled at ~1m.
- Soil moisture was measured by gravimetric analysis.
- %C was estimated from empirical relationships with organic matter content (loss on ignition, LOI).
- Extracellular enzyme activity rates were measured to examine microbial activities regulating carbon degradation[3].

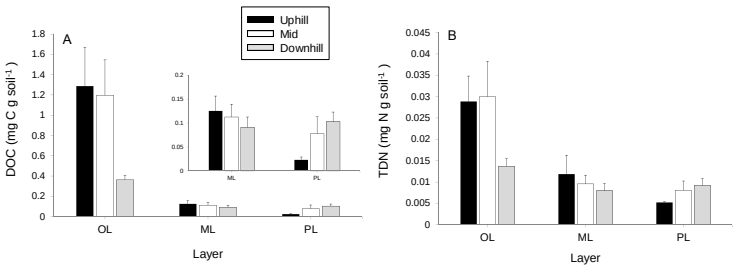

Figure 3. Hill slope distribution of leachable DOC (A) and TDN (B) within organic and mineral soils (OL and ML) and permafrost at ~1m (PL).

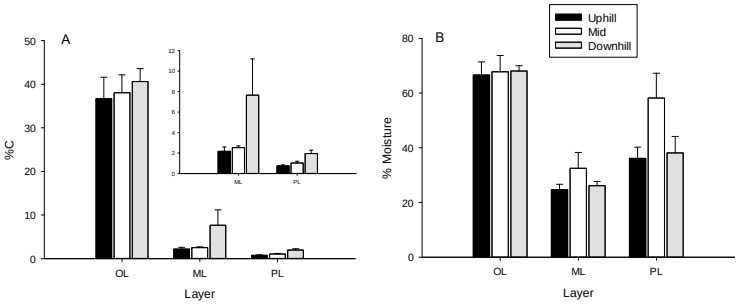

Figure 4. Hill slope distribution of %C (A) and % Moisture (B) within organic and mineral soils (OL and ML) and permafrost at ~1m (PL). Permafrost %moisture is also %ice content.

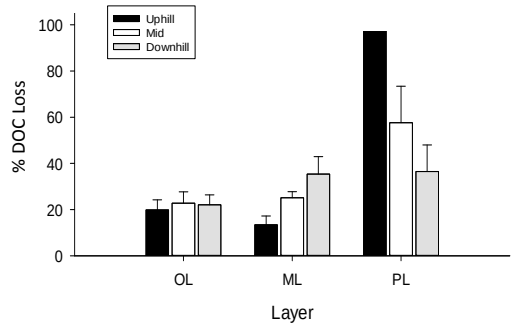

Figure 5. % DOC loss from organic and mineral soils (OL and ML), and permafrost at ~1m (PL) across the hill slope.

Summary of Results:

(1) The amount of leachable DOC/TDN from organic and mineral soils is greatest in uphill relative to downhill areas (Fig. 3).

(2) Downhill permafrost may contain more leachable DOC/TDN relative to uphill areas, with quantities near that of downhill mineral soils (Fig. 3).

(3) Downhill mineral soils and permafrost contain higher %C relative to uphill areas (Fig. 4).

(4) Mid-slope mineral soils and permafrost contain the highest % moisture (Fig. 4).

(5) Permafrost contains a highly labile pool of water extractable OC (Fig. 5).

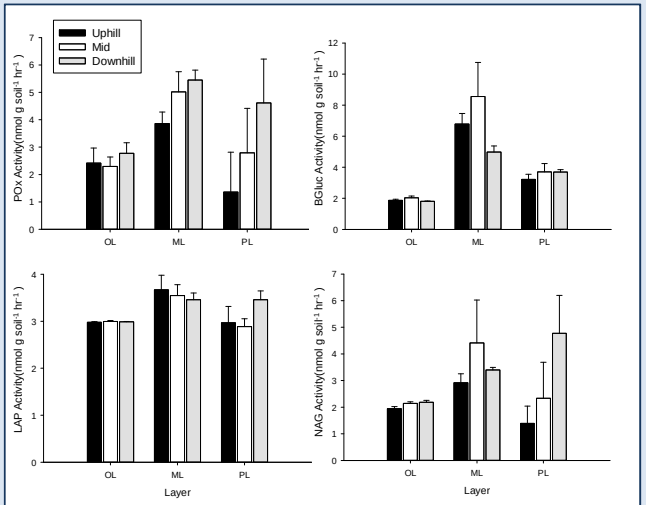

Figure 6. Enzyme activity rates (see Table 1) of organic and mineral soils (OL and ML) and permafrost at ~1m (PL) along the hill slope. Phosphatase activity (not shown) is high in all soils layers and shows little variation across the hill slope regions.

Table 1. Function of enzyme activities in carbon degradation[3]

Phenol Oxidase	**POx**	Degradation of lignin; compounds that inhibit hydrolase activity
Phosphatase	**PHOS**	Releases ester-bound phosphate
β-Glucosidase	**BGLUC**	Releases glucose from cellulose decomposition
Leucine- aminopeptidase	**LAP**	Degrades proteins into amino acids
Glucosaminidase	**NAG**	Degradation of chitin

Discussion:

(1) Organic soils clearly contain the largest pool of available OC in comparison to mineral soils and permafrost.

(2) There is a distribution of OM within the active layer and along a hill slope, showing a possible downhill accumulation of labile OC within the mineral layer.

(3) Permafrost contains a highly labile pool of water extractable OC.

(4) Results suggest that water leaching DOC may accumulate downhill and percolate into permafrost, creating ice lenses high in DOC.

Acknowledgements:

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